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

Greenhouse Gas Emissions *in the Netherlands* 1990-2016

National Inventory Report 2018

National Institute for Public Health
and the Environment
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Greenhouse gas emissions in the Netherlands 1990–2016 National Inventory Report 2018

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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 cooperation 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 Maarten 't Hoen (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 Sietske van der Sluis (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 and Dirk Wever for their contributions to data processing, chart production and quality control.

We greatly appreciate the contributions of each of these groups and individuals to this National Inventory Report and supplemental CRF tables, as well as those of the external reviewers who provided comments on the draft report.

[1] Intergovernmental Panel on Climate Change

Synopsis

Greenhouse gas emissions in the Netherlands 1990–2016

Total greenhouse gas (GHG) emissions in the Netherlands in 2016 increased by approximately 0.2%, compared with 2015 emissions. This increase was mainly the result of increased natural gasconsumption for space heating. On the other hand, the emission of electricity production has declined.

In 2016, 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 12.4% below the emissions in the base year[2] (222.9 Tg CO_2 eq.).

CO_2 emissions in 2016 were still above the level in the base year (+1.6%). This increase was offset by the reduction since 1990 in emissions of methane, nitrous oxide and fluorinated gases (CH_4, N_2O and F-gases).

This report documents the Netherlands' annual submission for 2018 of its GHG 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 (KP) 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 total 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 F-gases.

Publiekssamenvatting

Emissies van broeikasgassen tussen 1990 en 2016

In 2016 is de totale uitstoot van broeikasgassen van Nederland met ongeveer 0,2 procent gestegen ten opzichte van de uitstoot in 2015. Deze stijging komt vooral doordat er meer aardgas is verbruikt om ruimtes te verwarmen. Daarentegen staat dat de uitstoot van de electriciteitsproductie is afgenomen.

De totale uitstoot van broeikasgassen naar de lucht wordt uitgedrukt in CO_2-equivalenten en bedroeg in 2016 195,2 miljard kilogram. Ten opzichte van het zogeheten Kyoto-basisjaar (222,9 miljard kilogram CO_2-equivalenten) is dit een afname van ongeveer 12,4 procent. Dit basisjaar, dat afhankelijk van het broeikasgas 1990 of 1995 is, dient voor het Kyoto Protocol als referentiejaar voor de uitstoot van broeikasgassen.

De emissie van CO_2 lag in 2014 voor het eerst onder het niveau van het basisjaar 1990. Sindsdien is de CO_2-uitstoot toegenomen met circa 5 procent en komt hij boven het niveau van het basisjaar 1990 (+1,6 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 Economische Zaken en Klimaat (EZK) opstelt. Met deze inventarisatie voldoet Nederland aan de nationale rapportageverplichtingen voor 2018 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 uitstoot van broeikasgassen in de periode 1990-2016, 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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Part II: Supplementary information required under Article 7, paragraph 1 — 297

Samenvatting

Het National Inventory Report (NIR) 2018 bevat de rapportage van broeikasgasemissies (CO_2, N_2O, CH_4 en de F-gassen) over de periode 1990 tot en met 2016. De emissiecijfers in de NIR 2018 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 2016. De methoderapporten zijn opgenomen in Annex 7 en ook elektronisch 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 Economische Zaken en Klimaat (EZK) opgesteld om te voldoen aan de nationale rapportageverplichtingen in 2018 van het Klimaatverdrag van de Verenigde Naties (UNFCCC), het Kyoto Protocol en het Bewakingsmechanisme Broeikasgassen van de Europese Unie.
De emissies in dit rapport zijn berekend conform de rapportagerichtlijnen van de UNFCCC en de 2006 IPCC Richtlijnen voor Nationale Broeikasgassen Inventarisatie[3].

Dit rapport bevat de volgende informatie:

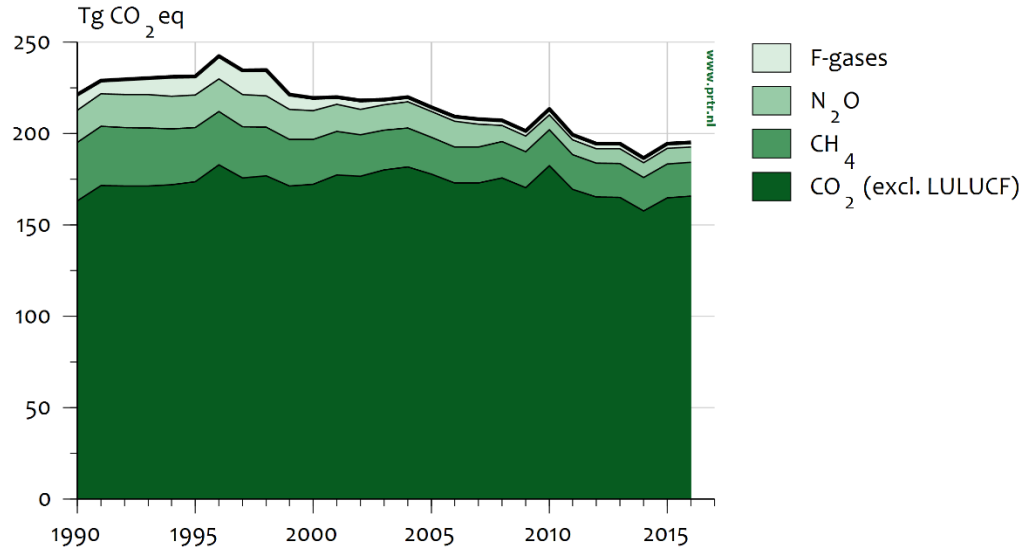
- trendanalyses voor de emissies van broeikasgassen in de periode 1990-2016;
- een analyse van zogenaamde sleutelbronnen en de onzekerheid in hun emissies volgens de 'Benadering 1'-methodiek van de 2006 IPCC Richtlijnen;
- documentatie van gebruikte berekeningsmethoden, databronnen en toegepaste emissiefactoren;
- een overzicht van het kwaliteitssysteem en de validatie van de emissiecijfers voor de Nederlandse EmissieRegistratie;
- overzicht van de herberekeningen van de broeikasgasemissies als gevolg van de meest recente wijzigingen in de berekeningsmethoden.

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 een aparte annex worden vanaf 2018 ook de methodiek rapporten meegeleverd. In de bijlagen bij dit rapport is onder meer een overzicht van sleutelbronnen en onzekerheden in de emissie opgenomen.

[3] 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

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 Balans van de Leefomgeving 2016 (opgesteld door het Planbureau voor de Leefomgeving, PBL), de zevende Nationale Communicatie onder het Klimaatverdrag (NC7; EZK, 2017) en de derde Tweejaarlijkse Voortgangsrapportage (BR3; EZK, 2017).



Figuur ES.1 Broeikasgassen: emissieniveaus en emissietrends (exclusief LULUCF), 1990-2016.

Ontwikkeling van de broeikasgasemissies

De emissieontwikkeling in Nederland wordt beschreven en toegelicht in dit Nationale Inventarisatie Rapport. Figuur ES.1 geeft het emissieverloop over de periode 1990-2016 weer. De totale emissies bedroegen in 2016 circa 195,2 Tg (Mton ofwel miljard kg) CO_2 equivalenten en zijn daarmee circa 12,4 procent afgenomen in vergelijking met de emissies in het basisjaar (222,9 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 1,6 procent toegenomen, de emissies van de andere broeikasgassen zijn met circa 50 procent afgenomen ten opzichte van het basisjaar.

In 2016 steeg de CO_2 emissie met circa 0,3 procent (ten opzichte van het jaar 2015) Deze stijging komt vooral doordat er meer aardgas is verbruikt voor ruimteverwarming. Daarentegen is de uitstoot van de elektriciteitsproductie afgenomen. De emissie van CH_4 steeg in 2016 licht ten opzichte van 2015, met ongeveer 0,8 procent. De N_2O emissie daalde in 2016 met circa 3 procent. De emissie van F-gassen steeg in 2016 met circa 3 procent ten opzichte van 2015. De totale emissie van broeikasgassen in 2016 ligt daarmee 0,2 procent hoger dan het niveau in 2015.

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 Benadering 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 2016 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 in 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 zijn opgenomen in Annex 7 en ook elektronisch beschikbaar 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' annual submission for 2018 of its greenhouse gas (GHG) 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 2018 (NIR 2018), therefore, provides explanations of the trends in GHG emissions, activity data (AD) and (implied) emission factors (EFs) for the period 1990–2016. It also summarizes the methods and data sources used in Approach 1 assessments of uncertainty in annual emissions and in emissions trends; it presents an assessment of key sources of emissions following Approaches 1 and 2 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 2016' (biennial edition; in Dutch: 'Balans van de Leefomgeving') prepared by the Netherlands Environmental Assessment Agency (PBL), the 7th National Communication (NC7; EZK, 2017a) and the Third Biennial Report (BR3; EZK, 2017b).

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 and the methodology reports, are also available 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 II of the NIR focuses on the supplementary information required by Article 7 of the Kyoto Protocol. One of the commitments is the development of a National System for GHG 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 was found to be in compliance with the requirements.

Key categories

To identify the 'key sources' (the source categories which constitute 95% of national emissions) according to the definition of the 2006 IPCC

Guidelines, national emissions are categorized according to the IPCC source categories list wherever possible. The IPCC Approach 1 method consists of ranking this list of source categories according to their contribution to both national total annual emissions (level assessment) and the national total trend (trend assessment). The results of this ranking are presented in Annex 1: 95% of the national total annual emissions derive from 29 key sources and 95% of the national total trend is due to 35 key sources, out of a total of 92 source categories. The two lists can be combined to give an overview of the source categories that are included in one or both of these groups. Next, the IPCC Approach 2 method for identifying the key sources is used; this requires incorporating the uncertainty in the emissions estimate of each of these sources before ranking them in relation to their share of total emissions. The result is a list of 46 key sources from the total of 92 source categories. Finally, after the inclusion of ten Land use, land use change and forestry (LULUCF) source categories in the key source analysis, four more key sources are found in the LULUCF sector.

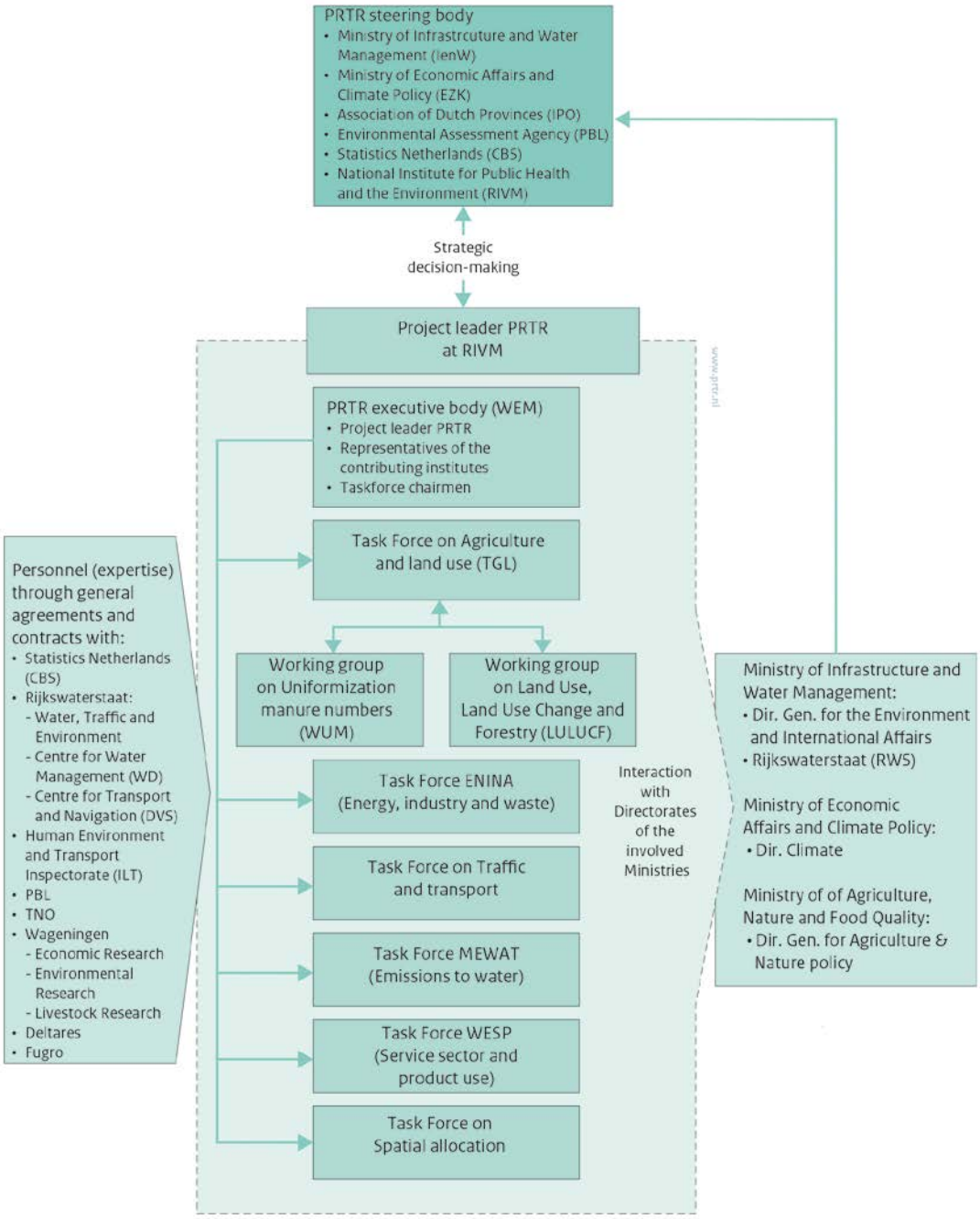


Figure ES.2: Main elements in the GHG emissions inventory compilation process

Institutional arrangements for inventory preparation

The GHG emissions 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 GHG 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 Economic Affairs and Climate policy (EZK) to compile and maintain the PRTR and to coordinate 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 coordinates 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 methodology reports are Part of the National GHG submission and the references are included in Annex 7 and are available at the National System website http://english.rvo.nl/nie. The methodology reports are reviewed by the NIE and approved by the chairperson of the PRTR Task Force concerned.

Organization of the report

This report is organized 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 sources and their uncertainties; a description of methods, data sources and emission factors (EFs); and a description of the quality assurance (QA) 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 and improvements. In addition, the report provides detailed information on key source categories and methodologies and other relevant details in nine annexes.

In Part II of this report, the supplementary information required under Article 7, paragraph 1 of the Kyoto Protocol is reported in five additional Chapters.

ES2 Summary of trends in national emissions and removals

In 2016, total 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 12.4% below total emissions in the base years (222.9 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 1.6% from 1990 to 2016. CH_4 emissions in 2016 were 42% lower than 1990 levels, mainly due to decreases in emissions from the Waste sector and the

Agricultural sector. N_2O emissions decreased by 54% in 2016 compared with 1990, mainly due to decreases in emissions from Agriculture and from Industrial processes and product use (IPPU). In contrast N_2O emissions from fossil fuel combustion (mainly from Transport) increased. The emissions of F-gases (HFCs, PFCs and SF_6) decreased in the period 1995 (chosen as the base year) to 2016 by 68%, 93% and 49%, respectively. Total emissions of all F-gases were approximately 73% lower than in 1995. A summary of these trends is given in Figure ES.3.

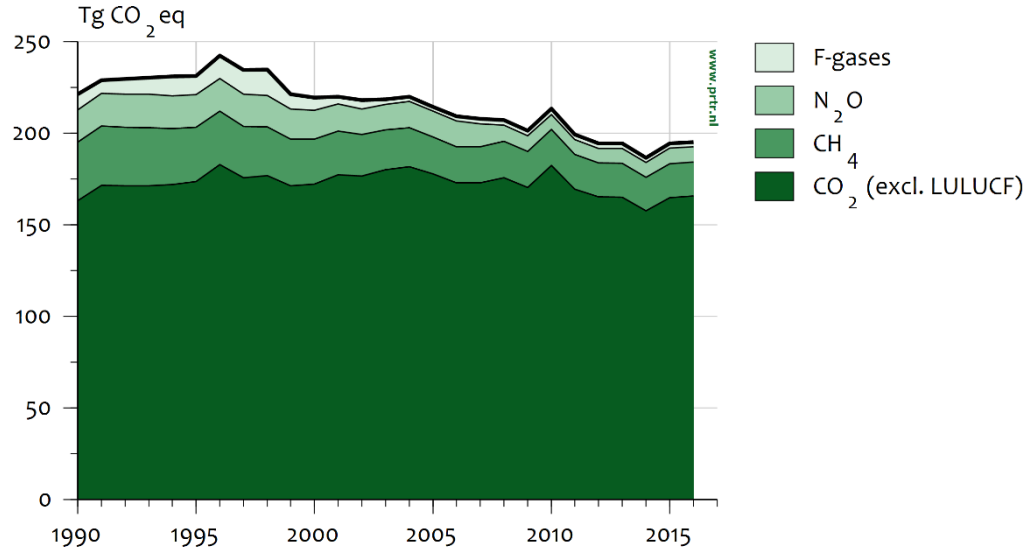


Figure ES.3: Overview of the trends in GHG emissions (excl. LULUCF) 1990–2016

Between 2015 and 2016, CO_2 emissions (excluding LULUCF) increased by 0.5 Tg. Emissions of CH_4 also showed a small increase of 0.15 Tg CO_2 eq. between 2015 and 2016. In the same period, N_2O emissions decreased by just under 0.3 Tg CO_2 eq. Emissions of HFCs, PFCs and SF_6 did not change significantly in 2016. Total F-gas emissions increased by 0.1 Tg CO_2 eq.
Overall, total GHG emissions increased by about 0.2% in comparison with 2015.

Total CO_2 eq. emissions including LULUCF increased between 2015 and 2016 by 0.5 Tg to the level of 201.9 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 2% higher than in 1990. Emissions from the LULUCF sector were 10% higher than in 1990. Emissions from the other sectors were lower than in the base year, the largest decreases being in IPPU, Waste and Agriculture.

Categories showing the largest increase in CO_2-equivalent emissions since 1990 are Transport (1A3) and Energy industries (1A1) (+9% and +27%, respectively).

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	**169.2**	**163.1**	**32.0**	**17.7**	**7.6**	**2.3**	**0.3**	**229.0**	**222.9**
1990	169.2	163.1	32.0	17.7	5.6	2.7	0.2	227.3	221.3
1991	177.6	171.5	32.4	17.9	4.4	2.6	0.1	235.0	228.9
1992	177.4	171.3	32.0	18.2	5.6	2.4	0.1	235.7	229.6
1993	177.6	171.4	31.5	18.5	6.3	2.4	0.1	236.5	230.2
1994	178.2	171.9	30.5	18.0	8.2	2.3	0.2	237.4	231.1
1995	179.7	173.5	29.8	17.9	7.6	2.3	0.3	237.5	231.3
1996	189.1	182.9	29.1	17.9	9.6	2.5	0.3	248.5	242.3
1997	181.8	175.7	27.9	17.7	10.2	2.8	0.3	240.7	234.5
1998	182.9	176.8	26.7	17.1	11.6	2.2	0.3	240.8	234.6
1999	177.5	171.4	25.5	16.4	6.0	1.8	0.3	227.4	221.2
2000	178.3	172.3	24.4	15.9	4.8	1.9	0.3	225.5	219.4
2001	183.4	177.4	23.7	14.9	1.9	1.8	0.3	226.0	219.9
2002	182.7	176.7	22.6	14.1	2.0	2.6	0.2	224.2	218.1
2003	186.3	180.1	21.9	13.9	1.8	0.8	0.2	224.8	218.6
2004	187.7	181.7	21.4	14.4	1.9	0.4	0.2	226.0	220.0
2005	183.7	177.8	20.0	14.3	1.7	0.4	0.2	220.3	214.4
2006	178.9	173.0	19.6	14.2	2.0	0.4	0.2	215.2	209.3
2007	178.7	172.9	19.7	12.6	2.1	0.4	0.2	213.8	207.8
2008	181.5	175.8	19.9	8.8	2.2	0.3	0.2	213.0	207.1
2009	176.4	170.4	19.6	8.6	2.4	0.3	0.1	207.5	201.4
2010	188.5	182.4	19.6	8.3	2.7	0.3	0.2	219.6	213.4
2011	175.5	169.4	19.0	8.1	2.5	0.3	0.1	205.5	199.3
2012	171.3	165.2	18.7	7.9	2.4	0.2	0.2	200.7	194.5
2013	171.5	165.0	18.6	8.1	2.5	0.1	0.1	201.0	194.5
2014	164.0	157.6	18.2	8.2	2.3	0.1	0.1	193.1	186.5
2015	171.8	165.3	18.4	8.5	2.4	0.1	0.1	201.4	194.8
2016	172.3	165.7	18.6	8.2	2.4	0.2	0.1	201.9	195.2

Table ES.2: Summary of emissions trends per sector (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	**158.6**	**25.1**	**25.0**	**6.1**	**14.2**	**229.0**	**222.9**
1990	158.6	23.5	25.0	6.1	14.2	227.3	221.3
1991	167.0	22.3	25.3	6.2	14.3	235.0	228.9
1992	166.8	23.3	25.4	6.2	14.1	235.7	229.6
1993	167.1	24.4	25.0	6.3	13.7	236.5	230.2
1994	167.7	26.3	24.1	6.3	13.2	237.4	231.1
1995	169.3	25.3	24.1	6.2	12.6	237.5	231.3
1996	179.2	27.2	23.8	6.2	12.2	248.5	242.3
1997	171.1	28.2	23.4	6.1	11.8	240.7	234.5
1998	171.9	29.1	22.3	6.2	11.3	240.8	234.6
1999	166.3	22.8	21.8	6.1	10.4	227.4	221.2
2000	167.1	21.9	20.7	6.1	9.8	225.5	219.4
2001	172.8	17.6	20.2	6.1	9.3	226.0	219.9
2002	172.2	18.1	19.1	6.1	8.8	224.2	218.1
2003	175.7	15.9	18.7	6.3	8.2	224.8	218.6
2004	176.9	16.6	18.5	6.0	7.9	226.0	220.0
2005	173.0	16.6	18.4	6.0	6.4	220.3	214.4
2006	168.4	16.5	18.4	6.0	5.9	215.2	209.3
2007	168.7	15.4	18.1	6.0	5.5	213.8	207.8
2008	172.2	11.6	18.2	5.9	5.2	213.0	207.1
2009	167.2	11.3	18.0	6.1	4.9	207.5	201.4
2010	178.9	11.9	18.1	6.1	4.6	219.6	213.4
2011	165.5	11.8	17.7	6.2	4.3	205.5	199.3
2012	161.8	11.1	17.5	6.2	4.1	200.7	194.5
2013	161.5	11.1	18.0	6.6	3.9	201.0	194.5
2014	154.0	10.7	18.2	6.6	3.6	193.1	186.5
2015	161.4	11.1	18.8	6.7	3.4	201.4	194.8
2016	161.9	10.9	19.2	6.7	3.3	201.9	195.2

ES4 Other information

General uncertainty evaluation

The results of the uncertainty estimation according to the IPCC Approach 1 uncertainty assessment are summarized in Annex 2 of this report. The Approach 1 estimation of annual uncertainty in CO_2-equivalent emissions results in an overall uncertainty of 3%, based on calculated uncertainties of 2% for CO_2 (excluding LULUCF), 17% for CH_4, 41% for N_2O and 41% 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 an Approach 2 uncertainty assessment. This submission includes the results of the Approach 2 uncertainty assessment (using Monte Carlo analysis).

The results show that the calculated uncertainty in the national emissions is of the same order of magnitude as the Approach 1 uncertainty assessment. Table ES.3 shows the currently estimated values for the Approach 1 and Approach 2 analyses.

Table ES.3: Approach 1 and Approach 2 uncertainty assessment of 2016 emissions (without LULUCF)

Greenhouse gas	Approach 1 annual uncertainty	Approach 2 annual uncertainty (Monte Carlo)
Carbon dioxide	3%	3%
Methane	17%	9%
Nitrous oxide	41%	27%
F-gases	41%	25%
Total	3%	3%

From Table ES.3 it can be seen that the Approach 2 analysis for the national total shows the same uncertainty as the Approach 1 analysis. For non-CO_2 GHG the Approach 2 uncertainties are lower than the results from Approach 1, as they are now based on revised uncertainty estimates at the lowest source level.

Annex 2 summarizes the estimates of trend uncertainties in the period 1990–2016 calculated according to IPCC Approach 1 (IPCC, 2006). The result is a trend uncertainty in total CO_2-equivalent emissions (excluding LULUCF) for 1990–2016 (1995–2016 for F-gases) of ±2%. This means that the trend in total CO_2-equivalent emissions between 1990 and 2016 (excluding LULUCF), which is calculated to be a 12.5% decrease, will be between a 10% decrease and a 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 (2018) 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 emissions inventory of the Netherlands. Compared with the NIR 2017, 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.4 shows the results of recalculations in the NIR 2018 compared with the NIR 2017.

Table ES.4: Differences between the NIR 2018 and NIR 2017 due to recalculations (Tg CO_2 eq. including indirect CO_2 emissions; F-gases: Gg CO_2 eq.)

	Source	1990	1995	2000	2005	2010	2015
CO_2 [Tg]	NIR 2018	**169.2**	179.7	178.3	183.7	188.5	171.8
Incl.	NIR 2017	**169.0**	179.5	178.0	183.3	188.8	171.9
LULUCF	*Difference*	0.1%	0.1%	0.2%	0.2%	-0.2%	-0.1%
CO_2 [Tg]	NIR 2018	**163.1**	173.5	172.3	177.8	182.4	165.3
Excl.	NIR 2017	**162.9**	173.3	172.0	177.4	182.8	165.3
LULUCF	*Difference*	0.1%	0.1%	0.2%	0.2%	-0.2%	-0.1%
CH_4 [Tg]	NIR 2018	**32.0**	29.8	24.4	20.0	19.6	18.4
	NIR 2017	**32.3**	30.3	25.1	20.5	20.1	19.0
	Difference	-1.1%	-1.7%	-2.8%	-2.2%	-2.6%	-3.0%
N_2O [Tg]	NIR 2018	**17.7**	17.9	15.9	14.3	8.4	8.6
	NIR 2017	**17.7**	17.8	15.8	14.2	8.2	8.5
	Difference	0.2%	0.5%	0.6%	0.6%	1.5%	1.6%
PFCs	NIR 2018	2663	**2280**	1903	366	314	104
[Gg]	*NIR 2017*	2663	**2280**	1903	366	314	104
	Difference	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HFCs	NIR 2018	5606	**7572**	4764	1733	2677	2373
[Gg]	*NIR 2017*	5606	**7571**	4765	1728	2666	2336
	Difference	0.0%	0.0%	0.0%	0.3%	0.4%	1.6%
SF_6	NIR 2018	207	**261**	259	204	154	139
[Gg]	*NIR 2017*	207	**261**	259	204	154	139
	Difference	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Total	NIR 2018	227.3	237.5	225.5	220.3	219.6	201.4
[Tg CO_2 eq.]	*NIR 2017*	227.5	237.7	225.8	220.3	220.3	202.0
Incl. LULUCF	*Difference*	-0.1%	-0.1%	-0.1%	0.0%	-0.3%	-0.3%
Total	NIR 2018	221.3	231.3	219.4	214.4	213.4	194.8
[Tg CO_2 eq.]	NIR 2017	221.4	231.5	219.7	214.4	214.2	195.2
Excl. LULUCF	*Difference*	-0.1%	-0.1%	-0.1%	0.0%	-0.3%	-0.2%

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 2016 by 52% and 71%, respectively. For SO_2, the reduction was 86%; for NO_x, the 2016 emissions were 62% lower than the 1990 level. Table ES.5 provides trend data.

Table ES.5: Emissions trends for indirect GHGs and SO_2 (Gg)

	1990	1995	2000	2005	2010	2015	2016
Total NO_X	586	485	398	347	286	233	224
Total CO	1,216	879	805	718	666	585	580
Total NMVOC	483	343	246	186	172	149	141
Total SO_2	188	125	70	61	33	29	27

Part I: 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 (NIR), together with the Common Reporting Format (CRF), represents the 2017 national emissions inventory of GHGs under the UNFCCC (Part I of this report) and under its Kyoto Protocol (Part II 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 the GHG emissions inventory

As indicated, this NIR documents the 2017 greenhouse gas emissions 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 can be found in 'Environmental balance 2016' (biennial edition; in Dutch: 'Balans van de Leefomgeving'), the 7th Netherlands National Communication under the United Nations Framework Convention on Climate Change (NC7: EZK, 2017) and the Third Biennial Report (BR3: EZK, 2017).

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 emissions estimates are taken from the Netherlands' Pollutant Release and Transfer Register (PRTR), which is compiled by a special project in which various organizations cooperate. The GHG emissions 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 emissions 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).

Emissions totals for the GHGs, including indirect CO_2 emissions, are reported in this NIR.

Emissions of the following indirect GHGs are also reported: nitrogen oxides (NO_x), carbon monoxide (CO), 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 1990–2016 period and summarizes the methods used and data sources for: (a) Approach 1 assessments of the uncertainty in annual emissions and in emissions trends; (b) key source assessments following Approach 1 and Approach 2 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 have been 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 methodologies described in these methodology reports, which should be considered as part of the National System. The reports are an integral part of this submission (see Annex 7) and are available at the National System website http://english.rvo.nl/nie. The methodology reports are reviewed by the National Inventory Entity (NIE) 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 the latest review from 2017. Information on the latest changes to the National System is reported in Chapter 13.

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 II of the NIR 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 recalculations performed since the last submission and the improvements made following the recommendations of the latest reviews.

1.1.3 Background information on supplementary information required by Article 7 of the Kyoto Protocol

Part II of this report provides the supplementary information required by (Article 7 of) the Kyoto Protocol. This supplementary information on Land use, land use change and forestry according the Kyoto Protocol definitions (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 Economic Affairs and Climate Policy (EZK) bears overall responsibility for climate change policy issues, including the preparation of the national GHG emissions 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 coordination of the establishment and maintenance of a National System, the tasks of RVO.nl include overall coordination of improved QA/QC activities as part of the National System and coordination of the support/response to the UNFCCC review process. The National System is described in greater detail in the Seventh Netherlands National Communication under the United Nations Framework Convention on Climate Change (NC7: EZK, 2017a).

The RIVM has been assigned by the EZK as the institute responsible for coordinating the compilation and maintenance of the pollutants emission register/inventory (PRTR system), which contains data on approximately 350 pollutants, including 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 are produced in an annual (project) cycle (RIVM, 2017). This system also serves as the basis for the national GHG emissions inventory. The overall coordination of the PRTR is outsourced by the EZK to the RIVM.
The main purpose of the PRTR project is 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 (see Box 1).

Box 1 Pollutant Release and Transfer Register (PRTR) project

Responsibilities for coordination of the PRTR project
Major decisions on tasks and priorities are taken by the Steering Committee ER (SCER) by approval of the Annual Work Plan. This committee consists of representatives of the commissioning ministries, regional governments, the RIVM and the PBL.

The PRTR project leader at the RIVM acts as coordinator and is responsible for the PRTR process; the outcomes of that process are the responsibility of the bodies involved. The collaboration of the various bodies is ensured by means of contracts, covenants or other agreements.

Task Forces
Various emissions experts from the participating organizations take part in the Task Forces that calculate national emissions from 650 emission sources. A formal agreement is drawn up by all the participating organizations. After intensive checking, national emissions figures are accepted by the leader of the PRTR project and the data set is stored in the Central Database.

The 650 emissions sources are logically divided into 55 work packages. An emissions expert is responsible for one or more work packages, the collection of the data and the calculation of the emissions. The experts are also closely involved in developing the methodologies to calculate the emissions. Work packages are grouped into five Task Forces, as described below.

Task Force on Energy, Industry and Waste Management (ENINA)
Covers emissions to air from the Industry, Energy production, Refineries and Waste management sector. ENINA includes emissions experts from the following organizations: RIVM, TNO, Statistics Netherlands (CBS),

Rijkswaterstaat Environment (Waste Management Department), Deltares and Fugro-Ecoplan.

Task Force on Transportation
Covers the emissions to soil and air from the Transportation sector (aviation, shipping, rail and road transport). The following organizations are represented: PBL, CBS, Rijkswaterstaat, Deltares and TNO.

Task Force on Agriculture
Covers the calculation of emissions to soil and airfrom agriculture. Participating organizations include RIVM, PBL, Wageningen University and Research Centre (WUR), Alterra, CBS and Deltares.

Task Force on Water (MEWAT)
Covers the calculation of emissions from all sectors to water. MEWAT includes Rijkswaterstaat, Deltares, PBL, RIVM, CBS and TNO.

Task Force on Consumers and other sources of emissions (WESP)
Covers emissions caused by consumers, trade and services. The members are emissions experts from RIVM, TNO and CBS.

1.2.2.1 Responsibility for reporting
The NIR Part I is prepared by the 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. RVO.nl also prepares the NIR Part II 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 EZK.

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 II. This information is prepared by the RVO.nl using information from various other organizations involved, such as the NEa (Dutch Emissions Authority), the WUR and the EZK.

1.2.3 Reporting, QA/QC, archiving and overall coordination
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 EZK formally approves the NIR before it is submitted; in some cases, approval follows consultation with other ministries. RVO.nl is responsible for coordinating 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 coordinating 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 aggregation to

the KP-LULUCF activities. The data and calculations are thus subject to the same QA/QC procedures (Arets et al., 2018).

The calculated values were generated using the LULUCF bookkeeping model at Wageningen Environmental Research (Alterra) and checked by the LULUCF sectoral expert. They were then sent to the GHG emission 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 required the establishment of the National System for the monitoring of GHGs and empowered the Minister of Economic Affairs and Climate Policy (EZK) to appoint an authority responsible for the National System and the National GHG Emissions 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, 2017) are summarized in this chapter, notably those relating to the current NIR.

1.2.3.2 QA/QC procedures for the CRF/NIR 2018

The system of methodology reports was developed 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, and this is now included in the methodology reports (which are an integral part of this 2018 submission, see Annex 7). The methodology reports sometimes refer to background documentation. Most of the background documentation is in English and can be made available for review purposes. This does not diminish the constant attention given by the Task Forces to further improve the quality and transparency of the methodology reports.
- In 2017 the Netherlands started a special project for the improvement of notation keys in the CRF tables. This resulted in much better filling of CRF with notation keys for the year 2015. In the preparation of this submission the explanations of the notation keys were improved but due to technical problems they are not yet included in the CRF, but are submitted for the year 2016 in a separate file Table9.xlsx.

- For the NIR 2018, changes were incorporated into both methodology reports and background documents. The methodology reports were published on the National System website (http://english.rvo.nl/nie) and are an integral part of the NIR 2018 (see Annex 7).

To facilitate the general QC checks, a checklist was developed and implemented. A number of general QC checks have been added to 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 filled in a standard-format database with emissions data for 1990–2016 (with the exception of LULUCF). After a first check of the data by the RIVM and TNO for completeness, the (corrected) data were made available to the relevant Task Forces for consistency checks and trend analyses (comparability, accuracy). The Task Forces had access to the national emissions database. Several weeks before the dataset was fixed, a trend verification workshop was organized by the RIVM (7 December 2017). The conclusions of this workshop (including how the Task Forces should resolve the clarity issues that had been identified) are documented at the RIVM. Required changes to the database were then made by the Task Forces.

Basic LULUCF data (e.g. forest inventories, forests statistics and land use maps) do not have the same routing as the other basic data (see Figure 1.1). QA/QC for these data are elaborated in the description of QA/QC of the external agencies (Wever, 2011).

QA for the current NIR includes the following activities:

- A peer and public review on the basis of the draft NIR in January/February 2018. Results of these reviews are summarized in Chapter 10 and the issues raised have been addressed as far as possible in the present NIR.
- In preparing this NIR, the results of former UNFCCC reviews and ESD reviews are taken into account and the requested improvements were made.

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, 2017), which 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. Figure 1.1 summarizes the main elements of the annual QA/QC cycle, including the corresponding timeline. To ensure high-quality and continuous improvement, the annual inventory process is implemented as a cyclical project.

This cycle is a key quality management tool (based on the Deming cycle of Plan–Do–Check–Act).

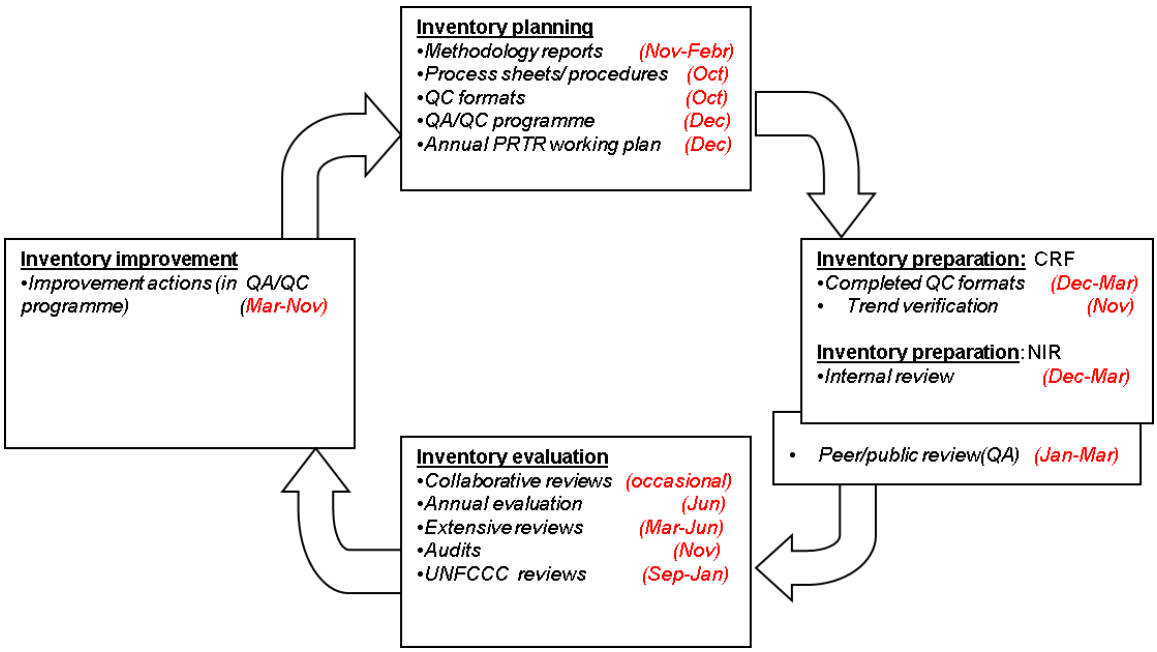


Figure 1.1: QA/QC cycle (including timeline)

- *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, 2017). 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 the 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 in the calculation of the national total emissions. (CO_2 emissions, however, are based on energy statistics from CBS and standard EFs, and only approved specific EFs from AERs are used.)
- *European Emission Trading Scheme (EU-ETS).* Selected companies (large emitters) are part of the EU-ETS. They are obliged to report their CO_2 emissions in accordance with strict monitoring procedures, which include strict QA/QC. The reported emissions are checked and approved by the Dutch Emission authority (NEa) and used in the inventory for QC and to calculate specific EFs.
- *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 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 institutions involved;
  - 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 setting these levels the Netherlands is strict, as, according to the IPCC 2006 Guidelines, 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 into 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 external agencies.
  - The methodology reports have been updated and documented and are an integral part of this submission (see Annex 7); they 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. RVO.nl (as the NIE) maintains the National System website and a central archive of relevant National System documents.
  - RVO.nl's own QA/QC procedures apply whenever a contributing institution cites or quotes data from the annually fixed database in their own reports.
- *Annual inventory improvement*: Within the inventory project, resources are made 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, air pollutants 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 priority over 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.
- *Category-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 improve and update the assessment of uncertainties and the sector-specific QC activities. A revised uncertainty assessment (Approach 2 using Monte Carlo analysis) of Dutch GHG emissions is included in this NIR.

