National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Greenhouse Gas Emissions *in the Netherlands* 1990-2015

National Inventory Report 2017

National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Greenhouse gas emissions in the Netherlands 1990–2015 National Inventory Report 2017

RIVM Report 2017-0033

Colophon

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The emissions and activity data of the Netherlands' inventory were converted into the IPCC[1] source categories contained in the Common Reporting Format (CRF) tables, which form a supplement to this report.

The description of the various sources, the analysis of trends and the uncertainty estimates (see Chapters 3 to 8) were made in co-operation with the following emissions experts: Eric Arets (KP and Land use), Guus van den Berghe (Waste), Jan-Peter Lesschen, Mart-Jan Schelhaas, Geerten Hengeveld and Peter Kuikman (Land use), Gerben Geilenkirchen and Stijn Dellaert (Transport), Romuald te Molder (key sources), Rianne Dröge (Energy and uncertainty assessment), Johanna Montfoort (Fugitive emissions), Kees Peek (Industrial processes and product use, data control, chart production), Kees Baas (Wastewater handling) and Jan Vonk and Stephanie Oude Voshaar (Agriculture). In addition, Bas Guis provided pivotal information on CO_2 emissions related to energy use. This group also provided activity data and additional information for the CRF tables in cases where these were not included in the data sheets submitted by the ER Task Forces. We are particularly grateful to Bert Leekstra, Jack Pesik and Dirk Wever for their contributions to data processing, chart production and quality control.

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[1] Intergovernmental Panel on Climate Change

Synopsis

Greenhouse gas emissions in the Netherlands 1990–2015

Total greenhouse gas (GHG) emissions from the Netherlands in 2015 increased by approximately 4%, compared with 2014 emissions. This increase was mainly the result of the increased electricity production in coal fired plants compared to 2014. Furthermore fuel combustion in all sectors was increased as the winter of 2015 was less mild as the one in 2014.

In 2015, total GHG emissions (including indirect CO_2 emissions and excluding emissions from Land use, land use change and forestry (LULUCF)) in the Netherlands amounted to 195.2 Tg CO_2 eq. This is approximately 12.5% below the emissions in the base year[2] (223.1 Tg CO_2 eq).

CO_2 emission have increased above the level in the base year 1990 in 2015 (+ 1.5%). This increase was offset by the reduction in the emissions since 1990 of methane, nitrous oxide and fluorinated gases (CH_4, N_2O and F-gases).

This report documents the Netherlands' 2017 annual submission of its greenhouse gas emissions inventory in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) provided by the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the European Union's Greenhouse Gas Monitoring Mechanism.

The report includes explanations of observed trends in emissions; an assessment of the sources with the highest contribution to the national emissions (key sources) and the uncertainty in their emissions; an itemization of methods, data sources and emission factors (EFs) applied; and a description of the quality assurance system and the verification activities performed on the data.

Keywords: greenhouse gases, emissions, trends, methodology, climate

[2] 1990 for CO_2, CH_4 and N_2O and 1995 for the F-gases.

Publiekssamenvatting

Emissies van broeikasgassen tussen 1990 en 2015

In 2015 is de totale uitstoot van broeikasgassen van Nederland met ongeveer 4 procent gestegen ten opzichte van de emissie in 2014. Deze stijging komt vooral doordat er meer elektriciteit is geproduceerd in de door steenkool gestookte elektriciteitscentrales. Daarnaast is er meer brandstof gebruikt voor ruimteverwarming dan in 2014 als gevolg van de koudere winter.

Totaal van alle broeikasgassen gedaald
De totale emissie van broeikasgassen naar de lucht wordt uitgedrukt in CO_2-equivalenten en bedroeg in 2015 195,2 miljard kilogram (megaton of teragram). Ten opzichte van het zogeheten Kyoto-basisjaar (223,1 miljard kilogram CO_2-equivalenten) is dit een afname van ongeveer 12,5 procent. Dit basisjaar, dat afhankelijk van het broeikasgas 1990 of 1995 is, dient voor het Kyoto-protocol als referentiejaar voor de uitstoot van broeikasgassen.

CO_2 emissie gestegen tot boven niveau 1990
De emissie van CO_2 lag in 2014 voor het eerst onder het niveau van het basisjaar 1990. In 2015 is de CO_2-uitstoot toegenomen met 4,5% en komt daarmee weer boven het niveau van het basisjaar 1990 (+1,5 procent) te liggen.
Deze toename werd voor de totale emissie van broeikasgassen ruim gecompenseerd door de lagere emissies van methaan, distikstofoxide en gefluoreerde gassen (CH_4, N_2O en F-gassen).

Dit blijkt uit een inventarisatie van broeikasgasemissies die het RIVM jaarlijks op verzoek van het ministerie van Infrastructuur en Milieu (IenM) opstelt. Met deze inventarisatie voldoet Nederland aan de nationale rapportageverplichtingen voor 2017 van het Klimaatverdrag van de Verenigde Naties (UNFCCC), van het Kyoto Protocol en van het Bewakingsmechanisme Broeikasgassen van de Europese Unie.

De inventarisatie bevat verder trendanalyses voor de emissies van broeikasgassen in de periode 1990-2015, een analyse van belangrijkste emissiebronnen (‘sleutelbronnen’), evenals de onzekerheid in hun emissies. Daarnaast zijn in de inventarisatie de gebruikte berekeningsmethoden beschreven, evenals databronnen en gebruikte emissiefactoren. Ten slotte bevat het een overzicht van het kwaliteitssysteem en de validatie van de emissiecijfers door de Nederlandse Emissieregistratie.

Kernwoorden: broeikasgassen, emissies, trends, methodiek, klimaat

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Samenvatting

Het National Inventory Report (NIR) 2017 bevat de rapportage van broeikasgasemissies (CO_2, N_2O, CH_4 en de F-gassen) over de periode 1990 tot en met 2015. De emissiecijfers in de NIR 2017 zijn berekend volgens de methoderapporten behorend bij het 'National System' dat is voorgeschreven in het Kyoto Protocol. In de methoderapporten zijn de berekeningswijzen vastgelegd voor zowel het basisjaar (1990 voor CO_2, CH_4 en N_2O en 1995 voor de F-gassen) als voor de emissies in de periode tot en met 2015. De methoderapporten zijn beschikbaar op de website http://www.rvo.nl/nie

National Inventory Report (NIR)
Dit rapport over de Nederlandse inventarisatie van broeikasgasemissies is op verzoek van het ministerie van Infrastructuur en Milieu (IenM) opgesteld om te voldoen aan de nationale rapportageverplichtingen in 2017 van het Klimaatverdrag van de Verenigde Naties (UNFCCC), het Kyoto protocol en het Bewakingsmechanisme Broeikasgassen van de Europese Unie.
Belangrijk is te vermelden dat in de emissies in dit rapport zijn berekend conform de nieuwste definities en richtlijn van de UNFCCC 2006. Tot en met de NIR 2014 werden de emissies volgens richtlijnen uit 1996 berekend. Door de definitieverschillen zijn de cijfers uit de rapportages van vóór 2015 en deze NIR niet vergelijkbaar.

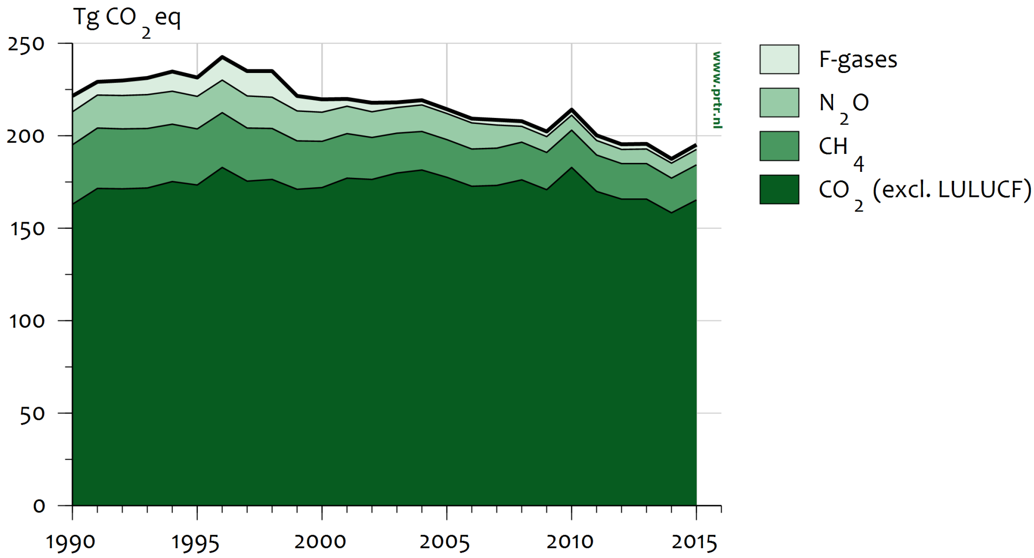
Dit rapport bevat de volgende informatie:
- trendanalyses voor de emissies van broeikasgassen in de periode 1990-2015;
- een analyse van zogenaamde sleutelbronnen en de onzekerheid in hun emissies volgens de 'Tier 1'-methodiek van de IPCC Good Practice Guidance;
- documentatie van gebruikte berekeningsmethoden, databronnen en toegepaste emissiefactoren;
- een overzicht van het kwaliteitssysteem en de validatie van de emissiecijfers voor de Nederlandse EmissieRegistratie;
- de meest recente wijzigingen die in de methoden voor het berekenen van broeikasgasemissies zijn aangebracht.

De NIR bevat ook de informatie die voorgeschreven is volgens artikel 7 van het Kyoto protocol (deel 2 van dit rapport). Hiermee voldoet Nederland aan alle rapportagerichtlijnen van de UNFCCC.

Een losse annex bij dit rapport bevat elektronische data over emissies en activiteit data in het zogenaamde Common Reporting Format (CRF), waar door het secretariaat van het VN-Klimaatverdrag om wordt verzocht. In de bijlagen bij dit rapport is onder meer een overzicht van sleutelbronnen en onzekerheden in de emissie opgenomen.

De NIR gaat niet specifiek in op de invloed van het gevoerde overheidsbeleid op de emissies van broeikasgassen; meer informatie hierover is te vinden in de de Balans van de Leefomgeving (opgesteld door het Planbureau voor de Leefomgeving, PBL), de zesde Nationale

Communicatie onder het Klimaatverdrag (NC6; IenM, 2013) en de tweede Tweejaarlijkse Rapportage (BR2; IenM, 2015).



Figuur ES.1 Broeikasgassen: emissieniveaus en emissietrends (exclusief LULUCF), 1990-2015.

Ontwikkeling van de broeikasgasemissies
De emissieontwikkeling in Nederland wordt beschreven en toegelicht in dit National Inventory Report (NIR 2017). Figuur ES.1 geeft het emissieverloop over de periode 1990-2015 weer. De totale emissies bedroegen in 2015 circa 195,2 Tg (Mton ofwel miljard kg) CO_2 equivalenten en zijn daarmee circa 12,5 procent afgenomen in vergelijking met de emissies in het basisjaar (223,1 Tg CO_2 eq). De hier gepresenteerde emissies zijn inclusief de indirecte CO_2 emissies en exclusief de emissies van landgebruik en bossen (LULUCF).

De emissie van CO_2 is sinds 1990 met circa 1,5 procent toegenomen, de emissies van de andere broeikasgassen zijn met circa 50 procent afgenomen ten opzichte van het basisjaar.
In 2015 steeg de CO_2 emissie met circa 4,5 procent (ten opzichte van het jaar 2014) ten gevolge van een hogere electriciteitsproductie in de nieuwe kolengestookte centrales. Daarnaast was er sprake van stijging van het brandstofgebruik (met name ten behoeve van ruimteverwarming) door de koudere winter dan die van 2014. De emissie van CH_4 steeg in 2015 licht ten opzichte van 2014, met ongeveer 1,2 procent. De N_2O emissie steeg in 2015 met circa 3,3 procent ten gevolge van verhoogde emissies in de landbouw. De emissie van F-gassen steeg in 2015 met circa 4,0 procent ten opzichte van 2014 door de opstart van een aluminiumfabriek. De totale emissie van broeikasgassen in 2015 ligt daarmee 4,1 procent hoger dan het niveau in 2014.

Box ES.1 Onzekerheden
De emissies van broeikasgassen kunnen niet exact worden gemeten of berekend. Onzekerheden zijn daarom onvermijdelijk. Het RIVM schat de onzekerheid in de jaarlijkse totale broeikasgasemissies op circa 3 procent. Dit is geschat op basis van informatie van emissie-experts in een eenvoudige analyse van de onzekerheid (volgens IPCC Tier 1). De totale uitstoot van broeikasgassen ligt daarmee met 95 procent betrouwbaarheid tussen de 189 en 201 Tg (Mton). De onzekerheid in de emissietrend tussen het basisjaar (1990/1995) en 2015 is geschat op circa 2 procent; dat wil zeggen dat de emissietrend in die periode met 95 procent betrouwbaarheid ligt tussen de -10 en -14 procent.

Methoden
De methoden die Nederland hanteert voor de berekening van de broeikasgasemissies zijn vastgelegd methoderapporten. Deze rapporten geven een gedetailleerde beschrijving van alle emissie schattingsmethoden voor alle stoffen in de EmissieRegistratie. Deze rapporten zijn opgesteld door deskundigen van de EmissieRegistratie (voor wat betreft de beschrijving en documentatie van de berekeningsmethoden voor broeikasgassen) in nauwe samenwerking met de Rijksdienst voor Ondernemend Nederland (RVO.nl).
De methoderapporten omvatten alle informatie die tot voorheen was opgenomen in de protocollen en zijn te vinden op http://english.rvo.nl/nie

Executive summary

ES1 Background information on greenhouse gas (GHG) inventories and climate change

This report documents the Netherlands' 2017 annual submission of its greenhouse gas emissions inventory in accordance with the guidelines provided by the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol (KP) and the European Union's Greenhouse Gas Monitoring Mechanism.
These guidelines, which relate to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), provide a format for the definition of source categories and for the calculation, documentation and reporting of emissions. The Guidelines are aimed at facilitating verification, technical assessment and expert review of the inventory information by the independent Expert Review Teams (ERTs) of the UNFCCC. The inventories should, therefore, be transparent, consistent, comparable, complete and accurate, as specified in the UNFCCC Guidelines for reporting, and be prepared using good practice.
This National Inventory Report 2017 (NIR 2017), therefore, provides explanations of the trends in GHG emissions, activity data and (implied) emission factors (EFs) for the period 1990–2015. It also summarizes the methods and data sources used in Tier 1 assessments of uncertainty in annual emissions and in emissions trends; it presents an assessment of key sources of emissions following the Tier 1 and Tier 2 approaches of the 2006 IPCC Guidelines and describes quality assurance and quality control (QA/QC) activities.
This report provides no specific information on the effectiveness of government policies for reducing GHG emissions. This information can be found in *Environmental balance* (biennial edition; in Dutch: ''Balans van de Leefomgeving') prepared by the Netherlands Environmental Assessment Agency (PBL) and the 6th National Communication (NC6; IenM, 2013) and the second Biennial Report (BR2; IenM, 2015).

The Common Reporting Format (CRF) spreadsheet files, containing data on emissions, activity data and implied emission factors (IEFs), accompany this report. The complete set of CRF tables, as well as the NIR in PDF format, can be found on the website http://english.rvo.nl/nie.

Climate Convention and Kyoto Protocol

This NIR is prepared as a commitment under the UNFCCC and under the Kyoto Protocol. Part 2 of the NIR focuses on supplementary information under Article 7 of the Kyoto Protocol. One of the commitments is the development of a National System for greenhouse gas emissions (Art. 5.1 of the Protocol). This National System developed in the period 2000–2005 was reviewed by an ERT of the UNFCCC in April 2007 and found to be in compliance with the requirements.

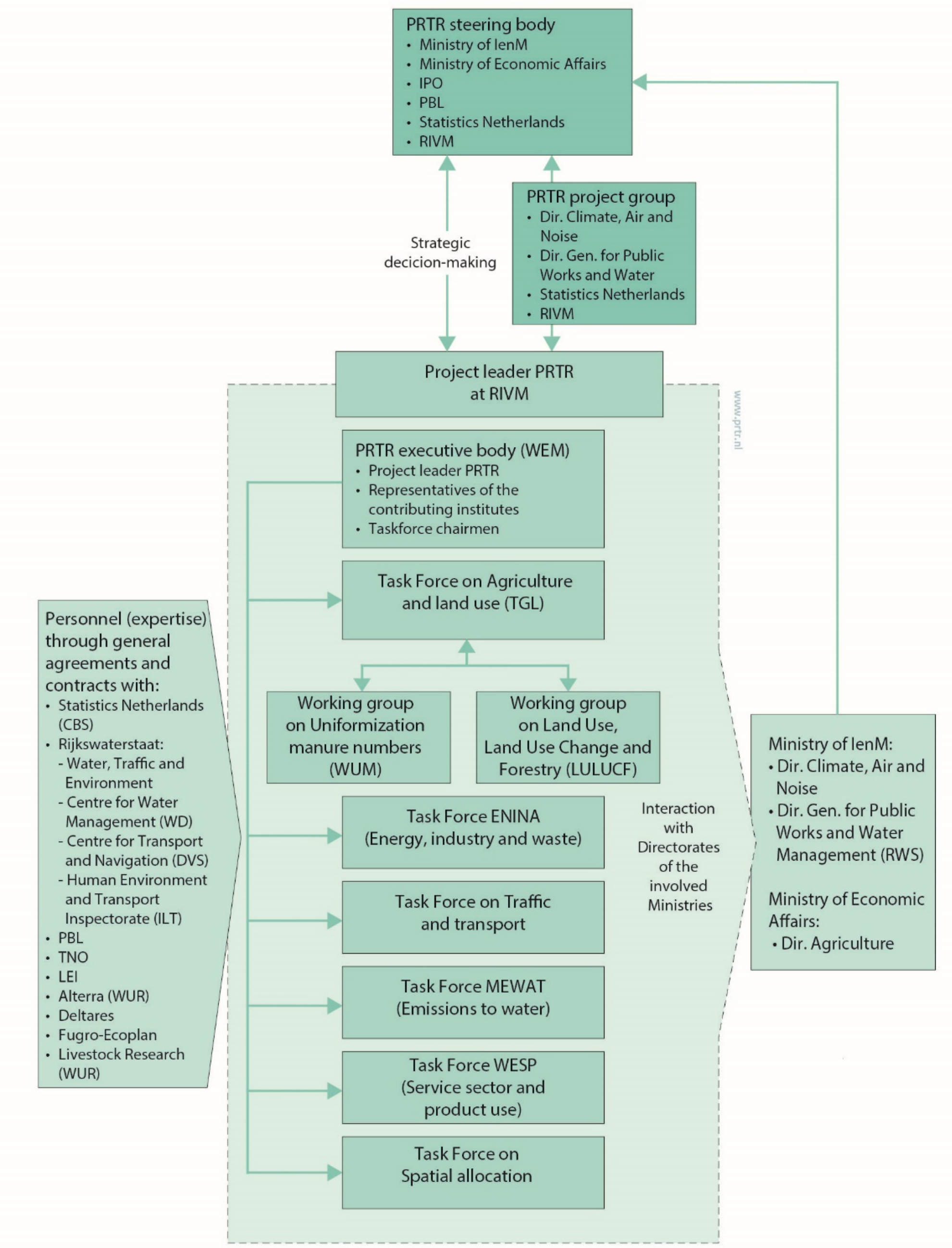


Figure ES.2 Main elements in the GHG inventory compilation process

Key categories

To identify the 'key categories' (the source categories which constitute 95% of the national emissions) according to the definition of the 2006 IPCC Guidelines, national emissions are categorized according to the IPCC potential key category list wherever possible. The IPCC Tier 1 method consists of ranking this list of source categories according to their contribution to both national total annual emissions and the national total trend. The results of this ranking are presented in Annex 1: 95% of the national total annual emissions derive from 31 sources and 95% of the national total trend is due to 36 sources, out of a total of 92 sources. The two lists can be combined to give an overview of sources that meet either or both of these two criteria. Next, the IPCC

Tier 2 method for identifying the key sources is used; this requires incorporating the uncertainty in the emission estimate of each of these sources before ranking them in relation to their share of total emissions. The result is a list of 50 source categories from the total of 92 that are identified as 'key sources'. Finally, after inclusion of ten Land use, land use change and forestry (LULUCF) sub-categories in the key category analysis, four more key sources are found in the LULUCF sector.

Institutional arrangements for inventory preparation
The GHG inventory of the Netherlands is based on the national Pollutant Release and Transfer Register (PRTR). The inventory is compiled annually in accordance with a procedure that has been in operation since 2000, when the process of compiling the GHGs inventory was transformed into a National System, in accordance with the requirements of Article 5.1 of the Kyoto Protocol, under the leadership of the Netherlands Enterprise Agency (RVO.nl).

The National Institute for Public Health and the Environment (RIVM) has been contracted by the Ministry of Infrastructure and the Environment (IenM) to compile and maintain the PRTR and to co-ordinate the preparation of the NIR and the completion of the CRF tables (see Figure ES.2). RVO.nl is designated by law as the National Inventory Entity (NIE) and co-ordinates the overall QA/QC activities and the support/response to the UNFCCC review process.

Methodology reports
Under the National System, in accordance with Article 5.1 of the Kyoto Protocol, the methodologies for calculating GHG emissions in the Netherlands were reassessed in 2005 and compared with UNFCCC and IPCC requirements.
From 2015 onwards, emissions data are reported according to the 2006 IPCC Guidelines (IPCC, 2006), implemented in accordance with the UNFCCC Reporting Guidelines. Therefore, the methodologies have been aligned with those Guidelines and described in methodology reports (which replace the former monitoring protocols).. The present CRF/NIR is based on these methodology reports, which are part of the National System. The reports are available at the National System website http://english.rvo.nl/nie. The methodology reports are formaly approved by the National Inventory Entity and approved by the chairperson of the PRTR Task Force concerned.

Organization of the report
This report is organised in line with the prescribed NIR format, starting with an introductory chapter, Chapter 1, which contains background information on the Netherlands' process of inventory preparation and reporting; key categories and their uncertainties; a description of methods, data sources and emission factors (EFs); and a description of the quality assurance system, along with verification activities applied to the data. Chapter 2 provides a summary of trends in aggregated GHG emissions by gas and by principal source. Chapters 3 to 9 present detailed explanations of emissions in the different CRF sectors. Chapter 10 presents information on recalculations, improvements. In addition, the report provides detailed information on key categories and methodologies and other relevant reports in eight annexes.

In part II of this report, the supplementary information required under Article 7, paragraph 1 of the Kyoto Protocol is reported.

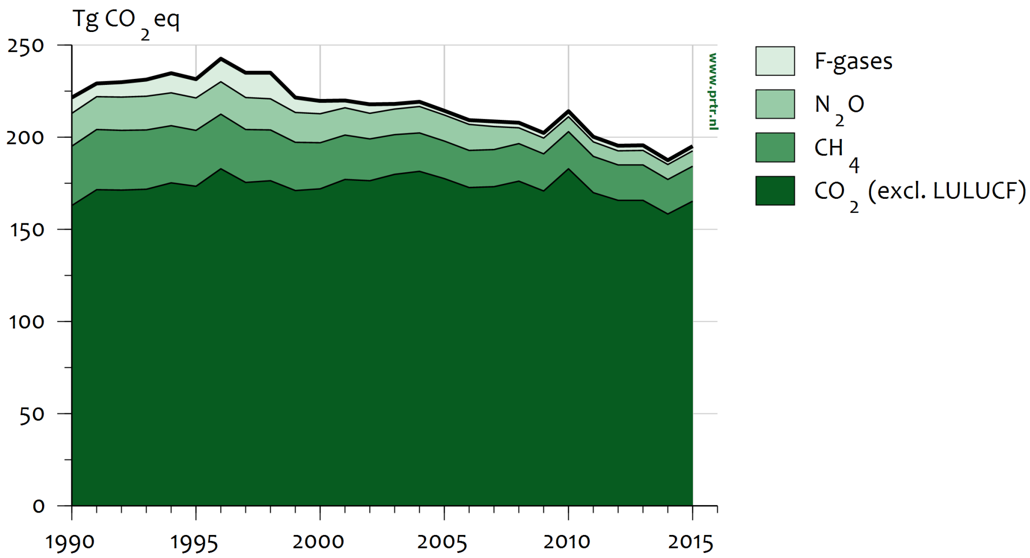


Figure ES.3 Overview of the trends in GHG emissions (excl. LULUCF) 1990–2015

ES2 Summary of trends in national emissions and removals
In 2015, total direct GHG emissions (including indirect CO_2 emissions and excluding emissions from LULUCF) in the Netherlands were estimated at 195.2 Tg CO_2 equivalents (CO_2 eq). This is approximately 12.5% below the emissions in the base years (223.1 Tg CO_2 eq). In the Netherlands, the base year for emissions of CO_2, CH_4 and N_2O is 1990, and the base year for emissions of fluorinated gases (F-gases) is 1995. CO_2 emissions (excluding LULUCF) increased by about 1.5% from 1990 to 2015 (a year with a colder winter than 2014). CH_4 emissions in 2015 decreased by 41% compared with 1990 levels, mainly due to decreases in emissions from the Waste sector and the Agricultural sector and in fugitive emissions from the Energy sector. N_2O emissions decreased by 53% in 2015 compared with 1990, mainly due to decreases in emissions from Agriculture and from Industrial processes, which partly compensated for N_2O emissions increases from fossil fuel combustion (mainly from Transport). The emissions of F-gases (HFCs, PFCs and SF_6) decreased in the period 1995 (chosen as the base year) to 2015 by 69%, 95% and 47%, respectively. Total emissions of all F-gases were approximately 74% lower than in 1995.

Between 2014 and 2015, CO_2 emissions (excluding LULUCF) increased by 7.1 Tg. Emissions of CH_4 also showed an increase of 0.2 Tg CO_2 eq between 2014 and 2015. In the same period, N_2O emissions increased by just under 0.3 Tg CO_2 eq. Emissions of HFCs, PFCs and SF_6 did not change significantly in 2015. Total F-gas emissions increased by 0.1 Tg CO_2 eq.
Overall, total GHG emissions increased by about 4.1% in comparison with 2014.

Total CO_2-eq emissions including LULUCF increased between 2014 and 2015 by 7.7 Tg to the level of 202.0 Tg CO_2 eq.

ES3 Overview of source and sink category emissions estimates and trends

Tables ES.1 and ES.2 provide an overview of the emissions trends (in CO_2 equivalents) per gas and per IPCC source category. The Energy sector is by far the largest contributor to national total GHG emissions. Emissions from this sector were slightly higher than in 1990. Emissions from the other sectors were lower than in the base year, the largest decreases being in Industrial processes, Waste and Agriculture.

Categories showing the largest increase in CO_2-equivalent emissions since 1990 are Transport (1A3) and Energy industries (1A1) (+11% and +29%, respectively). It should be noted that half the increase of almost 30% in the Public electricity category (1A2) between 1990 and 1998 was caused by a shift of cogeneration plants from Manufacturing industries to the Public electricity and heat production sector due to a change of ownership (joint ventures), which simultaneously caused a 15% decrease in Industry emissions in the early 1990s

Table ES.1 Summary of emissions trends per gas (Tg CO_2 equivalents, including indirect CO_2 emissions)

	CO_2 incl. LULUCF	**CO_2 excl. LULUCF**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Total (incl. LULUCF)**	**Total (excl. LULUCF)**
Base year	**169.0**	**162.9**	**32.3**	**17.7**	**7.6**	**2.3**	**0.3**	**229.1**	**223.1**
1990	169.0	162.9	32.3	17.7	5.6	2.7	0.2	227.5	221.4
1991	177.7	171.5	32.7	17.9	4.4	2.6	0.1	235.4	229.2
1992	177.5	171.3	32.3	18.1	5.6	2.4	0.1	236.1	229.9
1993	178.1	171.8	32.1	18.4	6.3	2.4	0.1	237.5	231.2
1994	181.5	175.2	31.1	17.9	8.2	2.3	0.2	241.1	234.8
1995	179.5	173.3	30.3	17.7	7.6	2.3	0.3	237.7	231.5
1996	189.0	182.8	29.6	17.8	9.6	2.5	0.3	248.8	242.6
1997	181.5	175.4	28.7	17.5	10.2	2.8	0.3	241.0	234.9
1998	182.6	176.5	27.5	16.9	11.6	2.2	0.3	241.1	234.9
1999	177.1	171.0	26.2	16.2	6.0	1.8	0.3	227.7	221.6
2000	178.0	172.0	25.1	15.7	4.8	1.9	0.3	225.8	219.7
2001	183.2	177.2	24.1	14.7	1.9	1.8	0.3	226.1	219.9
2002	182.4	176.4	22.7	13.9	2.0	2.6	0.2	223.9	217.8
2003	186.1	179.8	21.6	13.8	1.8	0.8	0.2	224.3	218.0
2004	187.4	181.4	21.0	14.2	1.9	0.4	0.2	225.2	219.2
2005	183.3	177.4	20.5	14.2	1.7	0.4	0.2	220.3	214.4
2006	178.6	172.8	20.1	14.1	2.0	0.4	0.2	215.4	209.4
2007	179.1	173.2	20.2	12.4	2.1	0.4	0.2	214.5	208.5
2008	182.0	176.2	20.3	8.6	2.2	0.3	0.2	213.8	207.9
2009	176.9	170.9	20.2	8.4	2.3	0.3	0.1	208.4	202.3
2010	188.8	182.8	20.1	8.1	2.7	0.3	0.2	220.3	214.2
2011	176.0	169.9	19.6	7.9	2.4	0.3	0.1	206.5	200.3
2012	171.9	165.8	19.2	7.8	2.4	0.2	0.2	201.7	195.4
2013	172.3	165.8	19.2	8.0	2.4	0.1	0.1	202.3	195.6
2014	164.8	158.3	18.8	8.1	2.3	0.1	0.1	194.3	187.6
2015	171.9	165.3	19.0	8.3	2.3	0.1	0.1	202.0	195.2

Table ES.2 Summary of emissions trends per source category (Tg CO_2 equivalents, including indirect CO_2 emissions)

	1. Energy	2. Ind. Processes and prod. use	3. Agriculture	4. LULUCF	5. Waste	Total (incl. LULUCF)	Total (excl. LULUCF)
Base year	**156.4**	**27.2**	**25.3**	**6.1**	**14.2**	**229.1**	**223.1**
1990	156.4	25.5	25.3	6.1	14.2	227.5	221.4
1991	165.0	24.3	25.6	6.2	14.3	235.4	229.2
1992	165.4	24.8	25.6	6.2	14.1	236.1	229.9
1993	166.2	25.8	25.5	6.3	13.7	237.5	231.28
1994	169.1	28.0	24.5	6.3	13.2	241.1	234.8
1995	167.7	26.7	24.5	6.2	12.6	237.7	231.5
1996	177.7	28.5	24.2	6.2	12.2	248.8	242.6
1997	169.2	29.8	24.1	6.1	11.8	241.0	234.9
1998	170.3	30.4	22.9	6.2	11.3	241.1	234.9
1999	164.9	23.9	22.4	6.1	10.4	222.7	221.6
2000	165.9	22.7	21.2	6.0	9.8	225.8	219.7
2001	171.7	18.5	20.8	6.1	9.0	226.1	219.9
2002	171.0	19.0	19.6	6.1	8.2	223.9	217.8
2003	174.4	17.0	19.2	6.3	7.4	224.3	218.0
2004	175.8	17.4	19.0	6.1	6.9	225.2	219.2
2005	171.8	17.5	18.8	6.0	6.3	220.3	214.4
2006	167.6	17.1	18.8	6.0	5.8	215.4	209.4
2007	167.8	16.6	18.6	6.0	5.4	214.5	208.5
2008	172.1	12.1	18.6	5.9	5.1	213.8	207.9
2009	167.1	11.9	18.5	6.1	4.8	208.4	202.3
2010	178.8	12.4	18.5	6.1	4.5	220.3	214.2
2011	165.2	12.6	18.2	6.2	4.2	206.5	200.3
2012	161.5	11.9	18.0	6.3	4.0	201.7	195.4
2013	161.6	11.8	18.4	6.7	3.8	202.3	195.6
2014	154.2	11.2	18.6	6.7	3.6	194.3	187.6
2015	161.0	11.7	19.2	6.7	3.4	202.0	195.2

ES4 Other information

General uncertainty evaluation

The results of the uncertainty estimation according to the IPCC Tier 1 uncertainty approach are summarized in Annex 2 of this report. The Tier 1 estimation of annual uncertainty in CO_2-eq emissions results in an overall uncertainty of 3%, based on calculated uncertainties of 2% for CO_2 (excluding LULUCF), 18% for CH_4, 40% for N_2O and 43% for F-gases.

However, these figures do not include the correlation between source categories (e.g. cattle numbers for enteric fermentation and animal manure production), nor a correction for non-reported sources.
The correlation between source categories can be included in a Tier 2 uncertainty assessment. Currently, a Tier 2 uncertainty assessment (using Monte Carlo analysis) is being performed and the first results for the calculated uncertainty in the national emissions are of the same order of magnitude as the Tier 1 uncertainty assessment. Table ES.3 shows the currently estimated values for the Tier 1 and Tier 2 analysis.

Table ES.3 Tier 1 and the Tier 2 uncertainty assessment of 2015 emissions (without LULUCF)

Greenhouse gas	Tier 1 annual uncertainty	Tier 2 annual uncertainty
Carbon dioxide	2%	3%
Methane	18%	16%
Nitrous oxide	40%	28%
F-gases	43%	26%
Total	3%	3%

From table ES 3 it can be seen that taking into account the correlations between source categories increases the uncertainty of the national CO_2 emission, due the correlations in emission factors. For the other gasses the Tier 2 analysis yields lower uncertainties.

Annex 2 summarizes the estimates of the trend uncertainties 1990–2014 calculated according to the IPCC Tier 1 approach set out in the 2006 IPCC Guidelines. The result is a trend uncertainty in total CO_2-eq emissions (including LULUCF) for 1990–2015 (1995–2015 for F-gases) of ± 2%. This means that the trend in total CO_2-eq emissions between 1990 and 2015 (excluding LULUCF), which is calculated to be a 12.5% decrease, will be between a 10% decrease and an 14% decrease. Per individual gas, the trend uncertainties in total emissions of CO_2, CH_4, N_2O and the total group of F-gases have been calculated at ± 2%, ± 6%, ± 7% and ± 12%, respectively. More details of the trend uncertainty assessment can be found in Annex 2.

Completeness of the national inventory
The Netherlands' GHG emissions inventory includes almost all sources identified by the 2006 IPCC Guidelines. The following very minor sources are not included in the inventory:

- CO_2 from Asphalt roofing (2D3), due to missing activity data;
- CO_2 from Road paving (2D3), due to missing activity data;
- CH_4 from Enteric fermentation of poultry (3A4), due to missing EFs;
- N_2O from Industrial wastewater (5D2) and septic tanks, due to negligible amounts;
- Part of CH_4 from Industrial wastewater (5D2 sludge), due to negligible amounts.

Precursor emissions (carbon monoxide (CO), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2)) from memo item 'International bunkers' (international transport) are not included.

Methodological changes, recalculations and improvements
This NIR (2017) is based on the National System of the Netherlands, in accordance with Article 5.1 of the Kyoto Protocol. In past years, the results of various improvement actions have been implemented in the methodologies and processes of compiling the GHG inventory of the Netherlands. Compared with the NIR 2016, some improvements of the inventory (including recalculations) have been undertaken in the last

year. The rationale behind the recalculations is documented in Chapters 3–10.

Table ES.3 shows the results of recalculations in the NIR 2017 compared with the NIR 2016.

Table ES.3 Differences between NIR 2017 and NIR 2016 due to recalculations (Tg CO_2 eq including indirect CO_2 emissions; F-gases: Gg CO_2 eq)

Gas	Source	1990	1995	2000	2005	2010	2014
CO_2 [Tg]	NIR 2017	169.0	179.5	178.0	183.3	188.8	164.8
Incl. LULUCF	NIR 2016	169.2	180.0	178.5	183.9	188.7	164.2
	Difference	-0.1%	-0.2%	-0.3%	-0.3%	0.1%	0.3%
CO_2 [Tg]	NIR 2017	162.9	173.3	172.0	177.4	182.8	158.3
Excl. LULUCF	NIR 2016	163.2	173.7	172.4	177.8	182.8	158.0
	Difference	-0.1%	-0.2%	-0.2%	-0.2%	0.0%	0.2%
CH_4 [Tg]	NIR 2017	32.3	30.3	25.1	20.5	20.1	18.8
	NIR 2016	32.9	30.7	25.3	20.4	20.0	18.8
	Difference	-1.8%	-1.3%	-1.0%	0.4%	0.6%	0.1%
N_2O [Tg]	NIR 2017	17.7	17.8	15.8	14.2	8.2	8.2
	NIR 2016	17.6	17.7	15.7	14.2	8.2	7.9
	Difference	0.3%	0.4%	0.5%	0.5%	0.9%	3.1%
PFCs [Gg]	NIR 2017	2663	2280	1903	366.0	313.8	93.2
	NIR 2016	2663	2280	1903	366.0	313.8	93.2
	Difference	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HFCs [Gg]	NIR 2017	5606	7571	4765	1728	2666	2252
	NIR 2016	5606	7571	4713	1619	2485	2241
	Difference	0.0%	0.0%	1.1%	6.8%	7.3%	0.5%
SF_6 [Gg]	NIR 2017	206.7	261.0	258.8	203.7	153.8	134.6
	NIR 2016	206.7	261.0	258.8	203.7	153.8	134.6
	Difference	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	NIR 2017	227.5	237.7	225.8	220.3	220.3	194.3
[Tg CO_2 eq]	NIR 2016	228.3	238.5	226.5	220.6	219.8	193.4
Incl. LULUCF	Difference	-0.3%	-0.3%	-0.3%	-0.1%	0.2%	0.4%
Total	NIR 2017	221.4	231.5	219.7	214.4	214.2	187.6
[Tg CO_2 eq]	NIR 2016	222.2	232.2	220.3	214.4	213.8	187.1
Excl. LULUCF	Difference	-0.3%	-0.3%	-0.2%	0.0%	0.2%	0.3%

Note: Base year values are indicated in bold.

Improving the QA/QC system

The QA/QC (quality assurance/quality control) programme is up to date and all procedures and processes meet National System requirements (as part of the annual activity programme of the Netherlands' PRTR). QA/QC activities needing to be undertaken as part of the National System are described in Chapter 1.

Emissions trends for indirect GHGs and SO_2

Compared with 1990, CO and NMVOC emissions were reduced in 2015 by 52% and 71%, respectively. For SO_2, the reduction was 84%; for NO_x, the 2015 emissions were 64% lower than the 1990 level. Table ES.4 provides trend data.

Table ES.4 Emissions trends for indirect GHGs and SO_2 (Gg)

	1990	1995	2000	2005	2010	2015
Total NO_X	554	458	377	325	263	202
Total CO	1.218	881	807	720	667	585
Total NMVOC	476	336	239	178	163	139
Total SO_2	189	126	71	62	33	29

Part 1: Annual inventory report

1 Introduction

1.1 Background information on greenhouse gas inventories and climate change

1.1.1 Background information on climate change

The United Nations Framework Convention on Climate Change (UNFCCC) was ratified for the European part of the Netherlands in 1994 and took effect in March 1994. One of the commitments made by the ratifying Parties to the Convention was to develop, publish and regularly update national emissions inventories of greenhouse gases (GHGs). This national inventory report, together with the CRF, represents the 2017 national emissions inventory of greenhouse gases under the UNFCCC (part 1 of this report) and under its Kyoto Protocol (part 2 of this report).

Geographical coverage

The reported emissions are those that derive from the legal territory of the Netherlands. This includes a 12-mile zone out from the coastline and inland water bodies. It excludes Aruba, Curaçao and Sint Maarten, which are constituent countries of the Kingdom of the Netherlands. It also excludes Bonaire, Saba and Sint Eustatius, which since 10 October 2010 have been public bodies (*openbare lichamen*) with their own legislation that is not applicable to the European part of the Netherlands. Emissions from offshore oil and gas production on the Dutch part of the continental shelf are included.

1.1.2 Background information on GHG inventory

As indicated, this NIR documents the 2017 Greenhouse Gas Emission Inventory for the Netherlands under the UNFCCC and under the Kyoto Protocol. The estimates provided in the report are consistent with the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The methodologies applied to the Netherlands' inventory are also consistent with the guidelines under the Kyoto Protocol and the European Union's Greenhouse Gas Monitoring Mechanism.

For detailed assessments of the extent to which changes in emissions are due to the implementation of policy measures, see the Environmental Balance (PBL, 2009; in Dutch), the Sixth Netherlands national communication under the United Nations Framework Convention on Climate Change (IenM, 2013) and the Second Biennial Report (BR2; IenM, 2015).

The Netherlands also reports emissions under other international agreements, such as the United Nations Economic Commission for Europe (UNECE), the Convention on Long Range Transboundary Air Pollutants (CLRTAP) and the EU's National Emission Ceilings (NEC) Directive. All emission estimates are taken from the Netherlands' Pollutant Release and Transfer Register (PRTR), which is compiled by a special project in which various organizations co-operate. The GHG inventory and the PRTR share underlying data, which ensures consistency between the inventories and other internationally reported data. Several institutes are involved in the process of compiling the GHG inventory (see also Section 1.3).

The NIR covers the seven direct GHGs included in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (the last three are called the F-gases; NF_3 is included in the figure for PFCs but cannot be reported separately due to the confidentiality of the data).

Emission totals for the GHG in this NIR are reported including indirect CO_2 emissions.

Emissions of the following indirect GHGs are also reported: nitrogen oxides (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOC) and sulphur oxides (SO_x).

This report provides explanations of the trends in GHG emissions per gas and per sector for the 1990–2015 period and summarizes the methods used and data sources for: (a) Tier 1 assessments of the uncertainty in annual emissions and in emissions trends; (b) key source assessments following the Tier 1 and Tier 2 approaches of the 2006 IPCC Guidelines; (c) quality assurance and quality control (QA/QC) activities.

Under the National System, in accordance with Article 5.1 of the Kyoto Protocol, the methodologies for calculating GHG emissions in the Netherlands were reassessed in 2005 and compared with UNFCCC and IPCC requirements. For the key sources and for sinks, the methodologies and processes were elaborated into (about 40) monitoring protocols. These protocols, describing the methodologies according to the Revised 1996 IPCC Guidelines (IPCC, 1997), were annually revised, where necessary, and used until 2014. Adjustments to the protocols required an official announcement in the *Government gazette* (*Staatscourant*).

From 2015 onwards, emissions data are reported according to the 2006 IPCC Guidelines (implemented in accordance with the UNFCCC Reporting Guidelines). Therefore, the methodologies have been aligned with those Guidelines and are documented in five methodology reports, one for each PRTR Task Force. The present NIR is based on the methodogies described in these methodology reports, which should be considered as part of the National System. The reports are available at the National System website http://english.rvo.nl/nie. The methodology reports are reviewed by the National Inventory Entity and approved by the chairperson of the PRTR Task Force concerned.

In 2007, the UN performed an in-country initial review under the Kyoto Protocol. The review concluded that the Netherlands' National System had been established in accordance with the guidelines and that it met the requirements. This was confirmed by later reviews, such as the review of the NIR 2014.

Since then, the following two changes to the National System have been implemented:

- On 1 January 2010, co-ordination of the aforementioned PRTR (emissions registration) project shifted from the PBL (Netherlands Environmental Assessment Agency) to the RIVM (National Institute for Public Health and the Environment). In 2010, institutional arrangements were made to ensure the quality of the products of the PRTR project in the new setting.
- From the NIR 2015 onwards, the system of monitoring protocols (including methodology descriptions) has been replaced by the production of five methodology reports. As a result, the official announcement in the *Government gazette* of revised monitoring protocols has been replaced by the approval of the methodology reports by the National Inventory Entity (NIE).

The structure of this report complies with the format required by the UNFCCC (FCCC/SBSTA/2004/8 and the latest annotated outline of the National Inventory report, including reporting elements under the Kyoto Protocol). It also includes supplementary information under Article 7 of the Kyoto Protocol. Part 2 gives an overview of this information.

Greenhouse gas (GHG) emissions are given in gigagrams (Gg) and teragrams (Tg) in this report. Global warming potential (GWP) weighted emissions of the GHGs are also provided (in CO_2 equivalents), using GWP values based on the effects of GHGs over a 100-year horizon, in accordance with UNFCCC Decision 24/CP.19 Annex III. The GWP of each individual GHG is given in Annex 7.

The Common Reporting Format (CRF) spreadsheet files accompany this report as electronic annexes. The CRF tables contain detailed information on GHG emissions, activity data and (implied) emission factors (EFs) by sector, source category and GHG. The complete set of CRF tables and this report comprise the NIR, which is published on the website http://english.rvo.nl/nie.

Chapter 10 provides details of the extent to which the CRF data files for 1990–2015 have been completed and of improvements made since the last submission.

1.1.3 Background information on supplementary information under Article 7 of the Kyoto Protocol

Part 2 of this report provides the supplementary information under (Article 7 of) the Kyoto Protocol. This supplementary information on KP-LULUCF pertains to activities under Article 3, paragraph 3 and Forest Management, the mandatory activity under Article 3, paragraph 4 of the Kyoto Protocol. The Netherlands has not elected any other activities to include under Article 3, paragraph 4 of the Kyoto Protocol. Information on the accounting of Kyoto units is also provided in the SEF file: RITL1_NL_2016_CP_02.xlsx .

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

The Ministry of Infrastructure and the Environment (IenM) bears overall responsibility for climate change policy issues, including the preparation of the national GHG inventory.

In December 2005, the Netherlands Enterprise Agency (RVO.nl) was designated by law as the National Inventory Entity (NIE), the single national entity required under the Kyoto Protocol. In addition to the co-ordination of the establishment and maintenance of a National System, the tasks of RVO.nl include overall co-ordination of improved QA/QC activities as part of the National System and co-ordination of the support/response to the UNFCCC review process. The National System is described in greater detail in the *Sixth Netherlands national communication under the United Nations Framework Convention on Climate Change* (IenM, 2013).

The RIVM has been assigned by the IenM as the institute responsible for co-ordinating the compilation and maintenance of the pollutants emission register/inventory (PRTR system), which contains data on approximately 350 pollutants, including the GHGs. The PRTR project system is used as the basis for the NIR and for the completion of the CRF tables.

1.2.2 Overview of inventory planning, preparation and management

The Dutch PRTR system has been in operation in the Netherlands since 1974. This system encompasses data collection, data processing and the registering and reporting of emissions data for approximately 350 policy-relevant compounds and compound groups that are present in air, water and soil. The emissions data is produced in an annual (project) cycle (RIVM, 2016). This system also serves as the basis for the national GHG inventory. The overall coordination of the PRTR is outsourced by the IenM to the RIVM.

The main purpose of the PRTR is to help in the production of an annual set of unequivocal emissions data that is up to date, complete, transparent, comparable, consistent and accurate. In addition to the RIVM, various external agencies contribute to the PRTR by performing calculations or submitting activity data. These include Statistics Netherlands, PBL (Netherlands Environmental Assessment Agency), TNO (Netherlands Organization for Applied Scientific Research), Rijkswaterstaat Environment, Centre for Water Management, Deltares and several institutes related to the Wageningen University and Research Centre (WUR).

1.2.2.1 Responsibility for reporting

The NIR part 1 is prepared by RIVM as part of the PRTR project. Most institutes involved in the PRTR also contribute to the NIR (including CBS and TNO). In addition, the Netherlands Enterprise Agency (RVO.nl) is involved in its role as NIE. The Netherlands Enterprise Agency also prepares the NIR part 2 and is responsible for integration and submission to the UNFCCC in its role as NIE. Submission to the UNFCCC takes place only after approval by the Ministry of IenM.

1.2.2.2 Overview of the inventory preparation and management under Article 7 of the Kyoto Protocol

Following the annotated outline, the supplementary information, as required according to Article 2 of the Kyoto Protocol, is reported in the NIR part 2. This information is prepared by the Netherlands Enterprise Agency (RVO.nl) using information from various other organizations involved, such as the NEa (Dutch Emissions Authority), the WUR and the Ministry of IenM.

1.2.3 Reporting, QA/QC, archiving and overall co-ordination

The NIR is prepared by the RIVM with input from the relevant PRTR Task Forces and from RVO.nl. The preparation of the NIR also includes the documentation and archiving of statistical data for the estimates and QA/QC activities. The IenM formally approves the NIR before it is submitted; in some cases, approval follows consultation with other ministries. RVO.nl is responsible for co-ordinating QA/QC and responses to the EU and for providing additional information requested by the UNFCCC after the NIR and the CRF have been submitted. RVO.nl is also responsible for co-ordinating the submission of supporting data to the UNFCCC review process.

For KP-LULUCF, consistency with the values submitted for the Convention is assured by using the same base data and calculation structure. The data, as required in the KP-LULUCF CRF tables, are derived from these Convention calculations using specific agregation to the KP-LULUCF activities. The data and calculations are thus subject to the same QA/QC procedures (Arets et al., 2017).

The calculated values were generated in the LULUCF bookkeeping model at Wageningen Environmental Research (Alterra) and checked by the LULUCF sectoral expert. They were then sent to the Dutch inventory, which entered the data into the CRF database for all sectors and checked them again. Any unexpected or incomplete values were reported to the LULUCF sectoral expert, checked and, if necessary, corrected.

1.2.3.1 Information on the QA/QC plan

The National System, in line with the Kyoto requirements, was finalized and established by the end of 2005. As part of this system, the Act on the Monitoring of Greenhouse Gases also took effect in December 2005. This Act requires the establishment of the National System for the monitoring of GHGs and empowered the Minister for Infrastructure and Environment to appoint an authority responsible for the National System and the National GHG Inventory. In a subsequent regulation, the Minister appointed RVO.nl as the NIE (National Inventory Entity, the single national entity required under the Kyoto Protocol).

As part of its National System, the Netherlands has developed and implemented a QA/QC programme. This programme is assessed annually and updated, if necessary. The key elements of the current programme (RVO.nl, 2016) are summarized in this chapter, notably those related to the current NIR.

1.2.3.2 QA/QC procedures for the CRF/NIR 2017

The system of methodology reports was elaborated and implemented in order to increase the transparency of the inventory (including methodologies, procedures, tasks, roles and responsibilities with regard to inventories of GHGs). Transparent descriptions of all these aspects are included in the methodology reports for each gas and sector and in process descriptions for other relevant tasks in the National System. The methodology reports are assessed annually and updated, if necessary.

Several QC issues relate to the NIR:

- The ERT recommended providing more information in the NIR report, which is now included in the background information. As most of the background documentation is in English and is available for review purposes, this background information is not included in the methodology reports. This does not diminish the constant attention given by the Task Forces to further improve the quality and transparency of the methodology reports.
- The ERT recommended providing more detailed information on sector-specific QC activities. In 2009 and early 2010, a project was performed to reassess and update both the information on uncertainties and the information on sector-specific QC activities (Ecofys, 2010). The PRTR Task Forces continued to work on the implementation of the recommendations from this report in 2017, especially in relation to the documentation of uncertainties in the PRTR database.
- In NIR 2017 the Netherlands started a special project on improvement of notation keys in the CRF tables.
  This resulted in much better filling of CRF with notation keys for the year 2015. This project will be finished next year.

For the NIR 2017, changes were incorporated in and references were updated to the National System website (http://english.rvo.nl/nie), providing additional information on the methodology reports and relevant background documents.

To facilitate the general QC checks, a checklist was developed and implemented. A number of general QC checks have been introduced as part of the annual work plan of the PRTR and are also mentioned in the methodology reports. The QC checks included in the work plan are aimed at covering issues such as the consistency, completeness and correctness of the CRF data. The general QC for the present inventory was largely performed at the institutes involved as an integrated part of their PRTR work (Wever, 2011). The PRTR Task Forces fill in a standard-format database with emissions data for 1990–2015 (with the exception of LULUCF). After a first check of the data by the RIVM and TNO for completeness, the (corrected) data is made available to the relevant Task Forces for consistency checks and trend analyses (comparability, accuracy). The Task Forces have access to the national emissions database. Several weeks before the dataset was fixed, a trend verification workshop was organized by the RIVM (1 December 2016). The conclusions of this workshop (including the actions for the Task Forces to resolve the identified clarification issues) are documented at the RIVM. Required changes to the database are then made by the Task Forces.

Basic LULUCF data (e.g. forest inventories, forests statistics and land use maps) has a different routing compared with the other basic data (see Figure 1.1). QA/QC for this data are elaborated in the description of QA/QC of the outside agencies (Wever, 2011).

Quality Assurance for the current NIR includes the following activities:

- A peer and public review on the basis of the draft NIR in January/February 2017. Results of these reviews are summarized in Chapter 10 and have been dealt with as far as possible in the present NIR.
- In preparing this NIR, the results of former UNFCCC reviews and ESD reviews. As described in chapter 10 the response to the UNFCCC review 2016 will be included in NIR 2018 because at the time of the submission of NIR 2017 the Netherlands has not received the ARR report.

The QA/QC system must operate within the available means (capacity, finance). Within those means, the focal points of the QA/QC activities are:

- The *QA/QC programme* (RVO.nl, 2016) that has been developed and implemented as part of the National System. This programme includes quality objectives for the National System, the QA/QC plan and a schedule for the implementation of the activities. It is updated annually as part of an 'evaluation and improvement cycle' for the inventory and National System and is kept available for review.
- The *adaptation of the PRTR project to the quality system* of the RIVM (ISO 9001:2008 system), completed in 2012;
- The annual *work plan* of the RIVM (RIVM, 2016). The work plan describes the tasks and responsibilities of the parties involved in the PRTR process, such as products to be delivered, scheduling (planning) and emissions estimation (including the methodology reports on GHGs), as well as those of the members of the Task Forces. The annual work plan also describes the general QC activities to be performed by the Task Forces before the annual PRTR database is fixed (see section 1.6.2).
- *Responsibility for the quality of data in annual environmental reports* (AER) and validation of the data. The former lies with the companies themselves, the latter with the competent authorities. It is the responsibility of the institutes involved in the PRTR to judge whether or not to use the validated data of individual companies to be used in the calculation of the national total emissions. (CO_2 emissions, however, are based on energy statistics and standard EFs, and only approved specific EFs from AERs are used.)
- *Agreements/covenants* between the RIVM and other institutes involved in the annual PRTR process. The general agreement is that, by accepting the annual work plan, the institutes involved commit themselves to deliver capacity for the work/products specified in that work plan. The role and responsibility of each institute have been described (and agreed upon) within the framework of the PRTR work plan.
- *Specific procedures* that have been established to fulfil the QA/QC requirements of the UNFCCC and Kyoto Protocol. General

agreements on these procedures are described in the QA/QC programme as part of the National System. The following specific procedures and agreements have been set out and described in the QA/QC plan and the annual PRTR work plan:

- QC on data input and data processing, as part of the annual trend analysis and consolidation of the database following approval of the involved institutions.
- Documentation of the consistency, completeness and correctness of the CRF data (also see Section 1.6.2). Documentation is required for all changes in the historical dataset (recalculations) and for emissions trends that exceed 5% at the sector level and 0.5% at the national total level. In doing so the Netherlands are strict, as, according to the IPCC 2006, only changes in trend greater than 10% need to be checked.
- Peer reviews of the CRF tables and NIR by RVO.nl and institutions not directly involved in the PRTR process;
- Public review of the draft NIR: Every year, RVO.nl organizes a public review (via the internet). Relevant comments are incorporated in the final NIR.
- Audits: In the context of the annual work plan, it has been agreed that the institutions involved in the PRTR will inform the RIVM about forthcoming internal audits. Furthermore, RVO.nl is assigned the task of organizing audits, if needed, of relevant processes or organizational issues within the National System.
- Archiving and documentation: Internal procedures are agreed (in the PRTR annual work plan,) for general data collection and the storage of fixed datasets in the RIVM database, including the documentation/archiving of QC checks. Since 2012, the RIVM database has held storage space where the Task Forces can store the data needed for their emissions calculations. The use of this storage space is optional, as the storage of essential data is also guaranteed by the quality systems at the outside agencies.
- The methodology reports have been documented and will be published on the website http://english.rvo.nl/nie. To improve transparency, the implemented QC checklists have also been documented and archived. As part of the QA/QC plan, the documentation and archiving system has been further upgraded. RVO.nl (as the NIE) maintains the National System website and a central archive of relevant National System documents.
- Their own QA/QC procedures apply whenever a contributing institution cite or quote data from the annually fixed database in their own reports.

- *Annual inventory improvement*: Within the inventory project, resources are available to keep the total inventory up to the latest standards. In an annual cycle, the Task Forces are invited to draft proposals for the improvement of their emissions estimates. The proposals are prioritized in a consensus process and budgets are made available for the selected improvements. The available resources have to be shared between the different items of the inventory (GHG, CLRTAP and water emissions).

GHG-related issues are given high priority when they relate to improvements of key source estimates and/or if the reviews ask for specific improvements in methods or activity data. Proposals for improvements that contribute to a decrease in the uncertainty of emissions estimates are given higher priority than others. All planned improvements are documented in the annual work plan.

- *Evaluation*: Those involved in the annual inventory tasks are invited once a year to participate in an evaluation of the process. In this evaluation, the results of any internal and external reviews and evaluations are taken into account. The results are used for the annual update of the QA/QC programme and the annual work plan.
- *Source-specific QC*: The comparison of emissions data with data from independent sources was one of the actions proposed in the inventory improvement programme. However, because it did not seem possible to reduce uncertainties substantially through independent verification (measurements) – at least not on a national scale – this issue has received low priority. In the PRTR project over the last two years, efforts have been made to reassess and update the assessment of uncertainties and the sector-specific QC activities. A revised uncertainty assessment of Dutch GHG emissions was planned for this NIR but, due to the late availability of a working CRF, the required resources were not available. The renewed assessment will take place prior to the next submission.

1.2.3.3 Verification activities for the CRF/NIR 2017

Two weeks prior to a trend analysis meeting, a snapshot from the database was made available by the RIVM in a web-based application (Emission Explorer, EmEx) for checking by the institutes and experts involved (PRTR Task Forces). This allowed the Task Forces to check for level errors and consistency in the algorithms/methods used for calculations throughout the time series. The Task Forces performed checks for all gases and sectors. The sector totals were compared with the previous year's dataset. Where significant differences were found, the Task Forces evaluated the emissions data in greater detail. The results of these checks were then brought up for discussion at the trend analysis workshop and subsequently documented. Furthermore, the Task Forces were provided with CRF Reporter software to check the time series of emissions per substance. During the trend analysis, the GHG emissions for all years between 1990 and 2015 were checked in two ways:

(1) The datasets from previous years' submissions were compared with the current submission; emissions from 1990 to 2014 should be identical to those reported last year for all non-energy related emissions.As the energy statistics were recalculated for the total time series all fuel and feedstock related emission have changed compared to the previous submission.

(2) The data for 2015 were compared with the trend development for each gas since 1990. Checks of outliers were carried out at a more detailed level for the sub-sources of all sector background tables:

- Annual changes in emissions of all GHGs;
- Annual changes in activity data;

- Annual changes in implied emission factors (IEFs);
- Level values of IEFs.

Exceptional trend changes and observed outliers were noted and discussed at the trend analysis workshop, resulting in an action list. Items on this list must either be processed within two weeks or be dealt with in the following year's inventory.

All the above-mentioned checks were included in the annual project plan for 2016 (RIVM, 2016). Furthermore, data checks (also for non-GHGs) were performed. To facilitate the data checks and the trend verification workshop, three types of data sheet were prepared from the PRTR emissions database:

- Based on the PRTR emissions database, a table with a comparison of emissions in 2014 and 2015. In this table, differences of >5% at sector level were used to document trends;
- Based on the PRTR emissions database, a table with a comparison of the complete inventories of 2015 and 2016, to check that no historical data had been accidentally changed;
- A table with a comparison of data from the two sources, to check that no errors had occurred during the transfer of data from the PRTR emissions database to the CRF tables.

The data checks were performed by sector experts and others involved in preparing the emissions database and the inventory. Communications (emails) between the participants in the data checks were centrally collected and analysed. This resulted in a checklist of actions to be taken. This checklist was used as input for the trend verification workshop and was supplemented by the actions agreed in this workshop. Furthermore, in the trend verification workshop, trends of >5% at sector level were explained. Table 1.1 shows the key verification actions for the CRF tables/NIR 2017.

Table 1.1 Key actions for the NIR 2017

Item	**Date**	**Who**	**Result**	**Documentation**
Automated initial check on internal and external data consistency	During each upload	Data Exchange Module (DEX)	Acceptation or rejection of uploaded sector data	Upload event and result logging in the PRTR database
Input of hanging issues for this inventory	08-07-2016	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten voorlopige cijfers 2015 v 8 juli 2016. xls
Comparison sheets with final data	28-11-2016	RIVM	Input for trend analyses	historische reeksen vergeleken LUCHT versie 28 november 2016.xls
Trend analysis	8-12-2016	Task Forces	Updated Action list	Actiepunten definitieve cijfers 1990-2015 v 8 december 2016.xls

Item	Date	Who	Result	Documentation
Resolving the issues on the action list	Until 15-12-2016	Task Forces RIVM/NIC/TNO	Final dataset	Actiepunten definitieve cijfers 1990-2015 v 13 dec 2016.xls
Comparison of data in CRF tables and EPRTR database	Until 10-3-2017	NIC/TNO	First draft CRF sent to the EU and final CRF to EU	15-01-2017 15-03-2016
Writing and checks of NIR	Until 12-3-2017	Task Forces/ NIC/TNO/NIE	Draft texts	S:\ \NI National Inventory Report\NIR 2017\NIR2017-werkversie
Generation of tables for NIR from CRF tables	Until 12-3-2017	NIC/TNO	Final text and tables NIR	NIR 2017 Tables and Figures v10.xlsx

The completion of an action was reported on the checklist. Based on the completed checklist and the documentation of trends, the dataset was formally agreed to by the two three principal institutes: RIVM, PBL and Statistics Netherlands. The acceptance of the dataset was, furthermore, a subject of discussion by the PRTR executive body (WEM).

As the CRF Reporter software was still not fully fit for purpose during the compilation of the NIR the QA/QC process was hampered and the process of preparing the NIR was delayed. The internal versions of CRF's and NIR and all documentation (emails, data sheets and checklists) as used in the preparation of the NIR are stored electronically on a server at the RIVM.

1.2.3.4 Treatment of confidentiality issues

Some of the data used in the compilation of the inventory is confidential and cannot be published in print or electronic format. For these data items, the Netherlands uses the code 'C' in the CRF. Although this requirement reduces the transparency of the inventory, all confidential data nevertheless can be made available to the official review process of the UNFCCC.

1.3 Inventory preparation; data collection, processing and storage

1.3.1 GHG and KP-LULUCF inventory

The primary process of preparing the GHG inventory in the Netherlands is summarized in Figure 1.1. This process comprises three major steps, which are described in greater detail in the following sections.

The preparation of the KP-LULUCF inventory is combined with the work for reporting LULUCF by the unit Wettelijke Onderzoekstaken Natuur & Milieu, part of Wageningen UR. The LULUCF project team (which is part of the Task Force Agriculture) is responsible for data management, the preparation of the reports on LULUCF, and the QA/QC activities, and decides on further improvements.

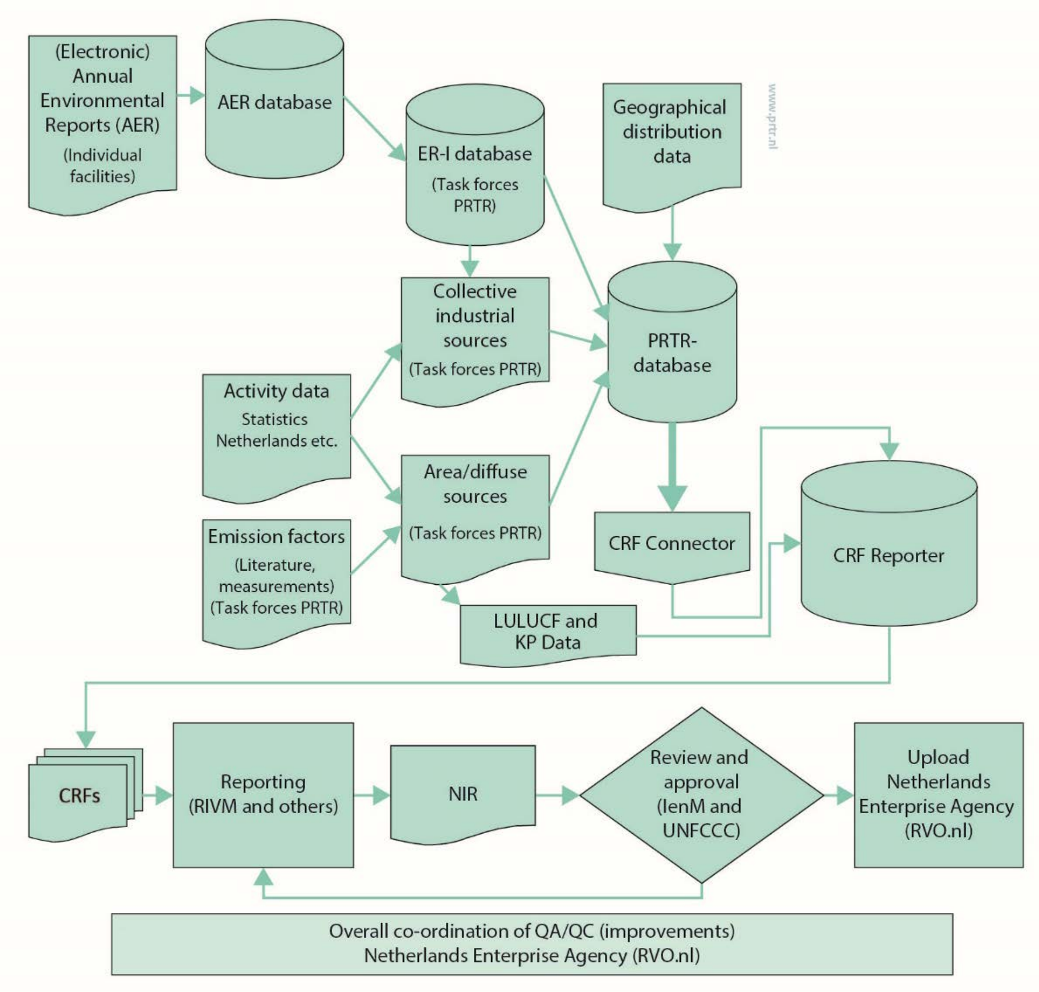


Figure 1.1 Main elements in the GHG inventory process

1.3.2 Data collection

Various data suppliers provide the basic input data for emissions estimates. The principal data sources for GHG emissions are:

Statistical data

Statistical data is provided under various (not specifically greenhouse gas-related) obligations and legal arrangements. These include national statistics from the CBS and a number of other sources of data on sinks, water and waste. The provision of relevant data for GHGs is guaranteed through covenants and an Order in Decree prepared by the IenM. For GHGs, relevant agreements with Statistics Netherlands and Rijkswaterstaat Environment with respect to waste management are in place. An agreement with the Ministry of Economic Affairs (EZ; formerly the Ministry of Agriculture, Nature and Food Quality (LNV)) and related institutions was established in 2005.

Data from individual companies

Data from individual companies is provided in the form of electronic annual environmental reports (e-AERs). A large number of companies have a legal obligation to submit an e-AER that includes – in addition to other environment-related information – emissions data validated by the competent authorities (usually provincial and occasionally local authorities, which also issue environmental permits to these companies). Some companies provide data voluntarily within the framework of environmental covenants.

The data in these AERs is used to verify the CO_2 emissions figures derived from energy statistics for industry, the energy sector and refineries. Whenever reports from major industries contain plant-specific activity data and EFs of sufficient quality and transparency, these are used in the calculation of CO_2 emissions estimates for specific sectors. The AERs from individual companies also provide essential information for calculating the emissions of substances other than CO_2. The calculations of industrial process emissions of non-CO_2 GHGs (e.g. N_2O, HFC-23 and PFCs released as by-products) are mainly based on information from these AERs, as are emissions figures for precursor gases (CO, NO_x, NMVOC and SO_2). Only those AERs with high-quality and transparent data are used as a basis for calculating total source emissions in the Netherlands.

Additional GHG-related data
Additional GHG-related data is provided by other institutes and consultants specifically contracted to provide information on sectors not sufficiently covered by the above-mentioned data sources. For example, the RIVM makes contracts and financial arrangements with various agricultural institutes and the TNO. In addition, RVO.nl contracts out various tasks to consultants, such as collecting information on F-gas emissions from cooling and product use. During 2004, the EZ issued contracts to a number of agricultural institutes; these consisted of, in particular, contracts for developing a monitoring system and methodology description for the LULUCF dataset. Based on a written agreement between the EZ and the RIVM, these activities are also part of the PRTR.

1.3.3 Data processing and storage
Data processing and storage are co-ordinated by the RIVM. These processes consist most notably of the elaboration of emissions estimates and data preparation in the PRTR database. The emissions data is stored in a central database, thereby satisfying – in an efficient and effective manner – national and international criteria for emissions reporting. Using a custom-made programme (CRF Connector), all relevant emissions and activity data is extracted from the PRTR database and included in the CRF Reporter, thus ensuring the highest level of consistency. Data from the CRF Reporter is used in the compilation of the NIR.

The emissions calculations and estimates that are made using the input data are performed by five Task Forces, each dealing with specific sectors or source categories:
- ENINA: Energy, industrial processes and waste (combustion, process emissions, waste handling);
- Agriculture (agriculture, LULUCF);
- WESP: Consumers and services (non-industrial use of products);
- Transport (including bunker emissions);
- MEWAT: Water (less relevant for GHG emissions).

The Task Forces consist of experts from several institutes – RIVM, PBL, TNO, Statistics Netherlands, Centre for Water Management, Deltares, Fugro-Ecoplan (which co-ordinates annual environmental reporting by companies), Rijkswaterstaat Environment and two agricultural research institutes: Alterra and LEI. The Task Forces are responsible for assessing emissions estimates based on the input data and EFs provided. The RIVM commissioned TNO to assist in the compilation of the CRF tables (see Figure 1.2).

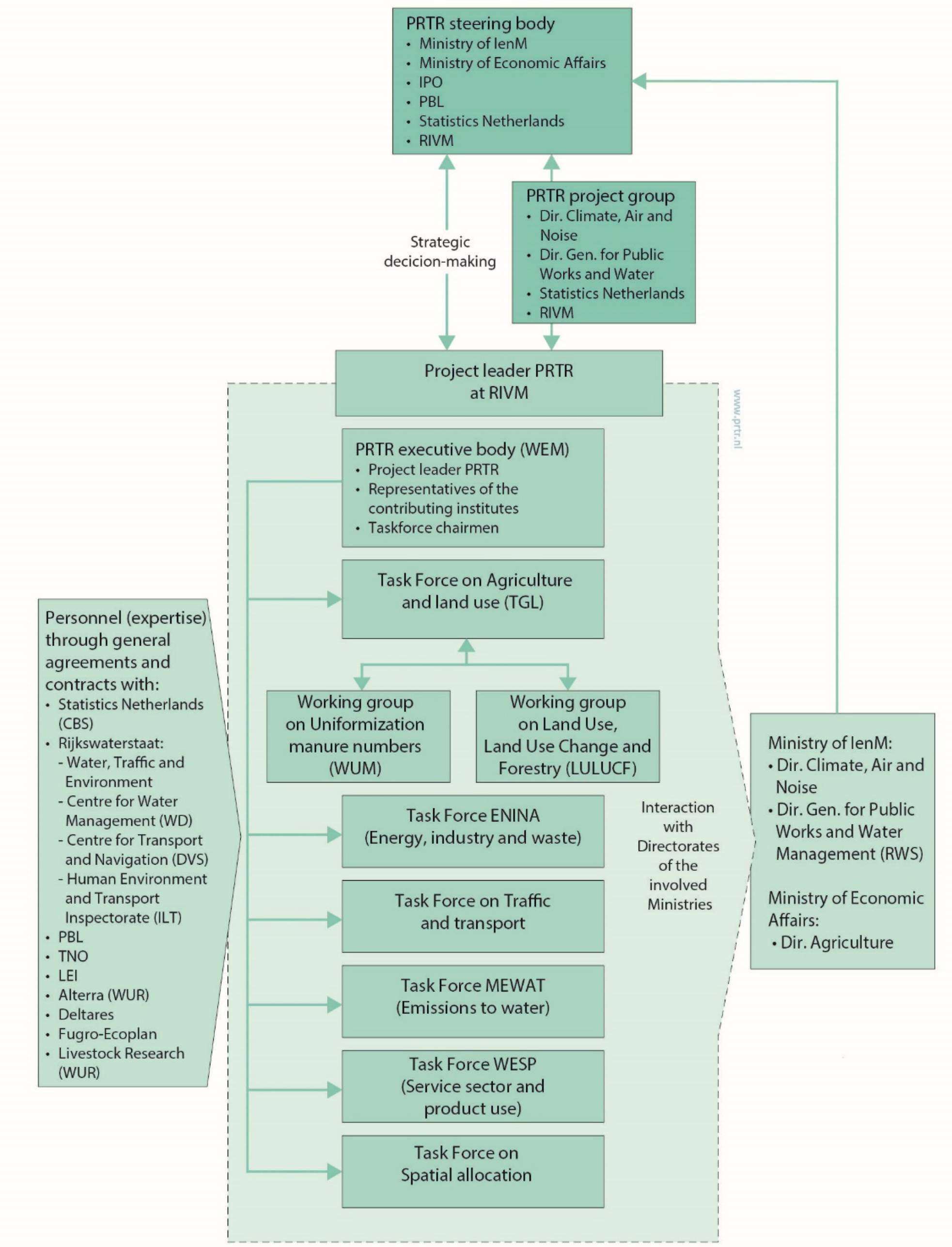


Figure 1.2 Organisational arrangements for PRTR project

1.4 General description of methodologies (including tiers used) and data sources used

1.4.1 GHG inventory

Methodologies

Table 1.2 provides an overview of the methods used to estimate GHG emissions. Methodology reports (formerly monitoring protocols), documenting the methodologies, data sources and QA/QC procedures used in the GHG inventory of the Netherlands, as well as other key documents, are listed in Annex 3.

All key documents are electronically available in PDF format at http://english.rvo.nl/nie.

The sector-specific chapters of this report provide a brief description of the methodologies applied for estimating the emissions from each key source.

Table 1.2 CRF Summary Table 3 with methods and EFs applied

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	CS,T1,T2,T3	CS,D,PS	T1,T1b,T2, T3	CS,D,PS	D,T1,T2	CS,D
A. Fuel combustion	CS,T1,T2	CS,D	T1,T2,T3	CS,D	D,T1,T2	CS,D
1. Energy industries	CS,T2	CS,D	T1,T2	CS,D	D,T1	D
2. Manufacturing industries and construction	T2	CS,D	T1,T2	CS,D	T1,T2	D
3. Transport	T1,T2	CS,D	T1,T2,T3	CS,D	T1,T2	CS,D
4. Other sectors	T1,T2	CS,D	T1,T2	CS,D	T1,T2	D
5. Other	T2	CS	T2	CS	T2	CS
B. Fugitive emissions from fuels	T1,T2,T3	CS,D,PS	T1,T1b,T2, T3	CS,D,PS		
1. Solid fuels	T3	CS				
2. Oil and natural gas	T1,T2,T3	CS,D,PS	T1,T1b,T2, T3	CS,D,PS		
C. CO_2 transport and storage						
2. Industrial processes	CS,T1,T1a,T2,T3	CS,D,PS	CS	CS	CS,T2	CS,PS
A. Mineral industry	CS,T1	CS,D,PS				
B. Chemical industry	CS,T1,T3	CS,D	CS	CS	T2	PS
C. Metal industry	T1a,T2	CS,D				
D. Non-energy products from fuels and solvent use	T1,T3	CS,D				
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	CS	CS	CS	CS	CS	CS
H. Other	T1	CS				
3. Agriculture	T1	D	T1,T2,T3	CS,D	CS,T1,T 1b,T2	CS,D
A. Enteric fermentation			T1,T2,T3	CS,D		
B. Manure management			T1,T2	CS,D	CS	CS
C. Rice cultivation						
D. Agricultural soils(3)					T1,T1b, T2	CS,D
E. Prescribed burning of savannas						
F. Field burning of agricultural residues						
G. Liming	T1	D				

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
H. Urea application						
I. Other carbon-containing fertilizers						
J. Other						
4. Land use, land-use change and forestry	CS,T1,T2	CS,D	CS,T1	CS,D	CS,D,T1	CS,D
A. Forest land	T1,T2	CS,D	T1	CS,D	T1	CS,D
B. Cropland	CS,T1	CS,D			D,T1	CS
C. Grassland	CS,T1,T2	CS,D	CS	D	CS,D,T1	CS,D
D. Wetlands	T1,T2	CS,D			D,T1	CS
E. Settlements	T1	CS,D			T1	CS
F. Other land	T1	CS,D			T1	CS
G. Harvested wood products	T1	D				
H. Other						
5. Waste			T1,T2	CS,D	T1,T2	CS,D
A. Solid waste disposal			T2	CS		
B. Biological treatment of solid waste			T2	CS	T2	CS
C. Incineration and open burning of waste						
D. Waste water treatment and discharge			T1,T2	CS,D	T1,T2	D
E. Other						
6. Other *(as specified in summary 1.A)*						
	HFCs		**PFCs**		**SF_6**	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
2. Industrial processes	T1,T2	CS,PS	T2	CS	T1,T3	CS
A. Mineral industry						
B. Chemical industry	T1	PS	T2	CS		
C. Metal industry			T2	CS		
D. Non-energy products from fuels and solvent use						
E. Electronic industry			T2	CS		
F. Product uses as ODS substitutes	T2	CS				
G. Other product manufacture and use					T1,T3	CS
H. Other						

1.4.2 *Data sources*

The methodology reports provide detailed information on the activity data used for the inventory. In general, the following primary data sources supply the annual activity data used in the emissions calculations:

- Fossil fuel data: (1) national energy statistics from Statistics Netherlands (Energy Monitor); (2) natural gas and diesel consumption in the agricultural sector (Agricultural Economics Institute, LEI); (3) (residential) bio fuel data: national renewable energy statistics from Statistics Netherlands (Renewable Energy);
- Transport statistics: (1) monthly statistics for traffic and transport; (2) national renewable energy statistics from Statistics Netherlands (Renewable Energy);

- Industrial production statistics: (1) AERs from individual companies; (2) national statistics;
- Consumption of HFCs: annual reports from the accountancy firm PriceWaterhouseCoopers (only HFC data are used, due to inconsistencies for PFCs and SF_6 with emissions reported elsewhere);
- Consumption/emissions of PFCs and SF_6: reported by individual firms;
- Anaesthetic gas: data provided by the three suppliers of this gas in the Netherlands; Linde gas (former HoekLoos), NTG (SOL group) and Air Liquide;
- Spray cans containing N_2O: the Dutch Association of Aerosol Producers (Nederlandse Aerosol Vereniging, NAV);
- Animal numbers: Statistics Netherlands/LEI agricultural database, plus data from the annual agricultural census;
- Manure production and handling: Statistics Netherlands/LEI national statistics;
- Fertilizer statistics: LEI agricultural statistics;
- Forest and wood statistics:
    - harvest data: FAO harvest statistics;
    - stem volume, annual growth and fellings: Dirkse et al. (2003);
    - carbon balance: data from three National Forest Inventories: HOSP (1988–1992), MFV (2001–2005) and 6^{th} Netherlands Forest Inventory (NBI6 2012-2013;
- Land use and land use change: based on digitized and digital topographical maps of 1990, 2004 (Kramer et al., 2009), 2009 and 2013 (Kramer and Clement 2015);
- Area of organic soils: Vries (2004);
- Soil maps: Groot et al. (2005a and b);
- Waste production and handling: Working Group on Waste Registration (WAR), Rijkswaterstaat Environment and Statistics Netherlands;
- CH_4 recovery from landfills: Association of Waste Handling Companies (VVAV).

Many recent statistics are available at Statistics Netherlands' statistical website StatLine and in the Statistics Netherlands/PBL environmental data compendium. It should be noted, however, that the units and definitions used for domestic purposes on those websites occasionally differ from those used in this report (for instance: temperature-corrected CO_2 emissions versus actual emissions in this report; in other cases, emissions are presented with or without the inclusion of organic CO_2 and with or without LULUCF sinks and sources).

1.4.3 KP-LULUCF inventory

Methodologies

The methods used to estimate data on sinks and sources as well as the units of land subject to Article 3.3 afforestation/reforestation (AR) and deforestation (D) and Article 3.4 Forest Management (FM) are additional to the methods used for LULUCF. The methodology used by the Netherlands to assess emissions from LULUCF is based on a wall-to-wall approach for the estimation of area per category of land use. For the wall-to-wall map overlay approach, harmonized and validated digital topographical maps dated 1 January 1990, 2004, 2009 and 2013 were used (Kramer et al., 2009; Van den Wyngeart et al., 2012; Kramer and Clement, 2015). The results were national scale land use and land-use change matrices (1990-2004, 2004-2009 and 2009-2013)..

To distinguish between mineral soils and peat soils, overlays were made with the Dutch Soil Map (De Vries et al., 2004). The result was a map with national coverage that identifies for each pixel whether it was subject to AR, D or FM between 1990 and 2013, whether it is located on a mineral soil or on an organic soil and, if on a mineral soil, what the aggregated soil type is. Land-use changes after 2013 are extrapolated from the latest land-use change matrix. These changes will then be updated once a new land-use map becomes available. Future land-use maps are anticipated with map dates of 1 January 2017 and 1 January 2021.

Data sources

The base data sources used for calculating emissions and removals for KP-LULUCF are the same as those used for reporting under the convention. Similar to the GHG inventory it uses:

- Forest and wood statistics:
  - harvest data: FAO harvest statistics;
  - stem volume, annual growth and fellings: Dirkse et al. (2003);
  - carbon balance: data from three National Forest Inventories: HOSP (1988–1992), MFV (2001–2005) and 6th Netherlands Forest Inventory (NBI6 2012-2013);
- Land use and land use change: based on digitized and digital topographical maps of 1990, 2004 (Kramer et al., 2009), 2009 and 2013 (Kramer and Clement 2015).

1.5 Brief description of key categories

1.5.1 GHG inventory

The analysis of key sources is performed in accordance with the 2006 IPCC Guidelines. To facilitate the identification of key sources, the contribution of source categories to emissions per gas is classified according to the IPCC potential key source list as presented in Volume 1, Chapter 4, Table 4.1, of the 2006 IPCC Guidelines. A detailed description of the key source analysis is provided in Annex 1 of this report. Per sector, the key sources are also listed in the first section of each of Chapters 3 to 9. In the NIR 2015 some smaller sources were aggregated in the Key source analysis. In the NIR 2016 these are desagregated which resulted in an increased number of key sources.

In comparison with the key source analysis for the NIR 2016 submission, one new key source was identified:

- 2B Fluorochemical production (HFC)

Key sources from the former submission which are no longer a key source are listed below:

- 2A4 Other process uses of carbonates (CO_2)
- 2B9 HFC-23 emissions from HCFC-22 manufacture (HFC)

This is due to reduced emissions as a result of the changed methodology and new data on uncertainty.

1.5.2 *KP-LULUCF inventory*

The smallest key category based on a level for Tier 1 level analysis including LULUCF is 739 Gg CO_2 (1A1a Public Electricity and Heat Production: liquids; see Annex 1). With net removals of 859.34 Gg CO_2, the absolute annual contribution of reforestation/afforestation under the KP in 2015 is larger than the smallest key category (Tier 1 level analysis including LULUCF). Deforestation under the KP in 2015 causes a net emission of 1,576.79 Gg CO_2, which is also more than the smallest key category (Tier 1 level analysis including LULUCF). With 1,390.78 Gg CO_2 also removals from Forest Management are larger than the smallest key category.

1.6 General uncertainty evaluation, including data on the overall uncertainty of the inventory totals

The IPCC Tier 1 methodology for estimating uncertainty in annual emissions and trends has been applied to the list of potential key sources (see Annex 1) in order to obtain an estimate of the uncertainties in annual emissions, as well as in the trends. These uncertainty estimates have also been used for a first Tier 2 analysis to assess error propagation and to identify key sources as defined in the 2006 IPCC Guidelines.

1.6.1 *GHG inventory*

The following information sources were used for estimating the uncertainty in activity data and EFs (Olivier et al., 2009):

- Estimates used for reporting uncertainty in GHG emissions in the Netherlands that were discussed at a national workshop in 1999 (Amstel et al., 2000);
- Default uncertainty estimates provided in the 2006 IPCC Guidelines;
- RIVM fact sheets on calculation methodology and data uncertainty (RIVM, 1999);
- Other information on the quality of data (Boonekamp et al., 2001);
- A comparison with uncertainty ranges reported by other European countries, which has led to a number of improvements in (and increased underpinning of) the Netherlands’ assumptions for the present Tier 1 assessment (Ramírez-Ramírez et al., 2006).

These data sources were supplemented by expert judgements by RIVM/PBL and Statistics Netherlands emissions experts. The expert judgements were based on independent uncertainty estimates from these experts. Their views were discussed to reach a consensus on the estimates. This was followed by an estimation of the uncertainty in the emissions in 1990 and 2015 according to the IPCC Tier 1 methodology – for both the annual emissions and the emissions trend for the Netherlands. All uncertainty figures should be interpreted as corresponding to a confidence interval of two standard deviations (2σ), or 95%. In cases where asymmetric uncertainty ranges were assumed, the larger percentage was used in the calculation.

The results of the uncertainty calculation according to the IPCC Tier 1 uncertainty approach are summarized in Annex 2 of this report. The Tier 1 calculation of annual uncertainty in CO_2-equivalent emissions results in an overall uncertainty of approximately 3% in 2015, based on calculated uncertainties of 2%, 18%, 40% and 43% for CO_2 (excluding LULUCF), CH_4, N_2O and F-gases, respectively. The uncertainty in CO_2-equivalent emissions, including emissions from LULUCF, is also calculated to be 3%.

However, these figures do not include the correlation between source categories (e.g. cattle numbers for enteric fermentation and animal manure production), nor a correction for non-reported sources.
The correlation between source categories can be included in a Tier 2 uncertainty assessment. Currently, a Tier 2 uncertainty assessment (using Monte Carlo analysis[3]) is being implemented in the Dutch emission inventory and the first results for the calculated uncertainty in the national emissions are of the same order of magnitude as the Tier 1 uncertainty assessment. Table 1.3 shows the currently estimated values for the Tier 1 and Tier 2 analysis.

Table 1.3 Tier 1 and the Tier 2 uncertainty assessment of 2015 emissions (without LULUCF)

Greenhouse gas	Tier 1 annual uncertainty	Tier 2 annual uncertainty
Carbon dioxide	2%	3%
Methane	18%	16%
Nitrous oxide	40%	28%
F-gases	43%	26%
Total	3%	3%

From table 1.3 it can be seen that taking into account the correlations between source categories increases the uncertainty of the national CO_2 emission. For the other gasses the Tier 2 analysis yield lower uncertainties.

Table 1.4 shows the ten sources (excluding LULUCF) contributing most to total annual uncertainty in 2015, ranked according to their calculated contribution to the uncertainty in total national emissions (using the column 'Combined uncertainty as a percentage of total national emissions in 2015' in Table A7.1).

[3] In the next NIR the Netherlands envisage to report all uncertainty information according to the Tier 2 Monte Carlo analysis.

Table 1.4 Ten sources contributing most to total annual uncertainty in 2015

IPCC category	Category	Gas	Combined uncertainty as a percentage of total national emissions in 2015
3Da	Direct emissions from agricultural soils		1.4%
4C	Grassland		1.2%
3B1	Cattle		1.1%
3B3	Swine		1.0%
1A2	Manufacturing Industries and Construction, liquids		0.9%
1A1b	Petroleum Refining: liquids		0.8%
4A	Forest Land		0.8%
4B	Cropland		0.7%
3Db	Indirect emissions from managed soils		0.6%
1A1a	Public Electricity and Heat Production: solids		0.6%

Table A2.1 of Annex 2 summarizes the estimates of the trend uncertainties 1990–2015 calculated according to the IPCC Tier 1 approach set out in the 2006 IPCC Guidelines. The result is a trend uncertainty in total CO2-eq emissions (including LULUCF) for 1990–2015 (1995–2015 for F-gases) of ± 2%. This means that the trend in total CO2-eq emissions between 1990 and 2015 (excluding LULUCF), which is calculated to be a 12.5% decrease, will be between a 10% decrease and an 14% decrease.

For each individual gas, the trend uncertainties in total emissions of CO_2, CH_4, N_2O and the total group of F-gases have been calculated to be ± 2%, ± 6%, ± 7% and ± 12%, respectively.

More details on the level and trend uncertainty assessment can be found in Annex 2. Table 1.5 shows the ten sources (excluding LULUCF) contributing most to the calculated trend uncertainty in the national total.

Table 1.5 Ten sources contributing most to trend uncertainty in the national total in 2015.

IPCC cat.	Category	Gas	Uncertainty introduced into the trend in total national emissions
5A	Solid waste disposal	CH_4	0.9%
3Db	Indirect emissions from managed soils	N_2O	0.8%
4C	Grassland	CO_2	0.7%
3Da	Direct emissions from agricultural soils	N_2O	0.6%
2B	Fluorochemical production	HFC	0.5%
2F1	Refrigeration and airconditioning	HFC	0.5%
1A4b	Residential gaseous	CO_2	0.5%
4B	Cropland	CO_2	0.5%
3B3	Swine	CH_4	0.4%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	0.4%

Four of these key sources are included in both the list presented above and the list of the largest contributors to annual uncertainty.

The propagation of uncertainty in the emissions calculations was assessed using the IPCC Tier 1 approach. In this method, uncertainty ranges are combined for all sectors or gases using the standard equations for error propagation. If sources are added, the total error is the root of the sum of the squares of the error in the underlying sources. Strictly speaking, this is valid only if the uncertainties meet the following conditions: (a) standard normal distribution ('Gaussian'); (b) 2s smaller than 60%; (c) independent (not-correlated) sector-to-sector and substance-to-substance. It is clear, however, that for some sources, activity data or EFs are correlated, which may change the overall uncertainty of the sum to an unknown extent. It is also known that for some sources the uncertainty is not distributed normally; particularly when uncertainties are very high (of an order of 100%), it is clear that the distribution will be positively skewed.

Even more important is the fact that, although the uncertainty estimates have been based on the documented uncertainties mentioned above, uncertainty estimates are ultimately – and unavoidably – based on the judgement of the expert. On occasion, only limited reference to actual data for the Netherlands is possible in support of these estimates. By focusing on the order of magnitude of the individual uncertainty estimates, it is expected that this dataset provides a reasonable assessment of the uncertainty of key source categories.
This is supported by the recent Tier 2 uncertainty assessment (Monte Carlo analysis) of which the first results reveal that the Tier 2 uncertainty is of the same order of magnitude as that found in the Tier 1 results (see Table 1.3). This is also in line with the 2006 Tier 2 uncertainty assessment as reported in former NIRs (Ramírez-Ramírez et al., 2006).
The current Tier 2 Monte Carlo assessment is based on improved uncertainty estimates and new statistical tooling taking into account the uncertainty estimates at the most detailed (non aggregated) source

level. More details will be provided in the next NIR. The first results, including a comparison to the Tier 1 uncertainty for 2015, are shown in Table 1.3.

As part of the 2006 study, the expert judgements and assumptions made for uncertainty ranges in EFs and activity data for the Netherlands were compared with the uncertainty assumptions (and their underpinnings) used in Tier 2 studies carried out by other European countries, Finland, the United Kingdom, Norway, Austria and Flanders (Belgium). The correlations that were assumed in the various European Tier 2 studies were also mapped and compared. The comparisons of assumed uncertainty ranges led to a number of improvements in (and have increased the underpinning of) the Netherlands' assumptions for the present Tier 1 approach. Although a one to one comparison is not possible, due to differences in the aggregation level at which the assumptions were made, results show that for CO_2 the uncertainty estimates of the Netherlands are well within the range of the European studies. For non-CO_2 gases, especially N_2O from agriculture and soils, the Netherlands uses IPCC defaults, which are on the high side compared with the assumptions used in some of the other European studies. This seems quite realistic in view of the state of knowledge about the processes that lead to N_2O emission. Another finding is that correlations (covariance and dependencies in the emissions calculations) seem somewhat under-addressed in most recent European Tier 2 studies and may require more systematic attention in the future.

In the assessments described above, only random errors were estimated, on the assumption that that the methodology used for the calculations did not include systematic errors, which in practice can occur.

A independent verification of emissions levels and emissions trends using, for example, comparisons with atmospheric concentration measurements is, therefore, encouraged by the 2006 IPCC Guidelines (IPCC, 2006). In the Netherlands, such approaches, funded by the National Research Programme on Global Air Pollution and Climate Change (NOP-MLK) or by the Dutch Reduction Programme on Other Greenhouse Gases (ROB), have been used for several years. The results of these studies can be found in Berdowski et al. (2001), Roemer and Tarasova (2002) and Roemer et al. (2003). In 2006, the research programme 'Climate changes, spatial planning' started to strengthen knowledge of the relationship between GHG emissions and land use/spatial planning.

1.6.2 *KP-LULUCF inventory*

The analysis combines uncertainty estimates of the forest statistics, land use and land-use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals (Olivier et al., 2009). The uncertainty analysis is performed for Forest Land and is based on the same data and calculations that were used for KP Article 3.3 categories. Thus, the uncertainty for total net emissions from units of land under Article 3.3 afforestation/reforestation are estimated at 63 per cent, equal to the uncertainty in land converted to forest land. The uncertainty for total net emissions from units of land under Article 3.3 deforestation is estimated at 56 per cent, equal to the uncertainty in land converted to grassland (which includes, for the sake of the uncertainty analysis, all forest land converted to any other type of land use). Similarly, the uncertainty for total net removals from units of land under Article 3.4 Forest Management is estimated at 67 per cent, equal to the uncertainty of Forest Land remaining Forest Land (See Olivier et al. (2009) for details).

1.7 General assessment of completeness

1.7.1 GHG inventory

At present, the GHG emissions inventory for the Netherlands includes all of the sources identified by the 2006 IPCC Guidelines, except for a number of (very) minor sources. Annex 6 presents the assessment of completeness and sources, potential sources and sinks for this submission of the NIR and the CRF tables.

1.7.2 KP-LULUCF inventory

The inventory for KP-LULUCF in general is complete. Changes in carbon stocks are reported for all pools for AR, D and Forest Management.

In The Netherlands conversion of non-forest to forest (AR) involves a build-up of carbon in litter. But because good data are lacking to quantify this sink, we report the accumulation of carbon in litter for reforestation/afforestation conservatively as zero. Similarly, no other land use has carbon in dead wood. The conversion of non-forest to forest, therefore, involves a build-up of carbon in dead wood. But as it is unlikely that much dead wood will accumulate in very young, the accumulation of carbon in dead wood in reforested/afforested plots is a very small sink that is too uncertain to quantify reliably. We therefore report this carbon sink during the first 20 years conservatively as zero. Once forest become older (>20 years), changes in carbon stocks in dead wood are estimated in the same way as is done for Forest land remaining Forest Land under the convention.

Fertilisation does not occur in Forests in the Netherlands. Therefore, fertilisation in re/afforested areas and areas under Forest Management is reported as NO. Fertilisation on Grassland and Cropland is included in the Agriculture Sector.

2 Trends in GHG emissions

2.1 Emissions trends for aggregated GHG emissions

Chapter 2 summarizes the trends in GHG emissions during the period 1990–2015 by GHG and by sector. Detailed explanations of these trends are provided in Chapters 3–8. In 2015, total GHG emissions (including indirect CO_2 emissions, excluding emissions from LULUCF) in the Netherlands were estimated at 195.2 Tg CO_2 eq. This is 12.5% lower than the 223.1 Tg CO_2 eq reported in the base year (1990; 1995 for fluorinated gases (F-gases)).

Figure 2.1 shows the trends and contributions of the different gases to the aggregated national GHG emissions. In the period 1990–2015, emissions of carbon dioxide (CO_2) increased by 1.5% (excluding LULUCF). The emissions of non-CO_2 GHGs methane (CH_4), nitrous oxide (N_2O) and F-gases decreased by 41%, 53% and 74%, respectively

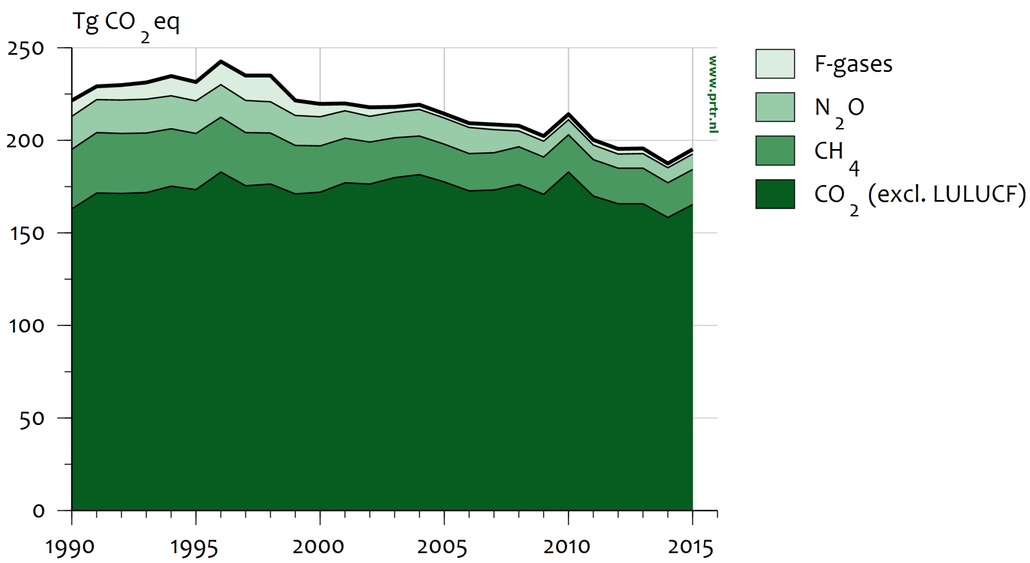


Figure 2.1 Greenhouse gases: trend and emissions levels (excl. LULUCF), 1990–2015.

Emissions of LULUCF-related sources increased over the period 1990 to 2015 by about 10%. The total GHG emissions in the Netherlands for the year 2015 (including LULUCF) was 202.0 Tg CO_2 eq).

2.2 Emissions trends by gas

2.2.1 Carbon dioxide

Figure 2.2 shows the contribution of the most important sectors, to the trend in total national CO_2 emissions (excluding LULUCF). In the period 1990–2015, national CO_2 emissions increased by 1.5% (from 162.9 to 165.3 Tg). The Energy sector is by far the largest contributor to CO_2 emissions in the Netherlands (97%), the categories 1A1 Energy industries (40%), 1A4 Other sectors (20%) and 1A3 Transport (19%) being the largest contributors in 2015.

The relatively high level of CO_2 emissions in for instance 2010 is mainly explained by the cold winter, which increased energy use for space heating in the residential sector. The resulting emissions are included in category 1A4 (Other sectors). The higher level of CO_2 emissions in 2015 is explained by a relatively colder winter.

Indirect CO_2 emissions (calculated from the oxidation of NMVOC emissions from solvents) are only a minor source in the Netherlands (0.2 Tg in 2015).

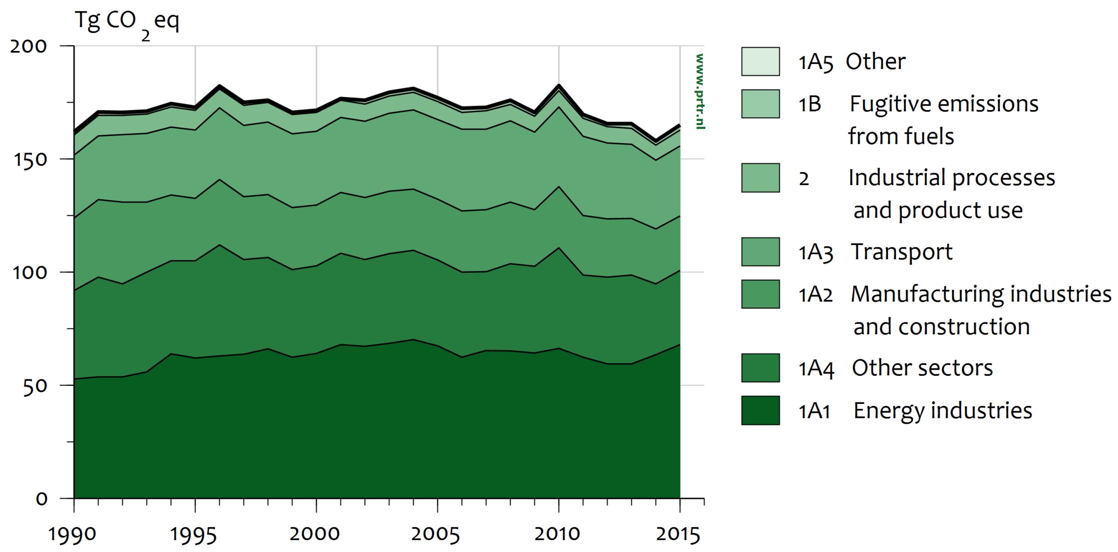


Figure 2.2 CO_2: trend and emissions levels of sectors (excl. LULUCF), 1990–2015.

2.2.2 *Methane*

Figure 2.3 shows the contribution of the most relevant sectors to the trend in total CH_4 emissions. National CH_4 emissions decreased by 41%, from 32.3 Tg in 1990 to 19.0 Tg CO_2 eq in 2015. The Agriculture and Waste sectors (67% and 18%, respectively) were the largest contributors in 2015.

Compared with 2014, national CH_4 emissions increased by about 1.2% in 2015 (0.2 Tg CO_2 eq). CH_4 emissions decreased in the category 5A (Solid waste disposal on land) but were balanced by an increase in emissions from Agriculture.

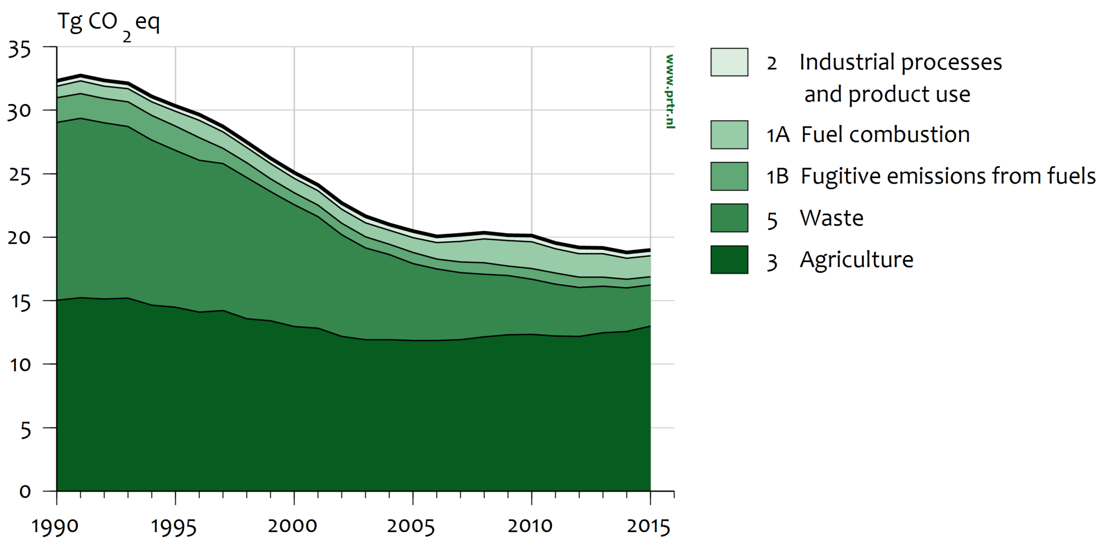


Figure 2.3 CH_4: trend and emissions levels of sectors, 1990–2015.

2.2.3 *Nitrous oxide*

Figure 2.4 shows the contribution of the most relevant sectors to the trend in national total N_2O emissions. The total national inventory of N_2O emissions decreased by about 53%, from 17.7 Gg CO_2 eq in 1990 to 8.3 Tg CO_2 eq in 2015. The Industrial processes sector contributed the most to this decrease in N_2O emissions (emissions decreased by almost 81% compared with the base year).

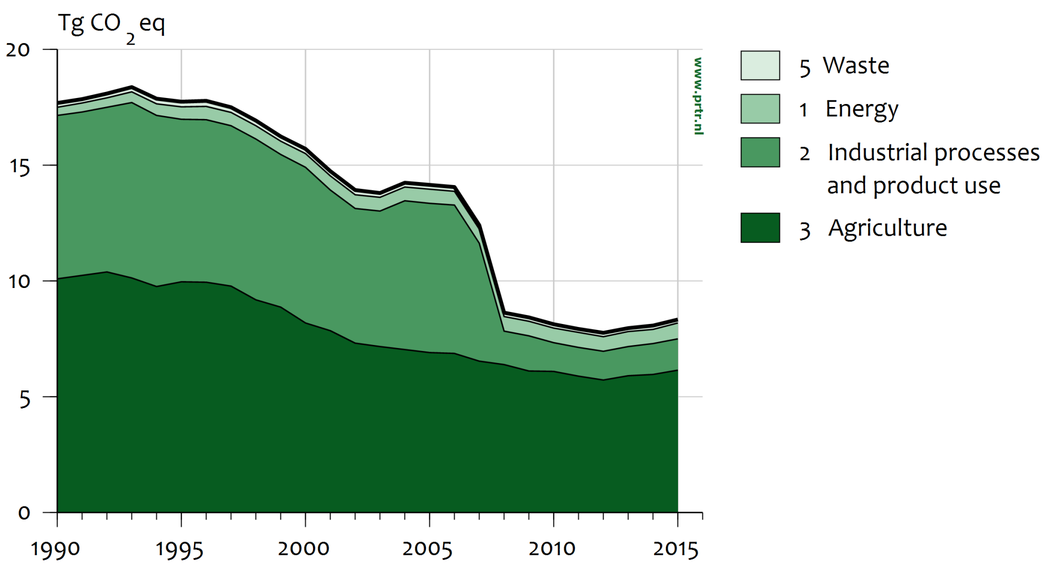


Figure 2.4 N_2O: trend and emissions levels of sectors, 1990–2015.

Compared with 2014, total N_2O emissions increased by 3.3% in 2015, mainly due to a rise in emissions in agriculture.

2.2.4 *Fluorinated gases*

Figure 2.5 shows the trend in F-gas emissions included in the national GHG inventory. Total emissions of F-gases decreased by 74% from 10.1 Tg CO_2 eq in 1995 (base year for F-gases) to 2.6 Tg CO_2 eq in 2015. Emissions of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) decreased by approximately 69% and 95%, respectively, during the same period, while sulphur hexafluoride (SF_6) emissions decreased by 47%. It should be noted that due to national circumstances the emissions of NF_3 can not be reported separately and are included in the PFC emissions.

HFCs emissions increased by 3.6% and PFCs emissions increased by 10.6% between 2014 and 2015, SF_6 emissions increased by 3.1% in the same period. The aggregated emissions of F-gases decreased by 1%.

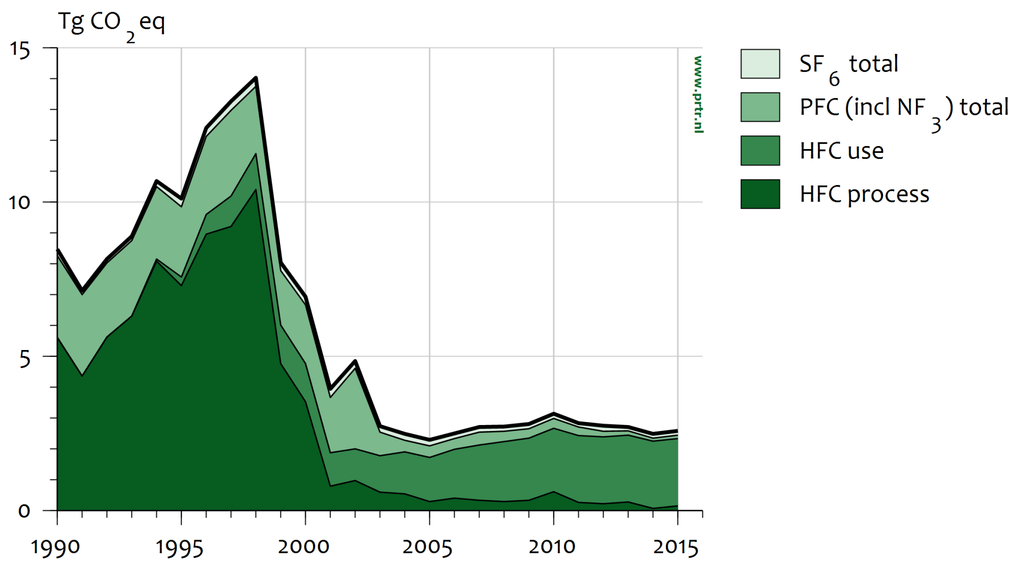


Figure 2.5 Fluorinated gases: trend and emissions levels of individual F-gases, 1990–2015.

2.2.5 *Uncertainty in emissions specified by greenhouse gas*

The uncertainty in the trend of CO_2 equivalent emissions of the six GHGs together is estimated to be approximately 2%, based on the IPCC Tier 1 Trend Uncertainty Assessment; see Section 1.7. For each individual gas, the trend uncertainty in total emissions of CO_2, CH_4, N_2O and the sum of the F-gases is estimated to be ± 2%, ± 6%, ± 7% and ± 12%, respectively. For all GHGs taken together, the uncertainty estimate in annual emissions is ± 3% and for CO_2 ± 2%. The uncertainty estimates in annual emissions of CH_4 and N_2O are ± 18% and ± 40%, respectively, and for HFCs, PFCs and SF_6, ± 43% (see Section 1.7).

2.3 Emissions trends by source category

Figure 2.6 provides an overview of emissions trends for each IPCC sector in Tg CO_2 equivalents.

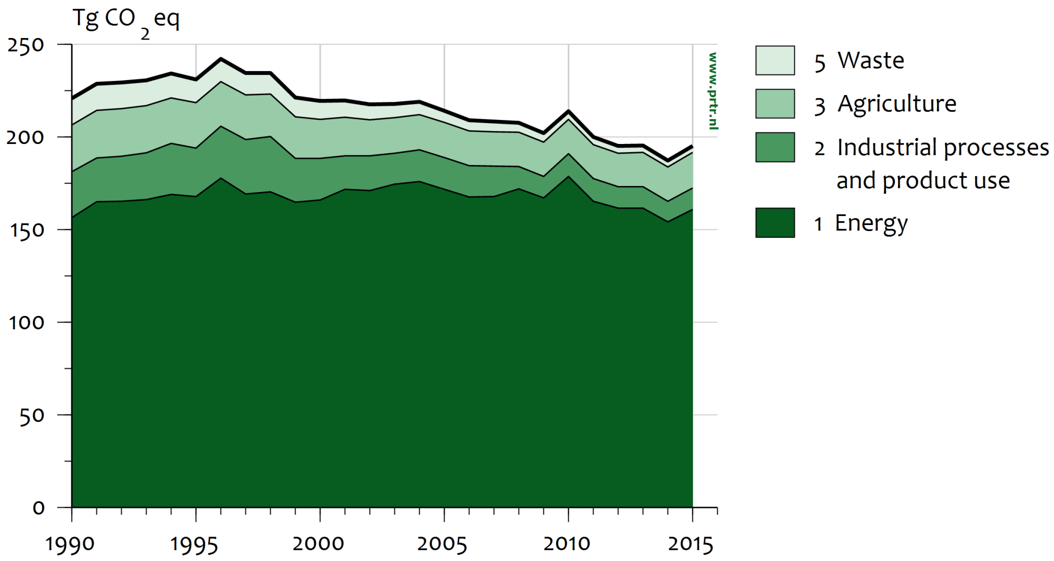


Figure 2.6 Aggregated GHGs: trend and emissions levels of sectors (excl. LULUCF), 1990–2015.

The Energy sector is by far the largest contributor to total GHG emissions in the national inventory (contributing 68% in the base year and 78% in 2015. The emissions level of the Energy sector increased by approximately 3% in the period 1990–2015.
Total GHG emissions from the the sectors Waste, Industrial processes and Agriculture sectors decreased by 77%, 57% and 24%, respectively, in 2015 compared with the base year LULUCF emissions increased by 11 % in the same period.

Trends in emissions by sector category are described in detail in Chapters 3–8.

2.3.1 *Uncertainty in emissions by sector*

The uncertainty estimates in annual CO_2-equivalent emissions of IPCC sectors Energy (1), Industrial processes (2), Agriculture (3) and Waste (4) are about ± 2%, ± 12%, ± 24% and ± 21%, respectively; for the LULUCF sector (4) the uncertainty is estimated at ± 100%. The uncertainty in the trend of CO_2-equivalent emissions per sector is calculated for sector 1 (Energy) at ± 2% in the 3% increase, for sector 2 (Industrial processes) at ± 5% in the 57% decrease, for sector 3 (Agriculture) at ± 8% in the 24% decrease and for sector 5 (Waste) at ± 1% in the 77% decrease.

2.4 Emissions trends for indirect greenhouse gases and SO_2

Figure 2.7 shows the trends in total emissions of carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2). Compared with 1990, CO and NMVOC emissions in 2015 reduced by 52% and 71%, respectively. For SO_2, the reduction was 84%; and for NO_x, 2015 emissions were 64% lower than the 1990 level. With the exception of NMVOC, most of the emissions stem from fuel combustion.

Because of the problems (incomplete reporting) identified with annual environmental reports, emissions of indirect greenhouse gases and SO_2 from industrial sources have not been verified. Therefore, the emissions data for the years 1991–1994 and 1996–1998 are of less quality.

In contrast to direct GHGs, calculations of the emissions of precursors from road transport are not based on fuel sales, as recorded in national energy statistics, but are directly related to transport statistics on a vehicle-kilometre basis. To some extent, this is different from the IPCC approach (see Section 3.2.8).

Uncertainty in the EFs for NO_x, CO and NMVOC from fuel combustion is estimated to be in the range of 10–50%. The uncertainty in the EFs of SO_2 from fuel combustion (basically the sulphur content of the fuels) is estimated to be 5%. For most compounds, the uncertainty in the activity data is relatively small compared with the uncertainty in the EFs. Therefore, the uncertainty in the overall total of sources included in the inventory is estimated to be in the order of 25% for CO, 15% for NO_x, 5% for SO_2 and approximately 25% for NMVOC (TNO, 2004).

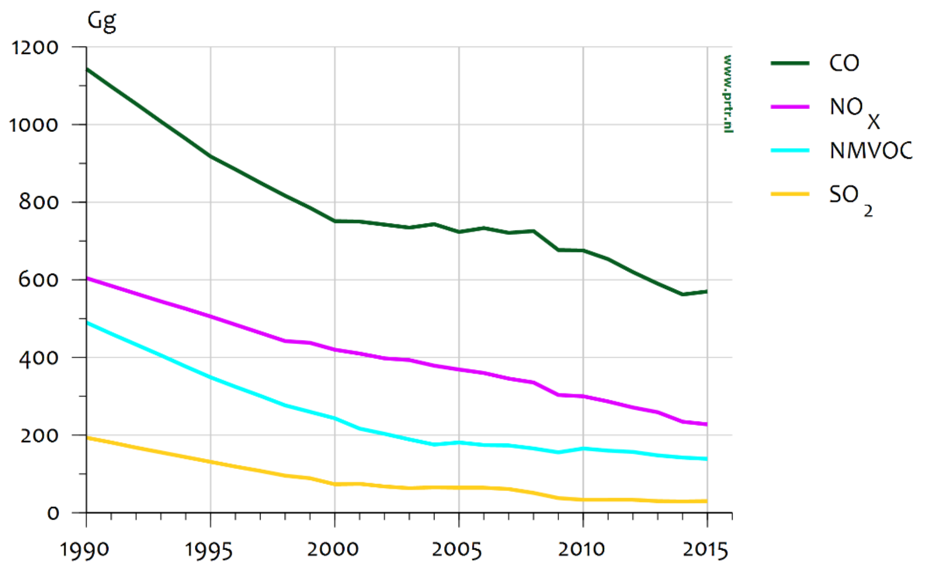


Figure 2.7 Emissions levels and trends of CO, NO_x, NMVOC and SO_2, 1990-2015 (Gg)

3 Energy (CRF sector 1)

Major changes in the Energy sector compared with the National Inventory Report 2015

Emissions:	Compared with 2014, GHG emissions in 2015 in the energy sector decreased by 4.4%.
Key sources:	No changes in key sources.
Methodologies:	Generator sets and mobile water pumps at pumping stations have been newly added to the model to calculate the non road combustion sectors. As the total amount of fuel in the sector remain the same as in earlier submissions. Only the allocation of the emissions changed significantly.
Activity data:	Statistics on the consumption of gas/diesel oil have been revised for the complete time series.

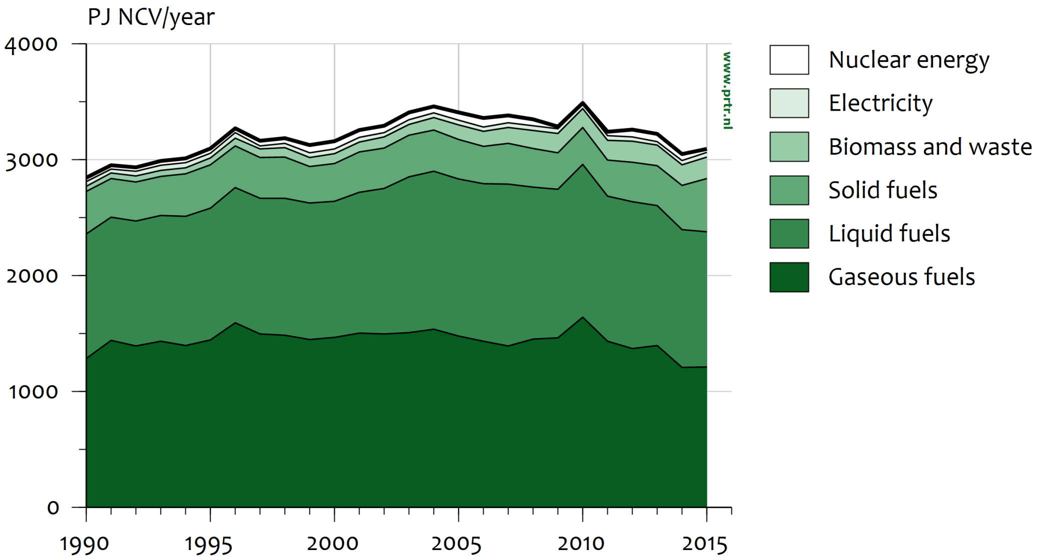
3.1 Overview of sector

Energy supply and energy demand
As in most developed countries, the energy system in the Netherlands is largely driven by the combustion of fossil fuels (Figure 3.1). Natural gas is used the most, followed by liquid fuels and solid fuels. The contribution of non-fossil fuels, including renewables and waste streams, is small.

Part of the supply of fossil fuels is not used for energy purposes. It is either used as feed stocks in the (petro-)chemical or fertilizer industries or lost as waste heat in cooling towers and cooling water in power plants.

Emissions from fuel combustion are consistent with national energy statistics.

Energy supply



Energy demand

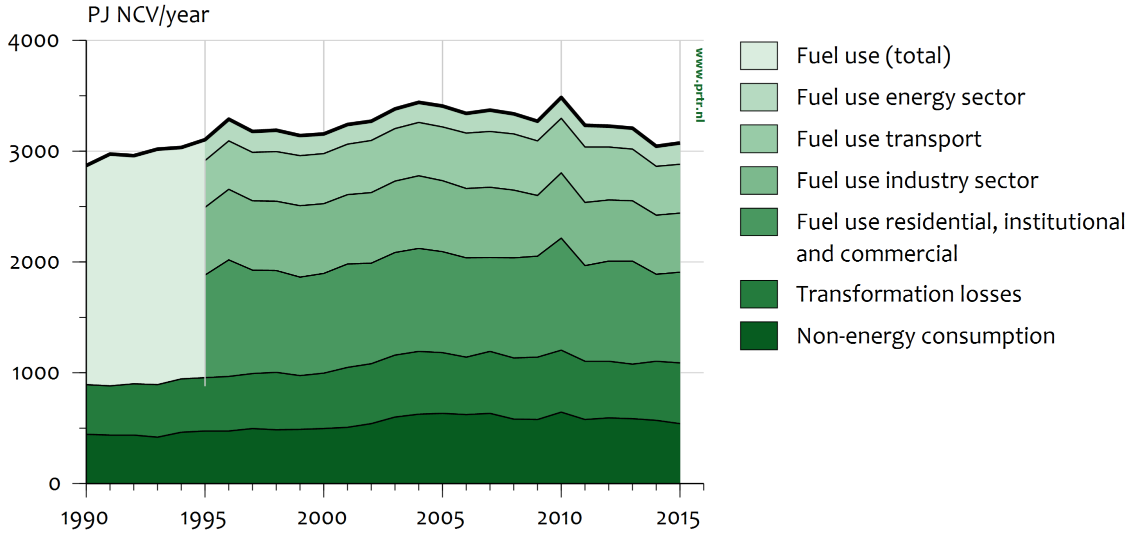


Figure 3.1 Overview of energy supply and energy demand in the Netherlands, 1990-2015 ('Electricity' refers to imported electricity only.)

Trends in fossil fuel use and fuel mix
Natural gas represents a very large share of national energy consumption in all non-transport sectors: Power generation, Industrial processes and Other (mainly for space heating). Oil products are primarily used in transport, refineries and the petrochemical industry, while the use of coal is limited to power generation and steel production.

In the 1990–2015 period, total fossil fuel combustion increased by 4%, due to a 26% increase in solid fuel consumption and a 9% increase in solid fuel consumption. At the same time, the combustion of gaseous fuels decreased by 6%.

Total fossil fuel consumption for combustion increased by about 1.5% between 2014 and 2015, mainly due to a 26% increase in solid fuel consumption. Gaseous fuels increased by 0.2% and liquid fuels decreased by 1.9%. The increase in solid fuel consumption is caused by the new coal-fired power plants that started in 2014 and which increased production in 2015.

The winter temperature has a large influence on the gas consumption, because natural gas is used for space heating in most buildings in the Netherlands. The years 1996 and 2010 both had a cold winter compared with the other years. This caused an increase in the use of gaseous fuel for space heating in these years compared with other years. The year 2014 had a warm winter compared with other years and this caused a decrease in the use of gaseous fuel for space heating.

3.1.1 *GHG emissions from the Energy sector*

During combustion, carbon and hydrogen from fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing the chemical energy in the fuel as heat. This heat is generally either used directly or used (with some conversion losses) to produce mechanical energy, often to generate electricity or for transport.

The Energy sector is the most important sector in the Dutch GHG emissions inventory and is responsible for more than 95% of the CO_2 emissions in the country.

The energy sector includes:

- Use of fuels in stationary and mobile applications;
- Conversion of primary energy sources into more usable energy forms in refineries and power plants;
- Exploration and exploitation of primary energy sources;
- Transmission and distribution of fuels.

These activities give rise to combustion and fugitive emissions. Emissions from the Energy sector are reported in the source category split as shown in Figure 3.2.

Overview of shares and trends in emissions

Table 3.1 and Figure 3.2 show the contributions of the source categories in the Energy sector to the total national GHG inventory. The main part of the CO_2 emissions from fuel combustion stems from the combustion of natural gas, followed by liquid fuels and solid fuels. CH_4 and N_2O emissions from fuel combustion contribute less than 2% to the total emissions from this sector.

Key sources

Table 3.1 presents the key categories in the Energy sector specified by both level and trend (see also Annex 1). The key categories 1A1, 1A2, 1A3 and 1A4 are based on aggregated emissions by fuel type and category, which is in line with the IPCC Guidelines (see Volume 1, Table 4.1 in IPCC, 2006). Since CO_2 emissions have the largest share in the total of national GHG emissions, it is not surprising that a large number of CO_2 sources are identified as key categories. CH_4 emissions from stationary combustion sources in the residential sector and in agriculture, forestry and fisheries are also identified as key categories.

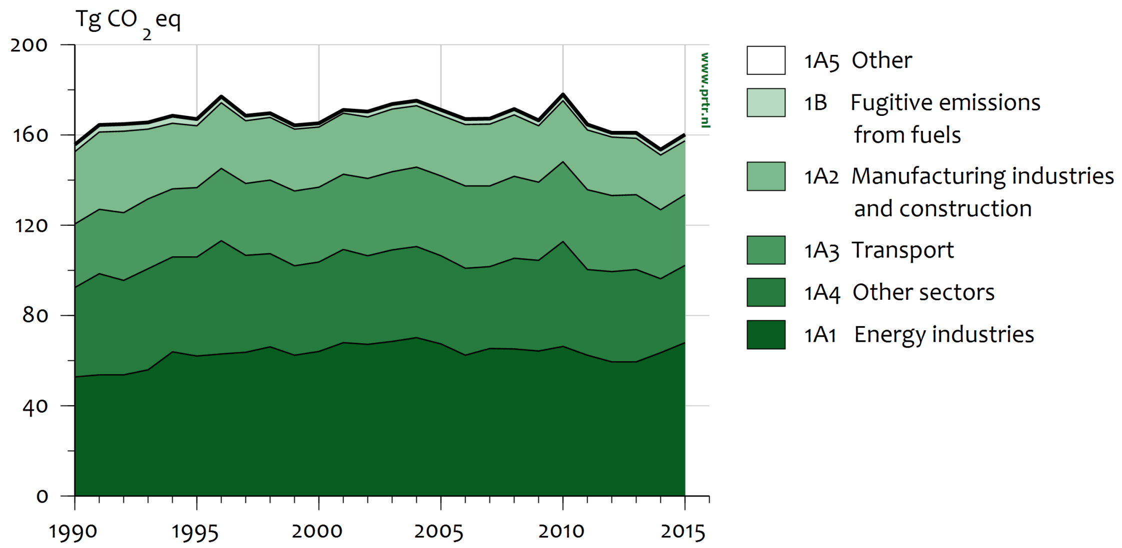


Figure 3.2 Sector 1 Energy: trend and emissions levels of source categories, 1990–2015.

Table 3.1 Contribution of main categories and key sources in CRF sector 1 Energy

			Emissions in Tg CO_2 eq			**Tg CO_2 eq**	**Contribution to total in 2015 (%)**		
Sector/category	**Gas**	**Key**	**Base year**	**2014**	**2015**	**Change 2014–2015**	**By sector**	**Of total gases**	**Of total CO_2 eq**
1 Energy	CO_2	-	153.2	158.3	151.2	6.7	98.1%	91.5%	80.6%
	CH_4	-	2.8	2.3	2.3	0.0	1.5%	12.2%	1.2%
	N_2O	-	0.4	0.6	0.7	0.1	0.4%	8.2%	0.4%
	All	-	156.4	161.3	154.2	6.8	100.0%		82.2%
1A Fuel combustion	CO_2	-	152.0	156.6	149.6	6.3	97.0%	90.5%	79.7%
	CH_4	-	0.9	1.9	1.6	0.0	1.1%	8.6%	0.9%
	N_2O	-	0.4	0.6	0.7	0.1	0.4%	8.2%	0.4%
	All	-	153.3	159.1	151.8	6.4	98.4%		80.9%
1A1 Energy Industries	CO_2	-	52.9	59.5	63.6	4.3	41.2%	38.5%	33.9%
	CH_4	non key	0.1	0.1	0.1	0.0	0.1%	0.6%	0.1%
	N_2O	non key	0.1	0.3	0.3	0.0	0.2%	3.7%	0.2%
	All	-	53.1	59.8	64.0	4.4	41.5%		34.1%
1A1a. Public Electricity and Heat Production	CO_2	-	40.0	47.7	51.3	4.3	33.3%	31.0%	27.4%
1A1a liquids	CO_2	L1, T	0.2	0.6	1.3	-0.6	0.8%	0.8%	0.7%
1A1a solids	CO_2	L, T	25.9	26.4	30.0	7.3	19.5%	18.2%	16.0%
1A1a gas	CO_2	L, T	13.3	17.8	17.2	-2.5	11.1%	10.4%	9.2%
1A1a other fuels	CO_2	L, T	0.6	2.8	2.8	0.0	1.8%	1.7%	1.5%

			Emissions in Tg CO_2 eq			Tg CO_2 eq	Contribution to total in 2015 (%)		
Sector/category	**Gas**	**Key**	**Base year**	**2014**	**2015**	**Change 2014–2015**	**By sector**	**Of total gases**	**Of total CO_2 eq**
1A1b. Petroleum refining	CO_2	-	11.0	9.3	9.7	0.1	6.3%	5.9%	5.2%
1A1b liquids	CO_2	L, T	10.0	5.9	6.3	0.5	4.1%	3.8%	3.4%
1a1b gases	CO_2	L, T	1.0	3.4	3.4	-0.4	2.2%	2.0%	1.8%
1A1c Manufacture of Solid Fuels and Other Energy Industries	CO_2	-	1.8	2.5	2.6	-0.1	1.7%	1.6%	1.4%
1A1c solids & liquid	CO_2	L	0.6	0.6	0.6	0.1	0.4%	0.4%	0.3%
1A1c gases	CO_2	L, T	1.2	1.9	2.0	-0.2	1.3%	1.2%	1.1%
1A2 Manufacturing industries and construction	CO_2	-	32.0	24.9	24.2	-0.2	15.7%	14.6%	12.9%
	CH_4	non key	0.1	0.1	0.1	0.0	0.0%	0.3%	0.0%
	N_2O	non key	0.0	0.0	0.0	0.0	0.0%	0.6%	0.0%
	All	-	32.1	25.0	24.3	-0.2	15.8%		13.0%
1A2 liquids	CO_2	L, T	8.6	8.2	8.5	-0.7	5.5%	5.1%	4.5%
1A2 solids	CO_2	L, T	4.4	3.3	3.3	0.1	2.1%	2.0%	1.7%
1A2 gases	CO_2	L, T	19.0	13.4	12.5	0.4	8.1%	7.6%	6.7%
1A2a. Iron and steel	CO_2	-	3.4	3.7	3.6	0.1	2.3%	2.2%	1.9%
1A2b. Non-Ferrous Metals	CO_2	-	0.2	0.2	0.1	0.0	0.1%	0.1%	0.1%
1A2c. Chemicals	CO_2	-	17.3	12.4	12.0	-0.2	7.8%	7.2%	6.4%
1A2d. Pulp, Paper and Print	CO_2	-	1.7	1.0	1.0	-0.1	0.7%	0.6%	0.5%
1A2e. Food Processing, Beverages and Tobacco	CO_2	-	4.0	3.3	3.5	0.1	2.3%	2.1%	1.9%
1A2f. Non metalic minerals	CO_2	-	2.3	1.1	1.1	0.0	0.7%	0.7%	0.6%
1A2g. Other	CO_2	-	3.2	3.2	2.9	-0.1	1.9%	1.8%	1.6%
1A3. Transport	CO_2	-	27.8	32.7	30.4	0.5	19.7%	18.4%	16.2%
	CH_4	-	0.2	0.1	0.1	0.0	0.0%	0.3%	0.0%
	N_2O	-	0.1	0.2	0.3	0.0	0.2%	3.0%	0.1%
	All	-	28.1	33.1	30.7	0.5	19.9%		16.4%
1A3a. Civil aviation	CO_2	non key	0.08	0.04	0.04	-0.01	0.0%	0.0%	0.0%
1A3b. Road vehicles	CO_2	-	26.5	31.2	29.0	0.3	18.8%	17.6%	15.5%
	CH_4	non key	0.2	0.1	0.1	0.0	0.0%	0.3%	0.0%
	N_2O	non key	0.1	0.2	0.2	0.0	0.2%	2.9%	0.1%
1a3b gasoline	CO_2	L, T1	10.8	11.9	11.6	0.2	7.5%	7.0%	6.2%
1a3b diesel oil	CO_2	L, T	13.0	18.6	16.9	0.2	11.0%	10.2%	9.0%
1a3b LPG	CO_2	T	2.7	0.6	0.5	-0.1	0.3%	0.3%	0.2%

			Emissions in Tg CO_2 eq			Tg CO_2 eq	Contribution to total in 2015 (%)		
Sector/category	**Gas**	**Key**	**Base year**	**2014**	**2015**	**Change 2014–2015**	**By sector**	**Of total gases**	**Of total CO_2 eq**
1A3c. Railways	CO_2	non key	0.1	0.1	0.1	0.0	0.1%	0.1%	0.0%
1A3d. Navigation	CO_2	L, T	0.9	1.2	1.1	0.2	0.7%	0.7%	0.6%
1A3e Other Transportation	CO_2	non key	0.3	0.2	0.1	0.0	0.1%	0.1%	0.1%
1A4. Other sectors	CO_2	-	39.0	39.3	31.2	1.7	20.2%	18.9%	16.6%
	CH_4	-	0.6	1.4	1.4	0.0	0.9%	7.6%	0.8%
	N_2O	non key	0.1	0.1	0.1	0.0	0.0%	0.8%	0.0%
	All	-	39.6	40.7	32.6	1.7	21.2%		17.4%
1A4 liquids (excl. from 1A4c)	CO_2	T	1.3	0.6	0.6	0.0	0.4%	0.3%	0.3%
1A4a. Commercial/Institutional	CO_2	-	8.4	9.0	7.2	0.3	4.7%	4.3%	3.8%
	CH_4	non key	0.0	0.1	0.1	0.0	0.1%	0.5%	0.1%
1A4a Natural gas	CO_2	L, T	7.8	8.6	6.8	0.3	4.4%	4.1%	3.6%
1A4b. Residential	CO_2	-	20.7	20.5	15.3	1.0	9.9%	9.2%	8.1%
	CH_4	L2	0.5	0.4	0.4	0.0	0.3%	2.3%	0.2%
1A4b Natural gas	CO_2	L, T	19.9	20.3	15.1	1.0	9.8%	9.1%	8.0%
1A4c. Agriculture/Forestry/ Fisheries	CO_2	-	9.8	9.8	8.7	0.3	5.7%	5.3%	4.7%
	CH_4	L, T	0.1	0.9	0.9	0.0	0.6%	4.8%	0.5%
1A4c liquids	CO_2	non key	2.5	1.8	1.9	0.0	1.2%	1.1%	1.0%
1A4c Natural gas	CO_2	L, T	7.3	8.0	6.9	0.3	4.4%	4.1%	3.7%
1A5 Other	CO_2	non key	0.3	0.2	0.2	0.0	0.1%	0.1%	0.1%
	CH_4	non key	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%
	N_2O	non key	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%
	All	-	0.3	0.2	0.2	0.0	0.1%		0.1%
1B Fugitive emissions from fuels	CO_2	-	1.2	1.8	1.7	0.5	1.1%	1.0%	0.9%
	CH_4	-	1.9	0.7	0.6	0.0	0.4%	3.4%	0.3%
	All	-	3.1	2.4	2.3	0.4	1.5%		1.2%
1B1. Solid fuels transformation	CO_2	L, T	0.4	0.7	0.7	0.2	0.4%	0.4%	0.3%
1B2. Fugitive emissions from oil and gas operations	CO_2	L, T	0.8	0.1	0.1	0.0	0.0%	0.0%	0.0%
1B2. venting/flaring	CH_4	T	1.5	0.3	0.3	0.0	0.2%	1.6%	0.2%

Note: Key sources in the 1A1, 1A2 and 1A4 categories are based on aggregated emissions of CO_2 by fuel type.

3.2 Fuel combustion (1A)

3.2.1 Comparison of the sectoral approach with the Reference Approach

Emissions from fuel combustion are generally estimated by multiplying fuel quantities combusted by specific energy processes with fuel specific EFs and, in the case of non-CO_2 GHGs, source category-dependent EFs. This sectoral approach (SA) is based on fuel demand statistics. The IPCC Guidelines also require – as a quality control activity – the estimation of CO_2 emissions from fuel combustion on the basis of a national carbon balance derived from fuel supply statistics. This is the Reference Approach (RA). This section gives a detailed comparison of the sectoral approach and the Reference Approach.

Energy supply balance

The energy supply balance for the Netherlands in 1990 and 2014 is shown in Table 3.2 at a relatively high aggregation level. The Netherlands produces large amounts of natural gas, both onshore (Groningen gas) and offshore; a large share of the gas produced is exported. Natural gas represents a very large share of the national energy supply.

Using the carbon contents of each specific fuel, a national carbon balance can be derived from the energy supply balance and, from this, national CO_2 emissions can be estimated by determining how much of this carbon is oxidized in any process within the country. To allow this, international bunkers are to be considered as 'exports' and subtracted from gross national consumption.

Table 3.2 Energy supply balance for the Netherlands (PJ NCV/year)

Year	Role	Indicator name	Solid fuels	Crude oil and petroleum	Gas
1990	Supply	Primary production	0	170	2283
		Total imports	520	5399	85
		Stock change	-22	9	0
		Total exports	-130	-3986	-1081
		Bunkers	0	-520	0
	Consumption	Gross inland consumption	-367	-1073	-1286
		whereof: Final non-energy consumption	-68	-345	-88
2015	Supply	Primary production	0	77	1633
		Total imports	1506	8586	1137
		Stock change	-71	-142	-30
		Total exports	-974	-6684	-1529
		Bunkers	0	-685	0
	Consumption	Gross inland consumption	-461	-1152	-1211
		whereof: Final non-energy consumption	-68	-455	-87

Comparison of CO_2 emissions
The IPCC Reference Approach (RA) to calculating CO_2 emissions from energy use uses apparent consumption data per fuel type to estimate CO_2 emissions from fossil fuel use. This approach is used as a means of verifying the sectoral total CO_2 emissions from fuel combustion (IPCC, 2006). In the RA, national energy statistics (production, imports, exports and stock changes) are used to determine apparent fuel consumption, which is then combined with carbon emission factors to calculate carbon content. The carbon that is not combusted but instead used as feedstock, reductant or for other non-energy purposes is then deducted.

National energy statistics are provided by Statistics Netherlands. National default, partly country-specific, CO_2 emission factors are taken from Zijlema, 2017 (see Annex 5).

Table 3.3 presents the results of the RA calculation for 1990–2015, compared with the official national total emissions reported as fuel combustion (source category 1A). The annual difference calculated from the direct comparison varies between -0.3% and +2.2%.

Table 3.3 Comparison of CO_2 emissions: Reference Approach (RA) versus National Approach (NA) (Tg)

	1990	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**
RA							
Liquid fuels	50.9	53.6	54.7	56.3	52.6	47.9	48.3
Solid fuels	31.0	32.2	28.9	30.3	28.9	34.2	42.0
Gaseous fuels	68.1	76.3	77.4	78.6	87.6	63.5	63.5
Others	1.0	1.6	2.2	2.7	3.7	4.2	4.0
Total RA	151.0	163.7	163.2	168.0	172.9	149.8	157.8
NA							
Liquid fuels	50.4	52.6	54.8	56.0	54.1	48.9	48.6
Solid fuels	31.1	32.4	28.5	29.9	28.2	33.9	41.4
Gaseous fuels	69.9	77.4	77.7	79.5	88.4	64.0	63.0
Others	0.6	0.8	1.6	2.1	2.5	2.8	2.9
Total NA	152.0	163.2	162.5	167.5	173.2	149.6	155.8
Difference							
Liquid fuels	0.9%	1.9%	-0.3%	0.5%	-2.7%	-2.1%	-0.7%
Solid fuels	-0.3%	-0.6%	1.5%	1.3%	2.6%	1.1%	1.4%
Gaseous fuels	-2.6%	-1.4%	-0.3%	-1.1%	-0.9%	-0.7%	0.8%
Other	74.1%	98.3%	41.8%	33.4%	50.3%	46.9%	40.7%
Total	-0.7%	0.3%	0.4%	0.2%	-0.2%	0.1%	1.2%

The differences between the Reference Approach and the National Approach are caused by three reasons:

- There is a statistical difference in the energy statistics. If this is taken into account, then the difference between the RA and NA varies between -2.5% and +1.5%. The largest differences are visible in the years 1991, 1992 and 1994. In other years, the difference is less than 1.5%.
- In the National Approach we used company specific emission factors, while country-specific emission factsor are used in the

Reference Approach. This results in small differences of the emission estimation

- The CO_2 emissions from other fuels show a large difference. This is due to the fact that the CO_2 emission in the Reference Approach is calculated with the emission factor from the fuel list (see annex 5). This emission factor is an average value for fossil waste (with a lower EF) and biogenic waste (with a higher EF) together. As a result, the calculated CO_2 emission from fossil waste in the Reference Approach is too high and therefore the difference between the RA and NA is rather large. If both the statistical difference and the CO_2 emission factor from fossiel waste would be taken into account, then the difference between RA and SA varies between -2.9% and +1.2%. The largest differences are visible in the years 1991, 1992 and 1994. In other years, the difference is less than 1.5%.

3.2.2 *International bunker fuels*

The deliveries of bunker fuels for international aviation and water-borne navigation are rather large in the Netherlands. Amsterdam Airport Schiphol is among the larger airports in Europe and the Port of Rotterdam is among the largest ports worldwide. Due to the small size of the country, most of the fuel deliverd is used for international transport, and as such reported as bunker fuels. The amounts of bunker fuels deliverd to both international aviation and water-borne navigation is derived from the Energy Balance and is shown in Figure 3.3. Fuel deliveries for international aviation increased between 1990 and 2000 and have stabilized since. Fuel deliveries for international waterborn navigation increased until 2008, and have decreased significantly. This decrease can be attributed to the economic crisis among other things.

CO_2 emissions from bunker fuels are calculated using a Tier 1 and Tier 2 approach. Default heating values and CO_2 emission factors are used for heavy fuel oil and jet kerosene, whereas country-specific heating values and CO_2 emission factors are used for diesel oil, as described in Netherlands' list of fuels (Zijlema 2017). CH_4 and N_2O emissions resulting from the use of bunker fuels are calculated using a Tier 1 approach, using default emissions factors for both substances, as described in Klein et al. (2017). Please note that bunker emissions as reported in this NIR were recalculated compared to last submission as a result of an update of the activity data from the 2016 revision of the energy statistics.

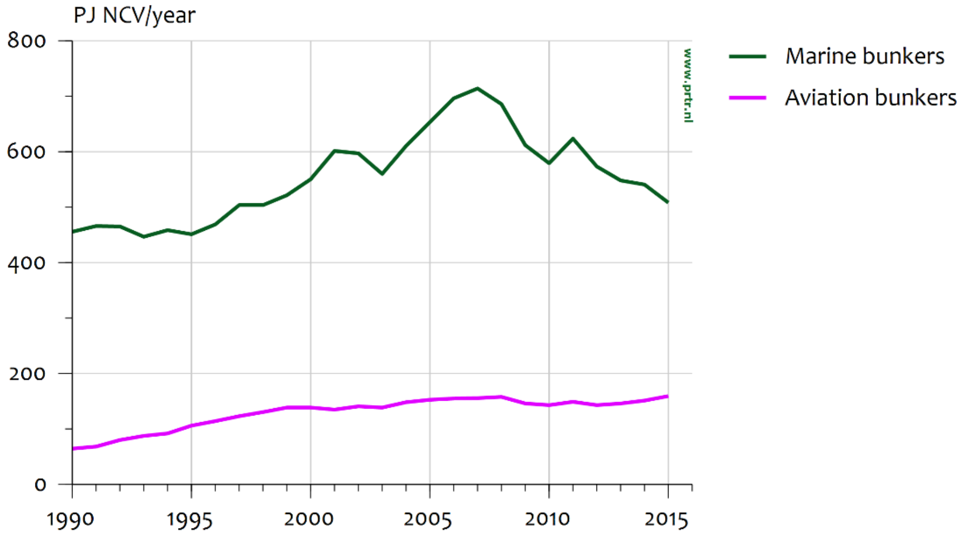


Figure 3.3 Marine and aviation bunker fuel exports, 1990-2015.

3.2.3 *Feed stocks and non-energy use of fuels*

Table 3.2 shows that a large share of the gross national consumption of petroleum products was used in non-energy applications. These fuels were mainly used as feedstock in the petro-chemical industry (naphtha) and in products in many applications (bitumen, lubricants, etc.). Also, a fraction of the gross national consumption of natural gas (mainly in ammonia production) and coal (mainly in iron and steel production) was used in non-energy applications and hence not directly oxidized. In many cases, these products are finally oxidized in waste incinerators or during use (e.g. lubricants in two-stroke engines). In the RA, these product flows are excluded from the calculation of CO_2 emissions.

3.2.4 *Energy industries (1A1)*

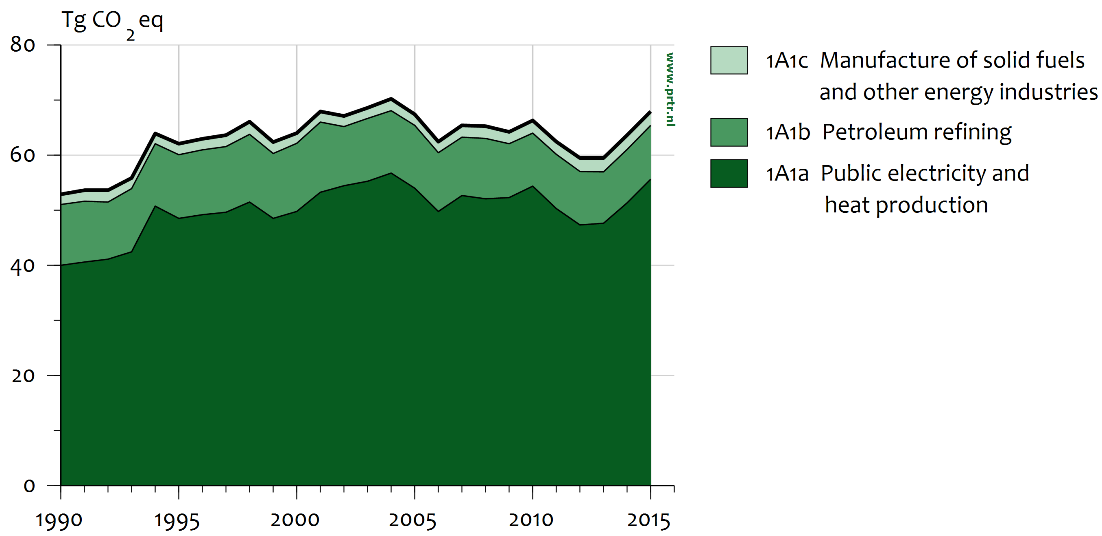


Figure 3.4 1A1 Energy industries: trend and emissions levels by source sub-category, 1990–2015.

3.2.4.1 Category description

Energy industries (1A1) is the main source category contributing to the Energy sector. This category is divided into three sub-categories:

- Public electricity and heat production (1A1a);
- Petroleum refining (1A1b);
- Manufacture of solid fuels and other energy industries (1A1c).

Within this category, natural gas and coal combustion in public electricity and heat production, and oil combustion in petroleum refining are the biggest sources. Other key sources are liquid fuels and other fuels (waste) in public electricity and heat production, and natural gas combustion in petroleum refining and in the manufacture of solid fuels and other energy industries. CH_4 and N_2O emissions from 1A1 contribute relatively little to the total national inventory of GHG emissions.
N_2O and CH_4 emissions from Energy industries are not a key source (see Table 3.1).

Public electricity and heat production (1A1a)
The Dutch electricity sector has a few notable features: it has a large share of coal-fired power stations and a large proportion of gas-fired cogeneration plants, many of the latter being operated as joint ventures with industries. In comparison with some other countries in the EU, nuclear energy and renewable energy provide very little of the total primary energy supply in the Netherlands. The two main renewable energy sources are biomass and wind. The public electricity and heat production source category also includes all emissions from large-scale waste incineration, since all incineration facilities produce heat and/or electricity and the waste incinerated in these installations is therefore regarded as a fuel. In addition, a large proportion of the blast furnace gas and a significant part of the coke oven gas produced by the single iron and steel plant in the Netherlands is combusted in the public electricity sector (see Figure 3.5).

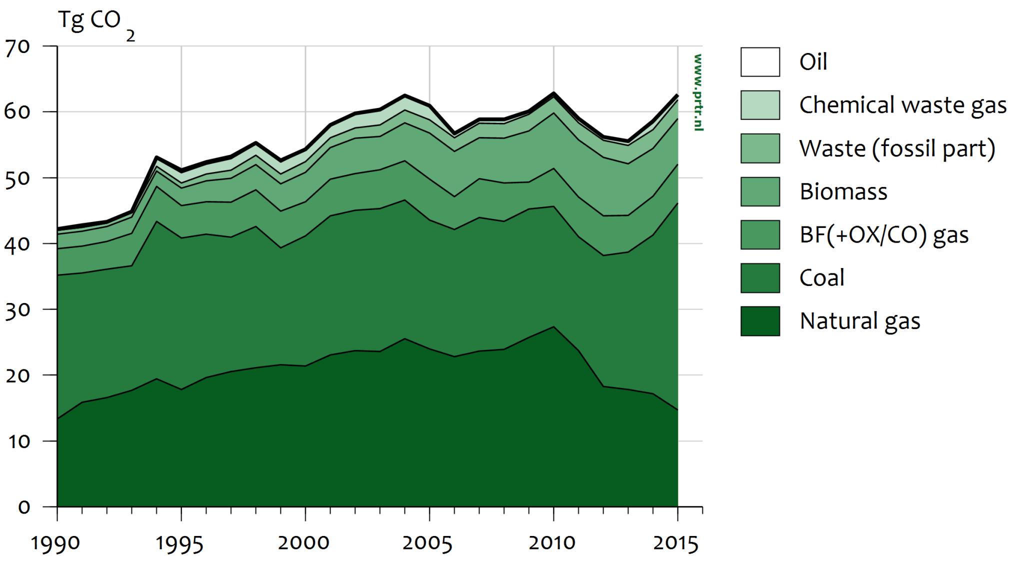


Figure 3.5 Trend in sources of CO_2 from fuel use in power plants, 1990-2015 (The abbreviation BF(+OX/CO) refers to blast furnace gas, oxygen furnace gas and coke oven gas.)

1A1a (public electricity and heat production) is the largest source category within the 1A1 Energy industries category (see Figure 3.4 and Table 3.1). Between 1990 and 2014, total CO_2 emissions from public electricity and heat production increased. The increasing trend in electric power production corresponds to a substantial increase in CO_2 emissions from fossil fuel combustion by power plants.

CO_2 emissions from the waste incineration of fossil carbon increased due to the increasing amounts of waste that are combusted instead of being deposited in landfills, which is the result of environmental policy aimed at reducing waste disposal in landfills as well as the import of waste (see Chapter 7). The increase in the CO_2 emission factor for other fuels since 2004 is due to the increase in the share of plastics (which have a high carbon content) in combustible waste (see paragraph 7.4). The decrease in the implied emission factor (IEF) for CO_2 from biomass is due to the increase in the share of pure biomass (co-combusted with coal-firing), as opposed to the organic carbon in waste combustion with energy recovery, which traditionally contributes the most to biomass combustion. For the former type, a lower EF is applied than for the latter.

Between 1990 and 1998, a change in the ownership structures of plants (joint ventures) caused a shift of cogeneration plants from category 1A2 (Manufacturing industries) to 1A1a (public electricity and heat production). Half of the almost 30% increase in natural gas combustion that occurred between 1990 and 1998 is largely explained by this shift and by the similar shift of a few large chemical waste gas-fired steam boilers. The corresponding CO_2 emissions allocated to the Energy sector increased from virtually zero in 1990 to 8.5 Tg in 1998 and 9.1 Tg in 2005.

Emissions from waste incineration are included in this category because they all recover heat and produce electricity. Most of the combustion of biogas recovered at landfill sites occurs in CHP plants operated by utilities; therefore, it is also allocated to this category.

The strong increase in liquid fuel use in 1994 and 1995, with a particularly sharp rise in 1995, was due to the use of chemical waste gas in joint venture electricity and heat production facilities. This also explains the somewhat lower IEF for CO_2 from liquids since 1995. A significant drop is seen in the emissions from 1A1a (electricity and heat production) in 1999 (-6% compared with 1998), which is explained by the higher share of imported electricity in domestic electricity consumption in that year, which was double that in 1998 (10% in 1998 versus 20% in 1999), and by a significant shift from coal to chemical waste gas and natural gas in 1999. The net import of electricity decreased again in 2001, and this was compensated for by an increased production of electricity from gas and coal combustion in the public electricity sector. In 2004, CO_2 emissions increased by 3% as a direct result of the start-up in 2004 of a 790 MWe gas-fired cogeneration plant and a 2% decrease in coal combustion. CO_2 emissions decreased in 2006 as a result of increased import of electricity, while they increased again in 2010 as a result of the increased export of electricity. In 2014, emissions increased due to a higher foreign electricity demand. New coal-fired power plants started in 2014, resulting in a large increase in CO2 from combustion of coal.

Petroleum refining (1A1b)
There are five large refineries in the Netherlands, which export approximately 50% of their products to the European market. Consequently, the Dutch petrochemical industry is relatively large.

1A1b (petroleum refining) is the second largest emission source in the category 1A1 (Energy industries). The combustion emissions from this category should be viewed in relation to the fugitive emissions reported under category 1B2. Between 1990 and 2014, total CO_2 emissions from the refineries (including fugitive CO_2 emissions from hydrogen production reported in 1B2a-iv Refining) fluctuated between 10 and 13 Tg CO_2.

For 1A1b (petroleum refining), the calculation of emissions from fuel combustion is based on sectoral energy statistics, using fuel consumption for energy purposes, and activity data (including the consumption of residual refinery gases). In 2002, the quality of the data was improved by incorporating the CO_2 emissions reported by the individual refineries in environmental reports.

Since 1998, one refinery has operated an SGHP unit, supplying all the hydrogen for a large-scale hydrocracker. The chemical processes involved in the production of hydrogen also generate CO_2 (CO_2 removal and a two-stage CO shift reaction). Refinery data specifying these fugitive CO_2 emissions are available and have been used since 2002, being reported in the category 1B2. The fuel used to provide the carbon for this non-combustion process is subtracted from the fuel consumption used to calculate the combustion emissions reported in this category.

The use of plant-specific EFs for refinery gas from 2002 onwards also caused a change in the IEF for CO_2 emissions from total liquid fuel, compared with the years prior to 2002. The EF for refinery gas is adjusted to obtain exact correspondence between the total CO_2 emissions calculated and the total CO_2 emissions officially reported by the refineries.

The interannual variation in the IEFs for CO_2, CH_4 and N_2O emissions from liquid fuels is explained by the high and variable proportion (between 45% and 60%) of refinery gas in total liquid fuel, which has a low default EF compared with most other oil products and has variable EFs for the years 2002 onward.

All remaining differences between the CO_2 calculation using plant-specific data and the CO_2 calculation based on national energy statistics and default EFs affect the calculated carbon content of the combusted refinery gas and thus the IEF of CO_2 emissions from liquid fuel. CO_2 emissions obtained from both calculation methods are the same.

Manufacture of solid fuels and other energy industries (1A1c)

Source category 1A1c comprises:

- Fuel combustion for on-site coke production by the iron and steel plant Tata Steel and fuel combustion from an independent coke production facility (Sluiskil, which ceased operations in 1999);
- Combustion of 'own' fuel by the oil and gas production industry for heating purposes (the difference between the amounts of fuel produced and sold, minus the amounts of associated gas that are flared, vented or lost by leakage);

The combustion emissions from oil and gas production refer to 'own use' for energy purposes by the gas and oil production industry (including transmission), which is the difference between the amounts of fuel produced and sold, after subtraction of the amounts of associated gas that are flared, vented or lost by leakage. Production and sales data are based on national energy statistics; amounts flared and vented are based on reports from the sector. CO_2 emissions from this source category increased, mainly due to the operation of less productive sites for oil and gas production, compared with those operated in the past. This fact explains the steady increase over time shown by this category with respect to gas consumption. The interannual variability in the EFs for CO_2 and CH_4 emissions from gas combustion is mainly due to differences in gas composition and the variable losses in the compressor stations of the gas transmission network, which are reported in the AERs of the gas transport company.
The fuel combustion for coke production by the iron and steel plant is based on a mass balance. See chapter 3.2.5.1 for more information on emissions from the iron and steel sector (including emissions from coke production).

3.2.4.2 Methodological issues

The emissions from this source category are estimated by multiplying fuel use statistics by the IPCC default and country-specific EFs (Tier 1 and Tier 2 method for CO_2, Tier 2 method for CH_4 and Tier 1 method for N_2O). Activity data are derived from the aggregated statistical data from national energy statistics published annually by Statistics Netherlands (see www.cbs.nl). The aggregated statistical data is based on confidential data from individual companies. When necessary, emissions data from individual companies is also used; for example, when companies report a different EF for derived gases (see the following section).

For CO_2, IPCC default EFs are used (see Annex 5), with the exception of CO_2 for natural gas, coal, cokes, waste, waste gases, gas/diesel oil, gasoline, LPG, liquid biomass and gaseous biomass, for which country-specific EFs are used. When available, company-specific or sector-specific EFs are used, particularly for derived gases such as refinery gas, chemical waste gas, blast furnace gas, coke oven gas, oxy gas and phosphor gas. If companies report different EFs for derived gases, it is possible to deviate from the standard EF when estimating emissions generated by these companies.

The CH_4 emission factors are taken from Scheffer and Jonker (1997), except for the use of natural gas in gas engines (see ENINA, 2017 for

more details on the CH_4 EF of gas engines). For N_2O, IPCC default EFs are used.
Emissions data from individual companies are used when companies report a different CO_2 EF for derived gases. For this, emissions data from the AERs and the reporting under the Emission Trading Scheme (ETS) from selected companies is used. The data is validated by the competent authority. If the data is not accepted by the competent authority, then the CO_2 emissions data is not used for the emissions inventory. Instead, country-specific EFs are used. This occurs only rarely, and the emissions are recalculated when the validated data from these companies becomes available.

Data from the AERs and the ETS is compared (QC check) and the data that provides greater detail for the relevant fuels and installations is used. The reported CO_2 emissions are combined with energy use, as recorded in energy statistics, to derive a company-specific EF. Since the energy statistics have been revised in 2014/2015, the company-specific EFs have also been recalculated.

- Refinery gas: Since 2002, company-specific EFs have been derived for all companies and are used in the emissions inventory. For the years prior to this, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Chemical waste gas: Since 1995, company-specific EFs have been derived for a selection of companies. For the remaining companies, the default EF is used. If any of these companies was missing, then a company-specific EF for the missing company was used (derived in 1995). For the period 1990–1994, a country-specific EF based on an average EF for four companies has been used.
- Blast furnace gas: Since 2007, company-specific EFs have been derived for most companies. Since blast furnace gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all blast furnace gas has the same content and the derived EF is used for all companies using blast furnace gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Coke oven gas: Since 2007, company-specific EFs have been derived for most companies. Since coke oven gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all coke oven gas has the same content and the derived EF is used for all companies that use coke oven gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Phosphor gas: Since 2006, company-specific EFs have been derived for the single company and are used in the emissions inventory. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Coal: Since 2006, company-specific EFs have been derived for most companies and for the remaining companies the default EFs is used. For previous years, EFs from the Netherlands list of fuels (Zijlema, 2017) are used.
- Coke oven/gas coke: Since 2006, a company-specific EF has been derived for one company. For the other companies, a

country-specific EF is used. For the years prior to this, a country-specific EF is used for all companies.

In 2015, approximately 98% of CO_2 emissions were calculated using country-specific or company-specific EFs. The remaining 2% of CO_2 emissions were calculated using default IPCC EFs. The latter mentioned emissions originate mostly from petroleum cokes, other oil, residual fuel oil and bitumen.

An overview of the EFs used for the most important fuels (up to 95% of the fuel use) in the category Energy industries (1A1) is provided in Table 3.4. Since some emissions data in this sector originates from individual companies, some of the values (in Table 3.4) are IEFs. For reasons of confidentiality, detailed data on fuel consumption and emission factors per CRF category and fuel is not presented in the NIR, but is available to the reviewers upon request.

Table 3.4 Overview of EFs used in 2015 in the category Energy industries (1A1)

Fuel	**Amount of fuel used in 2015 (TJ NCV)**	**(Implied) emission factors (g/GJ)**		
		CO_2 (x1000)	**N_2O**	**CH_4**
Natural gas	341,847	57.0	0.18	9.82
Other Bituminous Coal	336,556	93.4	1.40	0.44
Waste gas	102,411	61.8	0.10	3.60
Waste, biomass	40,827	124.0	6.26	
Waste, fossil	34,471	83.0	5.02	
Blast Furnace Gas	25,755	244.3	0.10	0.35
Other	14,096	NA	NA	NA

Explanation for the source-specific EFs:

- The standard CH_4 EF for natural gas is 5.7 g/GJ. Only in category 1A1c 'other energy industries' is 'wet' natural gas (directly extracted from the wells) used for combustion. For this unprocessed gas, a higher EF is used, which explains the higher EF for this category. Also, the CO_2 and N_2O EFs for natural gas deviate from the standard EFs (56.5 kg CO_2/GJ and 0.1 g N_2O/GJ), because this category includes emissions from the combustion of crude gas 'wet' natural gas.
- The CO_2 emissions from coal are based on emissions data from the ETS and the implied EF is different from the country-specific EF.
- The CO_2 emissions from refinery gas are counted as emissions occurring in refineries and in the Energy sector. The emissions are partly based on emissions data from the ETS.
- The EF for N_2O emissions from waste combustion (fossil and biomass) is either with or without an SNCR (9.43 g/GJ and 1.89 g/GJ, respectively), depending on the amount of waste incinerated in incinerators. The EF for CH_4 from waste incineration has been changed to 0 g/GJ as a result of a study on emissions from waste incineration (DHV, 2010, and NL Agency, 2010). The emissions are reported in the CRF file with the code 'NO' (as the CRF cannot handle 0 (zero) values). The EF of CO_2 is dependent on the carbon content of the waste, which is determined annually (Rijkswaterstaat, 2015).

- The CO_2 emissions from blast furnace gas are based on emissions data from the ETS, and the implied EF is different from the country-specific emission factor.

More details on EFs, methodologies, data sources and country-specific source allocation issues are provided in the *Methodology report on the calculation of emissions to air from the sectors Energy, Industry and Waste* (ENINA, 2017).

In accordance with the IPCC Guidelines, only fossil fuel-related CO_2 emissions are included in the total national inventory, thus excluding CO_2 from organic carbon sources from the combustion of biomass. The CO_2 from biomass resulting from waste incineration is reported as a memo item.

3.2.4.3 Uncertainty and time series consistency

The uncertainty in CO_2 emissions of this category is estimated to be 2% (see Section 1.7 for details). The accuracy of data on fuel consumption in power generation and oil refineries is generally considered to be very high, with an estimated uncertainty of approximately 0.5%. The high accuracy in most of this activity data is due to the limited number of utilities and refineries, their large fuel consumption and the fact that the data is recorded in national energy statistics and verified as part of the European ETS.

The consumption of gas and liquid fuels in the 1A1c category is mainly from the oil and gas production industry, where the split into 'own use' and 'venting/flaring' has proven to be quite difficult to establish, and therefore a high uncertainty of 20% has been assigned. For other fuels, a 2% uncertainty is used, which relates to the amount of fossil waste being incinerated and therefore to the uncertainties in the total amount of waste and the fossil and biomass fractions.

For natural gas, the uncertainty in the CO_2 EF is estimated to be 0.25%, based on the fuel quality analysis reported by Heslinga and Van Harmelen (2006) and further discussed in Olivier et al. (2009). This value is used in the uncertainty assessment in Section 1.7 and key source assessment in Annex 1. For hard coal (bituminous coal), an analysis was made of coal used in power generation (Van Harmelen and Koch, 2002), which is accurate within approximately 0.5% for 2000 (based on 1,270 samples taken in 2000). In 1990 and 1998, however, the EF varied ± 0.9 CO_2/GJ (see Table 4.1 in Van Harmelen and Koch, 2002); consequently, when the default EF is applied to other years, the uncertainty is larger, approximately 1%.

Analysis of the default CO_2 EFs for coke oven gas and blast furnace gas reveals uncertainties of approximately 10% and 15%, respectively (data reported by the steel plant). Since the share of BF/OX gas in total solid fuel emissions from power generation is approximately 15–20%, the overall uncertainty in the CO_2 EF for solids in power generation is estimated to be approximately 3%. The CO_2 EFs for chemical waste gas and – to a lesser extent – BF/OX gas are more uncertain than those for other fuels used by utilities. So, for liquid fuels in these sectors, a higher

uncertainty of 20–25% is assumed in view of the quite variable composition of the derived gasses used in both sectors.
For natural gas and liquid fuels in oil and gas production (1A1c), uncertainties of 5% and 2%, respectively, are assumed, which relates to the variable composition of the offshore gas and oil produced. For the CO_2 EF for other fuels (fossil waste), an uncertainty of 6% is assumed, which reflects the limited accuracy in the waste composition and therefore the carbon fraction per waste stream. The uncertainty in the EFs for emissions of CH_4 and N_2O from stationary combustion is estimated at approximately 50%, which is an aggregate of the various sub-categories (Olivier et al., 2009).

3.2.4.4 Category-specific QA/QC and verification

The trends in fuel combustion in public electricity and heat production (1A1a) are compared with trends in domestic electricity consumption (production plus net imports). Large annual changes are identified and explained (e.g. changes in fuel consumption by joint ventures). For oil refineries (1A1b), a carbon balance calculation is made to check completeness. Moreover, the trend in total CO_2 reported as fuel combustion by refineries is compared with trends in activity indicators such as total crude throughput. The IEF trend tables are then checked for changes and interannual variations are explained in this NIR.

CO_2 emissions reported by companies (both in their AERs and within the ETS) are validated by the competent authority and then compared. More details on the validation of energy data are to be found in ENINA (2017).

3.2.4.5 Category-specific recalculations

The activity data of gas/diesel oil has been revised for the complete time series. For 2014, this results in a decrease of 18.7 kton CO2 for category 1A1a.
Emissions from natural gas combustion for gas transportation has been reallocated from 1A1c to 1A3e.

3.2.4.6 Category-specific planned improvements

No planned improvements.

3.2.5 Manufacturing industries and construction (1A2)

3.2.5.1 Source category description

This source category consists of six sub-categories:

- Iron and steel (1A2a);
- Non-ferrous metals (1A2b);
- Chemicals (1A2c);
- Pulp, paper and print (1A2d);
- Food processing, beverages and tobacco (1A2e);
- Non-metallic minerals (1A2f);
- Other (1A2g).

Within these categories, liquid fuel and natural gas combustion by the chemical industry and natural gas combustion by the food processing industries are the dominating emissions sources. Natural gas in the pulp and paper industries and liquid fuels (mainly for off-road machinery) in the other industries are also large emission sources. The shares of CH_4

and N_2O emissions from industrial combustion are relatively small and these are not key sources.

Natural gas is mostly used in the chemical, food and drinks and related industries; solid fuels (i.e. coal and coke-derived fuels, such as blast furnace/oxygen furnace gas) are mostly used in the iron and steel industry (1A2a); liquid fuels are mostly used in the chemicals industry (1A2c) and in other industries (1A2f) (see Table 3.5).

Table 3.5 Fuel use in 1A2 Manufacturing industries and construction in selected years (TJ PJ NCV/year)

	Amount of fuel used (PJ NCV)						
Fuel type/Category	**1990**	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**
Gaseous fuels							
Iron and steel	11.7	13.0	13.7	12.5	12.0	11.3	11.1
Non-ferrous metals	3.8	4.3	4.2	4.0	3.6	2.2	2.7
Chemicals	170.7	139.0	117.8	105.3	97.6	88.7	95.8
Pulp, paper and print	29.2	24.4	27.4	29.7	21.0	17.9	15.7
Food processing, beverages and tobacco	63.7	68.5	73.7	67.1	57.0	60.0	61.9
Non-metallic minerals	26.1	23.8	26.5	23.5	22.6	17.0	17.6
Other	30.1	34.8	36.3	32.6	31.4	24.3	23.2
Liquid fuels							
Iron and steel	0.3	0.3	0.1	0.1	0.1	0.2	0.2
Non-ferrous metals	NO	NO	NO	NO	NO	NO	NO
Chemicals	96.2	77.6	82.6	93.2	112.7	104.3	94.9
Pulp, paper and print	0.03	0.02	NO	NO	NO	NO	NO
Food processing, beverages and tobacco	2.2	0.6	0.2	0.2	NO	NO	NO
Non-metallic minerals	5.6	4.2	1.9	0.8	0.7	0.2	0.2
Other	19.3	21.3	23.4	21.9	20.2	20.2	19.5
Solid fuels							
Iron and steel	19.9	24.3	17.7	21.2	20.3	19.1	20.0
Non-ferrous metals	0.005	NO	NO	NO	NO	NO	NO
Chemicals	12.8	0.2	0.1	NO	NO	NO	NO
Pulp, paper and print	0.1	NO	NO	NO	NO	NO	NO
Food processing, beverages and tobacco	2.4	1.2	1.1	0.6	1.0	1.0	0.8
Non-metallic minerals	3.3	2.1	2.3	1.5	1.5	1.4	1.5
Other	0.4	0.2	0.3	0.5	1.6	0.6	0.6

Another feature of industry in the Netherlands is that it operates a large number of CHP facilities (and also some steam boilers). As mentioned before (see Section 3.2.4), several of these facilities have changed ownership and are now operated as joint ventures with electrical utilities, the emissions of which are reported in Energy industries (1A1).

Within the category 1A2 (Manufacturing industries and construction), the category 1A2c (chemicals) is the largest fuel user (see Table 3.6). Other fuel-using industries are included in 1A2a (iron and steel), 1A2e (food processing, beverages and tobacco) and 1A2g (other). Solid fuels are almost exclusively used in 1A2a (iron and steel). In this industry, a small amount of natural gas is also used. All other industries almost completely operate on natural gas.

In the period 1990–2015, CO_2 emissions from combustion in 1A2 (Manufacturing industries and construction) decreased (see Figure 3.6). The chemical industry contributed the most to the decrease in emissions in this source category.

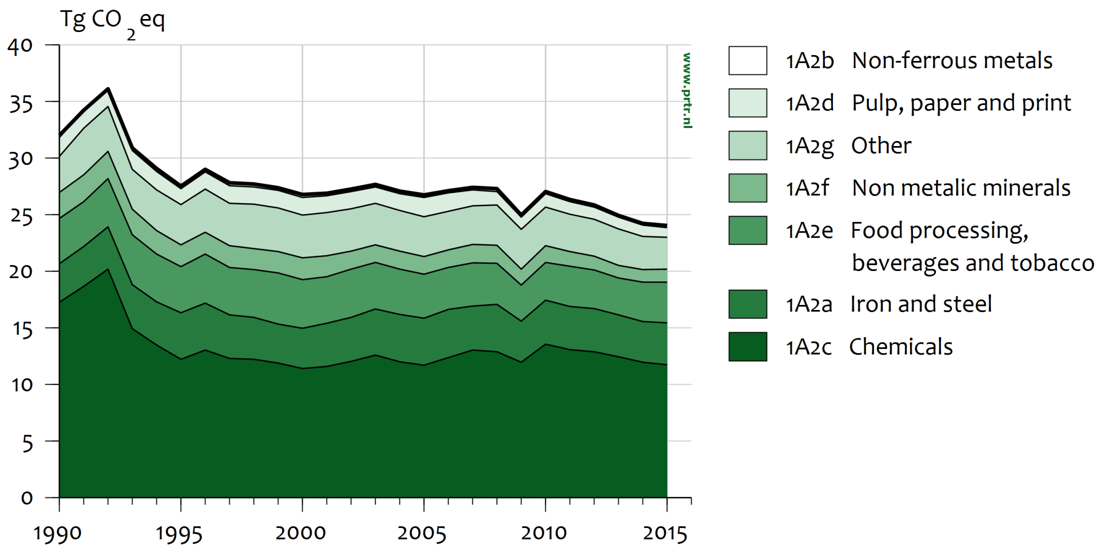


Figure 3.6 1A2 Manufacturing industries and construction: trend and emissions levels of source categories, 1990–2015.

The derivation of these figures, however, should also be viewed in the context of the allocation of industrial process emissions of CO_2. Most industry process emissions of CO_2 (soda ash, ammonia, carbon electrodes and industrial gases such as hydrogen and carbon monoxide) are reported in CRF sector 2 (Industrial processes). However, in manufacturing processes, the oxidation is accounted for in energy statistics as the production and combustion of residual gases (e.g. in the chemical industry), the corresponding CO_2 emissions are then reported as combustion in category 1A2 and not as an industrial process in sector 2.

Iron and steel (1A2a)
This category refers mainly to the integrated steel plant Tata Steel, which produces approximately 6,000 ktons of crude steel (in addition to approximately 100 ktons of electric steel production and iron foundries). The category also includes emissions from electric arc furnaces at another (small) plant.

The emissions calculation for this category is based on a mass balance, which can not be included in the NIR (for reasons of confidentiality), but will be made available for the UNFCCC review.

Interannual variations in CO_2 emissions from fuel combustion in the iron and steel industry can be explained as being mainly due to the varying amounts of solid fuels used in this sector.

When all CO_2 emissions from the sector are combined – including the net process emissions reported under category 2C1 – total emissions closely follow the interannual variation in crude steel production (see Figures 3.7 and 3.8). Total CO_2 emissions from the iron and steel sector decreased over time, even though production increased. This indicates a substantial energy efficiency improvement in the sector.

The interannual variation in the IEF for CO_2 emissions from solid fuels is due to the variable shares of BF/OX gas and coke oven gas, which have much higher and lower EFs, respectively, than do hard coal and coke. The low IEFs in 1990–1994 compared with later years were due to the higher share of coke oven gas in the solid fuel mix in those years, attributable to coke oven gas combustion by the independent coke manufacturer in Sluiskil, which in these years was not accounted for in the energy statistics separately, but was included in this category.

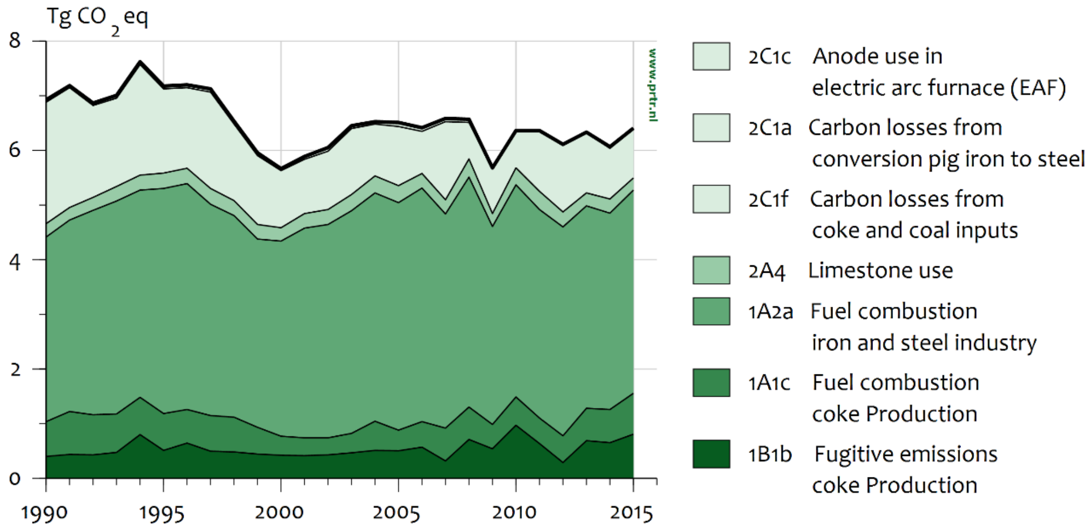


Figure 3.7. Emissions levels (Gg-eq) from the iron and steel industry, 1990-2015.

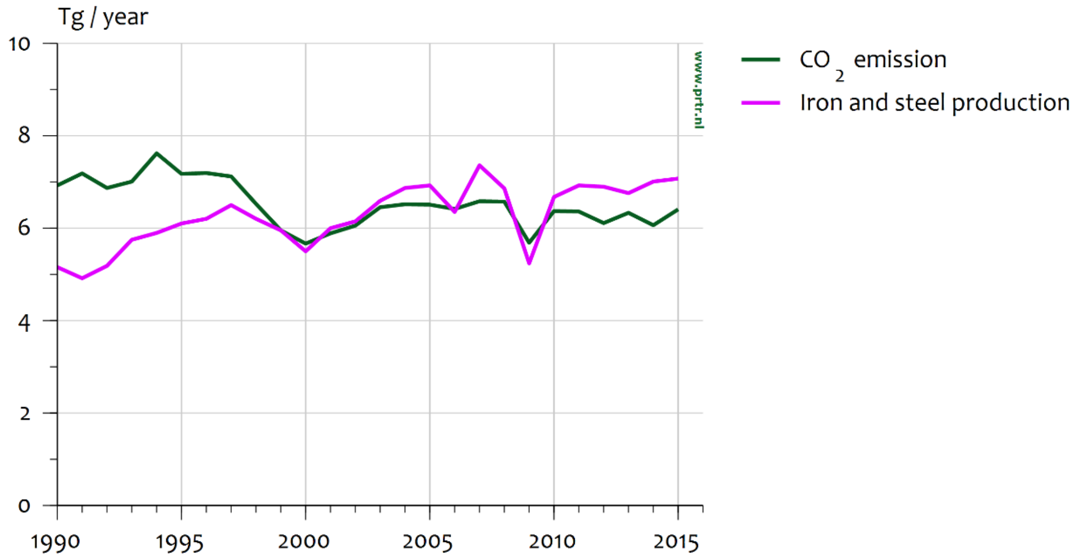


Figure 3.8. CO_2 emissions (Gg) from the iron and steel industry compared with the iron and steel production, 1990-2015 (ktonnes)

Non-ferrous metals (1A2b)
This category consists mainly of two aluminium smelters. CO_2 emissions from anode consumption in the aluminium industry are included in 2C (Metal production). This small source category contributes only about 0.1 Tg CO_2 to the total national GHG inventory, predominantly from the combustion of natural gas. Energy production in the aluminium industry is largely based on electricity, the emissions of which are included in 1A1a (public electricity and heat production).

The amounts of liquid and solid fuels vary considerably between years, but both the amounts and the related emissions are almost negligible. The interannual variation of the IEFs for liquid fuels is largely a result of changes in the mix of underlying fuels (e.g. the share of LPG, which has a relatively low EF) and partly due to the small amounts used.

Chemicals (1A2c)
CO_2 emissions from this source category have decreased since 1990, mainly due to a large decrease in the consumption of natural gas during the same period.

The steadily decreasing CO_2 emissions from the combustion of natural gas can be largely explained by the decreasing numbers of cogeneration facilities in this industrial sector. CO_2 emissions from liquid fuel combustion stem predominantly from the combustion of chemical waste gas. The decrease in liquid fuel consumption in the 90s is not due to a decrease in chemical production or data errors, but mainly to a shift in the ownership of cogeneration plants to joint ventures, thus reallocating it to energy industries. This also explains the large decrease in solid fuel combustion.

The increase in 2003 of the IEF for CO_2 emissions from liquid fuels is explained by the increase in the use of chemical waste gas and a change in its composition. For CO_2 from waste gas (reported under liquid and solid fuels), source-specific EFs were used from 1995 onwards based on data from selected years. For 16 individual plants, the residual chemical gas from the combustion of liquids was hydrogen, for which the CO_2 EF is 0. For another 9 companies, plant-specific CO_2 EFs based on annual reporting by the companies were used (most in the 50–55 range, with exceptional values of 23 and 95). The increased use of chemical waste gas (included in liquid fuels) since 2003 and the changes in the composition of the gasses explain the increase in the IEF for liquid fuels from approximately 55 to approximately 67 kg/GJ. For 1990, an average sector-specific value for the chemical industry was calculated using the plant-specific EFs for 1995 from the four largest companies and the amounts used per company in 1990.

For CO_2 from phosphorous furnace gas, plant-specific values were used, with values of around 149.5 kg/GJ. This gas is made from coke and therefore included in solid fuels. The operation of the phosphorous plant started around the year 2000, which explains the increase in the IEF for solid fuels and the plants closed in 2012, resulting in a decrease in the IEF for solid fuels.

Pulp, paper and print (1A2d)
In line with the decreased consumption of natural gas, CO_2 emissions have decreased since 1990. A substantial fraction of the natural gas has been used for cogeneration. The relatively low CO_2 emissions in 1995 can be explained by the reallocation of emissions to the Energy sector, due to the aforementioned formation of joint ventures.

The amounts of liquid and solid fuel combustion vary considerably between years, but the amounts and related emissions are almost negligible. The interannual variation in the IEFs for liquid fuels is due to variable shares of derived gases and LPG in total liquid fuel combustion.

Food processing, beverages and tobacco (1A2e)
CO_2 emissions from this category decreased in the period 1990–2015. This is due to the reallocation (since 2003) of joint ventures at cogeneration plants, whose emissions were formerly allocated to 1A2e but are now reported under public electricity and heat production (1A1a).

The amounts of liquid and solid fuels vary considerably between years, but the amounts and related emissions are verifiably small. The interannual variation in the IEFs for liquid fuels is due to variable shares of LPG in total liquid fuel combustion.

Non-metallic minerals (1A2f)
CO_2 emissions from this category decreased in the period 1990–2014 as a result of the decreasing consumption of natural gas in this category.

The amounts of liquid and solid fuels vary considerably between years, but the amounts and related emissions are verifiably small. The interannual variation in the IEFs for liquid fuels is due to variable shares of LPG in total liquid fuel combustion, which has a lower CO_2 EF.

Other (1A2g)
This category includes all other industry branches, including production of textiles, wood and wood products and electronic equipment. It also includes GHG emissions from non-road mobile machinery (NRMM) used in industry and construction. Most of the CO_2 emissions from this source category stemmed from gas, liquid fuels and biomass combustion. The emissions from NRMM changed as a result of the addition of new sub sources (mobile pumps) in the sector. This additional speciation resulted in an improved reallocation of the fuel use and thus emissions over the different NRMM sectors.

3.2.5.2 Methodological issues

The emissions from this source category are estimated by multiplying fuel use statistics by IPCC default and country-specific EFs (Tier 1 and Tier 2 method for CO_2, Tier 2 method for CH_4 and Tier 1 method for N_2O). Activity data is derived from the aggregated statistical data from national energy statistics published annually by Statistics Netherlands (see www.cbs.nl). The aggregated statistical data is based on confidential data from individual companies. When necessary, emissions data from individual companies is also used; for example, when companies report a different EF for derived gases (see the following section).

For CO_2, IPCC default EFs are used (see Annex 5), with the exception of CO_2 from natural gas, coal, waste, blast furnace gas, coke oven gas, oxy gas, phosphor gas, coke oven/gas coke, gas/diesel oil, petrol, LPG, liquid biomass and gaseous biomass, for which country-specific EFs are used. When available, company-specific or sector-specific EFs are used, in particular for derived gases such as refinery gas, chemical waste gas, blast furnace gas, coke oven gas, oxy gas and phosphor gas. If companies report different EFs for derived gases, it is possible to deviate from the standard EF for estimating the emissions for these companies.

The CH_4 EFs were taken from Scheffer and Jonker (1997), except for the use of natural gas in gas engines (see ENINA (2017) for more details on the CH_4 EF of gas engines).

For N_2O, IPCC default EFs were used.

Emissions data from individual companies is used when companies report a different CO_2 EF for derived gases. For this, emissions data from the AERs of selected companies and the ETS is used. The data is validated by the competent authority. If the data is not accepted by the competent authority, then the CO_2 emissions data is not used for the emission inventory. Instead, country-specific EFs are used. This situation occurs only rarely, and the emissions are recalculated when the validated data from these companies becomes available.
Data from the AERs and the ETS is compared (QC check) and the data which provides greater detail on the relevant fuels and installations is used. The reported CO_2 emissions are combined with energy use, as recorded in energy statistics, to derive a company-specific EF. Since the energy statistics have been revised in 2014/2015, the company-specific EFs have also been recalculated.

- Refinery gas: Since 2002, company-specific EFs have been derived for all companies and are used in the emissions inventory. For the years prior to this, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Chemical waste gas: Since 1995, company-specific EFs have been derived for a selection of companies. For the remaining companies, the default EF is used. If any of these companies was missing, then a company-specific EF for the missing company was used (derived in 1995). For the period 1990–1994, a country-specific EF based on an average EF for four companies has been used.
- Blast furnace gas: Since 2007, company-specific EFs have been derived for most companies. Since blast furnace gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all blast furnace gas has the same content and the derived EF is used for all companies using blast furnace gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Coke oven gas: Since 2007, company-specific EFs have been derived for most companies. Since coke oven gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all coke oven gas has the same content and the derived EF is used for all companies that use coke oven gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Phosphor gas: Since 2006, company-specific EFs have been derived for one company and are used in the emissions inventory. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2017) are used.
- Coal: Since 2006, company-specific EFs have been derived for most companies and for the remaining companies the default EFs is used. For previous years, EFs from the Netherlands list of fuels (Zijlema, 2017) are used.
- Coke oven/gas coke: Since 2006, a company-specific EF has been derived for one company. For the other companies, a country-specific EF is used. For the years prior to this, a country-specific EF is used for all companies.

For 2015, approximately 99% emissions were calculated using country-specific or company-specific EFs. The remaining 1% of CO_2 emissions were calculated with default IPCC EFs. These remaining emissions mainly are the result of the combustion of other oil, lignite, residual fuel oil and kerosene.

More details of methodologies, data sources and country-specific source allocation issues are provided in ENINA (2017).

An overview of the EFs used for the principal fuels (up to 95% of the fuel use) in the Manufacturing industries and construction category (1A2) is provided in Table 3.6. Since some emissions data in this sector originates from individual companies, the values in Table 3.6 partly represent implied emission factors. For reasons of confidentiality, detailed data on fuel consumption and EFs per CRF category and fuel are not presented in the NIR, but are available to reviewers upon request.

Table 3.6 Overview of emission factors used (in 2015) in the category Manufacturing industries and construction (1A2)

Fuel	Amount of fuel used in 2015 (TJ NCV)	Implied emission factors (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	228,008	56.5	0.10	6.4
Waste gas	94,276	66.4	0.10	3.6
Gas / Diesel oil	17,520	74.3	3.14	1.3
Solid biomass	14,105	109.6	4.00	32.1
Blast Furnace Gas	10,945	244.3	0.10	0.3
Coke Oven Gas	8,817	42.8	0.10	2.8
Other	8,606	NA	NA	NA

Explanations for the IEFs:

- The standard CH_4 EF for natural gas is 5.7 g/GJ. Only for gas-powered CHP plants is a higher EF used, which explains the higher EF for this sector.
- Reported CO_2 emissions from coke oven gas, blast furnace gas and waste gas are based on emissions data from the ETS. Therefore, the IEF is different from the standard country-specific EF.
- The EFs for CH_4 and N_2O from gas/diesel oil used in machinery are based on source-specific estimation methods.
- The CH_4 emissions from solid biomass are calculated with an EF of 30 g/GJ for the industrial sector and an EF of 300 g/GJ for the building construction sector.

More details on EF methodologies, data sources and country-specific source allocation issues are provided in ENINA (2017).

In the iron and steel industry, a substantial proportion of total CO_2 emissions is reported as process emissions in CRF 2C1, based on net losses calculated from the carbon balance of the process (coke and coal inputs in the blast furnaces and the blast furnace gas produced). Since the fraction of BF/OX gas captured and used for energy varies over time, the trend in the emissions of CO_2 accounted for by this source category should be viewed in association with the reported process emissions (see Figure 3.7). The emission calculation of the iron and steel industry is based on a mass balance.

For the chemical industry, CO_2 emissions from the production of silicon carbide, carbon black, methanol and ethylene from the combustion of residual gas (a by-product of the non-energy use of fuels) are included in 1A2c (chemicals). Although these CO_2 emissions are more or less process-related, they are included in 1A2 to keep the consistency with energy statistics that account for the combustion of residual gases.

The fuel consumption data in 1A2g (other) is not based on large surveys and therefore is the least accurate in this part of category 1A2g.

Details of the method for this source category can be found in ENINA (2017).
Fuel consumption by non-road mobile machinery used in industry and construction is derived from the EMMA model (Hulskotte & Verbeek,

2009). This model is based on sales data for different types of mobile machinery and assumptions made about average use (hours per year) and fuel consumption (kilograms per hour) for different machine types. The methodology used to estimate fuel consumption in different economic sectors, including industry and construction, is described in Klein et al. (2017). From this year onwards the model includes an additional speciation of mobile pumps and generators. This inclusion led to the redistribution of fuel use and emissions over the different NRMM sectors.
CO_2 emissions from NRMM are estimated using a Tier 2 methodology. Country-specific heating values and CO_2 emission factors are derived from the Netherlands' list of fuels (Zijlema, 2017). CH_4 and N_2O emissions from NRMM are estimated using a Tier 1 methodology, using emission factors derived from the 2013 EEA Emission Inventory Guidebook, as described in Klein et al. (2017).