1.2.3.3 Verification activities for the CRF/NIR 2018

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 inconsistency 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 gas. During the trend analysis, the GHG emissions for all years between 1990 and 2016 were checked in two ways:

(1) The datasets from previous years' submissions were compared with the current submission; emissions from 1990 to 2015 should be identical to those reported last year for all emissions for which no methodological changes have been announced.

(2) The data for 2016 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 2015 and 2016. 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 2017 and 2018, 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 2018.

Table 1.1: Key actions for the NIR 2018

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 outstanding issues for this inventory	10-07-2017	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten voorlopige cijfers 10 juli 2017. xls
Comparison sheets with final data	5-12-2017	RIVM	Input for trend analyses	Verschiltabel_LuchtIPCC_05-12-2017.xls
Trend analysis	7-12-2017	Task Forces	Updated action list	Actiepunten definitieve cijfers v 14 december 2017.xls

Item	Date	Who	Result	Documentation
Resolving the issues on the action list	Until 19-12-2017	Task Forces RIVM/NIC/TNO	Final dataset	Actiepunten definitieve cijfers v 19 december 2017.xls
Comparison of data in CRF tables and EPRTR database	Until 10-2-2018	NIC/TNO	First draft CRF sent to the EU and final CRF to EU	17-01-2018 15-03-2018
Writing and checks of NIR	Until 15-3-2018	Task Forces/ NIC/TNO/NIE	Draft texts	S:\ \NI National Inventory Report\NIR 2018\NIR redactie
Generation of tables for NIR from CRF tables	Until 15-3-2018	NIC/TNO	Final text and tables NIR	NIR 2018 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 three principal institutes: RIVM, PBL and CBS. The acceptance of the dataset was, furthermore, a subject of discussion by the PRTR executive body (WEM).

The internal versions of the CRF and NIR and all documentation (emails, data sheets and checklists) 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 are 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 emissions inventory in the Netherlands is summarized in Figure 1.2. This process comprises three major steps, which are described in greater detail in the following sections.

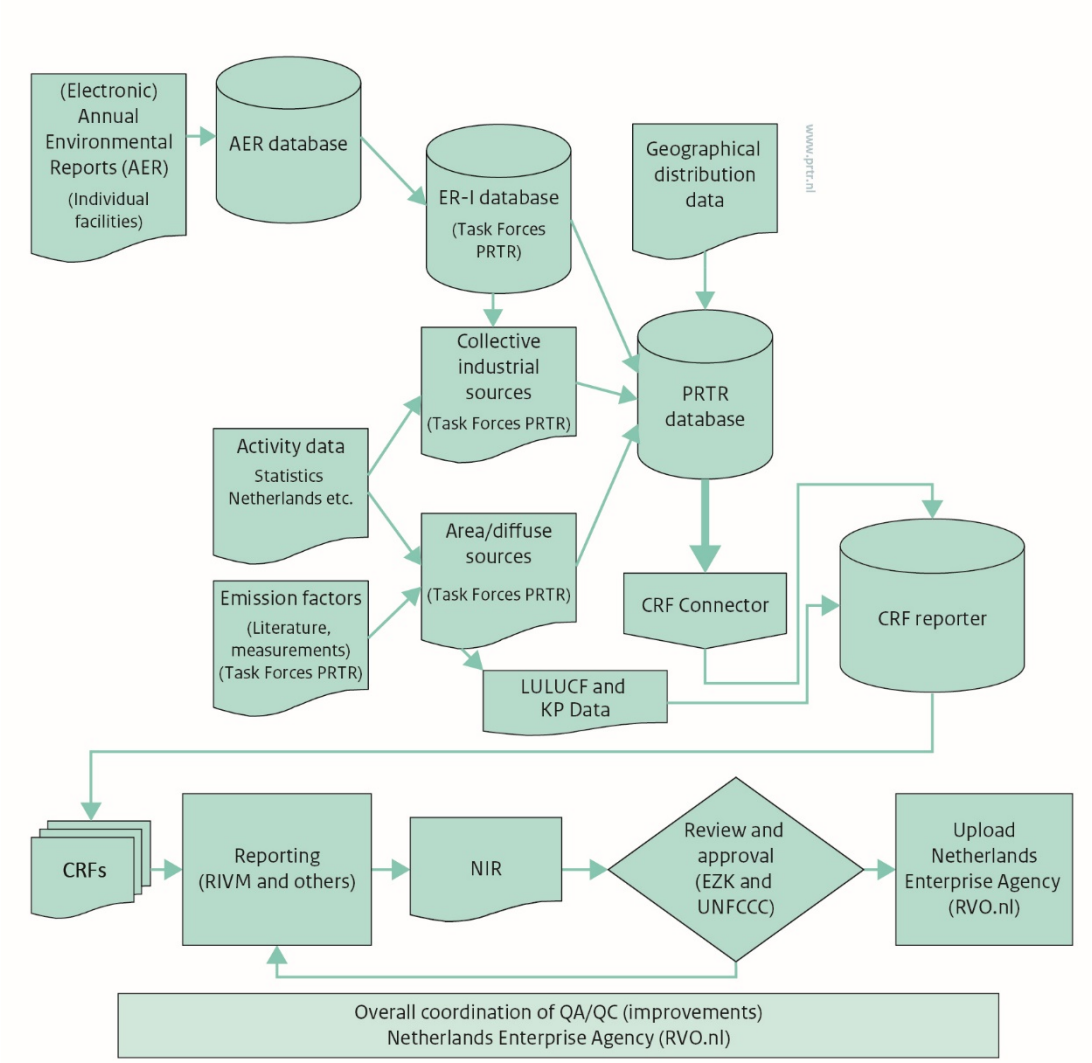


Figure 1.2: Main elements in the GHG emissions inventory process

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.

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 are provided under various (not specifically GHG-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 EZK. For GHGs, relevant agreements with Statistics Netherlands and Rijkswaterstaat

Environment with respect to waste management are in place. An agreement with the Ministry of Agriculture, Nature and Food Quality (LNV) and related institutions was established in 2005.

Data from individual companies

Data from individual companies are 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).

Every industrial activity in the Netherlands requires an environmental permit. As part of the permit application the operator has to submit a documented account of the emissions and the production capacity (which need not be made available to the general public). On the basis of these data, the competent authority will set (emissions) limits in the environmental permit. The determination of the applicable (emissions) limits is based on national policies and the specific expertise from the competent authorities. This expertise is also used in the annual verification of the emissions in the environmental reports. The national inventory relies on this verification and only performs sample checks on these data. This procedure is only possible due to the country-specific situation in the Netherlands where industry is fully aware of the need for emissions reductions as required by the legislation. This results in a very open and constructive communication (on activity levels and emissions) between plant operators and competent authorities (although these data are not available to the general public). For this reason the inventory team can limit the verification of the emissions data from individual companies to a minimum.

Some companies provide data voluntarily within the framework of environmental covenants. Large companies are also obliged to participate in the European Emission Trading System (EU-ETS). These companies have to report their CO_2 emissions in specific annual ETS emissions reports.

Whenever these 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.

Many Dutch industrial (sub)sectors consist of just a single company. This is the reason why the Netherlands cannot report activity data (confidential business information) in the NIR or CRF on the most detailed level. Although this may hamper the review process, all confidential data can and will be made available to the ESD (on request) and UNFCCC review teams.

Additional GHG-related data

Additional GHG-related data are 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 Ministry of Economic Affairs (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 coordinated by the RIVM. These processes consist most notably of the elaboration of emissions estimates and data preparation in the PRTR database. The emissions data are 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 are extracted from the PRTR database and included in the CRF Reporter, thus ensuring the highest level of consistency. Data from the CRF Reporter are 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, IPPU 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, CBS, Centre for Water Management, Deltares, Fugro-Ecoplan (which coordinates 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 the TNO to assist in the compilation of the CRF tables (see Figure 1.3).

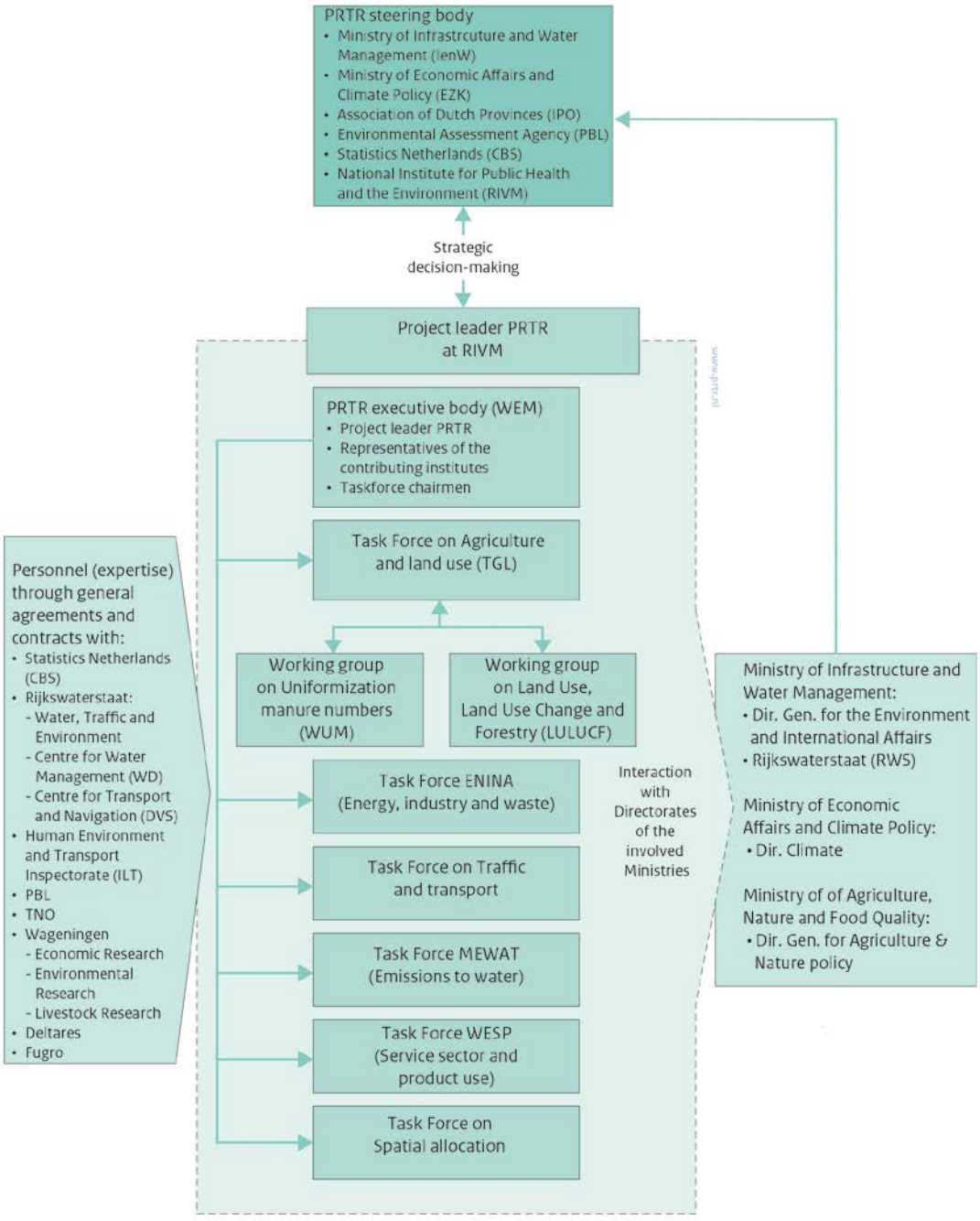


Figure 1.3: Organizational arrangements for PRTR project

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

1.4.1 GHG emissions 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 emissions 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	OTH,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,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	OTH,T1,T1b,T2,T3	CS,D,PS		
1. Solid fuels	T2	CS	OTH			
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	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,T1b,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				
H. Urea application						
I. Other carbon-containing fertilizers						

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
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,T2	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,T2	CS,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 CBS (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 CBS (Renewable Energy);
- Transport statistics: (1) monthly statistics for traffic and transport; (2) national renewable energy statistics from CBS (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: CBS /LEI agricultural database, plus data from the annual agricultural census;
- Manure production and handling: CBS /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 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);
- Area of organic soils: Vries (2004);
- Soil maps: Groot et al. (2005a and b);
- Waste production and handling and CH_4 recovery from landfills: Working Group on Waste Registration (WAR), Rijkswaterstaat Environment and CBS.

Many recent statistics are available at CBS's statistical website StatLine and in the CBS/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 managementmanagement (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 and van Dorland, 2009; Van den Wyngaert 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 (Vries de et al., 2004). The result was a map with national coverage that identifies for each pixel whether it was subject to afforestation/reforestation (AR), deforestation (D) or Forest management (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 emissions 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 and van Dorland, 2009), 2009 and 2013 (Kramer and Clement, 2015).

1.5 Brief description of key categories

1.5.1 GHG emissions 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 category 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. Please note that the Netherlands uses a country-specific aggregation of sources. In this way we accommodate the use of the key source analysis for the prioritization of possible

inventory improvement actions.

In comparison with the key source analysis for the NIR 2018 submission, one new key source was identified:

- 5D Wastewater treatment and discharge (CH_4).

Key sources in the previous submission that are no longer key sources are listed below:

- 1B1b Solid fuel transformation (CO_2);
- 2C1 Iron and steel production (CO_2);
- 2C3 Aluminium production (CO_2);
- 2G Other product manufacture and use (N_2O);
- 3G Liming (CO_2).

The first two of these differences are the result of a reallocation of emissions from iron and steel production to the Energy sector. The others are due to reduced emissions.

1.5.2 KP-LULUCF inventory

The smallest key category based on the Approach 1 level analysis including LULUCF is 755.2 Gg CO_2 (2B4 Caprolactam production; see Annex 1). With net emissions of 783.40 Gg CO_2, the absolute annual contribution of afforestation/reforestation under the KP-LULUCF in 2016 is larger than the smallest key category (Approach 1 level analysis including LULUCF). Deforestation under the KP-LULUCF in 2016 causes a net emission of 1,311.24 Gg CO_2, which is also more than the smallest key category (Approach 1 level analysis including LULUCF). With a net figure of 1,319.63 Gg CO_2, emissions from Forest management are also larger than the smallest key category.

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

The IPCC Approach 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. The IPCC Approach 2 methodology for estimating uncertainty in annual emissions has been applied to all of the emissions sources in order to obtain an estimate of the uncertainties in annual emissions (and to compare this to the Approach 1 methodology).

1.6.1 GHG emissions inventory

Approach 1 uncertainty – propagation of error

The following information sources were used for estimating the Approach 1 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 Approach 1 assessment (Ramírez-Ramírez et al., 2006).

The uncertainty of waste incineration, landfilling and composting, and digestion is described in a separate report (Onzekerheid emissies afval, voor stortplaatsen, AVI's en composteren en vergisten. - Utrecht : RWS Water, Verkeer en Leefomgeving, 2014. - 52 p. - 978-94-91750-08-3. Dutch only).

These data sources were supplemented by expert judgements by RIVM/PBL and CBS 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 2016 according to the IPCC Approach 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 Approach 1 are summarized in Annex 2 of this report. The Approach 1 calculation of annual uncertainty in CO_2-equivalent emissions results in an overall uncertainty of approximately 3% in 2016, based on calculated uncertainties of 2%, 17%, 41% and 41% 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 an Approach 2 uncertainty assessment.

Approach 2 uncertainty – Monte Carlo analysis

Currently, an Approach 2 uncertainty assessment (using Monte Carlo analysis) is implemented in the Dutch emissions inventory and this is used as a comparison with the Approach 1 results.

Most of the uncertainty estimates now incorporated in the Dutch Inventory database are based on the results of expert elicitations (within the Task Forces ENINA (Energy/Industry/Waste), Traffic and transport, Agriculture, and WESP (product use)). For the sectors Agriculture and Waste, the expert elicitation was combined with a recent Approach 1 uncertainty calculation (Agriculture and Waste). For LULUCF a sector-specific Approach 2 uncertainty calculation was already available from the Task Force.

The expert elicitations were set up following the expert elicitation guidance in the IPCC 2006 Guidelines (motivating, structuring, conditioning, encoding and verification). These expert elicitations were performed to assess the uncertainties of the individual source-specific activity data and EFs separately (this detailed approach is more detailed than the uncertainty assessment on the level of the CRF categories). Correlations between activity data and the EFs of different emissions sources have been included in the Monte Carlo analysis (as far as possible). These correlations are included for the following types of data:

- Activity data:
  - The energy statistics are more accurate on an aggregated level (e.g. for Industry) than on a detailed level (e.g. for the individual industry sectors separately). This type of correlation is also used in several Transport sub-sectors (such as road transport, shipping and aviation).
  - The number of animals in one emission source is correlated to the number of animals in another emission source. This type of correlation is used were the identifier of the activity (animal number or inhabitants) has to be equal in different source/ pollutant combinations.
- Emission factors
  - The uncertainty of an EF of a fuel from stationary combustion is assumed to be equal for all of the sources that use the specific fuel in the stationary combustion sector. This type of correlation is also used in several Transport subsectors (such as shipping and aviation).
  - The EF for the different types of cows (cows for meat production or dairy cows) are assumed to be correlated. The same holds for the EF for ducks and chickens, and for horses and asses.

The results of the Approach 2 uncertainty analysis are presented in Table 1.3.

Table 1.3: Uncertainty (95% confidence ranges) for CO_2, CH_4, N_2O, F-gases and total CO_2 equivalents for each CRF category and for the national total. The uncertainty is calculated for emissions in 2016, using the Approach 2 uncertainty assessment (Monte Carlo analysis).

CRF category	CO_2	CH_4	N_2O	F-gases	Total (CO_2 eq.)
1	3%	31%	25%		3%
2	10%	65%	21%	25%	10%
3	25%	10%	35%		13%
4	51%				51%
5		23%	13%		21%
Total	3%	9%	27%	25%	3%

Results of the uncertainty analyses

The results of the calculated Approach 2 uncertainty analysis are of the same order of magnitude as the Approach 1 uncertainty assessment for total CO_2 equivalents. For methane, nitrous oxide and F-gases, the uncertainty according to Approach 2 is somewhat lower. Table 1.4 shows the currently estimated values for the Approach 1 and Approach 2 analyses.

Table 1.4: Approach 1 and the Approach 2 uncertainty assessment of 2016 emissions (without LULUCF)

Greenhouse gas	Approach 1 annual uncertainty	Approach 2 annual uncertainty
Carbon dioxide	3%	3%
Methane	17%	10%
Nitrous oxide	41%	27%
F-gases	41%	25%
Total	3%	3%

From Table 1.4 it can be seen that taking into account the correlations between source categories increases the uncertainty of the national CO_2 emissions figure. For the other gases the Approach 2 analysis yields lower uncertainties. The lower uncertainties in the Approach 2 calculations are also caused by lower initial uncertainties. For example, for agriculture, the overall uncertainty of CH_4 emissions is lower in the Approach 2 assessment than in the Approach 1 assessment.

Table 1.5 shows the ten sources (excluding LULUCF) contributing most to total annual uncertainty in 2016, 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 2016' in Table A7.1).

Table 1.5: Ten sources contributing most to total annual uncertainty in 2016 (based on the Approach 1 uncertainty assessment)

IPCC cat.	Category	Gas	Combined uncertainty as a percentage of total national emissions in 2016
3Da	Direct emissions from agricultural soils	N_2O	1.6%
1A2	Manufacturing industries and construction, liquids	CO_2	1.1%
3B1	Cattle	CH_4	1.1%
1A1b	Petroleum refining: liquids	CO_2	0.9%
3B3	Swine	CH_4	0.9%
3Db	Indirect emissions from managed soils	N_2O	0.7%
2F1	Refrigeration and air-conditioning	HFC	0.6%
1A1a	Public electricity and heat production: solids	CO_2	0.6%
3A1	Mature dairy cattle	CH_4	0.5%
1A4a	Commercial/Institutional: gaseous	CO_2	0.4%

Table A2.1 of Annex 2 summarizes the estimates of the trend uncertainties 1990–2016 calculated according to the IPCC Approach 1 analysis set out in the 2006 IPCC Guidelines. The result is a trend uncertainty in total CO_2-equivalent emissions (including LULUCF) for 1990–2016 (1995–2016 for F-gases) of ±2%. This means that the trend in total CO_2-equivalent emissions between 1990 and 2016 (excluding

LULUCF), which is calculated to be a 12.5% decrease, will be between a 10% decrease and a 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 1.6 shows the ten sources (excluding LULUCF) contributing most to the calculated trend uncertainty in the national total.

Table 1.6: Ten sources contributing most to trend uncertainty in the national total in 2016 (based on the Approach 1 uncertainty assessment)

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	0.6%
2F1	Refrigeration and air-conditioning	HFC	0.5%
2B	Fluorochemical production	HFC	0.5%
1A4a	Commercial/Institutional: gaseous	CO_2	0.5%
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO_2	0.5%
3B3	Swine	CH_4	0.5%
3Da	Direct emissions from agricultural soils	N_2O	0.4%
3B1	Cattle	CH_4	0.4%
1B2	Fugitive emissions from oil and gas operations	CO_2	0.3%

Six 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 Approach 1. 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 sources.
This is supported by the recent Approach 2 uncertainty assessment (Monte Carlo analysis), which reveals that the Approach 2 uncertainty is of the same order of magnitude as that found in the Approach 1 results (see Table 1.4). This is also in line with the 2006 Approach 2 uncertainty assessment as reported in former NIRs (Ramírez-Ramírez et al., 2006).

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 Approach 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 Approach 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 Approach 1 approach. Although a one-to-one comparison was 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 was that correlations (covariance and dependencies in the emissions calculations) seem somewhat under-addressed in most recent European Approach 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 the methodology used for the calculations did not include systematic errors, which in practice can occur.

An 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 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 is estimated at 63%, 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%, 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%, 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 emissions 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 managementFM.

In the Netherlands, the 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 AR 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 trees, the accumulation of carbon in dead wood in AR 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 becomes 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.

Fertilization does not occur in forests in the Netherlands. Therefore, fertilization in re/afforested areas and areas under Forest management is reported as NO. Fertilization on Grassland and Cropland is included in the Agriculture sector.

2 Trends in GHG emissions

2.1 Emissions trends for aggregated GHG emissions

This chapter summarizes the trends in GHG emissions during the period 1990–2016 by GHG and by sector. Detailed explanations of these trends are provided in Chapters 3–8. In 2016, 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 12.4% lower than the 222.9 Tg CO_2 eq. reported in the base year (1990; 1995 for F-gases).

Figure 2.1 shows the trends and contributions of the different gases to the aggregated national GHG emissions. In the period 1990–2016, emissions of carbon dioxide (CO_2) increased by 1.6% (excluding LULUCF). Emissions of non-CO_2 GHGs methane (CH_4), nitrous oxide (N_2O) and F-gases decreased by 42%, 53% and 73%, respectively.

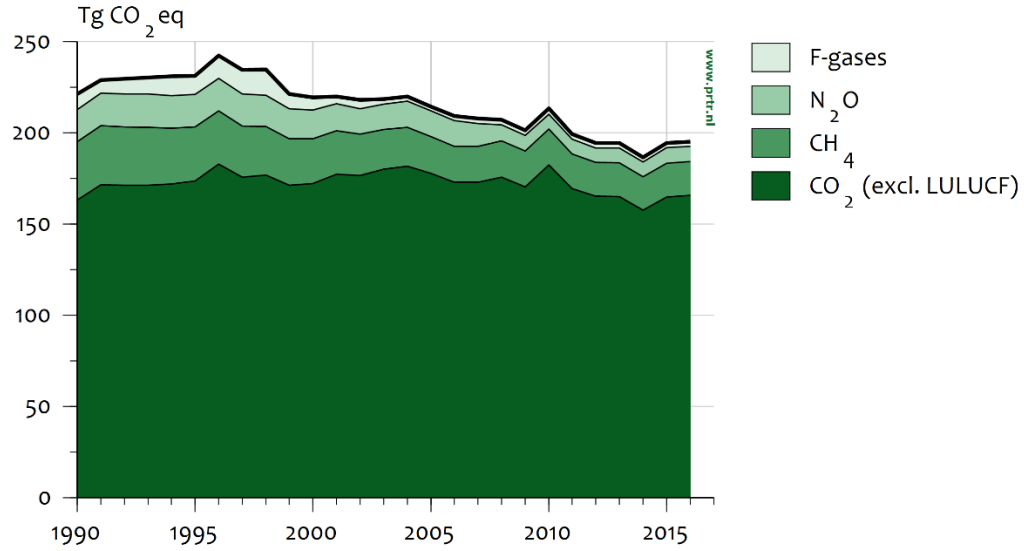


Figure 2.1: Greenhouse gases: trend and emissions levels (excl. LULUCF), 1990–2016

Emissions from LULUCF-related sources increased over the period 1990–2016 by about 8%. Total GHG emissions in the Netherlands for the year 2016 (including LULUCF) was 201.9 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 1990–2016, national CO_2 emissions increased by 1.6% (from 163.1 to 165.7 Tg). The Energy sector is by far the largest contributor to CO_2 emissions in the Netherlands (96%), the categories 1A1 Energy industries (41%), 1A4 Other sectors (20%) and 1A3 Transport (18%) being the largest contributors in 2016.

The relatively high level of CO_2 emissions in 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).

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 2016).

Carbon storage is not applied in the Netherlands.

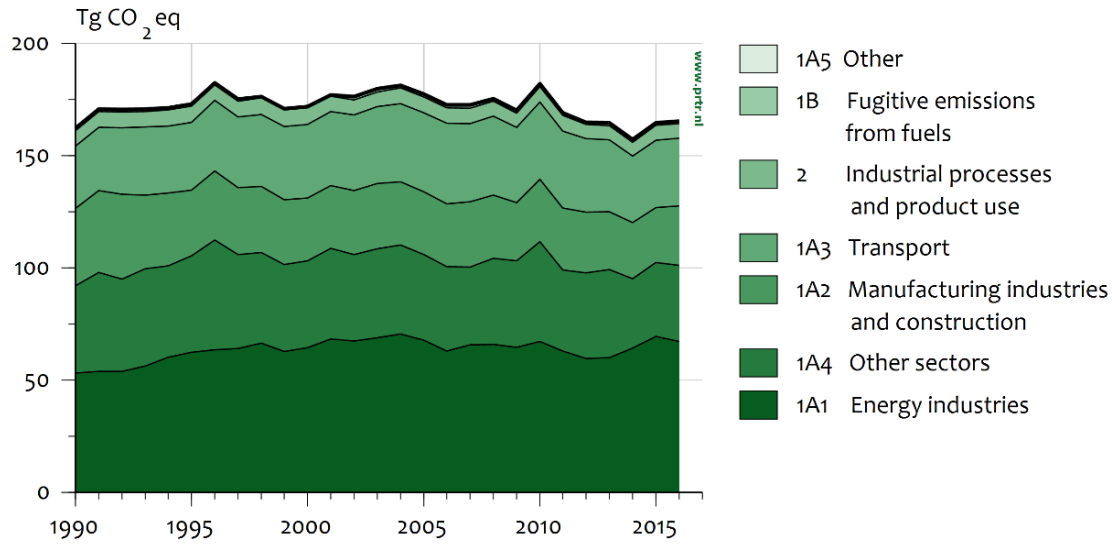


Figure 2.2: CO_2 – trend and emissions levels of sectors (excl. LULUCF), 1990–2016

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 42%, from 32.0 Tg in to 18.6 Tg CO_2 eq., between 1990 and 2016. The Agriculture and Waste sectors (69% and 17%, respectively) were the largest contributors in 2016.

Compared with 2015, national CH_4 emissions increased by about 0.8 % in 2016 (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. This increase was due to higher animal numbers in 2016.

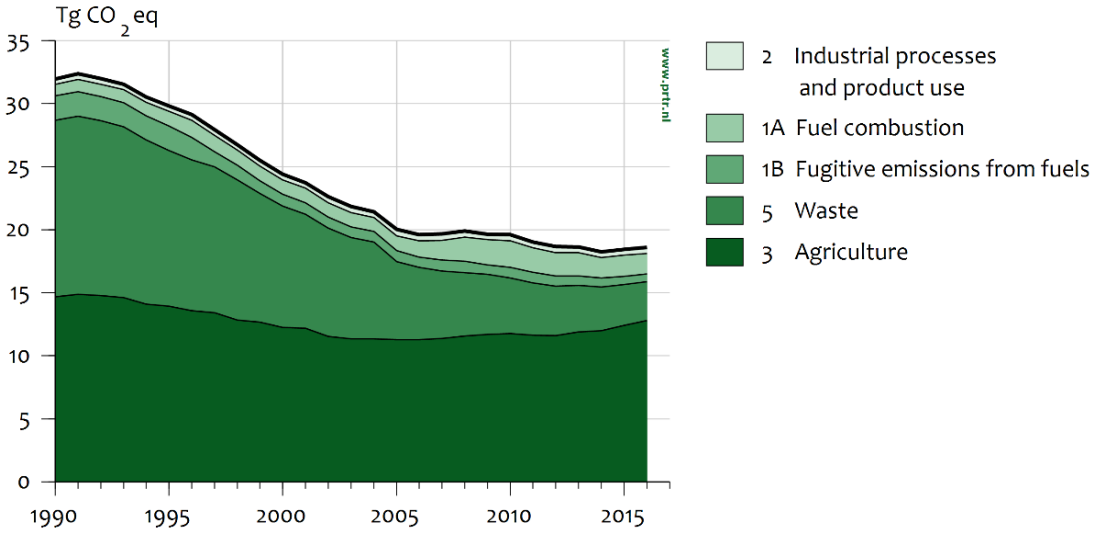


Figure 2.3: CH_4 – trend and emissions levels of sectors, 1990–2016

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 8.2 Tg CO_2 eq. in 2016. The IPPU sector contributed the most to this decrease in N_2O emissions (emissions decreased by almost 81% compared with the base year).

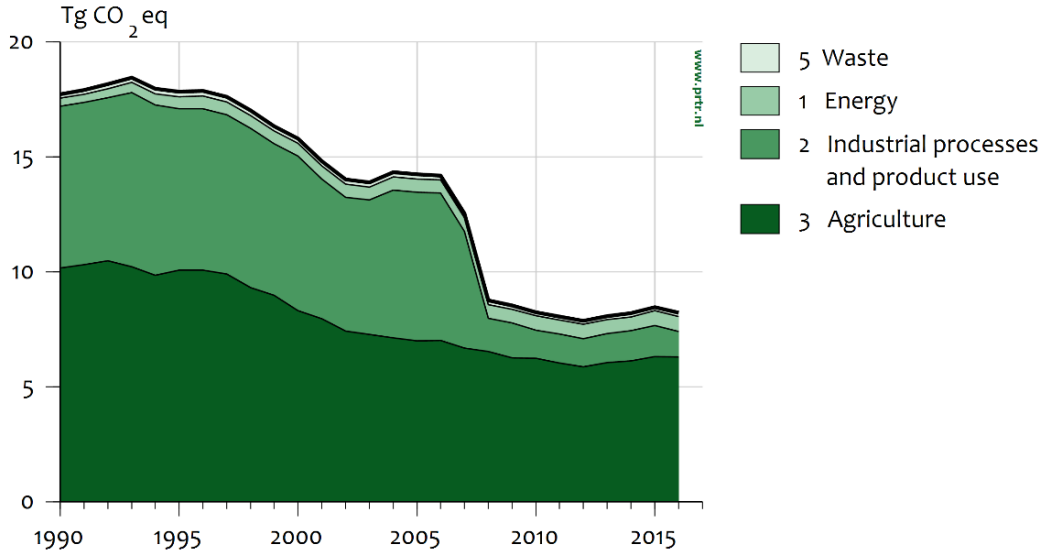


Figure 2.4: N_2O – trend and emissions levels of sectors, 1990–2016

Compared with 2015, total N_2O emissions decreased by 3.0% in 2016, mainly due to lower emissions in nitric acid and caprolactam production.

2.2.4 *Fluorinated gases*

Figure 2.5 shows the trend in F-gas emissions included in the national GHG emissions inventory. Total emissions of F-gases decreased by 73%

from 10.1 Tg CO_2 eq. in 1995 (base year for F-gases) to 2.7 Tg CO_2 eq. in 2016. Emissions of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) decreased by approximately 68% and 93%, respectively, during the same period, while sulphur hexafluoride (SF_6) emissions decreased by 49%. It should be noted that due to national circumstances (no separate registration of NF_3) the emissions of NF_3 can not be reported separately and are included in the PFC emissions.

HFCs emissions increased by 1.9% and PFCs emissions increased by 45.7% between 2015 and 2016. The latter increase was the result of the restart of an aluminium plant in 2016. SF_6 emissions increased by 3.8% in the same period. Aggregated emissions of F-gases decreased by 3.3%.

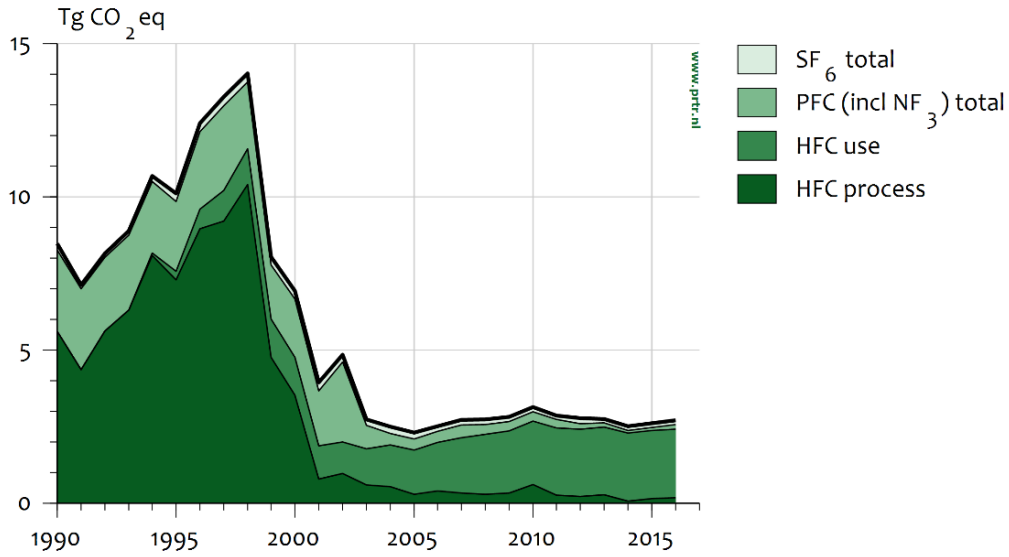


Figure 2.5: Fluorinated gases – trend and emissions levels of individual F-gases, 1990–2016

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 Approach 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 ±17% and ±41%, respectively, and for HFCs, PFCs and SF_6 also ±41% (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.

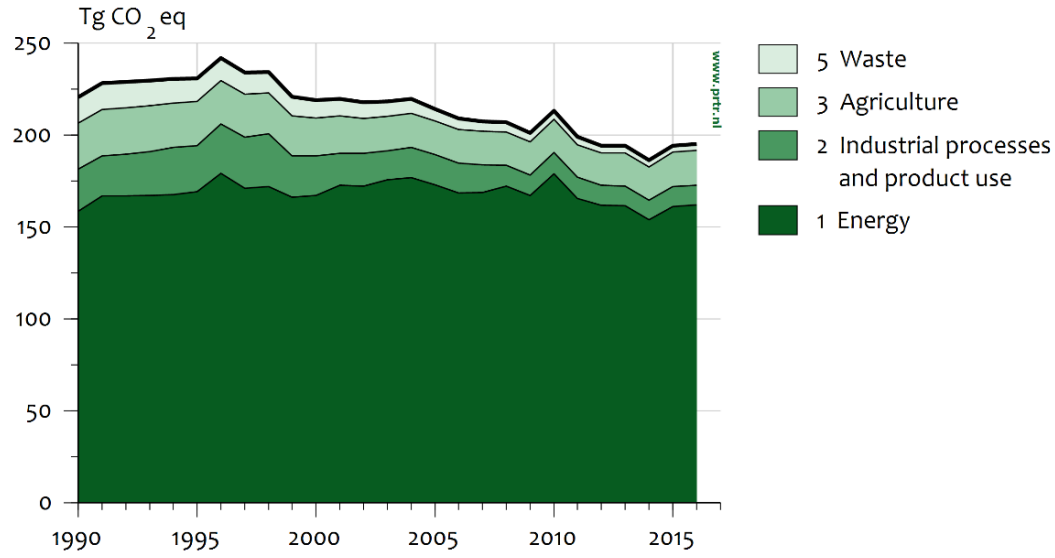


Figure 2.6: Aggregated GHGs – trend and emissions levels of sectors (excl. LULUCF), 1990–2016

The Energy sector is by far the largest contributor to total GHG emissions in the national inventory (contributing 69% in the base year and 80% in 2016. The emissions level of the Energy sector increased by approximately 2% in the period 1990–2016.
Total GHG emissions from the sectors Waste, IPPU and Agriculture decreased by 77%, 57% and 23%, respectively, in 2016 compared with the base year. LULUCF emissions increased by 10% 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), IPPU (2), Agriculture (3) and Waste (5) are about ±2%, ±13%, ±23% 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 (IPPU) at ±5% in the 57% decrease, for sector 3 (Agriculture) at ±8% in the 23% 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 2016 reduced by 52% and 71%, respectively. For SO_2, the reduction was 86%; and for NO_x, 2016 emissions were 62% 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 lower 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.