3.2.5.3 Uncertainty and time series consistency

The uncertainty in CO_2 emissions of this category is estimated to be about 2% (see Section 1.7 for details). The uncertainty of fuel consumption data in the manufacturing industries is about 2%, with the exception of that for derived gases included in solids and liquids (Olivier et al., 2009). The uncertainty of fuel consumption data includes the uncertainty in the subtraction of the amounts of gas and solids for non-energy/feedstock uses, including the uncertainty in the conversion from physical units to Joules, and the assumed full coverage of capturing blast furnace gas in total solid consumption and full coverage of chemical waste gas in liquid fuel consumption.

For natural gas, the uncertainty in the CO_2 EF is estimated to be 0.25%, based on the recent fuel quality analysis reported by Heslinga and Van Harmelen (2006) and further discussed in Olivier et al. (2009). The 25% uncertainty estimate in the CO_2 EF for liquids is based on an uncertainty of 30% in the EF for chemical waste gas in order to account for the quite variable composition of the gas and its more than 50% share in the total liquid fuel use in the sector. An uncertainty of 10% is assigned to solids, which reflects the uncertainty in the carbon content of blast furnace gas/oxygen furnace gas based on the standard deviation in a three-year average. BF/OX gas accounts for the majority of solid fuel use in this category.

3.2.5.4 Category-specific QA/QC and verification

The trends in CO_2 emissions from fuel combustion in the iron and steel industry, non-ferrous industry, food processing, pulp and paper and other industries are compared with trends in the associated activity data: crude steel and aluminium production, indices of food production, pulp and paper production and cement and brick production. Large annual changes are identified and explained (e.g. changed allocation of fuel consumption due to joint ventures). Moreover, for the iron and steel industry, the trend in total CO_2 emissions reported as fuel combustion-related emissions (included in 1A2a) and industrial process emissions (included in 2C1) is compared with the trend in the activity data (crude steel production). A similar comparison is made for the total trend in CO_2 emissions from the chemical industry (sum of 1A2c and 2B) and trends split per main fuel type or specific process (chemical waste gas combustion and process emissions from ammonia production). IEF trend tables are checked for large changes and large interannual variations at different levels, which are explained in the NIR.

CO_2 emissions reported by companies (both in AERs and as part of the ETS) are validated by the competent authority and then compared (see also Section 3.2.4.4).

More details on the validation of the energy data can be found in ENINA (2017).

3.2.5.5 Category-specific recalculations

The activity data of gas/diesel oil has been revised for the complete time series (update of the 2016 revision). The emission calculation of gas/diesel oil and gasoline by off road machinery was also slightly improved. For 2014, these recalculations result in a decrease of 85.4 kton CO2 for category 1A2 (+0.3 kton CO2 in 1A2b, +1.6 kton CO2 in 1A2c, +21.3 kton CO2 in 1A2f, +25.5 kton CO2 in 1A2giii and -134.2 kton CO2 in 1A2gvii).

3.2.5.6 Category-specific planned improvements

No planned improvements.

3.2.6 Transport (1A3)

3.2.6.1 Category description

The source category Transport (1A3) includes emissions from civil aviation, road transport, railways, waterborne navigation and pipeline transport, as shown in Table 3.7. Civil aviation (1A3a) includes only emissions from domestic aviation, i.e. aviation with departure and arrival in the Netherlands. This includes emissions from overland flights which depart from and arrive at the same airport. Similarly, waterborne navigation (1A3d) includes only emissions from domestic waterborne navigation. Emissions from fuels delivered to international aviation and navigation companies (aviation and marine bunkers) are reported separately in the inventory (see Section 3.2.2). Emissions from military aviation and shipping are included in 1A5 (see Section 3.2.8). Energy consumption for pipeline transport is not recorded separately in national energy statistics but, is from this submission onwards, CO_2 and N_2O combustion emissions for gas transport are included in 1A3e. CO_2 process emissions- and CH_4 emissions of gas transport are reported in Gas transmission and storage (1B2b) and CO_2 and CH_4 emissions from oil pipelines are included in Oil transport (1B2a), as described in Section 3.3.2.

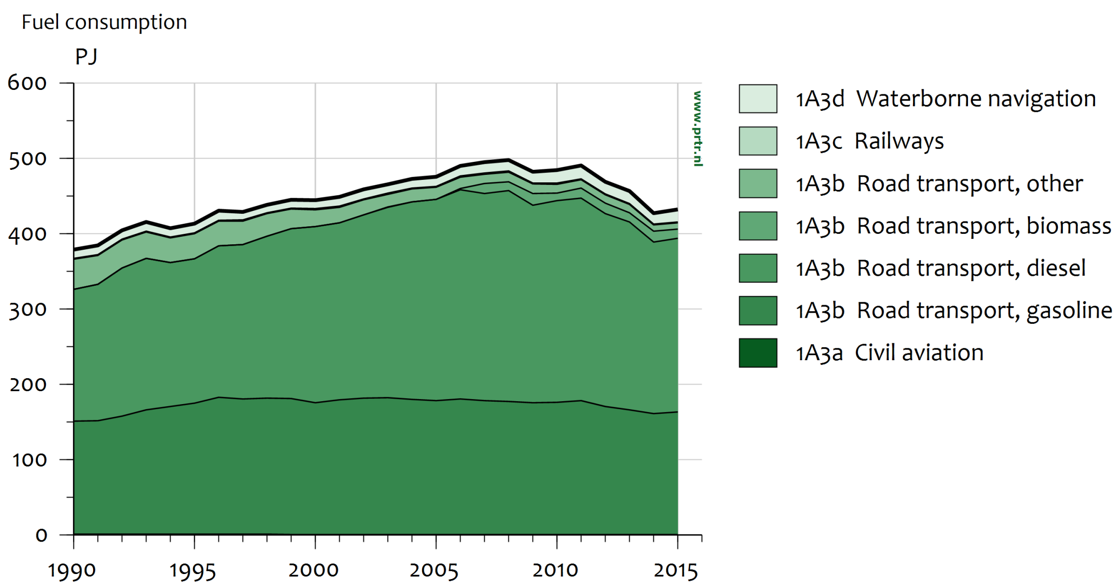
Table 3.7 Overview of Transport (1A3)

CRF code	**Source category description**	**Method**	**EF**
1A3a	Civil aviation	T1	CS, D
1A3b	Road transport	T2, T3	CS, D
1A3c	Railways	T1, T2	CS, D
1A3d	Waterborne navigation	T1, T2	CS, D
1A3e	Pipeline transport	T2	CS, D
See below	Non road mobile machinery	T2	CS, D

CO_2 emissions from lubricant use in two-stroke engines in mopeds and motorcycles have now been included under 1A3b iv, consistent with the 2006 IPCC Guidelines.

The emissions from non-road mobile machinery (NRMM) are reported under different source categories, in line with the agreed CRF format:
- Emissions from industrial and construction machinery are reported under 1A2g;
- Emissions from commercial and institutional machinery are reported under 1A4a;
- Emissions from residential machinery are reported under 1A4b;
- Emissions from agricultural machinery are reported under 1A4c.

Overview of shares and trends in emissions
Transport was responsible for 16% of GHG emissions in the Netherlands in 2015. Greenhouse gas emissions from transport increased by 29% between 1990 and 2006, from 28.1 to 36.4 Tg CO_2-eq. This increase was mainly due to an increase in diesel fuel consumption and resulting CO_2 emissions from road transport. Since 2006, GHG emissions from transport have decreased by 14% to 31.2 Tg CO_2-eq. in 2015. Total energy use and resulting GHG emissions from transport are summarized in Figure 3.9. Road transport accounts for 95-97% of energy use and GHG emissions over the time series. CO_2 is by far the most important GHG within the transport sector, accounting for 99% of total GHG emissions (in CO_2 eq.) from transport throughout the 1990–2015 period.



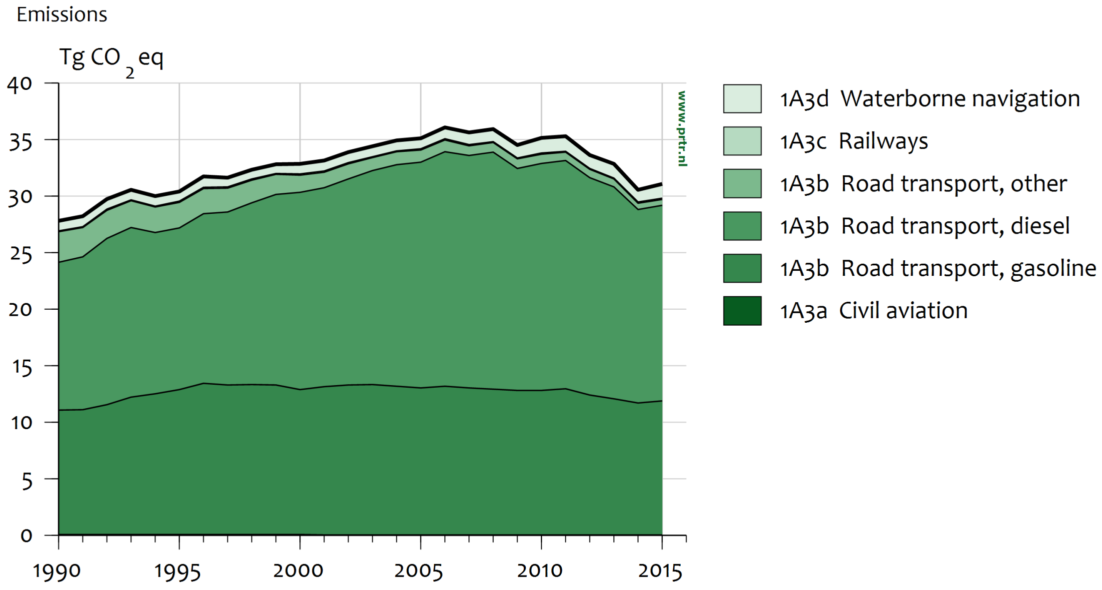


Figure 3.9 1A3 Transport: energy use and emissions levels of source categories, 1990–2015.

Figure 3.9 shows that the GHG emissions from transport steadily increased between 1990 and 2006, on average by 1.7% per year. This increase is more or less in line with the increase in road transport volumes. Between 2006 and 2008, emissions stabilized due to an increase in the use of biofuels in road transport. CO_2 emissions from biofuels are reported separately in the inventory and are not part of the national emissions totals. In 2009, GHG emissions from transport decreased by 4%, primarily due to the economic crisis and the resulting decrease in freight transport volumes. In 2010 and 2011, emissions increased slightly due to a decrease in the use of biofuels in 2010 and an increase in road transport volumes in 2011. But emissions have since decreased again.
In 2015, GHG emissions from transport were 1.6% higher than in 2014, breaking the declining trend in transport emissions seen in the 2011-2014 period. The largest contributors to the increase are road transport and domestic navigation. An explanation for the growing traffic and transport volumes and resulting energy use and GHG emissions can be found in the improving economic conditions in the Netherlands.

Civil aviation (1A3a)
The share of civil aviation in GHG emissions in the Netherlands was less than 0.1% in both 1990 and 2015. Given the small size of the country, there is hardly any domestic aviation in the Netherlands. The use of jet kerosene for domestic aviation decreased from 1 PJ in 1990 to 0.5 PJ in 2015, whereas the use of aviation gasoline decreased from 0.16 PJ in 1990 to 0.06 PJ in 2015. GHG emissions from civil aviation decreased accordingly.

Road transport (1A3b)
The share of Road transport (1A3b) in national GHG emissions increased from 11.8% in 1990 to 14.8% in 2015. Between 1990 and 2015, GHG emissions from road transport increased from 26.8 to 29.7 Tg CO_2-eq.,

resulting for the most part from an increase in diesel fuel consumption (i.e. fuel sold), as shown in Figure 3.9. Between 1990 and 2008, diesel fuel consumption increased by 60% (105 PJ). This increase was, in turn, caused by the large growth in freight transport volumes and the growing number of diesel passenger cars and light duty trucks in the Dutch car fleet.

Since 2008, diesel fuel consumption has decreased by 18% to 231 PJ in 2015. This decrease can be attributed to three factors: the improved fuel efficiency of the diesel passenger car fleet, the slight decrease in diesel road transport volumes and an increase in cross-border fuelling. The fuel efficiency of the passenger car fleet in the Netherlands has improved in recent years resulting from increasingly stringent EU CO_2 emissions standards for new passenger cars and fiscal incentives for purchasers of fuel-efficient cars. As more fuel-efficient cars have entered the car fleet, average fuel-efficiency has improved in recent years. Also, road transport volumes were more or less stable between 2008 and 2014, mainly due to the economic crisis. Finally, an increase in excise duties for diesel fuel in the Netherlands in 2014 has led to an increase in cross-border fuelling, especially for freight transport (Ministry of Finance, 2014).

Gasoline consumption increased from 150 to 181 PJ between 1990 and 1996 and subsequently fluctuated between 175 and 181 PJ until 2011. Since 2011, gasoline sales to road transport decreased to 163 PJ in 2015. This decrease can be attributed to a combination of improved fuel efficiency of the passenger car fleet, stabilization of road transport volumes and an increase in cross-border fuelling.

LPG consumption for road transport has decreased steadily throughout the time series: from 40 PJ in 1990 to 6 PJ in 2015, mainly due the decreasing number of LPG-powered passenger cars in the car fleet. As a result, the share of LPG in total energy use by road transport decreased significantly between 1990 and 2015, as shown in Figure 3.10. The use of natural gas in road transport has increased in recent years, but is still very small. In 2000, natural gas use in road transport was estimated to be 6 TJ, whereas in 2015 it was estimated to be 1.7 PJ, according to Statistics Netherlands. Within the transport sector, natural gas is mainly used for public transport buses, although the number of CNG-powered passenger cars and light-duty trucks has increased in recent years.

Biofuels have been used in road transport since 2003. The use of biofuels increased from 0,1 PJ in 2003 to 13 PJ in 2007, and has since fluctuated between 9.5 and 15.5 PJ. In 2015, biofuel use for road transport amounted to 12.2 PJ, accounting for 3 per cent of total energy use for road transport. Even though the legal obiligation for the use of energy from renewable sources in transport increases every year, the actual use of biofuels has not increased accordingly. The contribution to reaching this target from certain more sustainable biofuels is considered to be twice that made by other biofuels, as is specified in the Renewable Energy Directive (EU Directive 2009/28/EC). Also, due to a change in the Dutch legislation, not all biofuels that were used to comply with the obligation in 2015 were actually used in the Dutch market. As such, the actual use of biofuels decreased from 14 PJ in 2014 to 12.3 PJ in 2015, even though the obligation to use a certain share of renewable energy in total transport fuel supply increased.The share of CH_4 in GHG emissions from road transport (in CO_2 eq.) is very small (0.2% in 2015). CH_4 emissions from road transport decreased by 69% between 1990 and 2015 (from 7.7 Gg to 2.3 Gg). CH_4 emissions from road transport stayed roughly the same between 2014 and 2015. The decrease in CH_4 emissions from road transport is due to a reduction in total VOC emissions, resulting from the implementation and subsequent tightening of EU emissions legislation for new road vehicles. Total VOC emissions from road transport decreased by 86% between 1990 and 2015, primarily due to the penetration of catalyst-equipped and canister-equipped vehicles in the passenger car fleet. Since CH_4 emissions are estimated as a proportion of total VOC emissions, the decrease in VOC emissions throughout the time series also results in a decrease in CH_4 emissions.

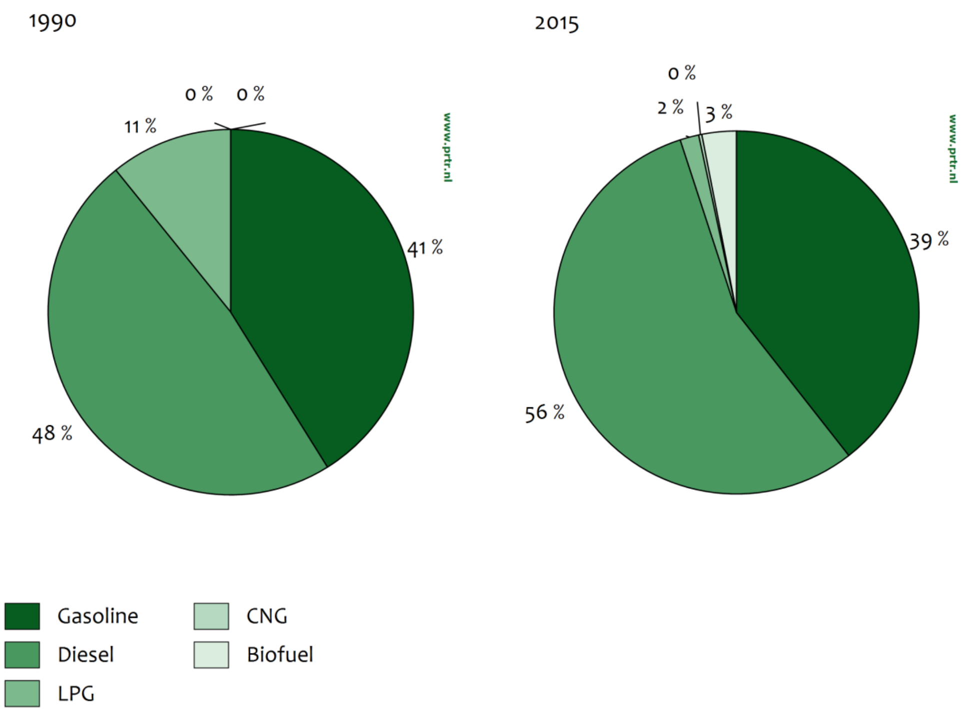


Figure 3.10 Shares of fuel types in total fuel sales to Road transport in 1990 and 2015.

The share of N_2O in total GHG emissions from road transport (in CO_2 eq) is also very small (0.8% in 2015). N_2O emissions from road transport increased from 0.3 Gg in 1990 to 0.9 Gg N_2O in 1997, but have since stabilized. The increase in N_2O emissions up to 1997 resulted from the increasing number of gasoline cars equipped with a three-way catalyst (TWC) in the passenger car fleet, as these emit more N_2O per vehicle kilometre than gasoline cars without a TWC. The subsequent stabilization of N_2O emissions between 1997 and 2015, despite a further increase in transport volumes, can be explained by a combination of developments:

- N_2O emissions per vehicle-kilometre of subsequent generations of TWC-equiped gasoline cars have decreased, causing N_2O

emissions from new gasoline passenger cars to decrease again after 1997 (Kuiper and Hensema, 2012).
- Recent generations of heavy-duty diesel trucks, equipped with selective catalytic reduction (SCR) catalysts to reduce NO_x emissions, emit more N_2O per vehicle kilometre than older trucks (Kuiper and Hensema, 2012). This has led to an increase in N_2O emissions from heavy-duty vehicles in recent years, which more or less offsets the decrease in N_2O emissions from gasoline-powered passenger cars.

In 2015 N_2O emissions from road transport increased by 2% (0.02 Gg) compared with 2014, which is due to an increase in emissions from heavy-duty diesel trucks.

Railways (1A3c)
Railways (1A3c) are a minor source of GHG emissions, accounting for 0.3% of total GHG emissions from transport in the Netherlands. Diesel fuel consumption by railways has shown a decreasing trend in recent years due to the increasing electrification of rail (freight) transport. In 2015, diesel fuel consumption by railways amounted to 1.3 PJ. Passenger transport by diesel trains accounts for approximately 0.4-0.5 PJ of diesel fuel consumption annually, the remainder being used for freight transport. Most rail transport in the Netherlands is electric, with total electricity use for rail transport amounting to over 5 PJ annually in recent years. GHG emissions resulting from electricity generation for Railways are not reported under 1A3c.

Waterborne navigation (1A3d)
Waterborne navigation is also a small source of GHG emissions in the Netherlands. Waterborne navigation for the most part is internationally orientated, i.e. either departs or arrives abroad. Emissions from international navigation are not part of the national emissions totals; therefore, the share of (domestic) waterborne navigation in total GHG emissions from transport is small and varies between 2% and 4% throughout the time series.

Domestic waterborne navigation includes emissions from passenger and freight transport within the Netherlands, including offshore operations and recreational craft. Fuel consumption for domestic waterborne navigation increased from 11.6 PJ in 1990 to 17.7 PJ in 2010, but has since decreased to 16.8 PJ in 2015. The increase in energy use up until 2010 can partially be attributed to an increase in fuel consumption for offshore operations, which increased from 2.4 PJ in 2000 to 7.3 PJ in 2010 and has since decreased to 5.6 PJ in 2015, according to the National Energy Balance.

In line with the increase in fuel consumption, GHG emissions from domestic waterborne navigation increased from 0.9 Tg CO_2-eq. in 1990 to 1.3 Tg in 2010 and has since stayed roughly constant on this level.

Other transportation (1A3e)
As of this year, the CO_2 and N_2O emissions at natural gas compressor stations have been reallocated from 1A1cii to 1A3e: pipeline transport.

This is a minor source which accounted for 1.2% of total transport GHG emission in 1990 and only 0.3% in 2015.

Key sources
CO_2 emissions from gasoline, diesel and LPG use in road transport are assessed separately in the key source analysis. CO_2 emissions from gasolineand diesel are key sources in the Tier 1 level and trend assessment, while LPG is a key source of CO_2 only in the trend assessment. CO_2 emissions from gasolineand diesel use in road transport are also key sources in the Tier 2 level assessment and diesel and LPG are key sources in the Tier 2 trend assessment. CO_2 emissions from gaseous fuels are a key source in the Tier 1 level and trend analysis. N_2O and CH_4 emissions from road transport are not a key source in the inventory.
CO_2 emissions from domestic waterborne navigation are a key source in the Tier 1 level and trend assessment. CO_2 emissions from civil aviation and railways are not a key source. The same holds for the (combined) N_2O and CH_4 emissions from waterborne navigation, railways and civil aviation.

3.2.6.2 Methodological issues

This section gives a description of the methodologies and data sources used to calculate GHG emissions from transport in the Netherlands.

Civil aviation (1A3a)
GHG emissions resulting from the use of aviation gasoline and kerosene for domestic civil aviation in the Netherlands are estimated using a Tier 1 methodology. Fuel deliveries for domestic and international aviation are derived from the Energy Balance. This includes deliveries of both jet kerosene and aviation gasoline. The heating values and CO_2 EFs for aviation gasoline and kerosene are derived from Zijlema (2017). Country-specific values are used for aviation gasoline, identical to those for gasoline use for road transport, whereas for jet kerosene default values are used from the 2006 IPCC Guidelines. For N_2O and CH_4 default EFs are used as well (Table 3.8). Since domestic civil aviation is not a key source in the inventory, the use of a Tier 1 methodology is deemed sufficient.

Emissions of precursor gases (NOx, CO, NMVOC and SO2), reported in the CRF under domestic aviation, are the uncorrected emissions values from the Netherlands PRTR and refer to aircraft emissions during landing and take-off (LTO) cycles at all Dutch airports.No attempt has been made to estimate non-GHG emissions specifically related to domestic flights (including cruise emissions of these flights), since these emissions are negligible.

Table 3.8 Emission factors for Civil aviation, Railways and Waterborne navigation.

Source Category		Fuel type	MJ/kg	g CO_2/MJ	mg N_2O/MJ	mg CH_4/MJ
1A3a	Civil aviation	AVGAS	44.0	72.0	2.0	0.5
1A3a	Civil aviation	Jet kerosene	43.5	71.5	2.0	0.5
1A3c	Railways	Diesel	42.7	74.3	0.56	4.26

1A3d	Waterborne navigation	Diesel	42.7	74.3	2.0	7.0
1A3d	Waterborne navigation	Gasoline	44.0	72.0	0.86	47.23
1A3e	Pipeline transport	Natural gas	31.7	57.2	0.09	NO

Road transport (1A3b)
According to the 2006 IPCC Guidelines, greenhouse gas emissions from road transport should be attributed to the country where the fuel is sold. Total fuel consumption by road transport therefore should reflect the amount of fuel sold within the country's territory. To comply with this, the activity data for calculating greenhouse gas emissions from road transport are derived from the Energy Balance. This includes fuel sales of gasoline, diesel, Liquefied Petroleum Gas (LPG), natural gas (CNG) and biofuels. Gasoline sales to road transport from the Energy Balance are adjusted for the use of gasoline in recreational craft and in non-road mobile machines used by households, which is not reported separately in the Energy Balance but instead is included in road transport. In the same manner, LPG sales to road transport from the Energy Balance are adjusted for the use of LPG by non-road mobile machinery, which is also not reported separately in the Energy Balance. Klein et al. (2017) provides an overview of the corrections made to the Energy Balance in order to derive activity data for calculating GHG emissions from road (and other) transport.

Fuel sales data for road transport in the Energy Balance are not divided according to vehicle categories. For emission reporting, total sales per fuel type are disaggregated to the various road transport subcategories (e.g. passenger cars, light duty trucks) in accordance with their share in total fuel consumed in the Netherlands, as calculated bottom-up using vehicle kilometres travelled per vehicle type and the specific fuel consumption per vehicle kilometre. This bottom-up calculation of fuel consumption by road transport in the Netherlands is described in detail in Klein et al. (2017). The resulting fuel consumption figures differ from fuel sales data due to varying reasons:

- Stockpiling is included in fuel sales data;
- Both approaches (fuel consumption and fuel sales) contain statistical inaccuracies;
- Cross-border refuelling. This concerns fuel purchased in the Netherlands (included in sales) that is used abroad (not included in consumption) or fuel purchased abroad (not included in sales) that is used in the Netherlands (included in consumption).

This results in annual differences between fuel sales per fuel type and fuel consumed as calculated bottom up. Due to the nature of the differences (such as cross-border refuelling and stockpiling), the difference between fuel used and fuel sold differs from year to year. In calculating greenhouse gas emissions from road transport, the fuel sales data are used to calculate total emissions, whereas the fuel consumption data is used to split sales per fuel type to the different vehicle categories included in the CRF. Since the N_2O and CH_4 EFs differ for the different vehicle types, the split of total fuel sales per fuel type does affect total

N_2O and CH_4 emissions. The share of both N_2O and CH_4 in total GHG emissions from road transport is very small though.

The CO_2 emissions from road transport are calculated using a Tier 2 methodology. Country-specific heating values and CO_2 emission factors were derived from the Netherlands' list of fuels (Zijlema, 2017), as shown in Table 3.9. These values were derived from the analysis of 50 fuel samples taken in 2004 in the Netherlands (Olivier, 2004). The country-specific EFs are slightly higher than the IPCC default EFs, as proposed in the 2006 IPCC Guidelines, but are within the uncertainty range.

Table 3.9 Heating values and CO_2 EFs for road transport

Fuel type	MJ/kg*	g CO_2/MJ*
Gasoline	44.0	72.0
Diesel	42.7	74.3
LPG	45.2	66.7
CNG	31.65**	56.5

*) Source: Zijlema, 2017
**) MJ/Nm^3 ae

N_2O and CH_4 emissions from road transport are dependant not only on the fuel type, but also on the combustion and emission control technology and the operating conditions of the vehicles. Emissions of N_2O and CH_4 from road transport therefore are calculated using a Tier 3 methodology, based on vehicle kilometres travelled on Dutch territory and technology-specific emission factors, expressed in grams per vehicle kilometre travelled. In this bottom-up approach, vehicle types are distinguished according to:

- Vehicle type, e.g. passenger cars, light-duty trucks, heavy-duty trucks and buses;
- Fuel type, e.g. gasoline, diesel, LPG and natural gas;
- Emission control technology, as a function of the different Euro standards per fuel type for pollutant emissions;
- Operating conditions, using different emission factors for urban driving, rural driving and highway driving and the degree of congestion per road type.

The activity data used for the bottom-up approach is derived from Statistics Netherlands and is described in detail in Klein et al. (2017).

N_2O is primarily emitted by gasoline and LPG powered vehicles equipped with three-way catalysts. Most emissions result from the cold start, when the catalyst is not yet warmed-up. The country-specific emissions factors for N_2O are derived from Kuiper & Hensema (2012). For older vehicle types, emission factors are derived from national emission measurement programmes (Gense and Vermeulen, 2002 & Riemersma et al., 2003). For recent generations of road vehicles with new emission reduction technologies, emission factors are derived from the 2013 EEA Emission Inventory Guidebook. The N_2O emission factors per vehicle type and road type are provided in Klein et al. (2017).

CH_4 emissions from road transport are derived from total VOC emissions using VOC species profiles. VOC EFs for different vehicle types are for the most part derived from the VERSIT+ emission model. The VERSIT+ model and resulting EFs are described in Klein et al. (2017). The mass fraction of CH_4 in total VOC emissions is dependent on the fuel type, vehicle type and – for gasoline vehicles – whether or not the vehicle is equipped with a three-way catalyst. Gasoline-fuelled vehicles equipped with a catalyst emit more CH_4 per unit of VOC than vehicles without a catalyst. In absolute terms, however, passenger cars with catalysts emit far less CH_4 per vehicle kilometre than passenger cars without a catalyst because total VOC emissions are far lower. The country-specific VOC species profiles used to derive CH_4 emissions from total VOC emissions are derived from Broeke and Hulskotte (2009) and are presented in Klein et al. (2017).

To make sure CH_4 and N_2O emissions from road transport are consistent with fuel sales data, the bottom-up approach described above is used to calculate fleet average CH_4 and N_2O EFs per unit of fuel used. These EFs are consequently combined with the fuel sales data from the Energy Balance to calculate total CH_4 and N_2O emissions from road transport.

Emissions resulting from the use of biofuels in road transport are reported separately in the CRF. These CO_2 emissions are reported as a memo item and are not part of the national emission totals. CH_4 and N_2O emissions from biofuels are included in the national emission totals. The emission calculation for biofuels is comparable to that for fossil fuels and is based on sales data for biodiesel and ethanol, derived from the Energy Balance. Emissions of CH_4 and N_2O from biodiesel and ethanol are calculated using the same emission factors as used for fossil diesel and gasoline, respectively.

CO_2 emissions from use of lubricants in mopeds and motorcycles are included under source category 1A3b iv. This is desbribed in Section 3.2.6.5.

Emissions of all other compounds, including ozone precursors and SO_2, which more directly affect air quality, are calculated bottom-up using data on vehicle-kilometres travelled.

CO_2 emissions from urea-based catalysts
CO_2 emissions from urea-based catalysts are estimated using a Tier 3 methodology using country-specific EFs for different vehicle types. Selective Catalytic Reduction (SCR) technology has been applied in diesel-fuelled heavy-duty vehicles since 2005 for reduction of NO_x. To estimate the CO_2 emissions from urea-based catalysts, TNO estimated road type specific CO_2 emission factors from the use of urea-additives. The resulting emission factors are presented in Klein et al. (2017). The use of urea-additive (AdBlue) was estimated as a percentage of diesel fuel consumption of 6% for Euro V engines and 3% for Euro VI engines. Urea-additive CO_2 emissions are calculated to be 0.6% or less of diesel fuel CO_2 emissions for Euro V engines and 0.3% or less for Euro VI engines. The methodology is described in detail in Stelwagen & Ligterink (2014). The emissions from urea-based catalysts are reported in CRF

category 2D3 (Non-energy products from fuels and solvent use, other) and amounted to 21.6 Gg in 2015.

Figure 3.11 shows the implied N_2O and CH_4 emission factors (IEFs) for gasoline, diesel and LPG for road transport. The CH_4 EFs have decreased steadily for all fuel types throughout the time series due to the EU emissions legislation for HC. The N_2O EFs for gasoline and LPG increased between 1990 and 1995 due to the increasing number of catalyst-equipped passenger cars in the car fleet, but have since decreased steadily. The IEF for diesel has increased in recent years, mainly due to the increasing number of heavy-duty trucks and buses equipped with an SCR catalyst.

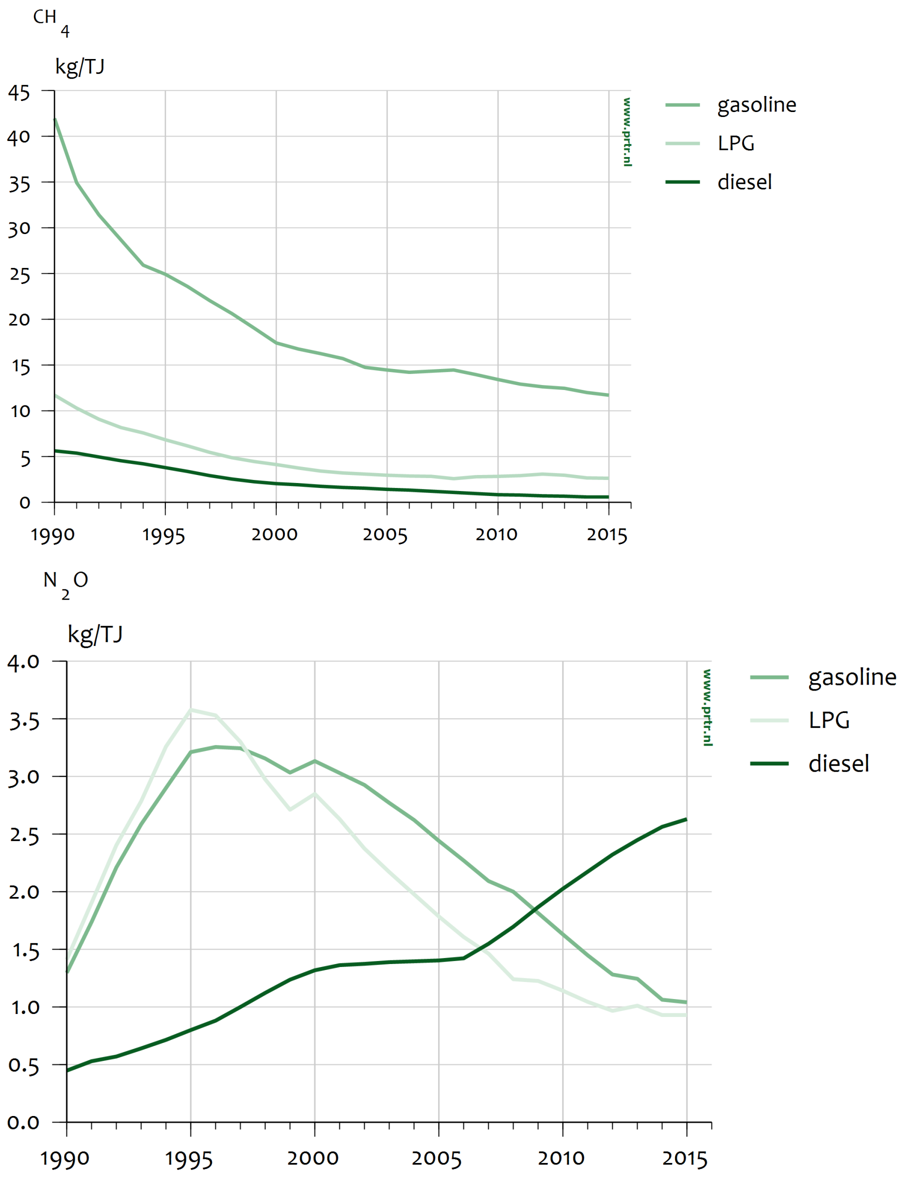


Figure 3.11: IEFs per fuel type for CH_4 and N_2O emissions by road transport, 1990-2015.

Railways (1A3c)
Fuel deliveries to railways in the Netherlands are derived from the Energy Balance. Since 2010, Statistics Netherlands has derived these data from Vivens, a recently founded co-operation of rail transport companies that purchases diesel fuel for the entire railway sector in the Netherlands. Before 2010, diesel fuel deliveries to the railway sector were obtained from Dutch Railways (NS), which was responsible for the purchase of diesel fuel for the entire railway sector in the Netherlands until 2009.

CO_2 emissions from railways are calculated using a Tier 2 methodology, using country-specific CO_2 EFs (Zijlema, 2017). Due to a lack of country-specific CH_4 and N_2O EFs for railways, CH_4 and N_2O emissions are estimated using a Tier 1 methodology, employing EFs derived from the 2016 EEA Emission Inventory Guidebook (EEA, 2016). The Guidebook provides EFs for N_2O (24 g/tonne fuel) and CH_4 (182 g/tonne fuel). The resulting EFs per MJ for railways are shown in Table 3.9. The default CH_4 and N_2O EFs for Railways included in the 2006 IPCC Guidelines are derived from the 2005 EEA Emission Inventory Guidebook. Since there are no country-specific CH_4 and N_2O EFs available, the Guidebook presents the best EFs for CH_4 and N_2O emissions in the EU. As such, the 2016 version of the Guidebook is applied instead of the 2005 version which is refered to in the 2006 IPCC Guidelines. Emissions from railways are not a key source in the inventory, so the use of Tier 1 and Tier 2 methodologies is deemed sufficient.

Waterborne navigation (1A3d)
Diesel fuel consumption for domestic inland navigation is derived from the Energy Balance. Gasoline consumption for recreational craft is not reported separately in the Energy Balance, but is included under Road transport. In order to calculate GHG emissions from gasoline consumption by recreational craft, fuel consumption is estimated annually using a bottom-up approach derived from Waterdienst (2005). Gasoline sales data for road transport, as derived from the Energy Balance, are corrected accordingly (as described above).

A Tier 2 methodology is used to calculate CO_2 emissions from domestic waterborne navigation, using country-specific CO_2 EFs as shown in Table 3.9. CH_4 and N_2O emissions from domestic waterborne navigation are derived using a Tier 1 method based on default IPCC EFs for diesel fuel and default EFs from the 2016 EEA Emission Inventory Guidebook (EEA, 2016) for gasoline. Neither the 2006 IPCC Guidelines nor the EEA Emission Inventory Guidebook provides specific N_2O and CH_4 EFs for inland shipping. The Tier 1 default CH_4 and N_2O EFs from the 2006 IPCC Guidelines actually apply to diesel engines using heavy fuel oil, but since no EFs are provided for diesel oil, these EFs are used in the inventory for diesel oil as well. N_2O and CH_4 EFs for gasoline use by recreational craft are not provided in either the Emission Inventory Guidebook or the IPCC Guidelines. EFs are therefore derived from gasoline use in NRMM, as provided by the 2013 Emission Inventory Guidebook.

Other transportation (1A3e)
The methodology used for calculating emissions from other transportation is described in Section 3.3.

3.2.6.3 Uncertainties and time series consistency

The uncertainty in the activity data for civil aviation is estimated to be approximately ± 10% for both jet kerosene and aviation gasoline. Fuel sales for domestic aviation are monitored by Statistics Netherlands. The uncertainty in the EFs for both jet kerosene and aviation gasoline are estimated to be ± 4% for CO_2, -70%/+150% for N_2O and -57%/+100% for CH_4. The uncertainty estimates for the CH_4 and N_2O EFs are derived from the 2006 IPCC Guidelines, whereas the uncertainty estimates for the CO_2 EFs are based on expert judgement.

The uncertainty in activity data for road transport (fuel sales) is estimated to be ± 2% for gasoline and diesel, ± 5% for LPG and ± 10% for natural gas. These estimates are derived from Statistics Netherlands. The uncertainty in the CO_2 EFs for gasoline, diesel, LPG and natural gas is estimated to be ± 2%. For gasoline and diesel fuel, the uncertainty in the CO_2 EFs was previously calculated to be ± 0.2% and ± 0.4%, respectively, based on the analysis of 50 samples of gasoline and diesel fuel from gasoline stations in the Netherlands in 2004 (Olivier, 2004). There are, however, indications that the carbon content of gasoline and diesel fuel used for road transport is changing due to factors such as the tightening of European fuel quality standards. Since no recent measurements have been performed, the uncertainty is thought to have increased and is currently estimated to be ± 2% for all fuel types. This estimate is based on expert judgement, taking into account the uncertainty range for the CO_2 EFs from road fuels in the 2006 IPCC Guidelines. Based on these estimates, total uncertainty in annual CO_2 emissions from road transport is estimated to be approximately ± 3%.

The uncertainty in total VOC emissions from road transport is estimated to be ± 30%. The uncertainty concerning the share of CH_4 in VOC emissions is estimated by Broeke and Hulskotte (2009) to be ± 40% for gasoline and ± 25% for diesel. Combined with the uncertainties in fuel sales and the share of both fuel types in total CH_4 emissions from road transport, the uncertainty of total CH_4 emissions from road transport is estimated to be ± 50%.
The uncertainty in annual N_2O emissions from road transport is estimated to be ± 50% as well. Recent measurements of N_2O are scarce; therefore, the current N_2O EFs are rather uncertain (estimated at ± 50%).

The uncertainty in the activity data for railways is estimated to be ± 1%, whereas the uncertainty in the activity data for waterborne navigation is estimated to be ± 5%. Both estimates are derived from Statistics Netherlands. The uncertainty in the activity data for waterborne navigation is higher because fuel consumption for recreational craft is not reported separately in the Energy Balance and therefore has to be estimated using a bottom-up approach. Fuel consumption for inland shipping and for railways is derived directly from the Energy Balance.

The uncertainty in CO_2 EFs for both railways and waterborne navigation is estimated to be ± 2% (in line with the uncertainty in the CO_2 EF for diesel in road transport). Uncertainty estimates for the N_2O and CH_4 EFs for both railways and waterborne navigation are derived from the 2006 IPCC Guidelines. For railways, uncertainty is estimated to be -50%/+300% for N_2O EFs and -40%/+251% for CH_4 EFs. For waterborne navigation, uncertainty is estimated to be -40%/+140% for N_2O EFs and -50%/+50% for CH_4 EFs.

3.2.6.4 Category-specific QA/QC and verification

The CO_2 emissions from transport are based on fuel sold. To check the quality of the emissions totals, CO_2 emissions from road transport are also calculated using a bottom-up approach based on vehicle-kilometres travelled and specific fuel consumption per vehicle-kilometre for different vehicle types. A comparison between the fuel sales data and the bottom-up calculation of fuel consumption gives an indication of the validity of the (trends in the) fuel sales data. Figure 3.12 shows both the time series for fuel sold and fuel used for gasoline (including bio ethanol), diesel (including biodiesel) and LPG in road transport.

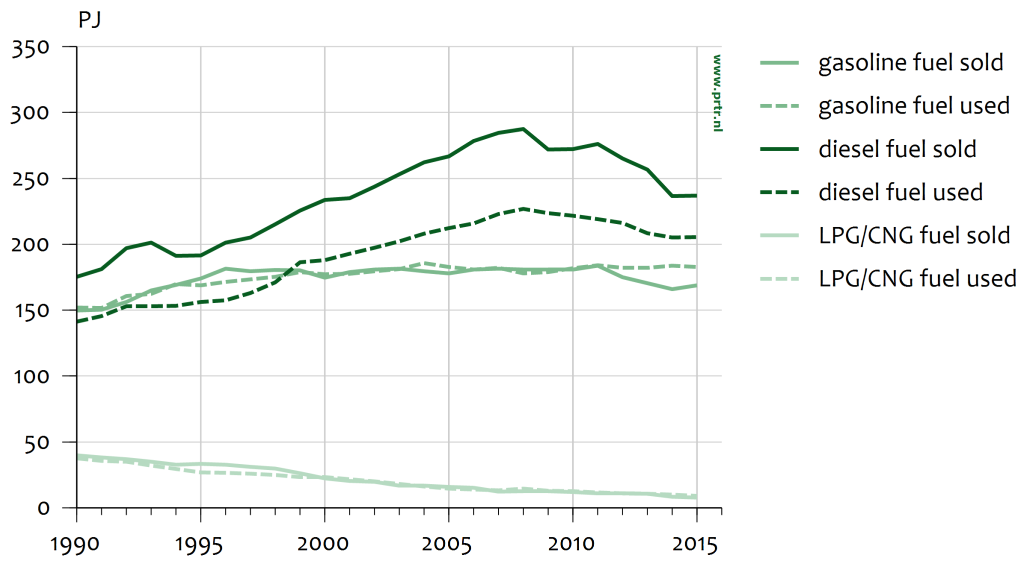


Figure 3.12: Fuel sold and fuel used for road transport in the Netherlands, 1990-2015.

The bottom-up calculation of gasoline consumption in road transport closely corresponds with the (adjusted) sales data from the Energy Balance; differences between the figures are small throughout the time series. The same holds for LPG sales and consumption, as can be seen in Figure 3.12. The time series for diesel differ, however. Although the trend is comparable for the most part, diesel sales are substantially higher than diesel consumption on Dutch territory throughout the time series. Differences vary between 13% and 26%, the difference growing larger until 2008 and becoming smaller again in recent years.

The difference between the two time series for diesel can partly be explained by the use of diesel in long-haul distribution trucks, which can travel several thousand kilometres on a full tank. Diesel fuel sold to long-haul trucks in the Netherlands can for the most part be consumed abroad and is therefore not included in the diesel consumption on Dutch territory. Although this omission is partially offset by the consumption by trucks that travel in the Netherlands but do not refuel here, it is expected that the impact of Dutch long-haul trucks refuelling in the Netherlands is dominant.

In order to validate the activity data for railways and water-borne navigation, as derived from the Energy Balance, the trends in fuel sales data for both source categories are compared with trends in transport volumes. Trends in energy use for waterborne navigation show rather close correspondence with trends in transport volumes, although this does not necessarily hold true for trends in domestic inland navigation. This would suggest that the growth in transport volumes mostly relates to international transport.

For railways, the correspondence between diesel deliveries and freight transport volumes is weak. This can be explained by the electrification of rail freight transport, as described above. In recent years, more electric locomotives have been used for rail freight transport in the Netherlands. Figures compiled by Rail Cargo (2007 & 2013) show that in 2007 only 10% of all locomotives used in the Netherlands was electric, whereas by 2012 the proportion of electric locomotives had increased to over 40%. For this reason, there has been a decoupling of transport volumes and diesel deliveries in recent years in the time series. Consequently, the decline in diesel consumption for railways, as derived from the Energy Balance, is deemed plausible.

In 2013, CE Delft conducted a sample check on the GHG emissions from transport as reported in the NIR 2013. They concluded that the reporting of underlying figures and assumptions was generally satisfactory. CE Delft (2014) was able to reproduce the reported emissions of N_2O and CO_2 from road transport using the NIR and the underlying methodology report (Klein et al., 2017). It did, however, recommend the improvement of consistency in reporting between the NIR and the methodology report, as well as the re-evaluation of the reported Tiers for estimating the emissions from the different source categories. In accordance with these recommendations, the descriptions in the transport methodology report were updated to ensure consistency and the Tiers for civil aviation and inland navigation were adjusted in the 2014 inventory report.

3.2.6.5 Category-specific recalculations

There have been several recalculations for GHG emissions by transport in the current inventory, most of them being minor adjustments.

Activity data for Waterborne Navigation

In this year’s inventory emissions from Waterborne Navigation (1A3d) have been recalculated using adjusted activity data derived from the revised Energy Balance from Statistics Netherlands. More specifically, the activity data for offshore work has been adjusted upwards for the entire 1990-2014 time series. For earlier years of the time series, the activity data and resulting GHG emissions have been adjusted upwards by approximately 12-15%. In more recent years, the adjustment is smaller, as is shown in Figure 3.13. Since emissions factors have remained unchanged, the GHG emissions have been adjusted accordingly.

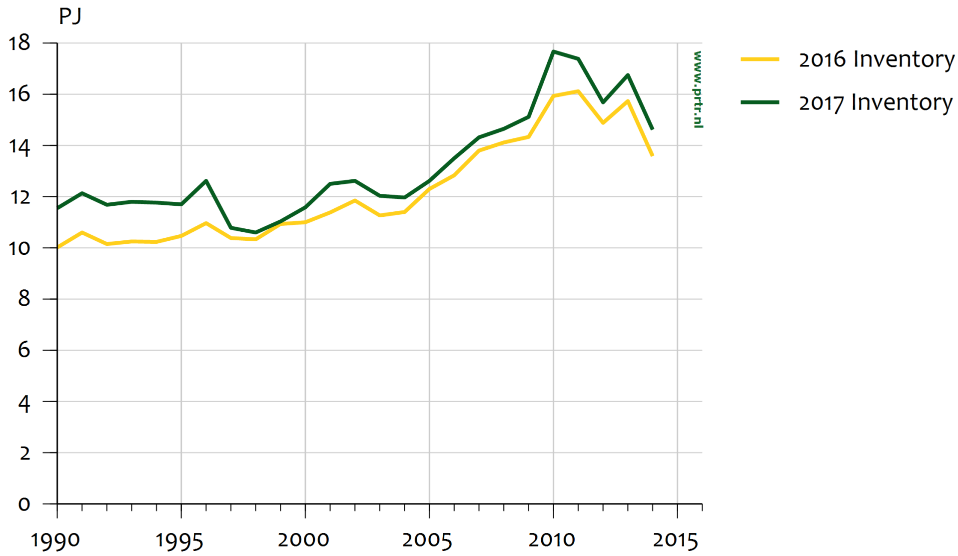


Figure 3.13: Revision of activity data for domestic waterborne navigation (1A3d), 1990-2014.

Lubricant use by two-stroke engines
CO_2 emissions from lubricant use in two-stroke engines in mopeds and motorcycles have been included under 1A3b iv in this year's inventory. There is no data available on the amount of two-stroke passenger cars in the Netherlands, but it is expected to be very small (much smaller than the amount of two-stroke motorcycles). Therefore, only the amount of lubricants used in two-stroke motorcycles and mopeds was estimated. The use of lubricants was estimated assuming that 1 kg of lubricants is used per 50 kg of gasoline (assumption provided by TNO). The emissions are calculated with an oxidation factor of 100%. The resulting CO_2 emissions from use of lubricants in 2-stroke motorcycles and mopeds is very small and amounts to 4 Gg in 1990, decreasing to 1.7 Gg in 2015. This decline can be attributed to the steady decrease of the number of two-stroke motorcycles and mopeds.
The remaining amount of lubricants used in transport is reported in CRF 2D1. This is calculated as the difference between the total amount of lubricants used (derived from the Energy Balance) and the estimated amount of lubricants used in motorcycles and mopeds.

Other recalculations
The emissions of the non-GHG pollutants are now based on all civil airfields in the Netherlands. In previous years only the LTO emissions for Amsterdam Airport Schiphol were reported. It should be noted though that Schiphol is by far the largest airport in the Netherlands so differences are only minor.

There have also been minor recalculations in the activity data for buses and light duty vehicles, and in the activity data for heavy duty vehicles (expecially 2014). Furthermore, there have been updates to the GHG emission factors for buses for the years 2013 and 2014, and for light duty vehicles in 2011.

Finally, the CO_2 and N_2O emissions at natural gas compressor stations have been reallocated from 1A1cii to 1A3ei: pipeline transport.

In total, GHG emissions from transport (1A3) have been adjusted upwards by 0.7-1.8% (231-499 Gg) throughout the time series in the current inventory, most of which results from adding the GHG emissions from natural gas compressor stations to source category 1A3e. Without this reallocation, GHG emissions by transport have been adjusted upwards by 0.1-0.5% (22-145 Gg) compared to last year's inventory.

3.2.6.6 Category-specific planned improvements

The Netherlands plans to further investigate the heating value and carbon content of the motor fuels used in road transport, in order to improve the CO_2 EFs for these fuels. This research will be completed in 2017. Results will be reported in the 2018 inventory report.

3.2.7 Other sectors (1A4)

3.2.7.1 Source category description

Source category 1A4 (other sectors) comprises the following sub-categories:

- 1A4a (commercial and institutional services): This category comprises commercial and public services such as banks, schools and hospitals, and services related to trade (including retail) and communications; it also includes emissions from the production of drinking water and miscellaneous combustion emissions from waste handling activities and from wastewater treatment plants (WWTP)) and emissions from non-road mobile machinery used in trade.
- 1A4b (residential): This category relates to fuel consumption by households for space heating, water heating and cooking. Space heating uses about three-quarters of the total consumption of natural gas. It also includes emissions from non-road mobile machinery used by households.
- 1A4c (agriculture, forestry and fisheries): This category comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding and forestry. It also includes emissions from agricultural non-road mobile machinery (1A4cii) and from fishing (1a4ciii).

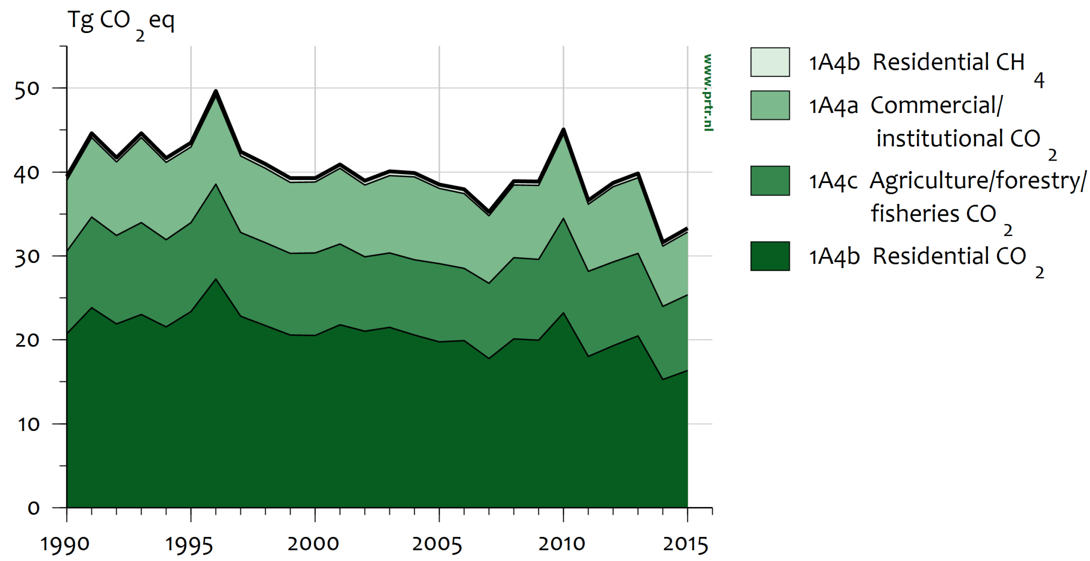


Figure 3.14 1A4 (other sectors): trend and emissions levels of source categories, 1990–2015.

Commercial and institutional services (1A4a)
CO_2 emissions in the commercial and institutional services (1A4a) category have decreased since 1990. The interannual variations are mainly caused by temperature. More natural gas is used during cold winters (e.g. 1996 and 2010).

Energy use by non-road mobile machinery used in trade increased from 3.3 PJ in 1990 to 5.5 PJ in 2015, with CO_2 emissions increasing accordingly. Energy use consists mostly of diesel fuel, although some gasoline is also used and in recent years biofuels have also been applied.

Residential (1A4b)
When corrected for the interannual variation in temperature, the trend in total CO_2 (i.e. in gas consumption) becomes quite steady, with interannual variations of less than 5%. The variations are much larger for liquid and solid fuels because of the much smaller figures. Biomass consumption relates almost entirely to wood.

The IEF for CH_4 emissions from national gas combustion is the aggregate of the standard EF for gas combustion of 5.7 g/GJ plus the 35 g/GJ of total residential gas combustion that represents start-up losses, which occur mostly in cooking devices, but also in central heating and hot-water production devices.

In the residential category, CO_2 emissions have decreased since 1990. The structural anthropogenic trend, including a temperature correction, shows a significant decrease in this period. Although the number of households and residential dwellings has increased since 1990, the average fuel consumption per household has decreased more, mainly due to the improved insulation of dwellings and the increased use of high-efficiency boilers for central heating.

Energy use by non-road mobile machinery used by households increased from 0.5 PJ in 1990 to 1.0 PJ in 2015, with CO_2 emissions increasing accordingly. Energy use consists mostly of gasoline, although some biofuels are being used in recent years as well as it is assumed that gasoline is supplied by regular gas stations.

Agriculture, forestry and fisheries (1A4c)
Most of the energy in this source category is used for space heating and water heating; although some energy is used for cooling. The major fuel used in the category is natural gas. Almost no solid fuels are used in this category. Non-road mobile machinery used in agriculture mostly uses diesel oil, although some biofuel and gasoline is used as well. Fishing mostly uses diesel oil, combined with some residual fuel oil.

Total CO_2 emissions in the agriculture, forestry and fisheries category have decreased since 1990, mainly due to a decrease in gas consumption for stationary combustion as a result of various energy conservation measures (e.g. in greenhouse horticulture; the surface area of heated greenhouses has increased but their energy consumption has been reduced). It should be noted that part of the CO_2 emissions from the agricultural sector consists of emissions from cogeneration facilities, which may also provide electricity to the national grid. It should also be noted that the increased use of internal combustion engines in CHP plants operating on natural gas has increased the IEF for methane in this category, as these engines are characterized by high methane emissions.

In addition, since the autumn of 2005, CO_2 emissions from two plants have begun to be used for crop fertilization in greenhouse horticulture, thereby reducing the net CO_2 emissions generated by CHP facilities. Total annual amounts are approximately 0.4 Tg CO_2.

GHG emissions from agricultural non-road mobile machinery (1A4cii) have been constant throughout the time series between 1.1 and 1.2 Tg CO_2 eq.

GHG emissions from fisheries have shown a decreasing trend since the year 2000, decreasing from 1.3 Tg in 2000 to 0.6 Tg in 2015. This has been caused by a decrease in the number of ships in the Netherlands: since 1990 the number of fishing vessels in the Netherlands has decreased, as has the engine power of these ships. Because of the smaller fleet, energy use and related emissions have decreased significantly throughout the time series.

3.2.7.2 Methodological issues

In this category gaseous fossil fuels are key sources of CO_2 emissions (in particular, gaseous fossil fuels, which account for about 95% of the source category 1A4). Emissions from the combustion of gases in the categories 1A4a, 1A4b and 1A4c are identified as key sources. IPCC methodologies (Tier 2 method for CO_2 and CH_4, Tier 1 for N_2O) are used to calculate GHG emissions from stationary combustion in this category. The emissions from this source category are estimated by multiplying fuel-use statistics by IPCC default and country-specific EFs (Tier 1 and Tier 2 method for CO_2 and CH_4 and Tier 1 method for N_2O).

The activity data for the residential category (1A4b) and from stationary combustion in agriculture (1A4c–i) is compiled using data from separate surveys for these categories. However, due to the late availability of the statistics on agricultural fuel use, preliminary data is often used for the most recent year in national energy statistics. Also, trends in agricultural fuel consumption are estimated using indicators that take no account of varying heating demand due to changes in heating degree days.

For CO_2, IPCC default EFs are used (see Annex 5), with the exception of CO_2 for natural gas, gas/diesel oil, LPG and gaseous biomass, for which country-specific EFs are used. In the Netherlands' list of fuels (Zijlema, 2017), it is indicated whether the EFs are country-specific or IPCC default values. For CH_4, country-specific EFs are used, with the exception of CH_4 for solid biomass and charcoal and CH_4 for diesel use in the fisheries sector. For the use of natural gas in gas engines, a different EF is used (see ENINA, 2017). The CH_4 country-specific EF for residential gas combustion includes start-up losses, a factor mostly neglected by other countries. For N_2O, IPCC default EFs are used.

Emissions from off-road machinery and fisheries (1A4c–ii and 1A4c-iii) are calculated on the basis of IPCC Tier 2 methodologies. The fuel-use data is combined with country-specific EFs for CO_2 and IPCC default EFs for N_2O and CH_4. The consumption of diesel oil and heavy fuel oil by fisheries is derived from the Energy Balance.

Fuel consumption by off-road agricultural machinery is derived from the EMMA model (Hulskotte & Verbeek, 2009). This model is based on sales data for different types of mobile machinery and assumptions made about average use (hours per year) and fuel consumption (kilograms per hour) for different machine types. CO_2 emissions from NRMM are estimated using a Tier 2 methodology. Country-specific heating values and CO_2 emission factors are derived from the Netherlands' list of fuels (Zijlema, 2017). CH_4 and N_2O emissions from NRMM are estimated using a Tier 1 methodology, using emission factors derived from the 2013 EEA Emission Inventory Guidebook, as described in Klein et al. (2017).

In 2014, 99% of the CO_2 emissions in this category were calculated using country-specific EFs (mainly natural gas). The remaining 1% of CO_2 emissions were calculated with default IPCC EFs. These mainly consist of residual fuel oil, other kerosene and lignite.

An overview of the EFs used for the most important fuels (up to 95% of the fuel use) in the other sectors (1A4) is provided in Table 3.10.

Table 3.10 Overview of EFs used (in 2015) in Other sectors (1A4).

Fuel	**Amount of fuel used in 2015 (TJ NCV)**	**Implied emission factors (g/GJ)**		
		CO_2 (x 1000)	**N_2O**	**CH_4**
Natural gas	537,962	56.5	0.1	94.5
Gas / Diesel oil	28,005	74.3	2.9	2.7
Biogas	8,417	84.2	0.1	5.0
Other	10,726	NA	NA	NA

Explanations for the IEFs:

- The standard CH_4 EF for natural gas is 5.7 g/GJ. Only for gas engines is a higher EF used, which explains the higher EF for this sector.
- Gas / diesel oil is used in stationary and mobile combustion, for which different emission factor for CH_4 and N_2O are used.

More details on EFs, methodologies, data sources and country-specific source allocation issues are provided in the methodology report (ENINA 2017) (see http://english.rvo.nl/nie).

3.2.7.3 Uncertainties and time series consistency

It should be noted that the energy consumption data for the category 1A4 (other sectors) as a whole is much more accurate than the data for the sub-categories of 1A4. In particular, energy consumption in the services and agriculture categories (particularly in the latest year) is less closely monitored than it is in the residential sector. Trends in emissions and activity data for these categories should be treated with some caution when drawing conclusions. The uncertainty in total CO_2 emissions from this source category is approximately 7%, with an uncertainty concerning the composite parts of approximately 5% for the residential category, 10% for the 'agriculture' category and 10% for the services category (see Section 1.6 and Annex 2 for more details).

The uncertainty in gas consumption data is similarly estimated at 5% for the residential category, 10% for agriculture and 10% for the services category. An uncertainty of 20% is assumed for liquid fuel use for the services category. Since the uncertainty in small figures in national statistics is generally larger than it is with large numbers, as indicated by the high interannual variability of the data, the uncertainty in solid fuel consumption is estimated to be even higher, i.e. at 50%. However, the uncertainty in the fuel statistics for the total of other sectors is somewhat smaller than the uncertainty in the data for the underlying sub-sectors: consumption per fuel type is defined as the remainder of total national supply after subtraction of the amount used in Energy, Industry and Transport. Subsequently, energy consumption by the residential and agricultural categories is estimated separately using a trend analysis of sectoral data ('HOME' survey of the residential category and LEI data for agriculture).

For natural gas, the uncertainty in the CO_2 EF is estimated at 0.25%, on the basis of the fuel quality analysis reported by Heslinga and Van Harmelen (2006) and further discussed in Olivier et al. (2009). For the CO_2 EFs for liquids and solids, uncertainties of 2% and 10%, respectively, have been assigned. The uncertainty in the CH_4 and N_2O EFs is estimated to be much higher (about 50%).

Since most of the fuel consumption in this source category is for space heating, consumption has varied considerably across the years due to variations in winter temperatures. For trend analysis, a method is used to correct the CO_2 emissions from gas combustion (the main fuel for heating purposes) for the varying winter temperatures. This involves the use of the number of heating degree days under normal climate conditions, which is determined by the long-term trend, as explained in Visser (2005).

3.2.7.4 Category-specific QA/QC and verification

The trends in CO_2 emissions from the three sub-categories were compared with trends in related activity data: number of households, number of people employed in the services sector and the area of heated greenhouses. Large annual changes were identified and explanations were sought (e.g. interannual changes in CO_2 emissions by calculating temperature-corrected trends to identify the anthropogenic emissions trends). The trend tables for the IEFs were then used to identify large changes and large interannual variations at the category level, for which explanations were sought and included in the NIR. More details on the validation of the energy data can be found in ENINA (2017).

3.2.7.5 Category-specific recalculations

Generator sets and mobile waterpumps at pumping stations have been newly added to the 1A4aiithe non-road mobile machinery categories. This additional speciation resulted in an improved reallocation of the fuel use and thus emissions over the different NRMM sectors. These machines are responsible for approximately 1.7 PJ additional fuel use in this category. The CO2 emissions have increased accordingly.

3.2.7.6 Category-specific planned improvements,

There are no source-specific recalculations envisaged.

3.2.8 Other (1A5)

3.2.8.1 Source category description

Source category 1A5 (Other) includes emissions from military aviation and navigation (in 1A5b). CO_2 emissions from this source category are approximately 0.2 Tg, with some interannual variation caused by different levels of operation. Emissions of CH_4 and N_2O are negligible.

3.2.8.2 Methodological issues

A country-specific top-down (Tier 2) method is used for calculating the emissions from fuel combustion from 1A5 (Other). The kerosene deliveries for military aircraft in the Netherlands are derived from the Energy Balance. This includes all fuel delivered for military aviation purposes within the Netherlands, including fuel deliveries to militaries of external countries. Deliveries of marine diesel oil for military purposes are not reported separately in the Energy Balance and therefore are derived directly from the Ministry of Defence. These deliveries include all fuel deliveries to the Dutch Navy within the Netherlands and abroad.

The emission factors used for calculating GHG emissions resulting from military aviation and water-borne navigation are presented in Table 3.11. The CO_2 emission factors are derived from the Ministry of Defence, whereas the emission factors for N_2O and CH_4 are derived from Hulskotte (2004a).

Table 3.11 Emission factors used for military marine and aviation activities.

Category		CO_2	CH_4	N_2O
Military ships	Emission factor (g/GJ)	75,250	2.64	1.87
Military aviation	Emission factor (g/GJ)	72,900	10.00	5.80
Total	Emissions in 2014 (Gg)	238.33	0.02	0.01

Source: Hulskotte, 2004

3.2.8.3 Uncertainties and time series consistency

The uncertainty in total CO_2 emissions from this source category is approximately 20% mainly determined by the uncertainty in the activity data.

3.2.8.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1.

3.2.8.5 Category-specific recalculations

No recalculations have been made.

3.2.8.6 Category-specific planned improvements

No source-specific improvements are planned.

3.3 Fugitive emissions from fuels (1B)

This source category includes fuel-related emissions from non-combustion activities in the energy production and transformation industries:

- 1B1 Solid fuels (coke manufacture);
- 1B2 Oil and gas (production, gas processing, hydrogen plant, refineries, transport, distribution).

The contribution of emissions from source category 1B to the total national GHG emissions inventory was 1.4% in 1990 and 1.3% in 2015. Table 3.1 shows that total GHG emissions in 1B decreased from 3.1 Tg CO_2 eq to 2.4 Tg CO_2 eq between 1990 and 2015.

3.3.1 Solid fuels (1B1)

3.3.1.1 Source category description

Fugitive emissions of CH_4 from this category refer to coke manufacture. The Netherlands currently has only one coke production facility at the iron and steel plant of Tata Steel. A second independent coke producer in Sluiskil discontinued its activities in 1999. In the past, another emission source in this category was the production of charcoal. Until 2009, the Netherlands had one large production location of charcoal that served most of the Netherlands and also occupied a large share of the market of neighbouring countries. The production at this location stopped in 2010.

3.3.1.2 Methodological issues

The sharp decrease in the time serie for the CH_4 emission can be addressed to the production of charcoal. The following emission factors have been used:1990-1997: 0.03 kg CH_4/kg charcoal (IPCC Guidelines) and 1998-2010: 0.0000111 kg CH_4/kg charcoal (Reumermann,P.J. , Frederiks, B., proceedings 12th European conference on Biomass for

Energy, Industry and Climate protection , Amsterdam, 2002). This sharp decrease in EF is implemented because the operator changed from a traditional production system to the Twin retort system (Charcoal production with reduced emissions). After the production of charcoal stopped the remaining emissions in this category are solely the fugitive emissions of the coke production. To calculate the emission of CH4 from coke production the standard IPCC value of 0,5 kg CH_4 per ton coke is used.
CO_2 emissions related to transformation losses (1B1) from coke ovens are only a small part of the total emissions from the iron and steel industry in the Netherlands. Emissions totals for the iron and steel industry and the CRF category that are reported in can be found in Section 3.2.5. The figures for emissions from transformation losses are based on national energy statistics of coal inputs and of coke and coke oven gas produced and a carbon balance of the losses. The completeness of the accounting for coke oven gas produced, in energy statistics, is not an issue, since any non-captured gas is by definition included in the net carbon loss calculation used for the process emissions. As a result of the 2011 in-country review, a mass balance for the year 2009 has been made available. For reasons of confidentiality, the mass balance for the iron and steel industry is not included in NIRs but can be made available for review purposes.

Detailed information on activity data and EFs can be found in the Methodology Report on the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste (ENINA, 2017).

3.3.1.3 Uncertainty and time series consistency

The uncertainty in annual CO_2 emissions from coke production (included in 1B1b) is estimated to be about 15%. This uncertainty relates to the precision with which the mass balance calculation of carbon losses in the conversion from coking coal to coke and coke oven gas can be made (for details, see Olivier et al., 2009).

The methodology used to estimate emissions from solid fuel transformation is consistent throughout the time series.

3.3.1.4 Source-specific QA/QC and verification

These source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1.

3.3.1.5 Source-specific recalculations

In the NIR 2015 CH_4 emissions from coke manufacture were allocated in 2.B.8.g (Petrochemical and carbon black production). This was not correct. In this submission emissions from coke manufacture were re-allocated from 2B8g to 1B1b. Due to the revision of the energy statistics the emissions in category changed compared to the previous submission.

3.3.1.6 Source-specific planned improvements

No source-specific improvements are planned.

3.3.2 Oil and natural gas (1B2) NIR2016

3.3.2.1 Source category description

The fugitive emissions from category 1B2 comprise:

- Emissions from oil and gas production, flaring and venting (CO_2, CH_4);
- Emissions from oil and gas transport (CO2, CH4);
- Emissions from gas distribution networks (pipelines for local transport) (CO_2, CH_4);
- Emissions from oil refining (CH_4);
- Emissions from hydrogen plants (CO_2).

Combustion emissions from exploration and production of oil and gas are reported under 1A1c. The combustion emissions of CO_2 and N_2O of gas transport are reported under 1A1ei gaseous. Fugitive CO_2 emissions from refineries are included in the combustion emissions reported in category 1A1b.

Since the 2007 submission, the process emissions of CO_2 from a hydrogen plant of a refinery (about 0.9 Tg CO_2 per year) were reported in this category (1B2a4). However, as refinery data specifying these fugitive CO_2 emissions was available from 2002 onwards (environmental reports from the plant), these emissions were re-allocated from 1A1b to 1B2a-iv from 2002 onwards. CH_4 from gas flaring/venting and fugitive CO_2 emissions from oil and gas operations are identified as key sources (see Table 3.1).

Gas production and gas transmission vary according to demand – in cold winters, more gas is produced. The gas distribution network is still gradually expanding as new estates are being built, mostly using PVC and PE, which are also used to replace cast iron pipelines (see also ENINA 2017). The IEF for gas distribution gradually decreases as the proportion of grey cast iron pipelines decreases due to their gradual replacement and the expansion of the network. Their present share of the total is less than 3.5%; in 1990 it was 10%.

The CO_2 and CH_4 emissions from oil and gas production, particularly for flaring and venting, have been reduced significantly starting in the nineties. This is due to the implementation of environmental measures to reduce venting and flaring as optimizing the use of gas that was formerly wasted for energy production purposes.

3.3.2.2 Methodological issues

Country-specific methods comparable to the IPCC Tier 3 method are used to estimate emissions of fugitive CH_4 and CO_2 emissions from Oil and gas production and processing (1B2). Each operator uses its own detailed installation data to calculate emissions and reports those emissions and fuel uses in aggregated form in its electronic AER (e-AER). Activity data for are taken from national energy statistics as a proxy and reported in the CRF tables. The data in the statistics can be adjusted retrospectively (changes in definitions/allocation) and these statistical changes will show up in the CRF tables.

The IPCC Tier 3 method for CH_4 emissions from Gas distribution due to leakages (1B2b5) is based on country-specific EFs calculated from leakage measurements. From 2004 onwards, the gas distribution sector annually recorded the number of leaks found per material and detailed information of pipeline length per material. For NIR 2016 the emissions from Gas distribution were evaluated and improved. In earlier submissions the IPCC Tier 3 method for methane (CH_4) emissions from Gas distribution due to leakages was based on two country-specific EFs: 610 m^3 methane per km of pipeline for grey cast iron, and 120 m^3 per km of pipeline for other materials. The EF's were based on the small base of seven measurements at one pressure level of leakage per hour for grey cast iron and 18 measurements at three pressure levels for other materials (PVC, steel, nodular cast iron and PE) and subsequently aggregated to factors for the pipeline material mix in 2004. As a result of a total of fourty additional leakage measurements an improved set of emission factors could be derived. Based on the (total of) 65 leakage measurements and the pipeline material mix in 2013 three new emission factors are calculated: 323 m^3 methane per km of pipeline for grey cast iron, 51 m^3 methane per km of pipeline for other materials with a pressure of <= 200 mbar and 75 m^3 methane per km of pipeline for other materials with a pressure of >200 mbar. Using these improved EF's led to a reduction of the emissions of methane for the whole time series 1990-2014.

Emissions of CO_2 and methane (CH_4) due to the transmission of natural gas (1B2b4) are taken from the V,G&M (safety, health and environment) part of the annual report of NV Nederlandse Gasunie. The emissions of CO_2 in the annual reports are considered combustion emissions and therefore reported under IPCC category 1A1c3ei gaseous. Additionally, to give a complete overview of emissions the amount of fugitive CO_2 emissions from gas transportation is calculated using the Tier 1 method with the new default IPCC EF of 8.8E-7 Gg per 106 m^3 of marketable gas, taken from the IPCC Guidelines 2006, chapter 4, table 4.2.4. This figure is added to CRF category 1B2b4 for the whole time series.

For NIR 2016 the emissions of methane from Gas transmission were evaluated and improved. As a result of the implementation of the LDAR (Leak Detection and Repair) programme of Gasunie new emission data of methane (CH_4) became available. Leakages at larger locations such as the thirteen compressorstations were all fully measured. Plus emissions of fugitive emissions of methane from each of those locations were added to the emissions the year after the facilities came into operation. The adjustments of the methane emissions for the smaller locations were based on the measurements of a sample of those locations and added for the whole time-series 1990-2014.

Fugitive emissions of methane from refineries in category 1B2a4 are based on a 4% share in total VOC emissions reported in the AERs of the refineries (Spakman et al., 2003) and for the most recent years have been directly reported in those AERs. These show significant annual fluctuations in CH_4 emissions, as the allocation of the emissions to either combustion or process has not been uniform over the years. For more information, see ENINA (2017). As the AERs account only for emissions, activity data for this category is taken from national energy statistics as a proxy and is reported in the CRF tables. The data in the statistics can be adjusted retrospectively (changes in definitions/allocation) and these will show up in the latest version of the CRF tables.

3.3.2.3 Uncertainty and time series consistency

The uncertainty in CO_2 emissions from gas flaring and venting is estimated to be about 50%, while the uncertainty in methane emissions from oil and gas production (venting) and gas transport and distribution (leakage) is estimated to be 50%.

The uncertainty in the EF of CO_2 from gas flaring and venting (1B2) is estimated at 2%. For flaring, this uncertainty takes the variability in the gas composition of the smaller gas fields into account. For venting,it accounts for the high CO_2 content of the natural gas produced at a few locations. This gas is processed and the remaining CO_2 is subsequently vented.

For CH_4 from fossil fuel production (gas venting) and distribution, the uncertainty in the EFs is estimated to be 25% and 50%, respectively. This uncertainty refers to the changes in reported venting emissions by the oil and gas production industry over the past years and to the limited number of actual leakage measurements for different types of materials and pressures, on which the Tier 3 methodology for methane emissions from gas distribution is based.
A consistent methodology is used to calculate emissions throughout the time series.

3.3.2.4 Source-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1.

3.3.2.5 Source-specific recalculations

The CO_2 emissions of CRF category 1.B.2.c.2.iii fugitive emissions from flaring are only a very small part of the total emissions of CO_2 eq from the Netherlands. In 2005, the reported flaring amount of 90,4 kton CO_2 was responsible for ca 0,042% of the total emissions of the Netherlands (214,4 Tg CO_2 eq exl. LULUCF). Changes in this very small amount are therefore considered below the threshold of significance. Nevertheless, we discovered during the ESD review that the preliminary values for flaring emissions in 2005 erroneuously were not replaced by the final emission values. In this submission the amount is therefore corrected from 90,43 to 91,72 kton CO_2. From this submission onwards, CO_2 and N_2O combustion emissions for gastransport are included in 1A3ei Pipeline transport gaseous fuels. CO_2 process emissions- and CH_4 emissions of gastransport can still be found in 1B2b4 Gas transmission and storage and CO_2 and CH_4 emissions from pipelines for oil are included in 1B2a3 Oil transport. This is consistent with the 2006 IPCC Guidelines.

3.3.2.6 Source-specific planned improvements

No specific improvements are planned although the ongoing LDAR (Leak Detection and Repair) programme of Gasunie will possibly provide new insights into the fugitive emissions of gas transmission.

4 Industrial processes and product use (CRF sector 2)

Major changes in the Industrial processes and product use sector compared with the National Inventory Report 2016

Emissions:	The total GHG emissions of the sector increased from 11.0 Tg CO_2 eq in 2014 to 11.5 Tg CO_2 eq in 2015.
Key sources:	CO_2 emissions from 2A4d is now a key source.
Methodologies:	The following changes have been made in this sector: • Due to minor changes in the production index series of chemicals the CO_2 emissions from Other uses of soda ash (2A4b) has been changed for the period 2003-2014. • In the NIR 2016 CO_2 emissions from Activated carbon production were allocated in 2.B.8. This was not correct. In this submission emissions from Activated carbon production were allocated in the correct source category (2.B.10). • In the NIR 2016 CH_4 emissions from coke manufacture were allocated in 2.B.8.g(Petrochemical and carbon black production). This was not correct. In this submission emissions from coke manufacture were re-allocated from 2B8g to 1B1b. • The CO_2 emissions from Lubricant use (2D1) have been changed for the years 1990-2014. The major part of this change is the result of of a review conducted by the European Commission. The remaining part of this change, is due to a reallocation of a small part from 2D1 to 1A3. • Also as a result of the review conducted by the European Commission the HFC emissions from Stationary refrigeration (2F1) have been recalculated for the period 1994-2014. • Because more detailed information of Mobile air-conditioning (2F1) became available, the HFC emissions have been changed for a number of years. • Due to a correction in the sale statistics of food aerosol cans the N2O emissions from 2G3 have been corrected for the years 2013 and 2014.

4.1 Overview of sector

Emissions of GHGs in this sector include the following:

- All non-energy-related emissions from industrial activities (including construction);
- All emissions from the use of F-gases (HFCs, PFCs (incl. NF_3) and SF_6), including their use in other sectors;
- N_2O emissions originating from the use of N_2O in anaesthesia and as a propelling agent in aerosol cans (e.g. cans of cream).

According to the Aarhus Convention, only emissions data must be made public. This means that unless a company authorizes publication, its production and energy data are confidential. In the case of the industrial sector, where many processes take place in only one or two companies, the taskforce ENINA has direct access to most of this confidential data. If reviewers sign a confidentiality clause, ENINA can provide it to them. The confidential information to which the taskforce ENINA has no direct access can be viewed by the taskforce ENINA and reviewers only at the companies' premises. This includes the following data:

- 2B2/2B4a: production levels and EFs;
- 2B9: HFC 23 load in the untreated flow; removal efficiency of Thermal Converter; production levels and EFs.

Because of transparency and consistency reasons the GHG emissions from fuel combustion in industrial activities and product use are all reported in the Energy sector and all non-energy-related emissions from industrial activities in the IPPU sector. GHG emissions from fuel combustion in industrial activities and product use are included in the Energy sector. Fugitive emissions of GHGs in the Energy sector (not relating to fuel combustion) are included in IPCC category 1B (Fugitive emissions). The main categories (2A–H) in the CRF sector 2 (Industrial processes and product use) are discussed in the following sections.

A description of the methodologies applied for estimating emissions of CO_2, CH_4, N_2O and F-gases from industrial processes and product use in the Netherlands can be found in the methodology report (ENINA, 2017).

Key sources

The key sources in this sector are presented in table 4.1. Annex 1 presents all sources identified in the Industrial processes and product use sector in the Netherlands.

Ammonia production (2B1) is a level and Tier 1 trend key source of CO_2 emissions, Iron and steel production (2C1) is a Tier 1 level and trend key source of CO_2 emissions. Other processes (2A4d) is a level Tier 2 level and trend key source of CO_2 emissions.

Nitric acid production (2B2) is trend key source of N_2O emissions, due to the reduction achieved in this category, and caprolactam production (2B4a) is a level key source of N_2O.

Aluminium production (2C3) is a Tier 1 trend key source for CO_2 and a trend key source of PFC emissions. Stationary refrigeration and Mobile air-conditioning (2F1) is a level and trend key source of HFC's and Fluorochemical production (2B9) is a trend key source of HFC's.

Other industrial processes and product use(2G3) is a Tier 2 trend key source for N_2O. Paraffin wax use (2D2) is a Tier 2 level and trend key source for CO_2. Petrochemical and carbon black production (2B8) is a Tier 2 level key source for CH_4 and a Tier 2 level and trend key source for CO_2.

Overview of shares and trends in emissions
Figure 4.1 and Table 4.1 show the trends in total GHG emissions from the Industrial processes and product use sector.

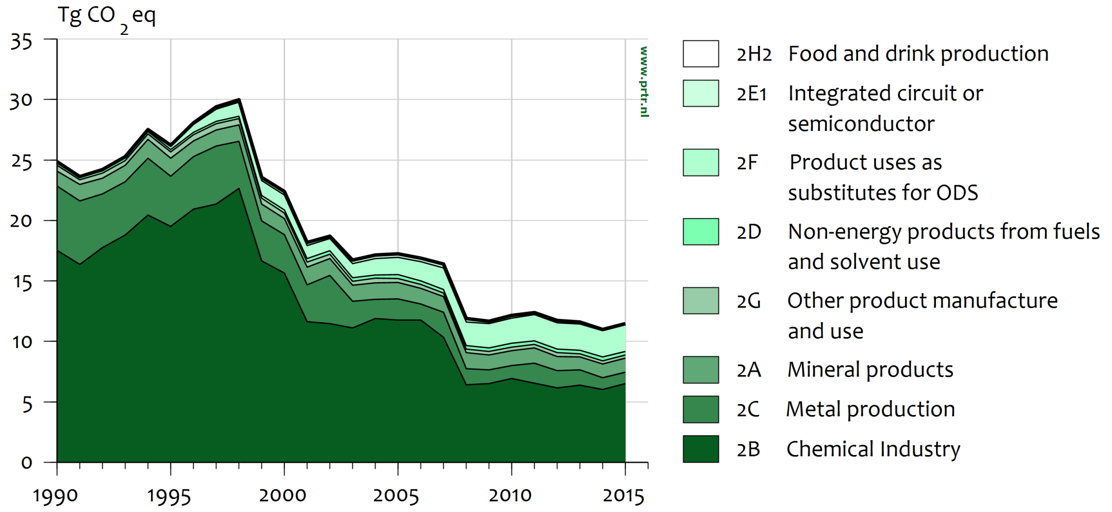


Figure 4.1 Sector 2 Industrial processes and product use: trend and emissions levels of source categories, 1990–2015.

Table 4.1 Contribution of the main categories and key sources in CRF sector 2, Industrial processes and product use

Sector/category	Gas	Key	Emissions in Tg CO_2 eq				Contribution to total in 2015 (%)		
			Base-year	2014	2015	Absolute 2015 - 2014	by sector	of total gas	of total CO_2 eq
2. Total Industrial Processes	CO_2	-	8.90	6.75	7.09	0.35	61.8%	4.3%	3.6%
	CH_4	-	0.43	0.46	0.45	0.00	3.9%	2.4%	0.2%
	N_2O	-	7.05	1.32	1.36	0.00	11.8%	16.3%	0.7%
	HFC	-	7.57	2.25	2.34	0.08	20.3%	100.0%	1.2%
	PFC	-	2.28	0.09	0.10	0.01	0.9%	100.0%	0.1%
	SF_6	-	0.26	0.13	0.14	0.00	1.2%	100.0%	0.1%
	All	-	26.49	11.00	11.48	0.48	100.0%		5.9%
2A. Mineral industry	CO_2	-	1.25	1.14	1.16	0.01	10.1%	0.7%	0.6%
2A1. Cement production	CO_2	non key	0.42	0.28	0.25	-0.03	2.2%	0.2%	0.1%
2A3. Glass production	CO_2	non key	0.14	0.09	0.10	0.01	0.8%	0.1%	0.0%
2A4d. Other process uses of carbonates	CO_2	L2. T2	0.69	0.78	0.81	0.04	7.1%	0.5%	0.4%
2B. Chemical industry	CO_2	-	4.71	4.32	4.66	0.34	40.6%	2.8%	2.4%
	CH_4	-	0.38	0.41	0.41	0.00	3.6%	2.2%	0.2%
	N_2O	-	6.82	1.23	1.27	0.00	11.1%	15.3%	0.7%
	HFC	-	7.30	0.07	0.15	0.08	1.3%	6.4%	0.1%
	PFC	-	0.00	0.00	0.01	0.01	0.1%	11.8%	0.0%
	All	-	19.22	6.04	6.50	0.46	56.6%		3.3%

Sector/category	Gas	Key	Emissions in Tg CO_2 eq				Contribution to total in 2015 (%)		
			Base-year	2014	2015	Absolute 2015 - 2014	by sector	of total gas	of total CO_2 eq
2B1. Ammonia production	CO_2	L. T1	3.73	3.56	3.92	0.36	34.1%	2.4%	2.0%
2B2. Nitric acid production	N_2O	T	6.08	0.36	0.37	0.00	3.2%	4.4%	0.2%
2B4. Caprolactam production	N_2O	L	0.74	0.87	0.90	0.00	7.9%	10.8%	0.5%
2B7. Soda ash production	CO_2	non key	19.01	NO	NO				
2B8. Petrochemical and carbon black production	CO_2	L2. T2	0.34	0.46	0.46	0.00	4.0%	0.3%	0.2%
	CH_4	L2	0.38	0.41	0.41	0.00	3.6%	2.2%	0.2%
2B9. Fluorochemical production	HFC	T	7.30	0.07	0.15	0.08	1.3%	6.4%	0.1%
	PFC	-	NO	0.00	0.01	0.01	0.1%	11.8%	0.0%
2B10. Other chemical industry	CO_2	non key	0.58	0.30	0.28	-0.02	2.4%	0.2%	0.1%
2C. Metal Production	CO_2	-	2.67	0.96	0.95	-0.01	8.2%	0.6%	0.5%
	PFC	-	2.23	0.00	0.01	0.01	0.1%	6.2%	0.0%
	All	-	4.90	0.96	0.95	-0.01	8.3%		0.5%
2C1. Iron and steel production	CO_2	L1. T1	2.27	0.96	0.91	-0.05	7.9%	0.5%	0.5%
2C3. Aluminium production	CO_2	T1	0.41	0.00	0.04	0.04	0.3%	0.0%	0.0%
2C3. Aluminium production	PFC	T	2.23	0.00	0.01	0.01	0.1%	6.2%	0.0%
2D. Non-energy products from fuels and solvent use	CO_2	-	0.19	0.31	0.31	0.00	2.7%	0.2%	0.2%
	CH_4	-	0.00	0.00	0.00	0.00	0.0%	0.0%	0.0%
	All	-	0.19	0.31	0.31	0.00	2.7%		0.2%
2D1. Lubricant use	CO_2	non key	0.08	0.08	0.08	0.00	0.7%	0.0%	0.0%
2D2. Paraffin wax use	CO_2	L2.T2	0.10	0.21	0.21	0.00	1.8%	0.1%	0.1%
2D3. Other non specified	CO_2	non key	IE.NO	0.02	0.02	0.00	0.2%	0.0%	0.0%
2E1. Integrated circuit or semiconductor	PFC	non key	0.05	0.09	0.09	0.00	0.7%	82.0%	0.0%
2F. Product uses as substitutes for ODS	HFC	-	0.27	2.18	2.19	0.00	19.0%	93.6%	1.1%
2F1. Stationary refrigeration and Mobile air-conditioning	HFC	L.T	0.07	2.04	2.04	0.01	17.7	87.2	1.0
2F6. Other	HFC	non	0.20	0.15	0.15	0.00	1.3	6.4	0.1

Sector/category	Gas	Key	Emissions in Tg CO_2 eq				Contribution to total in 2015 (%)		
			Base-year	2014	2015	Absolute 2015 - 2014	by sector	of total gas	of total CO_2 eq
		key							
2G. Other	CO_2	non key	0.00	0.00	0.00	0.00	0.0%	0.0%	0.0%
	CH_4	non key	0.05	0.04	0.04	0.00	0.4%	0.2%	0.0%
	N_2O	T2	0.22	0.09	0.09	0.00	0.7%	1.0%	0.0%
2G2. SF_6 and PFCs from other product use	SF_6	non key	0.26	0.13	0.14	0.00	1.2%	100.0%	0.1%
	All	-	0.54	0.27	0.27	0.00	2.3%		0.1%
2G3. N_2O from product uses	N_2O	T2	0.22	0.08	0.08	0.00	0.7%	0.9%	0.0%
2H. Other	CO_2	non key	0.07	0.01	0.03	0.01	0.2%	0.0%	0.0%
Indirect CO_2 emissions		-	0.67	0.21	0.21	0.00	1.8%	0.1%	0.1%
Total National emissions	CO_2		162.9	158.3	165.3	7.1			
	CH_4		32.3	18.8	19.0	0.2			
	N_2O		17.7	8.1	8.3	0.3			
	HFCs		7.6	2.3	2.3	0.1			
	PFCs		2.3	0.1	0.1	0.0			
	SF_6		0.0	0.1	0.1	0.0			
National Total GHG emissions (excl. CO_2 LUCF)	All		223.1	187.6	195.2	7.7			

Base year for F-gases (HFCs, PFCs (incl. NF_3) and SF_6) is 1995.

In 2015, Industrial processes and product use contributed 5.9% of the total national GHG emissions (without LULUCF) in comparison with 11.8 % in the base year. The sector is a major source of N_2O emissions in the Netherlands, accounting for 16.3% of total national N_2O emissions.

Category 2B (Chemical industry) contributes most to the emissions from this sector with 6.5 Tg CO_2 eq in 2015.

4.2 Mineral products (2A)

4.2.1 Category description

4.2.1.1 General description of the source categories

This category comprises CO_2 emissions related to the production and use of non-metallic minerals in:

- Cement clinker production (2A1);
- Glass production (2A3);
- Other process uses of carbonates (2A4);
  - Ceramics (2A4a): Ceramics include bricks and roof tiles, vitrified clay pipes and refractory products. Process-related

CO_2 emissions from ceramics result from the calcination of carbonates in the clay;
- Other uses of soda ash (2A4b);
- Other (2A4d).

CO_2 emissions from Lime production (2A2) are not included here, as production is known to occur only in four plants of the sugar industry and it is not possible to separate emissions due to lime production from those due to other processes. Emissions from lime production are therefore accounted for as part of the Food Processing, beverages and tobacco category (1A2e). Lime production does not occur in the paper industry in the Netherlands.

CO_2 emissions from other process uses of carbonates (2A4d) originate from:
- Limestone use for flue gas desulphurization (FGD);
- Limestone use in iron and steel production;
- Dolomite consumption (mostly used for road construction).

4.2.1.2 Key sources

The aggregate 2A4d is a Tier 2 level and trend key source of CO_2 emissions.

4.2.1.3 Overview of shares and trends in emissions

Total CO_2 emissions in category 2A decreased from 1.25 Tg in 1990 to 1.16 Tg in 2015 (see Table 4.1). In 2015, CO_2 emissions increased by 0.012 Tg compared with 2014.

4.2.2 Methodological issues

For all the source categories, country-specific methodologies are used to estimate emissions of CO_2 in compliance with the 2006 IPCC Guidelines, volume 3. More detailed descriptions of the methods and EFs used can be found in ENINA (2017), as indicated in Section 4.1.

2A1 (Cement clinker production):

Because of changes in raw material composition over time, it is not possible to reliably estimate CO_2 process emissions on the basis of clinker production activity data and a default EF. For that reason, the only cement producer in the Netherlands company has chosen to base the calculation of CO_2 emissions on the carbonate content of the process input. From 2002 onwards, the methodology for carbon measurements and for calculating emissions can be described as follows:
The first carbonate input in the kiln is the raw material. The CO_2 emissions from this input are calculated on a monthly basis by multiplying the amount of raw material by a derived process EF. From every batch in a month, a sample is taken just before the raw material is fed into the kiln. The process EF and composition of the batch are determined in a laboratory. The EF is determined by measuring the weight loss of the sample (excluding the amount of organic carbon). The monthly EF is set as the average of all sample EFs determined that month. The second carbonate input in the kiln is sewage sludge. The emissions from this source are also calculated monthly by multiplying the amount of sewage sludge by the monthly derived process EF.
Besides the CO_2 emissions resulting from calcination of the carbonate

input in the kiln, the company considers the CO_2 emissions from burning off the small amount of organic carbon in the raw material as process emissions.
As a result, the total yearly process emissions of the company are the sum of all monthly CO_2 emissions from the following sources:

A. Calcination of the carbonate input of the raw material (lime marl);
B. Calcination of the carbonate input of sewage sludge;
C. Burning of organic carbon in the raw material.

This methodology is also included in a monitoring plan applied to emissions trading. This plan has been approved by the Dutch Emissions authority (NEa), the government organization responsible for the emissions trading scheme (ETS) in the Netherlands. This organization is also responsible for the verification of the data reported by this company. The verified CO_2 emissions are also reported in its AER.
For the years prior to 2002, only total CO_2 emissions from the AER are available, so that it is not possible to allocate the total CO_2 emissions to fuel use and the above mentioned subsources. Therefore, for that period, CO_2 process emissions have been calculated by multiplying the average IEF of 2002 and 2003 by the clinker production. Clinker production figures are obtained from the AERs.
CO_2 process emissions from the AERs are related to clinker production figures to give the annual CO_2 IEF for clinker production. Table 4.2 shows the trend in the CO_2 IEFs for clinker production during the period 2002–2015 (IPCC Default = 0.52 t/t clinker).

Table 4.2 IEFs for CO_2 from Clinker production (2A1) (t/t clinker)

Gas	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2	0.54	0.54	0.54	0.52	0.51	0.48	0.48	0.52	0.50	0.52	0.51	0.50	0.51	0,48

2A3 (Glass production):
Until the 2015 submission, the CO_2 emissions were based on plant-specific EFs and gross glass production. Plant-specific EFs have been used for the years 1990 (0.13 t CO_2/t glass), 1995 (0.15 t CO_2/t glass) and 1997 (0.18 t CO_2/t glass). For other years in the time series, there was not enough data available to calculate plant-specific EFs. For the years 1991–1994 and 1996, EFs have been estimated by interpolation. Because no further measurement data is available, the EF for 1998–2012 was kept at the same level as the EF of 1997 (0.18 t CO_2/t glass). Because no reliable data regarding the growth in the use of recycled scrap glass (cullet) in the glass production sector is available for the period 1997–2012, the estimation of CO_2 emissions for that period does not take into account the growth in the use of cullet in glass production. The activity data (gross glass production) is based on data from Statistics Netherlands and the glass trade organization.

From the 2015 submission, the figures are based on the verified EU ETS Emission Reports of the glass production companies and the emissions as estimated in earlier submissions for the year (‘old 1990’ emissions). EU ETS Emission Reports are available from 2005 onwards. For the calculation of CO_2 emissions from limestone, dolomite and soda ash, consumption default IPCC EFs are used; for the other substances, the C-content is multiplied by 44/12. Consumption figures for limestone, dolomite, soda ash and other substances are confidential.

Due to the lack of information on the use of cullet, emissions for the period 1991–2005 have been determined by interpolation. For this calculation the 'old 1990' emissions have been used as the starting point.

2A4a (ceramics):
The calculation of CO_2 emissions from the manufacture of ceramic products in the Netherlands complies with the Tier 1 method as described in the 2006 IPCC Guidelines, volume 3, chapter 2, p. 2.34:

CO_2 emissions = Mc x (0.85EFls + 0.15EFd)

Where:
- Mc = mass of carbonate consumed (tonnes)
- 0.85 = fraction of limestone
- 0.15 = fraction of dolomite
- EF ls = EF limestone (0.440 ton CO_2/ton limestone)
- EF d = EF dolomite (0.477 ton CO_2/ton dolomite)

The fractions and EFs (both defaults) are obtained from the 2006 Guidelines.

The mass of carbonate consumed (Mc) is determined as follows:

Mc = Mclay x cc

Where:
Mclay = amount of clay consumed; this is calculated by multiplying the national production data for bricks and roof tiles, vitrified clay pipes and refractory products by the default loss factor of 1.1 from the 2006 Guidelines. National production data is obtained from the ceramics trade organization.
cc = the default carbonate content of clay (0.1) from the 2006 Guidelines.

2A4b (other uses of soda ash):
For the years 2001 and 2002, net domestic consumption of soda ash is estimated by taking the production figure of 400 kton as a basis, then adding the import figures and deducting the export figures for the relevant year. For the years 1990–2000 and 2003 onwards, these figures are estimated by extrapolating from the figures for 2001 and 2002. This extrapolation incorporates the trend in chemicals production, since this is an important user of soda ash. Emissions are calculated using the standard IPCC EF of 415 kg CO_2 per ton of soda ash (Na2CO3) (2006 IPCC Guidelines, volume 3, chapter 2, table 2.1).

2A4d (other):
CO_2 emissions from this source category are based on consumption figures for limestone use for flue gas desulphurization (FGD) in coal-fired power plants and in iron and steel production and for apparent dolomite consumption (mostly in road construction). Activity data on plaster production for use in desulphurizing installations at power plants is based on the AERs of the coal-fired power plants. To calculate CO_2 emissions from the use of limestone in iron and steel production, the amount of limestone reported in the AERs of Tata Steel is used. The

AERs are also used for emissions data. The consumption of dolomite is based on statistical information obtained from Statistics Netherlands, which can be found on the website www.cbs.nl.
From 2000 onwards, data reported in the AERs of Tata Steel has been used to calculate CO_2 emissions from limestone use in iron and steel production. For the period 1990–2000, CO_2 emissions were calculated by multiplying the average IEF (107.9 kg CO_2 per ton of crude steel produced) over the 2000–2003 period by the crude steel production.
CO_2 from limestone use = limestone use x $f_{(limestone)}$ x $EF_{limestone}$, where f is the fractional purity.
CO_2 emissions from the use of limestone and dolomite and from the use of other substances in the glass production sector are included in 2A3, Glass production.
The emissions are calculated using the standard IPCC EF of 415 kg CO_2 per ton of soda ash (Na_2CO_3) (2006 IPCC Guidelines, volume 3, chapter 2, table 2.1; for limestone use: EF = 0.440 t/t (IPCC default); for dolomite use: EF = 0.477 t/t (IPCC default)).

4.2.3 *Uncertainties and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides the estimates of uncertainties by IPCC source category.

Uncertainty estimates used in the Tier 1 analysis are based on the judgement of experts, since no detailed information is available that might enable the uncertainties of the emissions reported by the facilities (cement clinker production, limestone and dolomite use, and soda ash production) to be assessed. The uncertainty in CO_2 emissions from cement clinker production is estimated to be approximately 10%; for limestone and dolomite use, the uncertainty is estimated to be 25% and for other sources 50%, on account of the relatively high uncertainty in the activity data.
Soda ash use, limestone and dolomite use, and glass production are assumed to be relatively uncertain (respectively 25%, 25% and 50%). The uncertainties of the IPCC default EFs used for some processes are not assessed. As these are minor sources of CO_2, however, this absence of data was not given any further consideration.

Time series consistency

Consistent methodologies have been applied to all source categories. The time series involves a certain amount of extrapolation with respect to the activity data for soda ash use and emissions data for glass production, thereby introducing further uncertainties in the first part of the time series for these sources.

4.2.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedure discussed in Chapter 1.

4.2.5 *Category-specific recalculations*

Due to minor changes in the production index series of chemicals the CO_2 emissions from Other uses of soda ash (2A4b) has been changed for the period 2003-2014. The results of these changes can be found in Table 4.3.

Table 4.3 Effects of changes applied to Other uses of soda ash (2A4b) 2003-2014 (Gg CO_2 eq)

Year	NIR 2017: CO_2 emission	NIR 2016: CO_2 emission	Difference
2003	94.5	93.9	0.6
2004	101.0	100.2	0.9
2005	101.7	101.5	0.2
2006	107.7	106.7	1.0
2007	112.8	109.5	3.3
2008	105.1	103.4	1.7
2009	103.1	97.8	5.2
2010	113.1	107.4	5.7
2011	112.0	106.3	5.7
2012	117.9	112.0	5.9
2013	113.6	107.9	5.7
2014	115.1	109.3	5.7

4.2.6 *Category-specific planned improvement*

No source-specific improvements are planned for this category.

4.3 Chemical industry (2B)

4.3.1 *Category description*

4.3.1.1 General description of the source categories

The national inventory of the Netherlands includes emissions of GHGs related to ten source categories belonging to 2B (Chemical industry):

- Ammonia production (2B1): CO_2 emissions: in the Netherlands, natural gas is used as feedstock for ammonia production. CO_2 is a by-product of the chemical separation of hydrogen from natural gas. During the process of ammonia (NH_3) production, hydrogen and nitrogen are combined and react together.
- Nitric acid production (2B2): N_2O emissions: The production of nitric acid (HNO_3) generates nitrous oxide (N_2O), which is a by-product of the high-temperature catalytic oxidation of ammonia. Until 2010, three companies, each with two HNO_3 production plants, were responsible for the N_2O emissions from nitric acid production in the Netherlands. Two plants of one company were closed in 2010 and one of these has been moved to one of the other companies. Since then, two companies, one with three and one with two HNO_3 production plants, are responsible for the N_2O emissions from nitric acid production in the Netherlands.
- Caprolactam production (2B4a): N_2O emissions. Caprolactam is produced in the Netherlands as part of the production cycle for nylon materials, and is manufactured (since 1952) by only one company. This emission source is therefore responsible for the entire (100%) nitrous oxide emissions by the caprolactam industry in the Netherlands. N_2O emissions from Caprolactam production in the Netherlands are not covered by the scope of EU ETS.

- Silicon carbide production (2B5a): CH_4 emissions: Petrol cokes are used during the production of silicon carbide; the volatile compounds in the petrol cokes form CH_4.
- Titanium dioxide production (2B6): CO_2 emissions arise from oxidation of coke as reductant.
- Soda ash production (2B7): CO_2 emissions are related to the non-energy use of coke.
- Petrochemical and carbon black production (2B8):
  - 2B8a: methanol: CH_4
  - 2b8b: ethylene: CH_4
  - 2B8d: ethylene oxide: CO_2
  - 2B8e: acrylonitrile: CO_2
  - 2B8f: carbon black: CH_4
- Fluorochemical production (2B9):
  - by-product emissions – production of HCFC-22 (2B9a1): HFC-23 emissions: Chlorodifluormethane (HCFC-22) is produced at one plant in the Netherlands. Tri-fluormethane (HFC-23) is generated as a by-product during the production of chlorodifluormethane and emitted through the plant condenser vent.
  - by-product emissions – other – handling activities (2B9b3): emissions of HFCs: One company in the Netherlands repackages HFCs from large units (e.g. containers) into smaller units (e.g. cylinders) and trades in HFCs. There are also many companies in the Netherlands that import small units with HFCs and sell them in the trading areas.
- Other (2B10):
  - Industrial gas production: Hydrogen and carbon monoxide are produced mainly from the use of natural gas as a chemical feedstock. During the gas production process CO_2 is emitted.
  - Carbon electrode production: Carbon electrodes are produced from petroleum coke and coke, used as feedstock, In this process CO_2 is produced.
  - Activated carbon production: Norit is one of world's largest manufacturers of activated carbon, for which peat is used as a carbon source, and CO_2 is a by-product.

Adapic acid (2B3), glyoxal (2B4b), glyoxylic acid (2B4c) and calcium carbide (2B5b) are not produced in the Netherlands. So the Netherlands do not report emissions in the CRF under 2B4 which are covered by the scope of EU ETS.
CO_2 emissions resulting from the use of fossil fuels as feedstocks for the production of silicon carbide, carbon black, ethylene and methanol are included in the Energy sector (1A2c; see Section 3.2.7 for details).

In the Netherlands, many processes related to this source category take place in only one or two companies. Because of the confidentiality of data from these companies, emissions from 2B5 and 2B6 are included in 2B8g.

4.3.1.2 Key sources

Ammonia production (2B1) is a level and Tier 1 trend key source of CO_2 emissions, while caprolactam production (2B4a) is identified as a level key source of N_2O emissions.

Since 2008, nitric acid production has not been a level key source of N_2O emissions; due to emissions reductions in 2007 and 2008, it has been devalued to a trend key source (see Table 4.1).
Fluorochemical production (2B9) is a trend key source of HFCs.
Petrochemical and carbon black production (2B8) is a Tier 2 key source of CH_4 and a Tier 2 level and trend key source for CO_2 emissions.

4.3.1.3 Overview of shares and trends in emissions

Figure 4.2 shows the trend in CO_2-equivalent emissions from 2B (Chemical industry) in the period 1990–2015. Table 4.1 gives an overview of proportions of emissions from the main categories.

Emissions from this category contributed 8.6% of total national GHG emissions (without LULUCF) in the base year and 3.3% in 2015.

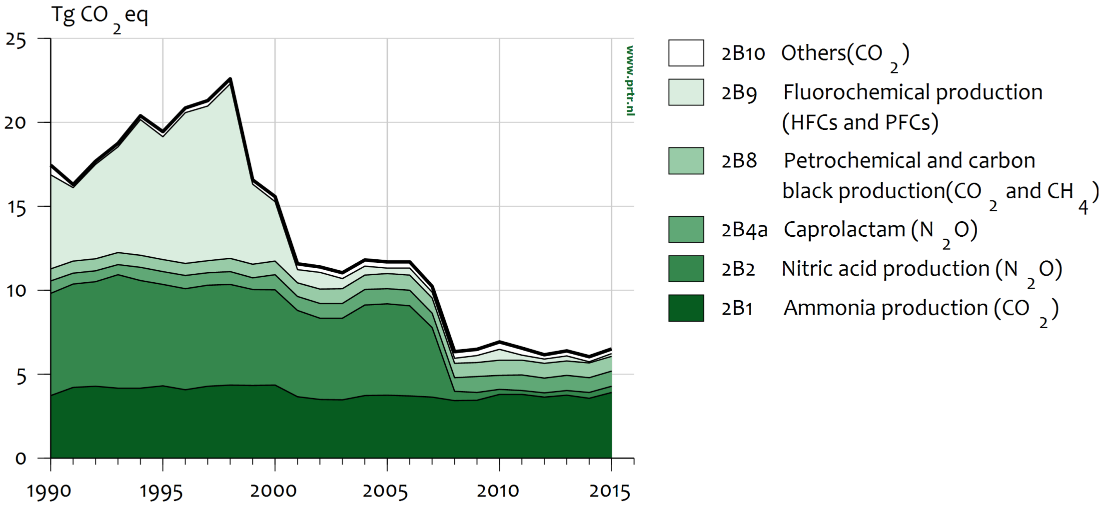


Figure 4.2 2B Chemical industry: trend and emissions levels of source categories, 1990–2015.

From 1995 to 2001, total GHG emissions from 2B (Chemical industry) decreased by 7.9 Tg CO_2 eq, mainly due to a reduction in HFC-23 emissions from HCFC-22 production. From 2001 to 2008, total GHG emissions from 2B (Chemical industry) decreased by 5.2 Tg CO_2 eq, mainly due to a reduction in N_2O emissions from the production of nitric acid. During the period 2009–2015, total GHG emissions from 2B remained at almost the same level as in 2008.

Table 4.4 shows that N_2O emissions from the chemical industry remained fairly stable between 1990 and 2000 (when there was no policy aimed at controlling these emissions).

Table 4.4 Trend in N_2O emissions from Chemical industry (2B) (Gg CO_2 eq)

Year	2B2 Nitric acid production	2B4a caprolactam production	Total
1990	6,085	740	6,825
1991	6,169	657	6,826
1992	6,228	648	6,877
1993	6,765	598	7,362
1994	6,407	784	7,191
1995	6,035	777	6,812
1996	6,020	794	6,813
1997	6,020	733	6,753
1998	5,990	774	6,764
1999	5,731	691	6,422
2000	5,670	903	6,573
2001	5,134	833	5,967
2002	4,837	866	5,703
2003	4,864	890	5,755
2004	5,400	921	6,321
2005	5,440	917	6,357
2006	5,380	926	6,306
2007	4,138	861	5,000
2008	536	822	1,359
2009	473	941	1,414
2010	290	846	1,135
2011	234	926	1,160
2012	254	895	1,148
2013	274	898	1,171
2014	356	874	1,230
2015	370	902	1,272

Nitric acid production (2B2)
Technical measures (optimizing the platinum-based catalytic converter alloys) implemented at one of the nitric acid plants in 2001 resulted in an emissions reduction of 9% compared with 2000. The decreased emissions level in 2002 compared with 2001 is related to the decreased production level of nitric acid in that year. In 2003, emissions and production did not change, whereas in 2004 the increased emissions level was once again related to production – in this case a marked increase. In 2005 and 2006, N_2O emissions of the nitric acid plants remained at almost the same level as in 2004.

Technical measures implemented at all nitric acid plants in the third quarter of 2007 resulted in an emissions reduction of 23% compared with 2006. In 2008, the full effect of the measures was reflected in the low emissions (a reduction of 90% compared with 2006). The further reduction in 2009 was primarily caused by the economic crisis. Because of the closure of one of the plants and an improved catalytic effect in another, emissions decreased again in 2010. The reduction in 2011 was caused by an improved catalytic effect in two of the plants. After 2011 the fluctuations in N_2O emissions from the nitric acid plants are mainly caused by the operating conditions (such as unplanned stops).

Table 4.5 gives an overview, with detailed information per plant, that explains the significant reductions in N_2O emissions from nitric acid production in 2007 and 2008.

Table 4.5 Overview with detailed information per nitric acid plant

Plant:	**1**	**2**	**3**	**4**	**5**	**6**
Type of production technology	Mono pressure (3.5 bar)	Dual pressure (4/10 bar)	Mono pressure (3.5 bar)	Dual pressure (4/10 bar)	Dual pressure (4–6/10–12 bar)	Dual pressure (4–6/10–12 bar)
Abatement technology implemented	Catalyst, which breaks down N_2O, in existing NH_3 reactors, just below the platinum catalyst system	EnviNOx[1] process variant 1 system from UHDE (tertiary technique)	Idem 1	Idem 2	Catalyst (pellets) technology which breaks down N_2O in the first stage of nitric acid production when ammonia is burned	Idem 5
Time of installation	Oct. 2007	Dec. 2007	Oct. 2007	Dec. 2007	Nov. 2007	May 2007
N_2O emissions in tonnes 2006: 2007: 2008:	 1,269 1,190 415	 1,273 1,026 0.05	 770 631 143	 4,015 3,275 2.26	 4,527 4,448 318	 5,888 3,311 921
Abatement efficiency 2007–2008[2]	80.40%	99.94%	69.68%	99.997%	92.84%	84.80%

1 As well as in two Dutch plants, EnviNOx process variant 1 systems are in operation – with similar, very high N_2O abatement rates (99% and above) – in nitric acid plants in Austria and elsewhere.

2 Abatement efficiency relates to IEFs. Because the IEFs are confidential, they are not included in this table.

From 2008 onwards, N_2O emissions from HNO_3 production in the Netherlands were included in the European Emission Trading Scheme (EU-ETS). For this purpose, the companies developed monitoring plans that were approved by the NEa, the government organization responsible for EU-ETS in the Netherlands. In 2016, the companies' emissions reports (2015 emissions) were independently verified and submitted to the NEa, where they were checked against those reported in the CRF tables (2015). No differences were found between the emissions figures in the CRF tables and those in the in the emissions reports under EU-ETS.

Caprolactam production (2B4a)
The emissions fluctuations were mainly caused by the production level. The increased emissions level in 2015 was caused by an increased production level.

Fluorochemical production (2B9)
Total HFC emissions in category 2B were 7.3 Tg in 1995 and 0.161 Tg CO_2 eq in 2015, HFC-23 emissions from HCFC-22 production (2B9a1) being the major source of HFC emissions. HFC emissions from Handling activities (2B9b3) were responsible for 27% of total HFC emissions from this category in 2015.

Table 4.6 shows the trend in HFC emissions from the categories HCFC-22 production and HFCs from handling activities for the period 1990–2015. Emissions of HFC-23 increased by approximately 35% in the period 1995–1998, due to increased production of HCFC-22. In the period 1998–2000, however, emissions of HFC-23 decreased by 69% following the installation of a thermal converter (TC) at the plant.

The removal efficiency of the TC (kg HFC-23 processed in TC/kg HFC-23 in untreated flow/year) is the primary factor and production level the secondary factor in the variation in emissions levels during the 2000–2008 period.

Due to the economic crisis, the production level of HCFC-22 was much lower in the last quarter of 2008 and in 2009, resulting in lower HFC-23 emissions in both 2008 and 2009. Primarily as a result of the economic recovery, the production level of HCFC-22 was much higher in 2010, resulting in higher HFC-23 emissions in 2010, compared with 2009. Due to the increasing removal efficiency of the Thermal Converter after 2010, HFC-23 emissions declined in both 2011 and 2012. After 2012 the emission fluctuations are caused by the fluctuations in the removal efficiency of the Thermal Converter.

The significant emissions fluctuations in category 2B9b3 (Handling activities) during the period 1992–2015 can be explained by the large fluctuations in handling activities, which depend on the demand from customers.

Table 4.6 Trends in HFC-23 by-product emissions from the production of HCFC-22 and HFC emissions from handling activities (2B9a and 2B9b) (Gg CO_2 eq)

Year	2B9a: HFC-23	2B9b3: HFCs/PFCs	Total
1990	5,606	NO	5,606
1991	4,366	NO	4,366
1992	5,594	27	5,621
1993	6,257	54	6,312
1994	7,941	137	8,078
1995	7,285	13	7,298
1996	8,712	248	8,960
1997	8,486	718	9,204
1998	9,855	544	10,399
1999	4,352	418	4,769
2000	3,062	472	3,534
2001	569	222	791
2002	866	110	976
2003	525	78	603
2004	448	97	546
2005	248	55	303
2006	355	58	413
2007	307	38	345
2008	268	25	293
2009	195	222	417
2010	494	156	651
2011	211	89	299
2012	159	80	239
2013	238	58	295
2014	45	28	73
2015	118	43	161

4.3.2 *Methodological issues*

For all the source categories of the chemical industry, the methodologies used to estimate GHG emissions are in compliance with the 2006 IPCC Guidelines, volume 3.

Country-specific methodologies are used for the CO_2 process emissions from the chemical industry. More detailed descriptions of the methods used and EFs can be found in the methodology report (ENINA, 2017), as indicated in Section 4.1. The main characteristics are:

- 2B1 (Ammonia production): A method equivalent to IPCC Tier 3 is used to calculate CO_2 emissions from ammonia production in the Netherlands. The calculation is based on the consumption of natural gas and a country-specific EF. Data on the use of natural gas is obtained from Statistics Netherlands. Because there are only two ammonia producers in the Netherlands, the consumption of natural gas and the country-specific EF are confidential information.
  CO_2 emissions from Ammonia production (2B1) in the Netherlands are covered by the scope of EU ETS. According to a Specific monitoring rule for CO_2 from ammonia production (listed

in Annex I to Directive 2003/87/EC) it is not allowed to deduct CO_2 used as feedstock for the production of urea or other chemicals.
To ensure the consistency between the EU-ETS(Emission Trading Scheme) part and the non EU-ETS part of the national system the Netherlands does not take into account the CO_2 recovered for urea production and use or production and use of other chemicals.
In addition The Netherlands does not have any data on urea and other chemical production, import and export available at this moment.

- 2B2 (Nitric acid production): An IPCC Tier 2 method is used to estimate N_2O emissions. Until 2002, N_2O emissions from nitric acid production were based on IPCC default EFs. N_2O emissions measurements made in 1998 and 1999 resulted in a new EF of 7.4 kg N_2O/ton nitric acid for total nitric acid production. The results of these measurements are confidential and can be viewed at the company’s premises.
  Plant-specific EFs for the period 1990–1998 are not available. Because no measurements were taken but the operational conditions did not change during the period 1990–1998, the EFs obtained from the 1998/1999 measurements have been used to recalculate the emissions for the period 1990–1998. Activity data are also confidential.
  The emissions figures are based on data reported by the nitric acid manufacturing industry and are included in the emissions reports under EU-ETS and the national Pollutant Release and Transfer Register (PRTR).
- 2B4a (Caprolactam production): From 2015 onwards, the N_2O emission are based on the updated and improved measurement program in 2014. Information about the methods used before 2015 can be found in ENINA (2017), as indicated in Section 4.1.
- 2B5 (Carbide production): The activity data (petcoke) is confidential, so the IPCC default EF was used to calculate CH_4 emissions.
- 2B6 (Titanium dioxide production): Activity data is confidential. Only emissions are reported by the company.
- 2B7 (Soda ash production): Before the closure in 2010 of the only soda ash producer, CO_2 emissions were calculated on the basis of the non-energy use of coke and the IPCC default EF (0.415 t/t), assuming the 100% oxidation of carbon. The environmental report was used for data on the non-energy use of coke. To avoid double counting, the plant-specific data on the non-energy use of coke is subtracted from the non-energy use of coke and earmarked as feedstock in national energy statistics. The Netherlands has included the notation code NO in the CRF tables (from 2010 onwards) as soda ash production stopped.
- 2B8 (Petrochemicals and carbon black production):
  2B8a: methanol
  2b8b: ethylene
  2B8e: acrylonitrile
  2B8f: carbon black
  The process emissions from these sources are calculated by multiplying the specific EF by the annual production.

- 2B8d: ethylene oxide production: CO_2 emissions are estimated on the basis of capacity data by using a default capacity utilization rate of 86% (based on Neelis et al., 2005) and applying a default EF of 0.45 t/t ethylene oxide. As there is no real activity data available at this moment in the Prodcom database from EUROSTAT, the Netherlands can not verify this assumption on thee activity data for ethylene production. For reasons of confidentiality all above mentioned sources of 2B8 are included in 2B8g.
- 2B9a1: production of HCFC-22: This source category is identified as a trend key source of HFC-23 emissions. In order to comply with the 2006 IPCC Guidelines, volume 3, an IPCC Tier 2 method is used to estimate the emissions from this source category. HFC-23 emissions are calculated using the following formula:
  HFC 23 emissions = HFC 23 load in untreated flow - amount of untreated HFC23, destroyed in the TC
  The HFC-23 load in the untreated flow is determined by a continuous flow meter in combination with an in-line analysis of the composition of the stream. The amount of HFC23, destroyed in the TC is registered by the producer.
- 2B9b3: Handling activities (HFCs): Tier 1 country-specific methodologies are used to estimate emissions of HFCs from handling activity. The estimations are based on emissions data reported by the manufacturing and sales companies. Activity data used to estimate HFC emissions is confidential. The EFs used are plant-specific and confidential, and they are based on 1999 measurement data.
- 2B10: Other: The aggregated CO_2 emissions included in this source category are not identified as a key source. Because no IPCC methodologies exist for these processes, country-specific methods and EFs are used. These refer to:
  - The production of industrial gases: With natural gas as input (chemical feedstock), industrial gases, e.g. H2 and CO, are produced. The oxidation fraction of 20% (80% storage) is derived from Huurman (2005). From the two producers in the Netherlands, the total amount of carbon stored in the industrial gases produced and the total carbon content of the natural gas used as feedstock are derived from the AERs. These data result in a storage factor of 80%. The storage factor is determined by dividing the total amount of carbon stored in the industrial gases produced by the carbon content of the natural gas used as feedstock.
  - Production of carbon electrodes: CO_2 emissions are estimated on the basis of fuel use (mainly petcoke and coke). A small oxidation fraction (5%) is assumed, based on data reported in the AERs.
  - Production of activated carbon: From 2013 onwards, CO_2 emissions from activated carbon production in the Netherlands were included in the European Emission Trading Scheme (EU-ETS). So, from the 2015 submission, the figures are based on the verified EU ETS Emission Reports of the activated carbon producer. For the years 2004 and 2005 peat use data have been obtained from the AERs and the emissions were calculated with the help of the C-content of

the peat in 2013. For the years before 2003 no peat use and C-content data are available. Therefore, the emissions for the period 1990-2002 are kept equal to the emissions of 2004. The emissions for the period 2005-2012 have been determined by extrapolation between 2004 and 2013.

Activity data for estimating CO_2 emissions is based on data for the feedstock use of fuels provided by Statistics Netherlands.

For the minor sources of CH_4 emissions included in this source category, IPCC Tier 1 methodologies and IPCC default EFs were used.

4.3.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2 (shown in Tables A2.1 and A2.2) provides estimates of uncertainties according to IPCC source categories.

The uncertainty in annual CO_2 emissions from ammonia production is estimated to be approximately 10%. For all the other sources in this category the uncertainty is estimated to be about 70%. The uncertainty in the activity data and the EF for CO_2 is estimated at 2% and 10% for ammonia production and at 50% for all the other sources in this category.
The uncertainty in the annual emissions of N_2O from caprolactam production is estimated to be approximately 30%.
Since N_2O emissions from HNO_3 production in the Netherlands are included in the EU-ETS, all companies have continuous measuring of their N_2O emissions. This has resulted in a lower annual emissions uncertainty, of approximately 8%.

The uncertainty in HFC-23 emissions from HCFC-22 production is estimated to be approximately 15%. For HFC emissions from handling activities the uncertainty is estimated to be about 20%. These figures are all based on the judgements of experts.

Time series consistency

Consistent methodologies are used throughout the time series for the sources in this category. The time series is based on consistent methodologies and activity data for this source.

4.3.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1. N_2O emissions from HNO_3 production are also verified by EU-ETS.

The confidential information is checked and verified as follows:

- As mentioned in the methodology report (ENINA, 2017), the confidential information (the HFC 23 load in the untreated flow, and the removal efficiency of the TC) can be viewed at the company's premises.
- During the annual verification of the AER, the competent authorities check the reliability of the information at the company.

- The industrial expert of the Dutch emission inventory team checks the information at the company.

4.3.5 *Category-specific recalculations*

In the NIR 2016 CO_2 emissions from Activated carbon production were allocated in 2.B.8.g. This was not correct. In this submission emissions from Activated carbon production were allocated in the correct source category (2.B.10). The results of this re-allocation can be found in Table 4.7.

Table 4.7 Effects of re-allocation from Activated carbon production from 2B8 to 2B10, 1990–2014 (Gg CO_2 eq)

Year	NIR 2017: 2B8: CO_2 emission	NIR 2016: 2B8: CO_2 emission	Diffe-rence	NIR 2017: 2B10: CO_2 emission	NIR 2016: 2B10: CO_2 emission	Diffe-rence
1990	336	490	-154	583	429	154
1995	340	495	-154	302	148	154
2000	424	579	-154	304	150	154
2001	426	581	-154	327	173	154
2002	435	590	-154	330	176	154
2003	421	575	-154	336	182	154
2004	446	601	-154	357	203	154
2005	448	570	-122	373	251	122
2006	453	571	-118	361	244	118
2007	449	562	-113	340	227	113
2008	438	546	-108	385	277	108
2009	451	555	-104	360	256	104
2010	464	564	-99	441	341	99
2011	463	558	-95	414	319	95
2012	452	542	-90	267	177	90
2013	460	546	-86	302	217	86
2014	457	538	-81	301	220	81

In the NIR 2016 CH_4 emissions from coke manufacture were allocated in 2.B.8.(Petrochemical and carbon black production). This was not correct. In this submission emissions from coke manufacture were re-allocated from 2B8g to 1B1b. The results of this re-allocation can be found in Table 4.8.

Table 4.8 Effects of re-allocation from coke manufacture from 2B8g to 1B1b, 1990–2014 (Gg CO_2 eq)

Year	NIR 2017: 2B8: CH_4 emission	NIR 2016: 2B8: CH_4 emission	Difference
1990	380.0	387.2	-7.2
1991	380.0	387.2	-7.2
1992	380.0	387.2	-7.2
1993	380.0	387.2	-7.2
1994	380.0	387.2	-7.2
1995	380.0	387.2	-7.2
1996	380.0	387.3	-7.3
1997	380.0	387.3	-7.3
1998	376.0	383.1	-7.1
1999	389.0	394.8	-5.8
2000	396.5	401.8	-5.3
2001	395.9	401.4	-5.5
2002	438.2	443.5	-5.3
2003	457.8	463.2	-5.4
2004	410.4	415.9	-5.5
2005	458.7	464.3	-5.6
2006	445.1	450.6	-5.4
2007	462.0	467.4	-5.4
2008	424.5	429.7	-5.2
2009	394.4	398.5	-4.2
2010	436.0	441.0	-5.0
2011	411.4	416.3	-5.0
2012	429.2	433.9	-4.7
2013	403.8	408.7	-4.9
2014	413.8	418.7	-5.0

4.3.6 Category-specific planned improvements

No source-specific improvements are planned for this category.

4.4 Metal production (2C)

4.4.1 Category description

General description of the source categories

The national inventory of the Netherlands includes emissions of GHGs related to two source categories belonging to 2C (Metal production):

- Iron and steel production (2C1): CO_2 emissions: the Netherlands has one integrated iron and steel plant (Tata Steel, previously Corus and/or Hoogovens). During the production of iron and steel, coke and coal are used as reducing agents in the blast and oxygen furnaces, resulting in the by-products blast furnace gas and oxygen furnace gas. A small percentage of these gases is emitted (lost) and the rest is used as fuel for energy purposes. Only the carbon losses are reported in category 2C1.
  In addition, CO_2 is produced during the conversion of pig iron to steel. These emissions are also reported in this category.

The process emission from anode use during steel production in the electric arc furnace is also included in this category.
As mentioned in Section 3.2.5 (1A2a), the emissions calculation for this sector is based on a mass balance, which is not included in the NIR for reasons of confidentiality but can be made available for the UNFCCC review.

- Aluminium production (2C3): CO_2 and PFC emissions: The Netherlands had two primary aluminium smelters: Zalco, previously Pechiney (partly closed at the end of 2011) and Aldel (closed at the end of 2013). By the end of 2014 Aldel made a restart under the name Klesch Aluminium Delfzijl.
  CO_2 is produced by the reaction of the carbon anodes with alumina and by the reaction of the anode with other sources of oxygen (especially air). PFCs (CF_4 and C_2F_6) are formed during the phenomenon known as the anode effect, which occurs when the concentration of aluminium oxide in the reduction cell electrolyte drops below a certain level.

There are some small Ferroalloy production (2C2) companies in the Netherlands. These companies are trading comapnies. They don't produce ferroalloys, so they do not have GHG process emissions. Their combustion emissions are included in 1A2.

The following source categories do not occur in the Netherlands:

- Magnesium production (2C4);
- Lead production (2C5);
- Zinc production via the electro-thermic distillation or the pyrometallurgical process (2C6);
- Other metal production (2C7).

Key sources
Iron and steel production (2C1) is identified as a Tier 1 level and trend key source of CO_2 emissions, aluminium production (2C3) is a Tier 1 trend key source for CO_2 emissions and a trend key source of PFC emissions (see Table 4.1).

Overview of shares and trends in emissions
Table 4.1 provides an overview of emissions, by proportion, from the main categories. Total CO_2 emissions from 2C1 (Iron and steel production) decreased by 1.4 Tg during the period 1990–2015. In 2015, CO_2 emissions decreased by 0.05 Tg compared with 2014.

From 2004 onwards, the level of the PFC emissions (see Table 4.9) depended mainly on the number of anode effects.

Because of the closure of Zalco, PFC emissions decreased after 2011 to 11 Gg CO_2 eq in 2013. In 2014 the PFC emissions decreased to 0.05 Gg CO_2 eq. This was caused by the closure of Aldel by the end of 2013 and the restart under the name Klesch Aluminium Delfzijl by the end of 2014. In 2015 the restart under the name Klesch Aluminium Delfzijl resulted in an increase of the PFC emissions to 6.5 Gg CO2 eq.

Table 4.9 Emissions for CF_4 and C_2F_6 from Aluminium production (2C3) (Gg CO_2 eq)

Year	PFK14 (CF_4)	PFK116 (C_2F_6)	Total
1990	2,049	588	2,638
1991	2,034	577	2,611
1992	1,849	521	2,369
1993	1,876	518	2,394
1994	1,799	498	2,297
1995	1,746	485	2,230
1996	1,946	521	2,467
1997	2,079	549	2,628
1998	1,530	491	2,020
1999	1,134	433	1,567
2000	1,188	454	1,642
2001	1,135	434	1,570
2002	1,744	706	2,450
2003	389	129	518
2004	100	24	124
2005	82	20	102
2006	56	13	69
2007	92	21	113
2008	67	16	84
2009	40	10	50
2010	57	11	67
2011	79	17	96
2012	15	3	18
2013	9	2	11
2014	0.04	0.01	0.05
2015	5.4	1.1	6.5

4.4.2 Methodological issues

The methodologies used to estimate the GHG emissions for all source categories of metal production comply with the 2006 IPCC Guidelines. More detailed descriptions of the methods and EFs used can be found in ENINA (2017).

Iron and steel production (2C1)

CO_2 emissions are estimated using a Tier 2 IPCC method and country-specific value for the carbon content of the fuels. Carbon losses are calculated from coke and coal input used as reducing agents in the blast and oxygen furnaces, and from other carbon sources such as the carbon content in the iron ore (corrected for the fraction that ultimately remains in the steel produced). The calculations are as follows:

- CO from coke/coal inputs = amount of coke * EF_{coke} + amount of coal * EF_{coal} – (blast furnace gas + oxygen oven gas produced) * EF_{BFgas} (1a);
- CO_2 from ore/steel = (C-mass in ore, scrap and raw iron purchased – C-mass in raw steel) * 44/12 (1c).

Data on coke production and coal input, limestone use and the carbon balance is reported by the relevant company (in AERs).

The same plant-specific EF (0.21485 tons CO_2 per GJ) is used for blast furnace gas and oxygen furnace gas (see Annex 5).

As mentioned above, only carbon losses are reported in category 2C1. The carbon contained in the blast furnace gas and oxygen furnace gas produced as by-products and subsequently used as fuel for energy purposes is subtracted from the carbon balance and included in the Energy sector (1A1a and 1A2a).

From 2000 onwards, data reported in the AERs of Tata Steel was used to calculate the CO_2 emissions from the conversion of pig iron to steel. For the period 1990–2000, the CO_2 emissions have been calculated by multiplying the average IEF (8.3 kg CO_2 per ton of crude steel produced) over the 2000–2003 period by the crude steel production.

For anode use in the electric arc furnace, an EF of 5 kg CO_2/ton steel produced is used.

Aluminium production (2C3)
A Tier 1a IPCC method (IPCC, 2006) is used to estimate CO_2 emissions from the anodes used in the primary production of aluminium, with aluminium production serving as activity data. Activity and emissions data is based on data reported in the AERs of both companies. In order to calculate the IPCC default EF, the stoichiometric ratio of carbon needed to reduce the aluminium ore to pure aluminium is based on the reaction:

$$Al_2O_3 + 3/2C \rightarrow 2Al + 3/2\ CO_2.$$

This factor is corrected to include additional CO_2 produced by the reaction of the carbon anode with oxygen in the air. A country-specific EF of 0.00145 tons CO_2 per ton of aluminium is used to estimate CO_2 emissions and it has been verified that this value is within the range of the IPCC factor of 0.0015 and the factor of 0.00143 calculated by the World Business Council for Sustainable Development (WBCSD) (WBCSD/WRI, 2004).

Estimations of the PFC emissions from primary aluminium production reported by these two facilities are based on the IPCC Tier 2 method for the complete period 1990–2015. Emission factors are plant-specific and confidential and are based on measured data.

4.4.3 *Uncertainty and time series consistency*

Uncertainty
The Tier 1 uncertainty analysis explained in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of uncertainties by IPCC source category. The uncertainty in annual CO_2 emissions is estimated to be approximately 6% for iron and steel production and 5% for aluminium production, whereas the uncertainty in PFC emissions from aluminium production is estimated to be 20%. The uncertainty in the activity data is estimated at 2% for aluminium production and 3% for iron and steel production. The uncertainty in the EFs for CO_2 (from all sources in this category) is estimated at 5% and for PFC from aluminium production at 20%.

Time series consistency
A consistent methodology is used throughout the time series.

4.4.4 *Category-specific QA/QC and verification*
The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.4.5 *Category-specific recalculations*
No recalculations have been made.

4.4.6 *Category-specific planned improvements*
No source-specific improvements are planned for this category.

4.5 Non-energy products from fuels and solvent use (2D)

4.5.1 *Category description*
General description of the source categories
The national inventory of the Netherlands includes emissions of GHGs related to three sources in this source category:
- Lubricant use (2D1);
- Paraffin wax use (2D2);
- Urea use in SCR (2D3).

The the CO_2 emissions reported in categories 2D1 and 2D2 stem from direct use of specific fuels for non-energy purposes, which results in partial or full oxidation during use (ODU) of the carbon contained in the products amongst others the burning of candles. CO_2 emissions reported in category 2D3 stem from Urea use in diesel vehicles (SCR).

Key sources
CO_2 emissions from paraffin wax use are identified as a Tier 2 level and trend key source in this category (see Annex 1).

Overview of shares and trends in emissions
The small CO_2 and CH_4 emissions from 2D1 and 2D2 remained fairly constant between 1990 and 2015. The CO_2 emission from Urea use in diesel vehicles increased sharply during the period 2005-2015.

4.5.2 *Methodological issues*
The methodologies used to estimate the GHG emissions in 2D1, 2D2 and 2D3 comply with the 2006 IPCC Guidelines, volume 3.

A Tier 1 method is used to estimate emissions from lubricants and waxes using IPCC default EFs. For the use of lubricants, an ODU factor of 20% and for the use of waxes an ODU factor of 100% have been used. CO_2 emissions from urea-based catalysts are estimated using a Tier 3 methodology using country-specific CO_2 emission factors for different vehicle types. More detailed descriptions of the method and EFs used can be found in Methods for calculating the emissions of transport in the Netherlands (Klein et al, 2017).

The activity data is based on fuel use data from Statistics Netherlands.

4.5.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of the uncertainties by IPCC source category.

The uncertainty in CO_2 EF is estimated to be approximately 50% in the ODU factor for lubricants. The uncertainty in the activity data (such as domestic consumption of these fuel types) is generally very large, since it is based on production, import and export figures.

These sources do not affect the overall total or the trend in direct GHG emissions.

Time series consistency

Consistent methodologies and activity data have been used to estimate the emissions from these sources.

4.5.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.5.5 *Category-specific recalculations*

The CO_2 emissions from Lubricant use (2D1) have been changed for the years 1990-2014. The major part of this change is the result of of a review conducted by the European Commission. The emissions for this submission have been calculated with the correct ODU factor of 0.2 (instead of 0.5).
The remaining part of this change, is due to a re-allocation of a small part from 2D1 to 1A3b iv. The results of these changes can be found in Table 4.10.

Table 4.10 Effects of changes applied to Lubricant use (2D1) 1990–2014 (Gg CO_2 eq)

Year	NIR 2017: CO_2 emission	NIR 2016: CO_2 emission	Difference
1990	85	201	-116
1991	77	306	-229
1992	85	351	-266
1993	118	327	-209
1994	88	349	-261
1995	99	270	-171
1996	92	267	-175
1997	96	268	-172
1998	99	280	-181
1999	106	271	-165
2000	95	245	-150
2001	103	259	-156
2002	109	275	-166
2003	108	266	-158
2004	107	269	-161

Year	NIR 2017: CO_2 emission	NIR 2016: CO_2 emission	Difference
2005	137	342	-205
2006	127	314	-188
2007	103	251	-149
2008	116	289	-174
2009	96	241	-145
2010	98	245	-147
2011	91	230	-139
2012	78	188	-110
2013	76	183	-107
2014	79	199	-120

4.5.6 Category-specific planned improvements
No source-specific improvements are planned for this category.

4.6 Electronics industry (2E)

4.6.1 Category description
General description of the source categories
PFCs (incl. NF_3) and SF_6 are released via the use of these compounds in Semiconductor manufacture (2E1). The SF_6 emissions are included in 2G2. PFC and SF_6 emissions from TFT flat panel display (2E2), Photovoltaics (2E3) and Heat transfer fluid (2E4) manufacturing do not occur in the Netherlands. No Other sources (2E5) are identified in the inventory.

Key sources
No key sources are identified in this category (see Annex 1).

Overview of shares and trends in emissions
The contribution of F-gas emissions from category 2E to the total national inventory of F-gas emissions was 0.5% in the base year 1995 and 3.3% in 2015. The latter figure corresponds to 0.1 Tg CO_2 eq and accounts for 0.04% of the national total GHG emissions in 2015.

Due to an increasing production level in the semiconductor manufacturing industry, PFC emissions increased from 25 Gg CO_2 eq in the base year to 305 Gg CO_2 eq in 2007. The decrease after 2007 was mainly realised by an intensive PFC (incl. NF_3) reduction scheme (see Table 4.11).

Table 4.11 Emissions trend from the use of PFCs (incl. NF_3) in Electronics industry (2E1) (Gg CO_2 eq)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PFCs	25	50	261	254	269	305	241	168	205	140	156	115	89	85

4.6.2 Methodological issues
The methodology used to estimate the PFC emissions from semiconductor manufacturing comply with the 2006 IPCC Guidelines.

In last submission the parameters used to estimate the PFC emissions from semiconductor manufacture (2E1) were not correct. This has been corrected in this submission.

Activity data on the use of PFCs in semiconductor manufacturing was obtained from the only manufactory company (confidential information). Emission factors are confidential information. Detailed information on the activity data and EFs can be found in the methodology report (ENINA, 2017).

4.6.3 *Uncertainty and time series consistency*

Uncertainty
The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of the uncertainties by IPCC source category. The uncertainty in PFC (incl. NF_3) emissions is estimated to be about 25%. The uncertainty in the activity data for the PFC (incl. NF_3) sources is estimated at 5%; for the EFs, the uncertainty is estimated at 25%. All these figures are based on the judgements of experts.

Time series consistency
Consistent methodologies have been used to estimate emissions from these sources.

4.6.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.6.5 *Category-specific recalculations*

No recalculations have been made.

4.6.6 *Category-specific planned improvements*

No source-specific improvements are planned.

4.7 Product use as substitutes for ODS (2F)

4.7.1 *Category description*

General description of the source categories
The national inventory comprises the following sources within this category:

- Stationary refrigeration (2F1): HFC emissions;
- Mobile air-conditioning (2F1): HFC emissions;
- Foam-blowing agents (2F2): HFC emissions (included in 2F6);
- Fire protection (2F3) (HFC emissions included in 2F6);
- Aerosols (2F4): HFC emissions (included in 2F6);
- Solvents (2F5): HFC emissions (included in 2F6);
- Other applications (2F6); HFC emissions from 2F2, 2F3, 2F4 and 2F5.

In the Netherlands, many processes related to the use of HFCs take place in only one or two companies. Because of the sensitivity of data from these companies, only the sum of the HFC emissions of 2F2–5 is reported (included in 2F6).

Key sources
Refrigeration and air conditioning (2F1) is a level and trend key source for HFC's.

Overview of shares and trends in emissions
The contribution of F-gas emissions from category 2F to the total national inventory of F-gas emissions was 2.7% in the base year 1995 and 85% in 2015. The latter figure corresponds to 2.2 Tg CO_2 eq and accounts for 1.1% of the national total GHG emissions in 2015.
Due to increased HFC consumption as a substitute for (H)CFC use, the level of HFC emissions increased by a factor of 8 in 2015 compared with 1995 (see Table 4.12).
For 2015 no consumption data of HFCs (stationary refrigeration, foam-blowing agents, aerosols, fire protection and solvents) are available. Therefore the emissions from these sources are kept equal to the emissions of 2014.

Table 4.12 Emissions trends specified per compound from the use of HFCs as substitutes for ODS (Gg CO_2 eq)

Year	HFC-134a	HFC-143a	HFC-125	HFC-32	HFC-23	Other HFCs	HFC Total
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	19	NO	NO	NO	NO	62	81
1995	52	9	10	1	0	201	274
1996	91	33	35	3	0	474	635
1997	129	60	57	6	0	746	996
1998	161	83	73	7	0	849	1,173
1999	188	107	94	7	0	849	1,243
2000	241	156	136	9	0	689	1,231
2001	298	208	184	10	0	386	1,086
2002	352	257	228	11	0	181	1,029
2003	405	311	275	12	0	167	1,170
2004	453	364	320	13	0	206	1,356
2005	501	411	362	14	0	147	1,435
2006	542	458	404	15	0	161	1,580
2007	581	510	450	16	0	227	1,785
2008	615	564	498	18	0	252	1,948
2009	637	614	536	19	0	216	2,022
2010	643	637	562	20	1	195	2,057
2011	653	650	582	20	1	259	2,166
2012	667	668	611	20	2	194	2,162

Year	HFC-134a	HFC-143a	HFC-125	HFC-32	HFC-23	Other HFCs	HFC Total
2013	684	662	644	21	3	155	2,169
2014	702	646	658	24	8	146	2,183
2015	706	646	658	24	8	146	2,187

4.7.2 *Methodological issues*

To comply with the 2006 IPCC Guidelines, volume 3, IPCC Tier 2 methods are used to estimate emissions of the sub-categories stationary refrigeration, mobile air-conditioning, aerosols and foam-blowing agents.

The activity data used to estimate emissions of F-gases derives from the following sources:

- Until the 2016 submission consumption data of HFCs (stationary refrigeration, foam-blowing agents, aerosols, fire protection and solvents) was obtained from the annual reports by PriceWaterhouseCoopers;
- For mobile air-conditioning, the number of cars (by year of construction) and the number of scrapped cars (by year of construction) were obtained from Statistics Netherlands. The amounts of recycled and destroyed refrigerants were obtained from ARN, a waste-processing organization.

Emission factors used to estimate the emissions of F-gases in this category are based on the following:

- Stationary refrigeration: Annual leak rates from surveys (Baedts et al., 2001).
- Mobile air-conditioning: Annual leak rates from surveys (Baedts et al., 2001) and other literature (Minnesota Pollution Control Agency, 2009; YU & CLODIC, 2008).
- Aerosols and foam-blowing agents: IPCC default EFs.

More detailed descriptions of the methods and EFS used can be found in the methodology report (ENINA, 2017), as indicated in Section 4.1.
For reasons of confidentiality, the detailed figures for Mobile air-conditioning are not included in this submission, but can be made available for review purposes.

4.7.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of uncertainties by IPCC source category. The uncertainty in HFC emissions from HFC consumption is estimated to be 54%. The uncertainty in the activity data related to the HFC sources is estimated at 20%; for the EFs, the uncertainty is estimated at 50%. All these figures are based on the judgements of experts.

Time series consistency
Consistent methodologies have been used to estimate emissions from these sources.

4.7.4 *Category-specific QA/QC and verification*
The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.7.5 *Category-specific recalculations*
Until the 2016 submission a leakage percentage of 5.0% has been used. This percentage is the average of the leakage percentages from CFCs, CFC+H(C)FC blends, HFCs and unspecified stocks from "Annual leak rates from surveys (Baedts et al., 2001)". Because the composition of the unspecified part of the stock is unknown and H(C)FC blends often contain HFCs, the decision has been taken to use the average leakage percentage of 5% (unrounded number is 4.8%).
As a result of the review conducted by the European Commission the HFC emissions from Stationary refrigeration (2F1) have been recalculated with a leakage percentage of 5.8% for the period 1994-2014. This percentage is the leakage percentage of the HFC part of the stock from "Annual leak rates from surveys (Baedts et al., 2001)".

Furthermore the following changes were made:
- an error in Stationary refrigeration(2F1) in 2014 was detected and corrected;
- because more detailed information of Mobile air-conditioning (2F1) became available, the HFC emissions have been changed for a number of years;

The results of these changes can be found in Table 4.13.

Table 4.13 Effects of emissions changes (Gg CO_2 eq) applied to Stationary refrigeration and Mobile air-conditioning (2F1) 1990-2014

Year	NIR 2017: 2F1 HFCs	NIR 2016: 2F1 HFCs	Difference
1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	NO	NO	NO
1994	19	19	0
1995	73	72	1
1996	162	157	5
1997	251	238	12
1998	324	301	23
1999	395	356	39
2000	542	490	52
2001	700	634	65
2002	848	771	77
2003	1 003	914	89
2004	1 150	1 050	100
2005	1 288	1 178	109

Year	NIR 2017: 2F1 HFCs	NIR 2016: 2F1 HFCs	Difference
2006	1 419	1 301	118
2007	1 557	1 426	132
2008	1 695	1 541	154
2009	1 806	1 632	174
2010	1 862	1 681	181
2011	1 907	1 725	182
2012	1 968	1 773	195
2013	2 014	1 802	212
2014	2 037	2 026	11

4.7.6 Category-specific planned improvements

At this moment we are working on the replacement of the current method by a new method. The new method will use a “Refrigerants registration system” with among others information about leakages, filling of new installation, dismantling, etc. In next submission new emission figures from 2013 onwards will be presented.

4.8 Other product manufacture and use (2G)

4.8.1 Category description

General description of the source categories

This source category comprises emissions related to Other product manufacture and use (2G) in:

- Electrical equipment (2G1): SF_6 emissions (included in 2G2);
- Other (2G2): SF_6 emissions from sound-proof windows, electron microscopes and the electronics industry;
- N_2O from product uses (2G3): N_2O emissions from the use of anaesthesia and from aerosol cans;
- Other industrial processes (2G4):
  - Fireworks: CO_2, CH_4 and N_2O emissions;
  - Degassing of drinking water: CH_4 emissions.

In the Netherlands, many processes related to the use of SF_6 take place in only one or two companies. Because of the sensitivity of data from these companies, only the sum of the SF_6 emissions of 2G1 and 2G2 is reported (included in 2G2).

Key sources

N_2O from Other product manufacture and use (2G) is a tier 2 trend key source.

Overview of shares and trends in emissions

Table 4.12 shows the trend in emissions from the use of SF_6 during the period 1990–2015.

Table 4.12 Emissions from the use of SF_6, 1990–2014 (Gg CO_2 eq)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
SF_6	207	261	259	204	154	125	173	120	135	139

After 2000, the decrease in SF_6 emissions was mainly caused by:
- the closure of the only manufacturer of high-voltage installations at the end of 2002;
- an intensive PFC-reduction scheme in the Semiconductor manufacture sector (2E1);
- the use of leak detection equipment in 2G1 Electrical equipment.

N_2O emissions from 2G3 decreased by 66% during the period 1990–2015. N_2O emissions from anaesthesia fell by 93% between 1990 and 2015 due to better dosing in hospitals and other medical institutions. Domestic sales of cream in aerosol cans have increased sharply between 1990 and 2015. For this reason, emissions of N_2O from food aerosol cans increased by 123% during the period 1990–2015.

The small CO_2 and CH_4 emissions remained fairly constant between 1990 and 2013. CO_2, CH_4 and N_2O emissions from fireworks and candles showed a peak in 1999 because of the millennium celebrations.

4.8.2 Methodological issues

The source Electrical equipment (2G1) comprises SF_6 emissions by users of high-voltage circuit breakers and the only international test laboratory for power switches. Figures for the emissions from the circuit breakers were obtained from EnergieNed, the Federation of energy companies in the Netherlands, and the emissions from testing were abtained from the single test laboratory wich uses the gas.

In 2006 (2008 submission), the method of estimating SF_6 emissions from electrical equipment changed. Before 2006, the method complied with the Tier 2 method (lifecycle EF approach, with a country-specific EF and total banked amounts of SF_6 as actiity data.

For the 2006–2008 period, the country-specific method for this source is equivalent to the IPCC Tier 3b method and from 2009 onwards to the IPCC Tier 3a method. So, from 2006 onwards the country-specific method is based on the annual input and output of SF_6.

Furthermore, based on the new emissions data from 2006 and existing emissions data from 1999, SF_6 emissions from electrical equipment have been recalculated by interpolation for the period 2000-2005 to achieve a consistent time series.

For the period 1990–1998, the amounts of SF_6 banked are estimated by EnergieNed. These are used to estimate emissions prior to 1999, using the same methodology as for the emissions estimates for 1999.

The Netherlands considers these estimates to be preferable to an extrapolation of emissions figures backwards from 1999, as the estimates reported are in line with the trend in volume of the energy production sector in that period.

The country-specific methods used for the sources semiconductor manufacturing, sound-proof windows, and electron microscopes are equivalent to IPCC Tier 2 methods.

Figures for the use of SF_6 in semiconductor manufacturing, sound-proof windows and electron microscopes were obtained from different individual companies (confidential information).

EFs used to estimate the emissions of SF_6 in this category are based on the following:

- Semiconductor manufacturing: confidential information from the only company;
- Sound-proof windows: EF used for production is 33% (IPCC default); EF (leak rate) used during the lifetime of the windows is 2% per year (IPCC default);
- Electron microscopes: confidential information from the only company.

Country-specific methodologies are used for the N_2O sources in 2G3. Since the N_2O emissions in this source category are from non-key sources, the present methodology complies with the 2006 IPCC Guidelines. A full description of the methodology is provided in WESP (2015).

The major hospital supplier of N_2O for anaesthetic use reports the consumption data for anaesthetic gas in the Netherlands annually. The Dutch Association of Aerosol Producers (NAV) reports data on the annual sales of N_2O-containing spray cans.

The EF used for N_2O in anaesthesia is 1 kg/kg gas used. Sales and consumption of N_2O for anaesthesia are assumed to be equal each year. The EF for N_2O from aerosol cans is estimated to be 7.6 g/can (based on data provided by one producer) and is assumed to be constant over time.

The methodologies used to estimate the GHG emissions of 2G4 are:

- Fireworks and candles: Country-specific methods and EFs are used to estimate emissions of CO_2, CH_4 and N_2O.
- Degassing of drinking water: A country-specific methodology and EF are used to estimate CH_4 emissions, this being the main source of CH_4 emissions in this category.

The activity data used in 2G4 derives from the following sources:

- Fireworks: data on annual sales from the trade organization;
- Candles: average annual use of 3.3 kg per person (www.bolsius.com);
- Production of drinking water: volume and fuel use from Statistics Netherlands.

The EFs used in 2G4 are based on the following:

- Fireworks: CO_2: 43 kg/t; CH_4: 0.78 kg/t; N_2O: 1.96 kg/t (Brouwer et al., 1995);
- Candles: CO_2: 2.3 kg/t (EPA, 2001);
- Production of drinking water: 2.47 tons CH_4/106 m3 (Brouwer et al., 1995).

4.8.3 Uncertainty and time series consistency

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of the uncertainties by IPCC source category.

The uncertainty in SF_6 emissions from 2G1 is estimated to be 34% (IPCC Tier 3a method). For the activity data and the EFs for 2G the uncertainty is estimated to be approximately 30% and 15%, respectively.

Time series consistency

Consistent methodologies have been applied to all source categories. The quality of the N_2O activity data needed was not uniform for the complete time series, requiring some extrapolation from the data. This is not expected to significantly compromise the accuracy of the estimates, which is still expected to be sufficient.

4.8.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.8.5 Category-specific recalculations

Due to a correction in the sales statistics of food aerosol cans, the N_2O emissions for 2013 and 2014 has been corrected. The results of these corrections can be found in Table 4.15.

Table 4.15 Effect of corrections applied to food aerosol cans (2G3) In 2013 and 2014 (Gg CO_2 eq)

Year	NIR 2017: N_2O emission	NIR 2016: N_2O emission	Difference
2013	81	53	- 28
2014	77	49	- 28

4.8.6 Category-specific planned improvements

No source-specific improvements are planned.

4.9 Other (2H)

4.9.1 Category description

General description of the source categories

This category comprises CO_2 emissions related to Food and drink production (2H2) in the Netherlands. CO_2 emissions in this source category are related to the non-energy use of fuels. Carbon is oxidized during these processes, resulting in CO_2 emissions. CO_2 process emissions in the paper industry (2H1) do not occur in the Netherlands.

Key sources

No key sources are identified in this source category (see Annex 1).

Overview of shares and trends in emissions

Emissions are very small (0.025 Tg in 2015) (see Table 4.1).

4.9.2 *Methodological issues*

The methodology used to estimate the GHG emissions complies with the IPCC 2006 Guidelines, volume 3. CO_2 emissions are calculated on the basis of the non-energy use of fuels by the food and drink industry as recorded by Statistics Netherlands in national energy statistics on coke consumption, multiplied by an EF. The EF is based on the national default carbon content of the fuels (see Annex 5), on the assumption that the carbon is fully oxidized to CO_2.

4.9.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of the uncertainties by IPCC source category. The uncertainty in the emissions of this category is estimated to be 50%.

Time series consistency

Consistent methodologies and activity data are used throughout the time series for this source.

4.9.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1.

4.9.5 *Category-specific recalculations*

No recalculations have been made.

4.9.6 *Category-specific planned improvements*

No source-specific improvements are planned.

5 Agriculture (CRF sector 3)

Major changes in the Agriculture sector compared to the National Inventory Report 2016

Emissions: Methane (CH_4) emissions from Agriculture increased by 3.4% from 2014 to 2015, mainly caused by increased number of cattle, swine and poultry. Nitrous oxide (N_2O) emissions from Agriculture increased with 2.9% from 2014 to 2015 due to increased application of synthetic N-fertilizers. Overall this led to a 3.2% increase in total CO_2 eq emissions produced by the Agriculture sector.

Key sources: CO_2 emissions from liming (CRF sector 3G) are now considered a key source based on trend.

Methodologies: The N_2O emissions from below-ground crop residues were included in the calculation of emissions from source category 3Da4 to comply with the IPCC Guidelines. N_2O emissions from crop residues including below-ground crop residues were recalculated for the entire time series 1990-2014. Emissions of N_2O from crop residues therefore increased with 70 kton CO_2 eq (50%) in 1990 to 55 kton CO_2 eq (60%) in 2014.

The 2014 emissions from sewage sludge and compost and 2013 and 2014 emissions from synthetic N-fertilizer were recalculated as new data became available. Therefore also indirect N_2O emissions from atmospheric deposition on agricultural soils are recalculated.

The Netherlands report emissions from the agricultural sector in four source categories:

- Enteric fermentation (3A): CH_4 emissions
- Manure management (3B): CH_4 and N_2O emissions
- Agricultural soils (3D): N_2O emissions
- Liming (3G): CO_2 emissions

The IPCC categories Rice cultivation (3C), Prescribed burning of savannahs (3E), Field burning of agricultural residues (3F), Other carbon-containing fertilizers (3I) and Other (3J) – do not occur in the Netherlands. To ensure consistency between the EU-ETS (Emission Trading Scheme) part and the non EU-ETS part of the national system the CO_2 emissions from application of urea fertilizer (3H) are included in 2B1 Ammonia production.

Emissions of GHGs from agriculture include all anthropogenic emissions from the agricultural sector, with the exception of emissions from fuel combustion (included in 1A2g 'Manufacturing industries and construction – Other' and 1A4c 'Other sectors – Agriculture/Forestry/Fisheries') and carbon dioxide (CO_2) emissions through land use in agriculture (CRF sector 4 Land use, land use change and forestry; see Chapter 6).

5.1 Overview of the sector

The total greenhouse gas emissions from agriculture decreased with approximately 24% between 1990 and 2015, from 25.3 Mton CO_2-eq in 1990 to 19.2 Mton CO_2-eq in 2015 (see Figure 5.1). In 2015 emissions from sector 3 Agriculture are responsible for 9.8% of total national emissions (without LULUCF), compared with 11.3% in 1990. Table 5.1 shows the emissions of greenhouse gasses in the agricultural sector for each subcategory. The publication of Vonk et al. (2016) provides the methodologies, activity data and emission factors used in estimating emissions from agriculture in the Netherlands in more detail.

Table 5.1 GHG emissions of sector 3 Agriculture in Mton CO_2-eq

Sector/category	Gas	Key*	Base year	2014	2015	Difference 2015-2014	Contribution to total in 2015 (%)		
				Tg CO_2-eq			by sector	of total gas	of total CO_2-eq
3. Agriculture	CO_2	-	0.2	0.1	0.1	0.0	0.4%	0.0%	0.0%
	CH_4	-	15.0	12.6	13.0	0.4	67.7%	68.4%	6.7%
	N_2O	-	10.1	6.0	6.1	0.2	32.0%	73.7%	3.1%
	All	-	25.3	18.6	19.2	0.6	100.0%		9.8%
3A. Enteric fermentation	CH_4	-	9.2	8.2	8.5	0.3	44.3%	44.8%	4.4%
3A1. Cattle	CH_4	-	8.2	7.3	7.6	0.3	39.6%	40.0%	3.9%
3A1. Mature dairy cattle	CH_4	L, T	5.2	5.0	5.2	0.2	27.2%	27.5%	2.7%
3A1. Other mature cattle	CH_4	non key	0.2	0.2	0.2	0.0	0.8%	0.8%	0.1%
3A1. Growing cattle	CH_4	L	2.8	2.2	2.2	0.0	11.5%	11.6%	1.1%
3A2. Sheep	CH_4	-	0.3	0.2	0.2	0.0	1.0%	1.0%	0.1%
3A3. Swine	CH_4	L2	0.5	0.5	0.5	0.0	2.5%	2.5%	0.2%
3A4. Other livestock	CH_4	non key	0.2	0.2	0.2	0.0	1.3%	1.3%	0.1%
3B. Manure management	CH_4	-	5.8	4.4	4.5	0.1	23.4%	23.6%	2.3%
	N_2O	L, T2	0.9	0.7	0.7	0.0	3.5%	8.1%	0.3%
	All	-	6.7	5.0	5.2	0.2	26.9%		2.6%
3B1. Cattle	CH_4	L,T	1.8	2.2	2.3	0.1	11.8%	11.9%	1.2%
2B2. Sheep	CH_4	-	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%
3B3. Swine	CH_4	L,T	3.5	2.1	2.1	0.0	11.0%	11.1%	1.1%
3B4. Poultry	CH_4	T	0.5	0.1	0.1	0.0	0.4%	0.4%	0.0%
3B4. Other livestock	CH_4	non key	0.0	0.0	0.0	0.0	0.2%	0.2%	0.0%
3B1-4. Direct emissions	N_2O	-	0.5	0.4	0.5	0.0	2.4%	5.4%	0.2%
3B5. Indirect emissions	N_2O	-	0.4	0.2	0.2	0.0	1.2%	2.7%	0.1%
3D. Agriculture soils	N_2O	-	9.2	5.3	5.5	0.2	28.5%	65.6%	2.8%
3Da. Direct N2O emissions from agricultural soils	N_2O	L,T	7.5	4.7	4.9	0.1	25.3%	58.3%	2.5%
3Da1. Inorganic ferilizers	N_2O	-	2.5	1.4	1.6	0.2	8.5%	19.7%	0.8%
3Da2. Organic N fertilizers	N_2O	-	0.8	1.2	1.3	0.0	6.5%	15.1%	0.6%

Sector/category	**Gas**	**Key***	**Base year**	**2014**	**2015**	**Difference 2015-2014**	**Contribution to total in 2015 (%)**		
3Da3. Urine and dung from grazing animals	N_2O	-	3.0	1.1	1.0	-0.1	5.2%	12.0%	0.5%
3Da4. Crop residues	N_2O	-	0.4	0.2	0.2	0.0	1.0%	2.3%	0.1%
3Da6. Cultivation of organic soils	N_2O	-	0.8	0.8	0.8	0.0	4.0%	9.3%	0.4%
3Db. Indirect N2O Emissions from managed soils	N_2O	L,T	1.6	0.6	0.6	0.0	3.2%	7.3%	0.3%
3G. Liming	CO_2	T2	0.2	0.1	0.1	0.0	0.4%	0.0%	0.0%
National Total GHG emissions (excl. CO2 LULUCF)	CO_2		162.9	158.3	165.3	7.1			
	CH_4		32.3	18.8	19.0	0.2			
	N_2O		17.7	8.1	8.3	0.3			
	All		223.1	187.6	195.2	7.7			

*Key sources: L = Level; T= Trend; 1 = Tier 1; 2 = Tier 2.

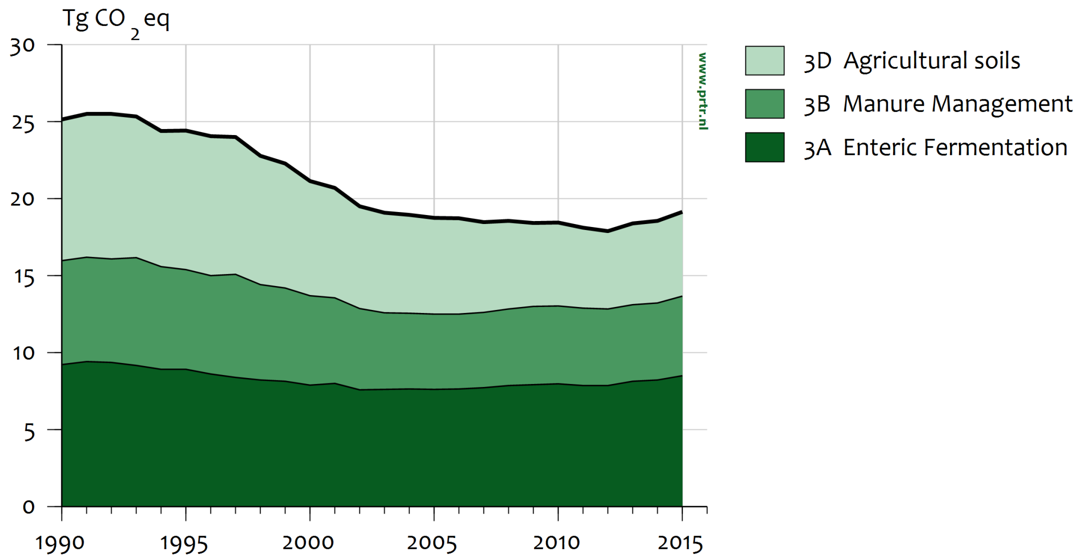


Figure 5.1 Category 3 Agriculture: trend and emission levels of source categories, 1990–2015.

Overview of trends in activity data
Animal numbers are the primary activity data used in emission calculations for agriculture. These animal numbers come from the annual agricultural survey which was performed by Statistics Netherlands. Table 5.2 presents an overview, in the background document of Van Bruggen et al. (2017) more detailed information on animal numbers is given.

Table 5.2 Animal numbers in 1990–2015 (x 1,000) (www.cbs.nl)

Animal type	1990	1995	2000	2005	2010	2013	2014	2015
Cattle	4,926	4,654	4,069	3,797	3,975	3,999	4,068	4,134
1,878	1,708	1,504	1,433	1,479	1,553	1,572	1,622	1,622
120	146	163	151	115	84	82	80	80
2,929	2,800	2,402	2,213	2,381	2,363	2,414	2,432	2,432
Sheep	1,702	1,674	1,305	1,361	1,130	1,034	959	946
Swine	13,915	14,397	13,118	11,312	12,255	12,212	12,238	12,603
Goats	61	76	179	292	353	413	431	470
Horses	370	400	417	433	441	429	426	417
Mules and asses	NO	NO	NO	NO	1	1	1	1
Poultry	94,902	91,637	106,517	95,190	103,371	99,370	104,685	108,558
Other livestock	1,340	951	981	1,058	1,261	1,342	1,324	1,404

Between 1990 and 2015 cattle, swine and sheep numbers decreased with 16%, 9% and 44%, respectively. Poultry and horse numbers increased with 14% and 13% and the number of goats increased with 673%. The number of rabbits decreased with 51% while the number of fur-bearing animals increased with 85%, leading to a net increase of 5% in the category 'Other livestock' between 1990 and 2015.

Cattle
Three categories of cattle are recognized (option B in the CRF):
- Mature dairy cattle: adult cattle for milk production

- Other mature cattle: adult cattle for beef production
- Growing cattle: dairy cattle and non-dairy cattle younger than 2 years of age including veal calves.

In mature dairy cattle the decrease in animal numbers (-14%) was associated with an increase in milk production per cow between 1990 and 2015. The increase in milk production per cow is the result of genetic changes (due to breeding programmes for milk yield), increases in feed intake and feed digestibility and changes in management systems. In order to comply with milk quotas the numbers of mature dairy cattle decreased to counteract the effect of increased milk production per cow. In the last few years, an increase in Dutch milk quotas led to a stabilized number of mature dairy cattle. The quota system was abolished in April 2015, which led to an increase in mature dairy cattle. Since 1990 the number of other mature cattle decreased with 33% until 2015.

Between 1990 and 2013, the numbers of young dairy cattle followed the same decreasing trend as mature dairy cattle. In anticipation of the abolishment of EU milk quotas, from 2013 onwards dairy farmers kept more growing cattle to be able to achieve a higher milk production directly after the abolition. The number of growing non-dairy cattle decreased, following the same trend as other mature cattle. Overall, from 1990 to 2015 the number of growing cattle decreased with 17%. In veal calves a small shift was seen from formula-fed production (white veal) towards nonformula-fed production (rosé veal).

Compared to 2014 3% more mature dairy cattle and 1% more growing cattle were kept in 2015. The decrease in young cattle kept for beef production (-1%) partly compensates the increase in young cattle for dairy production (2%). In 2015 the number of other mature cattle reduced with 2% compared to 2014.

Sheep
The population of sheep in the Netherlands almost halved since 1990. The decrease is partially explained by the outbreak of foot-and-mouth disease in 2001. A regulatory change in 2006 where farmers no longer received a separate bonus per ewe, further decreased sheep numbers. The decrease in 2015 was 1% compared to 2014.

Swine
The number of swine was stable in the early 1990s. In 1997 the increased number of swine was a direct result of the outbreak of classical swine fever in that year (see NIR 2009). In areas where this disease was present transportation of fattening pigs, sows and piglets was prohibited so animals had to remain on the farms for a relatively long period (accumulation of swine). In 1998 the ban was lifted which led to a large decrease in swine numbers. This decreasing trend continued to 2004, followed by a relatively small increasing trend up until 2011. From 2012 onwards swine numbers were fairly stable. In 2015 swine numbers increased with 3% compared to 2014.

The Netherlands' manure and fertilizer policy also influences livestock numbers. Swine numbers in particular decreased when the government purchased some of the swine production rights (ceilings for total phosphate production by animals) and lowered the maximum application limits for manure and synthetic N-fertilizer.

Goats
The increase in the number of goats can be partially explained as a side effect of the developments in the dairy cattle sector. As a result of the milk quotas for cattle, the decreasing milk price for cow milk and the strongly increasing market for goat milk products, some dairy farmers became goat farmers. In 2015 goat numbers increased with 9% compared to 2014.

Horses
From 1990 to 2009 the number of horses and ponies kept on farms increased with 107%. From 2010 onwards the number of horses on farms decreased as an effect of the economic crisis. Besides horses and ponies kept on farms, horses and ponies can also be privately owned. The number of privately owned horses was estimated by the Product Boards for Livestock, Meat and Eggs to be approximately 300,000 in 2005 (PVE, 2005). As information on activity data for privately owned horses is scarce, this estimate is used for the whole time series. Because the Netherlands chooses not to report emissions in CRF sector 6 Other, the estimated 300,000 privately owned horses are added to the livestock numbers from the agricultural census. It is subsequently used in calculations and reported as part of agriculture.
The overall number of horses and ponies (both kept on farms and privately owned) decreased with 2% in 2015 compared to 2014. During the time series 1990 to 2015 the total number of horses and ponies decreased with 68%.

Mules and asses
On some farms in the Netherlands mules and asses are kept. Since 2010 these animals are reported in the Agricultural Census and therefore included in the emission inventory. In absolute numbers the changes in animal numbers are small. Due to the small amount of mules and asses the percentual changes however can be large. From 2010 to 2015 the total number increased with 3% (+28 animals).

Poultry
An increase in the number of poultry was observed between 1990 and 2002. In 2003 poultry numbers decreased by almost 30% as a direct result of the avian flu outbreak. In 2004 poultry numbers followed an increasing trend again. In 2010 the number of poultry was equal to the number of poultry in 2002, indicating the poultry sector recovered from the avian flu outbreak. From 2011 onwards poultry numbers more or less stabilized, with small yearly increases and decreases. In 2015 poultry numbers increased with 4% compared to 2014.

Other livestock
This category includes rabbits and minks. The number of rabbits showed a continuous decreasing trend from 1990 to 2015 (-51%). The number of mink showed an increasing trend until 2012 and remained fairly stable between 2012 and 2015 (+85% from 1990 to 2015). Foxes were kept from 1990 until 2007 and from 2008 onwards were no longer

allowed to be kept in the Netherlands (-100%). In 2015 the overall number of rabbits and minks increased with 5% compared to 2014.

5.2 Enteric fermentation (3A)

5.2.1 Category description

Methane emissions are a by-product of enteric fermentation, the digestive process by which organic matter (mainly carbohydrates) is degraded and utilized by micro-organisms under anaerobic conditions. Both ruminant animals (e.g. cattle, sheep and goats) and non-ruminant animals (e.g. swine, horses, mules and asses) produce CH_4, but per unit of feed intake ruminants produce considerably more CH_4.

In ruminants, the digestive system is specialized to break down fibrous material and has a strongly expanded chamber (the rumen) in front of the stomach. This allows for a selective retention of feed particles and supports an intensive microbial fermentation of the feed, which has several nutritional advantages – including the capacity to digest fibrous material and the synthesis of microbial protein, which can be digested in the intestine. However, the process also produces large amounts of hydrogen. Methanogens utilize this hydrogen as an energy source, with methane as the end product that is mainly exhaled through the respiratory system of the host ruminant. With a variation in feed characteristics, there is a variation in the extent of rumen fermentation and the amount of hydrogen produced and converted into methane.

Enteric fermentation from poultry is not estimated due to the negligible amount of CH_4 production in this animal category. The IPCC 2006 Guidelines do not provide a default EF for enteric CH_4 emissions from poultry.

5.2.2 Methodological issues

In 2015, enteric fermentation accounted for 44% of the total GHG emissions from the Agriculture sector in the Netherlands (see Table 5.1). Cattle accounted for the majority (89%) of CH_4 emissions from enteric fermentation in 2015. Swine contributed 6% and the animal categories sheep, goats, horses and mules and asses accounted for the remaining 5%.

Trends in CH_4 emission from enteric fermentation are explained by changes in livestock numbers, changes in EF or both. CH_4 emissions from enteric fermentation decreased from 9.2 Mton CO_2 eq to 8.5 Mton (-8%) between 1990 and 2015, which is almost entirely explained by a decrease in CH_4 emissions from cattle due to decreasing livestock numbers. Although EFs for enteric fermentation in cattle increased during this period, the reduction in cattle numbers has more than compensated for the effect.

Detailed information on activity data sources and EFs can be found in chapter 2 of the methodology report (Vonk et al., 2016). Table 5.2 presents an overview of the livestock numbers, in the background document of Van Bruggen et al. (2017) more detailed information on livestock numbers is given.

Cattle
The EFs for cattle are calculated annually for the different sub-categories. For mature dairy cattle, a country-specific method based on a Tier 3 methodology is followed. For the other cattle categories, the calculation is based on a country-specific Tier 2 methodology.

Feed intake is the most important parameter in the calculation of the CH_4 EFs for cattle, and is estimated from the energy requirement calculations used in the Netherlands (WUM, 2012). For instance, the energy requirement for dairy cows (expressed as the net energy value of lactation, or VEM in Dutch) is calculated based on the requirements for total milk production, maintenance and other functions. For growing cattle, the energy requirement is calculated based on total weight gain.

Data on feed composition and feed intake (fresh grass; grass-, hay- and maize silage; wet by-products and standard and protein-rich concentrates) is estimated from national statistics and presented in Van Bruggen et al. (2017). Data on the chemical nutrient composition of individual roughages is provided by Eurofins Agro (a leading laboratory in the Dutch agricultural and horticultural sector with roughage sampling, analytical and advisory activities that is able to deliver data that can be taken as representative of average Dutch farming conditions, formerly known as Blgg).

Mature dairy cattle
CH_4 emissions from enteric fermentation by mature dairy cattle are calculated with a Tier 3 approach using an updated version of the model of Mills et al. (2001), which was published by Bannink et al. (2005) and described extensively in Bannink (2011). This model is based on the mechanistic, dynamic model of rumen fermentation processes developed by Dijkstra et al. (1992). It has been developed for mature cattle and is therefore not suitable for other ruminant categories such as growing cattle. The model calculates the gross energy (GE) intake, CH_4 EF (in kg CH_4/cow/year) and the methane conversion factor (Y_m; % of GE intake converted into CH_4) on the basis of data on the share of feed components (grass silage, maize silage, wet by-products and concentrates), their chemical nutrient composition (soluble carbohydrates, starch, neutral detergent fiber, crude protein, ammonia, crude fat, organic acids and ash) and the intrinsic degradation characteristics of starch, neutral detergent fiber and crude protein in the rumen.

Because of differences in fed diets the calculations are split for the north-west (NW; diet contains mainly grass) and south-east (SE; large fraction of maize in diet) regions of the country. Data used between 1990 and 2012 are published in an annex to Van Bruggen et al. (2014).

Other mature cattle and growing cattle
The EFs for methane emissions from enteric fermentation in other mature cattle and growing cattle categories are calculated by multiplying the GE intake by a methane conversion factor (Smink, 2005). Changes in GE intake are based on changes in the total feed intake and on the share of feed components. The equation for calculating the EF (in kg CH_4/animal/year) is:

$$EF = (Y_m \times GE\ intake \times 365\ day/year)/55.65\ MJ/kg\ CH_4$$

Where:

EF:	Emission factor (kg CH_4/animal/year);
Y_m:	Methane conversion factor; fraction of the GE of feed intake converted to CH_4;
GE intake:	Gross energy intake (MJ/animal/day).

And:

GE intake =	Dry matter intake (kg DM/animal/day) × 18.45 MJ/kg DM (IPCC, 2006);
Y_m =	Country- and year-specific value for white veal calves (Gerrits et al., 2014) and 0.065 for the other categories of young cattle and mature non-dairy cattle (IPCC, 2006).

The country- and year-specific Y_m for formula-fed veal calves is calculated using the proportion of milk products and other ration components with respective Y_m values of 0.003 and 0.055. Milk products bypass the rumen and escape ruminal fermentation, while Y_m for other ration components is lower because the rumen is not fully developed in formula-fed beef calves. An energy content of 21 MJ/kg DM for milk products is assumed (Gerrits et al., 2014).

An overview of the GE intake and EFs calculated for cattle is presented in Van Bruggen et al. (2017). Although a Tier 2 method is used for estimating emissions of other mature cattle and growing cattle, data on average feed intake in CRF Table 3As2 is not applicable for the Netherlands.

Trends in cattle EFs

Table 5.3 shows the EFs of the different cattle categories that are reported, including the subdivision into the NW and SE regions for mature dairy cattle. The EF for growing cattle is a weighted average calculated from several sub-categories (Van Bruggen et al., 2017).

Table 5.3 EFs for methane emissions from enteric fermentation specified according to CRF animal category (kg CH_4/animal/year).

	1990	**1995**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**
Mature dairy cattle	110.3	114.3	119.9	124.9	128.1	128.1	127.2	129.1
of which NW region	110.9	115.3	121.6	126.3	129.9	130.5	129.4	131.2
of which SE region	109.9	113.5	118.4	123.6	126.8	126.5	125.6	127.6
Other mature cattle	70.3	71.3	72.1	76.7	78.1	78.6	79.1	79.1
Growing cattle	38.3	38.6	35.4	34.4	35.0	35.4	35.9	36.4

For both mature dairy cattle and other mature cattle, EFs increased primarily as a result of an increase in total feed intake during the period 1990–2015. For mature dairy cattle, a change in the feed nutrient composition partly counteracted this effect (see Section 5.2.2). For growing cattle, the decrease of EF between 1990 and 2015 can be explained by a decrease in the average total feed intake due to an increased share of veal calves in the population of growing cattle.

Comparison of cattle EFs with IPCC defaults

Table 5.4 shows that the mature dairy cattle EF follows the increasing trend in milk production per cow. The default IPCC EF is 117 kg CH_4 per cow per year at a milk production rate of 6,000 kg/cow/year. The average milk yield in the Netherlands is higher than the IPCC default. Corrected for a cow with a milk yield of 6,000 kg, the Dutch would have been (129/8,338)*6,000 = 93 kg CH_4 per cow per year at a milk production of 6,000 kg/cow/year. An explanation of the difference can be found in the country-specific data on feed intake, dietary composition and the nutrient composition of dietary components as input to the Tier 3 approach that predicts the methane EF for mature dairy cattle (Bannink, 2011).

Table 5.4 Milk production (kg milk/cow/year) and EF (kg CH_4/cow/year) for mature dairy cattle.

	1990	1995	2000	2005	2010	2013	2014	2015
Milk production	6,003	6,596	7,416	7,568	8,075	7,990	8,052	8,338
IEF for methane	110	114	120	125	128	128	127	129

With increasing milk production per cow, a decrease in CH_4 emissions per unit of milk produced (from 0.018 to 0.015 kg CH_4/kg milk) is seen.

The higher EF for other mature cattle compared with the IPCC default value is explained by the higher total feed intake per other mature cow in the Netherlands. The relatively large share of calves for veal production explains the relatively low EF for growing cattle compared with the IPCC default value.

Other livestock

For swine, sheep, goats, horses and mules and asses the IPCC default EFs are used (1.5, 8, 5, 10 and 18 kg CH_4/animal, respectively). According to the IPCC Guidelines, no Tier 2 method is needed if the share of a source category is less than 25% of the total emission from a key source category. The animal categories sheep, goats, horses, mules and asses, and swine all have a share in total CH_4 emissions from enteric fermentation of less than 10%. As the Tier 1 EFs are averages over all age groups, they must be multiplied with the total number of animals in the respective categories. This differs from the method used for manure management, where excretion by young and adult male animals is included in that of adult female animals. Changes in emissions from these animal categories are explained entirely by changes in livestock numbers.

A detailed description of the method, data sources and EFs is given in chapter 2 of the methodology report (Vonk et al., 2016). In 2009 a recalculation was carried out with regard to feed intake and the resulting cattle EFs for the whole time series (CBS, 2012; Bannink, 2011). During the establishment of splitting the single category ‘mature dairy cattle’ into the NW and SE regions of the Netherlands, some small deviations from basic data on the chemical composition of feed components were corrected (Van Bruggen et al., 2014).

Emissions from enteric fermentation are calculated from activity data on animal numbers and the appropriate EFs:

CH_4 emission = ΣEF_i (kg CH_4/animal$_i$) * [number of animals for livestock category i]

5.2.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis explained in Annex 2 provides estimates of uncertainty according to IPCC source categories. The uncertainty of CH_4 emissions from enteric fermentation in mature dairy cattle is based on the judgements of experts, and is estimated to be approximately 16% in annual emissions, using a 5% uncertainty for animal numbers (Olivier et al., 2009) and a 15% uncertainty for the EF (Bannink, 2011). For the other cattle categories, the uncertainty in emissions is 21%, based on 5% uncertainty in activity data and 20% in the EF. The uncertainty in the EFs for swine and all other animal categories is estimated to be 50% and 30%, respectively (Olivier et al., 2009)

Time series consistency

A consistent methodology is used throughout the time series; see Section 5.2.2. Emissions are calculated as the product of livestock numbers and EFs. The livestock numbers were collected in an annual census and published by Statistics Netherlands. Consistent methods are used in compiling the census to ensure continuity in the collected data. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected through an annual survey.

5.2.4 *Source-specific QA/QC and verification*

This source category is covered by the general QA/QC procedures discussed in Chapter 1.

5.2.5 *Source-specific recalculations*

No source-specific recalculations were carried out in this source category.

5.2.6 *Source-specific planned improvements*

No improvements are planned for this source category.

5.3 Manure management (3B)

5.3.1 *Category description*

Both CH_4 and N_2O are emitted during the handling and storage of manure from cattle, swine, poultry, sheep, goats, horses, mules and asses, and other livestock (rabbits and mink). These emissions are related to the quantity and composition of the manure, and to the different types of manure management systems used. For instance, aerobic conditions in a manure management system will generally increase N_2O emissions and decrease CH_4 emissions compared to an anaerobic situation. A longer storage time and higher temperature will increase CH_4 emissions.

Three different manure management systems were used in the Netherlands and included in emission estimation for CH_4 and N_2O emissions:

- liquid manure management systems
- solid manure management systems

- manure produced on pasture land while grazing

In accordance with IPCC Guidelines N_2O emissions from manure produced on pasture during grazing are not taken into account in source category 3B Manure management, but are included in source category 3D Agricultural soils (see Section 5.4).

5.3.2 Methodological issues

Overview of shares and trends in emissions

In 2015 CH_4 from manure management accounted for 23% of the total greenhouse gas emissions of the Agriculture sector. In the Netherlands CH_4 emissions from manure management are particularly related to cattle and swine manure management. Cattle and swine manure management contributed 12% and 11% respectively to the total greenhouse gas emissions of the Agriculture sector in 2015. Poultry is a minor key source of CH_4 emissions from manure management based on trend (-84% from 1990 to 2015).
In 2015 N_2O emissions from manure management contribute 4% to the total greenhouse gas emissions of the Agriculture sector.

CH_4 from manure management

Between 1990 and 2015, emissions of CH_4 from manure management decreased with 23%. Emissions from cattle increased by 24%, while swine and poultry emissions decreased by 40% and 84% during this period. With an increasing percentage of cattle kept indoors, a larger proportion of the manure is excreted inside animal housing facilities with higher EFs compared to excretion on pasture. In cattle emissions decreased due to lower livestock numbers; this outweighs the small increase in EF.

In poultry the large decrease is associated with changing housing systems. Battery cage systems with liquid manure are changed to floor housing systems or aviary systems with solid manure with lower EF.

The decreasing volatile solid (VS) excretions for swine (Van Bruggen et al., 2017) resulted in a decreasing trend in CH_4 emissions from swine during the time series. The decrease was somewhat softened by an increase in livestock numbers and an increase in the methane conversion factor (Van der Hoek and Van Schijndel, 2006). The methane conversion factor (MCF) increased due to a larger fraction of manure stored under higher temperatures, i.e. inside animal housing.

N_2O from manure management

Direct N_2O emissions from manure management decreased with 15% between 1990 and 2015. Decreasing livestock numbers and lower N excretions per animal are the main cause of this trend. Indirect N_2O emissions following atmospheric deposition of NH_3 and NO_x emitted during the handling of animal manure decreased from 0.4 to 0.2 Mton CO_2 eq (-44%) between 1990 and 2015. This decrease is explained by reduction measures for NH_3 and NO_x emissions from animal housing systems and manure storages over the years.
N_2O emissions from manure management increased slightly with 10 kton CO_2 eq (2%) from 2014 to 2015 due to an increase in livestock numbers.

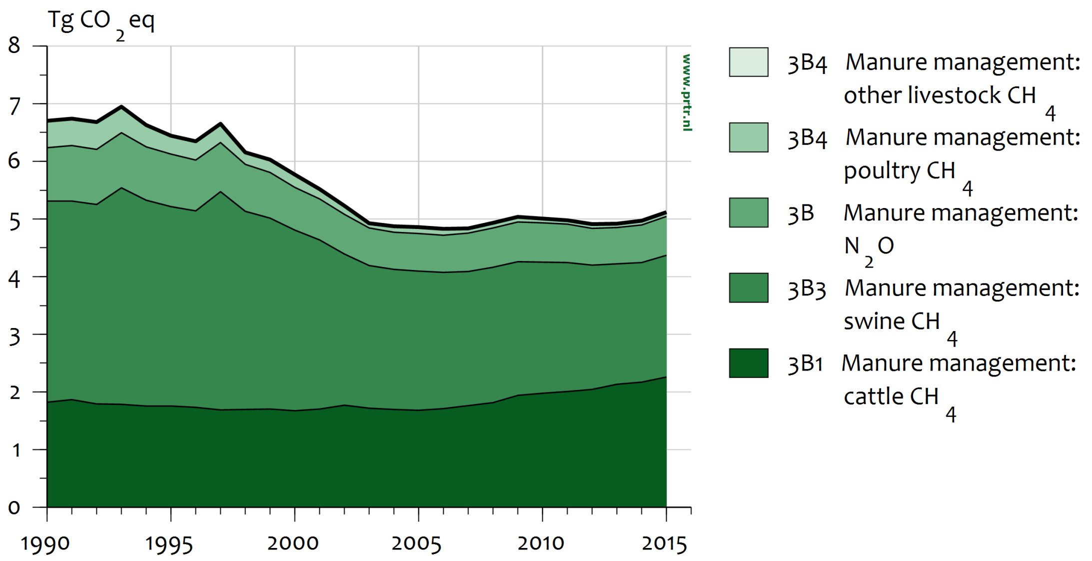


Figure 5.2 Category 3B Manure management: trend and emissions levels of source categories, 1990–2015.

Activity data and (implied) EFs
Detailed information on data sources for activity data and EFs is found in chapters 3 (CH_4) and 6 (N_2O) of the methodology report (Vonk et al., 2016). Table 5.2 presents an overview of the animal numbers, in the background document of Van Bruggen et al. (2017) more detailed information on livestock numbers is given. Van Bruggen et al. (2017) also includes more detailed information used for the calculation and resulting CH_4 EFs.

CH_4 IEF for manure management
A country-specific Tier 2 approach is used to calculate CH_4 EFs for manure management annually. The EFs are calculated for liquid and solid manure management systems within the key animal categories cattle, swine and poultry and where applicable, for the manure produced on pasture during grazing. These calculations are based on country-specific data on:

- Manure characteristics: volatile solids excretion (VS, in kg) and maximum CH_4 producing potential (B0, in m^3 CH_4/kg VS);
- Manure management system conditions (storage temperature and period) for liquid manure systems, which determine the MCF.

In formula: EF = VS * B0 * MCF * 0.67

Where:
0.67 = specific weight of methane, kg per m^3

In the Netherlands animal manure is stored in pits underneath the slatted floors of animal housing facilities. Regularly, liquid manure is pumped into outside storage facilities or spread on the land. Given this practice, country-specific MCF values were calculated, as demonstrated in Van der Hoek and Van Schijndel (2006). For solid manure systems and manure produced on pasture while grazing, IPCC default values are used. The IPCC Guidelines recommend an MCF value of 0.02 for stored solid cattle and swine manure, MCF = 0.015 for stored solid poultry manure, and a value of 0.01 for manure produced on pasture during grazing.

For comparison, Table 5.5 shows the IEFs for manure management per animal category. These are expressed in kg CH_4 per animal per year and are calculated by dividing total emissions by livestock numbers in a given category.

Table 5.5 CH_4 implied emission factor (kg/animal/year) for manure management specified by animal category, 1990–2015.

Animal type	1990	1995	2000	2005	2010	2013	2014	2015
Cattle								
- mature dairy cattle	26,2	27,4	31.8	35.3	40.2	41.4	41.5	42.2
- other mature cattle	8.4	8.6	8.5	8.9	9.1	9.1	9.1	9.1
- growing cattle	7.8	7.9	7.3	6.9	7.8	8.6	8.6	8.7
Sheep	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Goats	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Horses	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Mules and asses	NO	NO	NO	NO	0.8	0.8	0.8	0.8
Swine*	10.0	9.6	9.6	8.5	7.4	6.8	6.8	6.7
Swine excl. piglets	16.0	15.7	15.7	14.3	12.8	12.0	12.1	12.1
- fattening pigs	13.3	13.0	12.8	11.5	10.3	9.5	9.5	9.5
- breeding swine	27.0	27.5	28.0	26.7	24.7	24.2	24.2	24.3
Poultry	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Other livestock	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5

* The IEF is calculated on total pig numbers. including piglets. Manure production by piglets is accounted for in manure production by adult breeding swine.

Trends in IEF

Mature dairy cattle

The IEF for the manure management of mature dairy cattle increased between 1990 and 2015 due to increased volatile solid (VS) production per cow. Also the shift in the proportion of the two main manure management systems used in dairy farming (liquid manure in the animal house and manure production on pasture) contributed to the increased IEF. The share of liquid manure increased between 1990 and 2015, compared to the amount of manure produced on pasture (Van Bruggen et al., 2017). There has been a shift from unlimited grazing towards daytime grazing and more dairy cows were kept indoors all year round to maximize grassland production and resulting animal production. Because of the higher EF for CH_4 emission from manure inside animal housing facilities compared to manure on pasture, this new practice of keeping herds in animal housing throughout the year increased the methane emission per animal (Van Bruggen, et al, 2017; Van der Hoek and Van Schijndel, 2006).