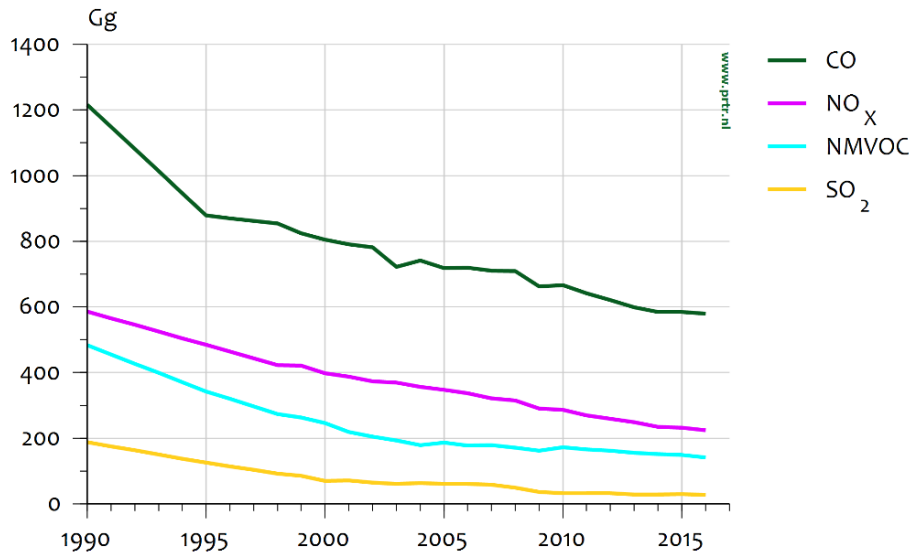


Figure 2.7: Emissions levels and trends of CO, NO_x, NMVOC and SO_2, 1990–2016 (Gg)

3 Energy (CRF sector 1)

Major changes in the Energy sector compared with the National Inventory Report 2017

Emissions:	Compared with 2015, GHG emissions in 2016 in the Energy sector increased by 1.5%.
Key sources:	Compared with the NIR 2017, 1B1b Solid fuel transformation (CO_2) is no longer a key source. The emissions are now included in 1.A.1.c.
Methodologies:	The reporting of the emissions from the integrated iron and steel plant (Tata steel) in the Netherlands have improved based on improved mass balance data from the company. This results in a reallocation of CO_2 emissions, but the total CO_2 emissions from the iron and steel industry remains the same. In the transport category improvements were made in fuel use data and emission factors. The most important change was the correction of the CO_2 emission factors for gasoline and diesel based on measurements in fuels.
Activity data:	Statistics on the consumption of gas/diesel oil have been revised for the complete time series. The revision of the energy statistics in 2015 was not yet fully implemented in the CRF 2017 submission. The next two revisions are included in the 2018 submission: • The activity data in 1A1, 1A2 and 1A4 for the years 1991–1994 have been revised. • The activity data for biomass combustion 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.

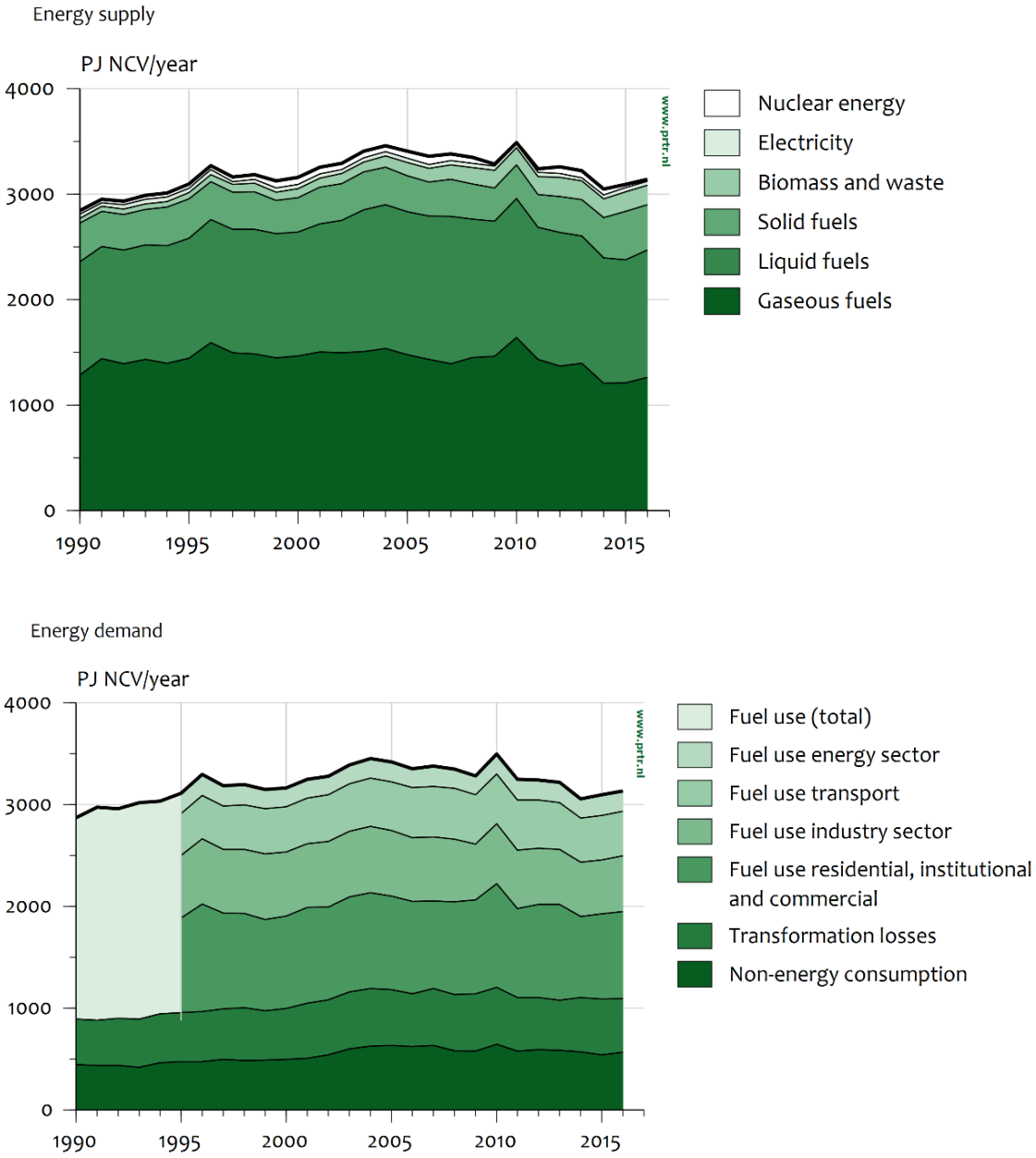


Figure 3.1: Overview of energy supply and energy demand in the Netherlands, 1990–2016 ('Electricity' refers to imported electricity only)

Trends in fossil fuel use and fuel mix

Natural gas represents a very large share of national energy consumption in all non-transport subsectors: 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 1990–2016 period, total fossil fuel combustion increased by 4%, due to a 26% increase in solid fuel consumption and a 9% increase in

liquid 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, which started in 2014 and increased production in 2015.

The winter temperature has a large influence on 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 prime 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 emission. 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 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 total national GHG emissions, it is not surprising that a large number of CO_2

sources are identified as key sources. CH_4 emissions from stationary combustion sources in the residential sector and in agriculture, forestry and fisheries are also identified as key sources.

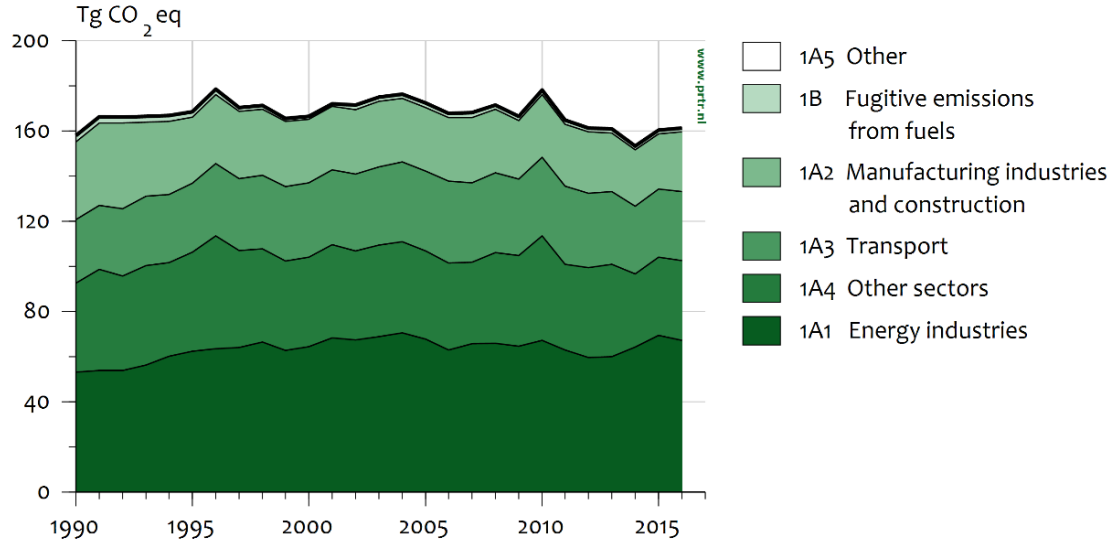


Figure 3.2: Sector 1 Energy – trend and emissions levels of total greenhouse gas emissions per source category, 1990–2016

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 2016 (%)		
Sector / category	**Gas**	**Key?**	**Base year**	**2015**	**2016**	**Change 2015–2016**	**By sector**	**Of total gases**	**Of total CO_2 eq.**
1 Energy	CO_2	-	155.4	158.5	159.1	0.6	98.2%	96.0%	81.5%
	CH_4	-	2.9	2.3	2.2	-0.1	1.4%	11.9%	1.1%
	N_2O	-	0.3	0.7	0.6	0.0	0.4%	7.9%	0.3%
	All	-	158.6	161.4	161.9	0.8	100.0%		82.9%
1A Fuel combustion	CO_2	-	154.5	157.4	158.0	0.5	97.6%	95.3%	80.9%
	CH_4	-	0.9	1.7	1.6	-0.1	1.0%	8.6%	0.8%
	N_2O	-	0.3	0.7	0.6	0.0	0.4%	7.9%	0.3%
	All	-	155.8	159.8	160.2	0.5	98.9%		82.1%
1A1 Energy industries	CO_2	-	53.1	69.4	67.3	-2.1	41.5%	40.6%	34.5%
	CH_4	-	0.1	0.1	0.1	0.0	0.1%	0.6%	0.1%
	N_2O	-	0.1	0.3	0.3	0.0	0.2%	3.7%	0.2%
	All	-	53.4	69.8	67.7	-2.2	41.8%		34.7%
1A1a Public elec./heat prod.	CO_2	-	40.0	56.0	54.9	-1.1	33.9%	33.1%	28.1%
1A1a liquids	CO_2	L1, T	0.2	0.8	0.7	0.0	0.4%	0.4%	0.4%
1A1a solids	CO_2	L, T	25.9	37.3	34.0	-3.3	21.0%	20.5%	17.4%
1A1a gas	CO_2	L1, T1	13.3	15.1	17.2	2.1	10.6%	10.4%	8.8%
1A1a other fuels	CO_2	L, T	0.6	2.9	3.0	0.1	1.8%	1.8%	1.5%

			Emissions in Tg CO_2 eq.			Tg CO_2 eq.	Contribution to total in 2016 (%)		
Sector / category	**Gas**	**Key?**	**Base year**	**2015**	**2016**	**Change 2015–2016**	**By sector**	**Of total gases**	**Of total CO_2 eq.**
1A1b Petroleum refining	CO_2	-	11.0	10.1	9.6	-0.5	5.9%	5.8%	4.9%
1A1b liquids	CO_2	L, T	10.0	7.2	7.1	-0.1	4.4%	4.3%	3.6%
1A1b gases	CO_2	L1, T1	1.0	3.0	2.5	-0.4	1.6%	1.5%	1.3%
1A1c Manufacture of solid fuels and other energy inds.	CO_2	-	2.1	3.3	2.8	-0.5	1.7%	1.7%	1.4%
1A1c solids & liquids	CO_2	L	2.1	3.3	2.8	-0.5	1.7%	1.7%	1.4%
1A1c gases	CO_2	L1, T1	1.2	1.8	1.6	1.6	1.0%	1.0%	0.8%
1A2 Manufacturing industry and construction	CO_2	-	34.5	24.7	26.5	1.7	16.3%	16.0%	13.6%
	CH_4	-	0.1	0.1	0.1	0.0	0.0%	0.3%	0.0%
	N_2O	-	0.0	0.0	0.0	0.0	0.0%	0.5%	0.0%
	All	-	34.6	24.8	26.6	1.7	16.4%		13.6%
1A2 liquids	CO_2	L, T	8.8	7.8	8.8	1.0	5.4%	5.3%	4.5%
1A2 solids	CO_2	L, T	6.6	4.1	4.5	0.4	2.8%	2.7%	2.3%
1A2 gases	CO_2	L, T1	19.0	12.8	13.2	0.4	8.1%	8.0%	6.8%
1A2a Iron and steel	CO_2	-	5.6	4.4	4.8	0.3	2.9%	2.9%	2.4%
1A2b Non-ferrous metals	CO_2	-	0.2	0.2	0.2	0.0	0.1%	0.1%	0.1%
1A2c Chemicals	CO_2	-	17.3	11.3	12.8	1.5	7.9%	7.7%	6.6%
1A2d Pulp, paper and print	CO_2	-	1.7	0.9	0.9	0.0	0.5%	0.5%	0.4%
1A2e Food processing, beverages and tobacco	CO_2	-	4.0	3.6	3.6	0.1	2.2%	2.2%	1.9%
1A2f Non metalic minerals	CO_2	-	2.3	1.2	1.2	0.0	0.8%	0.7%	0.6%
1A2g Other	CO_2	-	3.4	2.9	3.0	0.1	1.9%	1.8%	1.5%
1A3 Transport	CO_2	-	27.7	30.0	30.2	0.2	18.7%	18.2%	15.5%
	CH_4	-	0.2	0.1	0.1	0.0	0.0%	0.3%	0.0%
	N_2O	-	0.1	0.3	0.2	0.0	0.2%	3.0%	0.1%
	All	-	28.0	30.4	30.5	0.2	18.8%		15.6%
1A3a Civil aviation	CO_2	-	0.08	0.03	0.03	0.0	0.0%	0.0%	0.0%
1A3b Road vehicles	CO_2	-	26.5	28.7	29.0	0.3	17.9%	17.5%	14.8%
	CH_4	-	0.2	0.1	0.1	0.0	0.0%	0.3%	0.0%
	N_2O	-	0.1	0.2	0.2	0.0	0.1%	2.9%	0.1%
1a3b gasoline	CO_2	L, T1	10.8	11.4	11.8	0.4	7.3%	7.1%	6.0%
1a3b diesel oil	CO_2	L, T	13.0	16.8	16.7	-0.1	10.3%	10.1%	8.6%
1a3b LPG	CO_2	T	2.6	0.4	0.4	0.0	0.3%	0.2%	0.2%
1A3c Railways	CO_2	-	0.1	0.1	0.1	0.0	0.1%	0.1%	0.1%

			Emissions in Tg CO_2 eq.			Tg CO_2 eq.	Contribution to total in 2016 (%)		
Sector / category	**Gas**	**Key?**	**Base year**	**2015**	**2016**	**Change 2015–2016**	**By sector**	**Of total gases**	**Of total CO_2 eq.**
1A3d Navigation	CO_2	L1, T1	0.7	1.1	1.0	-0.1	0.6%	0.6%	0.5%
1A3e Other transportation	CO_2	-	0.3	0.1	0.1	0.0	0.1%	0.1%	0.0%
1A4 Other sectors	CO_2	-	38.9	33.1	33.9	0.8	20.9%	20.4%	17.3%
	CH_4	-	0.6	1.4	1.4	-0.1	0.9%	7.4%	0.7%
	N_2O	-	0.1	0.1	0.1	0.0	0.0%	0.6%	0.0%
	All	-	39.5	34.5	35.3	0.7	21.8%		18.1%
1A4 liquids (excl. from 1A4c)	CO_2	T	1.2	0.2	0.2	0.2	0.1%	0.1%	0.1%
1A4a Commercial/Institutional	CO_2	-	8.3	7.8	7.9	0.1	4.9%	4.7%	4.0%
	CH_4	-	0.0	0.1	0.1	0.0	0.0%	0.3%	0.0%
1A4a natural gas	CO_2	L, T	7.8	7.4	7.5	0.1	4.6%	4.5%	3.8%
1A4b Residential	CO_2	-	20.7	16.3	17.0	17.0	10.5%	10.2%	8.7%
	CH_4	L2	0.5	0.4	0.4	0.4	0.3%	0.3%	0.2%
1A4b natural gas	CO_2	T	19.9	16.1	16.8	0.7	10.4%	10.1%	8.6%
1A4c Agriculture/Forestry/Fisheries	CO_2	-	9.8	9.0	9.0	9.0	5.6%	5.5%	4.6%
	CH_4	L, T	0.1	0.9	0.9	0.9	0.6%	0.5%	0.5%
1A4c liquids	CO_2	L1	2.5	1.9	1.9	1.9	1.1%	1.1%	1.0%
1A4c natural gas	CO_2	L, T1	7.3	7.159	7.2	7.2	4.4%	4.3%	3.7%
1A5 Other	CO_2	-	0.3	0.2	0.2	0.2	0.1%	0.1%	0.1%
	CH_4	-	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%
	N_2O	-	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	-	0.9	1.0	1.1	0.1	0.7%	0.7%	0.6%
	CH_4	-	1.9	0.6	0.6	0.0	0.4%	3.3%	0.3%
	All	-	2.8	1.7	1.7	0.0	1.1%		0.9%
1B1 solid fuels transformation	CO_2	L1, T	0.1	0.1	0.1	0.0	0.0%	0.0%	0.0%
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%	1.5%	0.1%
Total national emissions (Tg)	CO_2		163.1	165.3	165.7	0.5			
	CH_4		32.0	18.4	18.6	0.2			
	N_2O		17.7	8.5	8.2	-0.3			

			Emissions in Tg CO_2 eq.			Tg CO_2 eq.	Contribution to total in 2016 (%)		
Sector / category	**Gas**	**Key?**	**Base year**	**2015**	**2016**	**Change 2015–2016**	**By sector**	**Of total gases**	**Of total CO_2 eq.**
Total national emissions (excl. CO_2 LULUCF)	All		222.9	194.8	195.2	0.5			

Note: Key sources in the 1A1, 1A2 and 1A4 categories are based on aggregated emissions of CO_2 by fuel type. See Annex 1 for more details on the key source analysis and an explanation of the abbreviations used.

3.2 Fuel combustion (1A)

In the 2016 submission, the energy statistics were revised for the years 1990 and 1995–2014. In the 2018 submission, the energy statistics for the years 1991–1994 have also been revised. This revision is similar to the revision in the 2016 submission (see NIR 2016 for more details on the revision in the energy statistics), ensuring time series consistency for this period.

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 actual 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 SA and the RA.

Energy supply balance

The energy supply balance of fossil fuels for the Netherlands in 1990 and 2016 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 not included in gross inland consumption.

Table 3.2: Energy supply balance for the Netherlands (PJ NCV/year) as reported by Statistics Netherlands

Year	Role	Indicator name	Solid fuels	Liquid fuels	Gaseous fuels
1990	Supply	Primary production	0	170	2283
		Total imports	520	5386	85
		Stock change	-22	8	0
		Total exports	-130	-3962	-1081
		Bunkers	0	-520	0
	Consumption	Gross inland consumption	-367	-1082	-1287
		whereof: Final non-energy consumption	-11	-345	-88
2016	Supply	Primary production	0	54	1671
		Total imports	1461	8374	1312
		Stock change	39	48	16
		Total exports	-1072	-6609	-1748
		Bunkers	0	-686	0
	Consumption	Gross inland consumption	-427	-1180	-1252
		whereof: Final non-energy consumption	0	-486	-82

Comparison of CO_2 emissions

The IPCC Reference Approach (RA) uses apparent consumption data (gross inland consumption) 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, stock changes and bunkers) are used to determine apparent fuel consumption, which is then combined with carbon EFs to calculate carbon content. The carbon that is not combusted but is instead used as feedstock, as a reductant or for other non-energy purposes is then deducted.

National energy statistics are provided by CBS. National default, partly country-specific, CO_2 EFs are taken from Zijlema, 2018 (see Annex 5).

The fuels from the energy statistics are allocated to the fuels in the RA, as shown in Table 3.3.

The energy statistics for motor gasoline and gas/diesel oil also contain the amount of biogasoline and biodiesel. Since the comparison between the RA and the SA is performed only for fossil fuels, biogasoline and biodiesel consumption is subtracted from the total apparent consumption of gasoline and gas/diesel oil in the RA.
The production/import/export data of biogasoline and biodiesel is confidential, and therefore no fuel supply data could be used. Instead we used biogasoline and biodiesel consumption and excluded this from 'imports' in the RA.

Table 3.3: Relation between fuel types in Reference Approach and in Dutch energy statistics

Fuel types in the Reference Approach			**Fuel types in the Netherlands' energy statistics**	
Fuel type			**Dutch**	**English**
Liquid fossil	Primary fuels	Crude oil	Ruwe aardolie	Crude oil
		Orimulsion	NO [1)]	
		Natural gas liquids	Aardgascondensaat	Natural gas liquids
	Secondary fuels	Gasoline	Additieven	Additives
			Jetfuel op benzinebasis	Gasoline type jet fuel
			Motorbenzine	Motor gasoline
			Vliegtuigbenzine	Aviation gasoline
		Jet kerosene	Vliegtuigkerosine	Kerosine type jet fuel
		Other kerosene	Overige kerosine (petroleum)	Other kerosene
		Shale oil	NO [1)]	
		Gas/diesel oil	Gas-, dieselolie en lichte stookolie	Heating and other gasoil
		Residual fuel oil	Zware stookolie	Fuel oil
		Liquefied petroleum gases (LPG)	Lpg	LPG
		Ethane	IE [3)]	
		Naphtha	Nafta	Naphtha
		Bitumen	Bitumen	Bitumen
		Lubricants	Smeermiddelen	Lubricants
		Petroleum coke	Petroleumcokes	Petroleum coke
		Refinery feedstocks	Overige aardoliegrondstoffen	Other hydrocarbons
		Other oil	Minerale wassen	Paraffin waxes
			Overige aardolieproducten	Other petroleum products
			Restgassen uit olie	Residual gas
			Terpentine en speciale benzine	White spirit and industrial spirit (SBP)
Solid fossil	Primary fuels	Anthracite	IE [2)]	
		Coking coal	IE [2)]	
		Other bituminous coal	Totaal steenkool	Total coal
		Sub-bituminous coal	IE [2)]	
		Lignite	Bruinkool	Lignite
		Oil shale and tar sand	NO [1)]	
	Secondary fuels	BKB and patent fuel	Bruinkoolbriketten	BKB (Braunkohlenbriketts)
		Coke oven/gas coke	Cokesovencokes	Coke-oven cokes
		Coal tar	Steenkoolteer	Coal tar
Gaseous fossil		Natural gas (dry)	Aardgas	Natural gas liquids
Waste (non-biomass fraction)		Other	Niet biogeen huish. afval en reststoom	Non-renewable municipal waste + residual heat
Peat			NO [1)]	
Biomass total		Solid biomass	Vaste en vloeibare biomassa [4)]	Solid and liquid biomass
		Liquid biomass	Biobenzine	Biogasoline

Fuel types in the Reference Approach			Fuel types in the Netherlands' energy statistics	
			Biodiesel	Biodiesel
		Gas biomass	Biogas	Biogas
		Other non-fossil fuels (biogenic waste)	Biogeen huishoudelijk afval	Municipal waste; renewable fraction

Notes:
1) Orimulsion, shale oil, oil shale, tar sand and peat are not used in the Netherlands.
2) Anthracite, coking coal and sub-bituminous coal are included in other bituminous coal.
3) Ethane is included in residual gas (which is included in other oil).
4) Solid and liquid biomass in the Dutch energy statistics does not contain biogasoline and biodiesel. Therefore, this is allocated to the CRF-fuel 'solid biomass'.

Table 3.4 presents the results of the RA calculation for 1990–2016, compared with the official national total emissions reported as fuel combustion (source category 1A). The annual difference calculated from the direct comparison varies between -1% and +0.5%.

Table 3.4 : Comparison of CO_2 emissions: Reference Approach (RA) versus sectoral approach (SA) (Tg)

	1990	1995	2000	2005	2010	2015	2016
RA							
Liquid fuels [1)]	50.5	52.6	53.7	55.7	52.2	47.9	48.7
Solid fuels [1)]	33.5	34.2	30.3	31.5	29.3	43.7	40.5
Gaseous fuels	68.1	76.3	77.4	78.6	87.6	62.4	66.1
Others	0.9	1.4	1.9	2.7	2.9	3.2	3.4
Total RA	153.0	164.5	163.3	168.5	172.4	157.1	158.7
SA							
Liquid fuels	50.4	52.6	55.0	56.2	53.6	47.9	49.2
Solid fuels	33.6	34.3	29.8	31.4	29.7	42.9	39.7
Gaseous fuels	69.9	77.4	77.7	79.5	88.4	63.5	66.1
Others	0.6	0.8	1.6	2.1	2.5	2.9	3.0
Total SA	154.5	165.1	164.1	169.2	174.2	157.1	158.0
Difference (%)							
Liquid fuels	0.2%	0.1%	-2.3%	-1.0%	-2.6%	0.1%	-1.0%
Solid fuels	-0.1%	-0.5%	1.6%	0.4%	-0.4%	1.9%	2.0%
Gaseous fuels	-2.6%	-1.4%	-0.3%	-1.1%	-0.9%	-1.7%	0.0%
Other	49.2%	74.4%	18.6%	29.8%	16.8%	10.5%	12.9%
Total	-1.0%	-0.4%	-0.5%	-0.4%	-1.0%	0.0%	0.5%

The differences between the RA and the SA are due to three factors:

- There is a "statistical difference" in the energy statistics, which is responsible for -0.5% and +1.5% of the SA total.
- In the SA we use company-specific EFs, while country-specific EFs are used in the RA. This results in small differences in the emissions estimation.
- CO_2 emissions from other fuels show a large difference. This is due to the fact that in the energy statistics (statline.cbs.nl), fossil waste is aggregated together with waste heat. Therefore, the amount of fossil waste is overestimated in the RA.

In January/February 2018, CE Delft performed a peer review on the RA calculation (CE Delft, 2018). The conclusion from this peer review was

that the RA in the Dutch NIR 2018 appears to be in line with the IPCC Guidelines and the CO_2 emissions calculated using the RA seem to be accurate, complete and consistent. The peer review also resulted in some recommendations for transparency and comparability. The transparency recommendations have been implemented in the NIR 2018 and the ENINA methodology report (Peek et al., 2018). The comparability recommendations refer to the comparability between IEA, Eurostat and CBS data. The differences are described in a report from the CBS on the revision of the energy balance (CBS, 2015). In the next submission, this will be improved further.

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 due to non-energy applications. These fuels were mainly used as feedstock in the petro-chemical industry (naphtha) and are stored in many products (bitumen, lubricants, etc.). A fraction of the gross national consumption of natural gas (mainly in ammonia production) and coal (mainly in iron and steel production) was also due to non-energy applications and hence the gas was 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)

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 (consisting of waste only) 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 (approximately 0.5%) to the total national inventory of GHG emissions.
N_2O and CH_4 emissions from Energy industries are not key sources (see Table 3.1).

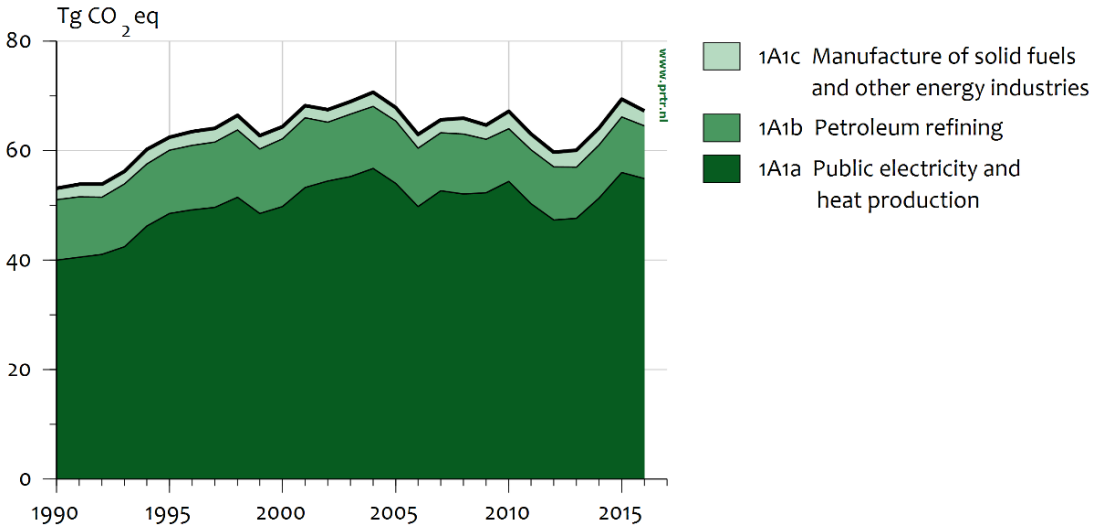


Figure 3.4: 1A1 Energy industries – trend in total GHG emission by sub-category, 1990–2016

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 sub-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 blast furnace gas and a significant part of 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).

Waste oils (waste oil, waste lubricant, waste solvent, etc.) are collected by certified waste management companies. Until 2002 waste oils were used in the preparation of bunker fuels. Since this date their use in bunker fuel has been prohibited for environmental reasons, and waste oils are either exported to Germany or recycled.

The recycling part (feedstock for chemical plants, clean-up and or distillation) results in only small fractions of non-useable wastes. In the past these were incinerated in a special combustion facility in the Netherlands (at that time reported under 1.A.1.a, as the plant recovered waste heat). Since the closure of this plant the residues have been exported for environmental friendly processing and the resulting foreign emissions are not included in the Dutch inventory.

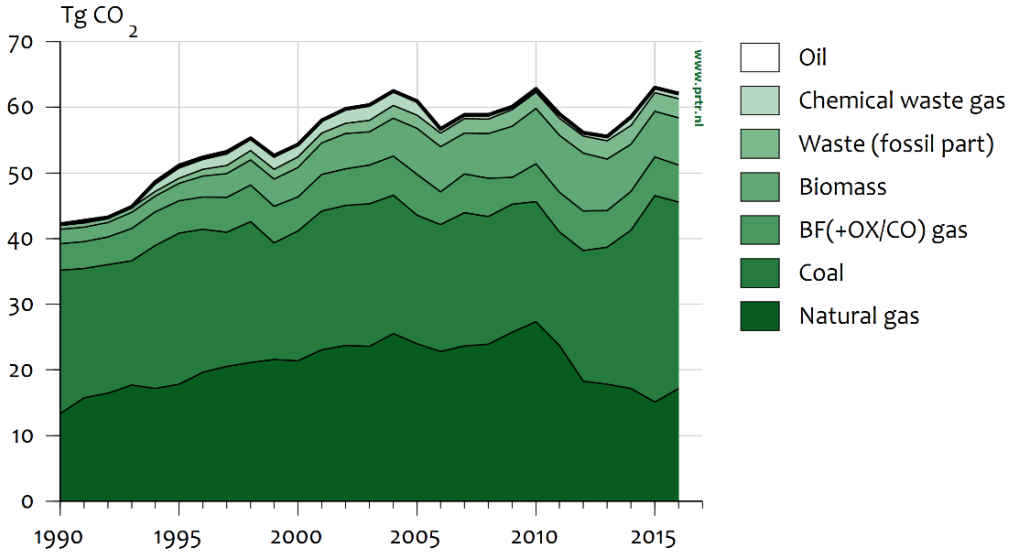


Figure 3.5: Trend in CO_2 emissions from fossil and biogenic fuel use in power plants, 1990–2016. The abbreviation BF/OX/CO refers to blast furnace gas, oxygen furnace gas, coke oven gas and phosphor oven gas. The biogenic part of waste is included in biomass.

1A1a (public electricity and heat production) is the largest source sub-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.

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 combined heat and power (CHP) plants operated by utilities; therefore, it is also allocated to this category.

CO_2 emissions from the waste incineration of fossil carbon increased from 1990 onwards 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 EF 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 Section 7.4).

The decrease in the 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.

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 CO_2 from the 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 sub-category in the category 1A1 (Energy industries). The combustion emissions from this sub-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 a Shell Gasification and Hydrogen Production (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 sub-category 1A1c comprises:

- Fuel combustion (of solid fuels) 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 (natural gas) 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’ of natural gas for energy purposes (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 sub-category increased in recent years, 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 (non-standard natural gas) 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.
Liquid fuels are generally not used in this sector. Only in 1990, a small amount of liquid fuels was used in this sector.
Fuel combustion for coke production by the iron and steel plant is based on a mass balance. See Section 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 the CBS (see www.cbs.nl). The aggregated statistical data are based on confidential data from individual companies. When necessary, emissions data from individual companies are 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, 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 Peek et al., 2018) 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 ETS from selected companies is used. The data are validated by the competent authority. If the data are not accepted by the competent authority, then the CO_2 emissions data are 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 become available.

Data from the AERs and the ETS are compared (QC check) and the data that provide greater detail for the relevant fuels and installations are used. The reported CO_2 emissions are combined with energy use, as recorded in energy statistics, to derive a company-specific EF.

- 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, 2018) 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 the selected 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, 2018) 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, 2018) 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, 2018) 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, 2018) 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 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 and from other biomass combustion) is reported as a memo item. The emission factors of biomass are also discussed here, because these emissions are also reported.

For the year 2016, 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 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 3.5. Since some emissions data in this sector originate from individual companies, some of the values (in Table 3.5) are IEFs. For reasons of confidentiality, detailed data on fuel consumption and emission factors per CRF category and fuel are not presented in the NIR, but are available to the reviewers upon request.

Table 3.5: Overview of EFs used for the year 2016 in the category Energy industries (1A1)

Fuel	Amount of fuel used in 2016 (TJ NCV)	IEFs (g/GJ)		
		CO_2 (x1000)	N_2O	CH_4
Other bituminous coal	387,559	92.8	1.24	0.44
Natural gas	375,002	56.8	0.18	8.21
Waste gas	102,308	64.2	0.10	3.60
Waste (biogenic fractionmass)	41,625	124.4	6.23	
Other fuels (not mentioned above)	21,743	NA	NA	NA

Explanation for the source-specific EFs:

- The standard CH_4 EF for natural gas is 5.7 g/GJ. Only in sub-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 'wet' natural gas.
- CO_2 emissions from coal are based on emissions data from the ETS, and the IEF is different from the country-specific EF.
- 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 (both the fossil and biomass fraction) is either with or without an SNCR (9.43 g/GJ and 1.89 g/GJ, respectively), depending on choices made by the operator of an incinerator. 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 (§2.3.2.1.2 of (Peek et al., 2018); DHV, 2010; and NL Agency, 2010). This is in line with IPCC 2006 V5, §5.2.2.3 and §5.4.2. 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, 2017).
- 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 EF.

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* (Peek et al., 2018).

Trends in the IEF for most sectors can be explained by the composition of fuels used in that sector. The largest fluctuations can be explained as follows:

- 1A1a solid CO_2: The trend in CO_2 IEF for solid fuels in 1A1a varies between 103 and 112 kg/GJ. The main fuels used are other bituminous coal (with an EF of 94.7 kg/GJ) and blast furnace gas (with a default EF of 247.4 kg/GJ). A larger share of blast furnace gas results in a higher IEF.

- 1A1c gaseous CO_2: The trend in CO_2 IEF for gaseous fuels in 1A1c varies between 56.2 and 64.7 kg/GJ. The main fuels used in the production of oil and natural gas sector are regular natural gas and crude “wet” natural gas (directly extracted from the wells). The EF of raw natural gas is variable and most often somewhat higher than the EF of regular natural gas. The variation in the EF of raw natural gas causes the variation of the IEF for gaseous fuels in 1A1c.

3.2.4.3 Uncertainty and time series consistency

The uncertainty in CO_2 emissions from 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 sub-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 3% 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 to within approximately 0.5% for 2000 (based on 1270 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 gases 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 Peek et al. (2018).

3.2.4.5 Category-specific recalculations

An error has been corrected in the allocation of CO_2 emissions from refineries. Part of the CO_2 emission was moved from 1B2a4 to 1A1b. Due to the reallocation of the emissions from iron and steel, emissions previously allocated to 1B1b are now allocated to 1A1C (see also Section 3.2.5.5).
The revision of the energy statistics in 2015 was not yet fully implemented in the CRF submission. The last two revisions were included in the 2018 submission:

- The activity data in 1A1, 1A2 and 1A4 for the years 1991–1994 have been revised.
- The activity data for biomass combustion have been revised for the complete time series

3.2.4.6 Category-specific planned improvements

No improvements are planned.