Poultry

In poultry the substantial decrease in CH_4 emissions is explained by a shift in the proportion of the two poultry manure management systems (solid and liquid manure) between 1990 and 2015. The proportion of the solid manure system increased from approximately 75% to 100% as the liquid manure system was fully replaced by the solid manure system.

The CH_4 EF for solid manure systems is 25 to 35 times lower than the EF for liquid manure systems, depending on the housing system (Van Bruggen et al., 2017). The increase in poultry numbers with 10% since 1990 is counteracted by the shift towards solid manure management systems leading to an overall decrease in CH_4 emissions of poultry (Van der Hoek and Van Schijndel, 2006).

Swine
Between 1990 and 2015, the IEF of swine manure management (based on total swine numbers, including piglets) decreased in line with lower VS excretions per animal. The decrease in VS excretion per animal counteracts the increase in animal numbers. As a result of increased storage capacity below animal housing (thus storing manure at higher temperatures), MCF values increased from 1993 onwards.

All other animal categories
Sheep, goats, horses and mules and asses produce only solid manure which has a low EF. Therefore the IEFs are also small, these represent the IPCC Tier 1 defaults. In the category 'other livestock' rabbits (solid manure) and minks (liquid manure) are included. The resulting IEF for this category therefore largely depended on the ratio between the two species in a given year. As rabbit numbers decreased and mink numbers increased over the entire time period, the CH_4 IEF increased because a larger proportion of the manure consisted of liquid manure with a higher EF.

Comparison with IPCC default EF for methane
The methods applied by the Netherlands for CH_4 calculations are in accordance with the IPCC Guidelines. For the key categories cattle, swine and poultry a Tier 2 approach is used to calculate CH_4 emissions from manure management. The amount of volatile solids (VS) produced per animal is calculated annually, based on feed intake and VS digestibility. The emission is then calculated by multiplying the respective MCF and B0 values. For all other animal categories emissions are estimated using a Tier 1 approach. Detailed descriptions of the methods are given in the methodology report (Vonk et al., 2016). More specified data on manure management based on statistical information on manure management systems is documented in Van der Hoek and Van Schijndel (2006) and in Van Bruggen et al. (2017).

The Netherlands' MCF values for liquid manure systems are equal to the IPCC default MCF values for cattle, but higher for swine, following the research of Zeeman (1994). For solid manure systems and for manure production on pasture, the Netherlands uses the IPCC default MCF values.

N_2O IEF for manure management
Emissions of N_2O from manure management are calculated using the 2006 IPCC default EFs. For liquid manure the IPCC default of 0.002 kg N_2O per kg N excreted is used ('Pit storage below animal confinements') and for solid manure management systems 0.005 kg N_2O per kg N excreted ('Solid storage') is used for the animal categories cattle, swine, sheep, horses, mules and asses and 'other animals'. For poultry manure the default value of 0.001 kg N_2O per kg N excreted ('Poultry manure

with/without litter') is used. For goat manure the default value of 0.01 kg N_2O per kg N excreted ('Cattle and swine deep bedding') is used.

Table 5.6 N_2O IEFs for manure management and total N excretion per management system, 1990–2015 (mln kg/year and kg N_2O/kg manure).

	1990	1995	2000	2005	2010	2013	2014	2015
Total N-excretion	514.5	516.1	432.5	393.5	423.3	419.6	433.3	447.6
liquid system	*410.8*	*410.7*	*337.3*	*304.9*	*326.7*	*327.1*	*338.7*	*350.4*
solid storage	*103.7*	*105.4*	*95.1*	*88.6*	*96.6*	*92.5*	*94.6*	*97.1*
N_2O emission manure management	1.8	1.8	1.5	1.3	1.4	1.4	1.5	1.5
N_2O IEF manure management	0.0035	0.0034	0.0034	0.0034	0.0033	0.0034	0.0034	0.0034

Please note note that the emissions of N_2O from manure management are calculated from the total amounts of stored liquid and solid manure, without distinction between the animal species of origin. Therefore the emissions cannot be allocated to specific animal categories. The N_2O emission from all liquid and solid manure stored is allocated to sector 3.B.2.4 Other.
As presented in Table 5.6 the N_2O emissions from manure management decreased between 1990 and 2015 due to a decreased total N-excretion. The increase between 2013 and 2015 is a result from increased N excretion, caused by increased livestock numbers and higher N excretion factors mainly in dairy cattle.

Comparison with IPCC default EF for nitrous oxide
For the relevant manure management systems and animal categories, the total N content of the manure is calculated by multiplying N excretion (kg/year/head) with livestock numbers. Activity data was collected in compliance with a Tier 2 method. The N_2O EFs used for liquid and solid manure management systems are IPCC defaults. The method used complies with the 2006 IPCC Guidelines. N_2O emissions from manure produced on pasture during grazing are not taken into account in the source category manure management; in accordance with the IPCC Guidelines, this source is included in the source category Agricultural soils (see Sections 5.1 and 5.4).

5.3.3 *Uncertainty and time series consistency*

Uncertainty
The Tier 1 uncertainty analysis detailed in Annex 2 provides estimates of uncertainty according to IPCC source categories. The uncertainty in the annual CH_4 and N_2O emissions from manure management is estimated to be approximately 100%. The uncertainty in the amount of animal manure (10%) is based on a 5% uncertainty in livestock numbers and a 5–10% uncertainty in manure production per animal. The resulting uncertainty of 7–11% is rounded off to 10%. The uncertainty in the CH_4 EFs for manure management, based on expert judgement, is estimated to be 100% (Olivier et al., 2009).

Time series consistency
A consistent methodology is used throughout the time series; see Section 5.3.2. Emissions are calculated from animal population data and EFs. The animal population data is collected in an annual census and

published by Statistics Netherlands. Consistent methods are used in compiling the census to ensure continuity in the collected data. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected through an annual survey.

5.3.4 *Source-specific QA/QC*

This source category is covered by the general QA/QC procedures discussed in Chapter 1.

5.3.5 *Source-specific recalculations*

No source-specific recalculations were carried out in this source category.

5.3.6 *Source-specific planned improvements*

A technical measure to prevent methane emissions caused by manure management is manure treatment in an anaerobic digester. In 2014, 2% of the total amount of manure in animal housing was treated in an anaerobic digester. The Netherlands is examining future needs and possibilities in this area to include anaerobic treatment in the methodology and to extend calculations. Results of initial research (Hoeksma et al., 2012) make it clear that further investigation is needed.

Maximum methane production potential (B0) and methane conversion factor (MCF) are currently reconsidered. Based on the results of a study of Groenestein et al. (2016) the currently used B0 and MCF will be updated in the NIR2018.

N-excretions of cattle categories are currently reconsidered, which might lead to a change in N_2O emissions to be reported in the NIR2018.

5.4 Agricultural soils (3D)

5.4.1 *Category description*

In the Netherlands this category consists of the following N_2O source categories:

- Direct soil emissions from the application of synthetic N-fertilizers (3Da1)
- Direct soil emissions from the application of organic N-fertilizers, i.e. animal manure, sewage sludge and compost (3Da2)
- Urine and dung deposited by grazing animals (3Da3)
- Crop residues (3Da4)
- Cultivation of organic soils (histosols; 3Da6)
- Indirect emissions from atmospheric deposition (3Db1)
- Indirect emissions from nitrogen leaching and run-off (3Db2)

Methane emissions from agricultural soils are regarded as natural, non-anthropogenic emissions and are therefore not estimated.

5.4.2 *Methodological issues*

In 2015 agricultural soils were responsible for 28% of the total greenhouse gas emissions in the Agriculture sector. Total N_2O emissions from agricultural soils decreased by 40% between 1990 and 2015 (see Figure 6.3). The decrease in N_2O emissions was caused by a relatively large decrease in N input into soil (from organic and synthetic N-fertilizer application and production of animal manure on pasture during grazing). This was partly counteracted by an increased IEF in this period, caused by a shift from applying manure on top of the soil (surface spreading) towards incorporation of manure into the soil, initiated by the Dutch ammonia policy. Incorporation of manure into the soils reduces emission of ammonia but increases emission of N_2O.

In 2015 the area of renovated grassland decreased from 2.1% in 2014 to 1.2%. This caused a 40% decrease in N_2O emission from renovated grassland in 2015 (23 kton CO_2 eq) compared to 2014 (38 kton CO_2 eq). An increase in the amount of applied synthetic N-fertilizer caused a 15% increase in N_2O emissions from synthetic N-fertilizers in 2015 compared with 2014.

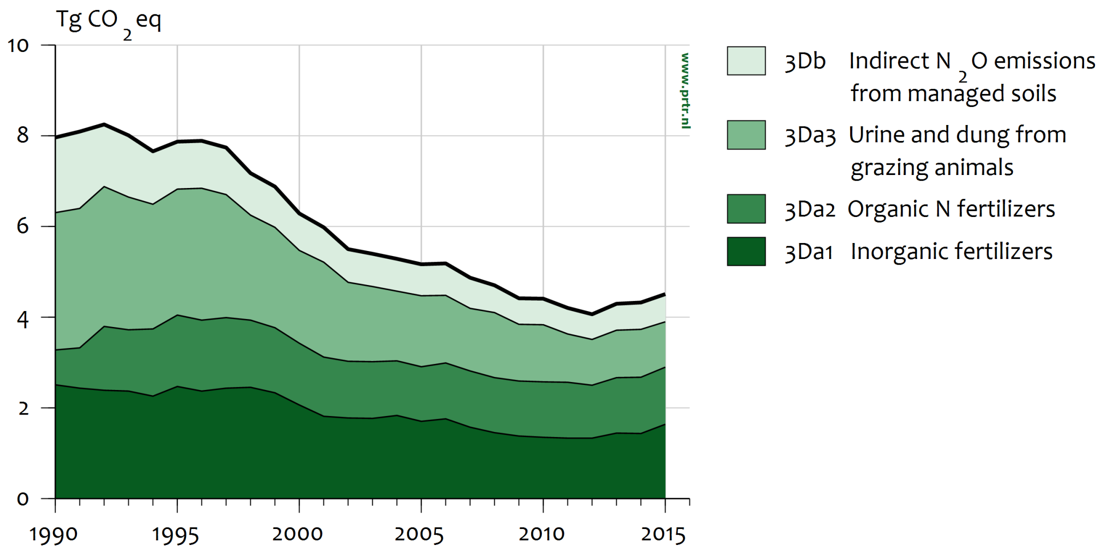


Figure 5.3 Category 3D Agricultural soils: trend and emissions levels of source categories, 1990–2015.

Key sources
Direct N_2O soil emissions from managed agricultural soils is a level and trend key source. Indirect N_2O soil emissions is a trend and Tier 2 level key source.

Activity data and (implied) EFs
Calculations of N_2O emissions from agricultural soils are based on a variety of activity data, including manure production (calculated as described in Section 5.3) and statistics on synthetic N-fertilizer application, compost and sewage sludge use, crop area and cultivated organic soil area. For an overview of data sources, see the methodology report (Vonk et al., 2016) or the background document Van der Hoek et al. (2007). The activity data and characteristics for crops are presented in Van Bruggen et al. (2017).

Nitrogen flows
In Figure 5.4 a schematic representation of N flows and the resulting emissions from agriculture is shown. Gross amounts are used

throughout, i.e. emissions of various N substances from a given source are calculated using the same basic nitrogen amount. For instance, with N excretion in animal housing, losses in the form of ammonia, nitric oxide, nitrogen gas and nitrous oxide are all relative to the amount of N excreted. Only at the end of the calculation the combined loss is subtracted in order to yield the remaining N available for application.

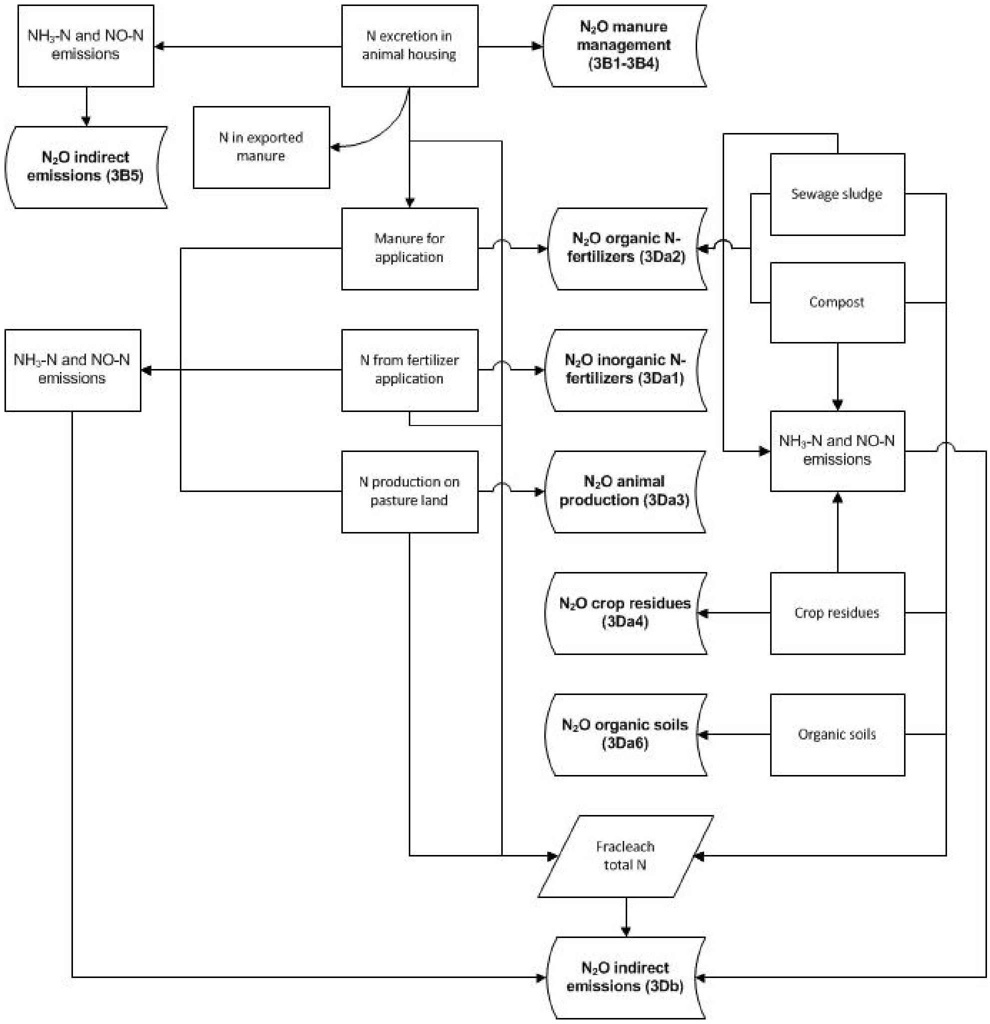


Figure 5.4 Schematic representation of N flows in agriculture and the allocation of emissions to source categories

Between 68% and 80% of the N excreted in animal housing is eventually applied to soils. A growing proportion of the manure N (from 1% in 1990 to 12% in 2015) is exported; while approximately 9–17% is emitted as ammonia or nitrous oxide during storage. Other N losses, mainly N_2 and NO, account for the remaining difference. The other N losses in kg N increased since 1990 due to an increase in amount of rinsing liquid from air scrubbers and due to an increase in free range housing systems for laying hens.

Of the manure N applied to the soil between 1990 and 2015, the part emitted as ammonia (NH_3) decreased from 44% to 11%, due to changes in the application methods of manure. Before 1991, manure was applied by surface spreading on both grassland and arable land. In accordance with the Netherlands' policy to reduce ammonia emissions, this practice changed in 1991, shifting to manure incorporation into the soil (e.g. shallow injection or ploughing-in), resulting in lower NH_3 emissions. Ultimately, between 1990 and 2015, NH_3-N emission (from animal housing, storage, grazing and application to the field) decreased from approximately 39% to 16% of total N in manure. In combination with lower synthetic N-fertilizer application (-36%) and lower nitrogen excretion by animals (-28%), this resulted in a reduction of 67% in the amount of N deposited atmospherically over the 1990–2015 period.

To calculate leaching and run-off, the total nitrogen supply to soil was taken into account: manure production in animal housing and on pasture, and application of synthetic N-fertilizer, sewage sludge and compost, corrected for the net export of manure.
In accordance with the 2006 IPCC Guidelines, no correction is made for N emissions since, after atmospheric deposition, this will also be subject to leaching and run-off. Total N supply to the soil decreased by 37% between 1990 and 2015. This can be explained by the Netherlands' manure and fertilizer policy, aimed at reducing N leaching and run-off. This policy regulates the amount of manure production and its application by the introduction of measures, such as restrictions on the numbers of swine and poultry per farm (so called 'manure production rights') and maximum application limits for manure and synthetic N-fertilizer. Since the leaching fraction has also decreased over time, the amount of nitrogen leached or run off has been reduced by 43% since 1990.

Emission factors
For inorganic N-fertilizer application the EF for direct N_2O emissions from agricultural soils is based on a weighted mean of different inorganic N-fertilizer types applied on both mineral and organic soils. The EFs for the application of animal manure or manure produced on pasture land during grazing are also based on weighted means of those two soil types. As arable farming hardly ever occurs on organic soils in the Netherlands, the EF for crop residues is based on mineral soils only. An overview of the EFs used is presented in Table 5.7, with default IPCC EFs included for comparison.

Table 5.7 EFs for direct N_2O emissions from soils (kg N_2O-N per kg N supplied).

Source	Default IPCC	EF used	Reference
Synthetic N-fertilizer	0.01	0.013	1
Animal manure application	0.01		
Surface spreading		0.004	1
Incorporation into soil		0.009	1
Sewage sludge	0.01		
Surface spreading		0.004	1
Incorporation into soil		0.009	1
Compost	0.01	0.004	
Crop residues	0.01	0.01	2
Cultivation of organic soils		0.02	2,3

Source	Default IPCC	EF used	Reference
Animal manure during grazing (cattle/swine/poultry)	0.02	0.033	1
Animal manure during grazing (sheep/other animals)	0.01	0.033	1

References 1 = Velthof et al., 2010; Velthof and Mosquera, 2011; Van Schijndel and Van der Sluis, 2011; 2 = Van der Hoek et al., 2007; 3 = Kuikman et al., 2005.

Implied EF
Table 5.8 shows the IEFs for direct N_2O emissions from agricultural soils for the application of animal manure. A 116% increase in IEF occurred in the period 1990–2015, which was caused by an ammonia policy-driven shift from the surface spreading of manure to the incorporation of manure into the soil. Combined with a 25% decrease in N manure input to soil, this explains the 63% increase in N_2O after manure application.

The net decrease in direct N_2O emissions can be explained by the decrease in the direct N input to the soil by manure and synthetic N-fertilizer application, partly countered by an increase in IEF because of the incorporation into soil.

Table 5.8 N_2O IEFs from animal manure applied to agricultural soils (kg N/kg N-input).

	1990	1995	2000	2005	2010	2013	2014	2015
IEF from manure applied to soils	0.004	0.008	0.009	0.009	0.009	0.009	0.009	0.009

Methodological issues
Direct and indirect N_2O emissions from agricultural soils, as well as N_2O emissions from urine and dung deposited by grazing, are estimated using country-specific activity data on N input to soil and NH_3 volatilization during grazing, manure management and manure application. Most of this data is estimated at a Tier 2 or Tier 3 level. The present methodologies comply with the 2006 IPCC Guidelines.
A description of the methodologies and data sources used is presented in Vonk et al. (2016).

Direct N_2O emissions
An IPCC Tier 1b/2 methodology is used to estimate direct N_2O emissions from agricultural soils. Emissions from animal manure application are estimated for two manure application methods: surface spreading (with a lower EF) and incorporation into soil (with a higher EF). The higher value for incorporation is explained by two mechanisms. Incorporation of animal manure into the soil produces less ammonia; therefore, more reactive nitrogen enters the soil available for N_2O emission. Furthermore, the manure is more concentrated (i.e. hot spots) than with surface spreading generally creating improving conditions for nitrification and denitrification processes.

Since 2010, calculations are made on gross N flows instead of net N flows to increase transparency. At the same time, EFs are updated based on laboratory and field experiments quantifying the effect of a manure application technique on N_2O emission (Velthof et al., 2010; Velthof and Mosquera, 2011; Van Schijndel and Van der Sluis, 2011).

Urine and dung deposited by grazing animals
An IPCC Tier 1b/2 methodology is used to estimate direct N_2O emissions from urine and dung deposited by grazing animals. The method calculates the total N excreted during grazing, multiplied by a country-specific EF to yield the emissions figure; see Section 5.3.2.

Indirect N_2O emissions
An IPCC Tier 1 method is used to estimate indirect N_2O emissions from atmospheric deposition. Country-specific data on NH_3 and NO_x emissions (estimated at a Tier 3 level) are multiplied by the IPCC default N_2O EF.

Indirect N_2O emissions resulting from leaching and run-off are estimated using country-specific data on total N input to soil and leaching fraction (estimated at a Tier 3 level). The difference in '$frac_{leach}$' is justified due to specific characteristics of the Netherlands' agricultural soils, with relatively high water tables. A model (STONE) was adopted to assess this fraction, as described in Velthof and Mosquera (2011), with IPCC default values used for the N_2O EF.

In the Netherlands, no experimental data is available to evaluate the value of the EFs for indirect emissions.

5.4.3 *Uncertainty and time series consistency*

Uncertainty
The Tier 1 uncertainty analysis, outlined in Annex 2, provides estimates of uncertainty by IPCC source category. The uncertainty in direct N_2O emissions from agricultural soils is estimated to be approximately 60%. The uncertainty in indirect N_2O emissions from N used in agriculture is estimated to be more than a factor of 2 (Olivier et al., 2009).

Time series consistency
A consistent methodology is used throughout the time series; see Section 5.4.2. Emissions are calculated as te product of livestock numbers and EFs. The livestock numbers were collected in an annual census and published by Statistics Netherlands. Consistent methods are used in compiling the census to ensure continuity in the collected data.

5.4.4 *Source-specific QA/QC*

This source category is covered by the general QA/QC procedures discussed in Chapter 1.

5.4.5 *Source-specific recalculations*

N_2O emissions from below-ground crop residues are included in the calculation of emissions from source category 3Da4 to comply with the IPCC 2006 Guidelines. N_2O emissions from crop residues including below-ground crop residues are recalculated for the whole time series 1990-2014. Emissions of N_2O from crop residues therefore increased with 70 kton CO_2 eq (50%) in 1990 to 55 kton CO_2 eq (60%) in 2014.

The 2014 emissions from sewage sludge and compost and 2013 and 2014 emissions from synthetic N-fertilizer were recalculated because final activity data became available. Data on synthetic N-fertilizer use in the Netherland are not available on an annual basis. Whenever new statistics become available the years since the last statistics are recalculated. Therefore also indirect N_2O emissions from atmospheric deposition on agricultural soils are recalculated.

5.4.6 *Source-specific planned improvements*

The planned improvements mentioned in 5.3.6 may also lead to changes in N_2O emissions from category 3D Agricultural soils. This means N flows and thus N available for application might change, followed by an expected change in indirect emissions following atmospheric deposition of NH_3 and NO_x.

Ammonia emission from poulty housing is reconsidered in 2017 which may lead to changes in N flows affecting emissions in sector 3D.

5.5 Liming (3G)

5.5.1 *Category description*

The source category 3G (Liming) includes the emissions of CO_2 from the application of limestone (calcium carbonate) and dolomite (calcium-magnesium carbonate) to agricultural soils. Limestone and dolomite are applied to maintain a suitable pH range for crop- and grass production.

5.5.2 *Methodological issues*

Limestone and dolomite make up 40% to 60% of the calcium-containing fertilizers used in agriculture. The remaining percentage consists mainly (30%–55% of the total) of sugar beet factory lime. The CO_2 emissions related to the latter fertilizer are balanced by the CO_2-sink in sugar production and are therefore not accounted for. Over the 1990-2015 period, the amounts of limestone used increased with 24% and the amounts of dolomite decreased with 76%.

Overview of shares and trends in emissions

Sector 3G Liming is a key source based on trend. CO_2 emissions from liming decreased with 62% from 1990 to 2015 caused by a decrease in dolomite use which was partly counteracted by an increase in limestone use.

Table 5.9 CO_2 emissions from the use of limestone and dolomite in agriculture (kton CO_2).

	1990	1995	2000	2005	2010	2013	2014	2015
3G Liming	183	98	98	75	60	70	70	69

Activity data and EFs

Data on liming is derived from annually updated statistics on fertilizer use. The yearly amounts of applied limestone and dolomite are converted into carbon dioxide emissions in line with the calculations in the IPCC 2006 Guidelines.

Methodological issues

Limestone and dolomite amounts, reported in CaO (calcium oxide) equivalents, are multiplied by the EFs for limestone (440 kg CO_2/ton pure limestone) and for dolomite (477 kg CO_2/ton pure dolomite). This method complies with the IPCC Tier 1 methodology. More detailed descriptions of the methodologies and EFs used can be found in the methodology report of Vonk et al. (2016)

The activity data on lime fertilizer use were not available for 2013 and 2014. Therefore the 2012 emissions from liming were kept constant in 2013 and 2014.

5.5.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 analysis explained in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The uncertainty in the CO_2 emissions from Liming of soils is calculated to be 100%. The uncertainty in the activity data is estimated to be 10% and the uncertainty in the EFs is 100%. When considered over a longer time span, all carbon applied through liming is emitted.

Time series consistency

The methodology used to calculate CO_2 emissions from limestone and dolomite application for the period 1990–2015 is consistent over time. Statistics on synthetic fertilizer use are collected by Wageningen Economic Research and published on the website agrimatie.nl (direct link: http://agrimatie.nl/KunstMest.aspx?ID=16927).

5.5.4 *Source-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

5.5.5 *Source-specific recalculations*

No source-specific recalculations were carried out in this source category.

5.5.6 *Source-specific planned improvements*

No improvements are planned for this source category.

6 Land use, land use change and forestry (CRF sector 4)

Major changes in the LULUCF sector compared with the National Inventory Report 2016	
Emissions:	The CO_2 emissions from LULUCF for 2015 have slightly increased compared to the year 2014 (0.46 per cent).
Key sources:	No changes in key sources.
Methodologies:	This year a new approach was implemented for growth of newly established forests. In the default method that was used until the NIR 2016, carbon stock changes in newly established forests under land converted to forest land (L-FL) would follow a young forests' growth curve until reaching 20 years. Further assessment of forest inventory data showed that actual time to reach the carbon stock of the average forest is about 30 years. In the new method carbon stock changes in newly established forests follow a growth model in which the carbon stocks on these units of land will reach the carbon stocks of the average forest after 30 years.

6.1 Overview of sector

Overview and trends in the 2015 results

This chapter describes the 2015 greenhouse gas inventory for the Land use, land-use change and forestry (LULUCF) sector. It covers both the sources and sinks of CO_2 greenhouse gases from land use, land-use change and forestry. The emission of nitrous oxide (N_2O) from land use is included in the Agriculture sector (category 3.D) and the emission of methane (CH_4) from wetlands is not estimated due to the lack of data.

Land use in the Netherlands is dominated by agriculture (approximately 55 per cent), settlements (15 per cent) and forestry (10 per cent, including trees outside forests); 3 per cent comprises dunes, nature reserves, wildlife areas, heather and reed swamp. The remaining area (18 per cent) in the Netherlands is open water.
The soils in the Netherlands are dominated by mineral soils, mainly sandy soils and clay soils (of fluvial or marine origin). Organic soils, used mainly as meadowland or hayfields, cover about 11 per cent of the land area of which one third are peaty soils.

The Netherlands has an intensive agricultural system with high inputs of nutrients and organic matter. The majority of agricultural land is used as grassland (55 per cent) or arable farming (27 per cent). The remaining land is fallow or used for horticulture, fruit trees, etc. 71 per cent of grassland is permanent grassland (5 per cent of which are high nature value grasslands); the remaining 24 per cent is temporary grassland, on which grass and fodder maize are cultivated in rotation (source: Statistics Netherlands, CBS, December 2016). Since 1990, the agricultural land area has decreased by about 5 per cent, mainly because of the conversion to settlements / infrastructure and nature.

The LULUCF sector in the Netherlands is estimated to be a net source of CO_2, amounting in 2015 to 6.58 Tg CO_2 . (The recalculated value for 2014 is: 6.55 Tg CO_2, compared to 6.24 Tg CO_2 reported in the NIR2016). The total LULUCF sector (including N_2O emissions) counts for 3.3 per cent of total net greenhouse gas emissions in the Netherlands (see Table 6.2).

Methodology and coverage
The methodology of the Netherlands for assessing the emissions from LULUCF is based on the 2006 IPCC Guidelines (IPCC 2006) and follows a carbon stock change approach based on inventory data subdivided into appropriate pools and land-use types and a wall-to-wall approach for the estimation of area per category of land use.

The information on the activities and land-use categories used covers the entire territorial (land and water) surface area of the Netherlands. The inventory comprises six classes: Forest Land (4A); Cropland (4B); Grassland (4C); Wetlands (4D) (including open water); Settlements (4E) and Other Land (4F). There is also a category 'Harvested wood products' (HWP) (4G), providing information on carbon gains and losses from the HWP carbon pool. Emissions from land-use-related activities such as liming are reported under the agriculture sector (Category 3.G) in section 5.5. The changes in land use ('remaining' or 'converted') are presented in a 6 x 6 matrix, which is fully in accordance with the approach described in the 2006 IPCC guidelines. To better match available national maps and databases on land use, the category Grassland is the aggregation of the main subdivisions Grassland and grasslands in Nature. The subdivision Nature also includes heather, peat land and moors. All categories are relevant in the Netherlands. The carbon cycle of managed forests and wood production system is considered in the calculations of the relevant CO_2 emissions.
An overview of the completeness of reporting for the NIR of the Netherlands is provided in Table 6.1.

Table 6.1. Carbon stock changes reported in the National System per land use (conversion) category.

From → To↓	**FL**	**CL**	**GL**	**WL**	**Sett**	**OL**
FL	BG-BL+DW-FF	BG-BL+MS+OS	BG-BL+MS+OS	BG+MS	BG+MS+OS	BG+MS+OS
CL	BG-BL-DW-Litt+MS	OS	BG-BL+MS+OS	BG+MS	BG+MS+OS	BG+MS
GL	BG-BL-DW-Litt+MS+OS	BG-BL+MS+OS	-WF+OS	BG+MS+OS	BG+MS+OS	BG+MS+OS
WL	-BL-DW-Litt+MS+OS	-BL+ML+OS	-BL+MS+OS		+MS+OS	+MS+OS
Sett	-BL-DW-	-	-	+MS+OS	+OS	+MS+OS

From → To↓	FL	CL	GL	WL	Sett	OL
	Litt+MS+OS	BL+MS+OS	BL+MS+OS			
OL	-BL-DW-Litt+MS+OS	-BL+MS+OS	-BL+MS+OS	+MS+OS	+MS+OS	n.a.

Carbon stock changes included are: BG: Biomass Gain; BL: Biomass Loss; DW: Dead Wood; FF: Forest fires; WF: other wildfires; Litt: Litter; MS: Mineral Soils; OS: Organic Soils . Land use types are: FL: Forest Land; CL: Cropland; GL: Grassland; WL: Wetland; Sett: Settlement; OL: Other Land.

Carbon stock changes in mineral soils

The Netherlands developed a Tier 2 approach for carbon stock changes in mineral soils and for organic soils. For mineral soils the approach is based on the overlay of the land use maps with the Dutch soil map, combined with soil carbon stocks that were quantified for each land use-soil type combination. For organic soils the procedure is based on an overlay of a map with water level regimes and the soil map indicating the area with peat and peaty soils, combined with assumptions typically valid for agricultural peat and peaty soils in the Netherlands. Detailed information is provided in Arets et al. (2017).

For the Netherlands the basis for quantifying the carbon emissions from land-use changes on mineral soils is the LSK national sample survey of soil map units (Finke et al., 2001) for about 1,400 locations and at five different depths. The carbon stock in the upper 30 cm was measured (de Groot et al., 2005). The data were classified into 11 soil types and 4 land use categories (at the time of sampling, Lesschen et al., 2012). Samples were taken only on forest land, cropland and grassland. For conversions of land use involving other land uses, estimates were made using the 2006 IPCC guidelines. The assumptions were:

- For conversion to settlements: 50 per cent is paved and has a soil carbon stock of 80 per cent of that of the former land use, 50 per cent consists of grassland or wooded land with corresponding soil carbon stock.
- For wetlands converted to or from forest, no change in carbon stock is assumed.
- For other land, a carbon stock of zero is assumed conservatively.

The 2006 IPCC guidelines prescribe a transition period of 20 years in which the carbon stock changes take place. Such a 20-year transition period for carbon stock changes in mineral soils means that land-use changes in 1970 will still have a small effect on reported carbon stock changes in mineral soils in 1990. Here we implemented a transition period starting with 1990, as we do not have sufficient information on land-use changes before 1990. This means that we have ignored removals and emissions from land-use changes that took place before 1990.

Carbon stock changes in organic Soils

Based on the definition for organic soils in the 2006 IPCC guidelines, two types of organic soils are considered. These are peat soils, which have a peat layer of at least 40 cm within the first 120 cm, and, peaty soils, in Dutch called ‘moerige gronden’, which have a peat layer of 5-40 cm within the first 80 cm. Based on the available data sets, two different approaches for elaborating the emission factors for peat soils and for peaty soils have been developed.

For CO_2 emissions from cultivated organic soils the methodology is described in Kuikman et al. (2005). This method is based on subsidence as a consequence of oxidation of organic matter. The estimated total annual emission from cultivated soils were then converted to an annual emission factor per ha peat soil to report emissions from peat soils for land-use (change) categories involving Grassland, Cropland and Settlement.

For the peaty soils, another approach was used, based on a large data set of soil profile descriptions over time (de Vries et al., in press). From this data set the average loss rate of peat, was derived from the change in thickness of the peat layer over time. Detailed information on calculations for peat and peaty soils is provided in Arets et al. (2017).

Emissions and removals from drainage and rewetting and other management of organic soils
Carbon stock changes resulting from drainage are included in organic soils under the various land-use categories. Rewetting and other management does not occur in the Netherlands.

Direct nitrous oxide emissions from disturbance associated with land-use conversions
Nitrous oxide (N_2O) emissions from soils by disturbance associated with land-use conversions until 2012 only had to be calculated for land use conversions to cropland. From the 2013 NIR onwards these emissions are calculated for all land-use conversions using a Tier 2 methodology (see Arets et al., 2017). The default EF1 of 0.01 kg N_2O-N/kg N was used. For three aggregated soil types, average C:N ratios, based on measurements, were available and used (Arets et al., 2017). For all other aggregated soil types, we used the default C:N ratio of 15 (2006 IPCC guidelines p. 11.16). For aggregated soil types where conversion of land use led to a net gain of carbon, the nitrous oxide emission was set to zero.

Controlled biomass burning
Controlled biomass burning is reported as included elsewhere (IE) and not occurring (NO). The area and emissions of the occasional burning done as nature management are included under wild fires. Other controlled burning, such as the burning of harvest residues, is not allowed in the Netherlands (see Article 10.2 of 'Wet Milieubeheer' - the Environmental Protection Act).

Changes of this year and the recalculation for years reported earlier

Land converted to forest land
This year a new approach was implemented for assessing carbon stock changes in newly established forests. In the default method that was used until the NIR 2016, the carbon stock changes in newly established forests under *"land converted to forest land"* (L-FL) followed a young

forests' growth curve until reaching 20 years, after which these forests moved to the the category *"forest land remaining forest land"* (FL-FL) and assumed the carbon stock of the average forest under this category (see Arets et al, 2016). Because carbon stocks in new forests after 20 years were not yet at the level of the average forest under FL-FL, this difference in carbon stock just before and after transition to FL-FL would result in an additional carbon flux in the year of transition. Further assessment of forest inventory data showed that the actual time needed to reach the carbon stock of the average forest is about 30 years. Therefore, a new method was implemented in which the time of maturation is 30 years instead of 20 year, even though the transition from the category L-FL to the category FL-FL still occurs after the 20 years default period as required in the guidelines. In the new approach carbon stock on units of newly established forest land annually increase with the difference between the carbon stock at that time and the carbon stock of the average forest under FL-FL divided by the number of years left to reach an age of 30 years. This implies that the carbon accumulation in new forests depends on the carbon stock changes in the average forest. With this new method the total accumulation of carbon in newly established forest land over the first 30 years after establishment is similar, but more gradually distributed than in the old method (see Arets et al., 2017, for detailed information on the methodological background).
All data are recalculated for the period 1990-2014.

Forest Land remaining Forest Land
The new approach for calculating carbon stock changes in newly established units of forest land also has an effect on calculation of carbon stock changes in FL-FL. Newly established forest that reaches the 20 years age limit will be further reported under FL-FL, but the calculation of carbon stock changes on these units of Forest Land will still follow the approach for L-FL until the time since afforestation reaches 30 years. From that time onwards the forests will follow the regular method used to assess carbon stock changes in FL-FL.
As information on newly established forests is only available from the year 1990 onwards, this new approach results only in recalculated data for the period 2010-2014.

Additionally the model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory (NBI6 in 2013) was recalibrated to better reflect observed mortality patterns (Arets et al., 2017). As a consequence net changes in carbon stocks in these forests for the years 2013 and 2014 were estimated to be smaller than in the previous submissions. Changes in carbon stocks will be updated again once a new National Forest Inventarisation (NFI) becomes available, which is expected by 2021.

Other categories
These changes in both newly established forests and forests remaining forests will affect emissions and removals in all categories in which biomass from Forest Land is included from 2010 onwards, i.e. FL converted to other land use categories, emissions from wildfires and harvested wood products (HWP). HWP is affected because different

calculated amounts of wood will become available from deforestation, which is included in HWP assuming instantaneous oxidation.

Contribution of the sector to GHG emissions and removals
Table 6.2 shows the sources and sinks in the LULUCF sector in 1990, 2014 and 2015. For 1990 and 2015, the total net emissions are estimated to be approximately 6.05 Tg CO_2 eq. and 6.58 Tg CO_2 eq., respectively. The results for 2014 are added to review annual changes. Sector 4 (LULUCF) accounted for about 3.3 per cent of total national CO_2 eq. emissions in 2015.

CO_2 emissions from the decrease in carbon stored in peat soils and peaty soils were the major source in the LULUCF sector, which totals to 6.16 Tg CO_2. This peat oxidation is due to agricultural and water management and contributes for the larger part to the result of 4C (Grassland).

The major sink is the storage of carbon in forests: -2.44 Tg CO_2, which includes emissions from Forest land remaining forest land (4A1) and Land converted to forest land (4A2).

Table 6.2 Contribution of main categories and key sources in sector 4 LULUCF

Sector/ category	**Gas**	**Key**	**Emissions in Tg CO_2 eq**				**Contribution to total in 2015 (%)**		
			Base-year	**2014**	**2015**	**Absolute 2015 - 2014**	**by sector**	**of total gas**	**of total CO_2 eq**
4. Total Land use Categories	CO_2	-	6.05	6.55	6.58	0.03	98.1	3.83	3.26
	CH_4	non key	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	N_2O	-	0.01	0.12	0.13	0.01	1.93	1.53	0.06
	All	-	6.06	6.67	6.71	0.04	100.0	3.33	3.33
4A. Forest land	CO_2	L2, T2	-1.91	-2.39	-2.43	-0.04	-36.27	-1.42	-1.21
4A1. Forest land remaining Forest Land	CO_2	-	-1.95	-1.69	-1.71	-0.02	-25.42	-0.99	-0.85
4A2. Land converted to Forest Land	CO_2	-	0.04	-0.70	-0.73	-0.02	-10.85	-0.42	-0.36
4B. Cropland	CO_2	L2, T2	1.64	2.60	2.67	0.06	39.73	1.55	1.32
4B1. Cropland remaining Cropland	CO_2	-	1.47	0.82	0.79	-0.03	11.83	0.46	0.39
4B2. Land converted to Cropland	CO_2	-	0.17	1.78	1.87	0.09	27.90	1.09	0.93

Sector/ category	Gas	Key	Emissions in Tg CO_2 eq				Contribution to total in 2015 (%)		
			Base-year	2014	2015	Absolute 2015 - 2014	by sector	of total gas	of total CO_2 eq
4C. Grassland	CO_2	L2, T2	5.48	4.45	4.42	-0.03	65.86	2.57	2.19
4C1. Grassland remaining Grassland	CO_2	-	5.20	4.02	3.96	-0.06	59.02	2.31	1.96
4C2. Land converted to Grassland	CO_2	-	0.29	0.43	0.46	0.03	6.85	0.27	0.23
4D. Wetlands	CO_2	non key	0.09	0.07	0.06	0.00	0.95	0.04	0.03
4D1. Wetlands remaining Wetlands	CO_2	-	NO,NE,IE	0.00	0.00	0.00	-0.01	0.00	0.00
4D2. Land converted to Wetlands	CO_2	-	0.09	0.07	0.06	0.00	0.96	0.04	0.03
4E. Settlements	CO_2	L2, T2	0.89	1.62	1.65	0.03	24.58	0.96	0.82
4E1. Settlements remaining Settlements	CO_2	-	0.38	0.39	0.40	0.01	5.95	0.23	0.20
4E2. Land converted to Settlements	CO_2	-	0.51	1.23	1.25	0.02	18.63	0.73	0.62
4F. Other land	CO_2	non key	0.03	0.12	0.13	0.00	1.88	0.07	0.06
4F1. Other land remaing other Land	CO_2	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4F2. Land converted to Other Land	CO_2	-	0.03	0.12	0.13	0.00	1.88	0.07	0.06
4G. Harvested wood products	CO_2	non key	-0.16	0.08	0.09	0.01	1.32	0.05	0.04

The methodologies applied for estimating CO_2 emissions and removals of the land-use change and forestry sector in the Netherlands are described in a methodological background document (Arets et al., 2017).

6.2 Land use definitions and the classification systems used and their correspondence to the land use, land use change and forestry categories

The Netherlands has defined the different land use categories in line with the descriptions given in the 2006 IPCC guidelines (IPCC, 2006). Below are the definitions the Netherlands uses for the six main land-use categories that need to be covered. For more detailed information see Arets et al. (2017).

Definitions
Forest land (4A)
The Netherlands has chosen to define the land-use *category "Forest Land"* as all land with woody vegetation, now or expected in the near future (e.g. clear-cut areas to be replanted, young afforestation areas). The following criteria define this category:

- forests are patches of land exceeding 0.5 ha with a minimum width of 30 m;
- a tree crown cover of at least 20% and;
- a tree height of at least 5 meters, or, if this is not the case, these thresholds are likely to be achieved at the particular site.

This definition conforms to the FAO reporting and was chosen within the ranges set by the Kyoto protocol.

Cropland (4B)
The Netherlands has chosen to define croplands as arable lands and nurseries (including tree nurseries). Intensive grasslands are not included in this category and are reported under Grasslands. For part of the agricultural land, rotation between cropland and grassland is frequent, but data on where exactly this is occurring are not available. Currently, the situation on the topographical map is used as the guideline, with lands under agricultural crops and classified as arable lands at the time of recording reported under Cropland and, lands with grass vegetation at the time of recording classified as Grassland.

Grassland (4C)
The Netherlands currently reports under grassland any type of terrain which is predominantly covered by grass vegetation. It also includes vegetation that falls below the threshold used in the forest land category and is not expected to exceed, without human intervention, the threshold used in the forest land category. It is stratified in:

- 'Grasslands', i.e. all areas predominantly covered by grass vegetation (whether natural, recreational or cultivated).
- 'Nature', i.e. all natural areas excluding grassland (natural grasslands and grasslands used for recreation purposes). It mainly consists of heathland, peat moors and other nature areas. Many have the occasional tree as part of the typical vegetation structure.

No spatially explicit distinction is made between agricultural intensively and extensively managed grasslands and natural grasslands. Nevertheless, for managed grasslands the emissions from organic soils are reported.

Apart from pure grasslands, all orchards (with standard fruit trees, dwarf varieties or shrubs) are included in the Grassland category. They do not conform to the forest definition, and while agro-forestry systems are mentioned in the definition of Croplands, in the Netherlands the main undergrowth of orchards is grass. Therefore, these orchards are reported under grasslands. As for Grasslands no change in above-ground biomass is reported, the carbon stored in these trees is not reported.

Wetlands (4D)
The Netherlands is characterized by many wet areas, but because many of these areas are covered by a grassy vegetation those are included under grasslands. Some wetlands are covered by a more rough vegetation of wild grasses or shrubby vegetation, which is reported in the subcategory 'Nature' of Grassland. Forested wetlands like willow coppice are included in Forest Land.

In the Netherlands, only reed marshes and open water bodies are included in the Wetland land-use category. This includes natural open water in rivers, but also man-made open water in channels, ditches and artificial lakes. It includes bare areas which are under water only part of the time, as a result of tidal influences, and very wet areas without vegetation. It also includes ‘wet’ infrastructure for boats, i.e., waterways as well as the water in harbors and docks.

Settlements (4E)
In the Netherlands, the main classes included under the category Settlement, are 1) built-up areas and 2) urban areas and transport infrastructure. Built-up areas include any constructed item, independent of the type of construction material, which is (expected to be) permanent, is fixed to the soil surface and serves as a place of residence or location for trade, traffic and/or labor. It therefore includes houses, blocks of houses and apartments, office buildings, shops and warehouses, as well as filling stations and greenhouses.

Urban areas and transport infrastructure include all roads, whether paved or not, with the exception of forest roads, which are included in the official forest definition. They also include train tracks, (paved) open spaces in urban areas, car parks and graveyards. Though some of the latter classes are covered by grass, the distinction cannot be made from a study of maps. Because even grass graveyards are not managed as grassland, their inclusion in the land-use category Settlements conforms better to the rationale of the land-use classification.

Other land (4F)
In general, ‘Other land’ does not have a substantial amount of carbon. The Netherlands uses this land-use category to report surfaces of bare soil that are not included in any other category. In the Netherlands, this means mostly almost bare sands and the earliest stages of succession on sand in coastal areas (beaches, dunes and sandy roads) or uncultivated land alongside rivers. It does not include bare areas that emerge from shrinking and expanding water surfaces (these ‘emerging surfaces’ are included in Wetland).

6.3 Information on approaches used to representing land areas and on land use databases used for the inventory preparation

One consistent approach was used over all land-use categories. The Netherlands has a full and spatially explicit land use mapping that allows for geographical stratification at 25 m x 25 m (0.0625 ha) pixel resolution (Kramer et al., 2009; van den Wyngaert et al., 2012). This corresponds with the wall-to-wall approach used for reporting under the Convention (approach 3 in Chapter 3 of IPCC 2006).
Harmonized and validated digital topographical maps of 1 January 1990, 2004, 2009 and 2013 were used for wall-to-wall map overlays (Kramer et al., 2009; Van den Wyngaert et al., 2012; Arets et al., 2017), resulting in three national scale land-use and land-use change matrices for the period 1990–2004 (Table 6.3), 2004–2009 (Table 6.4) and 2009-2013 (Table 6.5). The information used concerning the activities and land-use categories covers the entire territorial (land and water) surface area of the Netherlands. The sum of all land-use categories is constant over time.

The detailed land-use maps that best represent land use on 1 January of 1990, 2004, 2009 and 2013 were originally developed to support temporal and spatial development in land use and policy in the field of nature conservation (MNP, 2008; Kramer et al., 2007, 2015). For more details see Arets et al. (2017).

Table 6.3 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the period 1990–2004 (ha)

				BN 1990			
BN 2004	**Forest land**	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	***Total***
Forest land	350,751	14,560	22,540	1,217	2,530	651	*392,248*
Cropland	1,605	739,190	196,595	596	1,623	8	*939,617*
Grassland	17,902	176,797	1,190,740	9,092	10,987	2,547	*1,408,064*
Wetlands	1,822	6,821	18,641	776,007	1,390	2,583	*807,265*
Settlements	10,019	81,783	78,259	2,836	392,805	630	*566,332*
Other land	809	201	907	2,791	122	33,144	*37,974*
Total	*382,907*	*1,019,353*	*1,507,682*	*792,539*	*409,457*	*39,563*	*4,151,500*

Note: For comparison with CRF tables, map dates are 1st January of 1990 and 2004, i.e. the areas for 2004 correspond to the areas reported in CRF tables for the 2003 inventory year.

Table 6.4 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the period 2004–2009 (ha)

				BN 2004			
BN 2009	**Forest land**	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	***Total***
Forest land	377,584	2,304	8,827	466	6,155	238	*395,573*
Cropland	487	813,282	106,547	177	4,367	2	*924,863*
Grassland	6,417	108,480	1,243,329	9,633	23,123	506	*1,391,488*
Wetlands	829	1,794	10,610	794,785	3,033	890	*811,941*
Settlements	6,694	13,729	37,705	1,441	529,417	137	*589,123*
Other land	238	27	1,047	762	237	36,200	*38,512*
Total	*392,248*	*939,617*	*1,408,064*	*807,265*	*566,332*	*37,974*	*4,151,500*

Table 6.5 Projected land use and land use change matrix for the six UNFCCC land use categories for the period 2009–2013 using the land use data available on 1-1-2013 (ha)

	BN 2009						
2013	**Forest land**	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	***Total***
Forest land	380,255	2,791	9,672	763	3,346	494	*397,320*
Cropland	1,535	793,892	145,410	304	3,198	1	*944,340*
Grassland	7,778	116,002	1,194,126	6,180	20,653	970	*1,345,709*
Wetlands	863	1,410	10,849	801,539	4,477	1,825	*820,962*
Settlements	4,907	10,740	30,915	1,311	557,312	328	*605,512*
Other land	235	28	516	1,846	135	34,897	*37,657*
Total	*395,572*	*924,863*	*1,391,488*	*811,941*	*589,121*	*38,515*	*4,151,500*

Annual land-use changes that can be assessed from the matrix 2009-2013 (Table 6.5) is used for extrapolation of annual land-use changes in later years until new land-use statistics become available in the future.

Table 6.6 Overview of the categories in LULUCF. Each category includes: land remaining in this category and land converted to this category.

Category	**Description**	**Issues**
4A	Forest land	Living biomass, Harvest, Thinning, Dead wood, Litter, Emissions from Forest Fires, Fertilizer use in forests (nitrous oxide emissions)
4B	Cropland	Living biomass, Emissions from: Disturbance associated with land-use conversions to cropland
4C	Grassland	Living biomass, Soil (drainage and subsidence of peatland) Emissions from wildfires
4D	Wetland	Reed marshes and open waterbodies only (including rivers, channels, ditches and artificial lakes) Included in grassland when covered with grassy vegetation and included in forest land when covered with willow coppice.
4E	Settlement	Including a national category built-up areas and a national category urban areas (including paved open areas in urban environment, car parks, graveyards) and transport infrastructure (including roads and rail tracks)
4F	Other land	All land not included in 4A-4E, mainly: bare sands (including beaches, dunes, sandy roads) and uncultivated land alongside the rivers.
4G	Other (related) activities	Harvested wood products

6.4 Forest land (4A)

6.4.1 Description

This category includes emissions and sinks of CO_2 caused by changes in forests. All forests in the Netherlands are classified as temperate, 30 per cent of which are coniferous, 38 per cent broadleaved and the remaining area a mixture of the two. The share of mixed and broadleaved forests has grown in recent decades (Schelhaas et al., 2014[4]). In the Netherlands, with its very high population density and strong pressure on land, all forests are managed. Consequently no further sub-division is used between managed and unmanaged forest land. Where such sub-divisions are asked for in the CRF, the notation key 'NO' will be used in the tables for unmanaged forests.

The category includes two sub-categories: 4A1 (Forest land remaining forest land) and 4A2 (Land converted to forest land). The first sub-category includes estimates of changes in the carbon stock from different carbon pools in the forest. The second sub-category includes estimates of the changes in land use from mainly agricultural areas to forest land since 1990 with a 20-year transition period, during which such transitions are reported under Land converted to Forest Land.

Also included in this section (under the heading 'Forest land converted to other land-use categories') are the descriptions related to the conversion of forest land to all other land-use categories (deforestation).

6.4.2 Methodological issues

Removals and emissions of CO_2 from forestry and changes in woody biomass stock are estimated based on country-specific Tier 2 methodology. The approach chosen follows the 2006 IPCC Guidelines (IPCC, 2006) where a stock difference approach is suggested. The basic assumption is that the net flux can be derived from converting the change in growing stock volumes in the forest into carbon. Detailed descriptions of the methods used and EFs can be found in the methodological background report for the LULUCF sector (Arets et al., 2017). The Netherlands' National System follows the carbon cycle of a managed forest and wood products system. Changes in the carbon stock are calculated for above-ground biomass, below-ground biomass and dead wood and litter in forests.

National Forest Inventories

Data on forests are based on three National Forest Inventories carried out during 1988–1992 (HOSP data, Schoonderwoerd and Daamen 1999), 2000–2005 (MFV data, Daamen and Dirkse, 2005) and in 2012-2013 (NBI6, Schelhaas et al., 2014). As these most accurately describe the state of Dutch forests, they were applied in the calculations for Forest land remaining forest land, Land converted to forest land and Forest land converted to other land use, representing the state of the forest at three moments in time; 1990 (HOSP), 2003 (MFV) and 2012

[4] Report on the 6th Forest Inventory with results only in Dutch. For English summary of the results and an English summary flyer "State of the Forests in The Netherlands", see: http://www.wageningenur.nl/en/Expertise-Services/Research-Institutes/alterra/Projects/Dutch-Forest-Inventory/Results.htm

(NBI6). Information between 2013 and 2020 was based on projections using the EFISCEN model (see Arets et al., 2017).

With plot level data from the HOSP, MFV and NBI6 changes in carbon stocks in living biomass in forests were calculated. In addition, changes in activity data were assessed using several databases with tree biomass information, with allometric equations to calculate above-ground and below-ground biomass and with forest litter.

More detailed descriptions of the methods used and EFs can be found in Arets et al. (2017).

6.4.2.1 Forest land remaining forest land

The net change in carbon stocks for Forest Land remaining Forest Land is calculated as the difference in carbon contained in the forest between two points in time. Carbon in the forest is derived from the growing stock volume, making use of other forest traits routinely determined in forest inventories. With the three repeated measures changes in biomass and carbon stocks were assessed for the periods 1990-2003 and 2003-2012. The annual changes during the years between 1990-2003 and 2003-2012 are determined using linear interpolation.

There is an exception on this for forest land remaining forest land that was afforested between 20 and 30 years ago. These units of land are reported under FL-FL, but the calculation of carbon stock changes in these areas of forest still follows the approach for newly established forests, as provided in 6.4.2.2, land converted to forest land.

Living biomass

For each plot that is measured during the forest inventories, information is available on the presence of the dominant tree species, standing stock (stem volumes) and the forest area it represents. Based on this information the following calculation steps are implemented (for more details see Arets et al., 2017):

1. Based on the growing stock information and biomass expansion functions (BCEF) for each plot in the NFI's total tree biomass per hectare is calculated. Tree biomass is calculated on the basis of growing stock information from the three forest inventories. For all plots in the NFI datasets, biomass is calculated using the dominant tree species group's specific BCEFs.
2. Weighted for the representative area of each of the NFI plots for each of the inventories the average growing stocks (m^3 ha^{-1}), average BCEF's (tonnes biomass m^{-3}) and average root-to-shoot ratios are calculated (Arets et al., 2017).
3. Based on the distribution of total biomass per hectare over coniferous and broadleaved plots (determined on the basis of the dominant tree species), the relative share of coniferous and broadleaved forest is determined.
4. The average growing stock, average BCEF's, average root-to-shoot ratios and shares of coniferous and broadleaved forests are

linearly interpolated between the NFI's to estimate those parameters for all the intermediate years.
5. Combining for each year average growing stock, the average BCEF and root-to-shoot ratios the average aboveground and belowground biomasses (tonnes d.m. ha-1) are estimated for each year (Table 6.7).
6. Using the relative share of coniferous and broadleaved forests and the differentiated T1 carbon fractions for conifers and broad-leaved species, above- and belowground biomass were converted to carbon.
7. Losses from wood harvesting are already included in the differences in carbons stocks between the three forest inventories, HOSP, MFV and NBI6.

Table 6.7 Annual values for growing stock, above- (AGB) and below-ground (BGB) biomass, and BCEF based on temporal interpolation between the inventories and/or model projections

Year	Growing stock (m^3 ha^{-1})		AGB (tonne d.m. ha^{-1})	BGB (tonne d.m. ha^{-1})
1990	158	0.714	113	20
1991	161	0.716	115	21
1992	164	0.717	117	21
1993	166	0.719	120	22
1994	169	0.721	122	22
1995	172	0.722	124	22
1996	175	0.724	127	23
1997	178	0.726	129	23
1998	181	0.728	131	24
1999	183	0.729	134	24
2000	186	0.731	136	24
2001	189	0.733	138	25
2002	192	0.734	141	25
2003	195	0.736	143	26
2004	197	0.739	145	26
2005	199	0.742	148	27
2006	201	0.744	150	27
2007	203	0.747	152	27
2008	206	0.750	154	28
2009	208	0.753	156	28
2010	210	0.756	159	29
2011	212	0.758	161	29
2012	214	0.761	163	29
2013	217	0.764	165	30
2014	219	0.763	167	30
2015	221	0.763	169	30

Dead wood
Dead wood volume was available from the three forest inventory datasets. The calculation of changes carbon stock changes in dead organic matter in forests follows the approach for calculation of carbon emissions from living biomass and is done for lying and standing dead wood.

Litter
Analysis of carbon stock changes based on collected data has shown that there is most probably a build-up in litter in Dutch forest land. Data from around 1990, however, are extremely uncertain and, therefore, this highly uncertain sink is not reported in order to be conservative.

Effects of wood harvests on biomass gains and losses
The effect of harvesting wood on carbon in the remaining forest biomass is already implicitly included in the carbon stock differences between the different NFIs. The gross gains in biomass between the inventories were thus higher than calculated from the NFIs' stock differences. Therefore the carbon in the biomass of the harvested wood in a given year was added to the carbon stock changes in living biomass. At the same time this same amount of carbon was reported under carbon stock losses from living biomass, resulting in a net change as determined from the carbon stock differences between the forest inventories. As a consequence, the net stock change is gradual, but the gains and losses are more erratic.

For each year, first the amount of timber recovered from deforestation is estimated by the area deforested multiplied with the average forest growing stock. This volume of wood is subtracted from the overall nationally harvested wood volume. Subsequently the remaining harvest is then allocated to forest management activities. The fraction of harvest from forest management from the total harvest is later used in the calculations for the harvested wood products (see 6.10). All harvests were calculated as thinnings.

Emissions from forest fires
In the Netherlands no recent statistics are available on the occurrence and intensity of wildfires in forests (forest fires). The area of burned forest is based on a historical series from 1980–1992, for which the annual number of forest fires and the total area burned is available (Wijdeven et al., 2006). The average annual area (37.77 ha) from the period 1980–1992 is used for all years from 1990 onwards (Arets et al., 2017).

Emissions of CO_2, CH_4 and N_2O from forest fires are reported at Tier 2 level according the method as described in the 2006 IPCC Guidelines (IPCC 2006; equation 2.27). Mass of fuel for forest fires is based on the average annual carbon stock in living biomass, litter and dead wood (Table 6.8). These values change yearly, depending on forest growth and harvesting.

With the available data it is not possible to distinguish between forest fires in forests remaining forests and land converted to forest land.

Therefore the total emissions from forest fires are reported in CRF Table 4(V) under wild fires for forests remaining forests.

Emissions from fertilizer use and drainage in forests
N_2O emissions might occur as a result of using fertilizer in forests or drainage. Neither management practice is much applied in forestry in the Netherlands. Therefore in CRF Table 4(I) direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs for Forest Land remaining Forest Land are reported as "Not Occurring" (NO).

6.4.2.2 Land converted to forest land

Removals and emissions of CO_2 from forestry and changes in woody biomass stock are estimated based on country-specific Tier 2 methodology. The approach chosen follows the IPCC 2006 Revised Guidelines.

Living biomass
The changes in carbon stocks in above- (AGB) and belowground (BGB) living biomass in land converted to Forest land is estimated based on an approach in which carbon stocks in newly established forests reach the carbon stock of the average forest of FL remaining FL in 30 years. Calculation of carbon stock changes is implemented using the following set of assumptions and calculation steps:

1. The emission factor is calculated for each annual set of newly established units of forest land separately. Thus, the specific age of the reforested/afforested units of land is taken into account.
2. At time of afforestation, carbon stocks in above- and belowground biomass arezero.
3. The specific growth curve of new forests is unknown, but analyses of NFI plot data showed that carbon stocks in newly planted forests reach the carbon stock of average forests in 30 years time.
4. Carbon stocks in AGB or BGB on units of newly established forest land annually increase with the difference between the carbon stock in AGB or BGB at that time and the carbon stock in AGB or BGB of the average forest under FL-FL divided by the number of years left to reach an age of 30 years.

For Croplands and Grasslands converted to Forest land, biomass loss in year of conversion is calculated using Tier 1 default values.

Litter and dead organic matter
The accumulation of dead wood and litter in newly established forest plots is not known, though it is definitely a sink of uncertain magnitude (see Arets et al., 2017). This sink is not reported in order to be conservative.

Emissions from forest fires
All emissions from forest fires are included under FL-FL and therefore here are reported as "IE".

Emissions from fertilizer use in forests
N_2O emissions might occur as a result of using fertilizer in forests or

drainage. Neither management practice is much applied in forestry in the Netherlands. Therefore in CRF Table 4(I) direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs for Land converted to Forest Land are reported not occurring (NO).

6.4.2.3 Forest land converted to other land use categories

Living biomass

The total emissions from the tree component after deforestation is calculated by multiplying the total area deforested by the average carbon stock in living biomass, above as well as below ground, as estimated by the calculations for Forest land remaining Forest land. Thus it is assumed that, with deforestation, all carbon stored above and below ground biomass is lost to the atmosphere. National averages are used (see Table 6.8), as there is no record of the spatial occurrence of specific forest types.

The IEF for carbon stock change from changes in living biomass, i.e. the average carbon stock in living biomass, follows the calculations from the NFI data. The calculated EFs show a progression over time. The systematic increase in average standing carbon stock reflects the fact that annual increment exceeds annual harvests in the Netherlands.

Table 6.8 Emission factors for deforestation (Mg C ha^{-1})

Year	EF biomass	EF dead wood	EF litter
1990	65.6	0.41	28.66
1991	67.0	0.49	29.22
1992	68.3	0.57	29.78
1993	69.6	0.64	30.34
1994	70.9	0.72	30.90
1995	72.3	0.80	31.46
1996	73.6	0.87	32.02
1997	75.0	0.95	32.59
1998	76.4	1.03	33.15
1999	77.7	1.10	33.71
2000	79.1	1.18	34.27
2001	80.5	1.26	34.83
2002	81.8	1.33	35.39
2003	83.2	1.41	35.95
2004	84.5	1.45	35.95
2005	85.7	1.50	35.95
2006	86.9	1.55	35.95
2007	88.2	1.59	35.95
2008	89.5	1.64	35.95
2009	90.7	1.69	35.95
2010	92.0	1.73	35.95
2011	93.3	1.78	35.95
2012	94.6	1.82	35.95
2013	95.8	1.87	35.95
2014	96.9	2.09	35.95
2015	97.9	2.31	35.95

Dead wood
The total emissions from the dead wood component after deforestation is calculated by multiplying the total area deforested by the average carbon stock in dead wood, as estimated by the calculations for Forest land remaining Forest land. Thus it is assumed that, with deforestation, all carbon stored in dead wood is lost to the atmosphere. National averages are used as there is no record of the spatial occurrence of specific forest types.

Litter
Total emissions from the litter component after deforestation are calculated by multiplying the total area deforested by the average carbon stock in litter. Thus it is assumed that, with deforestation, all carbon stored above and below ground biomass is lost to the atmosphere. National averages are used, as there is no record of the spatial occurrence of specific forest types.

The average carbon stock in the litter layer was estimated at national level (Van den Wyngaert et al., 2012). Data for litter layer thickness and carbon in litter were available from five different datasets. Additional, selected forest stands on poor and rich sands were intensively sampled with the explicit purpose of providing conversion factors or functions. None of the available datasets could be used exclusively. Therefore, a stepwise approach was used to estimate the national litter carbon stock in a consistent way. A step-by-step approach was developed to accord mean litter stock values with any of the sampled plots of the available forest inventories (HOSP, MFV and NBI6).

6.4.3 *Uncertainties and time series consistency*

Forest land remaining forest land (4A1)

Uncertainties
The Tier 1 analysis in Annex 2, shown in Table A2.1, provides estimates of uncertainty by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates of forest statistics, land use and land-use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in CO_2 emissions from 4A1 (Forest land remaining forest land) is calculated at 67 per cent. See Olivier et al. (2009) for details.

The uncertainty in the IEF of increment in living biomass is calculated at 13 per cent. The uncertainty in the IEF of decrease in living biomass is calculated at 30 per cent. The uncertainty in the net carbon flux from dead wood is calculated at 30 per cent.

Time series consistency
To assure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emission calculation is used. More detailed information is provided in section 6.4.2.1. The recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory (i.e. from 2013 onwards) resulted in improved time series consistency between carbon stock changes as calculated from the latest NFI and the projections beyond 2013. The new method for calculating carbon stock changes in

above- and belowground biomass in newly established forests removed a high correction flux that previously occurred after 20 years after afforestation due to the transition in the calculation of carbon stock changes from newly established forest to FL-FL (also see Chapter 6.1 and Arets et al., 2017). This new approach thus strongly improves time series consistency compared to the method used until the NIR2016.

Land converted to forest land (4A2)
Uncertainties
The Tier 1 analysis in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates of forest statistics, land use and land-use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in the CO_2 emission from 4A2 (Land converted to forest land) is calculated at 63 per cent. See Olivier et al. (2009) for details.

Uncertainty in IEF of 4A2 (Land converted to forest land)
For the increment in living biomass, the same data and calculations have been used as were used for 4A1 (Forest land remaining forest land) and, therefore, the same uncertainty figures are used in the Tier 1 calculation spreadsheet.

Time series consistency
To assure time series consistency, for all years the same approach for activity data, land use area and emission calculation is used. More detailed information is provided in section 6.4.2.2. The new method for calculating carbon stock changes in above- and belowground biomass in newly established forests removed a high correction flux that previously occurred after 20 years after afforestation due to the transition in the calculation of carbon stock changes from newly established forest to FL-FL (also see Chapter 6.1 and Arets et al., 2017). This new approach thus strongly improves time series consistency compared to the method used until the NIR2016

Forest land converted to other land use categories
Uncertainties
The Tier 1 analysis in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates of forest statistics, land use and land-use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in the CO_2 emission from Forest land converted to other land-use categories is calculated at 50 per cent. See Olivier et al. (2009) for details.

Time series consistency
To assure time series consistency, for all years the same approach for activity data, land use area and emission calculation is used. More detailed information is provided in section 6.4.2.3.

6.4.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, as discussed in Chapter 1. Additional Forest Land specific QA/QC includes:

- During the measurements of the three National Forest Inventories specific QA/QC measures were implemented to prevent errors in measurements and reporting (see Arets et al., 2016).
- Previously changes in forest area and mean carbon stocks in Dutch forests were verified with data from the FAO Forest Resources Assessment (FRA).

6.4.5 *Category-specific recalculations*

Reported carbon stock gains and losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the reported carbon stock changes.

6.4.6 *Category-specific planned improvements*

For this land-use category, no improvements are planned in the immediate future.

6.5 Cropland (4.B)

6.5.1 *Description*

In annual cropland over time no net accumulation of biomass carbon stocks will occur (IPCC, 2006). Because cropland in the Netherlands mainly consists of annual cropland, carbon stock changes in living biomass are not estimated for Cropland remaining Cropland. Like for living biomass, also no carbon stock changes in mineral soils are expected. Therefore for Cropland remaining Cropland also no net carbon stock changes in mineral soils are calculated. Emissions from lowering the ground water table in organic soils under Cropland, however, are explicitly calculated for areas of Cropland remaining Cropland (see Arets et al., 2017).

6.5.2 *Methodological issues*

For the soil emissions, a 20-year transition period is included, starting from 1990, while carbon stock changes in biomass will be instantaneous on conversion. In the CRF, the area associated with the transition period for soil is reported.

Living biomass

Emissions and removals of CO_2 from carbon stock changes in living biomass for Land converted to Cropland is calculated using a Tier 1 approach. This value is also used for determining emissions for Cropland converted to other land-use categories (4.A2, 4.C2-4.F2). Net carbon stock changes in both mineral and organic soils for land use changes involving Cropland are calculated based on the methodology provided in Arets et al. (2017).

6.5.3 *Uncertainties and time series consistency*

Uncertainties

The Tier 1 analysis in Annex 2, shown in Table A2.1 provides estimates of uncertainties according to IPCC source categories. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The uncertainties in the Dutch analysis of carbon levels depend on the collective factors which feed into the calculations (calculation of the organic substances in the soil profile and conversion to a national level) and data on land-use and land-use change (topographical data). The uncertainty in the CO_2 emissions from 4B2 (Land converted to cropland) is calculated at 56 per cent; see Olivier et al. (2009) for details (rounded off to 50 per cent in the Tier 1 calculation spreadsheet, since it is the order of magnitude that is important).

The activity data used relate to area change, calculated by comparing three topographical maps. The uncertainty of one topographical map is estimated to be 5 per cent (expert judgement).

Time series consistency

To assure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emission calculation is used. The yearly emission of CO_2 due to the conversion of land to cropland shows an increase from 169 Gg CO_2 in 1990 to 1873 Gg CO_2 in 2015.

6.5.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.5.5 *Category-specific recalculations*

Reported carbon stock losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the reported carbon stock changes in every category in which biomass from forest land is included. This includes units of land that were afforested before 2004 and were deforested again later in time.

6.5.6 *Category-specific planned improvements*

For this land use category, no improvements are planned in the immediate future.

6.6 Grassland (4C)

6.6.1 *Description*

The annual production of biomass in grasslands can be large, but due to rapid turnover changes of standing biomass will be limited in permanent grasslands (IPCC, 2006). For carbon stock changes in living biomass in Grassland remaining Grassland the Netherlands applies the Tier 1 method assuming there is no change in carbon stocks (IPCC 2006). Like for living biomass, also no carbon stock changes in mineral soils are expected and therefore these are not calculated for 4.C1 Grassland remaining Grassland. Emissions from lowering the ground water table in organic soils under Grassland, however, are explicitly calculated for areas of Grassland remaining Grassland (see Arets et al., 2017).

6.6.2 *Methodological issues*

For the soil emissions, a 20-year transition period is included, starting from 1990, while carbon stock changes in biomass will be instantaneous on conversion. In the CRF, the area associated with the transition period for soil is reported.

Living biomass

Emissions and removals of CO_2 from carbon stock changes in living biomass for 4.C2 Land converted to Grassland are calculated using a Tier 1 approach. This value is also used for determining emissions for Grassland converted to other land-use categories (4.A2, 4.B2, 4.D2-4.F2). Net carbon stock changes in both mineral and organic soils for land use changes involving Grassland are calculated based on the methodology provided in Arets et al. (2017).

Wildfires

There are no recent statistics available on the occurrence and intensity of wild fires in The Netherlands. Emissions of CO_2, CH_4 and N_2O from wild fires are reported according the Tier 1 method as described in the 2006 IPCC guidelines (IPCC 2006).

The area of wild fires is based on a historical series from 1980–1992, for which the annual number of forest fires and the total area burned are available (Wijdeven et al., 2006). Forest fires are reported under forest land (see 6.4.2). The average annual area of other wild fires is 210 ha (Arets et al., 2017). This includes all land-use categories. Most wild fires in the Netherlands, however, are associated with heath and grassland. All other emissions from wild fires, except forest fires, are therefore included under Grasslands remaining Grasslands. CO_2, CH_4 and N_2O emissions from wild fires are based on the default carbon stock in living biomass on grasslands.

6.6.3 *Uncertainties and time series consistency*

Uncertainties

The Tier 1 analysis in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The uncertainty for the CO_2 emissions in categories 4C1 (Grassland remaining grassland) and 4C2 (Land converted to grassland) is calculated to be 56 per cent; see Olivier et al. (2009) for details.

The uncertainty for the oxidation of organic soils in category 4C1 is calculated at 55 per cent (50 per cent used in the Tier 1 calculation spreadsheet).

For the uncertainty of 4C2 (Land converted to grassland), reference is made to the description of 4B2 (Land converted to cropland) (section 6.6.6). The calculation for Land converted to grassland is based on the same assumptions as those made for Land converted to cropland and is, therefore, identical. The uncertainty is estimated to be 56 per cent (50 per cent used in the Tier 1 calculation spreadsheet).

Time series consistency
To assure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emission calculation is used. The annual emission of CO_2 due to the conversion of land to grassland shows an increase, from 287 Gg CO_2 in 1990 to 460 Gg CO_2 in 2015.

6.6.4 *Category-specific QA/QC and verification*
The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.6.5 *Category-specific recalculations*
Reported carbon stock gains and losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the reported carbon stock changes in every category in which biomass from forest land is included. This includes units of land that were afforested before 2004 and were deforested again later in time.

6.6.6 *Category-specific planned improvements*
For this land use category, no improvements are planned in the immediate future.

6.7 Wetlands (4D)

6.7.1 *Description*
The land-use category Wetlands, mainly includes open water. Therefore for 4.D1 ‘Wetland remaining Wetland’ no changes in carbon stocks in living biomass and soil are estimated. For land-use changes from Forest Land, Cropland and Grassland to Wetlands (4.D2) the losses in carbon stocks in living biomass are included. For all land use conversions to Wetlands (4.D2) net carbon stock changes in soils are included.

6.7.2 *Methodological issues*
Living biomass
Carbons stocks in living biomass and dead organic matter for flooded land and open water are considered to be zero. For conversion from other land uses to Wetlands, the Netherlands applies a stock difference method assuming that all the carbon in biomass and organic matter that existed before conversion is emitted.

Emissions of CH_4 from wetland are not estimated, due to a lack of data.

Emissions from fertilizer use in Wetlands
The land-use category Wetland, mainly includes open water on which no direct nitrogen inputs occur. Therefore in CRF Table 4(I) direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs for Wetlands are reported not occurring (NO).

6.7.3 *Uncertainties and time series consistency*

Uncertainties
For information on uncertainty estimates, the reader is referred to section 6.6.3, which discusses the uncertainty of soil carbon and changes in land use.

Time series consistency
To assure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emission calculation is used. The time series shows an decrease in CO_2 emissions from 88 Gg CO_2 in 1990 to 64.4 Gg CO_2 in 2015.

6.7.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.7.5 *Category-specific recalculations*

Reported carbon stock gains and losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the reported carbon stock changes in every category in which biomass from forest land is included. This includes units of land that were afforested before 2004 and were deforested again later in time.

6.7.6 *Category-specific planned improvements*

For this land use category, no improvements are planned in the immediate future.

6.8 Settlements (4E)

6.8.1 *Description*

Although Settlements also include areas with grass and trees, biomass gains and losses are expected to be in balance. Moreover, land within urban areas that meets the criteria for Forest Land or Grassland will be reported under those land-use categories and is not reported under Settlements. Since no additional data are available on carbon stocks in biomass and dead organic matter in Settlements, the Netherlands applies the Tier 1 method, assuming no change in carbon stocks in biomass in 4.E1 Settlements remaining Settlements. Similarly it is assumed that no carbon stock changes occur in soils under Settlements remaining Settlements. Similarly for conversion from other land uses to Settlements, the Netherlands applies a stock difference method assuming that all the carbon in living biomass and organic matter that existed before conversion is emitted at once.

6.8.2 *Methodological issues*

Methodology to calculate carbon stock changes in biomass for Forest Land converted to Settlements is provided in Chapter 6.4. Chapters 6.5 (Cropland) and 6.6 (Grassland) provide the methodology to calculate carbon stock changes in biomass for conversions from Cropland and Grassland to Settlement. Land-use conversions from Wetlands or Other

Land to Settlements will result in no changes in carbon stocks in living biomass.

Emissions from fertilizer use in Settlements
The direct N_2O emissions in category 4E, Settlements, are reported under 3Da2c Other organic fertilizers applied to soils (including compost). Therefore in CRF Table 4(I) direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs for Settlements are reported as "Included Elsewhere" (IE).

6.8.3 *Uncertainties and time series consistency*

Uncertainties
Uncertainty estimates are provided in Section 6.6.3, which discusses the uncertainty of soil carbon and changes in land use.

Time series consistency
To assure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emission calculation is used. The time series shows a consistent increase from 888 Gg CO_2 in 1990 to 1650 Gg CO_2 in 2015.

6.8.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.8.5 *Category-specific recalculations*

Reported carbon stock gains and losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the reported carbon stock changes in every category in which biomass from forest land is included. This includes units of land that were afforested before 2004 and were deforested again later in time.

6.8.6 *Category-specific planned improvements*

For this land use category, no improvements are planned in the immediate future.

6.9 Other land (4F)

6.9.1 *Description*

This source category 4F (Other Land) includes only CO_2 emissions from 4F1 (Other Land remaining Other Land) and 4F2 (Land converted to Other Land). In general, Other Land does not have a substantial amount of carbon. The Netherlands uses this land-use category to report the surfaces of bare soils that are not included in any other category.

6.9.2 *Methodological issues*

Methodology to calculate carbon stock changes in biomass for Forest Land converted to Settlements is provided in Chapter 6.4. Chapters 6.5 (Cropland) and 6.6 (Grassland) provide the methodology to calculate carbon stock changes in biomass for conversions from Cropland and

Grassland to Settlement. Land-use conversions from Wetlands or Other Land to Settlements will result in no changes in carbon stocks in living biomass.

6.9.3 *Uncertainties and time series consistency*

Uncertainties

For information on uncertainty estimates, the reader is referred to Section 6.6.3, which discusses the uncertainty of soil carbon and changes in land use.

Time series consistency

To assure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emission calculation is used. The time series shows a consistent, slow increase from 26 Gg CO_2 in 1990 to 126 Gg CO_2 in 2015.

6.9.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.9.5 *Category-specific recalculations*

Reported carbon stock gains and losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the reported carbon stock changes in every category in which biomass from forest land is included. This includes units of land that were afforested before 2004 and were deforested again later in time.

6.9.6 *Category-specific planned improvements*

For this land use category, no improvements are planned in the immediate future.

6.10 Harvested wood products (4G)

6.10.1 *Description*

The Netherlands calculates sources and sinks from Harvested Wood Products (HWP) on the basis of the change of the pool, as suggested in the 2013 IPCC KP guidance (IPCC 2014). For greater transparency, and following footnote 12 in the Convention CRF Table 4.G s1, both the HWP changes reported to the convention and reported to KP are calculated using the same methodology (see Arets et al., 2017). Under the convention HWP is then reported in the CRF under Approach B2.

6.10.2 *Methodological issues*

The approach taken to calculate the HWP pools and fluxes follow the guidance in chapter 2.8 of the 2013 IPCC KP guidance (IPCC, 2014). As required by the guidelines, carbon from harvests allocated to deforestation is reported using instantaneous oxidation (Tier 1) as the method for calculations. The remainder of the harvests is allocated to Forest Management and subsequently is added to the respective HWP pools. As no country specific methodologies or half-life constants exist, the calculations for the HWP-pools follows the Tier 2 approach outlined in the 2013 IPCC KP guidance (i.e. applying equations 2.8.1 to 2.8.6 in that guidance).

Four categories of HWP are taken into account: sawn wood, wood-based panels, other industrial round wood, and paper and paperboard.

The distribution of material inflow in the different HWP pools is based on the data reported to FAO-stat as import, production and export for the different wood product categories, including those for industrial round wood and wood pulp as a whole.

To assess carbon amounts in the different HWP categories, the default carbon conversion factors for the aggregated HWP categories sawn wood, wood-based panels, and paper and paperboard were used from the 2013 IPCC KP guidance (see Table 6.9). For the category other industrial round wood, the values for sawn wood were used.

Table 6.9. Tier 1 default carbon conversion factors and half-lives factors for the HWP categories.

HWP category	C conversion factor (Mg C per m^3 air dry volume)	Half lives (years)
Sawn wood	0.229	35
Wood based panels	0.269	25
Other	0.229	35
Paper and paperboard	0.386	2

6.10.3 *Uncertainties and time series consistency*

Uncertainties

For harvested wood products no Tier 1 uncertainty is available at the moment. Instead for LULUCF a Tier 2/3 Monte Carlo approach is being developed and implemented. The results of this analysis will be reported in future inventories.

Time series consistency

The annual changes in carbon stocks in HWP are erratic by nature because they depend on highly variable input of wood production, imports and exports over a longer time period. The net CO_2 emissions and removals in the period 1990-2015 ranges between -144 Gg CO_2 (removals) and 136 Gg CO_2.

6.10.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.10.5 *Category-specific recalculations*

Reported carbon stock gains and losses in biomass in this category were recalculated for the whole time series due to the methodological changes as described in paragraph 6.1. The use of a new approach to calculate carbon stock changes in newly established forests and a recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory, affected the calculated biomass in forest land, which subsequently changed the calculated amounts of wood that will become available from deforestation, which is included in HWP assuming instantaneous oxidation.

6.10.6 Category-specific planned improvements

For this land use category, no improvements are planned in the immediate future.

7 Waste (CRF sector 5)

Major changes in the Waste sector compared with the National Inventory Report 2016

Emissions:	In 2015, total GHG emissions in this sector decreased further.
Key sources:	No changes in key sources in this category.
Methodologies:	No methodology changes.

7.1 Overview of sector

The national inventory of the Netherlands comprises four source categories in the Waste sector:

- Solid waste disposal on land (5A): CH_4 (methane) emissions;
- Composting and digesting of organic waste (5B): CH_4 and N_2O emissions;
- Treatment of waste, including communal waste incineration plants (5C): CO_2 and N_2O emissions (included in 1A1a);
- Wastewater treatment and discharge (5D): CH_4 and N_2O emissions.

Carbon dioxide emissions from the anaerobic decay of waste in landfill sites are not included, since these are considered to be part of the carbon cycle and are not a net source. The Netherlands does not report emissions from waste incineration facilities in the Waste sector because these facilities also produce electricity and/or heat used for energy purposes; these emissions are therefore included in category 1A1a (to comply with IPCC reporting guidelines).

Methodological issues concerning this source category are briefly discussed in Section 7.4. The methodology is described in detail in the methodology report (ENINA, 2017) available on the website http://english.rvo.nl/nie.

The Waste sector accounted for 1.7 percent of total national emissions (without LULUCF) in 2015, compared with 6 percent in 1990, emissions of CH_4 and N_2O accounting for 96 percent and 4 percent of CO_2-equivalent emissions from the sector, respectively. Emissions of CH_4 from waste – almost all (87%) originates from landfills (5A1 Managed waste disposal on land) – accounted for 17 percent of total national CH_4 emissions in 2015. N_2O emissions from the Waste sector originates from biological treatment of solid waste and from wastewater treatment. Fossil fuel-related emissions from waste incineration, mainly CO_2, are included in the fuel combustion emissions from the Energy sector (1A1a), since all large-scale incinerators also produce electricity and/or heat for energy purposes.

Emissions from the Waste sector decreased by 77 percent between 1990 and 2015 (see Figure 7.1), mainly due to a 78 percent reduction in CH_4 from landfills (5A1). Between 2014 and 2015, CH_4 emissions from landfills decreased by approximately 6 percent. Decreased methane emissions from landfills since 1990 are the result of:

- Increased recycling of waste;
- A considerable reduction in the amount of municipal solid waste (MSW) disposal at landfills;
- A decreasing organic waste fraction in the waste disposed; Increased methane recovery from landfills (from 4% in 1990 to 13% in 2015).

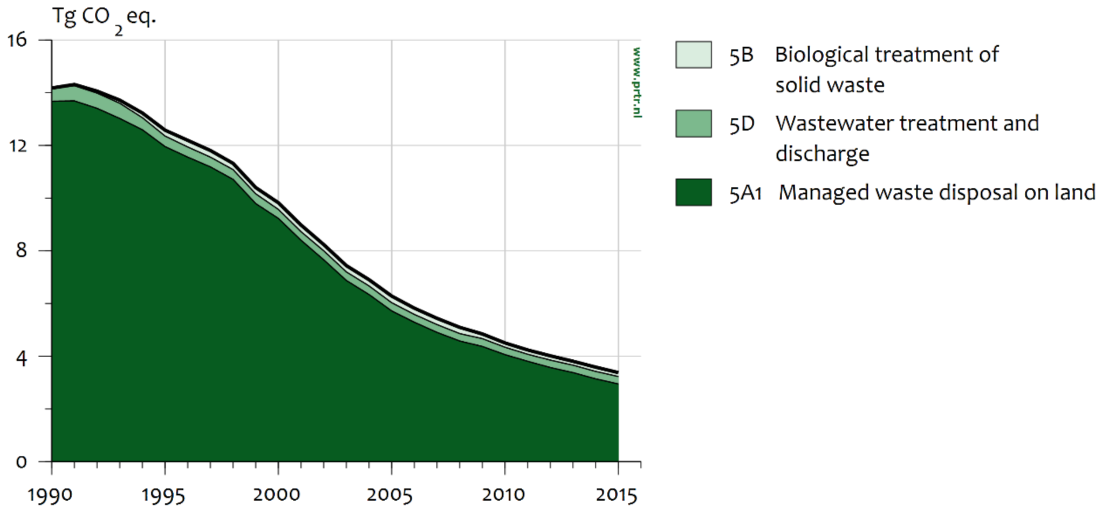


Figure 7.1 Sector 5 Waste: trend and emissions levels of source categories, 1990–2015.

Table 7.1 shows the contribution of the emissions from the Waste sector to total GHG emissions in the Netherlands and also presents the key sources in this sector by level, trend or both. The list of all (key and non-key) sources in the Netherlands is shown in Annex 1. Total GHG emissions from the Waste sector decreased from 14.2 Tg CO_2 eq in 1990 to 3.6 Tg CO_2 eq in 2015.

Table 7.1 Contribution of main categories and key sources in sector 5 Waste

Sector/category	**Gas**	**Key**	**Emissions in Tg CO_2 eq**				**Contribution to total in 2015 (%)**		
			Base-year	**2014**	**2015**	**Absolute 2015 – 2014**	**by sector**	**of total gas**	**of total CO_2 eq**
5 Waste	CH_4	-	14.0	3.4	3.2	-0.2	95.6	17.0	1.7
	N_2O	-	0.2	0.1	0.1	0.0	4.4	1.8	0.1
	All	-	14.2	3.6	3.6	-0.2	100.0		1.7
5A. Solid Waste Disposal	CH_4	-	13.7	3.1	2.9	-0.2	87.2	15.5	1.5
5A1. Managed Waste Disposal on Land	CH_4	L,T	13.7	3.1	2.9	-0.2	87.2	15.5	1.5
5B. Biological treatment of solid waste	CH_4	non key	0.0	0.1	0.1	0.0	2.2	0.4	0.0

Sector/category	Gas	Key	Emissions in Tg CO_2 eq				Contribution to total in 2015 (%)		
			Base-year	2014	2015	Absolute 2015 – 2014	by sector	of total gas	of total CO_2 eq
	N_2O	non key	0.0	0.1	0.1	0.0	2.3	0.9	0.0
5D. Wastewater treatment and discharge	N_2O	non key	0.2	0.1	0.1	0.0	2.1	0.9	0.0
	CH_4	non key	0.3	0.2	0.2	0.0	6.2	1.1	0.1
	All	-	0.5	0.3	0.3	0.0	8.4		0.1

CH_4 emissions from landfills constitute the largest proportion of GHG emissions in this sector. Category 5A1 (Solid waste disposal sites (SWDS)) is a key source of CH_4 emissions by both level and trend.

7.2 Solid waste disposal on land (5A)

7.2.1 Category description

In 2015 there were 19 operating landfill sites, as well as a few thousand old sites that were still reactive. As a result of the anaerobic degradation of the organic material within the landfill body, all of these landfills produce CH_4 and CO_2. Landfill gas comprises about 50 percent (vol.) CH_4 and 50 percent (vol.) CO_2. Due to a light overpressure, landfill gas migrates into the atmosphere. CH_4 recovery takes place at 54 sites in the Netherlands. At several landfill sites, the gas is extracted before it is released into the atmosphere and subsequently used as an energy source or flared off. In both of these cases, the CH_4 in the extracted gas is not released into the atmosphere. The CH_4 may be degraded (oxidized) to some extent by bacteria when it passes through the landfill cover; this results in lower CH_4 emissions.

The anaerobic degradation of organic matter in landfills may take many decades. Some of the factors influencing this process are known; some are not. Each landfill site has unique characteristics: concentration and type of organic matter, moisture and temperature, among others. The major factors determining decreased net CH_4 emissions are lower quantities of organic carbon deposited in landfills (organic carbon content × total amount of land-filled waste) and higher methane recovery rates from landfills (see Sections 7.2.2 and 7.2.3).

The share of CH_4 emissions from landfills in the total national inventory of GHG emissions was 6.4 percent in 1990 and 1.5 percent in 2015 – a decrease of 78 percent. This decrease is partly due to the increase in recovered $CH_{4,}$ from about 4 percent in 1990 to 13 percent in 2015. A second cause is the decrease of methane produced at solid waste disposal sites and the decrease of the relative amount of methane in landfill gas from 57 percent to 50 percent.

In 2015, solid waste disposal on land accounted for 87.2 percent of total emissions from the Waste sector and 1.5 percent of total national CO_2-equivalent emissions (see Table 7.1).

The policy that has been implemented in the Netherlands is directly aimed at reducing the amount of waste sent to landfill sites. This policy requires enhanced prevention of waste production and increased recycling of waste, followed by incineration. As early as the 1990s, the government introduced bans on the landfilling of certain categories of waste; for example, the organic fraction of household waste. Another means of reducing landfilling was raising landfill taxes in line with the higher costs of incinerating waste. Depending on calamities, an increase in the demand for incineration capacity due to a great supply etcetera, the regional government can grant exemption from these 'obligations'. As a result of this policy, the amount of waste sent to landfills decreased from more than 14 million tons in 1990 to 2.3 million tons in 2015, thereby reducing emissions from this source category. Table 7.2 shows an overview of waste land filled and its degradable organic carbon (DOC) content. A complete overview for all the years since 1945 is given in Enina (2017).

Table 7.2 Amounts of waste land filled and degradable orghanic carbon content

Year	Amount land filled (Mton)	Degradable organic carbon (kg/ton)
1945	0.1	132
1950	1.2	132
1955	2.3	132
1960	3.5	132
1965	4.7	132
1970	5.9	132
1975	8.3	132
1980	10.6	132
1985	16.3	132
1990	13.9	131
1995	8.2	125
2000	4.8	110
2005	3.5	62
2010	2.1	33
2011	1.9	31
2012	3.3	32
2013	2.7	33
2014	2.2	34
2015	2.3	43

7.2.2 *Methodological issues*

A more detailed description of the method and EFs used can be found in ENINA (2017) on the website http://english.rvo.nl/nie.

Data on the amount of waste disposed of at landfill sites derives mainly from the annual survey performed by the Working Group on Waste Registration at all the landfill sites in the Netherlands. This data can be found on the website http://english.rvo.nl/nie and is documented in Rijkswaterstaat (2016). This document also contains the amount of CH_4 recovered from landfill sites yearly. The IEFs correspond with the IPCC default values.

In order to calculate CH_4 emissions from all the landfill sites in the Netherlands, it was assumed that all waste was disposed of at one landfill site; an action that started in 1945. As stated above, however, characteristics of individual sites vary substantially. CH_4 emissions from this 'national landfill' were then calculated using a first-order decomposition model (first-order decay function) with an annual input of the total amounts deposited and the characteristics of the landfilled waste and the amount of landfill gas extracted. This is equivalent to the IPCC Tier 2 methodology. Since landfills are a key source of CH_4 emissions, the present methodology is in line with the 2006 IPCC Guidelines (IPCC, 2006).

The parameters used in the landfill emissions model are as follows:
- Total amount of landfilled waste;
- Fraction of degradable organic carbon (DOC) (see Table 7.2 for a detailed time series);
- CH_4 generation (decomposition) rate constant (k): 0.094 up to and including 1989, decreasing to 0.0693 in 1995; decreasing from 2000 to 2004 to 0.05 (IPCC parameter) and remaining constant thereafter; this corresponds to a half-life of 14.0 years (see Table 7.2 for a detailed time series);
- CH_4 oxidation factor for managed landfills (IPCC parameter): 10 percent;
- Fraction of DOC actually dissimilated (DOCF): 0.58 until 2000 (see also Oonk et al., 1994); from 2000 to 2004, decreasing to 0.5 (IPCC parameter) and remaining constant thereafter;
- CH_4 conversion factor (IPCC parameter): 1.0;
- The fraction of methane in landfill gas produced. For the years up until 2001, the fraction of methane in landfill gas has been set at 57.4 percent (see also Oonk, 2016); decreasing from 2001 to 2005 to 50 percent (IPCC parameter) and remaining constant thereafter.
- The amount of recovered landfill gas is yearly published in the report Waste treatment in the Netherlands (Rijkswaterstaat, 2016);
- The delay time when deposited waste starts to produce methane is set at 6 months (IPCC parameter). Waste landfilled on average in year x, start to contribute to the methane emissions in year x+1.

Trend information on IPCC Tier 2 method parameters that change over time is provided in Table 7.3. The change in DOC values was due to factors such as the prohibition on depositing combustible waste in landfills, whereas the change in k-values (CH_4 generation rate constant) was caused by a sharp increase in the recycling of vegetable, fruit and garden waste in the early 1990s. Moreover, since 2008 there has been a decrease in the amount of combustible waste deposited in landfills, due to overcapacity at incineration plants. The integration time for the emissions calculation is defined as the period from 1945 to the year for which the calculation is made.
The fraction of methane in landfill gas has been adapted, as a result of the UNFCCC review in 2016. In earlier research the ammount of CO_2 absorbed in seepage water was not included. Research (Oonk, 2016) estimated that 2-10 percent of the CO_2 was removed by the leachate. In

the calculations 10 percent of the CO_2 is removed, resulting in a fraction of methane in landfill gas of 57.4 percent for the period 1990-2000.

Table 7.3 Parameters used in the IPCC Tier 2 method that change over time (additional information on solid waste handling)

Parameter	1990	1995	2000	2005	2010	2014	2015
Waste generation rate (kg/cap/day)	1.52	1.50	1.69	1.75	1.66	1.55	1.54
Fraction MSW disposed to SWDS	0.38	0.29	0.09	0.01	0.00	0.01	0.01
Fraction DOC in MSW	0.13	0.13	0.11	0.06	0.03	0.03	0.04
CH_4 generation rate constant (k)	0.09	0.07	0.07	0.05	0.05	0.05	0.05
Number of SWDS recovering CH_4	45	50	55	50	53	53	54
Fraction CH_4 in landfill gas	0.57	0.57	0.57	0.5	0.5	0.5	0.5

7.2.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis shown in Tables A2.1 and A2.2 of Annex 2 provides estimates of uncertainties by IPCC source category and gas. The uncertainty in CH_4 emissions from solid waste disposal sites is estimated to be approximately 24 percent in annual emissions. The uncertainty in the activity data and the EF are estimated to be less than 0.5 percent and 24 percent, respectively. For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time series consistency

The estimates for all years are calculated from the same model, which means that the methodology is consistent throughout the time series. The time series consistency of the activity data is very good, due to the continuity in the data provided.

7.2.4 *Source-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1, and the specific QA/QC described in the document on QA/QC of outside agencies (Wever, 2011).

7.2.5 *Source-specific recalculations*

Compared with the previous submission, no recalculations took place for this submission.

7.2.6 *Source-specific planned improvements*

In 2016, potential improvements for this category (in coherence with the categories Solid waste disposal on land and Other waste handling) were investigated. Due to the prioritizing of all possible improvements in the Dutch inventory, however, none of the waste improvements was selected to be carried out.

7.3 Biological treatment of solid waste (5B)

7.3.1 Category description

This source category, which consists of the CH_4 and N_2O emissions from the composting and digesting of separately collected organic waste from households and green waste from gardens and companies, is not considered to be a key source. Emissions from the small-scale composting of garden waste and food waste by households are not estimated, as these are assumed to be negligible.

The amount of composted and digested organic waste increased from nearly 0 million tons in 1990 to 3.4 million tons in 2015. In 2015, this treatment accounted for 4.5% of the emissions in the Waste sector (see Table 7.1).

7.3.2 Methodological issues

Activity data and EFs

Detailed information on activity data and EFs can be found in ENINA (2017) on the website www.english.rvo.nl/nie. The activity data for the amount of organic waste composted at industrial composting facilities derives mainly from the annual survey performed by the Working Group on Waste Registration at all industrial composting sites in the Netherlands. Data can be found on the website www.english.rvo.nl/nie and in a background document (Rijkswaterstaat, 2016). This document also contains the amount of compost produced on a yearly basis.

7.3.3 Uncertainty and time series consistency

Uncertainty

The emissions from this source category are calculated using an average EF that has been obtained from the literature. The uncertainty in annual CH_4 and N_2O emissions is estimated at 67% and 54%, respectively, with an uncertainty in the activity data of 96% and in the EF of 66% and 54%. For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time series consistency

The time series consistency of the activity data is very good, due to the continuity in the data provided.

7.3.4 Source-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1, and the specific QA/QC described in the document for QA/QC of outside agencies (Wever, 2011).

In general, the QA/QC procedures within the waste sector are:

- Checking activity data against other sources within the monitoring of waste;
- Checking trends in the resulting emissions;
- Checking EFs every four to five years against EFs in other European countries.

7.3.5 Source-specific recalculations

Compared with the previous submission, no recalculations took place for this submission.

7.3.6 *Source-specific planned improvements*

In 2016, potential improvements for this category (in coherence with the categories Solid waste disposal on land and Other waste handling) were investigated. Due to the prioritizing of all possible improvements in the Dutch inventory, however, none of the waste improvements was selected to be carried out.

7.4 Waste incineration (5C)

7.4.1 *Category description*

Emissions from the source category Waste incineration are included in category 1A1 (Energy industries) as part of the source 1A1a (public electricity and heat production), since all waste incineration facilities in the Netherlands also produce electricity and/or heat used for energy purposes. According to the 2006 IPCC Guidelines, these activities should be included in category 1A1a (public electricity and heat production: other fuels, see Section 3.2.4).

7.4.2 *Methodological issues*

Activity data and EFs

The activity data for the amount of waste incinerated derives mainly from the annual survey performed by the Working Group on Waste Registration at all 14 waste incinerators in the Netherlands. Data can be found on the website http://english.rvo.nl/nie and in a background document (Rijkswaterstaat, 2016).

A more detailed description of the method and the EFs used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

Fossil-based and organic CO_2 and N_2O emissions from waste incineration are calculated from the total amount of waste incinerated. The composition of the waste is determined for each waste stream (e.g. business waste). An assumption is made for each of the six types of waste composition with respect to the specific carbon and fossil carbon fractions, which subsequently yield the CO_2 emissions. For some waste streams, the composition is updated on a yearly basis, based on analyses of the sorting of household residual waste.
Table 7.4 shows the total amounts of waste incinerated, the fractions of organic carbon in the waste (from their fossil and organic carbon fraction) and the corresponding amounts of fossil and organic carbon in the total waste incinerated.

The method is described in detail in the methodology report (ENINA, 2017). Based on measurement data (Spoelstra, 1993), an EF of 20 g/ton waste is applied to N_2O from incineration with SCR. For incineration with SNCR, an EF of 100 g/ton is applied. The percentage of SCR increased from 6% in 1990 to 46% in 2015.

A survey of EFs for CH_4 used in other countries and an analysis of emissions from waste incinerators in the Netherlands made it clear that the CH_4 concentration in the flue gases from waste incinerators is below the background CH_4 concentration in ambient air. The Netherlands therefore uses an EF of 0 g/GJ and reports no methane. When it is

unable to record such a value, the code ‘NO’ is used. More information can be found in the methodology report (ENINA, 2017).
Open burning of waste does not occur in the Netherlands. It is prohibited by law.

Table 7.4 Composition of incinerated waste

	1990	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**
Total waste incinerated (Gg)	2,780	2,913	4,896	5,503	6,459	7,601	7,564
Total waste incinerated (TJ)	22,746	27,903	51,904	55,058	63,818	74,571	75,299
Energy content (MJ/kg)	8.2	9.6	10.6	10.0	9.9	9.8	10
Fraction organic (energy %)	58.2	55.2	50.4	47.8	53.1	54.3	54.2
Amount of fossil carbon (Gg)	164	221	433	561	675	771	780
Amount of organic carbon (Gg)	544	561	938	909	1,172	1,379	1,381

7.4.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis is shown in Tables A2.1 and A2.2, in Annex 2, and provides estimates of uncertainties by IPCC source category and gas. The uncertainty in the fossil CO_2 emissions for 2015 from waste incineration is estimated at 6%. The main factors influencing these emissions are the total amount being incinerated and the fractions of different waste components used for calculating the amounts of fossil and organic carbon in the waste (from their fossil and organic carbon fraction) and the corresponding amounts of fossil and organic carbon in the total waste incinerated. The uncertainty in the amounts of incinerated fossil waste and the uncertainty in the corresponding EF are estimated to be 3.0% and 5.7%, respectively.

The uncertainty in annual N_2O emissions from waste incineration is estimated at 71%. The uncertainty in the activity data and the uncertainty in the corresponding EF for N_2O are estimated to be less than 0.5% and 71%, respectively.

For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time series consistency

The time series are based on consistent methodologies for this source category. The time series consistency of the activity data is considered to be very good, due to the continuity of the data provided by the Working Group on Waste Registration.

7.4.4 *Source-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1, and the specific QA/QC described in the document for QA/QC of outside agencies 2011 (Wever, 2011).

7.4.5 *Source-specific recalculations*

There are no source-specific recalculations for this category.

7.4.6 *Source-specific planned improvements*

In 2016, potential improvements for this category (in coherence with the categories Solid waste disposal on land and Other waste handling) were investigated. Due to the prioritizing of all possible improvements in the Dutch inventory, however, none of the waste improvements was selected to be carried out.

7.5 Wastewater handling (5D)

7.5.1 Category description

This source category covers emissions from wastewater handling and includes emissions from industrial wastewater, domestic or urban wastewater and septic tanks. In 2015, only 0.6% of the Dutch population was not connected to a closed sewer system, and these households were obliged to treat wastewater in a small scale on-site treatment system (a septic tank or a more advanced system).

In 2015, urban wastewater (the mixture of domestic, industrial and commercial wastewater, including urban run-off) was treated aerobically in 334 public wastewater treatment plants (WWTP). The treatment of the resulting wastewater sludges is accomplished mainly by anaerobic digesters. During the wastewater treatment, the biological breakdown of degradable organic compounds (DOC) and nitrogen compounds can result in CH_4 and N_2O emissions. Incidental venting of biogas also leads to CH_4 emissions. Moreover, as 0.6% of the resident population is still connected to a septic tank, CH_4 emissions from septic tanks are also calculated, but these are very small compared with those from public WWTPs. The discharge of effluents as well as other direct discharges from households and companies result in indirect N_2O emissions from surface water due to the natural breakdown of residual nitrogen compounds. The source category also includes CH_4 emissions from the operational anaerobic industrial WWTPs (IWWTPs) (2015: 53 plants).

N_2O emissions from the wastewater sector (see Table 7.4) contributed about 0.9% of total N_2O emissions in 2015 and 0.037% in total CO_2-equivalent emissions. N_2O emissions from wastewater handling and effluents decreased by 59% during the period 1990–2015. This decrease is mainly the result of lower untreated discharges, resulting in lower effluent loads (see Table 7.5) and a subsequent decrease in (indirect) N_2O emissions from domestic and industrial effluents.

The contribution of wastewater handling to the national total of CH_4 emissions in 2015 was 1.1%, or 0.11% of total CO_2-equivalents. Since 1994, CH_4 emissions from public WWTPs have decreased due to the introduction in 1990 of a new sludge stabilization system in one of the largest WWTPs. As the operation of the plant took a few years to optimize, venting emissions were higher in the introductory period (1991–1994) than under subsequent normal operating conditions. CH_4 emissions from wastewater handling decreased by 32% during the period 1990–2015. The amount of wastewater and sludge being treated does not change much over time. Therefore, the interannual changes in methane emissions can be explained by varying fractions of methane being vented incidentally instead of flared or used for energy purposes. It should be noted that non-CO_2 emissions from the combustion of biogas at wastewater treatment facilities are allocated to category 1A4 (Fuel combustion – other sectors) because this combustion is partly used for heat or power generation at the treatment plants.

Table 7.5 shows the trend in GHG emissions from the different types of wastewater handling.

Table 7.5 Wastewater handling emissions of CH_4 and N_2O (Gg/year)

	1990	2000	2010	2014	2015
CH_4 domestic wastewater	8.13	6.88	7.40	7.28	7.38
CH_4 industrial wastewater	0.29	0.39	0.38	0.37	0.38
CH_4 septic tanks	3.93	1.99	0.68	0.66	0.67
Net CH_4 emissions	12.35	9.25	8.46	8.31	8.43
CH_4 recovered and/or flared	33.0	40.6	40.0	43.5	43.6
N_2O domestic WWTP	0.076	0.076	0.079	0.081	0.083
N_2O effluents	0.501	0.302	0.174	0.154	0.157
Total N_2O emissions	0.577	0.378	0.253	0.235	0.240

7.5.2 Methodological issues

Activity data and EFs

Most of the activity data on wastewater treatment is collected by Statistics Netherlands (StatLine, 2016) in yearly questionnaires that cover all public WWTPs as well as all anaerobic IWWTPs; see also www.statline.nl for detailed statistics on wastewater treatment. Table 7.5 shows the development in the main activity data with respect to domestic wastewater treatment as well as industrial wastewater treatment and septic tanks.

Due to varying weather conditions, the volumes of treated wastewater and of the total load of DOC of domestic wastewater can fluctuate from year to year, depending on the amount of run-off rainwater that enters the sewer systems. In the method developed for calculating methane emissions, the DOC (or TOW) is based on an organic load expressed in terms of chemical oxygen demand (COD). the calculation of the COD of produced sewage sludge it is made use of the average content of 1.4 kg COD per kg organic dry solids.

From Table 7.6 it can be concluded that the DOC of treated wastewater and sludge does not significantly change over time. Therefore, interannual changes in CH_4 emissions can be explained by varying fractions of CH_4 being vented instead of flared or used for energy purposes. The source Septic tanks has steadily decreased since 1990. This can be explained by the increased number of households connected to the sewer system in the Netherlands (and therefore no longer using septic tanks; see Table 7.6).

A full description of the methodology is provided in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

In general, emissions are calculated according to the 2006 IPCC Guidelines, with country-specific activity data.

Table 7.6 Activity data of domestic and industrial wastewater handling

	Unit	1990	2000	2010	2014	2015
Treated volume WWTP	Mm3/yr	1,711	2,034	1,934	1,841	1,956
TOW urban WWTP [1)]	Gg / year	933	921	953	977	1,002
Sludge DOC Urban WWTP [1)2)]	Gg/ year	365	431	476	504	505
Biogas recovered [3)]	mio m3/yr	74.0	87.9	98.5	108.0	107.0
Biogas flared	1,000 m3/yr	8,961	6,150	7,360	6,568	7,405
Biogas vented	1,000 m3/yr	2,524	284	1,066	203	82.3
TOW IWWTP [1)]	Gg/ year	144	194	192	186	190
Resident population [4)]	1,000	14,952	15,926	16,615	16,864	16,936
inhabitants with septic tank	% of pop.	4.0	1.9	0.62	0.60	0.60
Actual PE load WWTP [5)]	1,000	23,798	23,854	24,745	25,325	25,790
Nitrogen in effluents [6)]	Gg/yr	63.8	38.5	22.1	19.6	20.0

[1]) Expressed in terms of chemical oxygen demand (COD).
[2]) DOC of primary and secondary sludge produced, before eventual sludge digestion.
[3]) Sum of measured biogas, total for energy conversion, flaring, venting and external deliveries.
[4]) Average population over a year.
[5]) PE = Population Equivalents, representing the total load of biodegradable substances in the mixture of domestic and industrial wastewater treated in urban WWTP's.
[6]) Sum of domestic and industrial discharges of N in wastewater to surface water.

CH_4 emissions from domestic wastewater treatment (5D1)
In 2015, 99.4% of the population was connected to closed sewer systems, which were in turn connected to 337 public WWTPs. All public WWTPs in the Netherlands are of the advanced aerobic treatment type. In addition, in larger plants sludge digestion is carried out.

For the category 5D1 domestic wastewater treatment, there are three processes for which CH_4 emissions are calculated:

1. Allthough according to IPCC 2006 GL the methane emission from advanced aerobic WWTP is zero, small amounts of methane can be formed in certain wastewater treatment process steps, e.g. from the influent cellars, from anaerobic zones created for phosphorus removal and from anaerobic pockets in zones with poor aeration.
2. Anaerobic sludge digestion in treatment plants. In addition to the methane that is recovered and used for energy processes, uncontrolled CH_4 emissions can arise from sludge (post-)thickeners, sludge silos and the digesters.
3. Incidental venting of biogas produced in anaerobic sludge digesters.

A more detailed description of the method and the EFs used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

1.Wastewater treatment process steps
Methane emissions from the wastewater treatment process are calculated using the B_o from the 2006 IPCC Guidelines, a country-specific MCF, and country-specific data for the TOW and sludge produced. This country-specific activity data on the influent COD, as well as the amounts of sludge produced in all public WWTPs, are derived from the yearly survey conducted by Statistics Netherlands among the Water Boards. Data is available for the years 1990 until the present for every treatment plant.

The COD of sludge is calculated using the conversion factor of 1.4 kg COD per kg organic solids. Organic solids are calculated as total dry solids minus the inorganic fraction, measured as ash content. Table 7.5 gives the time series of the values of influent COD and sludge COD.

2.Anaerobic sludge digestion
Emissions of CH_4 from sludge digesters and related process steps (e.g. post-thickening) are calculated using a country-specific method based on an EF per m^3 biogas produced in the sludge digesters. The emissions are calculated per WWTP with sludge digestion facilities.In 2015, 80 WWTPs were equipped with sludge digesters. A more detailed description of the method and the EFs used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

In this submission the formula for calculating the EF of methane emissions from anaerobic sludge digestion has been corrected and the whole time series is recalculated.

The old EF (previous submission) was calculated as:

$$EF = (1\text{-}MR) \times F_{CH4} = 0.0264 \text{ kg } CH_4/m^3 \text{ biogas recovered}$$

Where:
MR = fraction of methane recovered from the digesters = 0.94 (-) (IPCC/Hobson, 2001);
F_{CH4} = methane content of biogas = 440 g CH_4/m^3 biogas (Baltussen et al., 2015).

Since the EF is calculated on basis of recovered biogas, the formula was not correct. The correct formula is:

$$EF = ((1\text{-}MR)/MR)*F_{CH4} = 0{,}028085 \text{ kg } CH_4 / m^3 \text{ biogas recovered.}$$

The resulting adjustment of the time series as well as the changes are explained further in paragraph 7.5.5.

Country-specific activity data on volume of recovered biogas in all public WWTPs with sludge digestion is derived from the yearly survey conducted by Statistics Netherlands among the Water Boards. Data is available for the years 1990 until the present for every treatment plant.

3.Incidental venting of biogas
Incidental venting of biogas at public WWTPs is recorded by the plant operators and subsequently reported to Statistics Netherlands. In 2015, the amount of CH_4 emitted by the venting of biogas was 0.036 Gg CH_4, equalling 0.5 % of total CH_4 emissions from the category Domestic wastewater. During the last decade, this value varied between 1% and 9%, which means that venting of biogas in 2015 was relatively low.

Recovered biogas is for largely used for energy generation purposes, but a small amount is also flared, vented or delivered to third parties. Table 7.5 provides the data on recovery of CH_4 (total) and CH_4 combusted via flaring.

CH_4 emissions from industrial wastewater treatment (5D2)
In the calculation of methane emissions from anaerobic industrial wastewater treatment, the Netherlands uses the default IPCC parameters for the EF and country-specific activity data for the TOW as well as a country-specific fraction for losses of methane by leakage. Recovered biogas is generally used as fuel in energy processes. The emissions from biogas combustion are included in the Energy sector. A more detailed description of the method and the EFs used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

In the Netherlands no information is available on the actual load of COD that is treated in the IWWTPs. The Total Organics in Wastewater (TOW) is thus determined by using statistics on the design capacity of the IWWTPs and an assumed average loading rate of 80% of the design capacity (Oonk, 2004).
The design capacity is expressed in terms of a standardized value for quantifying organic pollution in industrial wastewater: Pollution Equivalents. One Pollution Equivalent equals an amount of 40 kg COD per year. Data on the design capacity is available from Statistics Netherlands (CBS, 2016). Table 7.5 provides the time series of total TOW for IWWTPs. In 2015, 62% of the anaerobic capacity was installed within the food and beverage industry. Other branches with anaerobic wastewater treatment are the waste processing facilities (17%), chemical industry (16%) and paper and cardboard industry (4%).

Statistics Netherlands has data on total biogas recovery from biomass fermentation plants, including anaerobic WWTP, but in the statistics no distinction is made in the type of substrate or type of installation. So biogas recovery at anaerobic IWWTP's is not quantified separately (see also 7.5.4).

CH_4 emissions from septic tanks (5D3, septic tanks)
Emissions of methane from septic tanks are calculated using IPCC default values for Bo and MCF and IPCC value of TOW of 60 g BOD per connected person per day (IPCC, 2006, table 6.4). A detailed description of the method and the EF used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

Table 7.5 shows the time series of the numbers of capita connected to septic tanks (P_{st}). These are calculated using mean population statistics per inventory year and the fraction of the population connected to septic tanks per inventory year. The % of population connected to septic tanks decreased from 4% in 1990 to 0.6% in 2015. This data derives from surveys and estimates by various organizations in the Netherlands, such as Rioned (Rioned, 2009) and the National Water Authorities.

N_2O emissions from centralized wastewater treatment (5D1)
N_2O emissions from domestic wastewater handling are determined on the basis of the IPCC default EF of 3.2 g N_2O/person/year and country-specific activity data for the number of capita connected, including the extra fraction of industrial and commercial wastewater. This is determined by the number of population equivalents (PE).

Rationale for using the Population Equivalent as AD (response to 2016 review question).
The Population Equivalents, as measured and reported by all UWWTP's, reflect the total amount of organic degradable matter that is treated in the plants. 1 Population Equivalent equals the waste water (and degradable substances in it) from one person. It's basis and method of calculation is anchored in Dutch water Laws.
As the PE's are calculated from influent data on COD and N-kjeldahl, it includes also the loads from industrial and commercial activities as well as loads from urban run-off into the sewer system. In formula 6.9, box 6.1 of the 2006GL, the total PE thus can replace the terms $P*T_{PLANT}*F_{IND-COM}$.

A more detailed description of the calculation of PE, the method and the EF used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie.

Table 7.5 provides a times series of the PE. In 2015, the total PE equalled 25.8 mln.

Wastewater treated at public WWTPs is a mixture of household wastewater, run-off rainwater and wastewater from industries and services, so forthcoming N_2O emissions are reported under category 5D1 (Domestic and commercial wastewater).

Indirect N_2O emission from surface water as a result of discharge of domestic and industrial effluents (CRF 5D3, Wastewater effluents)
For the calculation of indirect N_2O emissions from wastewater effluents, the Netherlands uses the default EF of 0.005 kg N_2O-N/kg N discharged (IPCC, 2006) and country-specific activity data. The country-specific activity data on kg N discharged per year via industrial, domestic and commercial effluents is derived from the Netherlands' Emission Inventory System (PRTR, 2016).

Rationale for country specific AD and not using the "Note" in the Box 6.1 in 2006 IPCC GL (response to 2016 review question).
For calculating indirect (or better: 'delayed') N_2O emissions from wastewater treatment effluent, The Netherlands uses country specific activity data on the total Nitrogen discharged to surface water via effluents of UWWTP plus industrial effluents, instead of using the

calculation method according to equation 6.8 of the IPCC 2006GL. The use of equation 6.8 might result in an overestimation of N-Effluent, because FAO statistics seem to be based on protein supply data and might also include amounts not being consumed (e.g. food waste) and consequently not being disposed to wastewater. Instead, the Netherlands has chosen to use activity data derived from other sources, like statistical surveys and environmental reporting and models, often based on actual measurements. These data are inventoried yearly via the National Emission Inventory system, in which several agencies and institutes work together. The data includes loads of Nitrogen of 1) effluents of all Urban Wastewater Treatment Plants, 2) all direct discharges from companies and households (via septic tanks), 3) estimates of incidental waste water discharges like from combined sewer overflows.
As a consequence of using these data, the Netherlands does not take into account the "Note" in Box 6.1. The discharges of N already represent 'end of pipe' values, so an adjustment for amounts of N related to emissions resulting from nitrification/dentrification processes in advanced centralized waste water treatment is not needed.

A more detailed description of the method and the EF used can be found in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie

Table 7.5 provides a times series of the AD: the total N discharges. Minor errors in the indirect N_2O emissions from surface water were detected and corrected for the period 1990-2012.

Emissions not calculated within category 5D
Within category 5D the following emissions are not calculated (NE):

N_2O emissions from industrial wastewater treatment
The IPCC 2006 Guidelines does not provide a method for N_2O emissions from industrial sources, except for industrial wastewater that is co-discharged with domestic wastewater into the sewer system. The N_2O emissions from industrial sources are believed to be insignificant compared to emissions from domestic wastewater. In the Netherlands most industries discharge their wastewater into the sewer system/WWTPs (emissions included in 5D1). Indirect emissions from surface water resulting from discharge of wastewater effluents, are already included (IE) under 5D3 (other, wastewater effluents).

Direct N_2O emissions from septic tanks (5D3, septic tanks)
Direct emissions of N_2O from septic tanks are not calculated since they are unlikely to occur, given the anaerobic circumstances in these tanks. Indirect N_2O emissions from septic tank effluents are included (IE) in CRF category 5D3 'Indirect N_2O emission from surface water as a result of discharge of domestic and industrial effluents'.

CH_4 emissions from industrial sludge treatment (5D2)
Data from the survey among IWWTPs conducted by Statistics Netherlands shows that only 2 out of a total of 160 IWWTPs are equipped with anaerobic sludge digestion reactors. This data is not published on www.cbs.statline.nl for reasons of confidentiality.

Forthcoming CH_4 emissions are not estimated (NE) because it is not known what sludge treatment capacity these plants have and how much sludge is digested. It is likely that these emissions are a very minor source and can be neglected.

7.5.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 uncertainty analysis shown in Tables A2.1 and A2.2, in Annex 2, provides estimates of uncertainties by IPCC source category and gas. The uncertainty in annual CH_4 and N_2O emissions from wastewater handling is estimated to be 38% and 102%, respectively.

The uncertainty in activity data is based on the judgements of experts and is estimated to be > 20%. The yearly loads of $DOC_{influent}$, $N_{influent}$ and $N_{effluent}$ are calculated on the basis of wastewater sampling and analysis, as well as flow measurements at 337 WWTPs; all these measurements can be a source of uncertainty.

The uncertainty in the EFs for CH_4 and N_2O is estimated to be 32% and 100%, respectively.

An international study (GWRC, 2011), in which the Dutch public wastewater sector also participated, showed that N_2O EFs, in particular, are highly variable among WWTPs as well as at the same WWTP during different seasons or even at different times of day. In fact, the same study concludes that the use of a generic EF (such as the IPCC default) to estimate N_2O emissions from an individual WWTP is inadequate; but at the same time the study provides no alternative method, except the recommendation that GHG emissions from an individual WWTP can be determined only on the basis of continuous measurements over the whole operational range of the WWTP (GWRC, 2011). The results of this study, therefore, provide no starting point from which to improve the method for estimating CH_4 and N_2O emissions and the related uncertainty.

Time series consistency

The same methodology has been used to estimate emissions for all years, thereby providing good time series consistency. The time series consistency of the activity data is very good due to the continuity in the data provided by Statistics Netherlands.

7.5.4 *Source-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, as discussed in chapter 1. Moreover, statistical data is covered by the specific QA/QC procedures of Statistics Netherlands.

For annual CH_4 and N_2O emissions from domestic and commercial wastewater handling, the results of a study (GWRC, 2011) neither confirm nor reject the use of current methods (see also Section 7.5.3). The Dutch wastewater sector will continue research to determine more precisely the factors and circumstances that lead to the formation of CH_4 and N_2O in public WWTP.

In the 2015 review it was recommended that future NIRs should include an estimate of the biogas recovery at anaerobic IWWTP. This will not be possible, at least not at the short term. Statistics Netherlands has data on total biogas recovery from biomass fermentation plants, including anaerobic WWTP, but in the statistics no distinction is made in the type of substrate or type of installation. It will require a substantial effort to elaborate this and, as resources are under pressure, priority will not be given to this issue.

7.5.5 *Source-specific recalculations*

CH_4 emissions from sludge handling (part of 5D1)

In this submission the formula for calculating the EF of CH_4 emissions from anaerobic sludge digestion (part of 5D1) has been corrected and the whole time series is recalculated. This is explained in chapter 7.5.2 and in the methodology report (ENINA, 2017) on the website http://english.rvo.nl/nie. The corrected formula results in an increase of the emissions from sludge digesters of 6.4% for all years. Due to this recalculation total CH_4 emission in category 5D1 in 1990 increased from 8.00 to 8,13 Gg CH_4 (+1,56%) compared to the previous submission. In 2014, the CH_4 emission from category 5D1 increased from 7.09 Gg to 7.28 Gg CH_4 (+2.57%).

N_2O emissions from centralized waste water treatment (5D1)

Due to final activity data on Population Equivalents in 2014, the emission of N2O from centralized waste water treatment in 2014 decreased with 0,00016 Gg N_2O (-0.2%) compared to the previous submission.

Indirect N_2O emission from surface water as a result of discharge of domestic and industrial effluents (5D3, other, wastewater effluents)

Minor errors in the indirect N_2O emissions from surface water were detected and corrected for the period 1990-2012, but this lead to very marginal changes (between +0.0015% and -0.0014%) compared to the previous submission. The emission of the base year 1990 increased with 0.0006%.

For 2013 and 2014, the activity data (total discharges of N to surface water) were updated following the latest information available from the Netherlands Emissions Inventory. As a result, Indirect N_2O emissions from waste water effluents decreased in 2013 with 0,16%, and in 2014 with 0,13% compared to the previous submission.

7.5.6 *Source-specific planned improvements*

There are no source-specific planned improvements.

8 Other (CRF sector 6)

The Netherlands allocates all GHG emissions to sectors 1 to 5. Therefore, no sources of GHG emissions are included in sector 6.

9 Indirect CO_2 and NO_2 emissions

9.1 Description of sources

Methane, carbon monoxide (CO) or NMVOC emissions are oxidized to CO_2 in the atmosphere. In this chapter the indirect CO_2 emissions as a result of this atmospheric oxidation are described.

As The Netherlands already assume 100% oxidation during the combustion of fuels only the process emissions of NMVOC (mainly from product use) are used to calculate the indirect CO_2 emissions.

Indirect CO_2 emissions orginates from the use and or evaporation of NMVOC in the following sectors:

1. Energy (Energy, Traffic & transport and Refineries);
2. IPPU (Consumers, Commercial and governmental institutions, Industry and Construction and building industries);
3. Agriculture;
4. Waste.

The indirect CO_2 emissions are decreasing from 0.66 Tg in 1990 to 0.21 Tg in 2015 as a result of the Dutch policy to reduce NMVOC emission.

9.2 Methodological issues

Until the 2014 submission country-specific carbon contents of NMVOC emissions(C-factors) have been used to calculate the indirect CO_2 emission from NMVOC use. Because these C-factors are dated and no recent country specific C-factors are or will come available in the future Netherlands has switched to the use of the IPCC default C content from the 2015 submission onwards.

The indirect CO_2 emissions are calculated as follows:

$$CO_2 \text{ (in Gg)} = \text{NMVOC emission (in Gg)} * C * 44/12$$

Where:
- C = default IPCC carbon content (C) of 0.6;
- NMVOC emissions data from the use of NMVOC.

NMVOC emissions data per sector are obtained from the Dutch PRTR.

9.3 Uncertainties and time series consistency

Based on expert judgement, the uncertainty in NMVOC emissions is estimated to be 25 per cent and the uncertainty in carbon content is estimated at 10 per cent, resulting in an uncertainty in CO_2 emissions of approximately 27 per cent.

Consistent methodologies and activity data have been used to estimate the indirect CO_2 emissions.

9.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

9.5 Category-specific recalculations

Because there were minor changes in the NMVOC emissions for the period 1990-2014 there were also minor changes in the indirect CO_2 emissions for the period 1990-2014.

9.6 Category-specific planned improvements

No source-specific improvements are planned for this category.

10 Recalculations and improvements

Major recalculations and improvements compared with the National Inventory Report 2016

For the NIR 2017, the data for the most recent year (2015) were added to the inventory and corresponding Common Reporting Format (CRF).

In the year 2015 Netherlands Statistic recalculated the energy balance of the Netherlands for the period 1990 to 2014. This NIR reports according to these recalculated values, affecting the sectoral approach and the reference approach.

Some errors from previous submissions were detected and corrected. These have resulted in minor changes in emissions over the entire 1990–2014 period.

Furthermore, some recalculations were performed based on new, improved activity data and/ or improved emission factors.

For more details on the effects of and justification for the recalculations, see Chapters 3–8.

10.1 Explanation of and justification for the recalculations

10.1.1 GHG inventory

For this submission (NIR 2017), the Netherlands uses the CRF Reporter software v6.0.1.
The present CRF tables are based on updated methodologies and data according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). Furthermore, we included to the extend possible the recommendations and remarks made in the ESD (EU) and UNFCCC reviews from 2016 in the national improvement program. The adapted and improved methodologies are described in so-called methodology reports.
This chapter summarizes the relevant changes in emission figures compared with the NIR 2016.
A distinction is made between:

- Methodological changes and data improvements;
- Changes in source allocation;
- Error correction

All relevant changes in previous data are explained in the sector chapters of this NIR.

Methodological changes and data improvements
The improvements of the QA/QC activities in the Netherlands as implemented in past years (process of assessing and documenting methodological changes) are still in place. This process (using a brief checklist for timely discussion on likely changes with involved experts and users of information) improves the peer review and timely documentation of the background to and justification for changes made.

Recalculations in this submission (compared with the previous NIR) are:
- Recalculation of the LULUCF sector based on improved data (1990-2014)
- Recalculation of F-gas emissions from stationary refrigeration based on corrected leak rate (1994-2014)
- Change in oxidation factor for Lubricants (in 2.D for1990-2014)
- Inclusion of lubricant combustion (100 % oxidation) in two stroke engines in motorcycles in 1.A.3.b.iv (1990-2014)
- Inclusion of N_2O emissions from below ground crop residues in the inventory (agricultural soils) (1990-2014)
- CH_4 emissions from wastewater treatment (sludge) due to improved calculation method (1990-2014)
- New data on the fuel use in transport (1990-2014). As these also affect the fuel use in other combustion sectors the emissions in 1.A.1, 1.A.2, 1.A.4 and 1.A.5 also changed.

Changes in source allocation
In the NIR 2017 part of the CO_2 emissions from lubricant use 2.D.1.are reallocated to the category 1.A.3e iv motorcycles (as the lubricant is used as fuel additive in two stroke engines).
In the years 1991-1994 a reallocation of process to combustion emissions within the Iron and steel sector was nescesarry.
CH_4 emissions from cokes production are no longer allocated in the chemical industry (2.B), these are reallocated to 1.B.1.b
Combustion emissions from pipeline transport are now allocated in 1.A.3.e. In former submissions these emissions were allocated in the 1.A category

Error correction/data improvements
In general, the 2014 figures have been updated whenever improved statistical data have become available since the 2016 submission. Furthermore, as a result of internal QA/QC procedures, minor errors (in activity data and emission figures) were detected and corrected.The most noticeable error corrections are:
- Inclusion of CH_4 and N_2O emissions from fuel combustion in refineries for the years 1991-1994.
- Use of unified CO_2 emission factor for brown coal over the total time series.
- Error correction in the emission of CH_4 from natural gas fired engines in the agricultural sector.
- Improved activity data for soda ash use from 2003 onwards.
- Recalculation of the N2O emissions from aerosols from 2013 and 2014 as a result of corrections in the statistical data.
- Corrected timeseries for Bunker emission according to the final revised energy statistics (update of the 2016 revision).

10.1.2 KP-LULUCF inventory
Some of the methodological changes in the LULUCF sector as reported in Chapter 6.2 also result in recalculations in the KP-LULUCF inventory:
- The improved method for calculating carbon stock changes in biomass for newly established forests as provided in Chapter 6.2 for ‘land converted to forest land’ also results in changes of biomass gains in units of land reported under Afforestation/Reforestation and in changes of biomass gains and

losses in units of land reported under Deforestation for the years 2013 and 2014.
- The effect of improved calibration of the model to project carbon stock changes in forests beyond 2012 as described in Chapter 6.2 for changes in FL remaining FL also result in recalculations for carbon stock changes on units of land reported under Forest Management or Deforestation in 2013 and 2014.

10.2 Implications for emissions levels in GHG inventory

10.2.1 GHG inventory

This chapter outlines and summarizes the implications of the changes described in section 10.1 for the emissions levels reported in the GHG inventory.

Table 10.1 shows the changes in emissions per relevant sector in Gg CO_2 eq, compared to the 2015 submission as a result of the recalculations.

Table 10.1 Summary of the recalculations for the period 1990–2014 (Gg CO_2 eq)

		1990	1995	2000	2005	2010	2012	2013	2014
CO_2, CH_4, N_2O	1.A.1 Energy industries	-313.9	-234.6	-230.3	-373.6	-240.4	-193.4	-259.6	-137.7
CO_2, CH_4, N_2O	1.A.2 Manufacturing industry	-315.5	-284.8	-235.6	-172.2	-129.4	-132.5	51.4	87.1
CO_2, CH_4, N_2O	1.A.3 Transport	470.8	362.5	289.8	404.6	387.4	240.6	312.9	230.6
CO_2, CH_4, N_2O	1.A.4 Other sectors	211.9	261.0	240.4	193.3	276.2	128.7	148.6	259.7
CO_2, CH_4, N_2O	1.A.5 Other	-136.4	-136.5	-168.4	-130.6	-14.1	-72.7	-59.4	-56.9
CH_4	1.B.2 Fugitive Emissions from Fuels	7.2	7.2	5.3	6.9	5.0	4.7	4.9	5.0
CO_2, CH_4, N_2O	2 Industrial processes	-123.5	-177.8	-155.1	-210.1	-146.1	-108.4	-77.9	-92.0
HFCs	2.F.1 Product uses	0.0	0.9	51.8	109.3	181.5	195.2	212.4	11.1
N_2O	3.D Agricultural soils	50.5	73.6	72.9	76.3	74.2	80.4	243.7	221.4
CO_2, CH_4, N_2O	4 LULUCUF	-20.6	-107.3	-161.1	-200.8	128.2	5.3	342.2	306.8
CH_4	5.B Biological treatment of solid waste	0	0	6.3	0	0	0	-0.2	-5.3
N_2O	5.D Waste water Handling	3.1	3.6	3.7	3.9	4.2	4.3	4.6	4.5
CO_2	Indirect CO_2 emissions	-0.3	1.4	0.8	0.5	-0.4	0.2	-0.1	-1.0
Total Difference		-166.7	-230.8	-285.8	-292.6	526.3	152.4	923.5	833.2

The relatively large changes in the emissions from Transport are due to a revised allocation of fuel use as result of updates of the models to calculate emissions from navigation, off-road vehicles. This resulted in a changes in the fuel use and thus emissions in the corresponding sectors for the total time serie.

As a result of some of the above-mentioned changes (and others), figures for emissions from precursor gases changed over the entire time series. The explanation of the recalculations can be found in the IIR report (2017). These recalculations (NMVOC) also induced the revision of the indirect CO_2 emissions.

10.2.2 KP-LULUCF inventory

As a result of issues with the CRF during the original NIR 2016 submission a comparison with the 2016 CRF tables is not a reliable source for assessment of the recalculations in the KP-LULUCF inventory. Instead the effects of the methodological improvements on the reported carbon stock changes under AR, D and FM are provided in Chapter 11.3.1.

10.3 Implications for emissions trends, including time series consistency

10.3.1 GHG inventory

The recalculations and error corrections further improved both the accuracy and the time series consistency of the estimated emissions.

Table 10.2 shows the changes made due to the recalculations for the 1990, 1995, 2000, 2005, 2010 and 2012-2014 (compared with the NIR 2016). From the table, it emerges that the recalculations changed national emissions only to a small extent (<0.5%). The years 2013 and 2014 hold the largest recalculations (around 0.9 Tg CO_2 eq). More detailed explanations are given in the relevant Chapters 3–9.

Table 10.2 Differences between NIR 2015 and the NIR 2016 for the period 1990–2014 due to recalculations (Units: Tg CO_2 eq; for F-gases: Gg CO_2 eq)

	Source	1990	1995	2000	2005	2010	2012	2013	2014
CO_2 Tg]	NIR 2017	**169.0**	179.5	178.0	183.3	188.8	171.9	172.3	164.8
Incl.	NIR 2016	**169.2**	180.0	178.5	183.9	188.7	172.0	171.9	164.2
LULUCF	*Difference*	-0.1%	-0.2%	-0.3%	-0.3%	0.1%	-0.1%	0.3%	0.3%
CO_2 [Tg]	NIR 2017	**162.9**	173.3	172.0	177.4	182.8	165.8	165.8	158.3
Excl.	NIR 2016	**163.2**	173.7	172.4	177.8	182.8	165.9	165.7	158.0
LULUCF	*Difference*	-0.1%	-0.2%	-0.2%	-0.2%	0.0%	-0.1%	0.1%	0.2%
CH_4 [Tg]	NIR 2017	**32.3**	30.3	25.1	20.5	20.1	19.2	19.2	18.8
	NIR 2016	**32.9**	30.7	25.3	20.4	20.0	19.2	19.2	18.8
	Difference	-1.8%	-1.3%	-1.0%	0.4%	0.6%	0.0%	0.0%	0.1%
N_2O [Tg]	NIR 2017	**17.7**	17.8	15.8	14.2	8.2	7.9	8.1	8.2
	NIR 2016	**17.6**	17.7	15.7	14.2	8.2	7.8	7.8	7.9
	Difference	*0.3%*	*0.4%*	*0.5%*	*0.5%*	*0.9%*	*1.0%*	*3.5%*	*3.1%*
PFCs	NIR 2017	2663	**2280**	1903	366	314	188	144	93
[Gg]	*NIR 2016*	2663	**2280**	1903	366	314	188	144	93
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
HFCs	NIR 2017	5606	**7571**	4765	1728	2666	2387	2446	2252
[Gg]	*NIR 2016*	5606	**7571**	4713	1619	2485	2192	2234	2241
	Difference	*0.0%*	*0.0%*	*1.1%*	*6.8%*	*7.3%*	*8.9%*	*9.5%*	*0.5%*
SF_6	NIR 2017	207	**261**	259	204	154	173	120	135
[Gg]	*NIR 2016*	207	**261**	259	204	154	173	120	135
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
Total	NIR 2017	227.5	237.7	225.8	220.3	220.3	201.7	202.3	194.3
[Tg CO_2-eq.]	*NIR 2016*	228.3	238.5	226.5	220.6	219.8	201.6	201.3	193.4
Incl. LULUCF	*Difference*	-0.3%	-0.3%	-0.3%	-0.1%	0.2%	0.1%	0.5%	0.4%
Total	NIR 2017	221.4	231.5	219.7	214.4	214.2	195.4	195.6	187.6
[Tg CO_2-eq.]	NIR 2016	222.2	232.2	220.3	214.4	213.8	195.3	195.0	187.1
Excl. LULUCF	*Difference*	-0.3%	-0.3%	-0.2%	0.0%	0.2%	0.1%	0.3%	0.3%

Note: Base year values are indicated in bold

The above changes translate to changes in the emission trends. In table 10.3 the changes in emission trend from base year to 2014 are shown compared to the trend as presented in the NIR 2016.

Table 10.3 Differences between NIR 2016 and NIR 2017 with respect to emission trends from the base year to 2014 (Units: Gg CO_2 eq.)

Gas	Trend base year-2014 (absolute)			Trend base year-2014 (percentage)		
CO_2 eq [Gg] [1)]	Reported in NIR 2017	Reported in NIR 2016	*Difference*	Reported in NIR 2017	Reported in NIR 2016	*Difference*
CO_2	2,851	2,526	262	1.7%	1.5%	0.2%
CH_4	-13,155	-13,120	35	-40.7%	-40.6%	0.1%
N_2O	-9,616	-9,841	225	-54.3%	-55.8%	1.4%
HFCs	-5,125	-5,336	211	-67.7%	-70.5%	2.8%
PFCs	-2,136	-2,136	0	-93.7%	-93.7%	0.0%
SF_6	-141	-141	0	-54.1%	-54.1%	0.0%
Total	-27,321	-28,048	726	-12.2%	-12.6%	0.3%

[1]) Including indirect emissions, excluding LULUCF

The table shows that the trend only changed significantly for the HFC emission recalculations.

10.3.2 KP-LULUCF inventory

The implemented changes have improved time series consistency. The new method for calculating carbon stock changes in above- and belowground biomass in newly established forests removed a high correction flux that previously occurred after 20 years after afforestation due to the transition in the calculation of carbon stock changes from newly established forest to FL-FL (also see Chapter 6.1 and Arets et al., 2017). Additionally the recalibration of the forest model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory (i.e. from 2013 onwards) resulted in improved time series consistency between carbon stock changes as calculated from the latest NFI and the projections beyond 2013.

10.4 Recalculations, response to the review process and planned improvements

10.4.1 GHG inventory

10.4.1.1 Response to the review process

Public and peer review

Drafts of the NIR are subject to an annual process of general public review and a peer review.
During the public review on the draft NIR of January 2017, several issues were raised for the waste sector. These issues will be considered in improvement actions on emission calculations in the near future.
The peer review includes a general check on all chapters. In addition, special attention has been given to a specific sector or topic each year. This year, a separate study (Kuikman, 2017) focused on the chapter N2O and CO2 emissions from Agriculture. In the report, the conclusion is drawn that the (draft) NIR 2017 for the Netherlands has good quality, and is complete, sufficient transparent and consistent with IPCC Guidelines and the underlying methodology report (Vonk, 2016). Further, the emissions have been allocated to the correct CRF

categories. Recommendations were made to improve transparency by, for example, more specific referencing to the methodology report and enhancing the level of detail in the NIR. Following these recommendations the transparency and readability of the Agriculture chapter can be improved.

Peer reviews in past years have focused on the following sectors and categories: Energy (excluding transport) (CE Delft, 2014), Industrial process emissions (Royal HaskoningDHV, 2013), LULUCF (Somogyi, 2012), Waste (Oonk, 2011), Transport (Hanschke, 2010), Combustion and process emissions in industry (Neelis et al., 2009) and Agriculture (Monteny, 2008). In general, the conclusion of these peer reviews has been that the Dutch NIR adequately describes the way that the Netherlands calculates the emissions of greenhouse gases. The major recommendations refer to the readability and transparency of the NIR and suggestions for textual improvement. In 2015 and 2016 peer reviews did not take place because of the strong delay of the inventory process due to the severe problems with the CRF software.

UNFCCC review
In September 2016, the centralized review of the NIR 2016 took place. In the end of the review week the Netherlands received a Saturday Paper with two issues. It took until February 2017 that the Netherlands and the ERT agreed about the solution of the issue for solid waste disposal (fraction of methane in landfill gas, see paragraph 7.2.2). That is one of the reasons that at the time of the submission of NIR 2017 the Netherlands have not received the ARR report. This means that the reaction to the 2016 review will be included in NIR 2018

10.4.1.2 Completeness of sources

The Netherlands' GHG emission inventory includes all sources identified by the revised Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC, 2006), with the exception of the following, very minor, sources:

- CO_2 from asphalt roofing (2A5), due to missing activity data;
- CO_2 from road paving (2A6), due to missing activity data;
- CH_4 from enteric fermentation of poultry (4A9), due to missing EFs;
- N_2O from industrial wastewater treatment (5D2) and septic tanks (5D3), due to missing method and negligible amounts;
- Part of CH_4 from industrial wastewater (5D2 sludge), due to negligible amounts;
- Precursor emissions (i.e. carbon monoxide (CO), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2)) from memo item 'International bunkers' (international transport).

For more detailed information on this issue, see Annex 6.

10.4.1.3 Completeness of CRF tables

The energy data for the years 1991–1994 are less detailed for all industrial source categories than in both the preceding and following years, but it adequately covers all sectors and source categories. All emissions are specified by fuel type (solid, liquid and gaseous fossil fuels). Coal-derived gases (coke oven gas, blast furnace gas, etc.) are included in 'solid fuels' and refinery gases and residual chemical gases (as well as LPG, except for Transport) are included in 'liquid fuels'. The fuel category 'other fuels' is used to report emissions from fossil waste in waste incineration (included in 1A1a).

Since the Industrial processes source categories in the Netherlands often relate to only a few companies, it is generally not possible to report detailed and disaggregated data. Activity data is confidential and not reported when a source category comprises three (or fewer) companies.

10.4.1.4 Planned improvements

The Netherlands' National System was established by the end of 2005, in line with the requirements of the Kyoto Protocol and the EU Monitoring Mechanism, as a result of the implementation of a monitoring improvement programme (see Section 1.6). In 2007, the system was reviewed during the initial review. The review team concluded that the Netherlands' National System had been established in accordance with the guidelines for National Systems under article 5, section 1 of the Kyoto Protocol (decision 19/CMP.1) and that it met the requirements for the implementation of the general functions of a National System, as well the specific functions of inventory planning, inventory preparation and inventory management.

Monitoring improvement
The National System includes an annual evaluation and improvement process. The evaluation is based on experience in previous years and results of UN reviews, peer reviews and audits. Where needed, improvements are included in the annual update of the QA/QC programme (RVO.nl, 2016).

QA/QC programme
The QA/QC programme for this year (RVO.nl, 2016) continues the assessment of improvement options in the longer term based on the consequences of the 2006 IPCC Guidelines on reporting from 2015 onwards. Improvement actions for new methodologies and changes of EF will be performed in 2017.

The ERT recommended to further centralize the archiving of intermediate calculations by Task Forces. Since 2011, the RIVM database has held storage space where Task Forces can store the data required for their emissions calculations.

10.4.2 KP-LULUCF inventory

The following future improvements are foreseen:
- In the NIR 2018 an updated land-use change matrix 2013-2017 is foreseen.
- An updated soil map is currently being implemented, allowing for improved future calculation of emissions from soil associated with land use changes.

Part ll: Supplementary information required under article 7, paragraph 1

11 KP-LULUCF

11.1 General information

11.1.1 Definition of forest and any other criteria

In its Initial Report for the first commitment period, the Netherlands identified the single minimum values under Article 3.3 of the Kyoto Protocol. Following Annex 1 to Decision 2/CMP.8 these values are also to be used during the second commitment period of the Kyoto Protocol. During the second commitment period of the Kyoto Protocol these definitions will also apply to the Forest Management activity under Article 3.4 of the Kyoto Protocol.

The complete forest definition the Netherlands uses for Kyoto reporting is: "Forest is land with woody vegetation and with tree crown cover of more than 20% and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity *in situ*. They may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest formations with a continuous vegetation cover in which tree crown cover exceeds 20%. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 20% or tree height of 5 m are included under forest as areas normally forming part of the forest area which are temporally unstocked as a result of human intervention or natural causes but which are expected to revert to forest. Forest land also includes:

- forest nurseries and seed orchards that constitute an integral part of the forest;
- roads, cleared tracts, firebreaks and other small open areas, all narrower than 6 m, within the forest;
- forests in national parks, nature reserves and other protected areas, such as those of special environmental, scientific, historical, cultural or spiritual interest, with an area of more than 0.5 ha and a width of more than 30 m;
- windbreaks and shelter belts of trees with an area of more than 0.5 ha and a width of more than 30 m.

This excludes tree stands in agricultural production systems; for example, in fruit plantations and agro-forestry systems."

This definition is in line with FAO reporting since 1984 and was chosen within the ranges set by the Kyoto Protocol. The definition also matches the category Forest land in the inventory under the Convention on Climate Change (Chapter 6 of this NIR, and Arets et al, 2017).

11.1.2 Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

The Netherlands has not elected any other activities to include under Article 3, paragraph 4 of the Kyoto Protocol.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each mandatory and elected activity under Article 3.4 have been implemented and applied consistently over time

Units of land subject to Article 3.3 *Afforestation and reforestation* (AR) are reported jointly and are defined as units of land that did not comply with the Forest definition on 1 January 1990 and do so at any moment before 31st December of 2015. Land is classified as re/afforested as long as it complies with the forest definition. Units of AR land that are deforested again later will be reported under Article 3.3 Deforestation from that point in time onwards.

Units of land subject to Article 3.3 *Deforestation* (D) are defined as units of land that did comply with the Forest definition on or after 1 January 1990 but ceased to comply with this definition at any moment in time after 1 January 1990. Once land is classified as deforested (D land), it remains in this category, even if it is reforested and thus complies with the Forest definition again later in time.

Units of land subject to Article 3.4 *Forest Management* (FM) are units of land meeting the definition of forest that is managed for stewardship and use of forest land and that have not been classified under AR or D. For this the Netherlands applies the broad interpretation of Forest Management. As a result all forest land under the UNFCCC that is not classified as AR or D land will be classified as FM. Further, since all forest land in the Netherlands is considered to be managed land, and conversions from other land uses to forest land are always human induced, such conversions to forest land will always be reported under AR.

For each individual pixel, an overlay of land-use maps shows all mapped land-use changes over time since 1990. All of these are taken into account to ensure that AR land remains AR land unless it is deforested and that D land remains D land, even when it is again converted to forest land later in time. CRF Table 4(KP-I)A.2 provides the information for D land desaggregated for the land-use categories in the reporting year, including Forest Land which refers to units of land that were reforestated after earlier deforestation.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities and how they have been consistently applied in determining how land was classified

This is not applicable, as besides the mandatory activity Forest Management no Article 3.4 activities have been elected.

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3 and Article 3.4

The Netherlands applies complete and spatially explicit land-use mapping that allows for geographical stratification at 25 m x 25 m (0.0625 ha) pixel resolution (Kramer et al., 2009). This corresponds with the wall-to-wall approach used for reporting under the Convention, i.e. approach 3 in Chapter 3 of IPCC (2006) and is described as reporting method 2 in the 2013 IPCC KP Guidance (Par. 2.2.2 of IPCC

2014)). Afforestation, reforestation, deforestation and forest management activities are recorded on a pixel basis. The status of each pixel is monitored over the full time series.

Any pixel changing from non-compliance to compliance with the Forest definition is treated as reforestation/afforestation. This may be the result of a group of clustered pixels that together cover at least 0.5 ha of non-forest land changing its land use to Forest land. Similarly, any pixel changing from compliance with the Kyoto Forest definition to non-compliance is treated as deforestation, whether it involves the whole group of clustered pixels or just a subgroup of them. Groups of clustered pixels that together cover at least 0.5 ha of forest land in 1990 and remain doing so over the full time period since 1990 are treated as Forest Management.

11.2.2 *Methodology used to develop the land transition matrix*

The basis for the spatially explicit land-use mapping are wall-to-wall maps for 1 January 1990, 1 January 2004 (Kramer et al., 2007 and 2009), 1 January 2009 (Van den Wyngaert et al., 2012) and 1 January 2013 (Kramer and Clement, 2015), also see par 11.2.3 below. An overlay was made between those four maps, a map with mineral soil types and a map with organic soil locations (Arets et al., 2017). This resulted in four land-use change matrices; a first matrix between 1 January 1990 and 1 January 2004, a second matrix covering the period 1 January 2004 and 1 January 2009 and a third matrix covering the period January 2009-1 January 2013 . Together, the 3 matrices thus cover the period 1 January 1990 - 1 January 2013, ensuring that we are able to capture all land-use changes. Mean annual rates of change for all land-use transitions in between the years with maps were calculated by linear interpolation.From 2013 onwards the annual changes as obtained from the matrix 2009-2013 are used to extrapolate the land use changes. These values will be used until a new land use map is available (provisionally planned to be included in the NIR2018 with a map date of 1 January 2017).

Table 11.1 gives the annual values from 1990 onwards for the cells in Table NIR-2 that are related to the Article 3.3 activities and forest management.

The summed values in Table 11.1 for AR (AR land remaining AR land + land converted to AR land) match the sum of values reported under the Convention sector 4.A.2 land converted to Forest Land subcategory for the respective years up to 2003. From 2004 onwards these start to differ because part of the afforestation that is included in the Convention sector 4.A.2 is on land that previously was deforestated between 1990 and 2003. Additionally, due to the 20 year transition period for forests, from 2010 onwards, land reported under sector 4.A.2 that was converted to Forest Land 20 years before, will be reported under the Convention sector 4.A.1 Forest land remaining Forest Land.

Up to 2009 the annual deforestation rates that can be calculated from the sum of conversions from Forest Land to other land uses in CRF Table 4.1 (land transition matrix) as reported under the Convention are equal to the sum of deforestation (AR to D and FM to D) in Table 11.1.

Because the land-use changes are based on three consequetive land-use change matrices, from 2009 onwards, ie. the onset of the third matrix, there are small areas of land that were first deforested in the period 1990-2004, then reforested during 2004-2009 and deforested again after 2009. In the Convention table such units of land are reported under conversions from Forest Land, while in the areas provided in Table 11.1 they are included under "D remaining D" since the first deforestation event on the unit particular unit of land.

Table 11.1 Results of the calculations of the area change (in kha) of reforestation/afforestation (AR), deforestation (D) and Forest Management (FM) in the period 1990–2015

Year	Land to AR	AR remaining AR	AR to D	FM to D	D remaining D	FM remaining FM	Land in KP article 3.3 ARD	Other (not in KP article 3.3 or FM)
1990	3.0	0	0	2.3	0	380.6	5.3	3765.6
1991	3.0	3.0	0	2.3	2.3	378.3	10.5	3762.6
1992	3.0	5.9	0	2.3	4.6	376.0	15.8	3759.6
1993	3.0	8.9	0	2.3	6.9	373.7	21.0	3756.7
1994	3.0	11.9	0	2.3	9.2	371.4	26.3	3753.7
1995	3.0	14.8	0	2.3	11.5	369.1	31.6	3750.8
1996	3.0	17.8	0	2.3	13.8	366.8	36.8	3747.8
1997	3.0	20.7	0	2.3	16.1	364.5	42.1	3744.8
1998	3.0	23.7	0	2.3	18.4	362.2	47.3	3741.9
1999	3.0	26.7	0	2.3	20.7	359.9	52.6	3738.9
2000	3.0	29.6	0	2.3	23.0	357.6	57.9	3735.9
2001	3.0	32.6	0	2.3	25.3	355.3	63.1	3733.0
2002	3.0	35.6	0	2.3	27.6	353.0	68.4	3730.0
2003	3.0	38.5	0	2.3	29.9	350.7	73.6	3727.0
2004	2.9	40.4	1.1	1.9	32.1	348.9	78.4	3724.1
2005	2.9	42.3	1.1	1.9	35.1	347.0	83.2	3721.3
2006	2.9	44.1	1.1	1.9	38.0	345.1	87.9	3718.4
2007	2.9	45.9	1.1	1.9	40.9	343.2	92.7	3715.5
2008	2.9	47.8	1.1	1.9	43.9	341.4	97.5	3712.6
2009	3.3	49.1	1.6	2.2	46.8	339.2	102.9	3709.3
2010	3.3	50.8	1.6	2.2	50.5	337.0	108.4	3706.0
2011	3.3	52.5	1.6	2.2	54.3	334.9	113.8	3702.7
2012	3.3	54.2	1.6	2.2	58.0	332.7	119.3	3699.5
2013	4.1	56.8	0.7	3.0	61.8	329.7	126.4	3695.4
2014	4.1	60.1	0.7	3.0	65.5	326.7	133.5	3691.2
2015	4.1	63.5	0.7	3.0	69.2	323.7	140.6	3687.1

11.2.3 Maps and/or database to identify the geographical locations and the system of identification codes for the geographical locations

The land-use information reported under both the Convention (see also par. 6.3) and the Kyoto Protocol is based on four land-use maps for monitoring nature development in the Netherlands, 'Basiskaart Natuur' (BN) for 1 January 1990, 1 January 2004 (Kramer et al., 2007 and 2009), 1 January 2009 (Van den Wyngaert et al., 2012) and 1 January 2013 (Kramer and Clement 2015). The source material for BN 1990 consists of the paper topographical map 1:25,000 (Top25) and the digital topographical map 1:10,000 (Top10Vector). The source materials for BN 2004, BN 2009 and BN 2013 consist of the digital topographical map 1:10,000 (Top10Vector) combined with four other sources, i.e. two subsidy regulations (information from 2004 and 2009, respectively), a map of the geophysical regions of the Netherlands (*Fysisch Geografische Regio's*) and a map of land use in 2000 (*Bestand BodemGebruik*, 2000; Kramer et al., 2007). Table 11.2 summarizes the characteristics of the 1990, 2004, 2009 and 2013 maps (also see Arets et al., 2017).

To distinguish between several mineral soils and organic soils, also an overlay is made between the land-use maps and the Dutch Soil Map (De Vries et al., 2003) resulting in land-use information with national coverage. For each pixel, it identifies whether it was subject to AR, D or remains as FM between 1990 and 2004, 2004 and 2009, and 2009 and 2013, and whether it is located on mineral or organic soil.

Because of the multiple year time intervals between the different land-use maps, it is unknown for each individual location in which year exactly AR or D occurred during the time intervals. A mean annual rate for the Netherlands as a whole is derived from the aforementioned analysis by interpolation.

Table 11.2 Characteristics of BN 1990, BN 2004, BN 2009 and BN2013

Characteristics	BN 1990	BN 2004	BN 2009	BN 2013
Name	Historical Land Use Netherlands 1990	Base Map Nature 2004	Base Map Nature 2009	Base Map Nature 2013
Aim	Historical land-use map for 1990	Base map for monitoring nature development	Base map for monitoring nature development	Specifically developed for KP end-of-period reporting following the methodology of BN2009
Resolution	25 m	25 m	25 m	25 m
Coverage	Netherlands	Netherlands	Netherlands	Netherlands
Map date	1 January 1990	1 January 2004	1 January 2009	1 January 2013
Base year source data	1986–1994	1999–2003	2004–2008	2009-2011
Source data	Hard copy topographical maps at 1:25,000 scale and digital topographical maps at 1:10,000	Digital topographical maps at 1:10,000 and additional sources to distinguish specific nature types	Digital topographical maps at 1:10,000 and additional sources to distinguish specific nature types	Digital topographical maps at 1:10,000 and additional sources to distinguish specific nature types
Number of classes	10	10	10	10
Distinguished classes	Grassland, Arable land, Heath land/peat moor, Forest, Buildings,	Grassland, Nature grassland, Arable land, Heath land,	Grassland, Nature grassland, Arable land, Heath land,	Grassland, Nature grassland, Arable land, Heath land,

Characteristics	BN 1990	BN 2004	BN 2009	BN 2013
	Water, Reed marsh, Sand, Built-up area, Greenhouses	Forest, Built-up area and Infrastructure, Water, Reed marsh, Drifting sands, Dunes and Beaches	Forest, Built-up area and infrastructure, Water, Reed marsh, Drifting sands, Dunes and beaches	Forest, Built-up area and infrastructure, Water, Reed marsh, Drifting sands, Dunes and beaches

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1 Description of the methodologies and the underlying assumptions used

Data on forests are based on three National Forest Inventories carried out during 1988–1992 (HOSP data, Schoonderwoerd and Daamen 1999), 2000–2005 (MFV data, Daamen and Dirkse, 2005) and 2012-2013 (NBI6, Schelhaas et al., 2014). As these most accurately describe the state of Dutch forests, they were applied in the calculations for Forest land remaining forest land, Land converted to forest land and Forest land converted to other land use, representing the state of the forest at three moments in time; 1990 (HOSP), 2003 (MFV) and 2012 (NBI6). Until a new forest inventory will be available, between 2013 and 2020 the development of carbon stocks in forests is based on projections using the EFISCEN model (see Arets et al., 2017).

With plot level data from the HOSP, MFV and NBI6 changes in carbon stocks in living biomass in forests were calculated. In addition, changes in activity data were assessed using several databases with tree biomass information, with allometric equations to calculate above-ground and below-ground biomass and with forest litter.

More detailed descriptions of the methods used and EFs can be found in Arets et al. (2017).

Afforestation/reforestation
Reporting of AR is linked to the following land-use categories as used for reporting under the Convention:

- 4.A.2.1 Cropland converted to forest land
- 4.A.2.2 Grassland converted to forest land
- 4.A.2.3 Wetland converted to forest
- 4.A.2.4 Settlement converted to forest
- 4.A.2.5 Other Land converted to forest land

The methodologies used to calculate carbon stock changes in biomass due to AR activities are in accordance with those under the Convention as presented in section 6.4.2.2. The carbon stock changes due to changes in forest biomass were attributed to changes in above-ground or below-ground biomass based on the fact that carbon stocks in newly planted plots would reach the carbon stocks of the average forest in 30 years time (see section 6.4.2.2 and Arets et al., 2017). Because these calculations have changed since the NIR 2016 (see Chapter 2.6) this also results in a recalculation of the Carbon Stock Changes in 2013 and

2014. Compared to the NIR 2016 net carbon stock changes in above- and belowground biomass in AR decreased with 1.99 Gg C in 2013 and decreased with 5.2 Gg C in 2014.
Carbon stock losses due to changes in above-ground and below-ground biomass in land use conversions from Cropland and Grassland were calculated on the basis of Tier 1 default carbon stocks. Carbon stock changes in dead wood and litter are not reported (see section 11.3.1.2). Methods for carbon stock changes in mineral and organic soils are presented below. Results for carbon stock changes for all pools during the second KP commitment period are given in Table 11.3.

Table 11.3 Net carbon stock changes (in Gg C) from reforestation/afforestation activities during the second commitment period. CSC: carbon stock change, AG: above ground, BG: below ground

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
2013	180.6	19.8	NE	6.2	0.41	-1.53
2014	193.2	22.0	NE	7.1	-0.19	-1.53
2015	206.0	24.4		8.0	-0.88	-1.53

Deforestation
Reporting of D is linked to the following land-use categories as used for reporting under the Convention:
- 4.B.2.1 Forest Land converted to Cropland;
- 4.C.2.1 Forest Land converted to Grassland;
- 4.D.2.1 Forest Land converted to Wetland;
- 4.E.2.1 Forest Land converted to Settlements;
- 4.F.2.1 Forest Land converted to 'Other Land'

After deforestation also subsequent other land-use changes are possible on D land. The methodologies used to calculate carbon stock changes in biomass due to deforestation and subsequent carbon stock changes on previously deforested land are in accordance with those under the Convention as presented in sections 6.4.2.3, and 6.5 to 6.9 and Arets et al., 2017.

The carbon stock changes due to changes in forest biomass were differentiated in above-ground or below-ground biomass using data available from the used bookkeeping model (Arets et al., 2017). Data from the 6th Dutch Forest Inventory 2012-2013 in combination with the data from the previous National Forest Inventory (MFV) in 2000, allowed the calculation of actual carbon stock changes of deforestation (see EF in Table 6.8 in section 6.4.2.3). Carbon stock change due to changes in above-ground and below-ground biomass in land-use conversions to Cropland and Grassland were calculated on the basis of Tier 1 default carbon stocks for Cropland and Grassland (see Arets et al, 2017). Net carbon stock changes in the different carbon pools are given in Table 11.4.

Changes in the Carbon Stock in forest biomass resulting from the methodological change in calculating biomass changes in newly established forests and an improved calibration of the model to project carbon stock changes in Forest Land remaing Forest Land beyond 2012 (see Chapter 6.2) resulted in recalculations of the carbon stock losses in biomass under Deforestation. Compared to the NIR2016 net carbon stock losses under Deforestation decreased with 7.7 Gg C in 2013 and with 8.7 Gg C in 2014.

Carbon stock changes in mineral soils are reported using a 20-year transition period, while carbon stock changes in organic soils are reported for all organic soils under Article 3.3 activities. The methods are presented below.

Deforestation of reforested/afforested land involved an emission of all accumulated carbon stocks up to the time of deforestation that had been calculated following the methodologies for reforestation/afforestation.

Table 11.4 Net carbon stock changes (in Gg C) of deforestation activities during the second commitment period. CSC: carbon stock change, AG: above ground, BG: below ground

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
2013	-243.28	-35.16	-111.20	-5.79	0.40	-15.48
2014	-247.83	-35.98	-112.26	-6.53	0.05	-16.82
2015	-252.41	-36.80	-113.33	-7.29	-0.30	-18.16

Forest management
Reporting of FM is linked to the category 4.A.1 Forest land remaining Forest land as used for reporting under the Convention. Yet the area and total figures of carbon stock changes differ due to the fact that under the convention reporting from 2009 onwards land that was afforested since 1990 surpasses the 20 year transition period and is included in the category Forest Land remaining Forest Land, while under the KP reporting such lands remain to be reported under AR.

Calculation of carbon stock changes and resulting emission factors are the same as used under the convention (see chapter 6.4.2.1 and Arets et al., 2017). Net carbon stock changes are given in Table 11.5. As a result of improved calibration of the model to project carbon stock changes in forest biomass beyond 2012 (see Chapter 6.2) these carbon stock changes under FM were recalculated. Compared to the NIR 2016 net carbon stock gains in above- and belowground biomass decreasd with 177.5 Gg C in 2013 and with 175.8 Gg C in 2014.

Carbon stock changes in litter in Forest land remaining Forest land were estimated but a Monte Carlo uncertainty assessment showed that while litter consistently was a carbon sink, the magnitude of it was very uncertain. Therefore it was considered to be the more conservative estimate to set the accumulation of carbon in Forest Management to zero (see Arets et al, 2017).

Table 11.5 Net carbon stock changes (in Gg C) in Forest Management during the second commitment period. CSC: carbon stock change, AG: above ground, BG: below ground

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
2013	288.18	51.87	NO	72.67	NO	NO
2014	285.17	51.33	NO	72.03	NO	NO
2015	282.15	50.79	NO	71.39	NO	NO

Method of estimating carbon stock change in ARD land in mineral soils

Carbon stock changes in mineral and organic soils are reported for all soils changing land use under Article 3.3. The carbon stock change in mineral soils was calculated from base data taken from the LSK survey (de Groot et al., 2005; Lesschen et al., 2012). The LSK database contains quantified soil properties, including soil organic matter, for approximately 1,400 locations at five depths. The soil types for each of the sample points were reclassified to 11 main soil types, which represent the main variation in carbon stocks within the Netherlands. Combined with the land use at the time of sampling, this led to a new soil/land use-based classification of all points (see Arets et al.,2017 for more details).

The LSK dataset contains only data on soil carbon stocks for the land uses Grassland, Cropland and Forest. About 44% of deforested land is Grassland in 2013, 2014 and 2015. For the remaining land-use categories, separate estimates were made. For Settlements, which is about 32% of deforested land in 2013, 2014 and 2015, the estimates make use of information in the IPCC 2006 guidelines. An average soil carbon stock under settlements that is 0.9 times the carbon stock of the previous land use is calculated on the basis of the following assumptions:

(i) 50% of the area classified as Settlements is paved and has a soil carbon stock of 0.8 times the corresponding carbon stock of the previous land use. Considering the high resolution of the land-use change maps in the Netherlands (25 m x 25 m grid cells), it can be assumed that, in reality, a large portion of that grid cell is indeed paved.

(ii) The remaining 50% consists mainly of Grassland and wooded land, for which the reference soil carbon stock from the previous land use, i.e. Forest, is assumed.

For the land-use category Wetland, which makes up 5% of deforested land, no change in carbon stocks in mineral soils is assumed upon conversion to or from Forest. For the category ‘Other land’, a carbon stock of zero is assumed. This is a conservative estimate, yet in many cases very realistic (‘Other land’ in the Netherlands comprises mainly sandy beaches and inland (drifting) sandy areas).

The estimated annual C flux associated with reforestation/afforestation or deforestation is then estimated from the difference between land-use classes divided by 20 years (the IPCC default transition period):

$$E_{\min\_xy} = \sum_{1}^{i} \left(\frac{C_{yi} - C_{xi}}{T} \cdot A_{\min\_xyi} \right)$$

$E_{\min\_xy}$	annual emission for land converted from land-use x to land-use y on soil-type i (Gg C yr^{-1})
$A_{\min\_xy}$	area of land converted from land-use x to land-use y on soil-type i in years more recent than the length of the transition period (= less than 20 years ago) (ha)
C_{yi}, C_{xi}	carbon stocks of land-use x or y on soil-type i (Gg C.ha^{-1})
T	length of transition period (= 20 years)

For units of land subject to land-use change during the transition period (e.g. changing from Forest to Grassland and then to Cropland), the estimated carbon stock at time of land-use change was calculated thus:

$$C_{\Delta yi_t} = C_{xi} + t \cdot \frac{C_{yi} - C_{xi}}{T}$$

With symbols as above and

$C_{\Delta yi_t}$	carbon stock of land converted from land-use x to land-use y on soil-type i at time t years after conversion (Gg C ha^{-1})
t	years since land-use change to land-use y

And this carbon stock was filled in the first formula to calculate the mineral soil emissions involved in another land-use change.
In mineral soils this resulted in net removals of 1.5 kton CO_2 (2013), and net emissions of 0.7 (2014) and 2.8 (2015) kton CO_2 per year for AR and net removals of 1.5 (2013) and 0.24 (2014) kton CO_2 and emissions of 1.1 kton CO_2 (2015) per year for Deforestation.

Method of estimating carbon stock change in ARD land in organic soils
The area of organic soils under forests in 2015 is small: 25.1 kha, which is 5% of the total area of organic soil. The area of AR land on organic soils was 8.3 kha in 2015 (12.3 % of total AR area) and the area of D land on organic soils was 7.1 kha in 2014 (9.7 % of deforested area). In 2015 the majority of this area of AR (86%) and D (60%) on organic soils was on agricultural land (Cropland or Grassland). Drainage of organic soils to sustain forestry is not part of the land management nor is it actively done.

Organic soils are divided in peat soils, which have a peat layer of at least 40 cm within the first 120 cm and peaty soils, in Dutch called ‘moerige gronden’, which have a peat layer of 5-40 cm within the first 80 cm. Based on the available data sets, two different approaches for the emission factors for peat and peaty soils have been developed (see Arets et al., 2017).

For CO_2 emissions from cultivated peat soils the methodology is described in Kuikman et al. (2005). This method is based on subsidence as a consequence of oxidation of organic matter. The estimated total annual emission from cultivated soils were then been converted to an annual emission factor of 19.03 tonnes CO_2 per ha peat soil to report emissions from peat soils for land-use (change) categories involving Grassland, Cropland and Settlement (see Arets et al., 2017, chapter 11.3).

For the peaty soils, another approach was used, based on a large data set of soil profile descriptions over time (de Vries et al., 2016, in press). From this data set the average loss rate of peat, was derived from the change in thickness of the peat layer over time. This resulted in an average overall emission factor of 13.02 tonnes CO_2 per ha per year for the peaty soils under agriculture. For settlements no data were available, but the same average emission factor was used. Detailed information on calculations for peat and peaty soils is provided in Arets et al. (2017).

For organic soils under deforestation, the assumption that emissions are equal to the emissions of cultivated organic soils is realistic. For reforestation/afforestation, this assumption is rather conservative, as active drainage in forests is not common practice. For this reason and since no data are available on emissions from peat soils under forest or on the water management of forests, it is assumed that during the first year of reforestation/afforestation, emissions remain equal to the emissions on cultivated organic soils before reforestation/afforestation.

N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

Nitrous oxide (N2O) emissions from soils by disturbance associated with land-use conversions are calculated using a Tier 2 methodology, with Equation 11.8 of the 2006 IPCC guidelines for each aggregated soil type (See Chapter 11.2 in Arets et al., 2017). The default EF1 of 0.01 kg N_2O-N/kg N was used. For three aggregated soil types, average C:N ratios, based on measurements, were available and used. For all other aggregated soil types, we used the default C:N ratio of 15 (2006 IPCC guidelines p. 11.16). For aggregated soil types where conversion of land use led to a net gain of carbon, the nitrous oxide emission was set to zero.

GHG emission due to biomass burning in units of land subject to Article 3.3 ARD and Article 3.4 Forest Management

Greenhouse gas emissions (CO_2, CH_4 and N_2O) related to controlled biomass burning in areas that are afforested or reforested (AR) or under Forest Management does not occur, as no slash burning, etc., is allowed; they are therefore reported as not occurring (NO).

Because wildfires in the Netherlands are infrequent and relatively small scale there is no actve monitoring of wildfires, and consequently no recent statistics on wildfires are available. Therefore greenhouse gas emissions (CO_2, CH_4 and N_2O) from forest fires on AR and FM land and other wildfires on D land are estimated using the Tier 1 method (see Arets et al., 2017) and are reported in Table 4(KP-II)4.

Average annual area of burned AR land and FM land was estimated from the historical series of total forest area burned between 1980 and 1992 (on average 37.8 ha, ~0.1% of the total area of forest land; Wijdeven et al., 2006) scaled to the proportion of AR or FM to total forest area.

Besides forest fires, the historic series in Wijdeven et al. (2006) also provides the total area of wildfires. The area of other wild fires outside forests is then calculated from the difference between total area of wildfires and area of forest fires, which on average is 210 ha per year. Because other wildfires in the Netherlands are predominantly on nature grasslands, it was assumed that these are burned nature grasslands.

Average annual area D land burned is then estimated from the fraction of nature grasslands that is D land. In the Netherlands, wild fires seldom lead to total loss of forest cover and therefore do not lead to Deforestation.

11.3.1.2 Justification for omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and mandatory and elected activities under Article 3.4

Carbon stock change due to changes in dead wood and litter in units of land subject to Article 3.3 AR

The national forest inventory provides an estimate for the average amount of litter (in plots on sandy soils only) and the amount of dead wood (all plots) for plots in permanent forests. The data provide the age of the trees and assume that the plots are no older than the trees. However, it is possible that several cycles of forest have been grown and harvested on the same spot. The age of the plot does not take into account this history or any effect it may have on litter accumulation from previous forests in the same location. Therefore, age does not necessarily represent the time since reforestation/afforestation. This is reflected in a very weak relation between tree age and carbon in litter (Figure 11.2) and a large variation in dead wood, even for plots with young trees (Figure 11.1).

Apart from Forest, no land use has a similar carbon stock in litter (in Dutch Grassland, management prevents the built-up of a significant litter layer). The conversion of non-forest to forest, therefore, always involves a build-up of carbon in litter. But because good data are lacking to quantify this sink, we report the accumulation of carbon in litter for reforestation/afforestation conservatively as zero.

Similarly, no other land use has carbon in dead wood. The conversion of non-forest to forest, therefore, involves a build-up of carbon in dead wood. But as it is unlikely that much dead wood will accumulate in very young forests (having regeneration years in 1990 or later), the accumulation of carbon in dead wood in reforested/afforested plots is most likely a very small sink that is too uncertain to quantify reliably.

We therefore report this carbon sink during the first 20 years conservatively as zero. Once forest become older (>20 years), changes in carbon stocks in dead wood are estimates in the same way as is done for Forest land remaining Forest Land under the convention (see Arets et al., 2017).

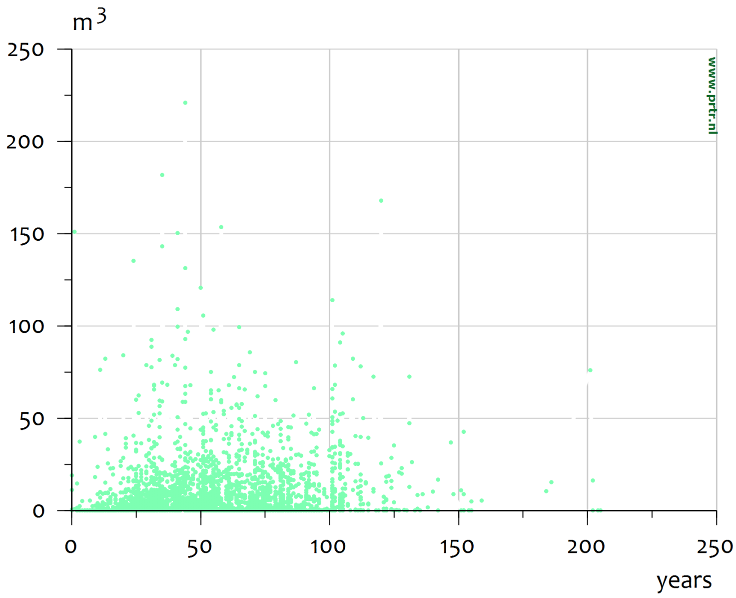


Figure 11.1 Volume of dead wood (standing and lying) in Dutch NFI plots in relation to tree age.

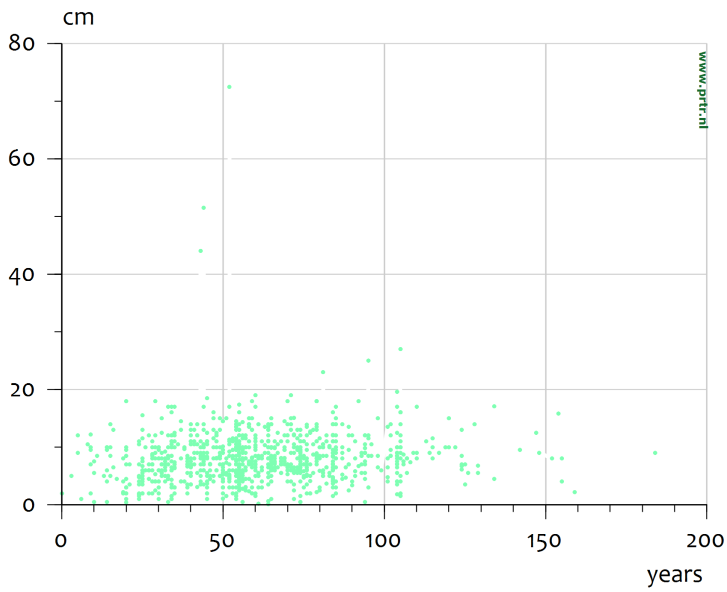


Figure 11.2 Thickness of litter layer (LFH) in Dutch NFI plots in relation to tree age. LFH measurements were conducted only in plots on sandy soils.

N_2O emissions due to nitrogen fertilisation in units of land subject to article 3.3 AR and Forest Management
Fertilisation does not occur in Forests in the Netherlands. Therefore, fertilisation in re/afforested areas and areas under Forest Management

is reported as NO. Fertilisation on Grassland and Cropland is included in the Agriculture Sector.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

For all article 3.3 AR activities, forests were created only after 1990 and the factoring-out of effects on age structure of practices and activities before 1990 is not relevant. For article 3.3 D activities, the increase in mean carbon stock since 1990 may be partly an effect of changes in management as well as a change in age structure resulting from activities and practices before 1990. However, it is not known which factor contributes to what extent. There has been no factoring-out of indirect GHG emissions and removals due to the effects of elevated carbon dioxide concentrations or nitrogen deposition.
This increase in mean carbon stock results in higher carbon emissions due to deforestation. Thus, not factoring out the effect of age structure dynamics since 1990 results in a more conservative estimate of emissions due to article 3.3 D activities.

11.3.2 Changes in data and methods since the previous submission (recalculations)

Afforestation

This year a new approach was implemented for assessing carbon stock changes in newly established forests (also see Chapter 6.1 and Arets et al., 2017). In the default method that was used until the NIR 2016, the carbon stock changes in newly established forests followed a young forests' growth curve until reaching 20 years, after which these forests assumed the carbon stock of the average forest under the category FL-FL (see Arets et al, 2016). However, because carbon stocks in new forests after 20 years were not yet at the level of the average forest, this difference in carbon stock just before and after transition to FL-FL would result in an additional carbon flux in the year of transition.

Further analysis of NFI data showed that the actual time needed to reach the carbon stock of the average forest is about 30 years. Therefore, a new method was implemented in which the time of maturation is 30 years instead of 20 year. Carbon stocks on units of afforested land annually increase with the difference between the carbon stock at that time and the carbon stock of the average forest under FL-FL divided by the number of years left to reach an age of 30 years. This implies that the carbon accumulation in new forests depends on the carbon stock changes in the average forest. With this new method the total accumulation of carbon in afforested land over the first 30 years after establishment is similar, but more gradually distributed than in the old method. During the first 20 years after afforestation the carbon stocks in biomass are bigger in the new method, while between 20 and 29 years after afforestation they are smaller than in the old method (see Arets et al., 2017, for detailed information on the methodological background).

Forest Management

Additionally the model used to project carbon stock changes in FL-FL beyond the latest National Forest Inventory (NBI6 in 2013) was recalibrated to better reflect observed mortality patterns (Arets et al., 2017). As a consequence for the years after the NBI, i.e. 2013 and 2014, net changes in carbon stocks in forests remaining forests, and hence Forest Management, were estimated to be smaller than in the previous submissions. Changes in carbon stocks will be updated again once a new NFI becomes available, which is expected by 2021.

Deforestation, HWP and wildfires
These changes above in both newly established forests and forests remaining forests will affect emissions and removals in all categories in which carbon stocks in biomass on Forest Land is included, i.e. carbon stock losses from deforestation, emissions from wildfires and HWP. HWP is affected because different calculated amounts of wood will become available from deforestation, which is included in HWP assuming instantaneous oxidation.

11.3.3 Uncertainty estimates
The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates of the forest statistics, land use and land-use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals (Olivier et al., 2009). The uncertainty analysis is performed for Forest Land and is based on the same data and calculations that were also used for KP Article 3.3 categories and Forest Management. Thus, the uncertainty for total net emissions from units of land under Article 3.3 afforestation/reforestation are estimated at 63 per cent, equal to the uncertainty in land converted to forest land. The uncertainty for total net emissions from units of land under Article 3.3 deforestation is estimated at 56 per cent, equal to the uncertainty in land converted to grassland (which includes for the uncertainty analysis, all forest land converted to any other type of land use). Similarly, the uncertainty for total net removals from units of land under Article 3.4 Forest Management is estimated at 67 per cent, equal to the uncertainty of Forest Land remaining Forest Land (See Olivier et al. (2009) for details).

11.3.4 Information on other methodological issues
There is no additional information on other methodological issues.

11.3.5 The year of the onset of an activity, if after 2013
The forestry activities under article 3, paragraph 3 and 4 are reported from the beginning of the commitment period.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are directly human-induced
Land use and land-use change is mapped using regularly updated land-use maps covering the whole land area of the Netherlands. Land use maps with dates 1 January 1990, 2004, 2009 and 2013 have been used to track changes in land-use on units of land. All AR and D activities between 1 January 1990 (map 1 January 1990) and 31 December 2013 have been taken into account. Subsequent land use changes are extrapolated from changes in the last period for which maps are

available (2009-2013). New land-use maps and corresponding land-use matrices are foreseen for the dates 1 January 2017 and 1 January 2021. By the end of the second commitment period this will allow to take into account all land-use changes between 1 January 1990 and 31 December 2020.

In the Netherlands, forests are protected by the Forest Law (1961), which stipulates that 'The owner of ground on which a forest stand, other than through pruning, has been harvested or otherwise destroyed, is obliged to replant the forest stand within a period of three years after the harvest or destruction of the stand'.

With the historic and current scarcity of land in the Netherlands, any land use is the result of deliberate human decisions.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Following the Forest definition and the mapping practice applied in the Netherlands, areas subject to harvesting or forest disturbance are still classified as Forest and as such will not result in a change in land use in the overlay of the land-use maps (Kramer et al., 2009; Arets et al., 2017).

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but are not yet classified as deforested

The land-use maps do not provide information on forest areas that have lost forest cover if they are not classified as deforested. From the National Forest Inventories, however, it can be estimated that approximately 0.3% of Forest annually can be classified as clear-cut area, i.e. without tree cover.

11.4.4 Information related to the natural disturbances provision under article 3.3

The Netherlands intends to apply the provisions to exclude emissions from natural disturbances for the accounting for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period. The Netherlands has established a background level and margin for natural disturbances as described below.

Types of natural disturbances

In the Netherlands Natural disturbances in forests are relatively rare and therefore limited data are available. For AR the Netherlands includes wildfires as disturbance type and for FM the Netherlands includes wildfires and wind storms (as an extreme weather event).

Time series for the calibration period

The time series of annual CO_2 emissions from the natural disturbances for the calibration period is provided in table 11.6. Based on the total extent of forest fires, greenhouse gas emissions from forest fires are calculated for FM and AR land under KP-LULUCF (see Section 11.3.1.1 on forest fires).

Information on wind storms is based from a proprietary database that is maintained at Wageningen Environmental Research (Alterra) in which damage from major storm events is collected. Part of this data is available through Schelhaas et al. (2003). Salvage logging is estimated to remove 60% of the fallen tree volume. The remaining 40% is included under natural disturbance for calibration.

Table 11.6. Time series of total annual emissions for disturbance types included under FM and AR

Activity	Disturbance type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		Inventory year during the calibration period																			
		Total annual emission [Gg CO_2 eq.]																			
FM	*Wildfires*	2.51	2.54	2.57	2.60	2.63	2.66	2.69	2.72	2.75	2.77	2.80	2.83	2.85	2.88	2.89	2.91	2.92	2.94	2.95	2.97
	Wind storms	283.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	118.25	0.00	0.00
	Total	**286.31**	**2.54**	**2.57**	**2.60**	**2.63**	**2.66**	**2.69**	**2.72**	**2.75**	**2.77**	**2.80**	**2.83**	**2.85**	**2.88**	**2.89**	**2.91**	**2.92**	**121.19**	**2.95**	**2.97**
AR	*Wildfires*	0.02	0.04	0.06	0.08	0.10	0.13	0.15	0.18	0.20	0.23	0.25	0.28	0.31	0.34	0.36	0.38	0.40	0.42	0.44	0.46
	Total	0.02	0.04	0.06	0.08	0.10	0.13	0.15	0.18	0.20	0.23	0.25	0.28	0.31	0.34	0.36	0.38	0.40	0.42	0.44	0.46

Table 11.7. Areas of FM and AR

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Area under FM (kha)	381	378	376	374	371	369	367	365	362	360	358	355	353	351	349	347	345	343	341	339
Area under AR (kha)	3	6	9	12	15	18	21	24	27	30	33	36	38	41	43	45	47	49	51	52

Background level and margin
The background level and margin are calculated using the default as provided in chapter 2.3.9.6 of the IPCC 2013 revised supplementary methods for KP (IPCC 2014). In 5 iterative steps all outliers have been removed. The resulting annual background level plus margin (twice the standard error) are the following:
FM: 4.38 Gg CO_2 eq.
AR: 0.012 Gg CO_2 eq.

11.4.5 *Information on Harvested Wood Products under article 3.3*

The approach taken to calculate the HWP pools and fluxes follow the guidance chapter 2.8 in the 2013 IPCC KP guidance (IPCC 2014). As required by the guidelines, carbon from harvests allocated to deforestation is reported using instantaneous oxidation (Tier 1) as the method for calculations. The remainder of the harvests is allocated to Forest Management and subsequently is added to the respective HWP pools. No harvest from AR forests is foreseen as these forests are considered too young for harvesting. As no country specific methodologies or half-life constants exist, the calculations for the HWP-pools follows the Tier-2 approach outlined in the 2013 IPCC KP guidance by applying equations 2.8.1 to 2.8.6.

Four categories of HWP are taken into account: sawnwood, wood-based panels, other industrial roundwood, and paper and paperboard.

From the land-use change calculations under Forest Land (see Arets et al., 2017), the fraction of harvest from deforestation is used. The remaining harvest is allocated to FM land.

The distribution of material inflow in the different HWP pools is based on the data reported to FAO-stat as import, production and export for the different wood product categories. Including those for industrial roundwood and wood pulp as a whole (equations 2.8.1 – 2.8.4.)

The dynamics of the HWP pools is then calculated by applying equations 2.8.5 and 2.8.6 and the half-life constants reported in table 2.8.2 of the 2013 IPCC KP guidance (see Arets et al, 2017).

Because the statistics on production, import and export of industrial round wood in 1990 appeared to be not correct in the FAO forestry statistics database. The data for the base year 1990 are adjusted on the basis of the statistics reported by PROBOS, the Dutch national correspondent to the Joint forest sector questionnaire (JFSQ), reporting national forestry statistics to FAO and other international organisations.

11.5 Article 3.4

11.5.1 *Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced*

See description in 11.4.1. The land-use mapping approach used allows for following Forest land over time. All forest land in the Netherlands is considered to be managed land. With the historic and current scarcity of land in the Netherlands (which has the highest population density of any country in Europe), any land use is the result of deliberate human decisions.

11.5.2 Information relating to Forest Management

11.5.2.1 Conversion of natural forest to planted forest

The vast majority of the forest in the Netherlands is planted and all of the forest area is considered managed forest. Conversion from (natural) forest, to highly productive plantations is not common. Moreover, the effects of such conversions will already be factored in the information on carbon stocks in forest land available from the National Forest Inventories. Therefore emissions arising from possible conversion of (natural) forest to plantations are already included in the carbon stock changes calculated from the National Forest Inventories and are reported already under Forest Management.

11.5.2.2 Forest Management Reference Level (FMRL)

The "Submission of information on forest management reference levels by the Netherlands" of 20 April 2011 holds the information of the FMRL as original submitted. It is published at https://unfccc.int/bodies/awg-kp/items/5896.php

After a correction in the calculation matrix of the used HWP model, changes in the submission of information on forest management reference levels by the Netherlands were communicated on 20 May 2011. This is published at https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_netherlands_corr.pdf. This correction holds updated values of the proposed reference levels.

During the subsequent technical assessment of the submission mentioned above, the expert review team noticed discrepancies in area data used by the models. Based on this The Netherlands rerun the models with updated area data. This resulted in a revised FMRL of –1.464 Mt CO_2 eq. per year (average 2013–2020) assuming instantaneous oxidation of HWP and a revised FMRL of –1.425 Mt CO_2 eq. per year applying a first-order decay function for HWP. These numbers are included in the "Report of the technical assessment of the forest management reference level submission of the Netherlands submitted in 2011", FCCC/TAR/2011/NLD, 19 September 2011 and published at http://unfccc.int/resource/docs/2011/tar/nld01.pdf.

The calculation of the cap on Forest Management as required by paragraph 13 of the annex to decision 2/CMP.7 follows the guidance provided in paragraph 12 of decision 6/CMP.7. It is calculated as 3.5% of the base year greenhouse gas emissions excluding LULUCF taking into account the corrected amount after review of the NIR2015 and Initial Report. These total base year GHG emissions excluding LULUCF were 223,198.40 Gg CO_2 eq. resulting in a 3.5% cap of 7,811.94 Gg CO_2 eq.

11.5.2.3 Technical Corrections of FMRL

A number of changes in the Netherlands inventory cause methodological inconsistencies between the inventory and FMRL. Partly this is because the accounting of HWP as agreed in decision 2/CMP.7 was not yet available at the time the FMRL was submitted. Natural disturbances were not yet included at the time of submission of the FMRL. Moreover, new National Forest Inventory statistics are available covering the period 2003 to 2012 and resulting in recalculated historical data.

As a result before accounting at the end of the commitment period a technical correction of the FMRL of the Netherlands will be necessary. The correction is currently being assessed and will be described in a forthcoming NIR.

11.5.2.4 Information related to the natural disturbances provision under article 3.4.
See section 11.4.4

11.5.2.5 Information on Harvested Wood Products under article 3.4.
See section 11.4.5

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any mandatory and elected activities under Article 3.4

The smallest key category based on a level for Tier 1 level analysis including LULUCF is 739.2 Gg CO_2 (1A1a Liquids; see Annnex 1). With net removals of 859.34 Gg CO_2, the absolute annual contribution of Reforestation/Afforestation under the KP in 2015 is larger than the smallest key category (Tier 1 level analysis including LULUCF). Deforestation under the KP in 2015 causes an emission of 1,576.79 Gg CO_2, which is more than the smallest key category (Tier 1 level analysis including LULUCF). Also removals from Forest Management without HWP are with 1390.78 Gg CO_2 more than the smallest key category (Tier 1 level analysis including LULUCF). Also in 2013 and 2014 the net removals from of Reforestation/Afforestation and Forest Management and emissions from Deforestation under the KP are more than the smallest key category (Tier 1 level analysis including LULUCF).

Table 11.8 shows the net emissions from AR, D and FM for the years 2013–2015.

Table 11.8 Net emissions from AR, D and FM (Gg CO_2)

Activities	Net emissions		
	2013	2014	2015
A. Article 3.3 activities			
A.1. Afforestation and Reforestation	-747.53	-802.87	-859.34
A.2. Deforestation	1510.89	1543.71	1576.79
B. Article 3.4 activities			
B.1. Forest Management	-1425.15	-1415.31	-1390.78

11.7 Information relating to Article 6

The Netherlands is not buying or selling emission rights from JI projects related to land that is subject to a project under Article 6 of the Kyoto Protocol.