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 emissions 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 3.6).

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 sub-category 1A2c (chemicals) is the largest fuel user (see Table 3.7). 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 1990–2016, 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. The increase in CO_2 emissions in 1A2c in 2016 is caused by the fact that one chemical plant was not working part of the year 2015, but was fully operational again in 2016.

Table 3.6: Fuel use in 1A2 Manufacturing industries and construction in selected years (TJ PJ NCV/year)

	Amount of fuel used (PJ NCV/year)						
Fuel type/Sub-category	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Gaseous fuels							
Iron and steel	11.7	13.0	13.7	12.5	12.0	11.1	10.8
Non-ferrous metals	3.8	4.3	4.2	4.0	3.6	2.8	2.8
Chemicals	170.7	139.0	117.8	105.3	97.6	94.7	98.2
Pulp, paper and print	29.2	24.4	27.4	29.7	21.0	15.6	15.4
Food processing, beverages and tobacco	63.7	68.5	73.7	67.1	57.0	61.6	62.7
Non-metallic minerals	26.1	23.8	26.5	23.5	22.6	17.9	18.5
Other	30.1	34.8	36.3	32.6	31.4	23.2	24.9
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	94.4	109.8
Pulp, paper and print	0.0	0.0	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	22.4	24.2	26.6	24.6	22.7	20.9	20.9
Solid fuels							

	Amount of fuel used (PJ NCV/year)						
Fuel type/Sub-category	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
Iron and steel	73.4	80.6	68.5	81.0	70.5	80.7	81.2
Non-ferrous metals	0.0	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	0.8	0.8
Non-metallic minerals	3.3	2.1	2.3	1.5	1.5	1.5	1.5
Other	0.4	0.2	0.3	0.5	1.6	0.5	0.9

The derivation of these figures, however, should also be viewed in the context of the allocation of industrial process emissions of CO_2. Most industrial 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 (IPPU). 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.

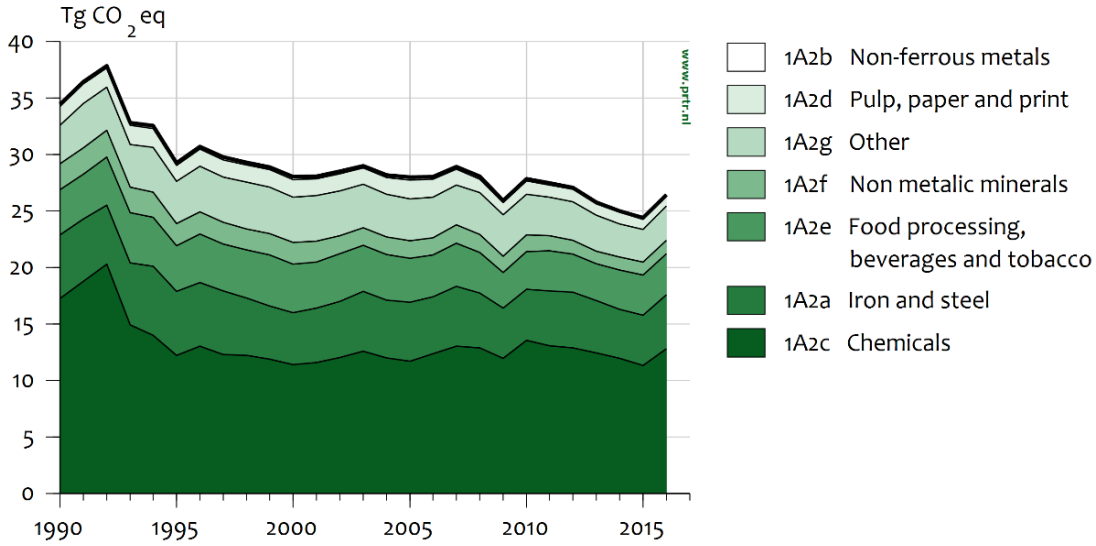


Figure 3.6: 1A2 Manufacturing industries and construction – trend and emissions levels of source categories, 1990–2016

Iron and steel (1A2a)

This sub-category refers mainly to the integrated steel plant (Tata Steel, previously Corus and/or Hoogovens), which produces approximately 7,000 ktons of crude steel per annum. Figure 3.7 shows the production process of the Tata Steel integrated steel plant.
Besides the integrated crude steel plant there is a (small) secondary steel making plant, which uses mostly scrap metal in an electric arc furnace to produce wire, and a number of iron foundries.

The method used for calculating CO_2 emissions from Tata Steel is based on a carbon mass balance, so CO_2 emissions are not measured directly. The method allocates a quantity of C to relevant incoming and outgoing process streams (Table 3.7). As a result of this calculation method, CO_2

emissions can be determined only at plant level. Allocation of emissions to the different sub-processes is not possible. The final difference between input and output, net C, is converted into a net CO_2 emission at plant level.

For reasons of confidentiality Table 3.7 does not include the quantities of the in- and outputs. The figures can, however, be made available for review purposes.

Table 3.7: Input/output table for the Tata Steel integrated steel plant

Input	**Output**
Excipients	Produced steel
Steel scrap and raw iron	Carbonaceous products
Oil	Cokes
Pellets	BTX
Additives (limestone/dolomite)	TPA
Iron ore	Mixed process gases: power plants
Injection coal	
Natural gas	
Coking coal	

Figure 3.7 shows the relation between the input streams from Table 4.1 (highlighted yellow) and the processes, together with the resulting emissions and the CRF categories where these are reported.

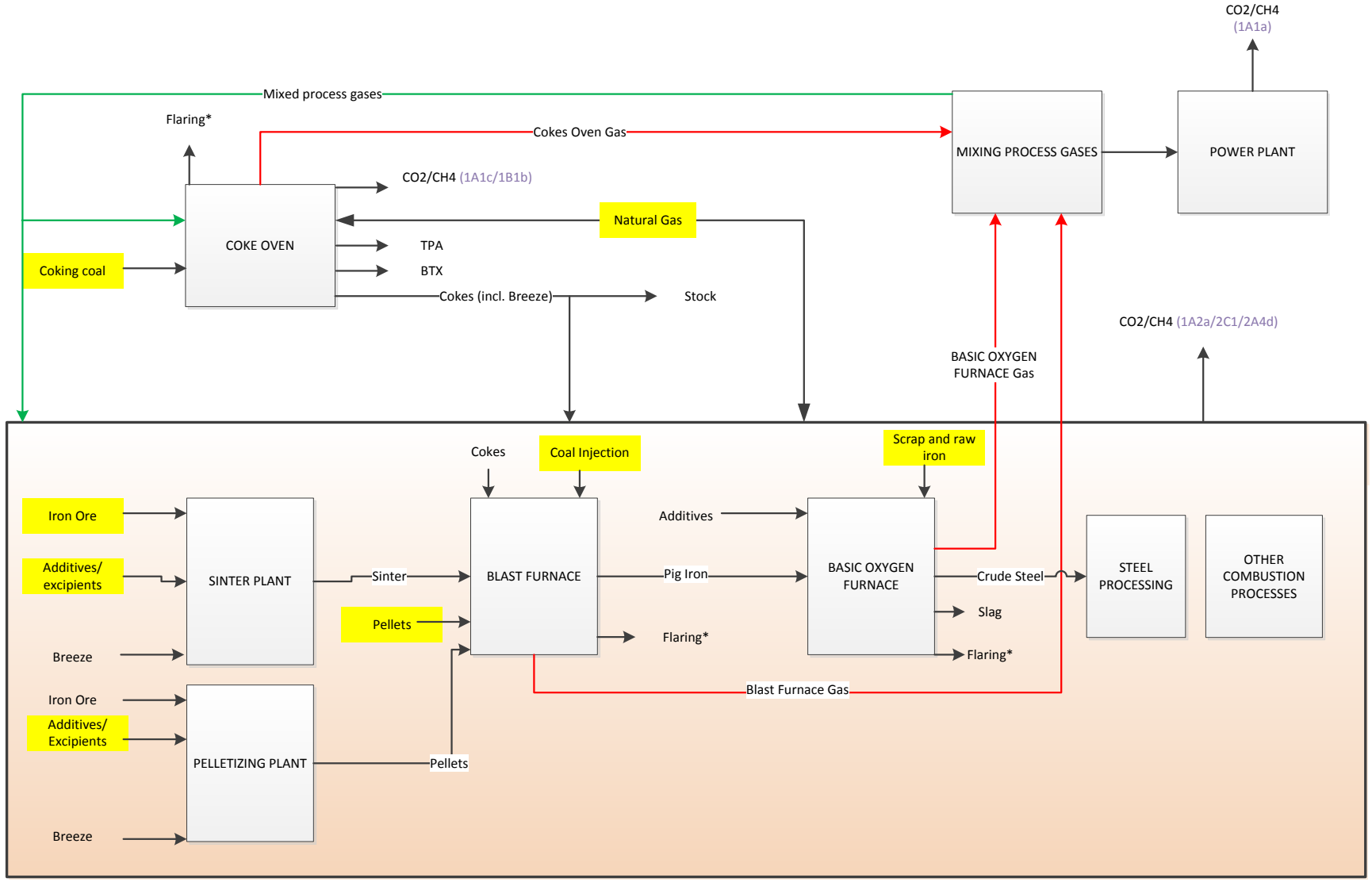
During the production of iron and steel, coke and coal are used as reducing agents in the blast and oxygen furnaces, resulting in the by-products blast furnace gas and oxygen furnace gas, which are used as fuel for energy purposes (see also Figure 3.7).
From the National Energy Balance of the CBS only energy figures from the Cokes Plant and the summed fuel use of the rest of processes in the integrated steel plant are available.

Therefore, only combustion emissions from the Coke Plant and the rest of the integrated crude steel plant can be estimated. These combustion emissions (included flaring emissions) are included in 1A1ci (manufacture of solid fuels) and 1A2a (energy iron and steel). Tata Steel also exports a large part of its carbon to the Energy sector in the form of mixed production gas. These emissions are included in 1A1a (public electricity and heat production). Furthermore the relevant net process emissions are reported under sub-categories 1B1b (solid fuel transformation), 2C1 (iron and steel production) and 2A4d (other process uses of carbonates).

Inter-annual variations in CO_2 combustion emissions from the crude steel plant can be explained mainly by the varying amounts of solid fuels used in this sector.

When all CO_2 emissions from the sector are combined, total emissions closely follow the inter-annual variation in crude steel production (see Figure 3.8). Total CO_2 emissions from crude steel production have

decreased over time, even though production has increased. This indicates a substantial energy efficiency improvement in the sector.



*Flaring only in special operating conditions

Figure 3.7: Production process of the Tata Steel integrated steel plant

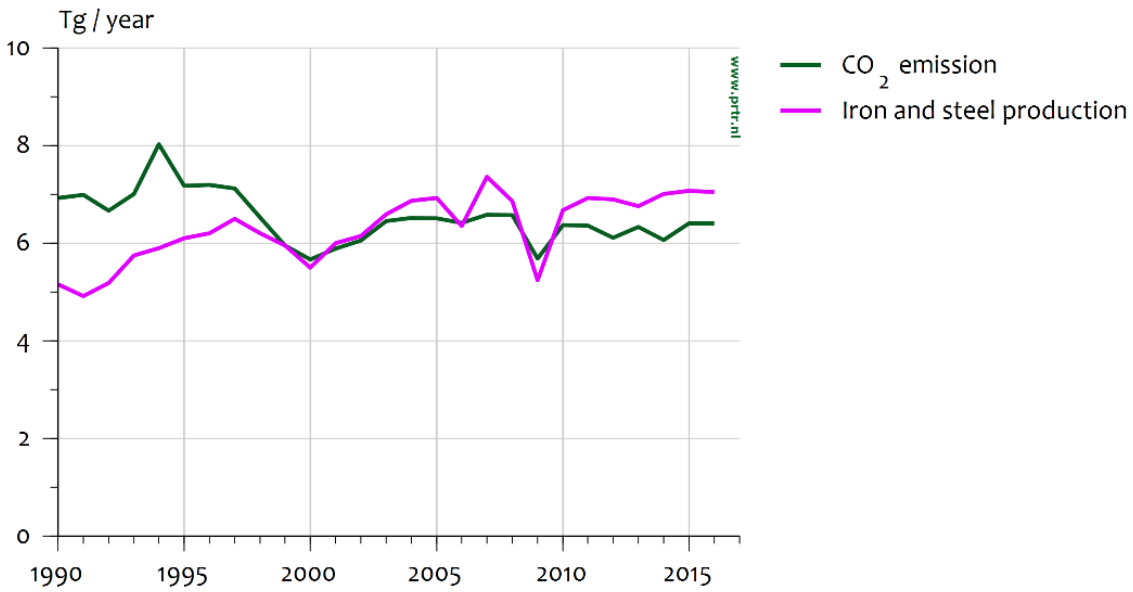


Figure 3.8: CO_2 emissions (Gg) from crude steel production compared with crude steel production, 1990–2016 (kton)

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 emissions 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 sub-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 largely be 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 1990s 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 gases 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 sub-category decreased in the period 1990–2016. 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 sub-category decreased in the period 1990–2016 as a result of the decreasing consumption of natural gas.

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 sub-category comprises 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 sub-category stemmed from gas, liquid fuels and biomass combustion.

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 are derived from the aggregated statistical data from national energy statistics published annually by the CBS (see www.cbs.nl). The aggregated statistical data are based on confidential data from individual companies. When necessary, emissions data from individual companies are 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 Peek et al. (2018) for more details on the CH_4 EF of gas engines).

For N_2O, IPCC default EFs were 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 of selected companies and the ETS are used. The data are validated by the competent authority. If the data are not accepted by the competent authority, then the CO_2 emissions data are 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 become available.
Data from the AERs and the ETS are compared (QC check) and the data which provide greater detail on the relevant fuels and installations are used. The reported CO_2 emissions are combined with energy use, as recorded in energy statistics, to derive a company-specific EF.

- 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, 2018) 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, 2018) 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, 2018) 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, 2018) are used.
- Coal: Since 2006, company-specific EFs have been derived for most companies and for the remaining companies the default EF is used. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2018) 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 2016, 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 are mainly 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 Peek et al. (2018).

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 3.8. Since some emissions data in this sector originate from individual companies, the values in Table 3.8 partly represent IEFs. 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 3.8: Overview of emission factors used (for the year 2016) in the category Manufacturing industries and construction (1A2)

Fuel	Amount of fuel used in 2016 (TJ NCV)	Implied emission factors (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	233,346	56.5	0.10	6.1
Waste gas	109,758	66.4	0.10	3.6
Coke oven/gas coke	56,293	106.8	0.30	1.44
Other bituminous coal	42,616	93.1	0.29	0.44
Other	20,827	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 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.
- For solid fuels, an EF of 0.27 g N_2O/GJ (based on reported emissions from Tata Steel) and an EF of 0.44 g CH_4/GJ (standard EF for other bituminous coal) is used to calculate emissions from the iron and steel plant. The standard EFs are used for solid fuel combustion in other sectors.

More details on EF methodologies, data sources and country-specific source allocation issues are provided in Peek et al.(2018).

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 emissions 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) are not based on large surveys and therefore are the least accurate in this part of sub-category 1A2g.

Details of the method for this source category can be found in Peek et al. (2018).

Fuel consumption by NRMM used in industry and construction is derived from the Energy balance, which in turn uses the output of the EMMA model (Hulskotte and 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. (2018). From this year onwards the model includes an additional speciation of mobile pumps and generators. This inclusion has led to the redistribution of fuel use and emissions over the different NRMM sectors, as is described in Section 3.2.5.5.
It is assumed that NRMM has used the same gasoline and diesel fuel as road transport since 2013, when the excise duty for diesel used in NRMM was increased to the same level as for road transport. Therefore, it is also assumed that the biofuels that are blended in road transport fuels have also been used in NRMM since 2013. The use of biofuels for NRMM is reported separately in the CRF and amounted to 2% of total energy use by NRMM in 1A2gvii in 2016 (0.4 PJ).

CO_2 emissions from NRMM are estimated using a Tier 2 methodology. Country-specific heating values and CO_2 emission factors were derived from Swertz et al. (2017). CH_4 and N_2O emissions from NRMM are estimated by the EMMA model using a Tier 3 methodology, based on country-specific EFs, as described in Klein et al. (2018).

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.

The uncertainty in activity data for NRMM is estimated to be 2% for gasoline and diesel and 5% for LPG, as reported in Klein et al. (2018). The uncertainty in the EFs is estimated to be 2% for CO_2 (all fuels): 50%/+300% for N_2O and -40%/+250% for CH_4. The CO_2 estimate was

assumed to be equal to the estimate for road transport fuels, which in turn was based on expert judgement. The estimates for CH_4 and N_2O were derived from the 2006 IPCC Guidelines.

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 Peek et al. (2018).

3.2.5.5 Category-specific recalculations

Integrated iron and steel plant TATA Steel

During the in-country review, recommendations were made to improve the transparency of the emissions from the Tata Steel plant. After some consultations between the company and the Dutch PRTR, these recommendations were followed and they resulted in the following changes:

- Reallocation of emissions within and between the following sub-categories:
  - 1A1ci manufacture of solid fuels;
  - 1A2a energy Iron and Steel;
  - 1B1b solid fuel transformation;
  - 2A4d other process uses of carbonates;
  - 2C1 iron and steel production.
- As we reallocated some of the former as process emission reported fuels (they now are included under combustion), the emissions of CH_4 and N_2O increased slightly. Overall CO_2 emissions did not change.
- Some notation keys in the CRF have been corrected.
- The sector description has been improved.

Description reallocation of emissions

- *From 1B1b to 1A1ci*

Until this submission the figures for emissions from transformation losses were based on national energy statistics of coal inputs and of coke and coke oven gas produced and a carbon balance of the losses. Any non-captured gas was by definition included in the net carbon loss calculation used for the process emissions. Because of the uncertainty in the very large input and output volumes of the coke oven the amount of fugitive emissions calculated with the used mass balance method was unrealistically high. Therefore, from this year on the CO_2-emission factor for fugitives is determined on the basis of the conservative assumption that about 1% of the coke oven input is lost in the form of fugitive emissions. In the CRF a new time serie from 1990-2016 can be found under 1B11
This resulted in a reallocation of the biggest part of the emissions from 1B1b to 1A1cI, Manufacture of solid fuels;

- *From 2C1 to 1A2 and 2A4d*
  In former submissions the Netherlands reported a big part of the fuel related emissions of the integrated iron and steel plant Tata Steel in 2C1. During the in-country review this was qualified as not transparent. To improve the transparency all fuel related emissions are now reported in 1A2, with the result that the emissions in 2C1 decreased strongly compared to previous submissions.
  Furthermore the Netherlands reported in former submissions a part of the process emissions from limestone and dolomite use in 2C1 instead of in 2A4d. This has been corrected in this submission.
  So, a large part of 2C1 has been reallocated to 1A2 and 2A4d

  Overall CO_2 emissions did not change.

  The differences in CO_2 emissions per CRF category between the 2017 and 2018 submission is presented in Figure 3.9 and Table 3.9.

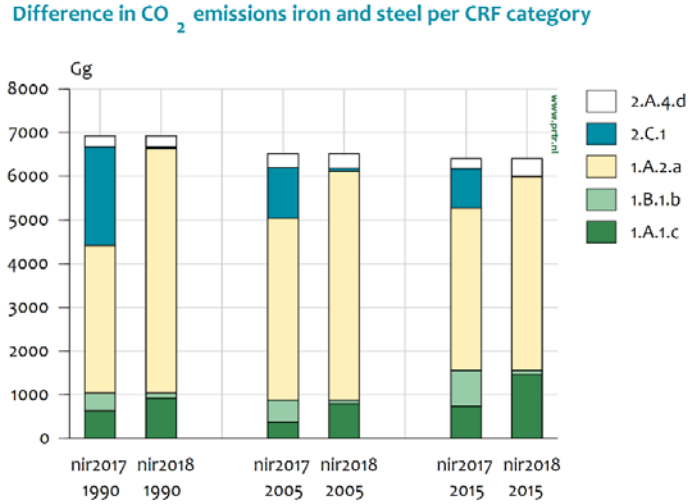


Figure 3.9: Difference in CO_2 emissions between the NIR 2017 and NIR 2018 submission

Table 3.9 Overview of Difference in CO_2 emissions between the NIR 2017 and NIR 2018 submissions.

	1.A.1.c			1.B.1.b			2.C.1			1.A.2.a			2.A.4.d			TOTAL		
Year	2018	2017	Δ	2018	2017	Δ	2018	2017	Δ	2018	2017	Δ	2018	2017	Δ	2018	2017	Δ
1990	925	633	292	110	403	-292	44	2,266	-2,223	5,599	3,376	2,222	249	249	0	6,926	6,926	0
1991	1,112	786	326	110	436	-326	42	2,229	-2,187	5,489	3,501	1,988	236	236	0	6,988	7,188	-200*
1992	1,050	728	322	110	432	-322	44	1,722	-1,678	5,218	3,741	1,477	243	243	0	6,666	6,866	-200*
1993	1,071	704	367	110	478	-367	48	1,662	-1,614	5,506	3,892	1,614	271	271	0	7,007	7,007	0
1994	1,470	681	788	111	797	-687	50	2,071	-2,021	6,128	3,797	2,331	273	273	0	8,032	7,620	411*
1995	1,077	676	401	111	513	-401	52	1,595	-1,543	5,660	4,117	1,543	278	277	0	7,178	7,178	0
1996	1,150	617	533	112	645	-533	52	1,524	-1,472	5,602	4,130	1,472	282	282	0	7,199	7,199	0
1997	1,037	650	388	111	499	-388	55	1,815	-1,761	5,626	3,865	1,760	294	293	0	7,123	7,123	0
1998	1,006	631	376	109	485	-376	52	1,446	-1,394	5,083	3,689	1,394	280	280	0	6,531	6,531	0
1999	844	491	354	89	443	-354	50	1,310	-1,260	4,705	3,444	1,260	269	269	0	5,957	5,957	0
2000	690	352	337	84	422	-337	34	1,082	-1,048	4,604	3,564	1,040	255	246	8	5,666	5,666	0
2001	660	332	328	84	412	-328	49	1,041	-993	4,814	3,831	984	280	271	9	5,887	5,887	0
2002	657	308	349	82	430	-349	67	1,131	-1,064	4,960	3,906	1,054	287	278	10	6,053	6,053	0
2003	738	354	384	81	464	-384	55	1,258	-1,203	5,269	4,076	1,193	310	300	10	6,453	6,453	0
2004	961	534	427	82	509	-427	43	989	-946	5,127	4,181	946	310	310	0	6,522	6,522	0
2005	797	378	419	86	505	-419	69	1,156	-1,087	5,235	4,159	1,076	322	311	11	6,509	6,509	0
2006	961	471	490	79	569	-490	63	831	-768	5,019	4,269	750	291	272	19	6,412	6,412	0
2007	837	604	233	83	316	-233	59	1,489	-1,430	5,314	3,913	1,401	293	264	29	6,586	6,586	0
2008	1,224	594	630	80	710	-630	65	732	-667	4,854	4,206	648	351	331	19	6,574	6,574	0
2009	922	441	482	61	543	-482	21	841	-820	4,429	3,626	802	249	232	18	5,682	5,682	0
2010	1,408	517	891	83	974	-891	22	685	-663	4,529	3,880	649	324	310	14	6,366	6,366	0
2011	1,025	462	563	77	640	-563	23	1,107	-1,085	4,864	3,817	1,046	374	336	38	6,362	6,362	0
2012	707	494	213	73	286	-213	20	1,237	-1,217	4,900	3,818	1,083	412	278	134	6,113	6,113	0
2013	1,207	593	614	78	691	-614	15	1,110	-1,095	4,619	3,702	916	412	234	178	6,331	6,331	0
2014	1,180	604	576	78	654	-576	25	956	-931	4,349	3,597	752	433	254	179	6,065	6,065	0
2015	1,476	743	733	78	811	-733	16	905	-889	4,436	3,720	716	400	226	174	6,406	6,405	2**

* *Difference is the result of the last year revision of the Energy statistics;*

** *Difference is the result of the update of the 2015 energy statistics*

Other recalculations:
The revision of the energy statistics in 2015 was not yet fully implemented in the CRF submission. The last two revisions were included in the 2018 submission:

- The activity data in 1A1, 1A2 and 1A4 for the years 1991–1994 have been revised.
- The activity data for biomass combustion have been revised for the complete time series.

Adjustment of activity data and CH_4 and N_2O emission factors for NRMM
The activity data for NRMM in 1A2gvii have been adjusted upwards in this year's inventory. This adjustment is caused by:

- A change in the correction factor that is used in the EMMA model to take into account the impact of economic fluctuations on average annual usage of the machinery, which resulted in an increase of the calculated fuel consumption of NRMM in construction for the latter period of the time series.
- The use of adjusted heating values for gasoline and diesel, as described in detail in Section 3.2.6.5. The new CO_2 emission factors for gasoline and for diesel, which are also described in Section 3.2.6.5, were also applied to NRMM. As is shown in Section 3.2.6.5, the changes in the heating values more or less even out the changes in the CO_2 emission factors. Consequently, the change in the resulting emissions totals is small.
- An error correction in the EMMA model.

In total, the activity data for NRMM in 1A2gvii have been adjusted upwards by 10–17% for the 1990–2012 period. In 2013, changes were minimal, whereas in 2014 and 2015 the activity data increased by 5% and 7%, respectively.

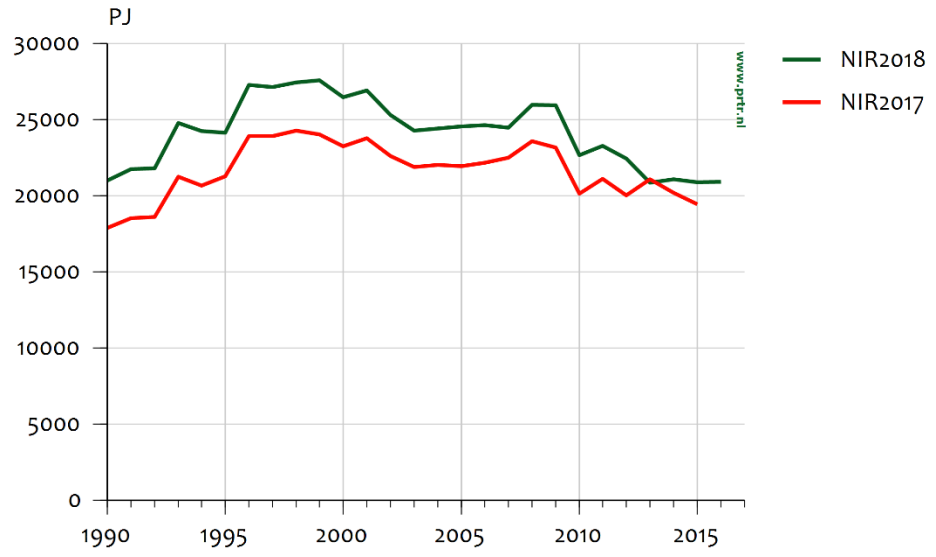


Figure 3.10: Activity data for non-road mobile machinery (1A2gvii), excluding biofuels), 1990–2016

The EFs for CH_4 and N_2O for NRMM have also been adjusted in this year's inventory. Default EFs were used in last year's inventory, whereas

in this year's inventory country-specific EFs were used, derived from the EMMA model (Hulskotte and Verbeek, 2009). The CH_4 EFs are based on the shares of different machine types per category of NRMM and NMVOC EFs per machine type, taking into account the increasingly stringent EU emission regulation. CH_4 emissions are derived from total VOC emissions using VOC species profiles, as described in Klein et al. (2018). The resulting implied CH_4 emission factors for 1A2gvii are shown in Figure 3.11. In the previous inventory, EFs for the different fuels were kept constant throughout the time series. The minor changes in the IEFs in last year's inventory resulted from changes in the fuel mix within 1A2g vii. The new IEFs show the decrease resulting from the increasingly stringent EU emission legislation for NRMM.

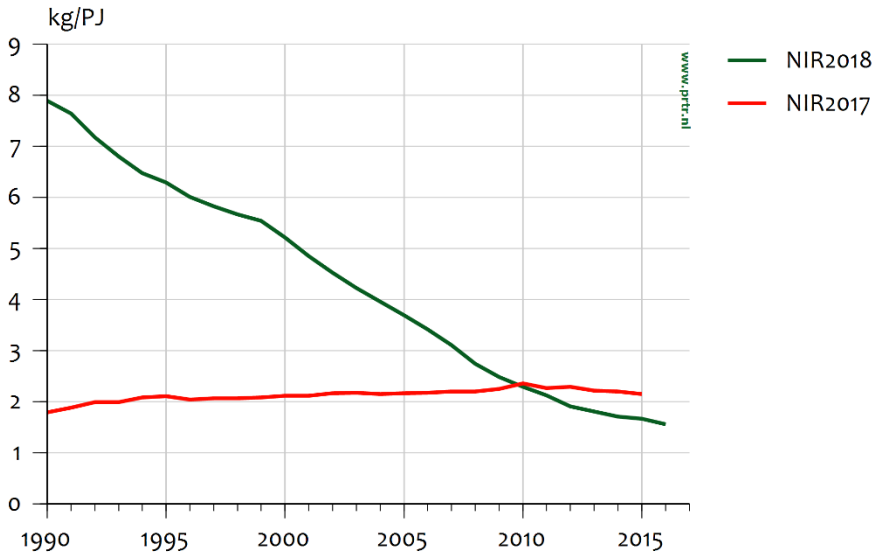


Figure 3.11: Implied CH_4 emission factors for 1A2gvii), 1990–2016

3.2.5.6 Category-specific planned improvements

No improvements are planned.

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 3.10. Civil aviation (1A3a) comprises 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 3.5). 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 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 1B2b (gas transmission and

storage) and CO_2 and CH_4 emissions from oil pipelines are included in 1B2a (oil transport), as described in Section 3.3.2. CO_2 emissions from lubricant use in two-stroke engines in mopeds and motorcycles have been included under 1A3biv.

Table 3.10 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	NRMM	T2	CS, D

CS: Country specific, D: Default

CO_2 emissions from lubricant use in two-stroke engines (in mopeds and motorcycles) have now been included under 1A3biv, in accordance with the 2006 IPCC Guidelines.

The emissions from NRMM are reported under different sub-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 2016. Greenhouse gas emissions from transport increased by 29% between 1990 and 2006, from 28.0 to 36.3 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 decreased by 16% to 30.5 Tg CO_2 eq. in 2016. Total energy use and resulting GHG emissions from transport are summarized in Figure 3.12. Road transport accounts for 95–97% of energy use and GHG emissions in this category 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 1990–2016 period.

Figure 3.12 shows that the GHG emissions from transport steadily increased between 1990 and 2006, on average by 1.6% 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 (and are therefore not included in Figure 3.11). 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.

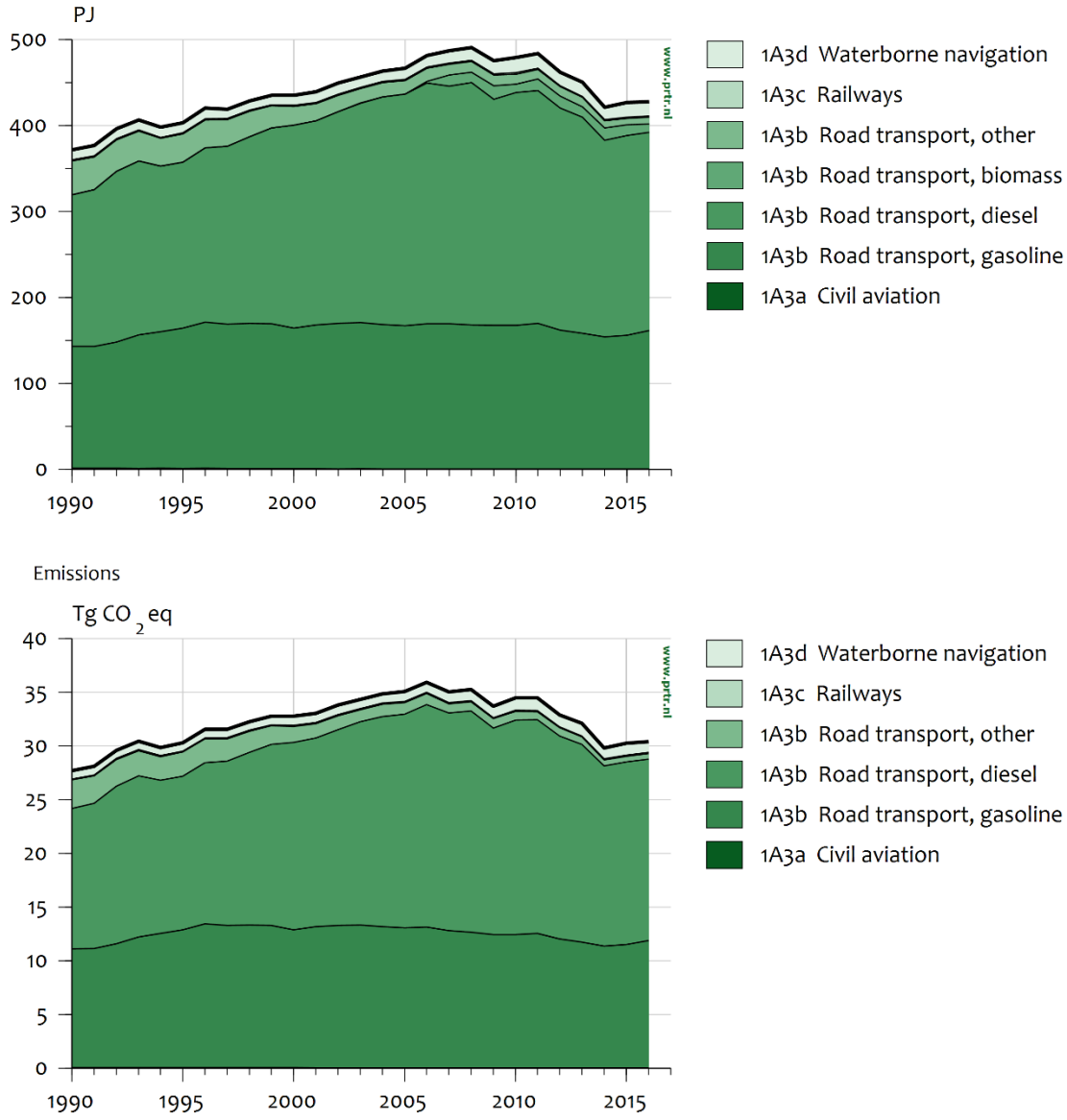


Figure 3.12: 1A3 Transport – energy use and emissions levels of source categories, 1990–2016

Between 2011 and 2014, CO_2 emissions decreased by 14%. This can for the most part be attributed to an increase in cross-border refuelling resulting from an increasing difference in fuel prices between the Netherlands and Belgium/Germany, as is shown in Geilenkirchen et al. (2017). In 2016, GHG emissions from transport were 0.5% higher than in 2015. This increase in emissions was caused by a decrease in the use of biofuels for transport in the Netherlands. Total energy use remained at the same level as in 2015.

Civil aviation (1A3a)

The share of civil aviation in GHG emissions in the Netherlands was less than 0.1% in both 1990 and 2016. 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 0.4 PJ in 2016, whereas the use of aviation gasoline decreased from 0.16 PJ in 1990 to 0.04 PJ in 2016. GHG emissions from civil aviation decreased accordingly.

Road transport (1A3b)

The share of road transport (1A3b) in national GHG emissions increased from 12.1% in 1990 to 15.0% in 2016. Between 1990 and 2016, GHG emissions from road transport increased from 26.8 to 29.3 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 2016. 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 as a result of increasingly stringent EU CO_2 emissions standards for new passenger cars and fiscal incentives for purchasers of fuel-efficient cars. In recent years, as more fuel-efficient cars have entered the car fleet, average fuel efficiency has improved (although it should be noted that improvements in fuel efficiency in the real world were much smaller than those indicated by type approval values). 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 led to an increase in cross-border refuelling, especially for freight transport (Geilenkirchen et al., 2017).

Gasoline consumption increased from 142 to 170 PJ between 1990 and 1996 and subsequently fluctuated between 165 and 170 PJ until 2011. Thereafter, gasoline sales to road transport decreased to 154 PJ in 2014 but then increased to 161 PJ in 2016. The decrease between 2011 and 2014 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 refuelling. The subsequent increase can be attributed to economic growth resulting in increased traffic volumes. According to the CBS, traffic volumes increased by 1.5% in 2015 and by 2.7% in 2016.

LPG consumption for road transport decreased steadily throughout the time series: from 40 PJ in 1990 to 6 PJ in 2016, mainly due to the decreasing number of LPG-powered passenger cars in the car fleet. As a result, the share of LPG in energy use by road transport decreased significantly between 1990 and 2015, as shown in Figure 3.11. The use of natural gas in road transport has increased in recent years, but is still

very low. In 2000, natural gas use in road transport was estimated to be 6 TJ, whereas in 2016 it was estimated to be 1.8 PJ, according to the CBS. 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 and 16 PJ. In 2016, biofuel use for road transport amounted to 10 PJ, accounting for 2.4% 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 until 2020, the actual use of biofuels has not increased accordingly. This is mainly due to double counting of more sustainable biofuels, as specified in the Renewable Energy Directive (EU Directive 2009/28/EC). Also, due to a change in Dutch legislation, not all biofuels that were used to comply with the legal obligation in 2015 and 2016 were used in the Dutch market. Therefore, the actual use of biofuels decreased from 14 PJ in 2009 to 10 PJ in 2016.