12 Information on accounting of Kyoto units

12.1 Information on accounting of Kyoto units 2016

12.1.1 Background information

The Netherlands' Standard Electronic Format report for 2016 containing the information required in paragraph 11 of the annex to decision 15/CMP.1, as updated by decision 3 CMP. 11 paragraph 12 and adhering to the guidelines of the SEF has been submitted to the UNFCCC Secretariat electronically - RITL1_NL_2016_CP_02.xlsx .

12.1.2 Summary of information reported in the SEF tables

The registry only contained CER's at the end of the year 2016

There were 7,562,197 CERs in the registry at the end of 2016: 465,289 CERs were held in the Party holding accounts, 7,015,968 CERs were held in entity holding accounts and 80,940 CERs were held in the voluntary cancellation account.

The total amount of the units in the registry corresponded to 7,562,197 tonnes CO_2 eq.

Annual Submission Item	Submission
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The Standard Electronic Format report for 2016 has been submitted to the UNFCCC Secretariat electronically (RITL1_NL_2016_CP_02.xlsx).

12.1.3 Discrepancies and notifications

Annual Submission Item	Submission
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	**There were no discrepant transactions in 2016**
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	**No CDM notifications occurred in 2016.**
15/CMP.1 annex I.E paragraph 15: List of non-replacements	**No non-replacements occurred in 2016.**
15/CMP.1 annex I.E paragraph 16: List of invalid units	**No invalid units exist as at 31 December 2016.**
15/CMP.1 annex I.E paragraph 17 : Actions and changes to address discrepancies	**No actions were taken or changes made to address discrepancies for the period under review.**

12.1.4 Publicly accessible information

Annual Submission Item	Submission
15/CMP.1 annex I.E Publicly accessible information	**The information as described in 13/CMP.1 annex II.E paragraphs 44-48 is publicly available at the following internet address (URL);** http://www.emissionsauthority.nl/topics/public-information-kyoto **All required information for a Party with an active Kyoto registry is provided with the following exceptions;** ***paragraph 46*** **Article 6 Project Information. The Netherlands does not host JI projects as laid down in National legislation. This fact is stated on the mentioned internet address.** **That the Netherlands does not host JI projects is implied by article 16.46c of the Environment Act (Wet milieubeheer) and explicitly stated in the explanatory memorandum to the act implementing the EC linking Directive (Directive 2004/101/EC, the Directive that links the ETS to the project based activities under the Kyoto Protocol). As is explained in the memorandum, the government decided not to allow JI projects in the Netherlands since it would only increase the existing shortage of emission allowances / assigned amount units.** ***paragraph 47a/d/f/l in/out/current*** **Holding and transaction information is provided on a holding type level, due to more detailed information being declared confidential by EU regulation.** **This follows from article 10 of EU Regulation 2216/2004/EC, that states that "All information, including the holdings of all accounts and all transactions made, held in the registries and the Community independent transaction log shall be considered confidential for any purpose other than the implementation of the requirements of this Regulation, Directive 2003/87/EC or national law."** ***paragraph 47c*** **The Netherlands does not host JI projects as laid down in National legislation (ref. submission paragraph 46 above).** ***paragraph 47e*** **The Netherlands does not perform LULUCF activities and therefore does not issue RMUs.** ***paragraph 47g*** **No ERUs, CERs, AAUs and RMUs have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4 to date.** ***paragraph 47h*** **No ERUs, CERs, AAUs and RMUs have been cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3,**

Annual Submission Item	**Submission**
	paragraph 1 to date. ***paragraph 47i*** **The number of other ERUs, CERs, AAUs and RMUs that have been cancelled is published by means of the SEF report.** ***paragraph 47j*** **The number of other ERUs, CERs, AAUs and RMUs that have been retired is published by means of the SEF report.** ***paragraph 47k*** **There is no previous commitment period to carry ERUs, CERs, and AAUs over from**.

12.1.5 Calculation of the commitment period reserve (CPR)
For the calculation of the CPR we refer to the document of the Netherlands reports which facilitates the calculation of the assigned amount and CPR.

12.1.6 KP-LULUCF accounting
Not applicable, because the Netherlands has chosen for end-of-period accounting for KP-LULUCF.

13 Information on changes in national system

Extensive information on the national inventory system is described in this National Inventory Report under the appropriate sections, as required by the UNFCCC Guidelines. More extensive background information on the National System is also included in the Netherlands 6th National Communication, the 2nd Biennial Report and in the Initial Report. The initial review in 2007 concluded that the Netherlands' National System had been established in accordance with the guidelines.

There have been no changes in the National System since the last submission and since the Initial Report, with the exception of the following issues:

- The co-ordination of the Emission Registration Project, in which emissions of about 350 substances are annually calculated, was performed until 1 January 2010 by PBL. As of 1 January 2010, co-ordination has been assigned to RIVM. Processes, protocols and methods remain unchanged. Many of the former experts from PBL have also shifted to RIVM.
- The name of SenterNovem (single national entity/NIE) changed as of 1 January 2010 to NL Agency.
- The name of NL Agency (single national entity/NIE) has changed, as of 1 January 2014, to Netherlands Enterprise Agency (RVO.nl)
- The name of the Ministry of Housing, Spatial Planning and the Environment (VROM) changed as of October 2010 to the Ministry of Infrastructure and the Environment (IenM), as a result of a merger with the Ministry of Transport, Public Works and Water Management.
- As a result of a merger with the Minstry of Economic Affairs, the current name of the former Ministry of Agriculture, Nature and Food Quality (LNV) is the Ministry of Economic Affairs (EZ). From 2010 until 2012 the ministry was called the Ministry of Economic Affairs, Agriculture and Innovation (EL&I).
- In 2015, the Netherlands replaced the 40 monitoring protocols (containing the methodology descriptions as part of the National System) by five methodology reports (one for each PRTR Task Force). The methodology reports are also part of the National System. From 2015 onwards the NIRs will be based on these methodology reports.
  The main reason for this change is that the update of five methodology reports is simpler than the update of 40 protocols. In addition, the administrative procedure is simplified because the updated methodology reports do not require an official announcement in the *Government gazette*. For this reason, the Act on the Monitoring of Greenhouse Gases was updated in 2014. The methodology reports are checked by the National Inventory Entity and approved by the chairperson of the PRTR Task Force concerned. As part of the National System, the methodology reports are available at the National System website http://english.rvo.nl/nie.

These changes do not have any impact on the functions of the National System.

14 Information on changes in national registry

14.1 Changes to national registry in 2016

The following changes to the national registry of Netherlands have therefore occurred in 2016.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change in the name the registry administrator occurred during the reported period. The contact information changed due to a move of office. The current contact information is: **Administrator** Dutch Emissions Authority P.O. Box 91503 NL-2509 EC The Hague Tel.: +31 70 456 8050 Fax: +31 70 456 8247 Web: www.emissieautoriteit.nl/english/ **Main Contact** Mr. Harm VAN DE WETERING Registry Manager Emissiontrading Dutch Emissions Authority P.O. Box 91503 NL-2509 EC The Hague Tel.: +31 70 456 8311 Fax: +31 70 456 8247 E-mail: harm.vandewetering@emissieautoriteit.nl **Alternative Contact** Mr. Alexander BRANDT ICT-coordinator Dutch Emissions Authority P.O. Box 91503 NL-2509 EC The Hague Tel.: +31 70 456 8522 Fax: +31 70 456 8247 E-mail: alexander.brandt@emissieautoriteit.nl **Release Manager** Mr. Alexander BRANDT ICT-coordinator Dutch Emissions Authority P.O. Box 91503 NL-2509 EC The Hague Tel.: +31 70 456 8522 Fax: +31 70 456 8247 E-mail: alexander.brandt@emissieautoriteit.nl

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report will provided at a later date. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B. Annex H testing was carried out in January 2017 and the test report will be provided at a later date.

15 Information on minimisation of adverse impacts in accordance with Article 3, paragraph 14

The Netherlands provided information on minimization of adverse impacts in accordance with Article 3, paragraph 14 in previous national inventory reports and national communications in accordance with the guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol (Decision 15/CMP.1, Section I. H. and in paragraph 36 in Section II. G.).

The Netherlands strives to implement its commitments under the Kyoto Protocol in such a way that social, environmental and economic impacts on other countries, and on developing countries in particular, are minimised.

Since the submission of the NIR 2016, there have been limited changes in the activities on minimising adverse impacts. Policies are still in place and are being executed.

Among the actions – a to f - listed in the Annex to Decision 15/CMP.1, Part I.H, 'Minimization of adverse impacts in accordance with Article 3, paragraph 14', the Netherlands implemented national actions as well as actions to support and to assist developing countries.

With regard to the progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions, and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities (action a), energy prices are reflecting market prices already for many years. With (increasing) environmental taxation the externalities of energy use related to greenhouse gas emissions are increasingly reflected in the energy prices. E.g. the environmental taxes on the use of natural gas up to 170 000 m3 increased from € 0.1639 per m3 in 2011 to € 0.25244 in 2017. An overview of all environmental taxes is available at https://www.belastingdienst.nl/wps/wcm/connect/bldcontentnl/belastingdienst/zakelijk/overige_belastingen/belastingen_op_milieugrondslag/tarieven_milieubelastingen/tabellen_tarieven_milieubelastingen?projectid=6750bae7-383b-4c97-bc7a-802790bd1110

Already for many years there are no subsidies in the Netherlands associated with the use of environmentally unsound and unsafe technologies, as referred to as action b. There are only subsidies for environmentally friendly technologies or technologies that ensure increased sustainability.
The Netherlands will continue supporting and cooperating with developing country Parties related to action d to f. Examples include the following:

- The Private Sector Investment Programme (PSI) is a Dutch government programme that supports innovative investment projects in emerging markets in Africa, Asia, Central and Eastern Europe and Latin America. A PSI project is an investment project, implemented by a Dutch or foreign company in cooperation with a local company in one of the eligible developing countries. Supported projects include climate-relevant initiatives such as renewable electricity production, biofuel production and crop improvement.

- The project Solar for Farms in Uganda/Milking the Sun makes high quality and affordable solar lamps and solar home systems available to dairy cooperative members through the provision of financing, thereby increasing farm production, lowering household emissions (substituting kerosene for solar), but also providing improved lighting for dairy and household activities.
- The African Biogas Partnership Program (ABPP) builds the capacity of the biogas sector in five African countries: Ethiopia, Uganda, Burkina Faso, Kenya and the United Republic of Tanzania. These countries are assisted to apply domestic biogas as a climate friendly solution for energy, organic fertiliser and livestock keeping.
- The Netherlands funds capacity building in geothermal energy as delivered by both bilateral and multilateral programmes, in particular by the World Bank and the International Finance Corporation (IFC). These programmes share the common characteristic of being 'upstream' interventions, aim at eliminating structural constraints such as feed-in tariff hurdles for electricity generated by geothermal sources.
- The Geothermal Alliance for National Geothermal Capacity Building Programme in Indonesia is targeted at strengthening the structure of human resources development needed to provide manpower for the development and implementation of the planned geothermal energy capacity in Indonesia.
- DME Energy Sector Management Assistance Programme (ESMAP) supported in the period 2011-2014, among other things, geothermal energy capacity and resource risk mitigation through South-South cooperation (support for targeted research, design and preparation, capacity development and knowledge dissemination). The Netherlands has specific expertise on how to improve the success rate of geothermal test drilling and how to mitigate geothermal resource risks. Through a trilateral approach it will also build upon the experience of countries with a track record in geothermal development (Indonesia, Kenya, Philippines and Turkey) that are open to share lessons with peer countries in the South.

Public-private partnerships are an essential feature of Dutch climate policies. In recent years the Netherlands has also joined or initiated several alliances such as the Global Delta Coalition, the Climate Smart Agriculture Alliance and the Tropical Forest Alliance.

In addition to mitigation the Netherlands attaches great importance to adaptation to climate change. For some time now it has been assisting other countries financially or with knowledge provided by the business community to make them more resilient to the consequences of climate change. Recent Dutch efforts on the minimisation of adverse impacts include active engagement for a full operationalisation of the Green Climate Fund and New Market Mechanisms.

Green Climate Fund
The Netherlands actively contributes to the full and timely operationalisation of the Green Climate Fund, and is committed to providing climate finance to support developing countries in their mitigation and adaptation activities. This Fund will, among other things, seek to use public funds to attract private finance for both mitigation and adaptation investments. On the Board of the Green Climate Fund, the Netherlands again shares a chair with Denmark, as it did in the Transitional Committee. A full operationalisation of the Green Climate Fund is crucial to support developing countries in their transformation to a low carbon and climate resilient development. In doing so the GCF should try and maximise development benefits by linking climate change to poverty reduction and gender. Enhancing the role of the private sector is a Dutch priority to which the Netherlands has actively contributed through the operationalisation of the private sector facility.

Collaboration between authorities, business and knowledge institutions
In the years ahead, the Netherlands will be working more closely with companies and knowledge institutions to contribute to combating climate change and its consequences. The innovations and financial strength of these parties are essential to meet the challenges of climate change together. the Netherlands has, for example, a great deal of expertise in the fields of water, food security and energy and we are already collaborating with various countries in these fields: on water security, for instance, with Vietnam, Colombia and Indonesia. In the future, the private sector and knowledge institutions will be more closely involved and this is a key factor in the Dutch strategy. It is also in line with our ambitions for the new climate instrument: to offer customisation and to let everyone make an appropriate contribution.

Fast start finance
We want to recall that the Netherlands has fulfilled the Copenhagen agreement on 'Fast Start Finance'. This involved financially supporting immediate action on climate change and kickstarting mitigation and adaptation efforts in developing countries from 2010 to 2012. the Netherlands provided € 300 million in Fast Start Finance over the period 2010-2012. In 2013 € 200 million was contributed.
In the context of meaningful mitigation actions and transparency of implementation and collective action, the Netherlands stand ready to continue scaling up its climate finance action in order to contribute its share to the developed countries' goal to jointly mobilize 100 billion US dollars per year by 2020.
The Netherlands also contributed to enhancing transparency regarding the Fast Start Financing initiative. At the initiative of the Netherlands a special module on fast start finance has been established on the financial portal of the UNFCCC website, http://www3.unfccc.int/pls/apex/f?p=116:13:601354855187581. With the establishment of this module on the UNFCCC website, the Netherlands is confident this transparency of fast start finance will be safeguarded.

Market Mechanisms
The flexible mechanisms under the Protocol – (1) International Emissions Trading (i.e. the European Union Emissions Trading Scheme

EU ETS), (2) Joint Implementation and (3) Clean Development Mechanism – are all tools incorporated into the Protocol in order to share efforts aimed at reducing greenhouse gases, ensuring that investments are made where the money has optimal greenhouse gas reducing effects, and thus ensuring a minimum impact on the world economy. the Netherlands has made use of each of the flexible mechanisms. It has also signed MoUs regarding CDM and JI projects with several countries worldwide. the Netherlands is supporting the World Bank's "Partnership for Market Readiness", which will help countries to make use of the benefits and advantages of the carbon market. The PMR promotes collective innovation and piloting of market-based instruments for GHG emissions reduction. In addition, the PMR also provides a platform for technical discussions of such instruments to spur innovation and support implementation.

Minimising adverse effects regarding biofuels production
All biofuels on the market in Europe and the Netherlands must be in compliance with the sustainability criteria laid down by the Renewable Energy Directive (2009/28/EG). Only if the biofuels are sustainable, they are allowed to be used for fulfilling the blending target. Compliance with these criteria must be demonstrated through one of the adopted certification systems. These certification systems are controlled by an independent audit. All biofuels produced in the Netherlands fulfil these requirements.

Annex 1 Key categories

A1.1 Introduction

As explained in the 2006 Guidelines (IPCC, 2006), a key source category is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend in emissions or both.

For the identification of key sources in the Netherlands' inventory, we allocated national emissions to the Intergovernmental Panel on Climate Change's potential key source list, as presented in table 4.1 in chapter 4 of the 2006 IPCC Guidelines (Volume 1). As suggested in the guidance, carbon dioxide (CO_2) emissions from stationary combustion (1A1, 1A2 and 1A4) are aggregated by fuel type. CO_2, methane (CH_4) and nitrous oxide (N_2O) emissions from Mobile combustion: road vehicles (1A3) are assessed separately. CH_4 and N_2O emissions from aircraft and ships are relatively small (about 1–2 Gg CO_2 equivalent). Other mobile sources are not assessed separately by gas. Fugitive emissions from oil and gas operations (1B) are important sources of GHG emissions in the Netherlands. The most important gas/source combinations in this category are separately assessed. Emissions in other IPCC sectors are disaggregated, as suggested by the IPCC.

The IPCC Tier 1 method consists of ranking the list of source category/gas combinations according to their contribution to national total annual emissions and to the national total trend. The categories at the top of the tables in this annex are the largest key sources, of which the total adds up to 95% of the national total (excluding LULUCF): 31 sources for annual level assessment (emissions in 2015) and 36 sources for the trend assessment out of a total of 92 sources. The two lists can be combined to obtain an overview of sources that meet one or both of these criteria.

The IPCC Tier 2 method for the identification of key sources requires the incorporation of the uncertainty in each of these sources before ordering the list of shares. This has been carried out using the uncertainty estimates presented in Annex 2 (for details of the Tier 1 uncertainty analysis see Olivier et al., 2009). Here, a total contribution of up to 90% to the overall uncertainty has been used to avoid the inclusion of too many small sources. The results of the Tier 1 and Tier 2 level and trend assessments are summarized in Table A1.1 and show a total of 50 key sources (excluding LULUCF). As expected, the Tier 2 level and trend assessments increase the importance of highly uncertain sources. It can be concluded that in using the results of a Tier 2 key source assessment, ten sources are added to the list of 40 Tier 1 level and trend key sources (excluding LULUCF):

- 1A4b Residential, all fuels: CH_4 (Tier 2 Level)
- 1A3b Road transportation: N_2O (Tier 2 Trend)
- 2A4d Other: CO_2 (Tier 2 Level and Trend)
- 2B8 Petrochemical and carbon black production: CO_2 (Tier2 Level and Trend)

- 2D2 Paraffin wax use : CO_2 (Tier2 Level and Trend)
- 2B8 Petrochemical and carbon black production: CH_4 (Tier2 Level)
- 2G Other product manufacture and use: N_2O (Tier 2 Trend)
- 3A3 Swine: CH_4 (Tier 2 Level)
- 3B Emission from Manure management N_2O (Tier 2 Level and Trend
- 3G Liming: CO_2 (Tier 2 Trend)

The share of these sources in the national annual total becomes larger when taking their uncertainty (50%–100%) into account (Table A1.4). When we include the most important Land use, land use change and forestry (LULUCF) emission sinks and sources in the Tier 1 and Tier 2 key source calculations, this results in four additional key sources, giving an overall total of 54 key sources; see also Table A1.2.

Please note that the key source analysis for the base year (1990 for direct GHGs and 1995 for F-gases) is included in the CRF Reporter and not in this annex
CO_2
CH_4
N_2O
SF_6

Table A1.1 Key source list identified by the Tier 1 level and trend assessments for 2015 emissions (excluding LULUCF sources)

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR				TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year without LULUCF**	**Tier 1 trend without LULUCF**	**Tier 2 level recent year without LULUCF**	**Tier 2 trend without LULUCF**
	ENERGY SECTOR						
1A1a	Public Electricity and Heat Production: liquids	CO_2	Key(L1,T)	1	1	0	1
1A1a	Public Electricity and Heat Production: solids	CO_2	Key(L,T)	1	1	1	1
1A1a	Public Electricity and Heat Production: gaseous	CO_2	Key(L1,T1)	1	1	0	0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	Key(L1,T)	1	1	0	1
1A1b	Petroleum Refining: liquids	CO_2	Key(L,T)	1	1	1	1
1A1b	Petroleum Refining: gaseous	CO_2	Key(L1,T1)	1	1	0	0
1A1c	Manufacture of Solid Fuels: solids	CO_2	Key(L1,)	1	0	0	0
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	Key(L,T)	1	1	1	1
1A2	Manufacturing Industries and Construction, liquids	CO_2	Key(L,)	1	0	1	0
1A2	Manufacturing Industries and Construction, solids	CO_2	Key(L,T1)	1	1	1	0
1A2	Manufacturing Industries and Construction, gaseous	CO_2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	Key(L1,T1)	1	1	0	0
1A4	Liquids excl. 1A4c	CO_2	Key(,T)	0	1	0	1
1A4	Solids	CO_2	Non key	0	0	0	0
1A4a	Commercial/Institutional:gaseous	CO_2	Key(L,T1)	1	1	1	0
1A4b	Residential gaseous	CO_2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	Key(L,T1)	1	1	1	0
1A5	Military use:liquids	CO_2	Non key	0	0	0	0
1A1	Energy Industries:all fuels	CH_4	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	CH_4	Non key	0	0	0	0
1A4a	Commercial/Institutional:all fuels	CH_4	Non key	0	0	0	0
1A4b	Residential:all fuels	CH_4	Key(L2,)	0	0	1	0

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR				TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year without LULUCF**	**Tier 1 trend without LULUCF**	**Tier 2 level recent year without LULUCF**	**Tier 2 trend without LULUCF**
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	Key(L,T)	1	1	1	1
1A5	Military use:liquids	CH_4	Non key	0	0	0	0
1A1	Energy Industries:all fuels	N_2O	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	N_2O	Non key	0	0	0	0
1A4	Other Sectors:all fuels	N_2O	Non key	0	0	0	0
1A5	Military use:liquids	N_2O	Non key	0	0	0	0
1A3b	Road transportation: gasoline	CO_2	Key(L,T1)	1	1	1	0
1A3b	Road transportation: diesel oil	CO_2	Key(L,T)	1	1	1	1
1A3b	Road transportation: LPG	CO_2	Key(,T)	0	1	0	1
1A3b	Road transportation:gaseous	CO_2	Non key	0	0	0	0
1A3d	Domestic navigation	CO_2	Key(L1,T1)	1	1	0	0
1A3a	Domestic aviation	CO_2	Non key	0	0	0	0
1A3c	Railways	CO_2	Non key	0	0	0	0
1A3e	Other	CO_2	Non key	0	0	0	0
1A3 exl 1A3b	Other	CH_4	Non key	0	0	0	0
1A3 exl 1A3b	Other	N_2O	Non key	0	0	0	0
1A3b	Road transportation	CH_4	Non key	0	0	0	0
1A3b	Road transportation	N_2O	Key(,T2)	0	0	0	1
1B2c	Venting and flaring	CH_4	Key(,T)	0	1	0	1
1B2b	Natural gas	CH_4	Non key	0	0	0	0
1B2a	Oil	CH_4	Non key	0	0	0	0
1B1b	Solid fuel transformation	CO_2	Key(L1,T1)	1	1	0	0
1B2	Fugitive emissions from oil and gas operations	CO_2	Key(L,T)	1	1	1	1

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR				TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year without LULUCF**	**Tier 1 trend without LULUCF**	**Tier 2 level recent year without LULUCF**	**Tier 2 trend without LULUCF**
	INDUSTRIAL PROCESSES AND PRODUCT USE						
2A1	Cement production	CO_2	Non key	0	0	0	0
2A3	Glass production	CO_2	Non key	0	0	0	0
2A4a	Ceramics	CO_2	Non key	0	0	0	0
2A4b	Other uses of soda ash	CO_2	Non key	0	0	0	0
2A4d	Other	CO_2	Key(L2,T2)	0	0	1	1
2B1	Ammonia production	CO_2	Key(L,T1)	1	1	1	0
2B2	Nitric acid production	N_2O	Key(,T)	0	1	0	1
2B4	Caprolactam production	N_2O	Key(L,)	1	0	1	0
2B8	Petrochemical and carbon black production	CO_2	Key(L2,T2)	0	0	1	1
2C1	Iron and steel production	CO_2	Key(L1,T1)	1	1	0	0
2C3	Aluminium production	CO_2	Key(,T1)	0	1	0	0
2C3	Aluminium production	PFC	Key(,T)	0	1	0	1
2G2	SF_6 use	SF_6	Non key	0	0	0	0
2F1	Refrigeration and airconditioning	HFC	Key(L,T)	1	1	1	1
2F6	Other	HFC	Non key	0	0	0	0
2B	Fluorochemical production	HFC	Key(,T)	0	1	0	1
2E	Electronic Industry	PFC	Non key	0	0	0	0
2B	Fluorochemical production	PFC	Non key	0	0	0	0
2B10	Other	CO_2	Non key	0	0	0	0
2D1	Lubricant use	CO_2	Non key	0	0	0	0
2D2	Paraffin wax use	CO_2	Key(L2,T2)	0	0	1	1
2D3	Other	CO_2	Non key	0	0	0	0
2G	Other product manufacture and use	CO_2	Non key	0	0	0	0

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR				TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year without LULUCF**	**Tier 1 trend without LULUCF**	**Tier 2 level recent year without LULUCF**	**Tier 2 trend without LULUCF**
2H	Other industrial	CO_2	Non key	0	0	0	0
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	Key(L2,)	0	0	1	0
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	Non key	0	0	0	0
2G	Other product manufacture and use	CH_4	Non key	0	0	0	0
2G	Other product manufacture and use	N_2O	Key(,T2)	0	0	0	1
2B7	Soda ash production	CO_2	Non key	0	0	0	0
	AGRICULTURE						
3A1	Mature dairy cattle	CH_4	Key(L,T)	1	1	1	1
3A1	Other mature cattle	CH_4	Non key	0	0	0	0
3A1	Young cattle	CH_4	Key(L,)	1	0	1	0
3A3	Swine	CH_4	Key(L2,)	0	0	1	0
3A4	Other	CH_4	Non key	0	0	0	0
3B	Emissions from manure management	N_2O	Key(L2,T2)	0	0	1	1
3B1	Cattle	CH_4	Key(L,T)	1	1	1	1
3B3	Swine	CH_4	Key(L,T)	1	1	1	1
3B4	Poultry	CH_4	Key(,T)	0	1	0	1
3B2, 3B4	Other	CH_4	Non key	0	0	0	0
3Da	Direct emissions from agricultural soils	N_2O	Key(L,T)	1	1	1	1
3Db	Indirect emissions from managed soils	N_2O	Key(L2,T)	0	1	1	1
3G	Liming	CO_2	Key(,T2)	0	0	0	1
	LAND USE, LAND-USE CHANGE AND FORESTRY						
4	LULUCF: CH_4	CH_4	Non key				
4A	Forest Land	CO_2	Key(L,T)				

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR				TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year without LULUCF**	**Tier 1 trend without LULUCF**	**Tier 2 level recent year without LULUCF**	**Tier 2 trend without LULUCF**
4B	Cropland	N_2O	Non key				
4B	Cropland	CO_2	Key(L,T)				
4C	Grassland	CO_2	Key(L,T)				
4C	Grassland	N_2O	Non key				
4G	Harvested wood products	CO_2	Non key				
4D	Wetlands	CO_2	Non key				
4E	Settlements	CO_2	Key(L,T)				
4F	Other Land	CO_2	Non key				
4H	Other	N_2O	Non key				
	WASTE						
5A	Solid waste disposal	CH_4	Key(L,T)	1	1	1	1
5B	Biological treatment of solid waste: composting	CH_4	Non key	0	0	0	0
5B	Biological treatment of solid waste: composting	N_2O	Non key	0	0	0	0
5D	Wastewater treatment and discharge	CH_4	Non key	0	0	0	0
5D	Wastewater treatment and discharge	N_2O	Non key	0	0	0	0
			SUM	31	36	30	29
				Tier 1 level recent year without LULUCF	**Tier 1 trend without LULUCF**	**Tier 2 level recent year without LULUCF**	**Tier 2 trend without LULUCF**

Table A1.2 Key source list identified by the Tier 1 level and trend assessments. Level assessment for 2015 emissions (including LULUCF sources)

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR			REPORT IN NIR and CRF	TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year with LULUCF**	**Tier 1 trend with LULUCF**	**Tier 2 level recent year with LULUCF**	**Tier 2 trend with LULUCF**
	ENERGY SECTOR						
1A1a	Public Electricity and Heat Production: liquids	CO_2	Key(L1,T)	1	1	0	1
1A1a	Public Electricity and Heat Production: solids	CO_2	Key(L,T)	1	1	1	1
1A1a	Public Electricity and Heat Production: gaseous	CO_2	Key(L1,T1)	1	1	0	0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	Key(L1,T)	1	1	0	1
1A1b	Petroleum Refining: liquids	CO_2	Key(L,T)	1	1	1	1
1A1b	Petroleum Refining: gaseous	CO_2	Key(L1,T1)	1	1	0	0
1A1c	Manufacture of Solid Fuels: solids	CO_2	Key(L1,)	1	0	0	0
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	Key(L,T)	1	1	1	1
1A2	Manufacturing Industries and Construction, liquids	CO_2	Key(L,)	1	0	1	0
1A2	Manufacturing Industries and Construction, solids	CO_2	Key(L,T1)	1	1	1	0
1A2	Manufacturing Industries and Construction, gaseous	CO_2	Key(L,T1)	1	1	1	1
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	Key(L1,T1)	1	1	0	0
1A4	Liquids excl. 1A4c	CO_2	Key(,T)	0	1	0	1
1A4	Solids	CO_2	Non key	0	0	0	0
1A4a	Commercial/Institutional:gaseous	CO_2	Key(L,T1)	1	0	1	0
1A4b	Residential gaseous	CO_2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	Key(L,T1)	1	1	1	0
1A5	Military use:liquids	CO_2	Non key	0	0	0	0
1A1	Energy Industries:all fuels	CH_4	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	CH_4	Non key	0	0	0	0

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR			REPORT IN NIR and CRF	TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year with LULUCF**	**Tier 1 trend with LULUCF**	**Tier 2 level recent year with LULUCF**	**Tier 2 trend with LULUCF**
1A4a	Commercial/Institutional:all fuels	CH_4	Non key	0	0	0	0
1A4b	Residential:all fuels	CH_4	Key(L2,)	0	0	1	0
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	Key(L,T)	1	1	1	1
1A5	Military use:liquids	CH_4	Non key	0	0	0	0
1A1	Energy Industries:all fuels	N_2O	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	N_2O	Non key	0	0	0	0
1A4	Other Sectors:all fuels	N_2O	Non key	0	0	0	0
1A5	Military use:liquids	N_2O	Non key	0	0	0	0
1A3b	Road transportation: gasoline	CO_2	Key(L,T1)	1	1	1	0
1A3b	Road transportation: diesel oil	CO_2	Key(L,T)	1	1	1	1
1A3b	Road transportation: LPG	CO_2	Key(,T)	0	1	0	1
1A3b	Road transportation:gaseous	CO_2	Non key	0	0	0	0
1A3d	Domestic navigation	CO_2	Key(L1,T1)	1	1	0	0
1A3a	Domestic aviation	CO_2	Non key	0	0	0	0
1A3c	Railways	CO_2	Non key	0	0	0	0
1A3e	Other	CO_2	Non key	0	0	0	0
1A3 exl 1A3b	Other	CH_4	Non key	0	0	0	0
1A3 exl 1A3b	Other	N_2O	Non key	0	0	0	0
1A3b	Road transportation	CH_4	Non key	0	0	0	0
1A3b	Road transportation	N_2O	Key(,T2)	0	0	0	1
1B2c	Venting and flaring	CH_4	Key(,T)	0	1	0	1
1B2b	Natural gas	CH_4	Non key	0	0	0	0

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR			REPORT IN NIR and CRF	TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year with LULUCF**	**Tier 1 trend with LULUCF**	**Tier 2 level recent year with LULUCF**	**Tier 2 trend with LULUCF**
1B2a	Oil	CH_4	Non key	0	0	0	0
1B1b	Solid fuel transformation	CO_2	Key(L1,T1)	1	1	0	0
1B2	Fugitive emissions from oil and gas operations	CO_2	Key(L,T)	1	1	1	1
	INDUSTRIAL PROCESSES AND PRODUCT USE						
2A1	Cement production	CO_2	Non key	0	0	0	0
2A3	Glass production	CO_2	Non key	0	0	0	0
2A4a	Ceramics	CO_2	Non key	0	0	0	0
2A4b	Other uses of soda ash	CO_2	Non key	0	0	0	0
2A4d	Other	CO_2	Key(L2,T2)	0	0	1	0
2B1	Ammonia production	CO_2	Key(L,T1)	1	1	1	0
2B2	Nitric acid production	N_2O	Key(,T)	0	1	0	1
2B4	Caprolactam production	N_2O	Key(L,)	1	0	1	0
2B8	Petrochemical and carbon black production	CO_2	Key(L2,T2)	0	0	1	1
2C1	Iron and steel production	CO_2	Key(L1,T1)	1	1	0	0
2C3	Aluminium production	CO_2	Key(,T1)	0	1	0	0
2C3	Aluminium production	PFC	Key(,T)	0	1	0	1
2G2	SF_6 use	SF_6	Non key	0	0	0	0
2F1	Refrigeration and airconditioning	HFC	Key(L,T)	1	1	1	1
2F6	Other	HFC	Non key	0	0	0	0
2B	Fluorochemical production	HFC	Key(,T)	0	1	0	1
2E	Electronic Industry	PFC	Non key	0	0	0	0
2B	Fluorochemical production	PFC	Non key	0	0	0	0
2B10	Other	CO_2	Non key	0	0	0	0
2D1	Lubricant use	CO_2	Non key	0	0	0	0

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR			REPORT IN NIR and CRF	TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year with LULUCF**	**Tier 1 trend with LULUCF**	**Tier 2 level recent year with LULUCF**	**Tier 2 trend with LULUCF**
2D2	Paraffin wax use	CO_2	Key(L2,T2)	0	0	0	1
2D3	Other	CO_2	Non key	0	0	0	0
2G	Other product manufacture and use	CO_2	Non key	0	0	0	0
2H	Other industrial	CO_2	Non key	0	0	0	0
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	Key(L2,)	0	0	1	0
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	Non key	0	0	0	0
2G	Other product manufacture and use	CH_4	Non key	0	0	0	0
2G	Other product manufacture and use	N_2O	Key(,T2)	0	0	0	0
2B7	Soda ash production	CO_2	Non key	0	0	0	0
	AGRICULTURE						
3A1	Mature dairy cattle	CH_4	Key(L,T)	1	1	1	1
3A1	Other mature cattle	CH_4	Non key	0	0	0	0
3A1	Young cattle	CH_4	Key(L,)	1	1	1	0
3A3	Swine	CH_4	Key(L2,)	0	0	0	0
3A4	Other	CH_4	Non key	0	0	0	0
3B	Emissions from manure management	N_2O	Key(L2,T2)	0	0	1	1
3B1	Cattle	CH_4	Key(L,T)	1	1	1	1
3B3	Swine	CH_4	Key(L,T)	1	1	1	1
3B4	Poultry	CH_4	Key(,T)	0	1	0	1
3B2, 3B4	Other	CH_4	Non key	0	0	0	0
3Da	Direct emissions from agricultural soils	N_2O	Key(L,T)	1	1	1	1
3Db	Indirect emissions from managed soils	N_2O	Key(L2,T)	0	1	1	1
3G	Liming	CO_2	Key(,T2)	0	0	0	1

Source category analysis of key sources last year (Tier 1 and Tier 2 approach) for reporting in NIR			REPORT IN NIR and CRF	TIER 1 assesment results		TIER 2 assesment results	
IPCC	**Source category**	**Gas**	**Key source?**	**Tier 1 level recent year with LULUCF**	**Tier 1 trend with LULUCF**	**Tier 2 level recent year with LULUCF**	**Tier 2 trend with LULUCF**
	LAND USE, LAND-USE CHANGE AND FORESTRY						
4	LULUCF: CH_4	CH_4	Non key	0	0	0	0
4A	Forest Land	CO_2	Key(L,T)	1	1	1	1
4B	Cropland	N_2O	Non key	0	0	0	0
4B	Cropland	CO_2	Key(L,T)	1	1	1	1
4C	Grassland	CO_2	Key(L,T)	1	1	1	1
4C	Grassland	N_2O	Non key	0	0	0	0
4G	Harvested wood products	CO_2	Non key	0	0	0	0
4D	Wetlands	CO_2	Non key	0	0	0	0
4E	Settlements	CO_2	Key(L,T)	1	1	1	1
4F	Other Land	CO_2	Non key	0	0	0	0
4H	Other	N_2O	Non key	0	0	0	0
	WASTE						
5A	Solid waste disposal	CH_4	Key(L,T)	1	1	1	1
5B	Biological treatment of solid waste: composting	CH_4	Non key	0	0	0	0
5B	Biological treatment of solid waste: composting	N_2O	Non key	0	0	0	0
5D	Wastewater treatment and discharge	CH_4	Non key	0	0	0	0
5D	Wastewater treatment and discharge	N_2O	Non key	0	0	0	1
			SUM	35	40	32	33
				Tier 1 level recent year with LULUCF	**Tier 1 trend with LULUCF**	**Tier 2 level recent year with LULUCF**	**Tier 2 trend with LULUCF**

A1.2 Changes in key sources compared with previous submission

Due to the use of emissions data for 2015 and new uncertainty data on mobile combustion, the following changes in key sources have taken place in comparison with the previous NIR:

- 2B Fluorochemical production (HFC)

Key sources from the former submission which are no longer a key source are listed below:

- 2A4 Other process use of carbonates (CO_2)
- 2B9 HFC-23 emissions from HCFC-22 manufacture (HFC)

A1.3 Tier 1 key source and uncertainty assessment

In Tables A1.3a and A1.3b, the source ranking is done according to the contribution to the 2014 annual emissions total and in Tables A1.4a and A1.4b to the base-year-to-2014 trend. This results in 34 level key sources and 38 trend key sources. Inclusion of LULUCF sources in the analysis adds four Tier 1 level and trend key sources (see Table A1.2).

Table A1.3a Source ranking using IPCC Tier 1 level assessment 2015 excluding LULUCF (Gg CO_2 eq)

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**37297,1**	**19,1%**	**19,1%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**17134,4**	**8,8%**	**27,9%**
1A4b	**Residential gaseous**	**CO_2**	**16117,2**	**8,3%**	**36,2%**
1A1a	**Public Electricity and Heat Production: gaseous**	**CO_2**	**14727,0**	**7,6%**	**43,7%**
1A2	**Manufacturing Industries and Construction, gaseous**	**CO_2**	**12882,4**	**6,6%**	**50,3%**
1A3b	**Road transportation: gasoline**	**CO_2**	**11741,7**	**6,0%**	**56,3%**
1A2	**Manufacturing Industries and Construction, liquids**	**CO_2**	**7768,8**	**4,0%**	**60,3%**
1A4c	**Agriculture/Forestry/Fisheries:gaseous**	**CO_2**	**7169,9**	**3,7%**	**64,0%**
1A4a	**Commercial/Institutional:gaseous**	**CO_2**	**7107,7**	**3,6%**	**67,7%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**6797,3**	**3,5%**	**71,1%**
3A1	**Mature dairy cattle**	**CH_4**	**5232,9**	**2,7%**	**73,8%**
3Da	**Direct emissions from agricultural soils**	**N_2O**	**4860,2**	**2,5%**	**76,3%**
2B1	**Ammonia production**	**CO_2**	**3920,9**	**2,0%**	**78,3%**
1A2	**Manufacturing Industries and Construction, solids**	**CO_2**	**3371,2**	**1,7%**	**80,1%**
1A1b	**Petroleum Refining: gaseous**	**CO_2**	**2975,9**	**1,5%**	**81,6%**
5A	**Solid waste disposal**	**CH_4**	**2945,0**	**1,5%**	**83,1%**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO_2**	**2861,1**	**1,5%**	**84,6%**
3B1	**Cattle**	**CH_4**	**2260,3**	**1,2%**	**85,7%**
3A1	**Young cattle**	**CH_4**	**2211,0**	**1,1%**	**86,8%**
3B3	**Swine**	**CH_4**	**2112,7**	**1,1%**	**87,9%**
2F1	**Refrigeration and airconditioning**	**HFC**	**2041,2**	**1,0%**	**89,0%**
1A4c	**Agriculture/Forestry/Fisheries: liquids**	**CO_2**	**1859,2**	**1,0%**	**89,9%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1792,5**	**0,9%**	**90,8%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**1315,4**	**0,7%**	**91,5%**
1A3d	**Domestic navigation**	**CO_2**	**1240,9**	**0,6%**	**92,2%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**910,8**	**0,5%**	**92,6%**
2C1	**Iron and steel production**	**CO_2**	**905,2**	**0,5%**	**93,1%**
2B4	**Caprolactam production**	**N_2O**	**901,9**	**0,5%**	**93,6%**
1B1b	**Solid fuel transformation**	**CO_2**	**810,7**	**0,4%**	**94,0%**
1A1c	**Manufacture of Solid Fuels: solids**	**CO_2**	**743,3**	**0,4%**	**94,3%**
1A1a	**Public Electricity and Heat Production: liquids**	**CO_2**	**739,2**	**0,4%**	**94,7%**
3B	Emissions from manure management	N_2O	674,2	0,3%	95,1%

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
3Db	Indirect emissions from managed soils	N_2O	609,1	0,3%	95,4%
1A4	Liquids excl. 1A4c	CO_2	601,3	0,3%	95,7%
2A4d	Other	CO_2	586,0	0,3%	96,0%
3A3	Swine	CH_4	472,6	0,2%	96,2%
2B8	Petrochemical and carbon black production	CO_2	458,3	0,2%	96,5%
3A4	Other	CH_4	436,0	0,2%	96,7%
1A4b	Residential:all fuels	CH_4	430,7	0,2%	96,9%
1A3b	Road transportation: LPG	CO_2	411,5	0,2%	97,1%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	409,2	0,2%	97,3%
2B2	Nitric acid production	N_2O	370,4	0,2%	97,5%
1B2b	Natural gas	CH_4	323,3	0,2%	97,7%
1B2c	Venting and flaring	CH_4	313,9	0,2%	97,9%
1A1	Energy Industries:all fuels	N_2O	312,2	0,2%	98,0%
2B10	Other	CO_2	278,0	0,1%	98,2%
2A1	Cement production	CO_2	249,4	0,1%	98,3%
1A3b	Road transportation	N_2O	241,2	0,1%	98,4%
5D	Wastewater treatment and discharge	CH_4	210,7	0,1%	98,5%
2D2	Paraffin wax use	CO_2	206,6	0,1%	98,6%
1A5	Military use:liquids	CO_2	175,2	0,1%	98,7%
3A1	Other mature cattle	CH_4	159,0	0,1%	98,8%
2B	Fluorochemical production	HFC	148,5	0,1%	98,9%
2F6	Other	HFC	146,0	0,1%	98,9%
2G2	SF_6 use	SF_6	138,8	0,1%	99,0%
2A4b	Other uses of soda ash	CO_2	114,2	0,1%	99,1%
1A1	Energy Industries:all fuels	CH_4	112,1	0,1%	99,1%
2A4a	Ceramics	CO_2	111,7	0,1%	99,2%
1A3c	Railways	CO_2	99,8	0,1%	99,2%
1A4a	Commercial/Institutional:all fuels	CH_4	96,8	0,0%	99,3%
1A3b	Road transportation:gaseous	CO_2	95,5	0,0%	99,3%
2A3	Glass production	CO_2	95,3	0,0%	99,4%
1A3e	Other	CO_2	92,9	0,0%	99,4%
2G	Other product manufacture and use	N_2O	86,0	0,0%	99,5%
2E	Electronic Industry	PFC	85,5	0,0%	99,5%

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
2D1	Lubricant use	CO_2	80,3	0,0%	99,6%
5B	Biological treatment of solid waste: composting	N_2O	77,2	0,0%	99,6%
5B	Biological treatment of solid waste: composting	CH_4	73,8	0,0%	99,6%
3B4	Poultry	CH_4	72,9	0,0%	99,7%
5D	Wastewater treatment and discharge	N_2O	71,4	0,0%	99,7%
3G	Liming	CO_2	68,7	0,0%	99,8%
1A4	Other Sectors:all fuels	N_2O	67,5	0,0%	99,8%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	59,9	0,0%	99,8%
1A3b	Road transportation	CH_4	57,1	0,0%	99,8%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	47,6	0,0%	99,9%
2G	Other product manufacture and use	CH_4	42,5	0,0%	99,9%
3B2, 3B4	Other	CH_4	40,5	0,0%	99,9%
2C3	Aluminium production	CO_2	39,9	0,0%	99,9%
1A3a	Domestic aviation	CO_2	30,6	0,0%	99,9%
2H	Other industrial	CO_2	25,2	0,0%	100,0%
2D3	Other	CO_2	21,6	0,0%	100,0%
2B	Fluorochemical production	PFC	12,3	0,0%	100,0%
1B2a	Oil	CH_4	12,1	0,0%	100,0%
1A3 exl 1A3b	Other	N_2O	10,2	0,0%	100,0%
2C3	Aluminium production	PFC	6,5	0,0%	100,0%
1A4	Solids	CO_2	5,7	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	4,1	0,0%	100,0%
1A5	Military use:liquids	N_2O	2,7	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,8	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,4	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,3	0,0%	100,0%
2B7	Soda ash production	CO_2	0,0	0,0%	100,0%

Lines in bold represent the key sources

Table A1.3b Source ranking using IPCC Tier 1 level assessment 2015 including LULUCF (amounts in Gg CO_2 eq)

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**37297,1**	**18,1%**	**18,1%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**17134,4**	**8,3%**	**26,3%**
1A4b	**Residential gaseous**	**CO_2**	**16117,2**	**7,8%**	**34,1%**
1A1a	**Public Electricity and Heat Production: gaseous**	**CO_2**	**14727,0**	**7,1%**	**41,3%**
1A2	**Manufacturing Industries and Construction, gaseous**	**CO_2**	**12882,4**	**6,2%**	**47,5%**
1A3b	**Road transportation: gasoline**	**CO_2**	**11741,7**	**5,7%**	**53,2%**
1A2	**Manufacturing Industries and Construction, liquids**	**CO_2**	**7768,8**	**3,8%**	**57,0%**
1A4c	**Agriculture/Forestry/Fisheries:gaseous**	**CO_2**	**7169,9**	**3,5%**	**60,4%**
1A4a	**Commercial/Institutional:gaseous**	**CO_2**	**7107,7**	**3,4%**	**63,9%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**6797,3**	**3,3%**	**67,2%**
3A1	**Mature dairy cattle**	**CH_4**	**5232,9**	**2,5%**	**69,7%**
3Da	**Direct emissions from agricultural soils**	**N_2O**	**4860,2**	**2,4%**	**72,0%**
4C	**Grassland**	**CO_2**	**4420,1**	**2,1%**	**74,2%**
2B1	**Ammonia production**	**CO_2**	**3920,9**	**1,9%**	**76,1%**
1A2	**Manufacturing Industries and Construction, solids**	**CO_2**	**3371,2**	**1,6%**	**77,7%**
1A1b	**Petroleum Refining: gaseous**	**CO_2**	**2975,9**	**1,4%**	**79,1%**
5A	**Solid waste disposal**	**CH_4**	**2945,0**	**1,4%**	**80,6%**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO_2**	**2861,1**	**1,4%**	**82,0%**
4B	**Cropland**	**CO_2**	**2666,5**	**1,3%**	**83,2%**
4A	**Forest Land**	**CO_2**	**-2433,8**	**1,2%**	**84,4%**
3B1	**Cattle**	**CH_4**	**2260,3**	**1,1%**	**85,5%**
3A1	**Young cattle**	**CH_4**	**2211,0**	**1,1%**	**86,6%**
3B3	**Swine**	**CH_4**	**2112,7**	**1,0%**	**87,6%**
2F1	**Refrigeration and airconditioning**	**HFC**	**2041,2**	**1,0%**	**88,6%**
1A4c	**Agriculture/Forestry/Fisheries: liquids**	**CO_2**	**1859,2**	**0,9%**	**89,5%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1792,5**	**0,9%**	**90,4%**
4E	**Settlements**	**CO_2**	**1649,6**	**0,8%**	**91,2%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**1315,4**	**0,6%**	**91,8%**
1A3d	**Domestic navigation**	**CO_2**	**1240,9**	**0,6%**	**92,4%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**910,8**	**0,4%**	**92,8%**
2C1	**Iron and steel production**	**CO_2**	**905,2**	**0,4%**	**93,3%**
2B4	**Caprolactam production**	**N_2O**	**901,9**	**0,4%**	**93,7%**

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
1B1b	**Solid fuel transformation**	**CO_2**	**810,7**	**0,4%**	**94,1%**
1A1c	**Manufacture of Solid Fuels: solids**	**CO_2**	**743,3**	**0,4%**	**94,5%**
1A1a	**Public Electricity and Heat Production: liquids**	**CO_2**	**739,2**	**0,4%**	**94,8%**
3B	Emissions from manure management	N_2O	674,2	0,3%	95,2%
3Db	Indirect emissions from managed soils	N_2O	609,1	0,3%	95,4%
1A4	Liquids excl. 1A4c	CO_2	601,3	0,3%	95,7%
2A4d	Other	CO_2	586,0	0,3%	96,0%
3A3	Swine	CH_4	472,6	0,2%	96,2%
2B8	Petrochemical and carbon black production	CO_2	458,3	0,2%	96,5%
3A4	Other	CH_4	436,0	0,2%	96,7%
1A4b	Residential:all fuels	CH_4	430,7	0,2%	96,9%
1A3b	Road transportation: LPG	CO_2	411,5	0,2%	97,1%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	409,2	0,2%	97,3%
2B2	Nitric acid production	N_2O	370,4	0,2%	97,5%
1B2b	Natural gas	CH_4	323,3	0,2%	97,6%
1B2c	Venting and flaring	CH_4	313,9	0,2%	97,8%
1A1	Energy Industries:all fuels	N_2O	312,2	0,2%	97,9%
2B10	Other	CO_2	278,0	0,1%	98,1%
2A1	Cement production	CO_2	249,4	0,1%	98,2%
1A3b	Road transportation	N_2O	241,2	0,1%	98,3%
5D	Wastewater treatment and discharge	CH_4	210,7	0,1%	98,4%
2D2	Paraffin wax use	CO_2	206,6	0,1%	98,5%
1A5	Military use:liquids	CO_2	175,2	0,1%	98,6%
3A1	Other mature cattle	CH_4	159,0	0,1%	98,7%
2B	Fluorochemical production	HFC	148,5	0,1%	98,7%
2F6	Other	HFC	146,0	0,1%	98,8%
2G2	SF_6 use	SF_6	138,8	0,1%	98,9%
4F	Other Land	CO_2	126,2	0,1%	98,9%
2A4b	Other uses of soda ash	CO_2	114,2	0,1%	99,0%
1A1	Energy Industries:all fuels	CH_4	112,1	0,1%	99,0%
2A4a	Ceramics	CO_2	111,7	0,1%	99,1%
1A3c	Railways	CO_2	99,8	0,0%	99,1%
1A4a	Commercial/Institutional:all fuels	CH_4	96,8	0,0%	99,2%

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
1A3b	Road transportation:gaseous	CO_2	95,5	0,0%	99,2%
2A3	Glass production	CO_2	95,3	0,0%	99,3%
1A3e	Other	CO_2	92,9	0,0%	99,3%
4G	Harvested wood products	CO_2	88,4	0,0%	99,4%
2G	Other product manufacture and use	N_2O	86,0	0,0%	99,4%
2E	Electronic Industry	PFC	85,5	0,0%	99,5%
2D1	Lubricant use	CO_2	80,3	0,0%	99,5%
4B	Cropland	N_2O	78,4	0,0%	99,5%
5B	Biological treatment of solid waste: composting	N_2O	77,2	0,0%	99,6%
5B	Biological treatment of solid waste: composting	CH_4	73,8	0,0%	99,6%
3B4	Poultry	CH_4	72,9	0,0%	99,6%
5D	Wastewater treatment and discharge	N_2O	71,4	0,0%	99,7%
3G	Liming	CO_2	68,7	0,0%	99,7%
1A4	Other Sectors:all fuels	N_2O	67,5	0,0%	99,7%
4D	Wetlands	CO_2	64,0	0,0%	99,8%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	59,9	0,0%	99,8%
1A3b	Road transportation	CH_4	57,1	0,0%	99,8%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	47,6	0,0%	99,9%
4H	Other	N_2O	45,3	0,0%	99,9%
2G	Other product manufacture and use	CH_4	42,5	0,0%	99,9%
3B2, 3B4	Other	CH_4	40,5	0,0%	99,9%
2C3	Aluminium production	CO_2	39,9	0,0%	99,9%
1A3a	Domestic aviation	CO_2	30,6	0,0%	99,9%
2H	Other industrial	CO_2	25,2	0,0%	100,0%
2D3	Other	CO_2	21,6	0,0%	100,0%
2B	Fluorochemical production	PFC	12,3	0,0%	100,0%
1B2a	Oil	CH_4	12,1	0,0%	100,0%
1A3 exl 1A3b	Other	N_2O	10,2	0,0%	100,0%
2C3	Aluminium production	PFC	6,5	0,0%	100,0%
4C	Grassland	N_2O	5,9	0,0%	100,0%
1A4	Solids	CO_2	5,7	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	4,1	0,0%	100,0%
1A5	Military use:liquids	N_2O	2,7	0,0%	100,0%

IPCC Category		Gas	Latest Year Estimate (CO_2 eq)	Level Assessment	Cumulative Total
2G	Other product manufacture and use	CO_2	0,8	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,4	0,0%	100,0%
4	LULUCF: CH_4	CH_4	0,3	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,3	0,0%	100,0%
2B7	Soda ash production	CO_2	0,0	0,0%	100,0%

Lines in bold represent the key sources

Table A1.4a Source ranking using IPCC Tier 1 trend assessment 2015 excluding LULUCF (Gg CO_2 eq)

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**25862,2**	**37297,1**	**0,0854**	**17,9%**	**17,9%**
5A	**Solid waste disposal**	**CH_4**	**13679,2**	**2945,0**	**0,0529**	**11,1%**	**28,9%**
2B	**Fluorochemical production**	**HFC**	**7297,7**	**148,5**	**0,0365**	**7,6%**	**36,6%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**13024,8**	**17134,4**	**0,0334**	**7,0%**	**43,5%**
2B2	**Nitric acid production**	**N_2O**	**6084,7**	**370,4**	**0,0290**	**6,1%**	**49,6%**
1A2	**Manufacturing Industries and Construction, gaseous**	**CO_2**	**19045,8**	**12882,4**	**0,0223**	**4,7%**	**54,3%**
1A1a	**Public Electricity and Heat Production: gaseous**	**CO_2**	**13330,2**	**14727,0**	**0,0177**	**3,7%**	**58,0%**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO_2**	**601,5**	**2861,1**	**0,0136**	**2,9%**	**60,8%**
1A3b	**Road transportation: gasoline**	**CO_2**	**10784,6**	**11741,7**	**0,0133**	**2,8%**	**63,6%**
1A1b	**Petroleum Refining: gaseous**	**CO_2**	**1042,3**	**2975,9**	**0,0121**	**2,5%**	**66,1%**
2F1	**Refrigeration and airconditioning**	**HFC**	**72,7**	**2041,2**	**0,0116**	**2,4%**	**68,6%**
2C3	**Aluminium production**	**PFC**	**2230,2**	**6,5**	**0,0114**	**2,4%**	**70,9%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**9968,2**	**6797,3**	**0,0114**	**2,4%**	**73,3%**
1A3b	**Road transportation: LPG**	**CO_2**	**2653,6**	**411,5**	**0,0112**	**2,3%**	**75,7%**
3Da	**Direct emissions from agricultural soils**	**N_2O**	**7518,5**	**4860,2**	**0,0101**	**2,1%**	**77,8%**
1A4b	**Residential gaseous**	**CO_2**	**19895,7**	**16117,2**	**0,0078**	**1,6%**	**79,4%**
2C1	**Iron and steel production**	**CO_2**	**2266,3**	**905,2**	**0,0063**	**1,3%**	**80,7%**
1B2c	**Venting and flaring**	**CH_4**	**1501,9**	**313,9**	**0,0059**	**1,2%**	**82,0%**
3B3	**Swine**	**CH_4**	**3489,3**	**2112,7**	**0,0055**	**1,2%**	**83,1%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**70,7**	**910,8**	**0,0050**	**1,0%**	**84,2%**
3Db	**Indirect emissions from managed soils**	**N_2O**	**1648,9**	**609,1**	**0,0049**	**1,0%**	**85,2%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1184,2**	**1792,5**	**0,0044**	**0,9%**	**86,1%**
1A4c	**Agriculture/Forestry/Fisheries:gaseous**	**CO_2**	**7329,3**	**7169,9**	**0,0043**	**0,9%**	**87,0%**
3A1	**Mature dairy cattle**	**CH_4**	**5179,2**	**5232,9**	**0,0040**	**0,8%**	**87,8%**
3B1	**Cattle**	**CH_4**	**1823,2**	**2260,3**	**0,0039**	**0,8%**	**88,7%**
2B1	**Ammonia production**	**CO_2**	**3730,1**	**3920,9**	**0,0038**	**0,8%**	**89,4%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**774,6**	**1315,4**	**0,0037**	**0,8%**	**90,2%**
1A4	**Liquids excl. 1A4c**	**CO_2**	**1329,1**	**601,3**	**0,0033**	**0,7%**	**90,9%**
1A1a	**Public Electricity and Heat Production: liquids**	**CO_2**	**233,2**	**739,2**	**0,0031**	**0,7%**	**91,6%**
1A3d	**Domestic navigation**	**CO_2**	**857,3**	**1240,9**	**0,0029**	**0,6%**	**92,2%**
1A2	**Manufacturing Industries and Construction, solids**	**CO_2**	**4400,9**	**3371,2**	**0,0029**	**0,6%**	**92,8%**

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
1B1b	**Solid fuel transformation**	**CO_2**	**402,5**	**810,7**	**0,0027**	**0,6%**	**93,3%**
1A4c	**Agriculture/Forestry/Fisheries: liquids**	**CO_2**	**2518,7**	**1859,2**	**0,0020**	**0,4%**	**93,7%**
3B4	**Poultry**	**CH_4**	**464,4**	**72,9**	**0,0020**	**0,4%**	**94,2%**
2C3	**Aluminium production**	**CO_2**	**408,4**	**39,9**	**0,0019**	**0,4%**	**94,5%**
1A4a	**Commercial/Institutional:gaseous**	**CO_2**	**7758,4**	**7107,7**	**0,0018**	**0,4%**	**94,9%**
1A2	Manufacturing Industries and Construction, liquids	CO_2	8568,9	7768,8	0,0015	0,3%	95,2%
2B4	Caprolactam production	N_2O	739,9	901,9	0,0015	0,3%	95,5%
3A1	Young cattle	CH_4	2801,8	2211,0	0,0014	0,3%	95,8%
2B10	Other	CO_2	583,3	278,0	0,0014	0,3%	96,1%
1A3e	Other	CO_2	342,2	92,9	0,0012	0,3%	96,4%
1A1c	Manufacture of Solid Fuels: solids	CO_2	632,6	743,3	0,0011	0,2%	96,6%
1A1	Energy Industries:all fuels	N_2O	147,4	312,2	0,0011	0,2%	96,8%
2A4d	Other	CO_2	481,0	586,0	0,0010	0,2%	97,0%
2B8	Petrochemical and carbon black production	CO_2	335,6	458,3	0,0010	0,2%	97,2%
1A3b	Road transportation	N_2O	97,9	241,2	0,0009	0,2%	97,4%
3B	Emissions from manure management	N_2O	926,2	674,2	0,0008	0,2%	97,6%
1A4	Solids	CO_2	162,7	5,7	0,0008	0,2%	97,8%
2D2	Paraffin wax use	CO_2	102,9	206,6	0,0007	0,1%	97,9%
2A1	Cement production	CO_2	415,8	249,4	0,0007	0,1%	98,0%
1A3b	Road transportation	CH_4	193,4	57,1	0,0007	0,1%	98,2%
2G	Other product manufacture and use	N_2O	224,7	86,0	0,0006	0,1%	98,3%
1A5	Military use:liquids	CO_2	312,0	175,2	0,0006	0,1%	98,4%
1A3b	Road transportation:gaseous	CO_2	0,0	95,5	0,0006	0,1%	98,6%
3G	Liming	CO_2	183,2	68,7	0,0005	0,1%	98,7%
2G2	SF_6 use	SF_6	261,0	138,8	0,0005	0,1%	98,8%
5D	Wastewater treatment and discharge	N_2O	172,1	71,4	0,0005	0,1%	98,9%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380,0	409,2	0,0004	0,1%	99,0%
5B	Biological treatment of solid waste: composting	N_2O	6,5	77,2	0,0004	0,1%	99,0%
5B	Biological treatment of solid waste: composting	CH_4	13,7	73,8	0,0004	0,1%	99,1%
5D	Wastewater treatment and discharge	CH_4	308,8	210,7	0,0004	0,1%	99,2%
1A4a	Commercial/Institutional:all fuels	CH_4	42,3	96,8	0,0003	0,1%	99,3%
2B7	Soda ash production	CO_2	63,8	0,0	0,0003	0,1%	99,3%
2A4b	Other uses of soda ash	CO_2	68,6	114,2	0,0003	0,1%	99,4%

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
1A1	Energy Industries:all fuels	CH_4	72,2	112,1	0,0003	0,1%	99,5%
1B2b	Natural gas	CH_4	421,1	323,3	0,0003	0,1%	99,5%
1A3a	Domestic aviation	CO_2	84,8	30,6	0,0003	0,1%	99,6%
2E	Electronic Industry	PFC	49,7	85,5	0,0002	0,1%	99,6%
2H	Other industrial	CO_2	72,5	25,2	0,0002	0,0%	99,7%
1A4b	Residential:all fuels	CH_4	456,0	430,7	0,0002	0,0%	99,7%
2F6	Other	HFC	201,0	146,0	0,0002	0,0%	99,7%
2A3	Glass production	CO_2	142,4	95,3	0,0002	0,0%	99,8%
3A1	Other mature cattle	CH_4	210,2	159,0	0,0001	0,0%	99,8%
2D3	Other	CO_2	0,0	21,6	0,0001	0,0%	99,8%
1A3c	Railways	CO_2	90,7	99,8	0,0001	0,0%	99,9%
3A4	Other	CH_4	514,4	436,0	0,0001	0,0%	99,9%
3A3	Swine	CH_4	521,8	472,6	0,0001	0,0%	99,9%
2B	Fluorochemical production	PFC	0,0	12,3	0,0001	0,0%	99,9%
1A4	Other Sectors:all fuels	N_2O	64,2	67,5	0,0001	0,0%	99,9%
2A4a	Ceramics	CO_2	140,1	111,7	0,0001	0,0%	99,9%
3B2, 3B4	Other	CH_4	33,7	40,5	0,0001	0,0%	100,0%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42,9	47,6	0,0001	0,0%	100,0%
2D1	Lubricant use	CO_2	84,6	80,3	0,0000	0,0%	100,0%
1B2a	Oil	CH_4	20,3	12,1	0,0000	0,0%	100,0%
1A3 exl 1A3b	Other	N_2O	7,8	10,2	0,0000	0,0%	100,0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	65,0	59,9	0,0000	0,0%	100,0%
1A5	Military use:liquids	N_2O	5,5	2,7	0,0000	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	2,8	4,1	0,0000	0,0%	100,0%
2G	Other product manufacture and use	CH_4	50,1	42,5	0,0000	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,2	0,8	0,0000	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,8	0,4	0,0000	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,2	0,3	0,0000	0,0%	100,0%

Lines in bold represent the key sources

Table A1.4b Source ranking using IPCC Tier 1 trend assessment 2015, including LULUCF (Gg CO_2 eq)

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**25862,2**	**37297,1**	**7,8%**	**16,8%**	**16,8%**
5A	**Solid waste disposal**	**CH_4**	**13679,2**	**2945,0**	**5,0%**	**10,8%**	**27,5%**
2B	**Fluorochemical production**	**HFC**	**7297,7**	**148,5**	**3,5%**	**7,4%**	**34,9%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**13024,8**	**17134,4**	**3,0%**	**6,5%**	**41,4%**
2B2	**Nitric acid production**	**N_2O**	**6084,7**	**370,4**	**2,7%**	**5,9%**	**47,3%**
1A2	**Manufacturing Industries and Construction, gaseous**	**CO_2**	**19045,8**	**12882,4**	**2,2%**	**4,7%**	**52,1%**
1A1a	**Public Electricity and Heat Production: gaseous**	**CO_2**	**13330,2**	**14727,0**	**1,6%**	**3,4%**	**55,4%**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO_2**	**601,5**	**2861,1**	**1,3%**	**2,7%**	**58,2%**
1A3b	**Road transportation: gasoline**	**CO_2**	**10784,6**	**11741,7**	**1,2%**	**2,5%**	**60,7%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**9968,2**	**6797,3**	**1,1%**	**2,4%**	**63,1%**
1A1b	**Petroleum Refining: gaseous**	**CO_2**	**1042,3**	**2975,9**	**1,1%**	**2,4%**	**65,5%**
2F1	**Refrigeration and airconditioning**	**HFC**	**72,7**	**2041,2**	**1,1%**	**2,3%**	**67,8%**
2C3	**Aluminium production**	**PFC**	**2230,2**	**6,5**	**1,1%**	**2,3%**	**70,1%**
1A3b	**Road transportation: LPG**	**CO_2**	**2653,6**	**411,5**	**1,1%**	**2,3%**	**72,4%**
3Da	**Direct emissions from agricultural soils**	**N_2O**	**7518,5**	**4860,2**	**1,0%**	**2,1%**	**74,5%**
1A4b	**Residential gaseous**	**CO_2**	**19895,7**	**16117,2**	**0,8%**	**1,8%**	**76,3%**
4B	**Cropland**	**CO_2**	**1637,0**	**2666,5**	**0,7%**	**1,4%**	**77,8%**
2C1	**Iron and steel production**	**CO_2**	**2266,3**	**905,2**	**0,6%**	**1,3%**	**79,1%**
1B2c	**Venting and flaring**	**CH_4**	**1501,9**	**313,9**	**0,6%**	**1,2%**	**80,2%**
3B3	**Swine**	**CH_4**	**3489,3**	**2112,7**	**0,5%**	**1,2%**	**81,4%**
4E	**Settlements**	**CO_2**	**888,3**	**1649,6**	**0,5%**	**1,0%**	**82,4%**
3Db	**Indirect emissions from managed soils**	**N_2O**	**1648,9**	**609,1**	**0,5%**	**1,0%**	**83,4%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**70,7**	**910,8**	**0,5%**	**1,0%**	**84,4%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1184,2**	**1792,5**	**0,4%**	**0,9%**	**85,3%**
4A	**Forest Land**	**CO_2**	**-1911,3**	**-2433,8**	**0,4%**	**0,9%**	**86,1%**
1A4c	**Agriculture/Forestry/Fisheries:gaseous**	**CO_2**	**7329,3**	**7169,9**	**0,4%**	**0,8%**	**86,9%**
3B1	**Cattle**	**CH_4**	**1823,2**	**2260,3**	**0,3%**	**0,7%**	**87,6%**
3A1	**Mature dairy cattle**	**CH_4**	**5179,2**	**5232,9**	**0,3%**	**0,7%**	**88,4%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**774,6**	**1315,4**	**0,3%**	**0,7%**	**89,1%**
2B1	**Ammonia production**	**CO_2**	**3730,1**	**3920,9**	**0,3%**	**0,7%**	**89,8%**
1A4	**Liquids excl. 1A4c**	**CO_2**	**1329,1**	**601,3**	**0,3%**	**0,7%**	**90,5%**

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
1A2	**Manufacturing Industries and Construction, solids**	**CO_2**	**4400,9**	**3371,2**	**0,3%**	**0,6%**	**91,1%**
1A1a	**Public Electricity and Heat Production: liquids**	**CO_2**	**233,2**	**739,2**	**0,3%**	**0,6%**	**91,8%**
1A3d	**Domestic navigation**	**CO_2**	**857,3**	**1240,9**	**0,3%**	**0,6%**	**92,3%**
1B1b	**Solid fuel transformation**	**CO_2**	**402,5**	**810,7**	**0,2%**	**0,5%**	**92,9%**
4C	**Grassland**	**CO_2**	**5483,3**	**4420,1**	**0,2%**	**0,5%**	**93,4%**
1A4c	**Agriculture/Forestry/Fisheries: liquids**	**CO_2**	**2518,7**	**1859,2**	**0,2%**	**0,4%**	**93,8%**
3B4	**Poultry**	**CH_4**	**464,4**	**72,9**	**0,2%**	**0,4%**	**94,2%**
2C3	**Aluminium production**	**CO_2**	**408,4**	**39,9**	**0,2%**	**0,4%**	**94,6%**
3A1	**Young cattle**	**CH_4**	**2801,8**	**2211,0**	**0,2%**	**0,3%**	**94,9%**
2B4	Caprolactam production	N_2O	739,9	901,9	0,1%	0,3%	95,2%
2B10	Other	CO_2	583,3	278,0	0,1%	0,3%	95,5%
1A4a	Commercial/Institutional:gaseous	CO_2	7758,4	7107,7	0,1%	0,3%	95,7%
1A3e	Other	CO_2	342,2	92,9	0,1%	0,2%	96,0%
1A1c	Manufacture of Solid Fuels: solids	CO_2	632,6	743,3	0,1%	0,2%	96,2%
1A1	Energy Industries:all fuels	N_2O	147,4	312,2	0,1%	0,2%	96,4%
2B8	Petrochemical and carbon black production	CO_2	335,6	458,3	0,1%	0,2%	96,6%
2A4d	Other	CO_2	481,0	586,0	0,1%	0,2%	96,8%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8568,9	7768,8	0,1%	0,2%	97,0%
1A3b	Road transportation	N_2O	97,9	241,2	0,1%	0,2%	97,1%
3B	Emissions from manure management	N_2O	926,2	674,2	0,1%	0,2%	97,3%
1A4	Solids	CO_2	162,7	5,7	0,1%	0,2%	97,5%
2A1	Cement production	CO_2	415,8	249,4	0,1%	0,1%	97,6%
2D2	Paraffin wax use	CO_2	102,9	206,6	0,1%	0,1%	97,8%
1A3b	Road transportation	CH_4	193,4	57,1	0,1%	0,1%	97,9%
2G	Other product manufacture and use	N_2O	224,7	86,0	0,1%	0,1%	98,0%
4F	Other Land	CO_2	26,3	126,2	0,1%	0,1%	98,1%
1A5	Military use:liquids	CO_2	312,0	175,2	0,1%	0,1%	98,3%
1A3b	Road transportation:gaseous	CO_2	0,0	95,5	0,1%	0,1%	98,4%
3G	Liming	CO_2	183,2	68,7	0,1%	0,1%	98,5%
2G2	SF_6 use	SF_6	261,0	138,8	0,1%	0,1%	98,6%
5D	Wastewater treatment and discharge	N_2O	172,1	71,4	0,0%	0,1%	98,7%
4B	Cropland	N_2O	3,1	78,4	0,0%	0,1%	98,8%

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380,0	409,2	0,0%	0,1%	98,9%
5B	Biological treatment of solid waste: composting	N_2O	6,5	77,2	0,0%	0,1%	98,9%
5D	Wastewater treatment and discharge	CH_4	308,8	210,7	0,0%	0,1%	99,0%
5B	Biological treatment of solid waste: composting	CH_4	13,7	73,8	0,0%	0,1%	99,1%
1A4a	Commercial/Institutional:all fuels	CH_4	42,3	96,8	0,0%	0,1%	99,2%
2B7	Soda ash production	CO_2	63,8	0,0	0,0%	0,1%	99,2%
2A4b	Other uses of soda ash	CO_2	68,6	114,2	0,0%	0,1%	99,3%
4G	Harvested wood products	CO_2	157,2	88,4	0,0%	0,1%	99,4%
1B2b	Natural gas	CH_4	421,1	323,3	0,0%	0,1%	99,4%
1A1	Energy Industries:all fuels	CH_4	72,2	112,1	0,0%	0,1%	99,5%
1A3a	Domestic aviation	CO_2	84,8	30,6	0,0%	0,1%	99,5%
4H	Other	N_2O	2,5	45,3	0,0%	0,1%	99,6%
2E	Electronic Industry	PFC	49,7	85,5	0,0%	0,0%	99,6%
2H	Other industrial	CO_2	72,5	25,2	0,0%	0,0%	99,7%
2F6	Other	HFC	201,0	146,0	0,0%	0,0%	99,7%
2A3	Glass production	CO_2	142,4	95,3	0,0%	0,0%	99,7%
3A1	Other mature cattle	CH_4	210,2	159,0	0,0%	0,0%	99,8%
1A4b	Residential:all fuels	CH_4	456,0	430,7	0,0%	0,0%	99,8%
2D3	Other	CO_2	0,0	21,6	0,0%	0,0%	99,8%
3A4	Other	CH_4	514,4	436,0	0,0%	0,0%	99,9%
1A3c	Railways	CO_2	90,7	99,8	0,0%	0,0%	99,9%
4D	Wetlands	CO_2	88,0	64,0	0,0%	0,0%	99,9%
2A4a	Ceramics	CO_2	140,1	111,7	0,0%	0,0%	99,9%
2B	Fluorochemical production	PFC	0,0	12,3	0,0%	0,0%	99,9%
3B2, 3B4	Other	CH_4	33,7	40,5	0,0%	0,0%	99,9%
1A4	Other Sectors:all fuels	N_2O	64,2	67,5	0,0%	0,0%	99,9%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42,9	47,6	0,0%	0,0%	100,0%
3A3	Swine	CH_4	521,8	472,6	0,0%	0,0%	100,0%
1B2a	Oil	CH_4	20,3	12,1	0,0%	0,0%	100,0%
4C	Grassland	N_2O	0,3	5,9	0,0%	0,0%	100,0%
2D1	Lubricant use	CO_2	84,6	80,3	0,0%	0,0%	100,0%
1A3 exl	Other	N_2O	7,8	10,2	0,0%	0,0%	100,0%

IPCC Category		Gas	Base Year Estimate (CO_2 eq)	Latest Year Estimate (CO_2 eq)	Trend Assessment	% Contribution to trend	Cumulative Total
1A3b							
1A5	Military use:liquids	N_2O	5,5	2,7	0,0%	0,0%	100,0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	65,0	59,9	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CH_4	50,1	42,5	0,0%	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	2,8	4,1	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,2	0,8	0,0%	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,8	0,4	0,0%	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,2	0,3	0,0%	0,0%	100,0%
4	LULUCF: CH_4	CH_4	0,2	0,3	0,0%	0,0%	100,0%

Lines in bold represent the key sources

A1.4 Tier 2 key source assessment

Using the uncertainty estimate for each key source as a weighting factor (see Annex 2), the key source assessment was performed again. This is called the Tier 2 key source assessment. The results of this assessment are presented in Tables A1.5a and A1.5b for the contribution to the 2015 annual emissions total and in Tables A1.6a and A1.6b for the contribution to the trend. Comparison with the Tier 1 assessment presented in Tables A1.3a and A1.4a shows fewer level and trend key sources (30 and 29, respectively, instead of 31 and 36).
The inclusion of LULUCF sources in the analysis adds six CO_2 sources: 4A Forest land, 4B Cropland, 4C Grassland, 4D Wetlands, 4E Settlements and 4F Other Land.

Table A1.5a Source ranking using IPCC Tier 2 level assessment 2015 excluding LULUCF (Gg CO_2 eq)

IPCC Category		Gas	CO_2-eq latest year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U
3Da	**Direct emissions from agricultural soils**	**N_2O**	**4860,2**	**2,5%**	**60,8%**	**1,5%**	**10,8%**	**10,8%**
3B1	**Cattle**	**CH_4**	**2260,3**	**1,2%**	**100,5%**	**1,2%**	**8,3%**	**19,0%**
3B3	**Swine**	**CH_4**	**2112,7**	**1,1%**	**100,5%**	**1,1%**	**7,7%**	**26,8%**
1A2	**Manufacturing Industries and Construction, liquids**	**CO_2**	**7768,8**	**4,0%**	**25,0%**	**1,0%**	**7,1%**	**33,8%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**6797,3**	**3,5%**	**25,5%**	**0,9%**	**6,3%**	**40,2%**
3Db	**Indirect emissions from managed soils**	**N_2O**	**609,1**	**0,3%**	**206,2%**	**0,6%**	**4,6%**	**44,7%**
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**37297,1**	**19,1%**	**3,2%**	**0,6%**	**4,3%**	**49,0%**
2F1	**Refrigeration and airconditioning**	**HFC**	**2041,2**	**1,0%**	**53,9%**	**0,6%**	**4,0%**	**53,0%**
3A1	**Mature dairy cattle**	**CH_4**	**5232,9**	**2,7%**	**15,8%**	**0,4%**	**3,0%**	**56,0%**
1A4b	**Residential gaseous**	**CO_2**	**16117,2**	**8,3%**	**5,0%**	**0,4%**	**2,9%**	**59,0%**
1A4c	**Agriculture/Forestry/Fisheries:gaseous**	**CO_2**	**7169,9**	**3,7%**	**10,0%**	**0,4%**	**2,6%**	**61,6%**
1A4a	**Commercial/Institutional:gaseous**	**CO_2**	**7107,7**	**3,6%**	**10,0%**	**0,4%**	**2,6%**	**64,2%**
5A	**Solid waste disposal**	**CH_4**	**2945,0**	**1,5%**	**24,0%**	**0,4%**	**2,6%**	**66,7%**
3B	**Emissions from manure management**	**N_2O**	**674,2**	**0,3%**	**100,5%**	**0,3%**	**2,5%**	**69,2%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**1315,4**	**0,7%**	**50,0%**	**0,3%**	**2,4%**	**71,6%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**17134,4**	**8,8%**	**2,8%**	**0,2%**	**1,8%**	**73,4%**
3A1	**Young cattle**	**CH_4**	**2211,0**	**1,1%**	**20,6%**	**0,2%**	**1,7%**	**75,0%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**910,8**	**0,5%**	**49,8%**	**0,2%**	**1,7%**	**76,7%**
2B1	**Ammonia production**	**CO_2**	**3920,9**	**2,0%**	**10,2%**	**0,2%**	**1,5%**	**78,1%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1792,5**	**0,9%**	**20,6%**	**0,2%**	**1,3%**	**79,5%**
1A2	**Manufacturing Industries and Construction, solids**	**CO_2**	**3371,2**	**1,7%**	**10,2%**	**0,2%**	**1,3%**	**80,7%**
1A3b	**Road transportation: gasoline**	**CO_2**	**11741,7**	**6,0%**	**2,8%**	**0,2%**	**1,2%**	**81,9%**
2B8	**Petrochemical and carbon black production**	**CO_2**	**458,3**	**0,2%**	**70,7%**	**0,2%**	**1,2%**	**83,1%**
2A4d	**Other**	**CO_2**	**586,0**	**0,3%**	**50,2%**	**0,2%**	**1,1%**	**84,2%**
2B8	**Chemical industry: Petrochemical and carbon black production**	**CH_4**	**409,2**	**0,2%**	**70,7%**	**0,1%**	**1,1%**	**85,3%**
2B4	**Caprolactam production**	**N_2O**	**901,9**	**0,5%**	**30,5%**	**0,1%**	**1,0%**	**86,3%**
1A2	**Manufacturing Industries and Construction, gaseous**	**CO_2**	**12882,4**	**6,6%**	**2,0%**	**0,1%**	**0,9%**	**87,2%**
1A4b	**Residential:all fuels**	**CH_4**	**430,7**	**0,2%**	**55,4%**	**0,1%**	**0,9%**	**88,1%**
3A3	**Swine**	**CH_4**	**472,6**	**0,2%**	**50,2%**	**0,1%**	**0,9%**	**88,9%**
2D2	**Paraffin wax use**	**CO_2**	**206,6**	**0,1%**	**102,0%**	**0,1%**	**0,8%**	**89,7%**

IPCC Category		Gas	CO_2-eq latest year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	2861,1	1,5%	6,5%	0,1%	0,7%	90,4%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	1859,2	1,0%	10,0%	0,1%	0,7%	91,1%
1A3b	Road transportation	N_2O	241,2	0,1%	70,0%	0,1%	0,6%	91,7%
1B2b	Natural gas	CH_4	323,3	0,2%	50,0%	0,1%	0,6%	92,3%
1A1a	Public Electricity and Heat Production: liquids	CO_2	739,2	0,4%	20,0%	0,1%	0,5%	92,8%
3A4	Other	CH_4	436,0	0,2%	30,4%	0,1%	0,5%	93,3%
1B1b	Solid fuel transformation	CO_2	810,7	0,4%	15,1%	0,1%	0,4%	93,7%
1A4	Liquids excl. 1A4c	CO_2	601,3	0,3%	20,1%	0,1%	0,4%	94,2%
2B10	Other	CO_2	278,0	0,1%	30,0%	0,0%	0,3%	94,5%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	14727,0	7,6%	0,6%	0,0%	0,3%	94,8%
1A1c	Manufacture of Solid Fuels: solids	CO_2	743,3	0,4%	10,9%	0,0%	0,3%	95,1%
1B2c	Venting and flaring	CH_4	313,9	0,2%	25,1%	0,0%	0,3%	95,4%
2F6	Other	HFC	146,0	0,1%	53,9%	0,0%	0,3%	95,6%
3B4	Poultry	CH_4	72,9	0,0%	100,5%	0,0%	0,3%	95,9%
3G	Liming	CO_2	68,7	0,0%	100,5%	0,0%	0,3%	96,2%
1A3d	Domestic navigation	CO_2	1240,9	0,6%	5,4%	0,0%	0,2%	96,4%
2G	Other product manufacture and use	N_2O	86,0	0,0%	70,7%	0,0%	0,2%	96,6%
1A1	Energy Industries:all fuels	N_2O	312,2	0,2%	18,6%	0,0%	0,2%	96,8%
2A4b	Other uses of soda ash	CO_2	114,2	0,1%	50,2%	0,0%	0,2%	97,0%
2A4a	Ceramics	CO_2	111,7	0,1%	50,2%	0,0%	0,2%	97,2%
2C1	Iron and steel production	CO_2	905,2	0,5%	5,8%	0,0%	0,2%	97,4%
1A4a	Commercial/Institutional:all fuels	CH_4	96,8	0,0%	48,7%	0,0%	0,2%	97,6%
2G2	SF_6 use	SF_6	138,8	0,1%	33,5%	0,0%	0,2%	97,8%
2D1	Lubricant use	CO_2	80,3	0,0%	57,9%	0,0%	0,2%	97,9%
5B	Biological treatment of solid waste: composting	CH_4	73,8	0,0%	62,9%	0,0%	0,2%	98,1%
3B2, 3B4	Other	CH_4	40,5	0,0%	100,5%	0,0%	0,1%	98,3%
5B	Biological treatment of solid waste: composting	N_2O	77,2	0,0%	49,7%	0,0%	0,1%	98,4%
1A5	Military use:liquids	CO_2	175,2	0,1%	20,1%	0,0%	0,1%	98,5%
2B	Fluorochemical production	HFC	148,5	0,1%	22,4%	0,0%	0,1%	98,7%
3A1	Other mature cattle	CH_4	159,0	0,1%	20,6%	0,0%	0,1%	98,8%
1A4	Other Sectors:all fuels	N_2O	67,5	0,0%	46,6%	0,0%	0,1%	98,9%
2B2	Nitric acid production	N_2O	370,4	0,2%	7,8%	0,0%	0,1%	99,0%

IPCC Category		Gas	CO_2-eq latest year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U
1A3b	Road transportation	CH_4	57,1	0,0%	50,0%	0,0%	0,1%	99,1%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	47,6	0,0%	58,7%	0,0%	0,1%	99,2%
2A1	Cement production	CO_2	249,4	0,1%	11,2%	0,0%	0,1%	99,3%
2A3	Glass production	CO_2	95,3	0,0%	25,5%	0,0%	0,1%	99,4%
1A3b	Road transportation: LPG	CO_2	411,5	0,2%	5,4%	0,0%	0,1%	99,5%
2E	Electronic Industry	PFC	85,5	0,0%	25,5%	0,0%	0,1%	99,5%
2G	Other product manufacture and use	CH_4	42,5	0,0%	50,5%	0,0%	0,1%	99,6%
1A1	Energy Industries:all fuels	CH_4	112,1	0,1%	18,6%	0,0%	0,1%	99,7%
1A1b	Petroleum Refining: gaseous	CO_2	2975,9	1,5%	0,6%	0,0%	0,1%	99,8%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	59,9	0,0%	15,9%	0,0%	0,0%	99,8%
1A3a	Domestic aviation	CO_2	30,6	0,0%	30,3%	0,0%	0,0%	99,8%
1A3 exl 1A3b	Other	N_2O	10,2	0,0%	70,0%	0,0%	0,0%	99,9%
1B2a	Oil	CH_4	12,1	0,0%	53,9%	0,0%	0,0%	99,9%
2D3	Other	CO_2	21,6	0,0%	26,7%	0,0%	0,0%	99,9%
1A3c	Railways	CO_2	99,8	0,1%	5,4%	0,0%	0,0%	99,9%
1A3b	Road transportation:gaseous	CO_2	95,5	0,0%	5,4%	0,0%	0,0%	99,9%
1A4	Solids	CO_2	5,7	0,0%	51,0%	0,0%	0,0%	100,0%
2B	Fluorochemical production	PFC	12,3	0,0%	22,4%	0,0%	0,0%	100,0%
1A5	Military use:liquids	N_2O	2,7	0,0%	82,3%	0,0%	0,0%	100,0%
2C3	Aluminium production	CO_2	39,9	0,0%	5,4%	0,0%	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	4,1	0,0%	50,0%	0,0%	0,0%	100,0%
2H	Other industrial	CO_2	25,2	0,0%	5,7%	0,0%	0,0%	100,0%
2C3	Aluminium production	PFC	6,5	0,0%	20,1%	0,0%	0,0%	100,0%
1A3e	Other	CO_2	92,9	0,0%	0,6%	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,8	0,0%	53,9%	0,0%	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,3	0,0%	111,8%	0,0%	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,4	0,0%	60,4%	0,0%	0,0%	100,0%
2B7	Soda ash production	CO_2	0,0	0,0%	7,1%	0,0%	0,0%	100,0%
5D	Wastewater treatment and discharge	CH_4	210,7		37,7%	0,0%	0,0%	100,0%
5D	Wastewater treatment and discharge	N_2O	71,4		102,0%	0,0%	0,0%	100,0%

Lines in bold represent the key sources

Table A1.5b Source ranking using IPCC Tier 2 level assessment 2015 including LULUCF (Gg CO_2 eq)

IPCC Category		Gas	CO_2-eq latest year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U
3Da	Direct emissions from agricultural soils	N_2O	4860,2	2,4%	60,8%	1,4%	8,6%	8,6%
4C	Grassland	CO_2	4420,1	2,1%	55,9%	1,2%	7,2%	15,8%
3B1	Cattle	CH_4	2260,3	1,1%	100,5%	1,1%	6,6%	22,4%
3B3	Swine	CH_4	2112,7	1,0%	100,5%	1,0%	6,2%	28,6%
1A2	Manufacturing Industries and Construction, liquids	CO_2	7768,8	3,8%	25,0%	0,9%	5,7%	34,3%
1A1b	Petroleum Refining: liquids	CO_2	6797,3	3,3%	25,5%	0,8%	5,0%	39,3%
4A	Forest Land	CO_2	2433,8	1,2%	66,7%	0,8%	4,7%	44,0%
4B	Cropland	CO_2	2666,5	1,3%	55,9%	0,7%	4,3%	48,4%
3Db	Indirect emissions from managed soils	N_2O	609,1	0,3%	206,2%	0,6%	3,7%	52,0%
1A1a	Public Electricity and Heat Production: solids	CO_2	37297,1	18,1%	3,2%	0,6%	3,4%	55,5%
2F1	Refrigeration and airconditioning	HFC	2041,2	1,0%	53,9%	0,5%	3,2%	58,7%
4E	Settlements	CO_2	1649,6	0,8%	55,9%	0,4%	2,7%	61,3%
3A1	Mature dairy cattle	CH_4	5232,9	2,5%	15,8%	0,4%	2,4%	63,8%
1A4b	Residential gaseous	CO_2	16117,2	7,8%	5,0%	0,4%	2,3%	66,1%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7169,9	3,5%	10,0%	0,3%	2,1%	68,2%
1A4a	Commercial/Institutional:gaseous	CO_2	7107,7	3,4%	10,0%	0,3%	2,1%	70,3%
5A	Solid waste disposal	CH_4	2945,0	1,4%	24,0%	0,3%	2,1%	72,3%
3B	Emissions from manure management	N_2O	674,2	0,3%	100,5%	0,3%	2,0%	74,3%
1B2	Fugitive emissions from oil and gas operations	CO_2	1315,4	0,6%	50,0%	0,3%	1,9%	76,2%
1A3b	Road transportation: diesel oil	CO_2	17134,4	8,3%	2,8%	0,2%	1,4%	77,6%
3A1	Young cattle	CH_4	2211,0	1,1%	20,6%	0,2%	1,3%	78,9%
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	910,8	0,4%	49,8%	0,2%	1,3%	80,3%
2B1	Ammonia production	CO_2	3920,9	1,9%	10,2%	0,2%	1,2%	81,4%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	1792,5	0,9%	20,6%	0,2%	1,1%	82,5%
1A2	Manufacturing Industries and Construction, solids	CO_2	3371,2	1,6%	10,2%	0,2%	1,0%	83,5%
1A3b	Road transportation: gasoline	CO_2	11741,7	5,7%	2,8%	0,2%	1,0%	84,5%
2B8	Petrochemical and carbon black production	CO_2	458,3	0,2%	70,7%	0,2%	0,9%	85,4%
2A4d	Other	CO_2	586,0	0,3%	50,2%	0,1%	0,9%	86,3%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	409,2	0,2%	70,7%	0,1%	0,8%	87,1%
2B4	Caprolactam production	N_2O	901,9	0,4%	30,5%	0,1%	0,8%	87,9%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	12882,4	6,2%	2,0%	0,1%	0,8%	88,7%

IPCC Category		Gas	CO_2-eq latest year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U
1A4b	**Residential:all fuels**	**CH_4**	**430,7**	**0,2%**	**55,4%**	**0,1%**	**0,7%**	**89,4%**
3A3	Swine	CH_4	472,6	0,2%	50,2%	0,1%	0,7%	90,1%
2D2	Paraffin wax use	CO_2	206,6	0,1%	102,0%	0,1%	0,6%	90,7%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	2861,1	1,4%	6,5%	0,1%	0,5%	91,2%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	1859,2	0,9%	10,0%	0,1%	0,5%	91,8%
1A3b	Road transportation	N_2O	241,2	0,1%	70,0%	0,1%	0,5%	92,3%
1B2b	Natural gas	CH_4	323,3	0,2%	50,0%	0,1%	0,5%	92,7%
1A1a	Public Electricity and Heat Production: liquids	CO_2	739,2	0,4%	20,0%	0,1%	0,4%	93,2%
3A4	Other	CH_4	436,0	0,2%	30,4%	0,1%	0,4%	93,5%
1B1b	Solid fuel transformation	CO_2	810,7	0,4%	15,1%	0,1%	0,4%	93,9%
1A4	Liquids excl. 1A4c	CO_2	601,3	0,3%	20,1%	0,1%	0,4%	94,3%
2B10	Other	CO_2	278,0	0,1%	30,0%	0,0%	0,2%	94,5%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	14727,0	7,1%	0,6%	0,0%	0,2%	94,7%
1A1c	Manufacture of Solid Fuels: solids	CO_2	743,3	0,4%	10,9%	0,0%	0,2%	95,0%
5D	Wastewater treatment and discharge	CH_4	210,7	0,1%	37,7%	0,0%	0,2%	95,2%
1B2c	Venting and flaring	CH_4	313,9	0,2%	25,1%	0,0%	0,2%	95,4%
2F6	Other	HFC	146,0	0,1%	53,9%	0,0%	0,2%	95,7%
3B4	Poultry	CH_4	72,9	0,0%	100,5%	0,0%	0,2%	95,9%
5D	Wastewater treatment and discharge	N_2O	71,4	0,0%	102,0%	0,0%	0,2%	96,1%
4F	Other Land	CO_2	126,2	0,1%	55,9%	0,0%	0,2%	96,3%
3G	Liming	CO_2	68,7	0,0%	100,5%	0,0%	0,2%	96,5%
1A3d	Domestic navigation	CO_2	1240,9	0,6%	5,4%	0,0%	0,2%	96,7%
2G	Other product manufacture and use	N_2O	86,0	0,0%	70,7%	0,0%	0,2%	96,9%
1A1	Energy Industries:all fuels	N_2O	312,2	0,2%	18,6%	0,0%	0,2%	97,0%
2A4b	Other uses of soda ash	CO_2	114,2	0,1%	50,2%	0,0%	0,2%	97,2%
2A4a	Ceramics	CO_2	111,7	0,1%	50,2%	0,0%	0,2%	97,4%
2C1	Iron and steel production	CO_2	905,2	0,4%	5,8%	0,0%	0,2%	97,5%
4B	Cropland	N_2O	78,4	0,0%	63,0%	0,0%	0,1%	97,7%
4G	Harvested wood products	CO_2	88,4	0,0%	55,9%	0,0%	0,1%	97,8%
1A4a	Commercial/Institutional:all fuels	CH_4	96,8	0,0%	48,7%	0,0%	0,1%	97,9%
2G2	SF_6 use	SF_6	138,8	0,1%	33,5%	0,0%	0,1%	98,1%
2D1	Lubricant use	CO_2	80,3	0,0%	57,9%	0,0%	0,1%	98,2%

IPCC Category		Gas	CO_2-eq latest year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U
5B	Biological treatment of solid waste: composting	CH_4	73,8	0,0%	62,9%	0,0%	0,1%	98,3%
3B2, 3B4	Other	CH_4	40,5	0,0%	100,5%	0,0%	0,1%	98,5%
5B	Biological treatment of solid waste: composting	N_2O	77,2	0,0%	49,7%	0,0%	0,1%	98,6%
4D	Wetlands	CO_2	64,0	0,0%	55,9%	0,0%	0,1%	98,7%
1A5	Military use:liquids	CO_2	175,2	0,1%	20,1%	0,0%	0,1%	98,8%
2B	Fluorochemical production	HFC	148,5	0,1%	22,4%	0,0%	0,1%	98,9%
3A1	Other mature cattle	CH_4	159,0	0,1%	20,6%	0,0%	0,1%	99,0%
1A4	Other Sectors:all fuels	N_2O	67,5	0,0%	46,6%	0,0%	0,1%	99,1%
2B2	Nitric acid production	N_2O	370,4	0,2%	7,8%	0,0%	0,1%	99,2%
1A3b	Road transportation	CH_4	57,1	0,0%	50,0%	0,0%	0,1%	99,2%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	47,6	0,0%	58,7%	0,0%	0,1%	99,3%
2A1	Cement production	CO_2	249,4	0,1%	11,2%	0,0%	0,1%	99,4%
2A3	Glass production	CO_2	95,3	0,0%	25,5%	0,0%	0,1%	99,5%
1A3b	Road transportation: LPG	CO_2	411,5	0,2%	5,4%	0,0%	0,1%	99,5%
2E	Electronic Industry	PFC	85,5	0,0%	25,5%	0,0%	0,1%	99,6%
2G	Other product manufacture and use	CH_4	42,5	0,0%	50,5%	0,0%	0,1%	99,7%
1A1	Energy Industries:all fuels	CH_4	112,1	0,1%	18,6%	0,0%	0,1%	99,7%
1A1b	Petroleum Refining: gaseous	CO_2	2975,9	1,4%	0,6%	0,0%	0,0%	99,8%
4H	Other	N_2O	45,3	0,0%	25,0%	0,0%	0,0%	99,8%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	59,9	0,0%	15,9%	0,0%	0,0%	99,8%
1A3a	Domestic aviation	CO_2	30,6	0,0%	30,3%	0,0%	0,0%	99,9%
1A3 exl 1A3b	Other	N_2O	10,2	0,0%	70,0%	0,0%	0,0%	99,9%
1B2a	Oil	CH_4	12,1	0,0%	53,9%	0,0%	0,0%	99,9%
2D3	Other	CO_2	21,6	0,0%	26,7%	0,0%	0,0%	99,9%
1A3c	Railways	CO_2	99,8	0,0%	5,4%	0,0%	0,0%	99,9%
1A3b	Road transportation:gaseous	CO_2	95,5	0,0%	5,4%	0,0%	0,0%	99,9%
4C	Grassland	N_2O	5,9	0,0%	55,9%	0,0%	0,0%	100,0%
1A4	Solids	CO_2	5,7	0,0%	51,0%	0,0%	0,0%	100,0%
2B	Fluorochemical production	PFC	12,3	0,0%	22,4%	0,0%	0,0%	100,0%
1A5	Military use:liquids	N_2O	2,7	0,0%	82,3%	0,0%	0,0%	100,0%
2C3	Aluminium production	CO_2	39,9	0,0%	5,4%	0,0%	0,0%	100,0%
1A3 exl	Other	CH_4	4,1	0,0%	50,0%	0,0%	0,0%	100,0%

IPCC Category		**Gas**	CO_2**-eq latest year abs**	**Share**	**Uncertainty estimate**	**Level * Uncertainty**	**Share L*U**	**Cum. Share L*U**
1A3b								
2H	Other industrial	CO_2	25,2	0,0%	5,7%	0,0%	0,0%	100,0%
2C3	Aluminium production	PFC	6,5	0,0%	20,1%	0,0%	0,0%	100,0%
1A3e	Other	CO_2	92,9	0,0%	0,6%	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,8	0,0%	53,9%	0,0%	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,3	0,0%	111,8%	0,0%	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,4	0,0%	60,4%	0,0%	0,0%	100,0%
4	LULUCF: CH_4	CH_4	0,3	0,0%	17,0%	0,0%	0,0%	100,0%
2B7	Soda ash production	CO_2	0,0	4,84E-11	0,070710678	0,0%	0,0%	100,0%

Lines in bold represent the key sources

With respect to Tier 2 level key sources, and perhaps surprisingly, the Energy industries, with the highest share (30%) in the national total, are not number one when uncertainty estimates are included. As Table A1.5a shows, three large but quite uncertain sources are now among the top five level key sources:

- 3Da N_2O emissions from agricultural soils (managed soils);
- 3B1 Emissions from manure management: cattle;
- 3B3 Swine (CH_4).