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 2016. This decrease was due to a reduction in VOC emissions, resulting from the implementation and subsequent tightening of EU emissions legislation for new vehicles. Total VOC emissions from road transport decreased by 87% between 1990 and 2016, primarily due to the penetration of catalyst-equipped and canister-equipped vehicles into the passenger car fleet. Since CH_4 emissions are estimated as a fraction of total VOC emissions, the decrease in VOC emissions throughout the time series also results in a decrease in CH_4 emissions. The share of CH_4 in total VOC has increased with the introduction of three-way catalysts in gasoline passenger cars. Therefore, the decrease in CH_4 emissions throughout the time series is smaller than the decrease in total VOC emissions. Since almost the entire gasoline car fleet is currently equipped with catalysts and carbon canisters, the decrease in VOC emissions has stagnated in recent years. Therefore, CH_4 emissions from road transport stayed roughly the same between 2014 and 2016.

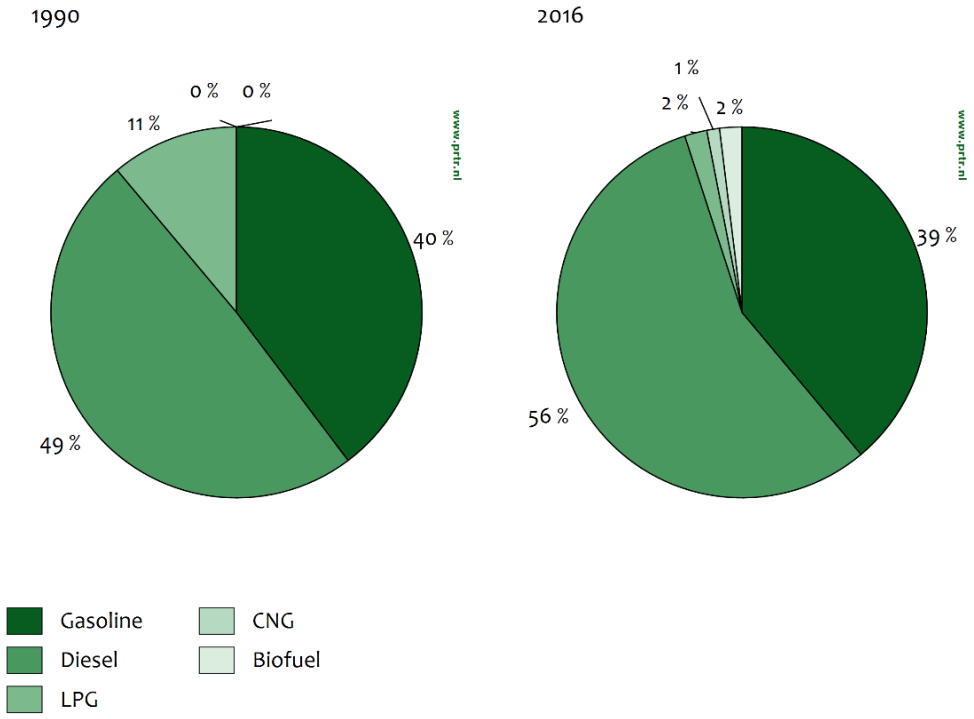


Figure 3.13: Shares of fuel types in total fuel sales to road transport in 1990 and 2016

The share of N_2O in total GHG emissions from road transport (in CO_2 eq.) is also very small (0.8% in 2016). N_2O emissions from road transport increased from 0.3 Gg in 1990 to 0.9 Gg N_2O in 1997, but have slightly decreased since to 0.8 Gg in 2016. 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 2016, despite a further increase in transport volumes, can be explained by a combination of the following factors:

- N_2O emissions per vehicle–kilometre of subsequent generations of TWC-equipped 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 2016 N_2O emissions from road transport decreased by 2% (0.01 Gg) compared with 2015, which is due to a decrease in emissions from gasoline passenger cars.

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 fluctuated between 1.1 and 1.4 PJ throughout the time series, even though transport volumes have grown. This decoupling between transport volumes and diesel fuel consumption was caused by the increasing electrification of rail (freight) transport. In 2016, diesel fuel consumption by railways amounted to 1.4 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 a small source of GHG emissions in the Netherlands. Waterborne navigation in the Netherlands 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, but are reported under bunkers (1D, Section 3.5). 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 10 PJ in 1990 to 16 PJ in 2011, but then decreased to 14 PJ in 2016. These fluctuations can partially be due to changes in offshore operations. Fuel consumption for offshore operations increased from 1 PJ in 1990 to 6 PJ in 2011 but then decreased to 3 PJ in 2016, according to the National Energy Balance.

In line with the increase in fuel consumption, GHG emissions from domestic waterborne navigation increased from 0.8 Tg CO_2 eq. in 1990 to 1.2 Tg in 2011 and then decreased to 1 Tg in 2016.

Other transportation (1A3e)

Other transportation consists of pipeline transport and the CO_2 and N_2O emissions at natural gas compressor stations. This is a minor source, which accounted for 1.2% of total transport GHG emission in 1990 and only 0.3% in 2016.

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 diesel are a key source in both the Tier 1 and 2 level and trend assessment. Gasoline is a key source in the Tier 1 and 2 level assessment and in the Tier 1 trend assessment. LPG is a key source of CO_2 in the Tier 1 and 2 trend assessment. N_2O emissions from road transport (total) are a key source in the Tier 2 trend assessment. CO_2 emissions from gaseous fuels and CH_4 emissions from road transport are not key sources 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 (2018). Country-specific values are used for aviation gasoline, whereas for jet kerosene default values from the 2006 IPCC Guidelines are used. For N_2O and CH_4 default EFs are also used (Table 3.12). 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 SO_2), 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 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 3.12: Emission factors for civil aviation, railways and waterborne navigation

Source sub-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
		Jet kerosene	43.5	71.5	2.0	0.5
1A3c	Railways	Diesel	*	*	0.56	4.26
1A3d	Waterborne navigation	Diesel	*	*	2.0	7.0
		Biofuels	*	76.8	0.56	4.26
1A3d	Waterborne navigation	Gasoline	*	*	0.86	47.23
		Biofuels	*	76.8	0.86	47.23
1A3e	Pipeline transport	Natural gas	31.7	57.2	0.1	NO

* See 3.2.6.5.

Road transport (1A3b)

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 NRMM 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 NRMM, which is also not reported separately in the Energy Balance. Table 2.1 of Klein et al. (2018) provides an overview of the corrections made to the Energy Balance in order to derive activity data for calculating GHG emissions from transport.

Fuel sales data for road transport in the Energy Balance are not divided according to vehicle categories. For emissions reporting, total sales per fuel type are disaggregated to the various road transport sub-categories (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. (2018). The resulting fuel consumption figures differ from fuel sales data for varying reasons:

- Stockpiling is included in fuel sales data.
- Both approaches (fuel consumption and fuel sales) contain statistical inaccuracies.
- Cross-border refuelling, i.e. 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 causal factors (such as cross-border refuelling and stockpiling), the difference between fuel used and fuel sold differs from year to year. In calculating GHG emissions from road transport, fuel sales data are used to calculate total emissions, whereas fuel consumption data are used to split sales per fuel type among 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 nevertheless very small.

CO_2 emissions from road transport are calculated using a Tier 2 methodology. Country-specific heating values and CO_2 EFs are used. Table 3.13 shows the heating values and CO_2 EFs used for LPG and CNG, which were derived from the Netherlands' list of fuels. The heating values and CO_2 EFs for gasoline and diesel were adjusted in this year's submission based on new measurements (Swertz et al., 2018). This is described in section 3.2.6.5.

Table 3.13: Heating values and CO_2 EFs for road transport

Fuel type	MJ/kg*	g CO_2/MJ*
LPG	45.2	66.7
CNG	31.65**	56.5

* Source: Zijlema (2018).
** MJ/Nm^3 ae

N_2O and CH_4 emissions from road transport are dependent not only on fuel type, but also on combustion and emissions control technology and the operating conditions of the vehicles. Emissions from road transport are therefore calculated using a Tier 3 methodology, based on vehicle–kilometres travelled on Dutch territory and technology-specific EFs, 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;
- Emissions control technology, as a function of the octane index of different types of petrol for pollutant emissions;
- Operating conditions, using different EFs for urban driving, rural driving and highway driving and congestion per road type.

The activity data used for the bottom-up approach are derived from the CBS and are described in detail in Klein et al. (2018).

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 EFs for N_2O are derived from Kuiper and Hensema (2012). For older vehicle types, EFs are derived from national emission measurement programmes (Gense and Vermeulen, 2002; Riemersma et al., 2003). For recent generations of road vehicles with new emissions reduction technologies, EFs are derived from the 2013 EEA Emission Inventory Guidebook. The N_2O EFs per vehicle type and road type are provided in table 3.16 of Klein et al. (2018).

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. (2018). VOC EFs for the over 350 different vehicle types that are distinguished in the emissions calculation for road transport are presented in table 3.29 of Klein et al. (2018). The mass fraction of CH_4 in total VOC emissions is dependent on the fuel type, vehicle type and – for gasoline-powered 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 table 3.27 of Klein et al. (2018).

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. Therefore, N_2O and CH_4 emissions presented in the CRF are consistent with fuel sold.

Emissions resulting from the use of biofuels in road transport are reported separately in the CRF. CO_2 emissions are reported as a memo item and are not part of the national emissions total. CH_4 and N_2O emissions from biofuels are included in the national emissions total. The emissions 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 EFs as are used for fossil diesel and gasoline, respectively. Emissions measurement programmes use market fuels (Spreen et al., 2016), including some biofuels. Therefore, the resulting EFs are representative of the market fuels that are currently used, which include small shares of biofuels.

CO_2 emissions from the use of lubricants in mopeds and motorcycles are included under source sub-category 1A3biv. There are no data available on the number of two-stroke passenger cars in the Netherlands, but it is expected to be very small (much smaller than the number 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 the use of lubricants in two-stroke motorcycles and mopeds is very small and amounted to 4 Gg in 1990, decreasing to 1.5 Gg in 2016. This decline can be attributed to the steady decrease in 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.

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. SCR technology has been applied in diesel-fuelled heavy-duty vehicles since 2005 for reduction of NO_x. To estimate CO_2 emissions from urea-based catalysts, the TNO first estimated road type-specific CO_2 EFs from the use of urea-additives. The resulting EFs are presented in tables 2.4 and 2.5 of Klein et al. (2018). The use of urea-additive (AdBlue) as a percentage of diesel fuel consumption was estimated at 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 and Ligterink (2014). 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 3.14 shows the implied N_2O and CH_4 emission factors by 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.

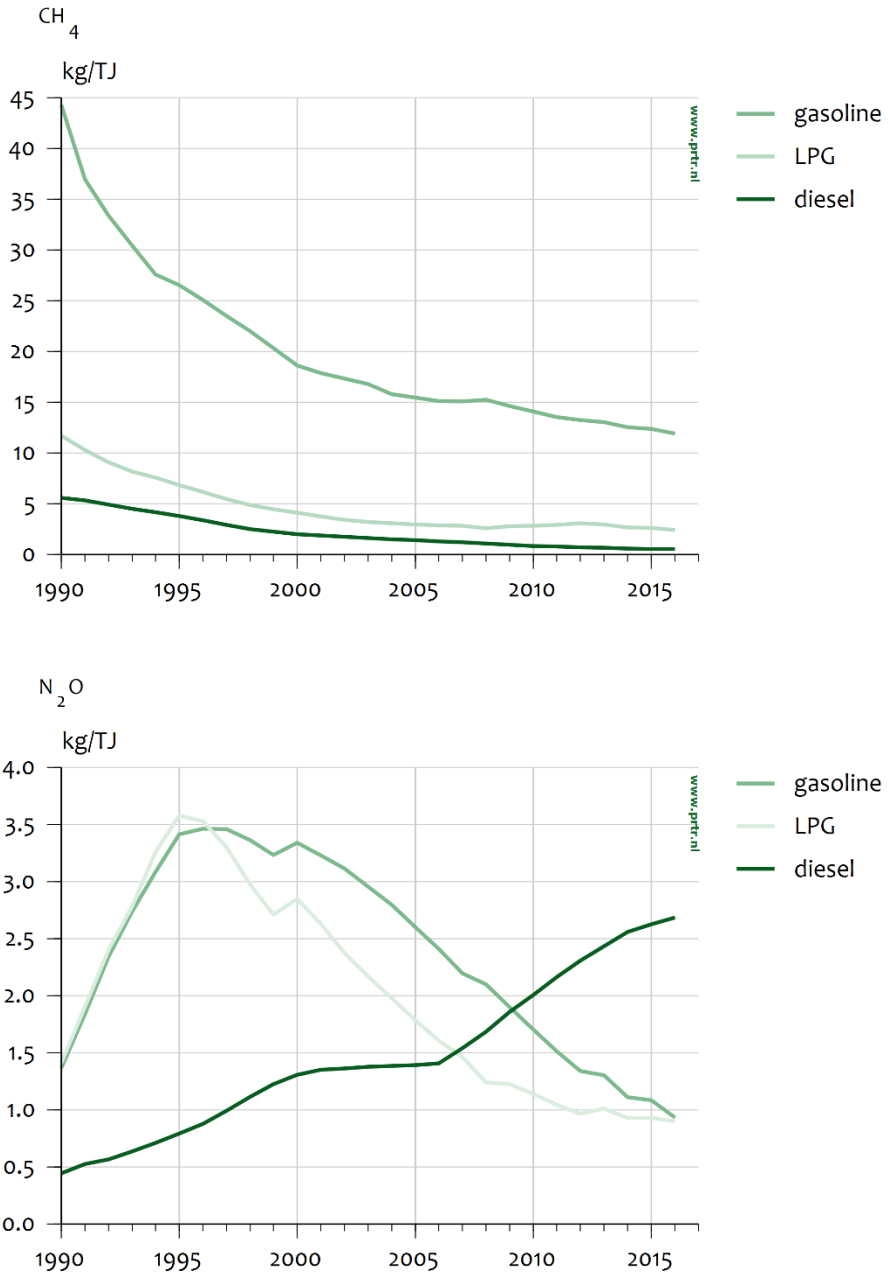


Figure 3.14: IEFs per fuel type for CH_4 and N_2O emissions by road transport, 1990–2016

Railways (1A3c)

Fuel deliveries to railways are derived from the Energy Balance. Since 2010, the CBS derives these data from Vivens, a cooperation 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, 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 (Swertz et al., 2018). Due to a lack of country-specific EFs, CH_4 and N_2O emissions for railways are estimated using a Tier 1 methodology, employing EFs derived from the 2016 EEA Emission Inventory Guidebook. 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 3.8. 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. Therefore, the 2016 version of the Guidebook is applied instead of the 2005 version, which is referred 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 and shown in table 2.1 of Klein et al., 2018).

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 3.8. 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

Uncertainty estimates for the activity data and IEFs used for calculating transport emissions are presented in table 2.6 of Klein et al. (2018), which also shows the sources used to estimate uncertainties.

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 the CBS. 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 by the members of the Task Force on Transportation of the Dutch PRTR.

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 national statistics. The uncertainty in the CO_2 EFs for gasoline, diesel, LPG and natural gas is estimated to be ±2%. This estimate is based on expert judgement, taking into account the uncertainty range for the CO_2 EFs for road fuels in the 2006 IPCC Guidelines.

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 also estimated to be ±50%. 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 national statistics. 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

Estimates of 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 3.15 shows both the time series for fuel sold and fuel used for gasoline (including bio ethanol), diesel (including biodiesel) and LPG in road transport.

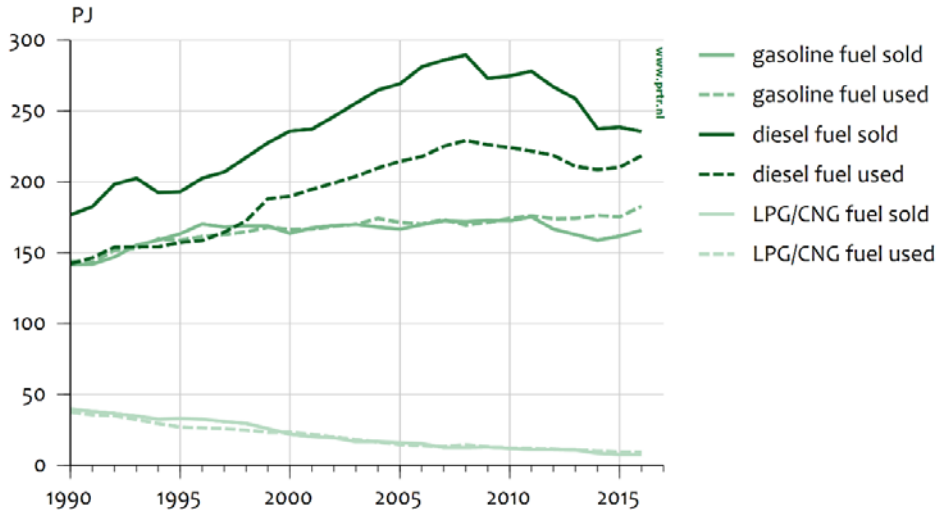


Figure 3.15: Fuel sold and fuel used for road transport in the Netherlands, 1990–2016

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 3.15. The time series for diesel differs, 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 8% 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 mostly 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 waterborne 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 were 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. It 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., 2018). 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 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.

Heating values and CO_2 emission factors for gasoline and diesel

In this year's inventory the heating values (MJ/kg) and CO_2 EFs (CO_2/MJ) for gasoline and diesel have been adjusted for the entire 1990–2016 time series. In previous inventories, the heating values and CO_2 EFs for both fuels were derived from an analysis of 50 fuel samples made in 2004 (Olivier, 2004). The results of these measurements were applied to the entire time series. Since the CBS used different heating values in the Energy Balance than were reported in the 2004 measurements (as shown in Table 3.11), the CO_2 EFs derived from the 2004 measurements were adjusted such that the resulting EFs in gram CO_2 per kilogram of fuel used corresponded with the 2004 measurement results. These adjusted values are shown in Table 3.11.

Table 3.11: Heating values and CO_2 EFs for road transport used in the previous inventory

Fuel type	MJ/kg	g CO_2/MJ	g CO_2/kg fuel
Gasoline	44.0	72.0	3170
Diesel	42.7	74.3	3173

Since the composition of both fuels has changed since 2004, e.g. due to the blending of biofuels and lowering of the sulphur content, new measurements were deemed necessary to assess the appropriateness of the 2004 measurement results for current market fuels. In 2015, measurements were performed on 25 gasoline and 19 diesel fuel samples (Ligterink, 2016). Samples were collected in both summer and winter at stations representing different brands (including budget stations) and in different regions in the Netherlands. The methods used for sample analysis are described in detail in Ligterink (2016). Results are presented in Table 3.14 (for the fossil part of the blends only).

Table 3.14: Heating values and CO_2 EFs derived from 2015 measurements

Fuel type		MJ/kg	g CO_2/MJ*	g CO_2/kg fuel
Gasoline	Winter	43.10	72.69	3133
	Summer	41.66	75.52	3146
Diesel	Winter	43.17	72.59	3133
	Summer	43.24	72.27	3125

Source: Ligterink (2016).

The variation in the measurement results (heating values and CO_2 EFs) for the diesel samples was limited. Only the FAME content in diesel varies significantly between summer and winter fuels but this does not affect the overall results because of the rather high heating value of FAME (37.2 MJ/kg). The resulting heating values are somewhat higher than previously used, whereas the CO_2 EFs (per MJ) are lower. Therefore, the resulting CO_2 EFs per kilogram of fuel used are approximately 1.4% lower.

The heating values for gasoline showed a rather large variation for the summer fuels (+/-5.5%). This was caused by one outlier that showed a heating value of 34.87 MJ/kg. The average heating values of the other samples amounted to 41.71 MJ/kg (+/-1.7%). This sample was retested, with similar results. Therefore, the sample was included in the averages presented below. It was, however, recommended to perform additional measurements to verify the outcomes of the 2015 campaign, specifically for gasoline, before applying them in the emissions calculations.

An additional measurement programme was performed in 2017. Fuel samples were collected monthly across the Netherlands, mixed (typically 6 samples, ranging from 4 to 7) in equal fractions and subsequently analysed to estimate monthly averages. The study ran through to the end of 2017, but the results of 8 monthly samples (December 2016 till August 2017) were available when the emissions calculations for the current report were performed. The heating values for gasoline derived from these new measuremens systematically deviate from the 2015 measurements. The average of the 2015 study is outside the range of

the 2017 measurements. The period from December till August is more or less representative of the annual average, as the autumn fuel transition period is not included. Therefore, the provisional results, with three-quarters of all samples analysed, serve as a good indication of the expected outcome. The results of the entire 2017 measurement campaign will be described in detail in Ligterink (expected in 2018). Using the results of the different measurement programmes, the CBS and TNO derived a methodology to construct new time series for the heating values and CO_2 EFs for gasoline and diesel for the entire 1990–2016 period. This is described in detail in Swertz et al. (2018). A summary of the methodology is given below.

For gasoline, the heating values derived from the summer fuel in the 2015 measurements were considered an outlier. Taking this into account, the average heating value for fossil gasoline is calculated to be 43.0 MJ/kg. The previously used heating value of 44.0 MJ/kg was assumed to be applicable to the start of the time series (i.e. 1970). In order to derive a consistent time series, the lowering of the heating value for gasoline was assumed to be caused by the replacement of lead by oxygenates. For lead-free gasoline without added biofuels, the result of the 2004 measurement programme was used (41.2 MJ/kg). To derive a consistent time series, the decrease in the lead content of gasoline between 1986 and 1997 was used as a proxy. In order to derive a consistent time series between 2004 and 2015, the addition of biogasoline has been used as a proxy.

The carbon content of petrol measured in 2004, which leads to a CO_2 EF of 3170 g/kg (as shown in Table 3.11), was applied for the entire 1997–2004 period. The average CO_2 EF for fossil petrol of 3140 g/kg, measured in 2015, has been applied for 2015 and 2016. This factor is based on the results for market fuel and corrected for the average biofuel content of the samples. The values between 2004 and 2015 have been interpolated on the basis of market biofuel content. It was assumed that the CO_2 EF amounted to 3200 g/kg from 1975 to 1985. The 1990 value of 3176 is the result of an interpolation between the 1985 and 1997 values. The trend of this interpolation was determined by the decline of the lead content, leading to a higher oxygen content and a lower carbon content.

For diesel fuel, the heating value of 42.7 MJ/kg previously used by the CBS was assumed to apply to the situation in 1970. The new heating value of fossil diesel is based on the 2004 measurements (43.1 MJ/kg) and the 2015 measurements (43.2 MJ/kg). The course of the heating values during 1970–2015 has been determined on the basis of the heating value-reducing sulphur content (Swertz et al., 2018). The carbon content of diesel fuel measured in 2004, which leads to a CO_2 EF of 3170 g/kg, has been applied for the entire period 1970–2004. The average CO_2 EF for market diesel fuel of 3121 g/kg, measured in 2015, has been applied for 2015 and 2016. After correction for the biofuel content in the samples, this gives 3130 g/kg for fossil diesel fuel. The values between 2004 and 2015 have been interpolated on the basis of market biofuel content.
The resulting adjustments in the IEFs in gram CO_2 per kilogram of fuel are shown in Figure 3.16. The underlying activity data for fuel used (in

kilogrammes) were unchanged. The activity data reported in the CRF (in PJ) and CO_2 EFs in gram CO_2 per MJ were changed for parts of the time series, but these changes for the most part compensate each other, as is shown in Figure 3.16. The change in the heating value for gasoline results in lower activity data (approximately 4–7%), as is shown in Figure 3.16, but this change is for the most part compensated by higher CO_2 EFs (increase of approximately 6–7% in the 1990–2006 period, decreasing to a 1.4% increase in 2015). As a result, total CO_2 emissions resulting from gasoline and diesel use in road transport are approximately the same as reported in the NIR 2017 for the 1990–2006 period (-0.1% compared with last year's submission). For the 2007–2015 period, CO_2 emissions are between 0.8% and 2.0% lower than in last year's inventory.

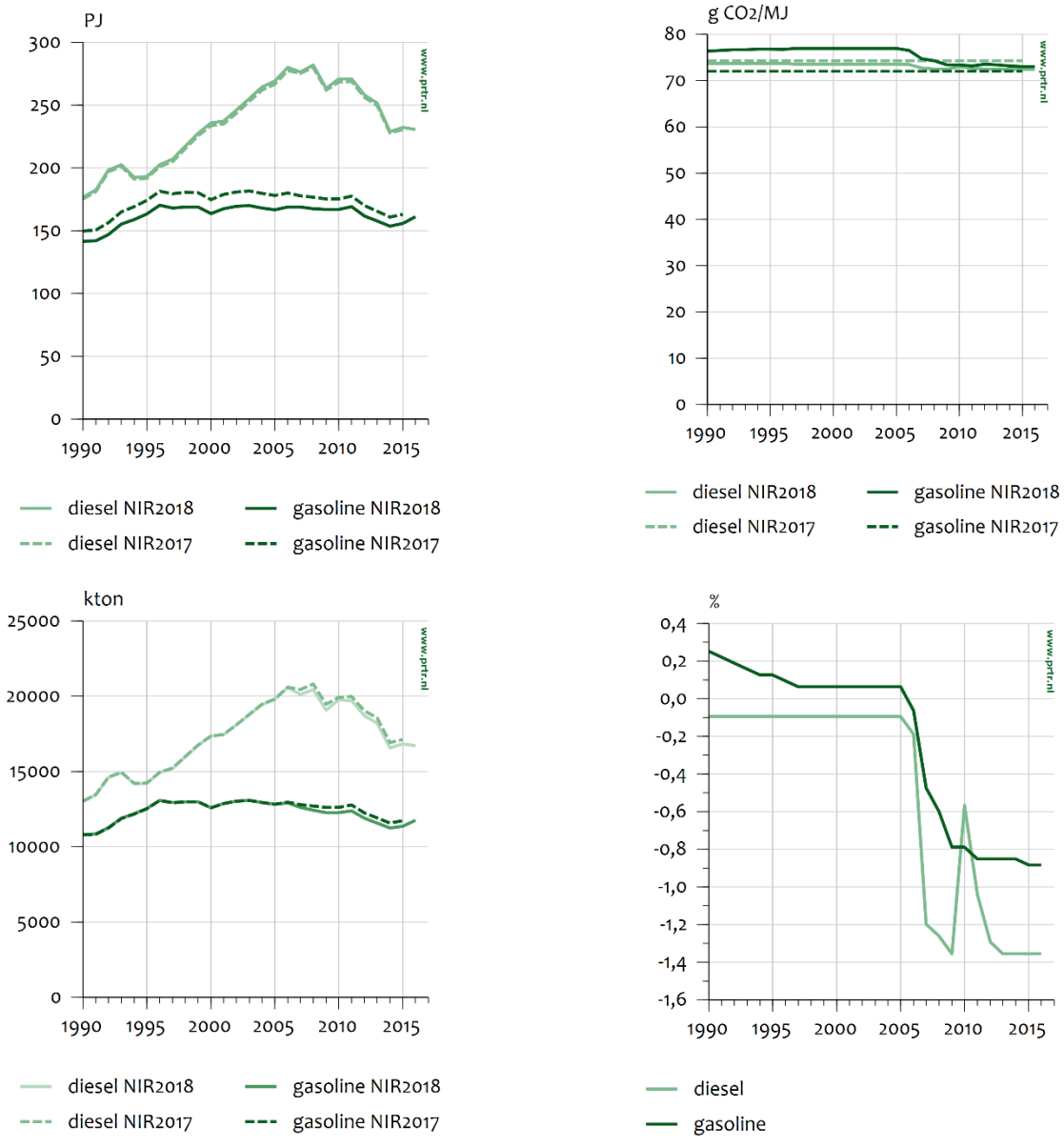


Figure 3.16: Activity data, CO_2 emission factors, CO_2 emissions for gasoline and diesel use in road transport and change in CO_2 emission factors (%), 1990–2016

The resulting changes in the heating values and CO_2 EFs for gasoline and diesel were also applied in the emissions calculations for railways (1A3c), inland navigation (1A3d), NRMM and fisheries (1A2 & 1A4).

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 the CBS.
More specifically, the activity data has been adjusted downwards for the entire 1990–2015 time series. This adjustment is an error correction. In last year's inventory the activity data for military navigation were included both in 1A5 (see also 3.2.7) and in 1A3d. This double counting has been corrected in the current inventory. The resulting activity data for 1A3d in this year's inventory are almost identical to the 1990–2014 time series from the 2016 inventory, as is shown in Figure 3.17. Since EFs have remained unchanged, the GHG emissions have been adjusted accordingly.

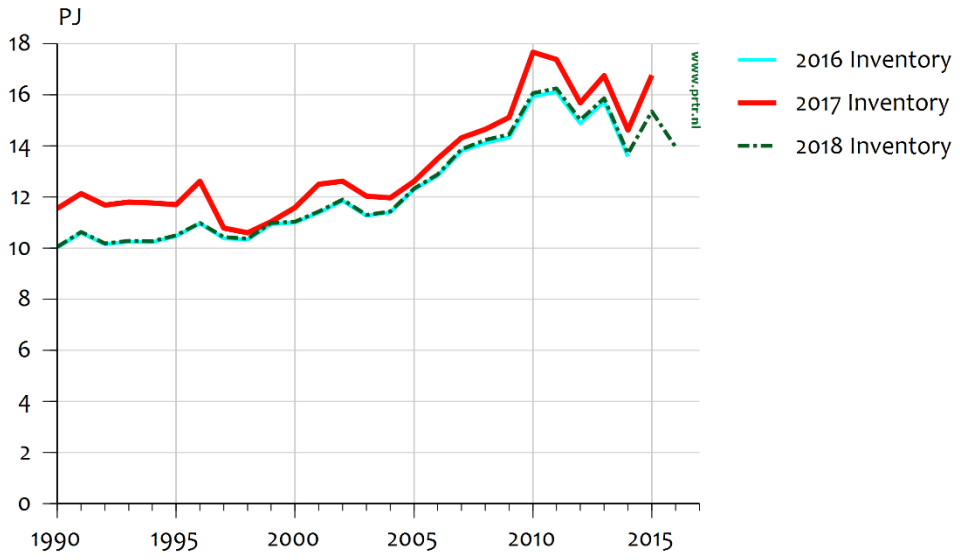


Figure 3.17: Revision of activity data for domestic waterborne navigation (1A3d), 1990–2016

Finally, 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 by -0.1% to -2.6% (-43/-809 Gg) throughout the time series in the current inventory.

3.2.6.6 Category-specific planned improvements
No improvements are planned.

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 sub-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 NRMM used in trade.
- 1A4b (residential): This sub-category relates to fuel consumption by households for space heating, water heating and cooking. Space heating uses about three-quarters of the Netherlands' total consumption of natural gas. The residential sub-category also includes emissions from NRMM used by households.
- 1A4c (agriculture, forestry and fisheries): This sub-category comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding and forestry. It also includes emissions from agricultural NRMM (1A4cii) and from fishing (1a4ciii).

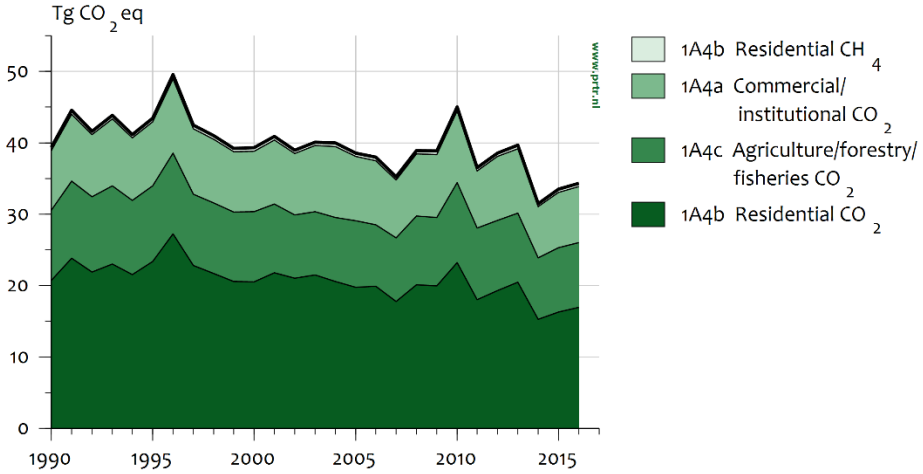


Figure 3.18: 1A4 (Other sectors) – trend and emissions levels of source sub-categories, 1990–2016

Commercial and institutional services (1A4a)

CO_2 emissions in the commercial and institutional services (1A4a) sub-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 NRMM used in trade increased from 3.3 PJ in 1990 to 5.5 PJ in 2016, 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 NRMM 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 have been used in recent years as well. It is assumed that gasoline is supplied by regular gas stations.

Agriculture, forestry and fisheries (1A4c)

Most of the energy in this source sub-category is used for space heating and water heating, although some is used for cooling. The major fuel used in the sub-category is natural gas. Almost no solid fuels are used in this sub-category. NRMM 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 sub-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 net CO_2 emissions generated by CHP facilities. Total annual amounts are approximately 0.4 Tg CO_2.

GHG emissions from agricultural NRMM (1A4cii) have been constant throughout the time series at between 1.1 and 1.2 Tg CO_2 eq.

GHG emissions from fisheries have shown a significantly decreasing trend falling from 1.3 Tg in 2000 to 0.6 Tg in 2016. This has been caused by a decrease in the number of fishing vessels in the Netherlands since 1990, along with a decrease in their engine power.

3.2.7.2 Methodological issues

Gaseous fossil fuels are the key sources for CO_2 emissions in this category (in particular, gaseous fossil fuels, which account for about 95% of the source category 1A4). Emissions from the combustion of gases in the sub-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) are compiled using data from separate surveys for these categories. However, due to the late availability of the statistics on agricultural fuel use, preliminary data are 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) for all fuels except natural gas, gas/diesel oil, LPG and gaseous biomass, for which country-specific EFs are used. In the Netherlands' list of fuels (Zijlema, 2018), it is indicated whether the EFs are country-specific or IPCC default values. For CH_4, country-specific EFs are used for all fuels except solid biomass and charcoal, and diesel in the fisheries sector. For natural gas in gas engines, a different EF is used (see Peek et al., 2018). 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 NRMM and fisheries (1A4c ii and 1A4c iii) are calculated on the basis of IPCC Tier 2 methodologies. Fuel-use data are 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 and 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 EFs are derived from the Netherlands' list of fuels (Zijlema, 2018). CH_4 and N_2O emissions from NRMM are estimated using a Tier 1 methodology, using EFs derived from the 2013 EEA Emission Inventory Guidebook, as described in Klein et al. (2018).

For 2016, 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 emissions from 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 (category 1A4) is provided in Table 3.15.

Table 3.15: Overview of EFs used (for the year 2016) in Other sectors (1A4)

Fuel	Amount of fuel used in 2016 (TJ NCV)	IEFs (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	556,256	56.5	0.1	86.5
Gas / Diesel oil	28,817	72.5	0.9	2.7
Solid biomass	22,411	111.6	4.0	300.0
Other	13,481	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 (due to gas slip) , which explains the higher EF for this sector.
- Gas / Diesel oil is used in stationary and mobile combustion, for which different EFs 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 (Peek et al.,2018) (see Annex 7).

Trends in the IEF for most sectors can be explained by the composition of fuels used in that sector. The largest fluctuations are visible for the CH_4 EF of gaseous fuels. This is caused by the difference in CH_4 EF that is used for natural gas combusted in gas engines (varying between 250 and 450 g/GJ) and the CH_4 EF that is used for natural gas combusted in other plants (5.7 g/GJ).

Figure 3.19 presents the trend in natural gas combusted in gas engines and in other plants. This figure also shows the trend in the IEF.

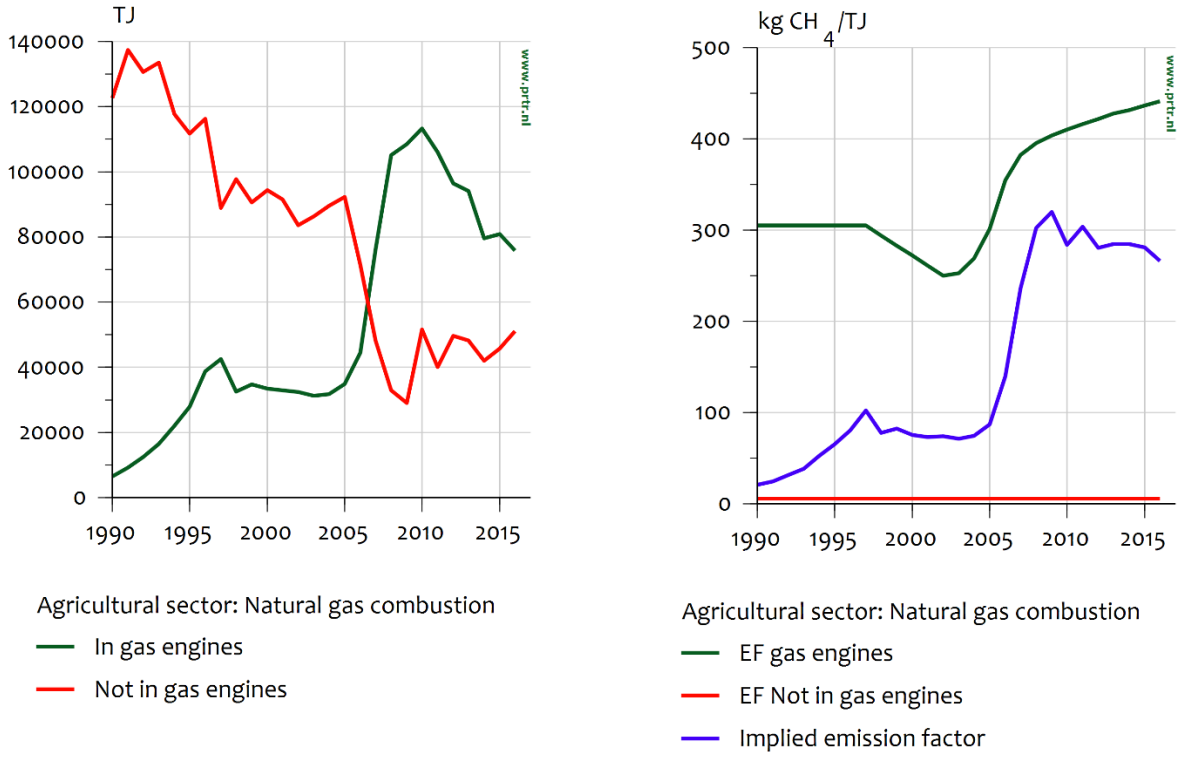


Figure 3.19: Trend in natural gas consumption in gas engines (with a relatively high emission factor) and other engines (with a relatively low emission factor) in the agricultural sector compared with the implied CH_4 emission factor from natural gas combustion in the agricultural sector, 1990–2016

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 are much more accurate than the data for the sub-categories of 1A4. This is because 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 therefore 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 figures, 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. Consequently, energy consumption by the

residential and agricultural sub-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 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 Peek et al. (2018).

3.2.7.5 Category-specific recalculations

The revision of the energy statistics in 2015 was not yet fully implemented in the CRF submission of 2017. The last two revisions were included in the 2018 submission:

- The activity data in 1A1, 1A2 and 1A4 for the years 1991–1994 have been revised.
- The activity data for biomass combustion have been revised for the complete time series.

Other recalculations:

- Energy statistics on the use of gasoil in the services and construction sub-sectors have been updated for the complete time series.
- An error in CH_4 emissions from residential gas combustion in the years 1998, 1999, 2007, 2008 and 2014 was corrected.
- The heating values and CO_2 EFs of gasoline and diesel oil have been updated. See Section 3.2.6.5 for more information on the new heating values and EFs. The new figures were also applied to NRMM (1A4a, 1A4b and 1A4c) and fisheries (1A4c).
- The activity data for fisheries (1A4ciii) have been adjusted in this year's inventory for the 2010–2014 period. Energy use decreased by 11–20% (1–1.5 PJ) as a result of an adjustment to residual

fuel oil deliveries to fisheries in the Netherlands, as reported in the Energy Balance.

Country-specific N_2O and CH_4 emission factors for non-road mobile machinery

The N_2O and CH_4 EFs for NRMM used in commercial/institution (1A4aii), residential (1A4bii) and agriculture (1A4cii) were updated in this year's inventory. In previous inventories, default EFs were applied, whereas in the current inventory country-specific EFs are used. These are derived from the EMMA model (Hulskotte and Verbeek, 2009), taking into account the fleet composition and the impact of EU emissions legislation for VOC emissions from non-road engines. CH_4 emissions are calculated as fractions of total VOC emissions using VOC species profiles.

Figure 3.20 shows the implied CH_4 EFs for 1A4aii, 1A4bii and 1A4cii in this year's inventory compared with last year's inventory. The impact of using country-specific values varies depending on the source category, but all new EFs show a decreasing trend, which is to be expected given the increasingly stringent EU emissions legislation. In the previous inventory, the CH_4 EFs per fuel type were kept constant throughout the entire time series. Since 1A4a ii uses both gasoline and diesel fuel, the implied EF in last year's inventory did vary from year to year due to changes in the fuel mix. 1A4bii only uses gasoline, whereas 1A4cii only uses diesel, resulting in fixed IEFs for the entire time series in the previous inventory, as shown in Figure 3.19. Therefore, the impact of EU emissions legislation on VOC (and consequently CH_4) emissions was not taken into account in the previous inventory.

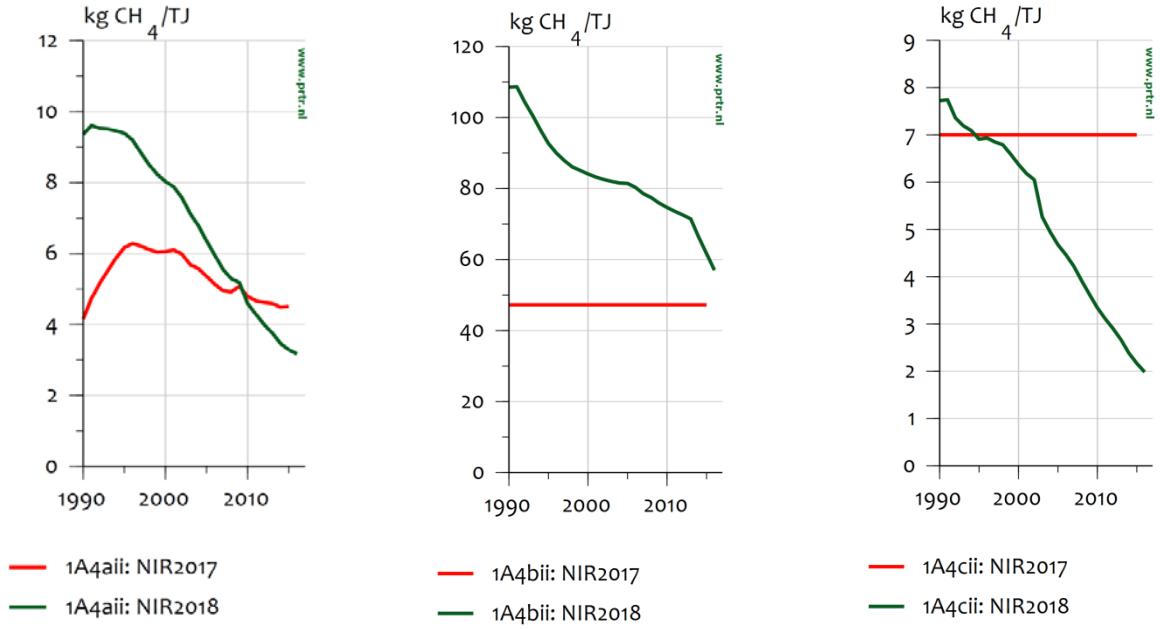


Figure 3.20 Implied CH4 emission factors for non-road mobile machinery used in commercial(1A4aii), residential(1A4bii) and agriculture (1A4cii) in the 2017 and 2018 submission.

3.2.7.6 Category-specific recalculations
There are no source-specific recalculations envisaged.

3.2.7.7 Category-specific planned improvements
No improvements are planned.

3.2.8 Other (1A5)

3.2.8.1 Source category description
Source category 1A5 (Other) consists of emissions from military aviation and navigation (in 1A5b). CO_2 emissions from this source sub-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 military aviation and navigation. Activity data for both aviation and navigation are derived from the Energy Balance, and include all fuel delivered for military aviation and navigation purposes within the Netherlands, including fuel deliveries to militaries of external countries. The EFs are presented in Table 3.16. The CO_2 EFs were derived from the Ministry of Defence, whereas the EFs for N_2O and CH_4 were derived from Hulskotte (2004).

Table 3.16 Emission factors used for military marine and aviation activities

Category		**CO_2**	**CH_4**	**N_2O**
Military ships	EF (g/GJ)	75,250	2.64	1.87
Military aviation	EF (g/GJ)	72,900	10.00	5.80
Total	Emissions in 2016 (Gg)	162.46	0.01	0.01

Source: Hulskotte (2004a).

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 category is 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 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 and comprises two categories:

- 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 relate 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 charcoal production location that served most of the Netherlands and also had a large share of the market in neighbouring countries. The production at this location stopped in 2010.

3.3.1.2 Methodological issues

The sharp decrease in CH_4 emissions over the time series can be attributed to changes in charcoal production. The following EFs 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 and Frederiks, 2002). This sharp decrease in EF was applied because the operator changed from a traditional production system to the Twin retort system (reduced emissions).
After the production of charcoal stopped, the emissions in this category were solely from coke production.
To calculate emissions of CH_4 from coke production the standard IPCC value of 0.1 g CH_4 per tonne of coke produced is used.

CO_2 emissions related to transformation losses 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 these are reported in can be found in Section 3.2.5. Until this submission the figures for emissions from transformation losses were based on national energy statistics of coal inputs and of coke and coke oven gas produced, from which a carbon balance of the losses was calculated. Any non-captured gas was by definition included in the net carbon loss calculation used for the process emissions. Because of uncertainty in the very large input and output volumes of the coke oven, the amount of fugitive emissions calculated with the mass balance method was unrealistically high. Therefore, from this year on the CO_2 EF for fugitives is determined on the basis of the conservative assumption that about 1% of coke oven input is lost in the form of fugitive emissions. See also Section 3.3.1.5.

Industrial producers in the Netherlands are not obliged to report any activity data in their AERs and only a limited set of activity data is published by the CBS. For category 1B1 the production of coke oven coke as registered by the CBS is reported in the CRF. Detailed information on activity data and EFs can be found in the annex ‘Methodology Report on the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste’ in Peek et al. (2018).

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 conservative assumption of the carbon losses in the conversion from coking coal to coke and coke oven gas.

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

3.3.1.4 Category-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 Category-specific recalculations

As the result of a recommendation from the in-country review, the emissions data from the integrated iron and steel plant of the Netherlands were evaluated. Because of uncertainty in the very large input and output volumes the amount of fugitive emissions from the coke production process calculated with the mass balance method was unrealistically high. Therefore, from this year onwards, the CO_2 EF is determined on the basis of the conservative assumption that about 1% of coking coal input is lost in the form of fugitive emissions. In the CRF a new time series from 1990 to 2016 can be found under 1B1. As the industrial producers in the Netherlands are not obliged to report any activity data in their AERs and only a limited set of activity data is registered by the CBS, for this category the production of coke oven coke as registered by the CBS is reported in the CRF.

3.3.1.6 Category-specific planned improvements

No improvements are planned.

3.3.2 Oil and natural gas (1B2)

3.3.2.1 Source category description

Emissions from oil and natural gas comprise:

- Emissions from oil and gas exploration, production, processing, flaring and venting (CO_2, CH_4, N_2O);
- Emissions from oil and gas transport (CO_2, CH_4, N_2O);
- 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 oil and gas exploration and production are reported under 1A1c. Fugitive emissions from gas and oil exploration and production are included in fugitive emissions from combined venting and flaring (1B2c) CO_2 and N_2O combustion emissions from gas transmission are included in 1A3ei (pipeline transport gaseous fuels). CO_2 process emissions and CH_4 emissions from gas transmission can still be found in 1B2b4 (gas transmission and storage). CO_2 and CH_4 emissions from pipelines for oil are included in 1B2a3 (oil transport). This is consistent with the 2006 IPCC Guidelines. Fugitive CO_2 emissions from refineries are included in the combustion emissions reported in category 1A1b. Since the 2007 submission, process emissions of CO_2 from a hydrogen plant of a refinery (about 0.9 Tg CO_2 per year) were

reported in 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 1B2a4 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).

There are no emissions to report in the Netherlands in category 1B2d.

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 housing estates are being built, mostly using PVC and PE, which are also used to replace cast iron pipelines (see also Peek et al., 2018). 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%.

CO_2 and CH_4 emissions from oil and gas production, particularly from flaring and venting, have been reduced significantly since the 1990s. This is due to the implementation of environmental measures to reduce venting and flaring such as optimizing the use of gas for energy production purposes that was formerly wasted.

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 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.

Since 2004, the gas distribution sector has annually recorded the number of leaks found per material and detailed information of pipeline length per material. A yearly survey of leakages per length, material and pressure range is also carried out, covering the entire length of the grid every five years. Total CH_4 emissions in m^3 are taken from the Methaanemissie door Gasdistributie (Methane Emission from Gas Distribution) annual report, commissioned by Netbeheer Nederland (Association of Energy Network Operators in the Netherlands) and compiled by KIWA (KIWA, multiple years). CH_4 emissions in m^3 are calculated using a bottom-up method which complies with the Tier 3 methodology as described in IPCC (2006: chapter 4). 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. Because of the availability of new sets of leakage measurements Netbeheer Nederland commissioned an evaluation of the EFs being applied. As a result, the calculation of emissions of methane from gas distribution were improved for NIR2016 (KIWA, 2015). 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 EFs were based on the small base of 7 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 emission factors for the pipeline material mix in 2004. As a result of a total of 40 additional leakage measurements an improved set of EFs could be derived. Based on the (total of) 65 leakage measurements, the pipeline material mix in 2013 and the results of the leakage survey, three new EFs were 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 EFs led to a reduction in the calculated 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 given 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 the NIR2016, 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 for methane (CH_4) became available. Leakages at larger locations such as the 13 compressor stations were all fully measured. In addition, 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 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 in 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 Peek et al., 2018). Also, process emissions of CO_2 from the only hydrogen factory of a refinery in the Netherlands are reported in category 1B2a4. As Dutch companies are not obliged to report activity data, the AERs account only for emissions. The energy input of refineries from national energy statistics is taken as a proxy for activity data for this category 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.

Detailed information on activity data and EFs can be found in the annex 'Methodology Report on the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste' in (Peek et al., 2018).

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%. The uncertainty in methane emissions from oil and gas production (venting) and gas transport and distribution (leakage) is also 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.

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 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 Category-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 Category-specific recalculations

No recalculations have been made, although the incorrect high value of CO_2 emissions from hydrogen production for the year 2015 of the previous submission is corrected in the newest submission. The high figure included about 300 kton combustion emissions, which are now allocated to category 1A (Fuel combustion). The revised figure for the process emissions in 2015 is 902 kton. It should be noted that the total of combustion and process emissions was correct; it was merely a case of re-allocation.

3.3.2.6 Category-specific planned improvements

No specific improvements are planned, although the ongoing LDAR programme of Gasunie may provide new insights into fugitive emissions from gas transmission.

3.4 CO_2 transport and storage (1C)

Underground storage of CO_2 is not yet implemented in the Netherlands. Transport of combustion off-gases (containing CO_2) occurs only over very short distances. The pipelines run from energy production facilities to nearby greenhouses to increase the CO_2 content of the greenhouse atmosphere (as growth enhancer). The emissions from this activity (probable very minor) are accounted for in the combustion emissions from the energy producers.

For that reason we use the notation key ‘NO’ in the CRF for the 1C category.

3.5 International bunker fuels (1D)

3.5.1 Source category description

The deliveries of bunker fuels for international aviation and 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 delivered is used for international transport, and therefore reported as bunker fuels. The amounts of bunker fuels delivered to both international aviation and navigation is derived from the Energy Balance and is shown in Figure 3.21.

Fuel deliveries for international aviation more than doubled between 1990 and 1999, stabilized between 1999 and 2003 and grew again by 14% between 2003 and 2008. The economic crisis led to a decrease in fuel deliveries of 10% between 2008 and 2012, but deliveries to international aviation have since increased again by 14% to 163 PJ in 2016. There are no deliveries of aviation gasoline or biomass for international aviation reported in the Energy Balance.
Fuel deliveries for international navigation increased by 55% between 1990 and 2008, but then decreased by 25% to 485 PJ in 2016. This decrease can be mainly attributed to the economic crisis. Deliveries of diesel oil for international maritime navigation almost doubled between 2014 and 2015, which can be attributed to more stringent sulphur regulation in the North Sea. Deliveries of lubricants for international navigation increased from 3.8 PJ in 1990 to 7.1 PJ in 2001, but then decreased to 3.4 PJ in 2016.

3.5.2 Methodological issues

CO_2 emissions from bunker fuels are calculated using a Tier 1 and 2 approach. Default heating values and CO_2 EFs are used for heavy fuel oil, jet kerosene and lubricants, whereas country-specific heating values and CO_2 EFs are used for diesel oil, derived from the Netherlands’ list of fuels (Zijlema, 2018). CH_4 and N_2O emissions resulting from the use of bunker fuels are calculated using a Tier 1 approach, using default EFs for both substances, as described in Klein et al. (2018).

3.5.3. Category-specific recalculations

Lubricant emissions were recalculated for the 2011–2015 period as a result of an error in the activity data. The use of the latest revised energy statistics resulted in minor ajustments to CO_2 emissions from navigation bunkers for the whole time series.
Activity data for residual fuel oil in 2015 were increased by 3% in this year’s inventory, using adjusted fuel deliveries data from the Energy Balance.

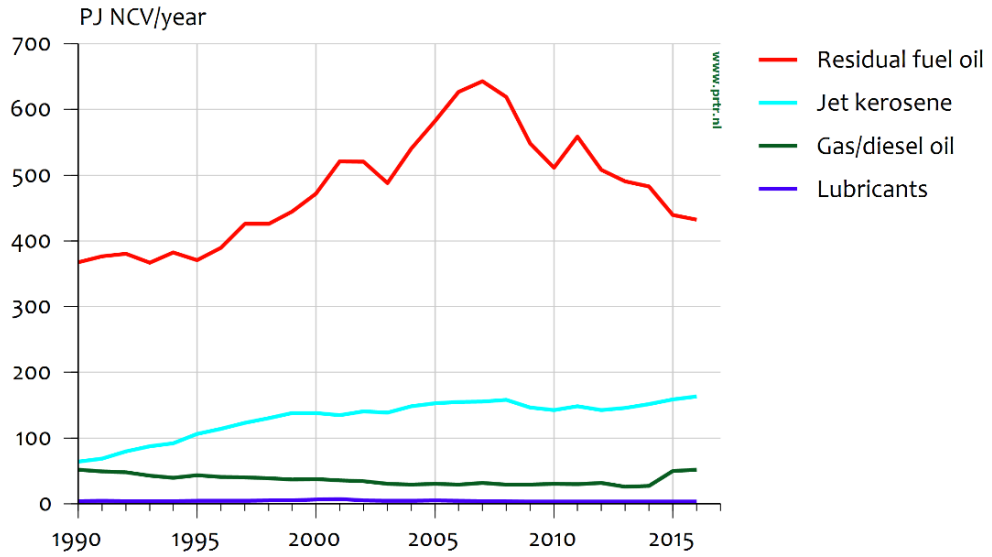


Figure 3.21: Marine and aviation bunker fuel exports, 1990–2016

4 Industrial processes and product use (CRF sector 2)

Major changes in the Industrial processes and product use (IPPU) sector compared with the National Inventory Report 2017

Emissions: The total GHG emissions of the sector decreased from 10.9 Tg CO_2 eq. in 2015 to 10.7 Tg CO_2 eq. in 2016.

Key sources: CO_2 emissions from 2C1 (Iron and steel production) and 2C3 (Aluminum production) are no longer key sources. 2G (Other product manufacture and use) is no longer a key source for N_2O.

Methodologies: The following changes have been made in this sector:

- During the in-country review recommendations were made to improve the transparency of the emissions data from the integrated iron and steel plant (see also 3.2.2). These resulted in reallocation of emissions between the categories 2C1, 2A4d, 1A1c, 1B1b and 1A2a.
- Due to minor changes in the production index series of chemicals, CO_2 emissions from other uses of soda ash (2A4b) have been changed for the period 2011–2015.
- As a result of last year's revision of the Energy statistics some flaws were detected. Correction of these flaws led to recalculation of the emissions for the following categories:
  - 2B1, Ammonia production: 1994;
  - 2B10, Other Chemicals: 1994;
  - 2H2, Food and drink production: 1994.
- An update of the 2015 energy statistics resulted in some minor changes in CO_2 emissions in 2015.
- CO_2 emissions from lime production were included as a result of the in-country review.
- Because more detailed information on Mobile air-conditioning (2F1) and Other uses of HFCs (2F6) became available, HFC emissions have been changed for a number of years.

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).

In the Netherlands, many industrial processes take place in only one or two companies. Because of the sensitivity of data from these companies, only total emissions are reported (according to the Aarhus Convention). Emissions at installation level and production data are, unless a company has no objection to publication, treated as confidential. All confidential information is, however, available for the inventory compilation, as the ENINA Task Force has direct access to it. ENINA can also provide this information to official review teams (after they have signed a confidentiality agreement).

For transparency and consistency reasons, 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.

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 IPPU sector 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 (Peek et al., 2018).

Key sources

The key sources in this sector are presented in Table 4.1. Annex 1 presents all sources identified in the IPPU sector in the Netherlands.

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

Nitric acid production (2B2) is a trend key source of N_2O emissions but no longer a level key source, due to the reduction achieved in this category. Caprolactam production (2B4) is a level key source of N_2O.

Aluminium production (2C3) is a trend key source of PFC emissions. Stationary refrigeration and mobile air-conditioning (2F1) is a level and trend key source of HFCs and Fluorochemical production (2B9) is a trend key source of HFCs.

Paraffin wax use (2D2) is a Tier 2 level and trend key source of CO_2. Petrochemical and carbon black production (2B8) is a Tier 2 level key source of CH_4 and a Tier 2 level and trend key source of 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 IPPU sector.

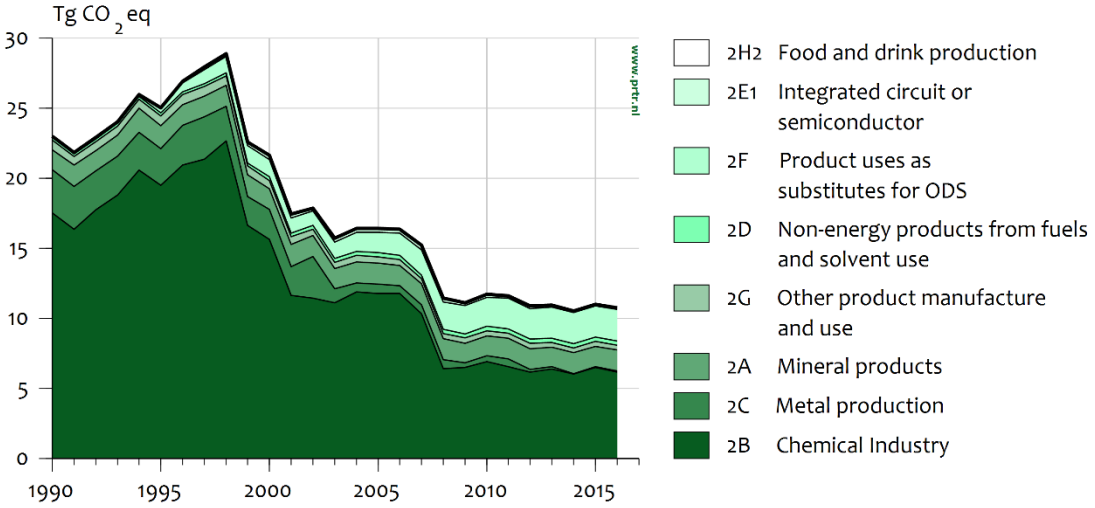


Figure 4.1: Sector 2 Industrial processes and product use – trend and emissions levels of source categories, 1990–2016

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 2016 (%)		
			Base year	2015	2016	Diff.	by sector	of total gas	of total CO_2 eq.
2 IPPU: Total	CO_2	-	6.8	6.5	6.4	-0.1	59.8%	3.9%	3.3%
Industrial Processes	CH_4	-	0.4	0.4	0.5	0.0	4.5%	2.6%	0.2%
	N_2O	-	7.0	1.4	1.1	-0.2	10.4%	13.5%	0.6%
	HFC	-	7.6	2.4	2.4	0.0	22.7%	100.0%	1.2%
	PFC	-	2.3	0.1	0.2	0.0	1.4%	100.0%	0.1%
	SF_6	-	0.3	0.1	0.1	0.0	1.3%	100.0%	0.1%
	All	-	24.4	10.9	10.7	-0.2	100.0%		5.5%
2A Mineral industry	CO_2	-	1.4	1.5	1.5	0.0	14.1%	0.9%	0.8%
2A1 Cement production	CO_2	-	0.4	0.2	0.2	0.0	2.2%	0.1%	0.1%
2A3 Glass production	CO_2	-	0.1	0.1	0.1	0.0	0.9%	0.1%	0.0%
2A4d other process uses of carbonates	CO_2	L, T	0.5	0.8	0.8	0.0	9.4%	0.6%	0.5%
2B Chemical industry	CO_2	-	4.7	4.7	4.5	-0.2	41.9%	2.7%	2.3%
	CH_4	-	0.4	0.4	0.4	0.0	4.1%	2.3%	0.2%
	N_2O	-	6.8	1.3	1.0	-0.2	9.6%	12.5%	0.5%
	HFC	-	7.3	0.1	0.2	0.0	1.7%	7.4%	0.1%
	PFC	-	0.0	0.0	0.0	0.0	0.4%	30.2%	0.0%
	All	-	19.2	6.5	6.2	-0.3	57.7%		3.2%
2B1 Ammonia	CO_2	L, T1	3.7	3.9	3.8	-0.1	35.7%	2.3%	2.0%

Sector / category	Gas	Key	Emissions in Tg CO_2 eq.				Contribution to total in 2016 (%)		
			Base year	2015	2016	Diff.	by sector	of total gas	of total CO_2 eq.
production									
2B2 Nitric acid production	N_2O	T	6.1	0.4	0.3	-0.1	2.5%	3.3%	0.1%
2B4 Caprolactam production	N_2O	L	0.7	0.9	0.8	-0.1	7.1%	9.2%	0.4%
2B7 Soda ash production	CO_2	-	0.1	NO	NO				
2B8 Petro-chemical and carbon black production	CO_2	L2, T2	0.3	0.5	0.5	0.0	4.3%	0.3%	0.2%
	CH_4	L2	0.4	0.4	0.4	0.0	4.1%	2.3%	0.2%
2B9 Fluoro-chemical production	HFC	T	7.3	0.1	0.2	0.0	1.7%	7.4%	0.1%
	PFC	-	NO	0.0	0.0	0.0	0.4%	30.2%	0.0%
2B10 Other chemical industry	CO_2	-	0.5	0.3	0.2	-0.1	1.9%	0.1%	0.1%
2C Metal Production	CO_2	-	0.5	0.1	0.1	0.0	0.6%	0.0%	0.0%
	PFC	-	2.2	0.0	0.0	0.0	0.1%	9.0%	0.0%
	All	-	2.7	0.1	0.1	0.0	0.7%		0.0%
2C1 Iron and steel production	CO_2	-	0.0	0.0	0.0	0.0	0.1%	0.0%	0.0%
2C3 Aluminium production	CO_2	-	0.4	0.0	0.1	0.0	0.5%	0.0%	0.0%
2C3 Aluminium production	PFC	T	2.2	0.0	0.0	0.0	0.1%	9.0%	0.0%
2D Non-energy products from fuels and solvent use	CO_2	-	0.2	0.3	0.3	0.0	3.0%	0.2%	0.2%
	CH_4	-	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%
	All	-	0.2	0.3	0.3	0.0	3.0%		0.2%
2D1 Lubricant use	CO_2	-	0.1	0.1	0.1	0.0	0.8%	0.1%	0.0%
2D2 Paraffin wax use	CO_2	L2,T2	0.1	0.2	0.2	0.0	1.9%	0.1%	0.1%
2D3 Other non-specified	CO_2	-	NO	0.0	0.0	0.0	0.2%	0.0%	0.0%
2E1 Integrated circuit or semiconductor	PFC	-	0.0	0.1	0.1	0.0	0.9%	60.8%	0.0%
2F Product uses as substitutes for ODS	HFC	-	0.3	2.2	2.2	0.0	21.0%	92.6%	1.1%

Sector / category	Gas	Key	Emissions in Tg CO_2 eq.				Contribution to total in 2016 (%)		
			Base year	2015	2016	Diff.	by sector	of total gas	of total CO_2 eq.
2F1 Stationary refrigeration and Mobile air-conditioning	HFC	L,T	0.1	2.0	2.1	0.0	19.3%	85.4%	1.1%
2F6 Other	HFC	-	0.2	0.2	0.2	NO	1.6%	7.2%	0.1%
2G Other	CO_2	-	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%
	CH_4	-	0.1	0.0	0.0	0.0	0.4%	0.2%	0.0%
	N_2O	-	0.2	0.1	0.1	0.0	0.8%	1.1%	0.0%
2G2 SF_6 and PFCs from other product use	SF_6	-	0.3	0.1	0.1	0.0	1.3%	100.0%	0.1%
	All	-	0.5	0.3	0.3	0.0	2.5%		0.1%
2G3 N_2O from product uses	N_2O	-	0.2	0.1	0.1	0.0	0.7%	0.9%	0.0%
2H. Other	CO_2	-	0.1	0.0	0.0	0.0	0.2%	0.0%	0.0%
Indirect CO_2 emissions			0.7	0.2	0.2	0.0	2.0%	0.1%	0.1%
Total national emissions	CO_2		163.1	165.3	165.7	0.5			
	CH_4		32.0	18.4	18.6	0.2			
	N_2O		17.7	8.5	8.2	-0.3			
	HFCs		7.6	2.4	2.4	0.0			
	PFCs		2.3	0.1	0.2	0.0			
	SF_6		0.3	0.1	0.1	0.0			
Total national emissions (excl. CO_2 LULUCF)	All		222.9	194.8	195.2	0.5			

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

In 2016, IPPU contributed 5.5% of the total national GHG emissions (without LULUCF) in comparison with 11.0% in the base year. The sector is a major source of N_2O emissions in the Netherlands, accounting for 13.5% of total national N_2O emissions.

Category 2B (Chemical industry) contributes most to the emissions from this sector with 1.0 Tg CO_2 eq. in 2016.

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);
- Lime production (2A2);

- 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 other process uses of carbonates (2A4d) originate from:

- Limestone use for flue gas desulphurization (FGD);
- Limestone and dolomite use in iron and steel production;
- Dolomite consumption (mostly used for road construction).

4.2.1.2 Key sources

The aggregate 2A4d is a 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, the methodologies used to estimate emissions of CO_2 comply with the 2006 IPCC Guidelines, volume 3. More detailed descriptions of the methods and EFs used can be found in Peek et al. (2018), 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 has chosen to base the calculation of CO_2 emissions on the carbonate content of the process input. From 2002 onwards, process emissions from Cement clinker production are calculated as follows:

$$Em = AD * Rf * C * 44/12$$

Where:

Em = Process Emissions (ton);
AD = amount of raw material (incl organic fraction) in ton;
Rf = Recirculation factor (calculated via vowel viewing);
C = Total C content of the raw material in ton C/ton raw material (determined weekly).

CO_2 emissions from the raw material are calculated on a monthly basis by multiplying the amount of raw material (incl organic fraction) by a derived process EF. The content of organic carbon in the raw material is < 0.5%. 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. The monthly EF is set as the average of all sample EFs determined that month.

As a result, the total yearly process emissions of the company are the sum of all monthly CO_2 emissions.

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 sources. 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 2002–2016 (IPCC Default = 0.52 t/t clinker).

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

Year	IEF (t/t Clinker)
2002	0.54
2003	0.54
2004	0.54
2005	0.52
2006	0.51
2007	0.48
2008	0.48
2009	0.52
2010	0.50
2011	0.52
2012	0.51
2013	0.50
2014	0.51
2015	0.48
2016	0.48

2A2 (Lime production)

CO_2 emissions occur in two plants in the sugar industry, where limestone is used to produce lime. The lime in the sugar process is used for sugar juice purification. Lime production does not occur in the paper industry in the Netherlands. Limestone use depends on the level of beet sugar production. Approximately 375 kg of limestone is required for each ton of beet sugar produced (SPIN, 1992).
The emissions are calculated using the IPCC default EF of 440 kg CO_2 per ton of limestone.

2A3 (Glass production)

Until the 2015 submission, 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 are available, the EF for 1998–2012 has been kept at the same level as the EF of 1997 (0.18 t CO_2/t glass). Because no reliable data regarding growth in the use of recycled scrap glass (cullet) in the glass production sector are 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) are based on data from the CBS and the glass trade organization.

From the 2015 submission, the CO_2 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, sect. 2.34:

$$CO_2 \text{ emissions} = Mc \times (0.85EFls + 0.15EFd)$$

Where:

Mc = mass of carbonate consumed (tonnes);
0.85 = fraction of limestone;
0.15 = fraction of dolomite;
J.G.J., L.J. Brandes & R.A.B. te Molder, 2009: Estimate of annual and trend uncertainty for Dutch sources of GHG emissions using the IPCC Tier 1 approach. PBL report 500080013. PBL, Bilthoven.

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:

$$Mc = Mclay \times cc$$

Where:

Mclay = amount of clay consumed, 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 = 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 6 coal-fired power plants, limestone and dolomite use in crude steel production and for apparent dolomite consumption (mostly in road construction). After comparison of the emissions with the limestone use, the sum of the CO_2 emissions from the AERs of the 6 coal-fired power plants are included in the national inventory.

From 2000 onwards, data reported in the AERs of Tata Steel have been used to calculate CO_2 emissions from limestone and dolomite 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 crude steel production. The emissions are calculated using the IPCC default EF (limestone use: EF = 0.440 t/t; dolomite use: EF = 0.477 t/t).

The consumption of dolomite is based on statistical information obtained from the CBS, which can be found on the website www.cbs.nl.

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.

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 expert judgement, since no detailed information is available that might enable the uncertainties in 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.
For the source categories 2A and 2A4d, the activity and emission data of the AERs were compared with the EU ETS monitoring reports. No differences were found.

4.2.5 Category-specific recalculations
During the in-country review recommendations were made to improve the transparency of the emissions from the integrated iron and steel plant (see also Section 3.2.2). These resulted in reallocations of emissions between the categories 2C1, 2A4d, 1A1c, 1B1.b and 1A2a. The effect for category 2A4d can be found in Table 4.3.

Table 4.3: Effects of reallocation for category 2A4d, 1990–2015 (Gg CO_2 eq.)

Year	NIR 2018: CO_2 emissions	NIR 2017: CO_2 emissions	Difference
1990	481.2	481.0	0.2
1991	512.0	511.9	0.2
1992	510.8	510.6	0.2
1993	541.1	540.9	0.2
1994	762.8	762.6	0.2
1995	703.2	703.0	0.2
1996	638.6	638.4	0.2
1997	585.9	585.7	0.2
1998	593.6	593.4	0.2
1999	538.6	538.5	0.2
2000	527.3	518.9	8.5
2001	621.6	612.3	9.3
2002	556.4	546.9	9.5
2003	575.0	564.7	10.3
2004	576.7	576.7	0.0
2005	585.1	574.4	10.7
2006	569.2	550.4	18.8
2007	568.3	539.4	28.8
2008	625.1	605.7	19.5
2009	523.5	505.9	17.6
2010	593.0	578.9	14.1
2011	641.3	603.1	38.2
2012	698.0	563.7	134.3
2013	698.8	520.7	178.2
2014	738.0	559.4	178.6
2015	760.3	586.0	174.3

Also as a result of the in-country review CO_2 emissions from Lime production (2A2) have been included in this submission. The results can be found in Table 4.4.

Table 4.4: Effects of including CO_2 emissions from Lime production (2A2) 1990–2016 (Gg CO_2 eq.)

Year	NIR 2018: CO_2 emissions	NIR 2017: CO_2 emissions	Difference
1990	162.7	-	162.7
1991	159.6	-	159.6
1992	156.5	-	156.5
1993	153.4	-	153.4
1994	150.2	-	150.2
1995	147.1	-	147.1
1996	144.0	-	144.0
1997	140.9	-	140.9
1998	137.8	-	137.8
1999	134.7	-	134.7
2000	131.6	-	131.6
2001	128.5	-	128.5
2002	125.4	-	125.4
2003	122.3	-	122.3
2004	118.3	-	118.3
2005	153.5	-	153.5
2006	135.9	-	135.9
2007	141.1	-	141.1
2008	128.6	-	128.6
2009	152.3	-	152.3
2010	141.7	-	141.7
2011	158.3	-	158.3
2012	149.4	-	149.4
2013	147.9	-	147.9
2014	166.4	-	166.4
2015	128.9	-	128.9
2016	166.0		-

Due to minor changes in the production index series of chemicals, CO_2 emissions from Other uses of soda ash (2A4b) have been changed for the period 2011–2015. The results of these changes can be found in Table 4.5.

Table 4.5: Effects of changes applied to Other uses of soda ash (2A4b) 2011–2015 (Gg CO_2 eq.)

Year	NIR 2018: CO_2 emissions	NIR 2017: CO_2 emissions	Difference
2011	111.1	112.0	-0.9
2012	117.1	117.9	-0.8
2013	112.0	113.6	-1.6
2014	111.4	115.1	-3.6
2015	108.5	114.2	-5.7

4.2.6 Category-specific planned improvements

No improvements are planned.

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 was 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 all (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 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 the 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):
  - methanol: CH_4 (2B8a);
  - ethylene: CH_4 (2B8b);
  - ethylene oxide: CO_2 (2B8d);
  - acrylonitrile: CO_2 (2B8e);
  - carbon black: CH_4 (2B8f).
- 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 does not report emissions in the CRF under 2B4, which are covered by the 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.

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 1990–2016. Table 4.1 gives an overview of the 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 3.2% in 2016.

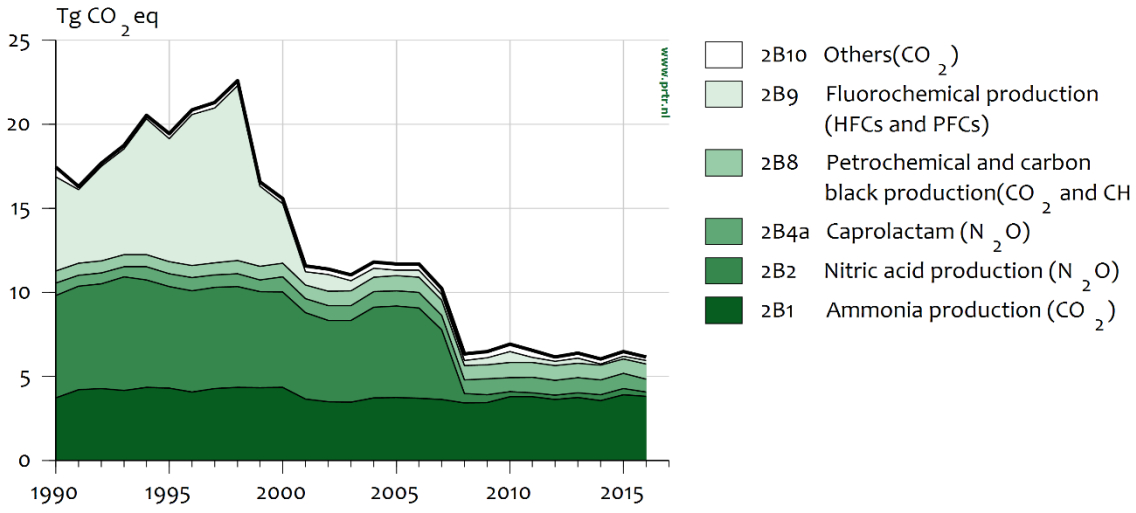


Figure 4.2: 2B Chemical industry – trend and emissions levels of source categories, 1990–2016

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 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. In 2016, total GHG emissions from 2B decreased by 0.3 Tg CO_2 eq., mainly due to a reduction in N_2O emissions.