The uncertainty in these emissions is estimated at 25% to 100%, an order of magnitude higher than the 3% uncertainty for CO_2 from the Energy industries.

Table A1.6a Source ranking using IPCC Tier 2 trend assessment excluding LULUCF (in Gg CO_2 eq)

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
5A	**Solid waste disposal**	**CH_4**	**13679,2**	**2945,0**	**1,5%**	**5,3%**	**24,0%**	**1,3%**	**14,2%**	**14,2%**
3Db	**Indirect emissions from managed soils**	**N_2O**	**1648,9**	**609,1**	**0,3%**	**0,5%**	**206,2%**	**1,0%**	**11,3%**	**25,5%**
2B	**Fluorochemical production**	**HFC**	**7297,7**	**148,5**	**0,1%**	**3,7%**	**22,4%**	**0,8%**	**9,2%**	**34,7%**
2F1	**Refrigeration and airconditioning**	**HFC**	**72,7**	**2041,2**	**1,0%**	**1,2%**	**53,9%**	**0,6%**	**7,0%**	**41,7%**
3Da	**Direct emissions from agricultural soils**	**N_2O**	**7518,5**	**4860,2**	**2,5%**	**1,0%**	**60,8%**	**0,6%**	**6,9%**	**48,6%**
3B3	**Swine**	**CH_4**	**3489,3**	**2112,7**	**1,1%**	**0,6%**	**100,5%**	**0,6%**	**6,2%**	**54,8%**
3B1	**Cattle**	**CH_4**	**1823,2**	**2260,3**	**1,2%**	**0,4%**	**100,5%**	**0,4%**	**4,4%**	**59,1%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**9968,2**	**6797,3**	**3,5%**	**1,1%**	**25,5%**	**0,3%**	**3,2%**	**62,4%**
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**25862,2**	**37297,1**	**19,1%**	**8,5%**	**3,2%**	**0,3%**	**3,0%**	**65,4%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**70,7**	**910,8**	**0,5%**	**0,5%**	**49,8%**	**0,2%**	**2,8%**	**68,2%**
2C3	**Aluminium production**	**PFC**	**2230,2**	**6,5**	**0,0%**	**1,1%**	**20,1%**	**0,2%**	**2,6%**	**70,8%**
2B2	**Nitric acid production**	**N_2O**	**6084,7**	**370,4**	**0,2%**	**2,9%**	**7,8%**	**0,2%**	**2,5%**	**73,3%**
3B4	**Poultry**	**CH_4**	**464,4**	**72,9**	**0,0%**	**0,2%**	**100,5%**	**0,2%**	**2,2%**	**75,5%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**774,6**	**1315,4**	**0,7%**	**0,4%**	**50,0%**	**0,2%**	**2,1%**	**77,6%**
1B2c	**Venting and flaring**	**CH_4**	**1501,9**	**313,9**	**0,2%**	**0,6%**	**25,1%**	**0,1%**	**1,6%**	**79,2%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**13024,8**	**17134,4**	**8,8%**	**3,3%**	**2,8%**	**0,1%**	**1,1%**	**80,3%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1184,2**	**1792,5**	**0,9%**	**0,4%**	**20,6%**	**0,1%**	**1,0%**	**81,3%**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO_2**	**601,5**	**2861,1**	**1,5%**	**1,4%**	**6,5%**	**0,1%**	**1,0%**	**82,3%**
3B	**Emissions from manure management**	**N_2O**	**926,2**	**674,2**	**0,3%**	**0,1%**	**100,5%**	**0,1%**	**0,9%**	**83,2%**
2D2	**Paraffin wax use**	**CO_2**	**102,9**	**206,6**	**0,1%**	**0,1%**	**102,0%**	**0,1%**	**0,8%**	**84,0%**
2B8	**Petrochemical and carbon black production**	**CO_2**	**335,6**	**458,3**	**0,2%**	**0,1%**	**70,7%**	**0,1%**	**0,8%**	**84,7%**
1A4	**Liquids excl. 1A4c**	**CO_2**	**1329,1**	**601,3**	**0,3%**	**0,3%**	**20,1%**	**0,1%**	**0,7%**	**85,5%**
3A1	**Mature dairy cattle**	**CH_4**	**5179,2**	**5232,9**	**2,7%**	**0,4%**	**15,8%**	**0,1%**	**0,7%**	**86,2%**
1A3b	**Road transportation**	**N_2O**	**97,9**	**241,2**	**0,1%**	**0,1%**	**70,0%**	**0,1%**	**0,7%**	**86,9%**
1A1a	**Public Electricity and Heat Production: liquids**	**CO_2**	**233,2**	**739,2**	**0,4%**	**0,3%**	**20,0%**	**0,1%**	**0,7%**	**87,6%**
1A3b	**Road transportation: LPG**	**CO_2**	**2653,6**	**411,5**	**0,2%**	**1,1%**	**5,4%**	**0,1%**	**0,7%**	**88,3%**

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
3G	**Liming**	**CO_2**	**183,2**	**68,7**	**0,0%**	**0,1%**	**100,5%**	**0,1%**	**0,6%**	**88,9%**
2A4d	**Other**	**CO_2**	**481,0**	**586,0**	**0,3%**	**0,1%**	**50,2%**	**0,0%**	**0,5%**	**89,4%**
2G	**Other product manufacture and use**	**N_2O**	**224,7**	**86,0**	**0,0%**	**0,1%**	**70,7%**	**0,0%**	**0,5%**	**90,0%**
2B4	Caprolactam production	N_2O	739,9	901,9	0,5%	0,1%	30,5%	0,0%	0,5%	90,5%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	19045,8	12882,4	6,6%	2,2%	2,0%	0,0%	0,5%	91,0%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7329,3	7169,9	3,7%	0,4%	10,0%	0,0%	0,5%	91,4%
2B10	Other	CO_2	583,3	278,0	0,1%	0,1%	30,0%	0,0%	0,5%	91,9%
1A4	Solids	CO_2	162,7	5,7	0,0%	0,1%	51,0%	0,0%	0,5%	92,4%
1B1b	Solid fuel transformation	CO_2	402,5	810,7	0,4%	0,3%	15,1%	0,0%	0,5%	92,8%
1A4b	Residential gaseous	CO_2	19895,7	16117,2	8,3%	0,8%	5,0%	0,0%	0,4%	93,3%
2B1	Ammonia production	CO_2	3730,1	3920,9	2,0%	0,4%	10,2%	0,0%	0,4%	93,7%
1A3b	Road transportation: gasoline	CO_2	10784,6	11741,7	6,0%	1,3%	2,8%	0,0%	0,4%	94,1%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8568,9	7768,8	4,0%	0,1%	25,0%	0,0%	0,4%	94,5%
2C1	Iron and steel production	CO_2	2266,3	905,2	0,5%	0,6%	5,8%	0,0%	0,4%	94,9%
1A3b	Road transportation	CH_4	193,4	57,1	0,0%	0,1%	50,0%	0,0%	0,4%	95,3%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380,0	409,2	0,2%	0,0%	70,7%	0,0%	0,4%	95,7%
3A1	Young cattle	CH_4	2801,8	2211,0	1,1%	0,1%	20,6%	0,0%	0,3%	96,0%
1A2	Manufacturing Industries and Construction, solids	CO_2	4400,9	3371,2	1,7%	0,3%	10,2%	0,0%	0,3%	96,3%
5B	Biological treatment of solid waste: composting	CH_4	13,7	73,8	0,0%	0,0%	62,9%	0,0%	0,3%	96,6%
5B	Biological treatment of solid waste: composting	N_2O	6,5	77,2	0,0%	0,0%	49,7%	0,0%	0,2%	96,8%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2518,7	1859,2	1,0%	0,2%	10,0%	0,0%	0,2%	97,0%
1A1	Energy Industries:all fuels	N_2O	147,4	312,2	0,2%	0,1%	18,6%	0,0%	0,2%	97,3%
1A4a	Commercial/Institutional:gaseous	CO_2	7758,4	7107,7	3,6%	0,2%	10,0%	0,0%	0,2%	97,5%
2G2	SF_6 use	SF_6	261,0	138,8	0,1%	0,1%	33,5%	0,0%	0,2%	97,7%
1A4a	Commercial/Institutional:all fuels	CH_4	42,3	96,8	0,0%	0,0%	48,7%	0,0%	0,2%	97,8%
2A4b	Other uses of soda ash	CO_2	68,6	114,2	0,1%	0,0%	50,2%	0,0%	0,2%	98,0%

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
1A3d	Domestic navigation	CO_2	857,3	1240,9	0,6%	0,3%	5,4%	0,0%	0,2%	98,2%
1B2b	Natural gas	CH_4	421,1	323,3	0,2%	0,0%	50,0%	0,0%	0,2%	98,3%
1A1c	Manufacture of Solid Fuels: solids	CO_2	632,6	743,3	0,4%	0,1%	10,9%	0,0%	0,1%	98,5%
1A5	Military use:liquids	CO_2	312,0	175,2	0,1%	0,1%	20,1%	0,0%	0,1%	98,6%
2C3	Aluminium production	CO_2	408,4	39,9	0,0%	0,2%	5,4%	0,0%	0,1%	98,7%
1A4b	Residential:all fuels	CH_4	456,0	430,7	0,2%	0,0%	55,4%	0,0%	0,1%	98,8%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13330,2	14727,0	7,6%	1,8%	0,6%	0,0%	0,1%	98,9%
2F6	Other	HFC	201,0	146,0	0,1%	0,0%	53,9%	0,0%	0,1%	99,0%
1A3a	Domestic aviation	CO_2	84,8	30,6	0,0%	0,0%	30,3%	0,0%	0,1%	99,1%
2A1	Cement production	CO_2	415,8	249,4	0,1%	0,1%	11,2%	0,0%	0,1%	99,2%
1A1b	Petroleum Refining: gaseous	CO_2	1042,3	2975,9	1,5%	1,2%	0,6%	0,0%	0,1%	99,3%
3B2, 3B4	Other	CH_4	33,7	40,5	0,0%	0,0%	100,5%	0,0%	0,1%	99,4%
2E	Electronic Industry	PFC	49,7	85,5	0,0%	0,0%	25,5%	0,0%	0,1%	99,4%
1A1	Energy Industries:all fuels	CH_4	72,2	112,1	0,1%	0,0%	18,6%	0,0%	0,1%	99,5%
2A3	Glass production	CO_2	142,4	95,3	0,0%	0,0%	25,5%	0,0%	0,0%	99,5%
3A3	Swine	CH_4	521,8	472,6	0,2%	0,0%	50,2%	0,0%	0,0%	99,6%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42,9	47,6	0,0%	0,0%	58,7%	0,0%	0,0%	99,6%
2D3	Other	CO_2	0,0	21,6	0,0%	0,0%	26,7%	0,0%	0,0%	99,7%
2A4a	Ceramics	CO_2	140,1	111,7	0,1%	0,0%	50,2%	0,0%	0,0%	99,7%
1A4	Other Sectors:all fuels	N_2O	64,2	67,5	0,0%	0,0%	46,6%	0,0%	0,0%	99,7%
3A1	Other mature cattle	CH_4	210,2	159,0	0,1%	0,0%	20,6%	0,0%	0,0%	99,8%
1A3b	Road transportation:gaseous	CO_2	0,0	95,5	0,0%	0,1%	5,4%	0,0%	0,0%	99,8%
3A4	Other	CH_4	514,4	436,0	0,2%	0,0%	30,4%	0,0%	0,0%	99,8%
2B7	Soda ash production	CO_2	63,8	0,0	0,0%	0,0%	7,1%	0,0%	0,0%	99,9%
2D1	Lubricant use	CO_2	84,6	80,3	0,0%	0,0%	57,9%	0,0%	0,0%	99,9%
1B2a	Oil	CH_4	20,3	12,1	0,0%	0,0%	53,9%	0,0%	0,0%	99,9%
2B	Fluorochemical production	PFC	0,0	12,3	0,0%	0,0%	22,4%	0,0%	0,0%	99,9%

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
1A3 exl 1A3b	Other	N_2O	7,8	10,2	0,0%	0,0%	70,0%	0,0%	0,0%	99,9%
2H	Other industrial	CO_2	72,5	25,2	0,0%	0,0%	5,7%	0,0%	0,0%	100,0%
1A5	Military use:liquids	N_2O	5,5	2,7	0,0%	0,0%	82,3%	0,0%	0,0%	100,0%
1A3e	Other	CO_2	342,2	92,9	0,0%	0,1%	0,6%	0,0%	0,0%	100,0%
1A3c	Railways	CO_2	90,7	99,8	0,1%	0,0%	5,4%	0,0%	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	2,8	4,1	0,0%	0,0%	50,0%	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CH_4	50,1	42,5	0,0%	0,0%	50,5%	0,0%	0,0%	100,0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	65,0	59,9	0,0%	0,0%	15,9%	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,2	0,8	0,0%	0,0%	53,9%	0,0%	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,2	0,3	0,0%	0,0%	111,8%	0,0%	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,8	0,4	0,0%	0,0%	60,4%	0,0%	0,0%	100,0%
5D	Wastewater treatment and discharge	CH_4	308,8	210,7	0,1%	0,0%	37,7%	0,0%	0,0%	100,0%
5D	Wastewater treatment and discharge	N_2O	172,1	71,4	0,0%	0,0%	102,0%	0,0%	0,0%	100,0%

Lines in bold represent the key sources

Table A1.6b Source ranking using IPCC Tier 2 trend assessment including LULUCF (Gg CO_2 eq)

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
5A	**Solid waste disposal**	**CH_4**	**13679,2**	**2945,0**	**1,4%**	**5,0%**	**24,0%**	**1,2%**	**12,6%**	**12,6%**
3Db	**Indirect emissions from managed soils**	**N_2O**	**1648,9**	**609,1**	**0,3%**	**0,5%**	**206,2%**	**1,0%**	**10,0%**	**22,6%**
2B	**Fluorochemical production**	**HFC**	**7297,7**	**148,5**	**0,1%**	**3,5%**	**22,4%**	**0,8%**	**8,0%**	**30,6%**
3Da	**Direct emissions from agricultural soils**	**N_2O**	**7518,5**	**4860,2**	**2,4%**	**1,0%**	**60,8%**	**0,6%**	**6,3%**	**36,9%**
2F1	**Refrigeration and airconditioning**	**HFC**	**72,7**	**2041,2**	**1,0%**	**1,1%**	**53,9%**	**0,6%**	**6,0%**	**42,9%**
3B3	**Swine**	**CH_4**	**3489,3**	**2112,7**	**1,0%**	**0,5%**	**100,5%**	**0,5%**	**5,6%**	**48,6%**
4B	**Cropland**	**CO_2**	**1637,0**	**2666,5**	**1,3%**	**0,7%**	**55,9%**	**0,4%**	**3,8%**	**52,4%**
3B1	**Cattle**	**CH_4**	**1823,2**	**2260,3**	**1,1%**	**0,3%**	**100,5%**	**0,4%**	**3,7%**	**56,1%**
1A1b	**Petroleum Refining: liquids**	**CO_2**	**9968,2**	**6797,3**	**3,3%**	**1,1%**	**25,5%**	**0,3%**	**3,0%**	**59,1%**
4A	**Forest Land**	**CO_2**	**1911,3**	**2433,8**	**1,2%**	**0,4%**	**66,7%**	**0,3%**	**2,8%**	**61,8%**
4E	**Settlements**	**CO_2**	**888,3**	**1649,6**	**0,8%**	**0,5%**	**55,9%**	**0,3%**	**2,7%**	**64,6%**
1A1a	**Public Electricity and Heat Production: solids**	**CO_2**	**25862,2**	**37297,1**	**18,1%**	**7,8%**	**3,2%**	**0,2%**	**2,6%**	**67,1%**
1A4c	**Agriculture/Forestry/Fisheries:all fuels**	**CH_4**	**70,7**	**910,8**	**0,4%**	**0,5%**	**49,8%**	**0,2%**	**2,4%**	**69,5%**
2C3	**Aluminium production**	**PFC**	**2230,2**	**6,5**	**0,0%**	**1,1%**	**20,1%**	**0,2%**	**2,3%**	**71,8%**
2B2	**Nitric acid production**	**N_2O**	**6084,7**	**370,4**	**0,2%**	**2,7%**	**7,8%**	**0,2%**	**2,2%**	**74,0%**
3B4	**Poultry**	**CH_4**	**464,4**	**72,9**	**0,0%**	**0,2%**	**100,5%**	**0,2%**	**1,9%**	**76,0%**
1B2	**Fugitive emissions from oil and gas operations**	**CO_2**	**774,6**	**1315,4**	**0,6%**	**0,3%**	**50,0%**	**0,2%**	**1,8%**	**77,8%**
1B2c	**Venting and flaring**	**CH_4**	**1501,9**	**313,9**	**0,2%**	**0,6%**	**25,1%**	**0,1%**	**1,5%**	**79,2%**
4C	**Grassland**	**CO_2**	**5483,3**	**4420,1**	**2,1%**	**0,2%**	**55,9%**	**0,1%**	**1,4%**	**80,6%**
1A3b	**Road transportation: diesel oil**	**CO_2**	**13024,8**	**17134,4**	**8,3%**	**3,0%**	**2,8%**	**0,1%**	**0,9%**	**81,5%**
1A1c	**Manufacture of Solid Fuels:.gaseous**	**CO_2**	**1184,2**	**1792,5**	**0,9%**	**0,4%**	**20,6%**	**0,1%**	**0,9%**	**82,4%**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO_2**	**601,5**	**2861,1**	**1,4%**	**1,3%**	**6,5%**	**0,1%**	**0,9%**	**83,3%**
3B	**Emissions from manure management**	**N_2O**	**926,2**	**674,2**	**0,3%**	**0,1%**	**100,5%**	**0,1%**	**0,8%**	**84,1%**
2D2	**Paraffin wax use**	**CO_2**	**102,9**	**206,6**	**0,1%**	**0,1%**	**102,0%**	**0,1%**	**0,7%**	**84,8%**
1A4	**Liquids excl. 1A4c**	**CO_2**	**1329,1**	**601,3**	**0,3%**	**0,3%**	**20,1%**	**0,1%**	**0,7%**	**85,4%**
2B8	**Petrochemical and carbon black production**	**CO_2**	**335,6**	**458,3**	**0,2%**	**0,1%**	**70,7%**	**0,1%**	**0,6%**	**86,1%**

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
1A3b	**Road transportation**	**N_2O**	**97,9**	**241,2**	**0,1%**	**0,1%**	**70,0%**	**0,1%**	**0,6%**	**86,7%**
1A1a	**Public Electricity and Heat Production: liquids**	**CO_2**	**233,2**	**739,2**	**0,4%**	**0,3%**	**20,0%**	**0,1%**	**0,6%**	**87,3%**
1A3b	**Road transportation: LPG**	**CO_2**	**2653,6**	**411,5**	**0,2%**	**1,1%**	**5,4%**	**0,1%**	**0,6%**	**87,9%**
3A1	**Mature dairy cattle**	**CH_4**	**5179,2**	**5232,9**	**2,5%**	**0,3%**	**15,8%**	**0,1%**	**0,6%**	**88,5%**
3G	**Liming**	**CO_2**	**183,2**	**68,7**	**0,0%**	**0,1%**	**100,5%**	**0,1%**	**0,5%**	**89,0%**
5D	**Wastewater treatment and discharge**	**N_2O**	**172,1**	**71,4**	**0,0%**	**0,0%**	**102,0%**	**0,0%**	**0,5%**	**89,5%**
1A2	**Manufacturing Industries and Construction, gaseous**	**CO_2**	**19045,8**	**12882,4**	**6,2%**	**2,2%**	**2,0%**	**0,0%**	**0,5%**	**89,9%**
2G	Other product manufacture and use	N_2O	224,7	86,0	0,0%	0,1%	70,7%	0,0%	0,5%	90,4%
2A4d	Other	CO_2	481,0	586,0	0,3%	0,1%	50,2%	0,0%	0,5%	90,8%
1A4b	Residential gaseous	CO_2	19895,7	16117,2	7,8%	0,8%	5,0%	0,0%	0,4%	91,3%
2B4	Caprolactam production	N_2O	739,9	901,9	0,4%	0,1%	30,5%	0,0%	0,4%	91,7%
2B10	Other	CO_2	583,3	278,0	0,1%	0,1%	30,0%	0,0%	0,4%	92,1%
1A4	Solids	CO_2	162,7	5,7	0,0%	0,1%	51,0%	0,0%	0,4%	92,5%
1B1b	Solid fuel transformation	CO_2	402,5	810,7	0,4%	0,2%	15,1%	0,0%	0,4%	92,9%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7329,3	7169,9	3,5%	0,4%	10,0%	0,0%	0,4%	93,3%
2C1	Iron and steel production	CO_2	2266,3	905,2	0,4%	0,6%	5,8%	0,0%	0,4%	93,7%
2B1	Ammonia production	CO_2	3730,1	3920,9	1,9%	0,3%	10,2%	0,0%	0,4%	94,0%
1A3b	Road transportation: gasoline	CO_2	10784,6	11741,7	5,7%	1,2%	2,8%	0,0%	0,3%	94,3%
4F	Other Land	CO_2	26,3	126,2	0,1%	0,1%	55,9%	0,0%	0,3%	94,7%
1A3b	Road transportation	CH_4	193,4	57,1	0,0%	0,1%	50,0%	0,0%	0,3%	95,0%
3A1	Young cattle	CH_4	2801,8	2211,0	1,1%	0,2%	20,6%	0,0%	0,3%	95,3%
1A2	Manufacturing Industries and Construction, solids	CO_2	4400,9	3371,2	1,6%	0,3%	10,2%	0,0%	0,3%	95,6%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380,0	409,2	0,2%	0,0%	70,7%	0,0%	0,3%	95,9%
4B	Cropland	N_2O	3,1	78,4	0,0%	0,0%	63,0%	0,0%	0,3%	96,2%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8568,9	7768,8	3,8%	0,1%	25,0%	0,0%	0,2%	96,4%
5B	Biological treatment of solid waste: composting	CH_4	13,7	73,8	0,0%	0,0%	62,9%	0,0%	0,2%	96,6%

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2518,7	1859,2	0,9%	0,2%	10,0%	0,0%	0,2%	96,9%
5B	Biological treatment of solid waste: composting	N_2O	6,5	77,2	0,0%	0,0%	49,7%	0,0%	0,2%	97,1%
1A1	Energy Industries:all fuels	N_2O	147,4	312,2	0,2%	0,1%	18,6%	0,0%	0,2%	97,2%
2G2	SF_6 use	SF_6	261,0	138,8	0,1%	0,1%	33,5%	0,0%	0,2%	97,4%
1A4a	Commercial/Institutional:all fuels	CH_4	42,3	96,8	0,0%	0,0%	48,7%	0,0%	0,2%	97,6%
4G	Harvested wood products	CO_2	157,2	88,4	0,0%	0,0%	55,9%	0,0%	0,2%	97,8%
2A4b	Other uses of soda ash	CO_2	68,6	114,2	0,1%	0,0%	50,2%	0,0%	0,2%	97,9%
1A3d	Domestic navigation	CO_2	857,3	1240,9	0,6%	0,3%	5,4%	0,0%	0,1%	98,0%
1B2b	Natural gas	CH_4	421,1	323,3	0,2%	0,0%	50,0%	0,0%	0,1%	98,2%
5D	Wastewater treatment and discharge	CH_4	308,8	210,7	0,1%	0,0%	37,7%	0,0%	0,1%	98,3%
1A4a	Commercial/Institutional:gaseous	CO_2	7758,4	7107,7	3,4%	0,1%	10,0%	0,0%	0,1%	98,5%
1A5	Military use:liquids	CO_2	312,0	175,2	0,1%	0,1%	20,1%	0,0%	0,1%	98,6%
1A1c	Manufacture of Solid Fuels: solids	CO_2	632,6	743,3	0,4%	0,1%	10,9%	0,0%	0,1%	98,7%
2F6	Other	HFC	201,0	146,0	0,1%	0,0%	53,9%	0,0%	0,1%	98,8%
2C3	Aluminium production	CO_2	408,4	39,9	0,0%	0,2%	5,4%	0,0%	0,1%	98,9%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13330,2	14727,0	7,1%	1,6%	0,6%	0,0%	0,1%	99,0%
1A4b	Residential:all fuels	CH_4	456,0	430,7	0,2%	0,0%	55,4%	0,0%	0,1%	99,1%
1A3a	Domestic aviation	CO_2	84,8	30,6	0,0%	0,0%	30,3%	0,0%	0,1%	99,1%
2A1	Cement production	CO_2	415,8	249,4	0,1%	0,1%	11,2%	0,0%	0,1%	99,2%
1A1b	Petroleum Refining: gaseous	CO_2	1042,3	2975,9	1,4%	1,1%	0,6%	0,0%	0,1%	99,3%
4H	Other	N_2O	2,5	45,3	0,0%	0,0%	25,0%	0,0%	0,1%	99,3%
3B2, 3B4	Other	CH_4	33,7	40,5	0,0%	0,0%	100,5%	0,0%	0,1%	99,4%
2E	Electronic Industry	PFC	49,7	85,5	0,0%	0,0%	25,5%	0,0%	0,1%	99,5%
1A1	Energy Industries:all fuels	CH_4	72,2	112,1	0,1%	0,0%	18,6%	0,0%	0,1%	99,5%
2A3	Glass production	CO_2	142,4	95,3	0,0%	0,0%	25,5%	0,0%	0,0%	99,5%
4D	Wetlands	CO_2	88,0	64,0	0,0%	0,0%	55,9%	0,0%	0,0%	99,6%
2A4a	Ceramics	CO_2	140,1	111,7	0,1%	0,0%	50,2%	0,0%	0,0%	99,6%
3A4	Other	CH_4	514,4	436,0	0,2%	0,0%	30,4%	0,0%	0,0%	99,7%
2D3	Other	CO_2	0,0	21,6	0,0%	0,0%	26,7%	0,0%	0,0%	99,7%

IPCC Category		Gas	CO_2-eq base year abs	CO_2-eq latest year abs	level assess-ment latest year	trend assess-ment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
3A1	Other mature cattle	CH_4	210,2	159,0	0,1%	0,0%	20,6%	0,0%	0,0%	99,7%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42,9	47,6	0,0%	0,0%	58,7%	0,0%	0,0%	99,8%
1A3b	Road transportation:gaseous	CO_2	0,0	95,5	0,0%	0,1%	5,4%	0,0%	0,0%	99,8%
1A4	Other Sectors:all fuels	N_2O	64,2	67,5	0,0%	0,0%	46,6%	0,0%	0,0%	99,8%
3A3	Swine	CH_4	521,8	472,6	0,2%	0,0%	50,2%	0,0%	0,0%	99,8%
2B7	Soda ash production	CO_2	63,8	0,0	0,0%	0,0%	7,1%	0,0%	0,0%	99,9%
1B2a	Oil	CH_4	20,3	12,1	0,0%	0,0%	53,9%	0,0%	0,0%	99,9%
4C	Grassland	N_2O	0,3	5,9	0,0%	0,0%	55,9%	0,0%	0,0%	99,9%
2D1	Lubricant use	CO_2	84,6	80,3	0,0%	0,0%	57,9%	0,0%	0,0%	99,9%
2B	Fluorochemical production	PFC	0,0	12,3	0,0%	0,0%	22,4%	0,0%	0,0%	99,9%
1A3 exl 1A3b	Other	N_2O	7,8	10,2	0,0%	0,0%	70,0%	0,0%	0,0%	99,9%
2H	Other industrial	CO_2	72,5	25,2	0,0%	0,0%	5,7%	0,0%	0,0%	100,0%
1A5	Military use:liquids	N_2O	5,5	2,7	0,0%	0,0%	82,3%	0,0%	0,0%	100,0%
1A3e	Other	CO_2	342,2	92,9	0,0%	0,1%	0,6%	0,0%	0,0%	100,0%
1A3c	Railways	CO_2	90,7	99,8	0,0%	0,0%	5,4%	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CH_4	50,1	42,5	0,0%	0,0%	50,5%	0,0%	0,0%	100,0%
1A3 exl 1A3b	Other	CH_4	2,8	4,1	0,0%	0,0%	50,0%	0,0%	0,0%	100,0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	65,0	59,9	0,0%	0,0%	15,9%	0,0%	0,0%	100,0%
2G	Other product manufacture and use	CO_2	0,2	0,8	0,0%	0,0%	53,9%	0,0%	0,0%	100,0%
1A5	Military use:liquids	CH_4	0,8	0,4	0,0%	0,0%	60,4%	0,0%	0,0%	100,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,2	0,3	0,0%	0,0%	111,8%	0,0%	0,0%	100,0%
4	LULUCF: CH_4	CH_4	0,2	0,3	0,0%	0,0%	17,0%	0,0%	0,0%	100,0%

Lines in bold represent the key sources

Annex 2 Assessment of uncertainty

2.1 Description of methodology used for estimating uncertainty

As described in Section 1.6, a Tier 1 uncertainty assessment was made to estimate the uncertainty in total national GHG emissions and in emissions trends. Tier 1 here means that non-Gaussian uncertainty distributions and correlations between sources have been ignored. The uncertainty estimates for the activity data and EFs listed in Table A2.2 were also used for a Tier 1 trend uncertainty assessment, as shown in Table A2.1. Uncertainties for the activity data and EFs are derived from a mixture of empirical data and expert judgement and are presented here as half the 95% confidence interval. The reason for halving the 95% confidence interval is that the value then corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus x%'.

Since 2012, all data on uncertainty for each source has been included in the PRTR database. At the start of the NIR compilation, the Task Forces are asked to submit new uncertainty information, which is included in the annual key source assessment of the NIR.

A new Tier 2 uncertainty assessment (Monte Carlo) is currently performed (as announced in last years NIR) and the first results show that the results are similar to the results from the Tier 1 uncertainty assessment (see Table A2.1 and A2.2).

Table A2.1 Tier 1 level and trend uncertainty estimates

	Uncertainty in emissions level	Uncertainty in emissions trend
CO_2	± 2%	± 2% of 4% increase
CH_4	± 18%	± 6% of 44% decrease
N_2O	± 40%	± 7% of 56% decrease
F-gases	± 43%	± 12% of 76% decrease
Total	± 3%	± 2% of 12.5% decrease

Table A2.2 Tier 2 level uncertainty estimates

	Uncertainty in emissions level
CO_2	± 3%
CH_4	± 16%
N_2O	± 28%
F-gases	± 26%
Total	± 3%

Also in earlier studies, a comparison with the Tier 1 uncertainty estimate based on similar data showed that, in the Dutch circumstances, the errors made in the simplified Tier 1 approach to estimating uncertainties are quite small (Olsthoorn and Pielaat, 2003; Ramírez-Ramírez et al., 2006).

Details of the Tier 1 calculation can be found in Table A2.3 and in Olivier et al. (2009). The Tier 2 uncertainty assessment is currently performed and the first results are shown in Table A2.2. In the next NIR, this Monte Carlo analysis will be will be elaborated in more detail[5].

It should be stressed that most uncertainty estimates in Table A2.3 are ultimately based on collective expert judgement and are therefore themselves rather uncertain (usually in the order of 50%). Nevertheless, these estimates help to identify the most important uncertain sources. For this purpose, a reasonable order-of-magnitude estimate of the uncertainty in activity data and in EFs is usually sufficient. Uncertainty estimates are a means of identifying and prioritizing inventory improvement activities, rather than an objective in themselves.

Part of the uncertainty is due to an inherent lack of knowledge concerning the sources. Another part, however, can be attributed to elements of the inventory whose uncertainty could be reduced over time by dedicated research initiated by either the NIE or other researchers. When this type of uncertainty is in sources that are expected to be significant for emission reduction policies, the effectiveness of these policies could greatly reduced if the unreduced emissions turn out to be much lower than originally estimated.
The results of this uncertainty assessment of potential key sources can also be used to refine the Tier 1 key source assessment discussed above.

[5] In the next NIR the Netherlands envisage to report all uncertainty information according to the Tier 2 Monte Carlo analysis.

Table A2.3 Tier 1 level and trend uncertainty assessment 1990–2015 (for F-gases with base year 1995) with the categories of the IPCC potential key source list (without adjustment for correlation sources)

IPCC	Category	Gas	CO_2-eq base year	CO_2-eq last year	AD unc	EF unc	Uncertainty estimate	Combined Uncertainty as % of total national emissions	ype A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
5A	Solid waste disposal	CH_4	13679,2	2945,0	0%	24%	24%	0,4%	-4,1%	1,3%	-1,0%	0,0%	1,0%
3Db	Indirect emissions from managed soils	N_2O	1648,9	609,1	50%	200%	206%	0,6%	-0,4%	0,3%	-0,8%	0,2%	0,8%
2B	Fluorochemical production	HFC	7297,7	148,5	10%	20%	22%	0,0%	-2,8%	0,1%	-0,6%	0,0%	0,6%
3Da	Direct emissions from agricultural soils	N_2O	7518,5	4860,2	10%	60%	61%	1,5%	-0,8%	2,2%	-0,5%	0,3%	0,6%
2F1	Refrigeration and airconditioning	HFC	72,7	2041,2	20%	50%	54%	0,6%	0,9%	0,9%	0,4%	0,3%	0,5%
1A4b	Residential gaseous	CO_2	19895,7	16117,2	5%	0%	5%	0,4%	-0,6%	7,2%	0,0%	0,5%	0,5%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7329,3	7169,9	10%	0%	10%	0,4%	0,3%	3,2%	0,0%	0,5%	0,5%
1A4a	Commercial/Institutional:gaseous	CO_2	7758,4	7107,7	10%	0%	10%	0,4%	0,1%	3,2%	0,0%	0,5%	0,5%
3B3	Swine	CH_4	3489,3	2112,7	10%	100%	100%	1,1%	-0,4%	1,0%	-0,4%	0,1%	0,4%
1B2	Fugitive emissions from oil and gas operations	CO_2	774,6	1315,4	50%	2%	50%	0,3%	0,3%	0,6%	0,0%	0,4%	0,4%
3B1	Cattle	CH_4	1823,2	2260,3	10%	100%	100%	1,2%	0,3%	1,0%	0,3%	0,1%	0,3%
1A1a	Public Electricity and Heat Production: solids	CO_2	25862,2	37297,1	1%	3%	3%	0,6%	6,6%	16,8%	0,2%	0,2%	0,3%
1A1b	Petroleum Refining: liquids	CO_2	9968,2	6797,3	5%	25%	25%	0,9%	-0,9%	3,1%	-0,2%	0,2%	0,3%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	1184,2	1792,5	20%	5%	21%	0,2%	0,3%	0,8%	0,0%	0,2%	0,2%
1A3b	Road transportation: diesel oil	CO_2	13024,8	17134,4	2%	2%	3%	0,2%	2,6%	7,7%	0,1%	0,2%	0,2%
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	70,7	910,8	10%	49%	50%	0,2%	0,4%	0,4%	0,2%	0,1%	0,2%
2A4d	Other	CO_2	481,0	586,0	50%	5%	50%	0,2%	0,1%	0,3%	0,0%	0,2%	0,2%
2C3	Aluminium production	PFC	2230,2	6,5	2%	20%	20%	0,0%	-0,9%	0,0%	-0,2%	0,0%	0,2%
3A1	Mature dairy cattle	CH_4	5179,2	5232,9	5%	15%	16%	0,4%	0,3%	2,4%	0,0%	0,2%	0,2%

IPCC	Category	Gas	CO_2-eq base year	CO_2-eq last year	AD unc	EF unc	Uncertainty estimate	Combined Uncertainty as % of total national emissions	ype A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
1A2	Manufacturing Industries and Construction, gaseous	CO_2	19045,8	12882,4	2%	0%	2%	0,1%	-1,7%	5,8%	0,0%	0,2%	0,2%
1A3b	Road transportation: gasoline	CO_2	10784,6	11741,7	2%	2%	3%	0,2%	1,0%	5,3%	0,0%	0,1%	0,2%
3B4	Poultry	CH_4	464,4	72,9	10%	100%	100%	0,0%	-0,2%	0,0%	-0,2%	0,0%	0,2%
2B8	Petrochemical and carbon black production	CO_2	335,6	458,3	50%	50%	71%	0,2%	0,1%	0,2%	0,0%	0,1%	0,2%
2B2	Nitric acid production	N_2O	6084,7	370,4	5%	6%	8%	0,0%	-2,2%	0,2%	-0,1%	0,0%	0,1%
2D2	Paraffin wax use	CO_2	102,9	206,6	100%	20%	102%	0,1%	0,1%	0,1%	0,0%	0,1%	0,1%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380,0	409,2	50%	50%	71%	0,1%	0,0%	0,2%	0,0%	0,1%	0,1%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2518,7	1859,2	10%	0%	10%	0,1%	-0,2%	0,8%	0,0%	0,1%	0,1%
2B4	Caprolactam production	N_2O	739,9	901,9	20%	23%	30%	0,1%	0,1%	0,4%	0,0%	0,1%	0,1%
1B2c	Venting and flaring	CH_4	1501,9	313,9	2%	25%	25%	0,0%	-0,5%	0,1%	-0,1%	0,0%	0,1%
1A4b	Residential:all fuels	CH_4	456,0	430,7	38%	40%	55%	0,1%	0,0%	0,2%	0,0%	0,1%	0,1%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601,5	2861,1	3%	6%	7%	0,1%	1,0%	1,3%	0,1%	0,1%	0,1%
1A4	Liquids excl. 1A4c	CO_2	1329,1	601,3	20%	2%	20%	0,1%	-0,3%	0,3%	0,0%	0,1%	0,1%
3B	Emissions from manure management	N_2O	926,2	674,2	10%	100%	100%	0,3%	-0,1%	0,3%	-0,1%	0,0%	0,1%
3A1	Young cattle	CH_4	2801,8	2211,0	5%	20%	21%	0,2%	-0,1%	1,0%	0,0%	0,1%	0,1%
2B1	Ammonia production	CO_2	3730,1	3920,9	2%	10%	10%	0,2%	0,3%	1,8%	0,0%	0,0%	0,1%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8568,9	7768,8	1%	25%	25%	1,0%	0,1%	3,5%	0,0%	0,0%	0,1%
1A3b	Road transportation	N_2O	97,9	241,2	2%	70%	70%	0,1%	0,1%	0,1%	0,0%	0,0%	0,0%

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1A2	Manufacturing Industries and Construction, solids	CO_2	4400,9	3371,2	2%	10%	10%	0,2%	-0,2%	1,5%	0,0%	0,0%	0,0%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233,2	739,2	1%	20%	20%	0,1%	0,2%	0,3%	0,0%	0,0%	0,0%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13330,2	14727,0	1%	0%	1%	0,0%	1,4%	6,6%	0,0%	0,0%	0,0%
3G	Liming	CO_2	183,2	68,7	10%	100%	100%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3d	Domestic navigation	CO_2	857,3	1240,9	5%	2%	5%	0,0%	0,2%	0,6%	0,0%	0,0%	0,0%
2G	Other product manufacture and use	N_2O	224,7	86,0	50%	50%	71%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
5D	Wastewater treatment and discharge	N_2O	172,1	71,4	20%	100%	102%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2A4b	Other uses of soda ash	CO_2	68,6	114,2	50%	5%	50%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2A4a	Ceramics	CO_2	140,1	111,7	50%	5%	50%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
1B1b	Solid fuel transformation	CO_2	402,5	810,7	2%	15%	15%	0,1%	0,2%	0,4%	0,0%	0,0%	0,0%
2B10	Other	CO_2	583,3	278,0	1%	30%	30%	0,0%	-0,1%	0,1%	0,0%	0,0%	0,0%
2C1	Iron and steel production	CO_2	2266,3	905,2	3%	5%	6%	0,0%	-0,5%	0,4%	0,0%	0,0%	0,0%
5D	Wastewater treatment and discharge	CH_4	308,8	210,7	20%	32%	38%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2G2	SF_6 use	SF_6	261,0	138,8	30%	15%	34%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2D1	Lubricant use	CO_2	84,6	80,3	50%	29%	58%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3b	Road transportation	CH_4	193,4	57,1	2%	50%	50%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
1A5	Military use:liquids	CO_2	312,0	175,2	20%	2%	20%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
1A3b	Road transportation: LPG	CO_2	2653,6	411,5	5%	2%	5%	0,0%	-0,9%	0,2%	0,0%	0,0%	0,0%
2F6	Other	HFC	201,0	146,0	20%	50%	54%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
5B	Biological treatment of solid waste:	CH_4	13,7	73,8	5%	63%	63%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

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	composting												
5B	Biological treatment of solid waste: composting	N_2O	6,5	77,2	5%	49%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A1	Energy Industries:all fuels	N_2O	147,4	312,2	2%	18%	19%	0,0%	0,1%	0,1%	0,0%	0,0%	0,0%
3A3	Swine	CH_4	521,8	472,6	5%	50%	50%	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
2A3	Glass production	CO_2	142,4	95,3	25%	5%	25%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A4a	Commercial/Institutional:all fuels	CH_4	42,3	96,8	10%	48%	49%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
3A4	Other	CH_4	514,4	436,0	5%	30%	30%	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
1A1c	Manufacture of Solid Fuels: solids	CO_2	632,6	743,3	2%	11%	11%	0,0%	0,1%	0,3%	0,0%	0,0%	0,0%
1B2b	Natural gas	CH_4	421,1	323,3	2%	50%	50%	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
1A1b	Petroleum Refining: gaseous	CO_2	1042,3	2975,9	1%	0%	1%	0,0%	0,9%	1,3%	0,0%	0,0%	0,0%
2A1	Cement production	CO_2	415,8	249,4	5%	10%	11%	0,0%	-0,1%	0,1%	0,0%	0,0%	0,0%
1A4	Other Sectors:all fuels	N_2O	64,2	67,5	18%	43%	47%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2C3	Aluminium production	CO_2	408,4	39,9	2%	5%	5%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
1A4	Solids	CO_2	162,7	5,7	50%	10%	51%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
1A3a	Domestic aviation	CO_2	84,8	30,6	30%	4%	30%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
3B2, 3B4	Other	CH_4	33,7	40,5	10%	100%	100%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
3A1	Other mature cattle	CH_4	210,2	159,0	5%	20%	21%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2E	Electronic Industry	PFC	49,7	85,5	5%	25%	25%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A1	Energy Industries:all fuels	CH_4	72,2	112,1	2%	18%	19%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2D3	Other	CO_2	0,0	21,6	25%	9%	27%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3c	Railways	CO_2	90,7	99,8	5%	2%	5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

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1A3b	Road transportation:gaseous	CO_2	0,0	95,5	5%	2%	5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42,9	47,6	3%	59%	59%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2G	Other product manufacture and use	CH_4	50,1	42,5	10%	50%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1B2a	Oil	CH_4	20,3	12,1	20%	50%	54%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2B	Fluorochemical production	PFC	0,0	12,3	10%	20%	22%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2B7	Soda ash production	CO_2	63,8	0,0	5%	5%	7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3 exl 1A3b	Other	N_2O	7,8	10,2	2%	70%	70%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2H	Other industrial	CO_2	72,5	25,2	3%	5%	6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A5	Military use:liquids	N_2O	5,5	2,7	7%	82%	82%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	65,0	59,9	2%	16%	16%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3e	Other	CO_2	342,2	92,9	1%	0%	1%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
1A3 exl 1A3b	Other	CH_4	2,8	4,1	2%	50%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2G	Other product manufacture and use	CO_2	0,2	0,8	50%	20%	54%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,2	0,3	100%	50%	112%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A5	Military use:liquids	CH_4	0,8	0,4	8%	60%	60%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	TOTAL	GHG	222385,6	195038,6				3,0%					2,1%

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5A	Solid waste disposal	CH_4	13679,2	2945,0	0%	24%	24%	0,3%	-4,0%	1,3%	-0,9%	0,0%	0,9%
3Db	Indirect emissions from managed soils	N_2O	1648,9	609,1	50%	200%	206%	0,6%	-0,4%	0,3%	-0,7%	0,2%	0,8%
4C	Grassland	CO_2	5483,3	4420,1	25%	50%	56%	1,2%	-0,2%	1,9%	-0,1%	0,7%	0,7%
3Da	Direct emissions from agricultural soils	N_2O	7518,5	4860,2	10%	60%	61%	1,4%	-0,8%	2,1%	-0,5%	0,3%	0,6%
2B	Fluorochemical production	HFC	7297,7	148,5	10%	20%	22%	0,0%	-2,7%	0,1%	-0,5%	0,0%	0,5%
2F1	Refrigeration and airconditioning	HFC	72,7	2041,2	20%	50%	54%	0,5%	0,8%	0,9%	0,4%	0,2%	0,5%
1A4b	Residential gaseous	CO_2	19895,7	16117,2	5%	0%	5%	0,4%	-0,7%	6,9%	0,0%	0,5%	0,5%
4B	Cropland	CO_2	1637,0	2666,5	25%	50%	56%	0,7%	0,5%	1,1%	0,3%	0,4%	0,5%
3B3	Swine	CH_4	3489,3	2112,7	10%	100%	100%	1,0%	-0,4%	0,9%	-0,4%	0,1%	0,4%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7329,3	7169,9	10%	0%	10%	0,3%	0,3%	3,1%	0,0%	0,4%	0,4%
1A4a	Commercial/Institutional:gaseous	CO_2	7758,4	7107,7	10%	0%	10%	0,3%	0,1%	3,1%	0,0%	0,4%	0,4%
4A	Forest Land	CO_2	1911,3	2433,8	25%	62%	67%	0,8%	0,3%	1,0%	0,2%	0,4%	0,4%
1B2	Fugitive emissions from oil and gas operations	CO_2	774,6	1315,4	50%	2%	50%	0,3%	0,3%	0,6%	0,0%	0,4%	0,4%
4E	Settlements	CO_2	888,3	1649,6	25%	50%	56%	0,4%	0,4%	0,7%	0,2%	0,3%	0,3%
3B1	Cattle	CH_4	1823,2	2260,3	10%	100%	100%	1,1%	0,3%	1,0%	0,3%	0,1%	0,3%

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1A1b	Petroleum Refining: liquids	CO_2	9968,2	6797,3	5%	25%	25%	0,8%	-0,9%	2,9%	-0,2%	0,2%	0,3%
1A1a	Public Electricity and Heat Production: solids	CO_2	25862,2	37297,1	1%	3%	3%	0,6%	6,2%	16,0%	0,2%	0,2%	0,3%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	1184,2	1792,5	20%	5%	21%	0,2%	0,3%	0,8%	0,0%	0,2%	0,2%
1A3b	Road transportation: diesel oil	CO_2	13024,8	17134,4	2%	2%	3%	0,2%	2,4%	7,4%	0,0%	0,2%	0,2%
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	70,7	910,8	10%	49%	50%	0,2%	0,4%	0,4%	0,2%	0,1%	0,2%
2A4d	Other	CO_2	481,0	586,0	50%	5%	50%	0,1%	0,1%	0,3%	0,0%	0,2%	0,2%
2C3	Aluminium production	PFC	2230,2	6,5	2%	20%	20%	0,0%	-0,8%	0,0%	-0,2%	0,0%	0,2%
3A1	Mature dairy cattle	CH_4	5179,2	5232,9	5%	15%	16%	0,4%	0,3%	2,2%	0,0%	0,2%	0,2%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	19045,8	12882,4	2%	0%	2%	0,1%	-1,7%	5,5%	0,0%	0,2%	0,2%
3B4	Poultry	CH_4	464,4	72,9	10%	100%	100%	0,0%	-0,1%	0,0%	-0,1%	0,0%	0,1%
1A3b	Road transportation: gasoline	CO_2	10784,6	11741,7	2%	2%	3%	0,2%	0,9%	5,0%	0,0%	0,1%	0,1%
2B8	Petrochemical and carbon black production	CO_2	335,6	458,3	50%	50%	71%	0,2%	0,1%	0,2%	0,0%	0,1%	0,1%
2B2	Nitric acid production	N_2O	6084,7	370,4	5%	6%	8%	0,0%	-2,2%	0,2%	-0,1%	0,0%	0,1%
2D2	Paraffin wax use	CO_2	102,9	206,6	100%	20%	102%	0,1%	0,0%	0,1%	0,0%	0,1%	0,1%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380,0	409,2	50%	50%	71%	0,1%	0,0%	0,2%	0,0%	0,1%	0,1%

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1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2518,7	1859,2	10%	0%	10%	0,1%	-0,2%	0,8%	0,0%	0,1%	0,1%
2B4	Caprolactam production	N_2O	739,9	901,9	20%	23%	30%	0,1%	0,1%	0,4%	0,0%	0,1%	0,1%
1B2c	Venting and flaring	CH_4	1501,9	313,9	2%	25%	25%	0,0%	-0,4%	0,1%	-0,1%	0,0%	0,1%
1A4b	Residential:all fuels	CH_4	456,0	430,7	38%	40%	55%	0,1%	0,0%	0,2%	0,0%	0,1%	0,1%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601,5	2861,1	3%	6%	7%	0,1%	1,0%	1,2%	0,1%	0,1%	0,1%
3B	Emissions from manure management	N_2O	926,2	674,2	10%	100%	100%	0,3%	-0,1%	0,3%	-0,1%	0,0%	0,1%
1A4	Liquids excl. 1A4c	CO_2	1329,1	601,3	20%	2%	20%	0,1%	-0,2%	0,3%	0,0%	0,1%	0,1%
3A1	Young cattle	CH_4	2801,8	2211,0	5%	20%	21%	0,2%	-0,1%	1,0%	0,0%	0,1%	0,1%
2B1	Ammonia production	CO_2	3730,1	3920,9	2%	10%	10%	0,2%	0,3%	1,7%	0,0%	0,0%	0,1%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8568,9	7768,8	1%	25%	25%	0,9%	0,1%	3,3%	0,0%	0,0%	0,1%
1A2	Manufacturing Industries and Construction, solids	CO_2	4400,9	3371,2	2%	10%	10%	0,2%	-0,2%	1,4%	0,0%	0,0%	0,0%
1A3b	Road transportation	N_2O	97,9	241,2	2%	70%	70%	0,1%	0,1%	0,1%	0,0%	0,0%	0,0%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233,2	739,2	1%	20%	20%	0,1%	0,2%	0,3%	0,0%	0,0%	0,0%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13330,2	14727,0	1%	0%	1%	0,0%	1,2%	6,3%	0,0%	0,0%	0,0%

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3G	Liming	CO_2	183,2	68,7	10%	100%	100%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3d	Domestic navigation	CO_2	857,3	1240,9	5%	2%	5%	0,0%	0,2%	0,5%	0,0%	0,0%	0,0%
5D	Wastewater treatment and discharge	N_2O	172,1	71,4	20%	100%	102%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2G	Other product manufacture and use	N_2O	224,7	86,0	50%	50%	71%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2A4b	Other uses of soda ash	CO_2	68,6	114,2	50%	5%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2A4a	Ceramics	CO_2	140,1	111,7	50%	5%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2B10	Other	CO_2	583,3	278,0	1%	30%	30%	0,0%	-0,1%	0,1%	0,0%	0,0%	0,0%
1B1b	Solid fuel transformation	CO_2	402,5	810,7	2%	15%	15%	0,1%	0,2%	0,3%	0,0%	0,0%	0,0%
4F	Other Land	CO_2	26,3	126,2	25%	50%	56%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2C1	Iron and steel production	CO_2	2266,3	905,2	3%	5%	6%	0,0%	-0,5%	0,4%	0,0%	0,0%	0,0%
5D	Wastewater treatment and discharge	CH_4	308,8	210,7	20%	32%	38%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
2G2	SF_6 use	SF_6	261,0	138,8	30%	15%	34%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
1A3b	Road transportation	CH_4	193,4	57,1	2%	50%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2D1	Lubricant use	CO_2	84,6	80,3	50%	29%	58%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
4B	Cropland	N_2O	3,1	78,4	25%	58%	63%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A5	Military use:liquids	CO_2	312,0	175,2	20%	2%	20%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
1A3b	Road transportation: LPG	CO_2	2653,6	411,5	5%	2%	5%	0,0%	-0,8%	0,2%	0,0%	0,0%	0,0%
2F6	Other	HFC	201,0	146,0	20%	50%	54%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
4G	Harvested wood products	CO_2	157,2	88,4	25%	50%	56%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
5B	Biological treatment of solid waste:	CH_4	13,7	73,8	5%	63%	63%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

IPCC	Category	Gas	CO_2-eq base year	CO_2-eq last year	AD unc	EF unc	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
	composting												
5B	Biological treatment of solid waste: composting	N_2O	6,5	77,2	5%	49%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A1	Energy Industries:all fuels	N_2O	147,4	312,2	2%	18%	19%	0,0%	0,1%	0,1%	0,0%	0,0%	0,0%
3A3	Swine	CH_4	521,8	472,6	5%	50%	50%	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
2A3	Glass production	CO_2	142,4	95,3	25%	5%	25%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A4a	Commercial/Institutional:all fuels	CH_4	42,3	96,8	10%	48%	49%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
3A4	Other	CH_4	514,4	436,0	5%	30%	30%	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
1A1c	Manufacture of Solid Fuels: solids	CO_2	632,6	743,3	2%	11%	11%	0,0%	0,1%	0,3%	0,0%	0,0%	0,0%
1B2b	Natural gas	CH_4	421,1	323,3	2%	50%	50%	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
4D	Wetlands	CO_2	88,0	64,0	25%	50%	56%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A1b	Petroleum Refining: gaseous	CO_2	1042,3	2975,9	1%	0%	1%	0,0%	0,9%	1,3%	0,0%	0,0%	0,0%
2A1	Cement production	CO_2	415,8	249,4	5%	10%	11%	0,0%	-0,1%	0,1%	0,0%	0,0%	0,0%
1A4	Other Sectors:all fuels	N_2O	64,2	67,5	18%	43%	47%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2C3	Aluminium production	CO_2	408,4	39,9	2%	5%	5%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
4H	Other	N_2O	2,5	45,3	25%	1%	25%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A4	Solids	CO_2	162,7	5,7	50%	10%	51%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
1A3a	Domestic aviation	CO_2	84,8	30,6	30%	4%	30%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
3A1	Other mature cattle	CH_4	210,2	159,0	5%	20%	21%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
3B2,	Other	CH_4	33,7	40,5	10%	100%	100%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

IPCC	Category	Gas	CO_2-eq base year	CO_2-eq last year	AD unc	EF unc	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
3B4													
2E	Electronic Industry	PFC	49,7	85,5	5%	25%	25%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A1	Energy Industries:all fuels	CH_4	72,2	112,1	2%	18%	19%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2D3	Other	CO_2	0,0	21,6	25%	9%	27%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3c	Railways	CO_2	90,7	99,8	5%	2%	5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3b	Road transportation:gaseous	CO_2	0,0	95,5	5%	2%	5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2G	Other product manufacture and use	CH_4	50,1	42,5	10%	50%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42,9	47,6	3%	59%	59%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1B2a	Oil	CH_4	20,3	12,1	20%	50%	54%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
4C	Grassland	N_2O	0,3	5,9	25%	50%	56%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2B	Fluorochemical production	PFC	0,0	12,3	10%	20%	22%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2B7	Soda ash production	CO_2	63,8	0,0	5%	5%	7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3 exl 1A3b	Other	N_2O	7,8	10,2	2%	70%	70%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2H	Other industrial	CO_2	72,5	25,2	3%	5%	6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A5	Military use:liquids	N_2O	5,5	2,7	7%	82%	82%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	65,0	59,9	2%	16%	16%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A3e	Other	CO_2	342,2	92,9	1%	0%	1%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%
1A3	Other	CH_4	2,8	4,1	2%	50%	50%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

IPCC	Category	Gas	CO_2-eq base year	CO_2-eq last year	AD unc	EF unc	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
exl 1A3b													
2G	Other product manufacture and use	CO_2	0,2	0,8	50%	20%	54%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0,2	0,3	100%	50%	112%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
1A5	Military use:liquids	CH_4	0,8	0,4	7,6%	59,9%	60,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
4	LULUCF: CH_4	CH_4	0,2	0,3	1,0%	17,0%	17,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	TOTAL	GHG	232583,1	206617,1				3,3%					2,2%

Colum legend:

Unc. Est:	Uncertainty estimate
Com. Unc.:	Combined Uncertainty as % of total national emissions
A sens :	Type A sensitivity
B.sens :	Type B sensitivity
Unc. Trend EF:	Uncertainty in trend in national emissions introduced by emission factor uncertainty
Unc. Trend AD:	Uncertainty in trend in national emissions introduced by activity data uncertainty
Unc. Trend :	Uncertainty introduced into the trend in total national emissions

Annex 3 Detailed methodological descriptions of individual source or sink categories

A detailed description of methodologies per source/sink category, including a list of country-specific EFs, can be found in the relevant methodology reports on the website http://english.rvo.nl/nie.

Annex 4 CO_2 The national energy balance for the most recent inventory year

The national energy balance for 2015 of the Netherlands (as used for this submission) can be found on the next page.

The national energy balance for other years is available online at:
http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=83140ENG&D1=a&D2=a&D3=l&LA=EN&HDR=G1,G2&STB=T&VW=T

The table below consists of two parts (part one)

Energy balance sheet the Netherlands 2015	**Hard coal**	**Lignite**	**Coke-oven cokes**	**BKB(Braun-kohlenbriketts)**	**Coal tar**	**Coke oven gas**	**Blast furnace gas**	**Crude oil**	**Natural gas liquids**	**Additives**	**Residual gas**	**Lpg**	**Naphtha**	**Motor gasoline**	**Aviation gasoline**
Energy supply															
Total Primary Energy Supply (TPES)	465,4	0,8	-2,1	0,3	-3,4			2254,0	314,6	29,1	12,0	129,0	179,6	-484,1	-3,9
Indigenous production								59,6	17,7	8,8	12,0				
Imports	1495,6	0,5	9,2	0,3	0,1			4111,5	331,1	119,2		215,1	701,1	436,3	
Exports	957,0	0,1	13,4	0,0	3,5			1880,4	30,7	97,4		82,6	537,6	916,6	3,8
Bunkers															0,0
Stock change	-73,3	0,4	2,1		0,0			-36,7	-3,5	-1,5		-3,4	16,1	-3,8	-0,1
Energy consumption															
Net energy consumption	465,5	0,8	-2,1	0,3	-3,4			2254,0	314,6	29,1	12,0	129,0	179,6	-484,1	-3,9
Energy transformation															
Total energy transformation input	464,4		54,6			8,0	28,0	2254,7	225,5	29,1	36,4	47,4	424,8	1,8	0,0
Electricity and CHP transformation input	336,6					2,0	26,0				14,3				
Other transformation input	127,8		54,6			6,0	2,0	2254,7	225,5	29,1	22,1	47,4	424,8	1,8	0,0
Total energy transformation output			58,0		3,4	16,2	36,7	0,7	13,0		193,0	83,3	422,1	657,3	3,9
Electricity/CHP transformation output															

Energy balance sheet the Netherlands 2015	Hard coal	Lignite	Coke-oven cokes	BKB(Braun-kohlenbriketts)	Coal tar	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Residual gas	Lpg	Naphtha	Motor gasoline	Aviation gasoline
Other transformation output			58,0		3,4	16,2	36,7	0,7	13,0		193,0	83,3	422,1	657,3	3,9
Total net energy transformation	464,4		-3,4		-3,4	-8,2	-8,7	2254,0	212,5	29,1	-156,6	-35,9	2,7	-655,5	-3,9
Net electricity/CHP transformation	336,6					2,0	26,0				14,3				
Net other transformation	127,8		-3,4		-3,4	-10,3	-34,7	2254,0	212,5	29,1	-170,9	-35,9	2,7	-655,5	-3,9
Energy sector own use															
Total energy sector own use						-0,1	0,0				81,3	1,8			
Extraction of crude petroleum and gas												0,0			
Coke-oven plants															
Oil refineries											81,3	1,8			
Electricity and gas supply						-0,1	0,0								
Distribution losses															
Distribution losses															
Final consumption															
Total final consumption	1,0	0,8	1,3	0,3		8,4	8,7		102,1	0,0	87,4	163,1	176,8	171,4	0,0
Total final energy consumption	0,8	0,8	1,2	0,3		8,4	8,7				87,4	13,6		171,4	0,0
Total industry	0,8	0,8	1,2	0,3		8,4	8,7				87,4	1,6			
Iron and steel			0,3			8,4	8,7					0,0			
Chemical and petrochemical											87,4	1,4			
Non-ferrous metals												0,0			
Non-metallic minerals	0,0	0,5	0,9									0,0			
Transport equipment												0,0			
Machinery												0,1			
Mining and quarrying		0,3										0,0			
Food and tobacco	0,8		0,0									0,0			
Paper, pulp and printing												0,0			
Wood and wood products															

Energy balance sheet the Netherlands 2015	Hard coal	Lignite	Coke-oven cokes	BKB(Braun-kohlenbriketts)	Coal tar	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Residual gas	Lpg	Naphtha	Motor gasoline	Aviation gasoline
Construction			0,1												
Textile and leather												0,0			
Non-specified				0,3								0,0			
Total transport												8,2		171,4	0,0
Domestic aviation															0,0
Road transport												8,2		171,4	
Rail transport															
Pipeline transport															
Domestic navigation															
Non-specified															
Total other sectors	0,0			0,1								3,7			
Services, waste, water and repair				0,0								1,8			
Households	0,0			0,0								1,0			
Agriculture												1,0			
Fishing															
Non-specified															
Total non-energy use	0,2		0,1						102,1	0,0		149,5	176,8		
Industry (excluding the energy sector)	0,2		0,1						102,1	0,0		149,5	176,8		
Of which chemistry and pharmaceuticals									102,1	0,0		149,5	176,8		
Transport															
Other sectors															
Statistical difference															
Statistical differences	0,0			0,0						0,0	0,0	0,0		0,0	

The table below consists of two parts (part two)

Energy balance sheet the Netherlands 2015	**Kerosene type jet fuel**	**Other kerosene**	**Heating and other gasoil**	**Fuel oil**	**White spirit and industrial spirit (SBP)**	**Lubricants**	**Bitumen**	**Paraffin waxes**	**Petroleum coke**	**Other petroleum products**	**Natural gas**	**Municipal waste; renewable fraction**	**Solid and liquid biomass**	**Biogas**	**Non-rene.municipal waste + residual heat**	**Energy from other sources**
Energy supply																
Total Primary Energy Supply (TPES)	-321,9	-14,2	-620,0	-330,0	28,2	-17,7	-12,5	-1,6	-1,4	26,6	1210,5	40,8	55,4	13,7	38,1	2,8
Indigenous production											1632,8	35,2	63,1	13,7	33,5	2,8
Imports	133,7	9,3	696,8	1582,1	61,9	65,4	7,7	5,5	43,1	59,4	1136,7	7,0	3,8		5,7	
Exports	284,7	23,9	1142,5	1470,7	29,9	81,2	20,6	7,2	44,5	29,5	1528,9	1,4	11,5		1,2	
Bunkers	159,0		83,7	439,3		3,2					0,0					
Stock change	-11,9	0,5	-90,6	-2,1	-3,9	1,3	0,4	0,2	0,0	-3,3	-30,1					
Energy consumption																
Net energy consumption	-321,9	-14,2	-612,1	-330,0	28,2	-17,6	-12,5	-1,6	-1,4	26,6	1185,7	40,8	55,4	13,8	38,1	2,8
Energy transformation																
Total energy transformation input	5,6	10,6	130,0	175,3	70,7	1,7	0,4	0,2	1,4	55,5	438,9	40,8	38,0	13,0	35,3	1,5
Electricity and CHP transformation input			0,8	0,0							412,6	40,8	21,3	10,5	33,8	1,5
Other transformation input	5,6	10,6	129,2	175,3	70,7	1,7	0,4	0,2	1,4	55,5	26,3	0,0	16,7	2,5	1,5	0,0
Total energy transformation output	329,0	28,1	1043,0	506,7	44,2	24,7	20,2	5,5	13,9	34,2	10,9					
Electricity/CHP transformation output																
Other transformation output	329,0	28,1	1043,0	506,7	44,2	24,7	20,2	5,5	13,9	34,2	10,9					
Total net energy transformation	-323,4	-17,5	-912,9	-331,4	26,5	-23,1	-19,9	-5,3	-12,5	21,3	428,0	40,8	38,0	13,0	35,3	1,5
Net electricity/CHP transformation			0,8	0,0							412,6	40,8	21,3	10,5	33,8	1,5
Net other transformation	-323,4	-17,5	-913,7	-331,5	26,5	-23,1	-19,9	-5,3	-12,5	21,3	15,4	0,0	16,7	2,5	1,5	0,0

Energy balance sheet the Netherlands 2015	**Kerosene type jet fuel**	**Other kerosene**	**Heating and other gasoil**	**Fuel oil**	**White spirit and industrial spirit (SBP)**	**Lubricants**	**Bitumen**	**Paraffin waxes**	**Petroleum coke**	**Other petroleum products**	**Natural gas**	**Municipal waste; renewable fraction**	**Solid and liquid biomass**	**Biogas**	**Non-rene.municipal waste + residual heat**	**Energy from other sources**
Energy sector own use																
Total energy sector own use			0,1	0,3			0,0		10,1		42,8					
Extraction of crude petroleum and gas			0,1								25,3					
Coke-oven plants																
Oil refineries			0,0	0,3			0,0		10,1		17,1					
Electricity and gas supply											0,4					
Distribution losses																
Distribution losses											1,2					
Final consumption																
Total final consumption	1,5	3,3	300,7	1,2	1,7	5,4	7,4	3,7	1,0	5,3	713,7	0,2	17,3	0,8	2,8	1,3
Total final energy consumption	1,5	0,3	300,7	1,2						0,6	626,9	0,2	17,3	0,8	2,8	1,3
Total industry		0,0	18,2	0,2						0,6	169,7	0,2	4,6	0,5	2,8	0,0
Iron and steel			0,2								10,0		.	.		
Chemical and petrochemical			0,0	0,0						0,6	65,2	0,1	.	.	1,5	
Non-ferrous metals			0,0								2,6	0,2	.	.	1,2	
Non-metallic minerals			0,2	0,2							17,2		.	.		
Transport equipment		0,0	0,5								1,9		.	.		
Machinery		0,0	0,1								10,1		.	.		
Mining and quarrying			0,3								2,0		.	.		
Food and tobacco			0,2								42,1		.	.		
Paper, pulp and printing			0,0								5,7		.	.		0,0
Wood and wood products											0,5		.	.		
Construction			16,6								4,0		.	.		
Textile and leather			0,0								2,3		.	.		
Non-specified			0,0								6,0		.	.		
Total transport	0,4		253,1								1,5					

Energy balance sheet the Netherlands 2015	Kerosene type jet fuel	Other kerosene	Heating and other gasoil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Municipal waste; renewable fraction	Solid and liquid biomass	Biogas	Non-rene.municipal waste + residual heat	Energy from other sources
Domestic aviation	0,4															
Road transport			237,0								1,5					
Rail transport			1,4													
Pipeline transport																
Domestic navigation			14,7													
Non-specified																
Total other sectors	1,2	0,3	29,5	1,0							455,7		12,8	0,2		1,3
Services, waste, water and repair			4,3	0,0							124,3		1,0	0,2		1,3
Households		0,3	0,3								285,3		9,3			
Agriculture			16,5								46,0		2,5			
Fishing			6,7	1,0												
Non-specified	1,2		1,7								0,2					
Total non-energy use		3,0	0,0		1,7	5,4	7,4	3,7	1,0	4,6	86,8					
Industry (excluding the energy sector)		2,9	0,0		1,7	1,8	7,4	3,7	1,0	4,6	86,8					
Of which chemistry and pharmaceuticals		2,9			0,8			2,0	1,0	4,6	86,8					
Transport						2,3										
Other sectors		0,1				1,3										
Statistical difference																
Statistical differences		0,0	-7,9	0,1	0,0	0,0		0,0			24,8			0,0	0,0	

Annex 5 The Netherlands' fuels and standard CO_2 EFs, version January 2017

Name (Dutch)	Name (English)	Unit	Calorific value (MJ/unit)				CO_2 EF (kg/GJ)			
			2015	2016	2017	Ref [1)]	2015	2016	2017	Ref [1)]
	A. Liquid Fossil, Primary Fuels									
Ruwe aardolie	Crude oil	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC
Orimulsion	Orimulsion	kg	27.5	27.5	27.5	IPCC	77.0	77.0	77.0	IPCC
Aardgascondensaat	Natural Gas Liquids	kg	44.0	44.0	44.0	CS	64.2	64.2	64.2	IPCC
Fossiele additieven	Fossil fuel additives	kg	44.0	44.0	44.0	CS	73.3	73.3	73.3	IPCC
	Liquid Fossil, Secondary Fuels/ Products									
Motorbenzine	Gasoline	kg	44.0	44.0	44.0	CS	72.0	72.0	72.0	CS
Vliegtuigbenzine	Aviation gasoline	kg	44.0	44.0	44.0	CS	72.0	72.0	72.0	CS
Kerosine luchtvaart	Jet Kerosene	kg	43.5	43.5	43.5	CS	71.5	71.5	71.5	IPCC
Petroleum	Other kerosene	kg	43.1	43.1	43.1	CS	71.9	71.9	71.9	IPCC
Leisteenolie	Shale oil	kg	38.1	38.1	38.1	IPCC	73.3	73.3	73.3	IPCC
Gas-/dieselolie	Gas/Diesel oil	kg	42.7	42.7	42.7	CS	74.3	74.3	74.3	CS
Zware stookolie	Residual Fuel oil	kg	41.0	41.0	41.0	CS	77.4	77.4	77.4	IPCC
LPG	Liquefied Petroleum Gas (LPG)	kg	45.2	45.2	45.2	CS	66.7	66.7	66.7	CS
Ethaan	Ethane	kg	45.2	45.2	45.2	CS	61.6	61.6	61.6	IPCC
Nafta's	Naphta	kg	44.0	44.0	44.0	CS	73.3	73.3	73.3	IPCC
Bitumen	Bitumen	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
Smeeroliën	Lubricants	kg	41.4	41.4	41.4	CS	73.3	73.3	73.3	IPCC
Petroleumcokes	Petroleum Coke	kg	35.2	35.2	35.2	CS	97.5	97.5	97.5	IPCC
Raffinaderij grondstoffen	Refinery Feedstocks	kg	43.0	43.0	43.0	IPCC	73.3	73.3	73.3	IPCC
Raffinaderijgas	Refinery Gas	kg	45.2	45.2	45.2	CS	67.0	67.0	67.0	CS
Chemisch restgas	Chemical Waste Gas	kg	45.2	45.2	45.2	CS	62.4	62.4	62.4	CS
Overige oliën	Other oil	kg	40.2	40.2	40.2	IPCC	73.3	73.3	73.3	IPCC
Paraffine	Paraffin Waxes	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC

Name (Dutch)	Name (English)	Unit	Calorific value (MJ/unit)				CO_2 EF (kg/GJ)			
			2015	2016	2017	Ref [1)]	2015	2016	2017	Ref [1)]
Terpentine	White Spirit and SBP	kg	43.6	43.6	43.6	CS	73.3	73.3	73.3	IPCC
Overige aardolie producten	Other Petroleum Products	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC
	B. Solid Fossil, Primary Fuels									
Antraciet	Anthracite	kg	29.3	29.3	29.3	CS	98.3	98.3	98.3	IPCC
Cokeskolen	Coking Coal	kg	28.6	28.6	28.6	CS	94.0	94.0	94.0	CS
Cokeskolen	Coking Coal (used in coke oven)	kg	28.6	28.6	28.6	CS	95.4	95.4	95.4	CS
Cokeskolen	Coking Coal (used in blast furnaces)	kg	28.6	28.6	28.6	CS	89.8	89.8	89.8	CS
Overige bitumineuze steenkool [2)]	Other Bituminous Coal [2)]	kg	25.0	25.0 [2)]	25.0 [2)]	CS	94.7	94.7	94.7	CS
Sub-bitumineuze kool	Sub-Bituminous Coal	kg	18.9	18.9	18.9	IPCC	96.1	96.1	96.1	IPCC
Bruinkool	Lignite	kg	20.0	20.0	20.0	CS	101.0	101.0	101.0	IPCC
Bitumineuze Leisteen	Oil Shale	kg	8.9	8.9	8.9	IPCC	107.0	107.0	107.0	IPCC
Turf	Peat	kg	9.76	9.76	9.76	IPCC	106.0	106.0	106.0	IPCC
	Solid Fossil, Secondary Fuels									
Steenkool- and bruinkoolbriketten	BKB & Patent Fuel	kg	20.7	20.7	20.7	IPCC	97.5	97.5	97.5	IPCC
Cokesoven/ gascokes	Coke Oven/Gas Coke	kg	28.5	28.5	28.5	CS	106.8	106.8	106.8	CS
Cokesovengas	Coke Oven gas	MJ	1.0	1.0	1.0	CS	42.8	42.8	42.8	CS
Hoogovengas	Blast Furnace Gas	MJ	1.0	1.0	1.0	CS	247.4	247.4	247.4	CS
Oxystaalovengas	Oxy Gas	MJ	1.0	1.0	1.0	CS	191.9	191.9	191.9	CS
Fosforovengas	Fosfor Gas	Nm3	11.0	11.0	11.0	CS	143.9	143.9	143.9	CS
Steenkool bitumen	Coal tar	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
	C. Gaseous Fossil Fuels									
Aardgas [3)]	Natural Gas (dry) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.5[3)]	56.6[3)]	CS
Compressed natural gas (CNG) [3)]	Compressed natural gas (CNG) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.5[3)]	56.6[3)]	CS
Liquified natural gas (LNG) [3)]	Liquified natural gas (LNG) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.5[3)]	56.6[3)]	CS
Koolmonoxide	Carbon Monoxide	Nm3	12.6	12.6	12.6	CS	155.2	155.2	155.2	CS
Methaan	Methane	Nm3	35.9	35.9	35.9	CS	54.9	54.9	54.9	CS
Waterstof	Hydrogen	Nm3	10.8	10.8	10.8	CS	0	0	0	CS
	Biomass [4)]									

Name (Dutch)	Name (English)	Unit	Calorific value (MJ/unit)				CO_2 EF (kg/GJ)			
			2015	2016	2017	Ref [1)]	2015	2016	2017	Ref [1)]
Biomassa vast	Solid Biomass	kg	15.1	15.1	15.1	CS	109.6	109.6	109.6	IPCC
Houtskool	Charcoal	kg	30.0	30.0	30.0	CS	112.0	112.0	112.0	IPCC
Biobenzine	Biogasoline	kg	27.0	27.0	27.0	CS	72.0	72.0	72.0	CS
Biodiesel	Biodiesels	kg	37.0	37.0	37.0	CS	74.3	74.3	74.3	CS
Overige vloeibare biobrandstoffen	Other liquid biofuels	kg	36.0	36.0	36.0	CS	79.6	79.6	79.6	IPCC
Biomassa gasvormig	Gas Biomass	Nm3	21.8	21.8	21.8	CS	90.8	90.8	90.8	CS
RWZI biogas	Wastewater biogas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
Stortgas	Landfill gas	Nm3	19.5	19.5	19.5	CS	100.7	100.7	100.7	CS
Industrieel fermentatiegas	Industrial organic waste gas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
	D Other fuels									
Afval [2)]	Waste [2)]	Kg	10.0	10.0[2)]	10.0[2)]	CS	105.2	105.2[2)]	105.2[2)]	CS

Notes on the fuel list
1) IPCC: default value from the 2006 IPCC Guidelines; CS: country specific
2) The calorific value and/or emission factor for these fuels are updated annually. Since the values for 2016 and 2017 are not yet known, they are set equal to the value for 2015. The figures in the above list may be modified in subsequent versions of the fuel list
3) The emission factors for natural gas, CNG and LNG are updated annually. The values given in this table represent the most up-to-date values for all years concerned.
4) For reporting of emissions from biomass the following rules have to be followed:
    a. Under the Convention (UNFCCC) the emissions from biomass have to be reported as memo-item, using the mentioned emission factors
    b. Under the Kyoto Protocol the emission factor for biomass is always zero.
    c. Under EU ETS the emission factor for biomass is zero, with exception of liquid biomass for which additional criteria have to be met to be allowed to use an emission factor of zero.

Netherlands Enterprise Agency (RVO.nl) has been publishing the list of fuels and standard CO_2 emission factors for the Netherlands annually since 2004.
This list was completely revised in 2015 as a result of the obligation to follow the *2006 IPCC Guidelines* in all international reports compiled in or after 2015 (the first reporting year of the second Kyoto budget period). The list contains not only calorific values and emission factors taken from the *2006 IPCC Guidelines* but also a number of country-specific values. The validity of values is governed by the following rules:

- *2006 IPCC* default emission factors are valid from 1990
- The country-specific calorific values and emission factors may be divided into the following three categories:
  - Most country-specific calorific values and emission factors are valid from 1990
  - A limited number of country-specific factors have an old value for the period 1990-2012 and are updated from 2013
  - The country-specific calorific value and/or emission factor for some fuels (natural gas, other bituminous coal and waste) are updated annually. In the present document (version January 2017) these values have been updated.

Readers are referred to the TNO report (Dröge, 2014) and the relevant factsheets for further details.
Various relevant institutes, were consulted during the compilation of this list. One of the involved organisations was Statistics Netherlands (CBS), to ensure consistency with the Dutch Energy Balance Sheet.

With effect from 2015, the lists of calorific values and of emission factors will both contain columns for three successive years. In the present version of the fuel list (that for January 2017), the years in question are 2015, 2016 and 2017. The values in these columns are used for the following purposes:

1. **2015**: these values are used in 2017 for calculations concerning the calendar year 2015, which are required for international reports concerning greenhouse gas emissions pursuant to the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the European Regulation on the monitoring and reporting of greenhouse gas emissions (MMR, 525/2013/EU). The National Inventory Report for 2017 (NIR 2017) gives full details of greenhouse gas emissions in the Netherlands up to and including 2015. The fuel list forms an integral part of the NIR 2017.
2. **2016**: these values are used in 2017 for reports on energy consumption and CO_2 emission for the calendar year 2016 in the Electronic Environmental Annual Report (e-MJV), in the monitoring of MJA3/LTA3 (Long Term Agreement on energy efficiency for the period 2005-2020) and the monitoring of the MEE/LEE covenant (Long Term Agreement on Energy-Efficiency for ETS Companies).
3. **2017**: these values will be used in 2018 in emission reports for the calendar year 2017 by companies participating in the EU Emission Trading Scheme (ETS) that are allowed to report the emission factor and calorific value for a given source flow in accordance with Tier 2a (country-specific values), as laid down in Art. 31-1, MRR EU No. 601/2012. The country-specific values in

question may be taken from those quoted in the last-published National Inventory Report, in this case NIR 2017.

Annex 6 Assessment of completeness and (potential) sources and sinks

The Netherlands' emissions inventory focuses on completeness, and accuracy in the most relevant sources. This means that for all 'NE' sources, it was investigated what information was available and whether it could be assumed that a source was really (very) small/negligible. For those sources that turned out not to be small, methods for estimating the emissions were developed during the improvement programme. As a result of this process, it was decided to keep only a very few sources as 'NE', where data for estimating emissions was not available and the source was very small. Of course, (developments in) data on NE sources that indicate any (major) increase in emissions and (new) data sources for estimating emissions are checked/re-assessed on a regular basis.

The Netherlands GHG emissions inventory includes all sources identified by the 2006 IPCC Guidelines, with the exception of the following (very) minor sources:

- CO_2 from asphalt roofing (2A5) and CO_2 from road paving (2A6), both due to missing activity data; information on the use of bitumen is available only in a division into two groups: the chemical industry and all others. There is no information on the amount of asphalt roofing production and no information on road paving with asphalt. The statistical information on the sales (value) of asphalt roofing and asphalt for road paving was ended by 2002.
  As a follow-up to the 2008 review, information was collected from the branch organization for roofing, indicating that the number of producers of asphalt roofing declined from about fifteen in 1990 to fewer than five in 2008 and that the import of asphalt roofing increased during that period.
  Information has also been sourced on asphalt production (for road paving), as reported in the progress of the voluntary agreements for energy efficiency. A first estimate indicates that the annual CO_2 emissions could be approximately 0.5 kton.
  On the basis of the above, it was assumed that emissions related to these two categories are very low/undetectable and that the effort expended in generating activity data would, therefore, not be cost-effective. So not only the missing activity data, but also the very limited amount of emissions were the rationale behind the decision not to estimate these emissions.
- CH_4 from Enteric fermentation: poultry (3A9), due to missing EFs; for this source category, no IPCC default EF is available.
- N_2O emissions from industrial wastewater treatment
  The IPCC 2006 Guidelines does not provide a method for N_2O emissions from industrial sources, except for industrial wastewater that is co-discharged with domestic wastewater into the sewer system. The N_2O emissions from industrial sources are believed to be insignificant compared to emissions from domestic wastewater. In the Netherlands most industries discharge their wastewater into the sewer system/WWTPs (emissions included in

5D1). Indirect emissions from surface water resulting from discharge of wastewater effluents, are already included (IE) under 5D3 (other, wastewater effluents).

- Direct N_2O emissions from septic tanks (5D3, septic tanks)
  Direct emissions of N_2O from septic tanks are not calculated since they are unlikely to occur, given the anaerobic circumstances in these tanks. Indirect N_2O emissions from septic tank effluents are included (IE) in CRF category 5D3 'Indirect N_2O emission from surface water as a result of discharge of domestic and industrial effluents'.
- CH_4 emissions from industrial sludge treatment (5D2)
  Data from the survey among IWWTPs conducted by Statistics Netherlands shows that only 2 out of a total of 160 IWWTPs are equipped with anaerobic sludge digestion reactors. This data is not published on www.cbs.statline.nl for reasons of confidentiality. Forthcoming CH_4 emissions are not estimated (NE) because it is not known what sludge treatment capacity these plants have and how much sludge is digested. It is likely that these emissions are a very minor source and can be neglected.

Precursor emissions (i.e. CO, NO_x, NMVOC and SO_2) from Memo item international bunkers (international transport) have not been included.

Annex 7 Chemical compounds, GWPs, units and conversion factors

A7.1 Chemical compounds

CF_4	Perfluoromethane (tetrafluoromethane)
C_2F_6	Perfluoroethane (hexafluoroethane)
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HNO_3	Nitric acid
NF_3	Nitrogen trifluoride
NH_3	Ammonia
NO_x	Nitrogen oxide (NO and NO_2), expressed as NO_2
N_2O	Nitrous oxide
NMVOC	Non-methane volatile organic compounds
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
VOC	Volatile organic compounds (may include or exclude methane)

A7.2 GWPs of selected GHGs

Table A7.1 lists the 100-year GWPs of selected GHGs. Gases indicated in italics are not emitted in the Netherlands.

Table A7.1 100-year GWPs of selected GHGs

Gas	**100-year GWP** [1]	
CO_2	1	
CH_4 [2]	25	
N_2O	298	
HFCs [3]:		
HFC-23	14,800	
HFC-32	675	
HFC-125	3,500	
HFC-134a	1,413	
HFC-143a	4,470	
HFC-152a	124	
HFC-227ea	*3,220*	
HFC-236fa	*9,810*	
HFC-245ca	*693*	
PFCs [3]:		
CF_4	7,390	
C_2F_6	12,200	
C_3F_8	*8,830*	
C_4F_{10}	*8,860*	
C_6F_{14}	*9,300*	
SF_6	22,800	
NF_3	17,200	

Source: IPCC (2014)

1) GWPs calculated with a 100-year time horizon in compliance with the UNFCCC Guidelines for reporting (UNFCCC, 2006).

2) The GWP of methane includes the direct effects and the indirect effects due to the production of tropospheric ozone and stratospheric water vapour; the indirect effect due to the production of CO_2 is not included.

3) The GWP-100 of emissions reported as 'HFC-unspecified' and 'PFC-unspecified' differ per reported year. They are in the order of magnitude of 3,000 and 8,400, respectively.

A7.3 Units

MJ	Mega Joule (10^6 Joule)
GJ	Giga Joule (10^9 Joule)
TJ	Tera Joule (10^{12} Joule)
PJ	Peta Joule (10^{15} Joule)
Mg	Mega gramme (10^6 gramme)
Gg	Giga gramme (10^9 gramme)
Tg	Tera gramme (10^{12} gramme)
Pg	Peta gramme (10^{15} gramme)
ton	metric ton (= 1,000 kilogramme = 1 Mg)
kton	kiloton (= 1,000 metric ton = 1 Gg)
Mton	Megaton (= 1,000,000 metric ton = 1 Tg)
ha	hectare (= 10^4 m^2)
kha	kilo hectare (= 1,000 hectare = 10^7 m^2 = 10 km^2)
mln	million (= 10^6)

A7.4 Conversion factors for emissions

From element basis to full molecular mass:		From full molecular mass to element basis	
$C \rightarrow CO_2$:	x 44/12 = 3.67	$CO_2 \rightarrow C$:	x 12/44 = 0.27
$C \rightarrow CH_4$:	x 16/12 = 1.33	$CH_4 \rightarrow C$:	x 12/16 = 0.75
$C \rightarrow CO$:	x 28/12 = 2.33	$CO \rightarrow C$:	x 12/28 = 0.43
$N \rightarrow N_2O$:	x 44/28 = 1.57	$N_2O \rightarrow N$:	x 28/44 = 0.64
$N \rightarrow NO$:	x 30/14 = 2.14	$NO \rightarrow N$:	x 14/30 = 0.47
$N \rightarrow NO_2$:	x 46/14 = 3.29	$NO_2 \rightarrow N$:	x 14/46 = 0.30
$N \rightarrow NH_3$:	x 17/14 = 1.21	$NH_3 \rightarrow N$:	x 14/17 = 0.82
$N \rightarrow HNO_3$:	x 63/14 = 4.50	$HNO_3 \rightarrow N$:	x 14/63 = 0.22
$S \rightarrow SO_2$:	x 64/32 = 2.00	$SO_2 \rightarrow S$:	x 32/64 = 0.50

Annex 8 List of abbreviations

AD	activity data
ARD	afforestation, reforestation and deforestation
AER	Annual Environmental Report
BF	blast furnace gas
BOD	biological oxygen demand
C	Confidential (notation code in CRF)
CO	coke oven gas
CS	country-specific (notation code in CRF)
CBS	Statistics Netherlands
CHP	combined heat and power
CLRTAP	Convention on Long-Range Transboundary Air Pollution (ECE)
COD	chemical oxygen demand
CRF	Common Reporting Format (of emissions data files, annexed to an NIR)
DM	dry matter
DOC	degradable organic carbon
DOCF	degradable organic carbon fraction
EC-LNV	National Reference Centre for Agriculture
ECE	Economic Commission for Europe (UN)
ECN	Energy Research Centre of the Netherlands
EEA	European Environment Agency
EF	emission factor
ENINA	Task Group Energy, Industry and Waste Handling
EPA	US Environmental Protection Agency
ER	Emission Registration (system)
ER-I	Emission Registration – Individual firms
ERT	Expert Review Team
ERU	Emission Reduction Unit
ETS	Emission Trading System
EU	European Union
EZ	Ministry of Economic Affairs
FADN	Farm Accountancy Data Network
FAO	Food and Agricultural Organization (UN)
F-gases	group of fluorinated compounds comprising HFCs, PFCs and SF_6
FGD	flue gas desulphurization
GE	gross energy
GHG	greenhouse gas
GWP	global warming potential
HDD	heating degree day
HOSP	Timber Production Statistics and Forecast (in Dutch: 'Hout Oogst Statistiek en Prognose oogstbaar hout')
IE	included elsewhere (notation code in CRF)
IEA	International Energy Agency
IEF	implied emission factor
IenM	Ministry of Infrastructure and Environment (formerly VROM)
IWWTP	industrial wastewater treatment plant
IPCC	Intergovernmental Panel on Climate Change

KP-LULUCF	Land use, land use change and forestry according the Kyoto Protocol definitions
LEI	Agricultural Economics Institute
LPG	liquefied petroleum gas
LULUCF	Land use, land use change and forestry
MCF	methane conversion factor
MFV	Measuring Network Functions (in Dutch: 'Meetnet Functievervulling')
MR	methane recovery
MSW	municipal solid waste
MW	mega watt
NA	not available/not applicable (notation code in CRF); National Approach
NACE	Statistical Classification of Economic Activities from the European Union: Nomenclature générale des Activités économiques dans les Communautés Européennes
NAV	Dutch Association of Aerosol Producers
ND	no data
NEa	Dutch Emissions Authority
NE	not estimated (notation code in CRF)
NEa	Netherlands Emission authority (Dutch Emission Authority)
NEC	National Emission Ceilings
NEMA	National Emission Model for Agriculture
NFI	National Forest Inventory
NGE	Nederlandse grootte-eenheid
NIE	National Inventory Entity
NIR	National Inventory Report (annual GHG inventory report to UNFCCC)
NOGEPA	Netherlands Oil and Gas Exploration and Production Association
NOP-MLK	National Research Programme on Global Air Pollution and Climate Change
NS	Dutch Railways
ODS	ozone depleting substances
ODU	oxidation during use (of direct non-energy use of fuels or of petrochemical products)
OECD	Organization for Economic Co-operation and Development
OM	organic matter
OX	oxygen furnace gas
PBL	Netherlands Environmental Assessment Agency (formerly MNP)
PE	Pollution Equivalent
PRTR	Pollutant Release and Transfer Register
QA	quality assurance
QC	quality control
RA	Reference Approach (vs. Sectoral or National Approach)
RIVM	National Institute for Public Health and the Environment
ROB	Reduction Programme on Other Greenhouse Gases
RVO.nl	Netherlands Enterprise Agency
SA	Sectoral Approach
SCR	selective catalytic reduction
SGHP	Shell Gasification and Hydrogen Production
SNCR	selective non-catalytic reduction

SO	standard output
SWDS	solid waste disposal site
TNO	Netherlands Organisation for Applied Scientific Research
TOW	total organics in wastewater
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	volatile organic compound
VS	volatile solids
WBCSD	World Business Council for Sustainable Development
WEM	Working Group Emission Monitoring
WUR	Wageningen University and Research Centre (or: Wageningen UR)
WWTP	wastewater treatment plant

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Total greenhouse gas (GHG) emissions from the Netherlands in 2015 increased by approximately 4%, compared with 2014 emissions. This increase was mainly the result of the increased electricity production in coal fired plants compared to 2014. Furthermore fuel combustion in all sectors was increased as the winter of 2015 was less mild as the one in 2014.

In 2015, total GHG emissions (including indirect CO_2 emissions and excluding emissions from Land use, land use change and forestry (LULUCF)) in the Netherlands amounted to 195.2 Tg CO_2 eq. This is approximately 12.5% below the emissions in the base year (223.1 Tg CO_2 eq).

CO_2 emission have increased above the level in the base year 1990 in 2015 (+ 1.5%). This increase was offset by the reduction in the emissions since 1990 of methane, nitrous oxide and fluorinated gases (CH_4, N_2O and F-gases).

This report documents the Netherlands' 2017 annual submission of its greenhouse gas emissions inventory in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) provided by the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the European Union's Greenhouse Gas Monitoring Mechanism.

The report includes explanations of observed trends in emissions; an assessment of the sources with the highest contribution to the national emissions (key sources) their validation and an uncertainty analysis.

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