Table 4.6 shows that N_2O emissions from 2B remained fairly stable between 1990 and 2000 (when there was no policy aimed at controlling these emissions).

Table 4.6: 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

Year	2B2 Nitric acid production	2B4a Caprolactam production	Total
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
2016	270	755	1,025

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 – in this case a marked increase – was once again related to production. In 2005 and 2006, N_2O emissions from 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 were mainly caused by operating conditions (such as unplanned stops) and to a lesser extent by the production level.

Table 4.7 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 4.7: 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:	1,269	1,273	770	4,015	4,527	5,888
2007:	1,190	1,026	631	3,275	4,448	3,311
2008:	415	0.05	143	2.26	318	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 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 2017, the companies' emissions reports (2016 emissions) were independently verified and submitted to the NEa, where they were checked against those reported in the CRF tables (2016). No differences were found between the emissions figures in the CRF tables and those in the emissions reports under EU-ETS.

Caprolactam production (2B4a)
The emissions fluctuations were mainly caused by the production level. The decreased emissions level in 2016 was caused by a decreased production level.

Fluorochemical production (2B9)
Total HFC emissions in category 2B were 7.3 Tg in 1995 and 0.178 Tg CO_2 eq. in 2016, HFC-23 emissions from HCFC-22 production (2B9a1) being the major source of HFC/PFC emissions. HFC/PFC emissions from handling activities (2B9b3) were responsible for 29% of total HFC emissions from this category in 2016.
Table 4.6 shows the trend in HFC emissions from the categories HCFC-22 production and HFCs/PFCs from handling activities for the period

1990–2016. 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. After 2010 the emission fluctuations are mainly caused by the fluctuations in the removal efficiency of the TC and to a lesser extent by the production level.

The significant emissions fluctuations in sub-category 2B9b3 (handling activities) during the period 1992–2016 can be explained by the large fluctuations in handling activities, which depend on the demand from customers.

Table 4.8: 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

Year	2B9a: HFC-23	2B9b3: HFCs/PFCs	Total
2015	118	43	161
2016	158	66	224

4.3.2 Methodological issues

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

Country-specific methodologies are used for CO_2 process emissions from the chemical industry. More detailed descriptions of the methods used and EFs can be found in the methodology report (Peek et al., 2018), 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 the CBS. 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 EU ETS.
  Because not enough information on urea production and use (import, export) or the production and use of other chemicals is available, it is assumed that the amount of CO_2 recovered is zero.
- 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 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, N_2O emissions are based on the updated and improved measurement programme in 2014. For the period 2005–2014 a recalculation was done with the help of the new insights of the updated and improved N_2O emissions measurement programme.
  The recalculation for the period 1990–2004 was done by using the 'new' average IEF 2005–2015.
  Information about the methods used before 2015 can be found in Peek et al. (2018), as indicated in Section 4.1.

- 2B5 (Carbide production): The activity data (petcoke) are confidential, so the IPCC default EF was used to calculate CH_4 emissions.
- 2B6 (Titanium dioxide production): Activity data, EF and emissions are confidential. CO_2 emissions are calculated on the basis of the non-energy use of coke and a plant-specific EF.
- 2B7 (Soda ash production): Before the closure in 2010 of the only soda ash producer in the Netherlands, 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 was 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 has stopped.
- 2B8 (Petrochemicals and carbon black production):
  - 2B8a: methanol, CH_4;
  - 2B8b: ethylene, CH_4;
  - 2B8e: acrylonitrile, CO_2;
  - 2B8f: carbon black, CH_4.

  The CO_2 and CH_4 process emissions from these minor sources are calculated by multiplying the IPCC default EFs by the annual production figures from the AERs (Tier 1).
- 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 the default EF of 0.86 t/t ethylene oxide. As there are no real activity data available at this moment in the Prodcom database from EUROSTAT, the Netherlands cannot verify this assumption on the activity data for ethylene production. For reasons of confidentiality all above-mentioned sources of 2B8, 2B5 and 2B6 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 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 are 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 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 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, emissions for the period 1990–2002 are kept equal to the emissions of 2004. Emissions for the period 2005–2012 have been determined by extrapolation between 2004 and 2013.

Activity data for estimating CO_2 emissions are based on data for the feedstock use of fuels provided by the CBS.

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%, respectively, 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 expert judgement.

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 the EU-ETS.
For Ammonia production (2B1) the energy and emissions data from the EU ETS companies were compared with the sector data from the CBS (AD) and the national inventory (emissions).
For both source categories no differences were found.

4.3.5 Category-specific recalculations
The recalculation in this source category is due to final improved activity data.

4.3.6 Category-specific planned improvements
No improvements are planned.

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). The process emission from anode use during steel production in the electric arc furnace is also included in this category.
- 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). Towards the end of 2014 Aldel restarted its plant 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 trading companies in the Netherlands, which do not produce ferroalloys and so do not have GHG process emissions that would be included in 2C2. Their combustion emissions are included in 1A2.
The following sources of GHG emissions do not exist in the Netherlands:

- Magnesium production (2C4);
- Lead production (2C5);

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

Key sources
Aluminium production (2C3) is 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 source categories. Total CO_2 emissions from 2C1 (Iron and steel production) decreased by 33 Gg during the period 1990–2016. In 2016, CO_2 emissions decreased by5 Gg compared with 2015.

From 2004 onwards, the level of the PFC emissions from aluminium production (2C3) (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 PFC emissions decreased to 0.05 Gg CO_2 eq.. This was caused by the closure of Aldel at the end of 2013. The restart under the name Klesch Aluminium Delfzijl at the end of 2014 resulted in increases in PFC emissions in 2015 and 2016.

Table 4.9: Emissions of 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

Year	PFK14 (CF_4)	PFK116 (C_2F_6)	Total
2015	5.4	1.1	6.5
2016	11.3	2.3	13.6

4.4.2 Methodological issues

The methodologies used to estimate GHG emissions in 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 Peek et al. (2018).

Iron and steel production (2C1)

As mentioned in Section 3.2.5 (for sub-category 1A2a), the emissions calculation for this category is based on a mass balance, which is not included in the NIR for reasons of confidentiality but can be made available for review purposes. Process emissions – from, amongst other things, the conversion of pig iron to steel – are obtained from the C mass balance.

From 2000 onwards, data reported in the C mass balance of Tata Steel have been used to calculate CO_2 process emissions. For the period 1990–2000, 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 crude steel production.

In former submissions the Netherlands reported fuel-related emissions in this category. During the in-country review this was considered not to be transparent. To improve transparency all fuel-related emissions are now reported in the Energy sector, with the result that emissions in this category have decreased strongly in comparison with previous submissions.

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

Aluminum 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 are 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 PFC emissions from primary aluminium production reported by these two facilities are based on the IPCC Tier 2 method for

the complete period 1990–2016. EFs 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 (see Tables A2.1 and A2.2), provides estimates of uncertainties by IPCC source category. The uncertainty in annual CO_2 emissions is estimated at 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*

During the in-country review recommendations were made to improve the transparency of the emissions from the integrated iron and steel plant. These resulted in reallocation of emissions between the categories 2C1, 2A4d, 1A1c, 1B1b and 1A2a. The effect of this shift for category 2C1 can be found in Table 4.10.

Table 4.10: Effects of reallocation for category 2C1, 1990–2016 (Gg CO_2 eq.)

Year	NIR 2018: CO_2 emissions	NIR 2017: CO_2 emissions	Difference
1990	43.7	2,266	-2,223
1991	41.7	2,229	-2,187
1992	43.9	1,722	-1,678
1993	48.4	1,662	-1,614
1994	49.8	2,071	-2,021
1995	51.6	1,595	-1,543
1996	52.0	1,524	-1,472
1997	54.6	1,815	-1,761
1998	52.0	1,446	-1,394
1999	49.9	1,310	-1,260
2000	33.6	1,082	-1,048
2001	48.5	1,041	-993
2002	67.5	1,131	-1,064
2003	55.1	1,258	-1,203
2004	43.1	989	-946
2005	68.9	1,156	-1,087
2006	62.8	831	-768
2007	59.1	1,489	-1,430
2008	64.5	732	-667
2009	20.8	841	-820

Year	NIR 2018: CO_2 emissions	NIR 2017: CO_2 emissions	Difference
2010	22.4	685	-663
2011	22.8	1,107	-1,085
2012	20.4	1,237	-1,217
2013	15.2	1,110	-1,095
2014	25.2	956	-931
2015	16.4	905	-889
2016	11.0		

4.4.6 Category-specific planned improvements

No improvements are planned.

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 category:

- Lubricant use (2D1);
- Paraffin wax use (2D2);
- Urea use in SCR (2D3).

The CO_2 emissions reported in categories 2D1 and 2D2 stem from the 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, e.g. candles. CO_2 emissions reported in category 2D3 stem from Urea use in SCR in diesel vehicles.

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 2016. CO_2 emissions from Urea use in diesel vehicles increased sharply during the period 2005–2016.

4.5.2 Methodological issues

The methodologies used to estimate 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 EFs for different vehicle types. More detailed descriptions of the method and EFs used can be found in Klein et al. (2018).

The activity data are based on fuel use data from the CBS.

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 the 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 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

No recalculations have been made.

4.5.6 Category-specific planned improvements

No improvements are planned.

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). SF_6 emissions are included in 2G2. PFC and SF_6 emissions from thin-film transistor (TFT) flat panel displays (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 0.7% in the base year 1995 and 3.8% in 2016. The latter figure corresponds to 0.09 Tg CO_2 eq. and accounts for 0.05% of the national total GHG emissions in 2016.

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 caused 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	2016
PFCs	25	50	261	254	269	305	241	168	205	140	156	115	89	85	92

4.6.2 Methodological issues

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

In the last submission the parameters used to estimate 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 were obtained from the only manufactory company (confidential information). EFs are confidential information. Detailed information on the activity data and EFs can be found in the methodology report (Peek et al., 2018).

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 (including NF_3) sources is estimated at 5%; for the EFs, the uncertainty is estimated at 25%. All these figures are based on expert judgement.

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 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 sub categories 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).
Because of data limitations it is not possible to include all information of individual sub-categories of 2F1 in CRF table 2(II)B-Hs2. Therefore, the sum of all emissions is included in the field 'emissions from stocks' for industrial refrigeration and mobile air-conditioning.

Key sources
Refrigeration and air-conditioning (2F1) is a level and trend key source for HFCs.

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, 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	**20**	NO	NO	NO	NO	62	**82**
1995	**53**	9	10	1	0	201	**274**
1996	**91**	33	35	3	0	474	**636**
1997	**130**	60	57	6	0	746	**998**
1998	**162**	83	73	7	0	849	**1,174**
1999	**188**	107	94	7	0	849	**1,243**
2000	**240**	156	136	9	0	689	**1,230**
2001	**297**	208	184	10	0	386	**1,085**
2002	**351**	257	228	11	0	181	**1,028**
2003	**404**	311	275	12	0	167	**1,170**
2004	**452**	364	320	13	0	214	**1,363**

Year	HFC-134a	HFC-143a	HFC-125	HFC-32	HFC-23	Other HFCs	HFC Total
2005	**501**	411	362	14	0	152	**1,440**
2006	**542**	458	404	15	0	171	**1,590**
2007	**581**	510	450	16	0	238	**1,796**
2008	**615**	564	498	18	0	261	**1,957**
2009	**638**	614	536	19	0	226	**2,033**
2010	**643**	637	562	20	1	205	**2,068**
2011	**654**	650	582	20	1	287	**2,195**
2012	**667**	668	611	20	2	222	**2,190**
2013	**687**	662	644	21	3	186	**2,203**
2014	**707**	646	658	24	8	175	**2,217**
2015	**714**	646	658	24	8	175	**2,224**
2016	**729**	646	658	24	8	175	**2,239**

4.7.2 Methodological issues

To comply with the 2006 IPCC Guidelines, volume 3, IPCC Tier 2 methods are used to estimate emissions in 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) were 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 the CBS. The amounts of recycled and destroyed refrigerants were obtained from ARN, a waste-processing organization.

EFs used to estimate 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 (Peek et al., 2018), 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 expert judgement.

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.
For the method to estimate HFC emissions from Stationary refrigeration (2F1): HFC emissions, a quality control procedure is included in Volume 3, paragraph 7.5.4.1 of the 2006 IPCC Guidelines. This control procedure compares the annual national HFC refrigerant market declared by the refrigerant distributors with annual HFC refrigerant needs. Because the data needed to estimate HFC refrigerant are not available, the Netherlands cannot conduct this quality control .

4.7.5 Category-specific recalculations

Because more detailed information on Mobile air-conditioning (2F1) became available, the HFC 134a 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), 1990–2015

Year	NIR 2018: 2F1 HFC134a	NIR 2017: 2F1 HFC134a	Difference
1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	NO	NO	NO
1994	**20**	**19**	**1**
1995	**53**	**52**	**1**
1996	**91**	**91**	**1**
1997	**130**	**129**	**1**
1998	**162**	**161**	**1**
1999	**188**	**188**	**0**
2000	**240**	**241**	**-1**
2001	**297**	**298**	**-1**
2002	**351**	**352**	**-1**
2003	**404**	**405**	**0**
2004	**452**	**453**	**-1**
2005	**501**	**501**	**0**
2006	**542**	**542**	**0**
2007	**581**	**581**	**0**
2008	**615**	**615**	**0**
2009	**638**	**637**	**1**
2010	**643**	**643**	**1**
2011	**654**	**653**	**1**
2012	**667**	**667**	**1**
2013	**687**	**684**	**3**
2014	**707**	**702**	**5**
2015	**714**	**706**	**8**

Better information about application methods (Open or Closed-Cell Foam) has also become available. The results of these changes can be found in Table 4.14.

Table 4.14: Effects of emissions changes (Gg CO_2 eq.) applied to Other applications (2F6), 2003–2015

Year	NIR 2018: 2F6 Other HFCs	NIR 2017: 2F6 Other HFCs	Difference
2003	167	167	0.1
2004	214	206	8
2005	152	147	5
2006	171	161	10
2007	238	227	11
2008	261	252	9
2009	226	215	10
2010	205	195	10
2011	287	259	28
2012	222	194	28
2013	186	155	31
2014	175	146	29
2015	175	146	29

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' and include information about leakages, the filling of new installations and dismantling. In the next submission a new time series will be presented. The new time series will be made using the current time series and new emission figures for the period 2013–2015.

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 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 in 2G1 and 2G2 is reported (included in 2G2).

Key sources

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

Overview of shares and trends in emissions

Table 4.15 shows the trend in emissions from the use of SF_6 during the period 1990–2016.

Table 4.15: Emissions from the use of SF_6, 1990–2016 (Gg CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
SF_6	207	261	259	204	154	125	173	120	135	139	134

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 Electrical equipment (2G1).

N_2O emissions from 2G3 decreased by 65% during the period 1990–2016. N_2O emissions from anaesthesia fell by 93% between 1990 and 2016 due to better dosing in hospitals and other medical institutions. Domestic sales of cream in aerosol cans increased sharply between 1990 and 2016. For this reason, emissions of N_2O from food aerosol cans increased by 126% during the period 1990–2016.

The small CO_2 and CH_4 emissions remained fairly constant between 1990 and 2016. CO_2, CH_4 and N_2O emissions from fireworks showed a peak in 1999 because of the millennium celebrations.

4.8.2 Methodological issues

The source category 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 emissions from 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 that 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 activity 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 for 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 Jansen et al., 2018.

The major hospital supplier of N_2O for anaesthetic use reports the consumption data for anaesthetic gas in the Netherlands annually. 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 emissions of 2G4 are:

- Fireworks: 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;
- Production of drinking water: volume and fuel use from the CBS.

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 (Jansen et al., 2018);
- Production of drinking water: 2.47 tons CH_4/106 m^3 (Jansen et al., 2018).

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 fireworks, CO_2 emissions for 2015 have been corrected. The result of this correction can be found in Table 4.16.

Table 4.16: Effect of correction applied to fireworks (2G4) in 2015 (Gg CO_2 eq.)

Year	NIR 2018: CO_2 emissions	NIR 2017: CO_2 emissions	Difference
2015	744	774	- 30

An error was corrected in the SF_6 emission for the year 2015.

4.8.6 Category-specific planned improvements

No 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 (0.021 Tg in 2016) (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 the CBS 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 improvements are planned.

5 Agriculture (CRF sector 3)

Major changes in the Agriculture sector compared to the National Inventory Report 2017

Emissions:	Methane (CH_4) emissions from Agriculture increased by 3.4% from 2014 to 2015, mainly as a result of increased numbers of cattle, swine and poultry. Nitrous oxide (N_2O) emissions from Agriculture increased by 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 no longer a key source.
Methodologies:	Small corrections were made to feed characteristics of mature dairy cattle. This has led to small adjustments in emissions from enteric fermentation in this category, ranging from +0.2 kton CH_4 (+4 kton CO_2 eq.) in 1990 to -0.1 kton CH_4 (-2 kton CO_2 eq.) in 2015. Parameters used for the calculation of CH_4 from Manure management (MCF and B0) have been updated. These changes have resulted in a decrease in emissions of 14.7 kton CH_4 (367 kton CO_2 eq.) in 1990 to 23.4 kton CH_4 (585 kton CO_2 eq.) in 2015. Changes in the N flow model have led to slight changes in direct and indirect N_2O emissions from agricultural soils. Following an update of NH_3 EFs for manure application, N_2O emissions following atmospheric deposition changed the most, decreasing 0.1 kton N_2O (36 kton CO_2 eq.) in 1990 and increasing 0.05 kton N_2O (14 kton CO_2 eq.) in 2015. Follow-up crops were added to the calculation of crop residues, increasing emissions by 0.3 kton N_2O (101 kton CO_2 eq.) to 0.4 kton N_2O (117 kton CO_2 eq.) in 2015.

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

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

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 part and the non EU-ETS part of the national system, CO_2 emissions from the 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

Total greenhouse gas emissions from agriculture decreased by approximately 23% between 1990 and 2016, from 25.0 Mton CO_2 eq. in 1990 to 19.2 Mton CO_2 eq. in 2016 (see Figure 5.1). In 2016 emissions from sector 3 Agriculture were responsible for 9.8% of total national emissions (without LULUCF), compared with 11.2% in 1990. Table 5.1 shows the emissions of GHGs in the Agricultural sector for each sub-category. The publication of Vonk et al. (2018) provides the methodologies, activity data and EFs 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	2015	2016	Difference 2016-2015	Contribution to total in 2016		
			Tg CO2-eq				by sector	of total gas	of total CO2-eq
3. Agriculture	CO_2	-	0.2	0.1	0.1	0.0	0.4%	0.0%	0.0%
	CH_4	-	14.7	12.4	12.8	0.0	66.8%	68.9%	6.6%
	N_2O	-	10.2	6.3	6.3	0.0	32.8%	76.6%	3.2%
	All	-	25.0	18.8	19.2	0.0	100.0 %		9.8%
3A. Enteric fermentation	CH_4	-	9.2	8.5	8.8	0.0	46.0%	47.4%	4.5%
3A1. Cattle	CH_4	-	8.2	7.6	7.9	0.0	41.3%	42.6%	4.1%
3A1. Mature dairy cattle	CH_4	L, T	5.2	5.2	5.6	0.1	29.4%	30.4%	2.9%
3A1. Other mature cattle	CH_4	-	0.2	0.2	0.1	-0.2	0.7%	0.7%	0.1%
3A1. Growing cattle	CH_4	L	2.8	2.2	2.1	0.0	11.2%	11.5%	1.1%
3A2. Sheep	CH_4	-	0.3	0.2	0.2	-0.1	0.9%	1.0%	0.1%
3A3. Swine	CH_4	L2	0.5	0.5	0.5	0.0	2.4%	2.5%	0.2%
3A4. Other livestock	CH_4	-	0.2	0.2	0.2	0.0	1.3%	1.3%	0.1%
3B. Manure management	CH_4	-	5.4	3.9	4.0	0.0	20.8%	21.5%	2.0%
	N_2O	L, T2	0.9	0.7	0.7	0.0	3.6%	8.4%	0.4%
	All	-	6.4	4.6	4.7	0.0	24.4%		2.4%

Sector/category	Gas	Key	Base year	2015	2016	Difference 2016-2015	Contribution to total in 2016		
3B1. Cattle	CH_4	L,T	1.6	2.0	2.1	0.1	11.2%	11.5%	1.1%
2B2. Sheep	CH_4	-	0.0	0.0	0.0	-0.1	0.0%	0.0%	0.0%
3B3. Swine	CH_4	L,T	3.4	1.8	1.7	0.0	9.1%	9.4%	0.9%
3B4. Poultry	CH_4	T	0.4	0.1	0.1	0.0	0.4%	0.4%	0.0%
3B4. Other livestock	CH_4	-	0.0	0.0	0.0	-0.1	0.2%	0.2%	0.0%
3B1-4. Direct emissions	N_2O	-	0.5	0.5	0.5	0.1	2.4%	5.7%	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	5.6	5.6	0.0	29.3%	68.2%	2.9%
3Da. Direct N2O emissions from agricultural soils	N_2O	L,T	7.6	5.0	5.0	0.0	25.9%	60.5%	2.5%
3Da1. Inorganic fertilizers	N_2O	-	2.5	1.6	1.6	0.0	8.6%	20.0%	0.8%
3Da2. Organic N fertilizers	N_2O	-	0.8	1.3	1.3	0.0	6.9%	16.0%	0.7%
3Da3. Urine and dung from grazing animals	N_2O	-	3.0	1.0	0.9	-0.1	4.8%	11.3%	0.5%
3Da4. Crop residues	N_2O	-	0.5	0.3	0.3	0.0	1.6%	3.8%	0.2%
3Da6. Cultivation of organic soils	N_2O	-	0.8	0.8	0.8	0.0	4.0%	9.4%	0.4%
3Db. Indirect N2O Emissions from managed soils	N_2O	L,T	1.6	0.6	0.6	0.0	3.3%	7.8%	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		163.1	165.3	165.7	0.5			
	CH_4		32.0	18.4	18.6	0.2			
	N_2O		17.7	8.5	8.2	-0.3			
	All		222.9	194.8	195.2	0.5			

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

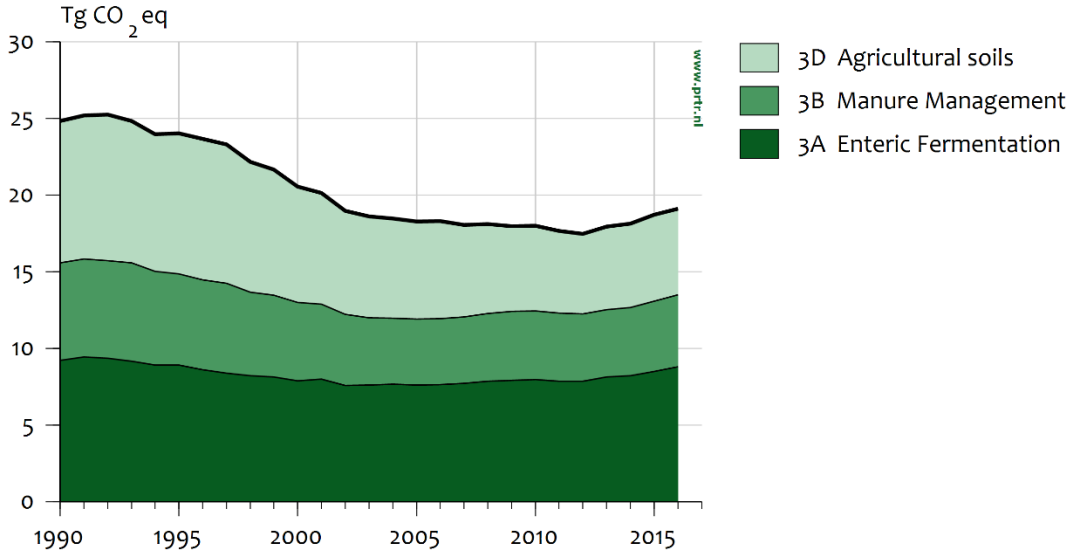


Figure 5.1: Sector 3 Agriculture – trend and emission levels of source categories, 1990–2016

Overview of trends in activity data

Animal numbers are the primary activity data used in emission calculations for Agriculture. Animal numbers come from the annual agricultural survey, which was performed by the CBS. Table 5.2 presents an overview. More detailed information on animal numbers can be found in the background document (Van Bruggen, 2017).

Table 5.2: Animal numbers in 1990–2016 (x 1,000) (www.cbs.nl)

Animal type	1990	1995	2000	2005	2010	2014	2015	2016
Cattle	4,926	4,654	4,069	3,797	3,975	4,068	4,134	4,251
Mature dairy cattle	1,878	1,708	1,504	1,433	1,479	1,572	1,622	1,745
Other mature cattle	120	146	163	151	115	82	80	68
Growing cattle	2,929	2,800	2,402	2,213	2,381	2,414	2,432	2,438
Sheep	1,702	1,674	1,305	1,361	1,130	959	946	891
Swine	13,915	14,397	13,118	11,312	12,255	12,238	12,603	12,479
Goats	61	76	179	292	353	431	470	500
Horses	370	400	417	433	441	426	417	406
Mules and asses	NO	NO	NO	NO	1	1	1	1
Poultry	94,902	91,637	106,517	95,190	103,371	104,685	108,558	107,312
Other livestock	1,340	951	981	1,058	1,261	1,324	1,404	1,286

Between 1990 and 2016 cattle, swine and sheep numbers decreased by 14%, 10% and 48%, respectively. Poultry and horse numbers increased by 13% and 10% and the number of goats increased by 722%. The number of rabbits decreased by 54%, while the number of fur-bearing animals increased by 67%, leading to a net decrease of 4% in the category Other livestock between 1990 and 2016.

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 (-7%) was associated with an increase in milk production per cow between 1990 and 2016. 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. Between 1990 and 2016, the number of other mature cattle decreased by 43%.

Between 1990 and 2013, the number of young dairy cattle followed the same decreasing trend as the number of 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 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 by 17%. In veal calves a small shift was seen from formula-fed production (white veal) towards non-formula-fed production (rosé veal).

Compared with 2015 8% more mature dairy cattle and equal numbers of growing cattle were kept in 2016. The increase in young cattle kept for beef production (3%) partly compensated for the decrease in young cattle for dairy production (-2%). In 2016 the number of other mature cattle reduced by 15% compared to 2015.

Sheep
The population of sheep in the Netherlands has almost halved since 1990. The decrease is partially explained by the outbreak of foot-and-mouth disease in 2001. A regulatory change in 2006 whereby farmers no longer received a bonus for each ewe further decreased sheep numbers. The decrease in 2016 was 6% compared with 2015.

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 2016 swine numbers decreased by 1% compared with 2015.

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 2016 goat numbers increased by 6% compared with 2015.

Horses
From 1990 to 2009 the number of horses and ponies kept on farms increased by 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 by 3% in 2016 compared with 2015. During the time series 1990 to 2016 the total number of horses and ponies increased by 10%.

Mules and asses
Mules and asses are kept on some farms in the Netherlands. Since 2010 these animals have been reported in the Agricultural Census and therefore included in the emissions inventory. For the years 1990–2009 the notation key NE is used, as it would take disproportional effort to estimate a negligible emissions source (and induce a deviation from official statistics). Due to the small numbers of mules and asses, the percentage changes in animal numbers can be large, but in absolute terms the changes are small. From 2010 to 2016 the total number decreased by 8% (-89 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 started an increasing trend again. In 2010 the number of poultry was equal to the number of poultry in 2002, indicating that the poultry sector had recovered from the avian flu outbreak. From 2011 onwards poultry numbers more or less stabilized, with small yearly increases and decreases. In 2016 poultry numbers decreased by 1% compared with 2015.

Other livestock

This category includes rabbits and fur-bearing animals. The number of rabbits showed a continuous decreasing trend from 1990 to 2016 (-54%). The number of fur-bearing animals showed an increasing trend until 2012 and remained fairly stable between 2012 and 2015 (+85% from 1990 to 2015). In 2016 a drop of 10% in animal numbers is seen, possibly because farmers were already anticipating the ban on mink husbandry, which will come into force in 2024. Foxes were kept in small numbers from 1990 until 2007, but were not allowed from 2008 on. In 2016 the overall number of rabbits and minks decreased by 4% compared with 2015.

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 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, which 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 2016, enteric fermentation accounted for 46% of the total GHG emissions from the Agriculture sector in the Netherlands (see Table 5.1). Cattle accounted for the majority (90%) of CH_4 emissions from enteric fermentation in 2016. Swine contributed 5% 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 8.8 Mton (-3.4%) between 1990 and 2016, which is almost entirely explained by the 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 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., 2018). Table 5.2 presents an overview of the livestock numbers. More detailed information on livestock numbers is given in the background document by Van Bruggen (2017).

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 (CBS, 2012b). For instance, the energy requirement for dairy cows (expressed as the net energy value of lactation, or VEM in Dutch) is calculated on the basis of the requirements for total milk production, maintenance and other functions. For growing cattle, the energy requirement is calculated on the basis of total weight gain.

Data on feed composition and feed intake (fresh grass; grass, hay and maize silage; wet by-products; standard and protein-rich concentrates) are estimated from national statistics and presented in Van Bruggen (2017). Data on the chemical nutrient composition of individual roughages is provided by Eurofins Agro (formerly known as Blgg – 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).

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 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 and growing cattle
The EFs for methane emissions from enteric fermentation in other mature and growing cattle 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:	EF (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).

Country and year specific calculation:

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 (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 are not applicable 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, 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	2014	2015	2016
Mature dairy cattle	110.4	114.4	120.0	125.0	128.0	127.2	129.0	129.3
of which NW region	111.0	115.4	121.7	126.4	129.9	129.5	131.2	130.9
of which SE region	109.9	113.5	118.4	123.6	126.7	125.5	127.5	128.2
Other mature cattle	70.3	71.3	72.1	76.7	78.1	79.1	79.1	78.6
Growing cattle	38.3	38.6	35.4	34.4	35.0	35.9	36.4	35.2

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 1990–2016. 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 2016 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 EF 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	2014	2015	2016
Milk production	6,003	6,596	7,416	7,568	8,075	8,052	8,338	8,328
IEF for methane	110.4	114.4	120.0	125.0	128.0	127.2	129.0	129.3

With increasing milk production per cow, a decrease in CH_4 emissions per unit of milk produced (from 0.018 to 0.016 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 subsource 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 by 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 with 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., 2018). In 2009 a recalculation was carried out with regard to feed intake and the resulting

cattle EFs for the whole time series (CBS, 2012a; Bannink, 2011). During the splitting of 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 expert judgement, and is estimated to be approximately 15% in annual emissions, using a 2% uncertainty for animal numbers (CBS, 2012) and a 15% uncertainty for the EF (Bannink, 2011). For the other mature cattle category, the uncertainty in emissions is 21%, based on 2% uncertainty in activity data and 21% in the EF. Young cattle emissions have an uncertainty of 11%, following from a 1% uncertainty in total animal numbers and 11% in combined EF (assuming independent estimates). The uncertainty in the EFs for swine and all other animal categories is 30–50% according to the 2006 Guidelines, of which 40% was used in the calculations following expert judgement.

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. Livestock numbers are collected in an annual census and published by the CBS. 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 Category-specific QA/QC and verification

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

5.2.5 Category-specific recalculations

In order to ensure consistency, new calculations of fecal N digestibility that had been developed for ammonia (NH_3) emission calculations in cattle were taken into account in the Tier 3 model for CH_4 from enteric fermentation in mature dairy cattle. This led to small adjustments for the whole time series, from +0.2 kton CH_4 (+4 kton CO_2 eq.) in 1990 to -0.1 kton CH_4 (-2 kton CO_2 eq.) in 2015.

5.2.6 Category-specific planned improvements

No improvements are planned.

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 in comparison with an anaerobic situation. A longer storage time and higher temperature will increase CH_4 emissions.

Three different manure management systems are used in the Netherlands and were included in the estimation of CH_4 and N_2O emissions:

- liquid manure management systems;
- solid manure management systems;
- manure produced on pasture land while grazing.

Shares of manure management systems are derived from the Agricultural census. In accordance with the 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). N excretion calculation for the different livestock categories is described in CBS (2012).

5.3.2 *Methodological issues*

Overview of shares and trends in emissions

In 2016 CH_4 from Manure management accounted for 21% of the total GHG emissions of the Agriculture sector. In the Netherlands CH_4 emissions from Manure management are particularly related to cattle and swine manure. Cattle and swine manure management contributed 11% and 9%, respectively, to the total GHG emissions of the Agriculture sector in 2016. Poultry is a minor key source of CH_4 emissions from manure management based on trend (-83% from 1990 to 2016).
In 2016 N_2O emissions from Manure management contribute 4% to the total GHG emissions of the Agriculture sector.

CH_4 from Manure management

Between 1990 and 2016, emissions of CH_4 from Manure management decreased by 27%. Emissions from cattle increased by 33%, while swine and poultry emissions decreased by 48% and 83% 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 than excretion on pasture. In young 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, which have a lower EF.

The decreasing volatile solid (VS) excretions for swine (Van Bruggen, 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 in the first part of the time series (up to 1997).

N_2O from Manure management

Direct N_2O emissions from Manure management decreased by 13% between 1990 and 2016. 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. (-43%) between 1990 and 2016. This decrease is explained by reduction measures for NH_3 and NO_x emissions from animal housing systems and manure stores over the years.
N_2O emissions from Manure management increased slightly (by 12 kton CO_2 eq. (2%)) from 2014 to 2016 due to an increase in mature dairy cattle numbers.

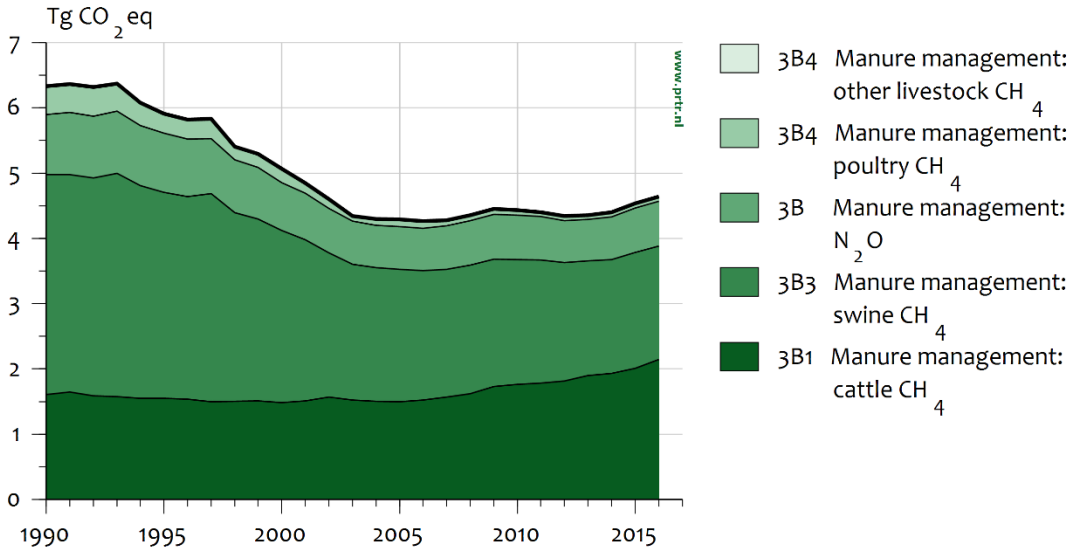


Figure 5.2: Category 3B Manure management – trend and emissions levels of source categories, 1990–2016

Activity data and (implied) EFs

Detailed information on sources of activity data and EFs is found in chapters 3 (CH_4) and 6 (N_2O) of the methodology report (Vonk et al., 2018). Table 5.2 presents an overview of the animal numbers. More detailed information on livestock numbers is given in the background document by Van Bruggen (2017). Van Bruggen (2017) also includes more details of the 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 Groenestein et al. (2016). 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, 1990–2016

Animal type	1990	1995	2000	2005	2010	2014	2015	2016
Cattle								
- mature dairy cattle	23.07	24.10	27.97	31.07	35.40	36.56	37.15	37.69
- other mature cattle	7.42	7.53	7.50	7.84	8.04	8.01	8.01	8.01
- growing cattle	6.88	7.07	6.66	6.35	7.19	7.90	8.01	7.98
Sheep	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Goats	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Horses	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Mules and asses	NO	NO	NO	NO	0.76	0.76	0.76	0.76
Swine*	9.68	8.77	8.05	7.19	6.25	5.70	5.64	5.57
Swine excl. piglets	15.44	14.34	13.18	12.06	10.74	10.17	10.15	10.11
- fattening pigs	12.87	11.81	10.76	9.70	8.65	8.01	8.01	8.01
- breeding swine	26.09	25.08	23.60	22.47	20.79	20.36	20.49	20.46
Poultry	0.18	0.13	0.08	0.05	0.03	0.03	0.03	0.03
Other livestock	0.33	0.37	0.44	0.48	0.54	0.53	0.52	0.51

* 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 2016 due to increased VS production per cow. 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) also contributed to the increased IEF. The share of liquid manure, compared with the amount of manure produced on pasture, increased between 1990 and 2016 (Van Bruggen, 2017). There has been a shift from unlimited grazing towards daytime grazing and more dairy cows are being kept indoors all year round to maximize grassland production and resulting animal production. Because of the higher EF for CH_4 emissions from manure inside animal housing facilities compared with manure on pasture, this new practice of keeping herds in animal housing throughout the year has increased methane emissions per animal (Van Bruggen, 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 2016. The proportion of solid manure 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, 2017). The increase in poultry numbers by 13% 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 2016, 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 in earlier years of the time series. With decreasing animal numbers later on, however, the effect is enhanced, and recent years show stable activity and trend.

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. The category ‘other livestock’ includes rabbits (solid manure) and minks (liquid manure). The resulting IEF for this category therefore largely depends 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 VS produced per animal is calculated annually, based on feed intake and VS digestibility. Emissions are 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., 2018). More detailed 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 (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 Groenestein et al. (2016). 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, 1990–2016 (mln kg/year and kg N_2O/kg manure)

	1990	1995	2000	2005	2010	2014	2015	2016
Total N-excretion	514.5	516.1	432.5	393.5	423.3	433.3	447.6	461.0
liquid system	*410.8*	*410.7*	*337.3*	*304.9*	*326.7*	*338.7*	*350.4*	*363.9*
solid storage	*103.7*	*105.4*	*95.1*	*88.6*	*96.6*	*94.6*	*97.1*	*97.0*
N_2O emission manure management	1.79	1.77	1.46	1.32	1.41	1.47	1.52	1.56
N_2O IEF manure management	0.0035	0.0034	0.0034	0.0034	0.0033	0.0034	0.0034	0.0034

Please note that 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. N_2O emissions from all liquid and solid manure stored is allocated to category 3B4 (Other livestock).
As presented in Table 5.6, N_2O emissions from Manure management decreased between 1990 and 2016 due to a decreased total N excretion. The increase between 2013 and 2016 is a result of 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) by 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 20 and 115%, respectively. The uncertainty in the amount of animal manure (3% for liquid and 8% for solid manure) is based on a 2–10% uncertainty in livestock numbers and a 4–22% uncertainty in manure production per animal. For horses and ponies larger uncertainties apply as a result of including privately owned animals. Based on expert judgement, the uncertainty in the CH_4 Tier 2 EFs for Manure management is estimated to be 20–74% depending on the animal category. For animal categories calculated using Tier 1 default EFs, the IPCC Guidelines give 30% as the uncertainty.

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 are collected in an annual census and published by the CBS. 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 *Category-specific QA/QC*

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

5.3.5 *Category-specific recalculations*

Groenestein et al. (2016) provided an update on previously used MCF and B0 values (Van der Hoek and Van Schijndel, 2006). The MCF for liquid cattle manure remained 0.17 but liquid swine and poultry manure were adjusted from 0.39 to 0.36 for the whole time series. The increases in MCF for liquid swine manure in the old series, to account for increased outside storage, were also removed, as the data were deemed insufficient for such a differentiation. B0 for liquid manure was adjusted from 0.25 to 0.22 and for for liquid swine manure from 0.34 to 0.31.

These changes result in a decrease in emissions of 14.7 kton CH_4 (367 kton CO_2 eq.) in 1990 to 23.4 kton CH_4 (585 kton CO_2 eq.) in 2015.

5.3.6 *Category-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.

B0 and MCF are currently being reconsidered. Based on the results of a study by Groenestein et al. (2016) the currently used B0 and MCF will be updated in the NIR 2019.

N excretions of cattle categories are currently being reconsidered, which might lead to a change in N_2O emissions to be reported in the NIR 2019.

5.4 Agricultural soils (3D)

5.4.1 Category description

In the Netherlands this category consists of the following N_2O source sub-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 2016 agricultural soils were responsible for 29% of total GHG emissions in the Agriculture sector. Total N_2O emissions from agricultural soils decreased by 39% between 1990 and 2016 (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 incorporating manure into the soil, initiated by the Dutch ammonia policy. Incorporating manure into the soil reduces emissions of ammonia but increases those of N_2O.

In 2016 N_2O emissions from grazing decreased by 7%, although the fraction of cattle actually grazing increased slightly. However, the hours spent grazing decreased, from 8 to 7 hours in limited grazing and from 20 to 19 hours in unlimited grazing. Emissions from organic N fertilizers increased by 3% because of the increase in mature dairy cattle numbers, and emissions from crop residues decreased by 2% as a result of less grassland renovation (which varies considerably from year to year depending on weather conditions).

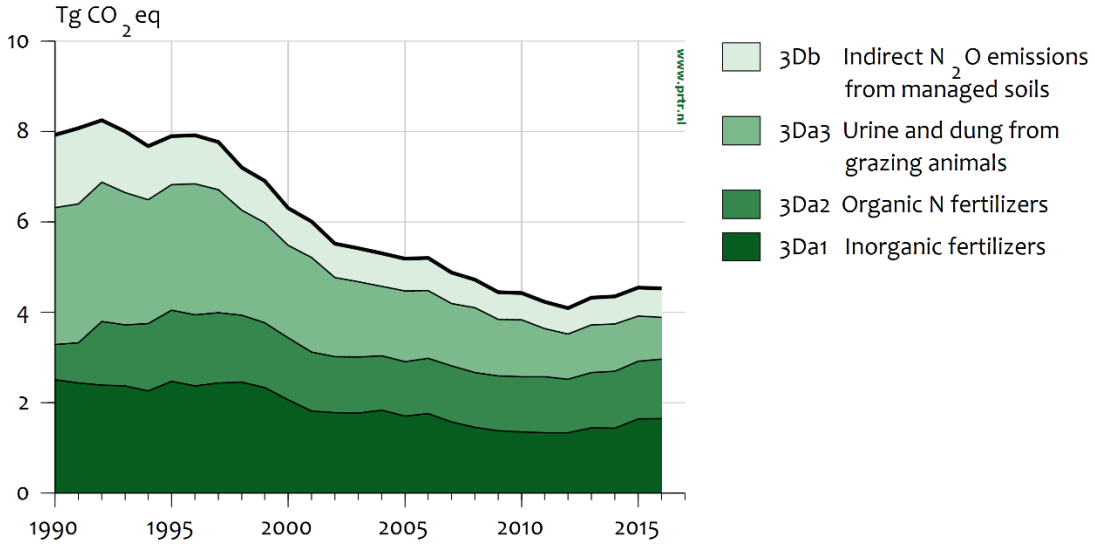


Figure 5.3: Category 3D Agricultural soils – trend and emissions levels of source categories, 1990–2016

Key sources
Direct N_2O soil emissions from managed agricultural soils are a level and trend key source. Indirect N_2O soil emissions are a trend and Tier 2 level key source.

Activity data and (implied) emission factors
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., 2018) or the background document by Van der Hoek et al. (2007). The activity data and characteristics for crops are presented in Van Bruggen (2017).

Nitrogen flows
Figure 5.4 is a schematic representation of N flows and the resulting emissions from agriculture. 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 is the combined loss subtracted in order to yield the remaining N available for application.

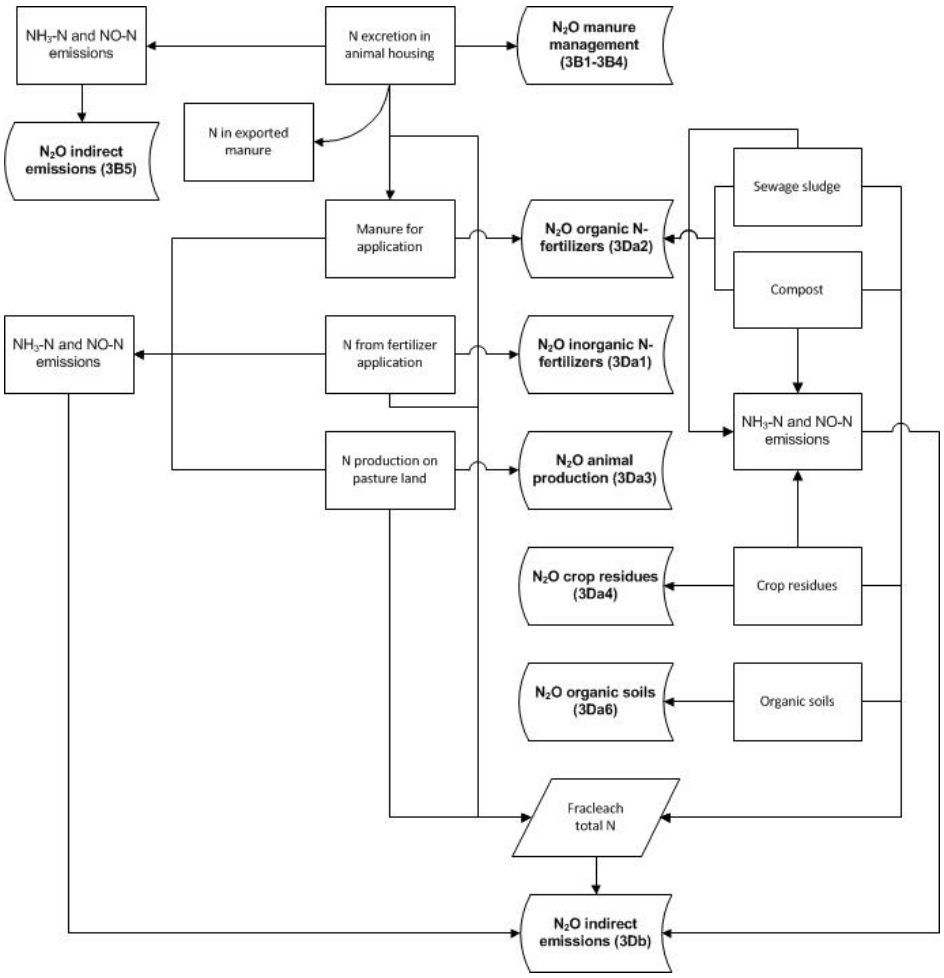


Figure 5.4: Schematic representation of N flows in agriculture and the allocation of emissions to source categories

Between 67% and 77% of the N excreted in animal housing is eventually applied to soils. A growing proportion of the manure N (from 2% in 1990 to 16% in 2016) is exported; while approximately 10–16% is emitted as ammonia or nitrous oxide during storage. Other N losses, mainly N_2 and NO, account for the remaining difference. These other N losses have increased since 1990 due to an increase in the amount of rinsing liquid from air scrubbers and an increase in free range housing systems for laying hens.

Of the manure N applied to the soil between 1990 and 2016, the part emitted as ammonia (NH_3) decreased from 41% to 10%, due to changes in manure application methods. Before 1991, manure was applied by surface spreading on both Grassland and Cropland. In accordance with the Netherlands' policy to reduce ammonia emissions, this practice changed in 1991, shifting to manure incorporation into the soil (i.e. shallow injection or ploughing-in), resulting in lower NH_3 emissions. Ultimately, between 1990 and 2016, NH_3-N emission (from animal housing, storage, grazing and application to the field) decreased from approximately 50% to 17% of total N in manure. In combination with lower synthetic N fertilizer application (-38%) and lower nitrogen

excretion by animals (-27%), this resulted in a reduction of 65% in the amount of N deposited atmospherically over the 1990–2016 period.

To calculate leaching and run-off, the total N supply to soil was taken into account: manure production in animal housing and on pasture, and the application of inorganic 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 because, after atmospheric deposition, these will also be subject to leaching and run-off. Total N supply to the soil decreased by 38% between 1990 and 2016. 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 inorganic N fertilizer. Since the leaching fraction has also decreased over time, the amount of nitrogen leached or run off has been reduced by 42% 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
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 emission factors

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 1990–2016. This 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 23% decrease in N manure input to soil, this explains the 69% 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 inorganic 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	2014	2015	2016
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 used and data sources is presented in Vonk et al. (2018).

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 have been based on gross N flows instead of net N flows to increase transparency. At the same time, EFs are updated on the basis of 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 (see Figure 5.3; 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 by 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 inorganic N fertilizer, organic N fertilizers and manure and dung deposited by grazing animals is estimated to be 45%, 66% and 67%, respectively. The uncertainty in indirect N_2O emissions from N used in agriculture is estimated to be a factor of 3 (leaching and run-off) or 4 (atmospheric deposition).

Time series consistency

A consistent methodology is used throughout the time series; see Section 5.4.2. Emissions are calculated as the product of livestock numbers and EFs. Livestock numbers are collected in an annual census and published by the CBS. Consistent methods are used in compiling the census to ensure continuity in the collected data.

5.4.4 Category-specific QA/QC

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

5.4.5 Category-specific recalculations

In the N flow approach used, adjustments to NH_3 emissions from manure management result in differences to the N available for application and thus in emissions from agricultural soils, including N_2O. These changes and those made to NH_3 emission calculations for agricultural soils will also influence indirect N_2O emissions. With the exception of atmospheric deposition the differences are slight; the updated EFs for NH_3 manure application have led to a decrease in indirect N_2O following atmospheric deposition by 0.1 kton N_2O (36 kton CO_2 eq.) in 1990 and an increase by 0.05 kton N_2O (14 kton CO_2 eq.) in 2015.

Follow-up crops were added to the calculation of crop residues, increasing emissions by 0.3 kton N_2O (101 kton CO_2 eq.) in 1990 to 0.4 kton N_2O (117 kton CO_2 eq.) in 2015.

The area of cultivated organic soils was adjusted to the latest available data, in order to match LULUCF reporting. Minor changes were applied to the whole time series.

With new activity data available, sewage sludge emissions for 2015 were also recalculated.

5.4.6 Category-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 that 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.

5.5 Liming (3G)

5.5.1 Category description

The source category 3G (Liming) includes 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. CO_2 emissions related to the latter are balanced by the CO_2 sink in sugar production and are therefore not accounted for. Over the 1990–2016 period, the amounts of limestone used increased by 24% and the amounts of dolomite decreased by 76%.

Overview of shares and trends in emissions

Sector 3G Liming is a key source based on trend. CO_2 emissions from liming decreased by 62% from 1990 to 2016 as a result of 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	2014	2015	2016
3G Liming	183	98	98	75	60	70	69	69

Activity data and EFs

Data on liming are derived from annually updated statistics on fertilizer use. The yearly amounts of applied limestone and dolomite are converted into CO_2 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 by Vonk et al. (2018).

Activity data on lime fertilizer use were not available for 2016. Therefore, 2015 emissions from liming were kept constant in 2016.

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 CO_2 emissions from Liming of soils is calculated to be 25%. The uncertainty in the activity data is estimated to be 25% and the uncertainty in the EFs is 1%. 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 *Category-specific QA/QC and verification*

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

5.5.5 *Category-specific recalculations*

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

5.5.6 *Category-specific planned improvements*

No improvements are planned.

6 Land use, land use change and forestry (CRF sector 4)

Major changes in the LULUCF sector compared with the National Inventory Report 2017

Emissions:	CO_2 emissions from LULUCF for 2016 slightly increased compared with the year 2015 (+0.25%). Due to methodological changes, compared with the NIR 2017, GHG emissions from LULUCF in 2015 decreased by 0.81%.
Key sources:	No changes in key sources.
Methodologies:	This year, three methodological changes have been implemented. The category Trees outside forests (TOF) has been included under Grassland. TOF comprises units of land with trees that do not meet the minimum area requirement for the forest definition. In the previous NIR these units of land were nevertheless included under Forest land. This has had an effect on reported activity data and emissions for conversions to and from Forest land, for Forest land remaining forest land, for conversions to and from Grassland, and for Grassland remaining grassland, in comparison with the NIR 2017. It has had a limited effect on total emissions from LULUCF, as the method of calculating carbon stock changes on these units of land has changed only in respect of dead organic matter. Carbon stocks in the Grassland (non-TOF) class have been changed to take into consideration the higher carbon stocks in orchards, which are included under Grassland. In the previous NIR only the default EF for grass vegetation was used for the whole Grassland area. This change has had an effect on reported emissions in conversions to and from Grassland and in Grassland remaining Grassland. The extrapolation of carbon stocks in dead wood in forest from 2013 (until data from a new Forest Inventory are available) is done on the basis of the trend from previous forest inventories rather than from model calculations (EFISCEN). This has an effect on reported emissions for Forest land remaining forest land.

6.1 Overview of sector

Overview and trends in the 2016 results

This chapter describes the 2016 GHG inventory for the Land use, land use change and forestry (LULUCF) sector. It covers both the sources and sinks of CO_2 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 3D) and the emission of methane (CH_4) from wetland is not estimated due to the lack of data.

Land use in the Netherlands is dominated by agriculture (approximately 55%), followed by settlements (15%) and forestry (10%, including trees outside forests); 3% comprises dunes, nature reserves, wildlife areas, heather and reed swamp. The remaining area (18%) 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% of the land area, one-third of them being peaty soils.

The Netherlands has an intensive agricultural system with high inputs of nutrients and organic matter. The majority of agricultural land is grassland (54%) or arable farming land (28%). The remaining land is fallow or used for horticulture, fruit trees, etc. 71% of grassland is permanent grassland (4% of which is high-nature-value grassland); the remaining 25% is temporary grassland, on which grass and fodder maize are cultivated in rotation (source: CBS, December 2017). Since 1990, the agricultural land area has decreased by about 5%, mainly because of conversion to settlements/infrastructure and nature.

The LULUCF sector in the Netherlands is estimated to be a net source of CO_2, amounting in 2016 to 6.54 Tg CO_2. (The recalculated value for 2015 is: 6.53 Tg CO_2, compared with the 6.58 Tg CO_2 reported in the NIR 2017). The total LULUCF sector (including N_2O emissions) accounts for 3.3% of total net GHG emissions in the Netherlands (see Table 6.2).

Methodology and coverage

The methodology of the Netherlands for assessing 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); Wetland (4D) (including open water); Settlements (4E) and Other land (4F). There is also a class 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 (3G; see Section 5.5). Changes in land use (‘remaining’ or ‘converted’) are presented in a matrix (see Chapter 6.3), which is in accordance with the approach described in the 2006 IPCC Guidelines.

The land use class Grassland is subdivided in two categories, Grassland (non-TOF) and Trees outside forests (TOF) (see Section 6.2 and Arets et al., 2018). The category Grassland (non-TOF) is the aggregation of the main sub-categories grassland (i.e. predominantly grass vegetation), nature (mainly heathland and peat moors) and orchards. All IPCC categories are applicable in the Netherlands.

Trees outside forests are units of land that do not meet the minimum area requirement for the forest definition, but otherwise fullfil those requirements in terms of tree cover and tree height. This category is included under Grassland to allow a better comparison between UNFCCC LULUCF reporting and KP-LULUCF reporting (Chapter 11). In terms of carbon stocks and changes to these, the TOF category is more similar to Forest land.

Conversions of land use from, to and between Grassland (non-TOF) and TOF are seperately monitored, and subsequent calculations of carbon stock changes differ (see Arets et al., 2018).

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 inventory per land use (conversion) category

From→ **To↓**	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**
FL	BG, BL, DW, FF	BG, BL, MS, OS	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, BL, MS, OS	BG, MS	BG, MS, OS	BG, MS
GL (non-TOF)	BG, BL, DW, Litt, MS, OS	BG, BL, MS, OS	BG, BL, WF, OS	BG, BL, MS, OS	BG, MS, OS	BG, MS, OS	BG, MS, OS
GL (TOF)	BG, BL, DW, Litt	BG, BL, MS, OS	BG, BL, MS, OS	BG	BG, MS	BG, MS, OS	BG, MS, OS
WL	BL, DW, Litt, MS, OS	BL, ML, OS	BL, MS, OS	BL, MS, OS		MS, OS	MS, OS
Sett	BL, DW, Litt, MS, OS	BL, MS, OS	BL, MS, OS	BL, MS, OS	MS, OS	OS	MS, OS
OL	BL, DW, Litt, MS, OS	BL, 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; TOF: Trees outside Forests; WL: Wetland; Sett: Settlements; OL: Other Land.

Carbon stock changes in mineral soils
The Netherlands has developed a Tier 2 approach for carbon stock changes in mineral and organic soils. For mineral soils the approach is based on the overlay of the land use maps with the Dutch soil map, combined with the soil carbon stocks that have been 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. (2018).

For the Netherlands, the basis for quantifying carbon emissions from land use changes on mineral soils is the LSK national sample survey of soil map units (Finke et al., 2001), which covers about 1,400 locations at five different depths. The carbon stock in the upper 30 cm was measured by de Groot et al. (2005a). 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 involving other land uses, estimates were made using the 2006 IPCC Guidelines. The assumptions were:

- For conversion to settlements: 50% is paved and has a soil carbon stock of 80% of that of the former land use, 50% consists of grassland or wooded land with corresponding soil carbon stock.
- For wetland converted to or from forest, there is no change in carbon stock.
- For other land, the carbon stock is zero (conservative assumption).

The 2006 IPCC Guidelines prescribe a transition period of 20 years in which carbon stock changes take place. Such a transition period in mineral soils means that land use changes in 1970 will still have a small effect on reported carbon stock changes in 1990. Here we have implemented a transition period starting in 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
On the basis of the definition of 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 (Dutch: ‘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 calculating the EFs 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. Estimated total annual emissions from cultivated soils were then converted to an annual EF per ha peat soil to report emissions from peat soils for land use (change) classes Grassland, Cropland and Settlements.

For 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. (2018).

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 are calculated for all land use conversions using a Tier 2 methodology (see Arets et al., 2018). 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., 2018). For all other aggregated soil types, we used the default C:N ratio of 15 (IPCC, 2006: sect. 11.16). For aggregated soil types where conversion of land use led to a net gain of carbon, N_2O emissions were set to zero.

Controlled biomass burning

Controlled biomass burning is reported as included elsewhere (IE) and not occurring (NO). The area of and emissions from the occasional burning carried out in the interest of nature management are included under wildfires. 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 this year and recalculations for years previously reported

Trees outside forests under Grassland

This year, the category Trees outside forests (TOF) has been introduced under Grassland. TOF constitutes of units of land with trees that do not meet the minimum area requirement for the forest definition.

Until the NIR 2014 these areas were included as a separate category under Forest land. This, however, appeared to be confusing when comparing UNFCCC and KP reporting and accounting and resulted in continuing questions and recommendations during the review proces. In the NIRs 2015–2017 these areas were included under Forest land without making a distinction between units of Forest land that did comply with the definition and those that did not. Due to new insights and to improve transparency the seperate reporting of Trees outside forests has been reinstated. But to prevent the previously observed confusion between emissions and removals as reported under UNFCCC and KP, the category TOF is now included under Grassland.

This change has had an effect on reported activity data and emissions relating to conversions to and from Forest land, Forest land remaining forest land, conversions to and from Grassland, and Grassland remaining grassland. Compared to the situation when these units of TOF were still reported under Forest land, for conversions to other land uses it is assumed that this will not contribute to wood harvest from forest land. Consequently, under Forest land remaining forest land the calculated wood harvest remaining after subtraction of the wood from deforestation will increase.

This methodological change has resulted in recalculations over the whole time series from 1990 onwards.

The other grassland category, which is equivalent to the previous main Grassland class, is now called Grassland (non-TOF).

Emission factor for orchards under Grassland (non-TOF)
To take into consideration the higher carbon stocks in orchards, in this NIR an EF for orchards is included to improve the average carbon stocks in the Grassland (non-TOF) category. In the previous NIR only the default EF for grass vegetation was used for the whole Grassland area, including orchards. This change has had an effect on reported emissions from conversions to and from Grassland (non-TOF) and Grassland (non-TOF) remaining grassland (non-TOF), and has resulted in recalculations over the whole time series from 1990 onwards.

Carbon stock changes in dead wood
From 2013 (until data from a new Forest Inventory are available), the extrapolation of carbon stock changes in dead wood in forest is based on the past trend (according to previous forest inventories) instead of on model calculations (EFISCEN). This has had an effect on reported emissions for Forest land remaining forest land and resulted in recalculations from 2013 onwards. Once the new Forest Inventory is completed (by 2021), carbon stock changes will be updated.

Contribution of the sector to GHG emissions and removals
Table 6.2 shows the sources and sinks in the LULUCF sector in 1990, 2015 and 2016. For 1990 and 2016, total net emissions are estimated to be approximately 6.05 Tg CO_2 eq. and 6.68 Tg CO_2 eq., respectively. The results for 2015 have been added to review annual changes. Sector 4 (LULUCF) accounted for about 3.3% of total national CO_2-equivalent emissions in 2016.

CO_2 emissions from the decrease in carbon stored in peat soils and peaty soils were the major source in the LULUCF sector and total 6.91 Tg CO_2. This peat oxidation is due to agricultural and water management and is the major contributor to the results of Cropland (4B), Grassland (4C) and Settlements (4E).

The major sink is the storage of carbon in forests: -2.27 Tg CO_2, which includes 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 2016 (%)		
			Base year	2015	2016	Absolute 2016–2015	by sector	of total gas	of total CO_2 eq.
4 Total LULUCF	CO_2	-	6.05	6.53	6.54	0.01	98.0	3.8	3.2
	CH_4	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	N_2O	-	0.01	0.13	0.14	0.01	2.0	0.1	0.1
	All	-	6.05	6.66	6.68	0.02	100.0		3.3
4A Forest land	CO_2	L2, T2	-1.81	-2.23	-2.27	-0.04	-34.0	-1.3	-1.1
4A1 Forest land remaining forest Land	CO_2	-	-1.84	-1.61	-1.63	-0.02	-24.3	-0.9	-0.8
4A2 Land converted to forest Land	CO_2	-	0.03	-0.62	-0.65	-0.02	-9.7	-0.4	-0.3
4B Cropland	CO_2	L2, T2	1.65	2.69	2.75	0.06	41.2	1.6	1.4
4B1 Cropland remaining ropland	CO_2	-	1.47	0.79	0.76	-0.03	11.4	0.4	0.4
4B2 Land converted to cropland	CO_2	-	0.18	1.89	1.99	0.09	29.8	1.2	1.0
4C Grassland	CO_2	L2, T2	5.39	4.21	4.17	-0.04	62.4	2.4	2.1
4C1 Grassland remaining grassland	CO_2	-	5.17	3.96	3.90	-0.06	58.4	2.3	1.9
4C2 Land converted to grassland	CO_2	-	0.22	0.25	0.27	0.02	4.0	0.2	0.1
4D Wetland	CO_2	-	0.09	0.06	0.06	0.00	0.9	0.0	0.0
4D1 Wetland remaining wetland	CO_2	-	NO,NE,IE	0.00	0.00	0.00	0.0	0.0	0.0
4D2 Land converted to wetlands	CO_2	-	0.09	0.06	0.06	0.00	0.9	0.0	0.0
4E Settlements	CO_2	L2, T2	0.87	1.60	1.62	0.03	24.3	0.9	0.8

Sector / category	Gas	Key	Emissions in Tg CO_2 eq.				Contribution to total in 2016 (%)		
			Base year	2015	2016	Absolute 2016–2015	by sector	of total gas	of total CO_2 eq.
4E1 Settlements remaining settlements	CO_2	-	0.38	0.40	0.41	0.01	6.1	0.2	0.2
4E2 Land converted to settlements	CO_2	-	0.49	1.20	1.21	0.02	18.2	0.7	0.6
4F Other land	CO_2	non key	0.03	0.12	0.13	0.00	1.9	0.1	0.1
4F1 Other land remaing other land	CO_2	-	0.00	0.00	0.00	0.00	0.0	0.0	0.0
4F2 Land converted to other land	CO_2	-	0.03	0.12	0.13	0.00	1.9	0.1	0.1
4G Harvested wood products	CO_2	non key	-0.16	0.09	0.09	0.00	1.3	0.1	0.0

Details of the methodologies applied to estimating CO_2 emissions and removals in the LULUCF sector in the Netherlands are given in a methodological background document (Arets et al., 2018).

6.2 Land use definitions and classification systems

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 classes that need to be covered. For more detailed information see Arets et al. (2018).

Definitions

Forest land (4A)

The Netherlands has chosen to define the land use class Forest land as 'all patches of 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 apply or likely to be achieved at a particular site:

- patches of land must exceed 0.5 ha, with a minimum width of 30 m;
- tree crown cover must be at least 20%; and
- tree height must be at least 5 m.

This definition conforms to FAO reporting standards and was chosen within the ranges set by the Kyoto Protocol.

Cropland (4B)

The Netherlands has chosen to define Cropland as 'arable land and nurseries (including tree nurseries)'. Intensively managed grasslands are not included in this category and are reported under Grassland. For part of the Netherlands' 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)

From this NIR onwards two distinct categories are identified within the Grassland class, and these are spatially explicitly assessed. These are (1) Trees outside forests (TOF) and (2) the old Grassland class, renamed Grassland (non-TOF) to prevent confusion with the new category. Both are explained below.

Grassland (non-TOF)

Under Grassland (non-TOF) any type of terrain which is predominantly covered by grass vegetation is reported. The category also includes vegetation that falls below, and is not expected to reach, the threshold used in the Forest land class. It is further stratified into the following sub-categories:

- Grassland vegetation, i.e. all areas predominantly covered by grass vegetation (whether natural, recreational or cultivated);
- Nature, i.e. all natural areas not covered by the grassland vegetation sub-category. This mainly consists of heathland and peat moors and may have the occasional tree.
- Orchards, i.e. areas with standard fruit trees, dwarf varieties or shrubs. They do not conform to the Forest land definition and, while agro-forestry systems are mentioned in the definition of Cropland, in the Netherlands the main undergrowth of orchards is grass. Therefore, orchards are reported under Grassland (non-TOF). From the NIR 2018 onwards a separate carbon stock for orchards is being estimated as part of an area-weighted averaged carbon stock in grasslands (see Section 6.6 and Arets et al., 2018).

In the calculations orchards are not spatially explicitly included. Instead, statistics on areas of orchards are used. See Arets et al. (2018) for more details.

Trees outside forests (TOF)

Trees outside forests (TOF) are wooded areas that comply with the Forest land definition except for their surface area (<0.5 ha or less than 30 m width). These represent fragmented forest plots as well as groups of trees in parks and natural terrains, and most woody vegetation lining roads and fields. Until the NIR 2014 these areas were included as a separate category under Forest land. This, however, appeared to be confusing when comparing UNFCCC and KP reporting and accounting and resulted in continuing questions and recommendations during the review proces. In NIR2015–2017 these areas were included under Forest land without making a distinction between units of Forest land

that did comply with the definition and those that did not. Due to new insights and to improve transparency the separate reporting of Trees outside forests has been reinstated. But to prevent the previously observed confusion between emissions and removals as reported under UNFCCC and KP, the category TOF is now included under Grassland.

Wetland (4D)
The Netherlands is characterized by wet areas. Many of these areas are covered by a grassy vegetation, and they are included under Grassland. Some wetland are covered by rougher vegetation consisting of wild grasses or shrubs, and these are reported in the category Nature under Grassland. Forested wetland (e.g. willow coppices) are included in Forest land.

Therefore, in the Netherlands, only reed marshes and open water bodies are included in the Wetland land use class. 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 harbours and docks.

Settlements (4E)
In the Netherlands, the main categories included under the class Settlements, 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 work. 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)
The Netherlands uses this land use class 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, which are included in Wetland.
In general, Other land does not have a substantial amount of carbon.

6.3 Representation of land areas and land use databases

One consistent approach was used over all land use classes. The Netherlands applies full and spatially explicit land use mapping that allows 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 (originally developed to support temporal and spatial development in land use and policy in the field of nature conservation) representing land use on 1 January 1990, 2004, 2009 and 2013 were used for wall-to-wall map overlays (Arets et al., 2018; Kramer and Clement, 2015; Kramer et al., 2007, 2009a, b; MNP, 2008; Van den Wyngaert et al., 2012), 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 classes, covers the entire territorial (land and water) surface area of the Netherlands. The sum of all land use classes is constant over time. For more details see Arets et al. (2018).

Because no land use map for 1970 is available that is similar to the maps used from 1990 onwards, the land use conversions included start from 1990. Because of this, given the 20-year transition period assumed by the IPCC Guidelines, potential inherited emissions and removals from land use changes in the period 1970–1990 are ignored. Although backward interpolation of the trend from 1990 to 2004 could have been used as an estimate, this trend is not consistent with statistical data on land use for the period before 1990. The statistical data at the national level show that the permanent grassland area of the Netherlands is continuously declining and that the cropland area increased before 1990 and since then has been slightly declining. Extending the trend from 1990–2004 to the previous period would not reflect this trend. Therefore and given the lack of data, using 1990 as a starting point for calculating carbon stock changes is considered reasonable.

Regarding the accounting of emissions from LULUCF under the Kyoto Protocol (Chapter 11), this will only affect the 1990 estimates for deforestation that are included in the calculations of the assigned amount. Therefore, to facilitate the calculation of the assigned amount for the second commitment period, inherited emissions and removals from Forest land converted to non-forest land in the period 1971–1989 were estimated from the carbon stock change data for Land converted to forest land in 1990.

Table 6.3: Land use and land use change matrix aggregated to the six UNFCCC land use categories for the period 1990–2004 (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2004							
BN 1990	**FL**	**CL**	**GL (non-TOF)**	**G (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	334,211	1,218	14,586	2,852	1,503	7,031	699	362,100
CL	12,520	739,190	176,797	2,039	6,821	81,783	201	1,019,353
GL-non TOF	18,066	196,595	1,190,740	4,475	18,641	78,259	907	1,507,682
GL-TOF	2,352	386	3,316	11,336	319	2,988	110	20,806
WL	888	596	9,092	328	776,007	2,836	2,791	792,539
Sett	1,452	1,623	10,987	1,078	1,390	392,805	122	409,457
OL	552	8	2,547	98	2,583	630	33,144	39,563
Total	*370,041*	*939,617*	*1,408,064*	*22,207*	*807,265*	*566,332*	*37,974*	*4,151,500*

Note: For comparison with CRF tables, map dates are 1 January 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) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2009							
BN 2004	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	357,474	350	5,219	1,516	703	4,572	208	*370,041*
CL	2,007	813,282	108,480	297	1,794	13,729	27	*939,617*
GL-non TOF	7,119	106,547	1,243,329	1,708	10,610	37,705	1,047	*1,408,064*
GL-TOF	1,701	137	1,198	16,893	126	2,122	30	*22,207*
WL	374	177	9,633	92	794,785	1,441	762	*807,265*
Sett	4,597	4,367	23,123	1,558	3,033	529,417	237	*566,332*
OL	209	2	506	29	890	137	36,200	*37,974*
Total	*373,480*	*924,863*	*1,391,488*	*22,092*	*811,941*	*589,123*	*38,512*	*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) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2013							
BN 2009	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	360,211	1,315	6,245	1,483	699	3,324	204	*373,480*
CL	2,480	793,892	116,002	311	1,410	10,740	28	*924,863*
GL-non TOF	8,081	145,410	1,194,126	1,591	10,849	30,915	516	*1,391,488*
GL-TOF	1,347	220	1,534	17,215	164	1,582	31	*22,092*
WL	651	304	6,180	112	801,539	1,311	1,846	*811,941*
Sett	2,530	3,198	20,653	816	4,477	557,312	135	*589,121*
OL	445	1	970	49	1,825	328	34,897	*38,515*
Total	*375,744*	*944,340*	*1,345,709*	*21,576*	*820,962*	*605,512*	*37,657*	*4,151,500*

Annual land use changes are derived from these land use change matrices. Where possible, 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).

As can be observed from the land use change matrices in the tables above, land use is very dynamic in a densely populated country like the Netherlands. Conversion of Grassland to Cropland and Cropland to Grassland is especially common. Temporary rotations of this sort are frequent, but the total areas of Grassland and Cropland remain relatively stable.

During the last period (between the 2009 and 2013 maps) an increase was observed in the conversion of Grassland to Cropland. This was caused by farmers anticipating possible limitations due to the proposed permanent grassland policy of the CAP. The extrapolation of annual land use changes from 2013 onwards probably results in an overestimation of such conversions. Once a new land use map is available, this will be corrected. A new map representing the situation on 1 January 2017 is expected to be included in the NIR 2019.

When comparing the three land use change matrices, however, the different length of time between the available land use maps should be taken into consideration, as this has an effect on the annualised land use changes. The long time between 1990 and 2004 means that some inter-annual changes, such as Cropland–Grassland rotations, are not captured, e.g. Cropland might be converted to Grassland in 1992, and converted again to Cropland in 1995, but these changes will not be captured when the land use maps of 1990 and 2004 are used. The more recent maps are closer together timewise and thus can better capture short-term rotations between Grassland and Cropland.

Since 2004, deforestation has been increasing in the Netherlands, for two principal reasons. First, deforestation takes place as part of nature development and Natura 2000 development, under which areas of heathland and shifting sand have especially increased at the cost of Forest land. Second, farmers' contracts under the set aside forest regulation11 and other national regulations from the 1980s that were aimed at temporarily increasing forest production capacity and addressing the perceived over-production in agriculture, came to an end in 1995, with the result that forests established in the 1980s and early 1990s are now being converted back into agricultural fields.

The classification of forest areas on the underlying topographical maps that are used to compile the LULUCF maps takes into consideration management interventions to prevent harvested areas from being classified under deforestation (D). Additional information on (planned) destination of areas and subsidies schemes is used support the classification.

Table 6.6: Overview of LULUCF classes, including land remaining in and land converted to each class

Class	Description	Issues
4A	Forest land	Living biomass, Harvest, Thinning, Dead wood, Litter Emissions from forest fires, fertilizer use in forests (N_2O 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	Settlements	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 rivers
4G	Other (related) activities	Harvested wood products

6.4 Forest land (4A)

6.4.1 Description

Reported in this class of land use are emissions and sinks of CO_2 caused by changes in forests. All forests in the Netherlands are classified as temperate, 30% of them coniferous, 38% broadleaved and the remainder 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 sub-division is applied between managed and unmanaged forest land. Where such a sub-division is asked for in the CRF, the notation key 'NO' will be used in the tables for unmanaged forests.

As from the NIR 2018, units of land that meet all the requirements for Forest land except the minimum area (0.5 ha) or width (30 m) are reported as Trees outside forests under the Grassland category.

[4] Report on the 6th Forest Inventory with results only in Dutch. For an English summary of the results and an English summary flyer 'State of the Forests in The Netherlands', see: https://www.wur.nl/en/Expertise-Services/Research-Institutes/Environmental-Research/Projects/Dutch-Forest-Inventory/Results.htm

The class includes three categories:

- Forest land remaining forest land (4A1): includes estimates of changes to the carbon stock in different carbon pools in Forest land;
- Land converted to forest land (4A2): includes estimates of changes in land use from mainly agricultural areas to forest land during the 20-year transition period, since 1990
- Forest land converted to other land use categories (4B2, 4C2, 4E2, 4F2) : includes emissions 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 using a country-specific Tier 2 methodology. The approach chosen follows the 2006 IPCC Guidelines (IPCC, 2006), which suggest a stock difference approach. The basic assumption is that the net flux can be derived by converting the change in growing stock volumes in the forest into volumes of carbon. Detailed descriptions of the methods and EFs used can be found in the methodological background report for the LULUCF sector (Arets et al., 2018). The Netherlands' national inventory follows the carbon cycle of a managed forest and wood products system. Changes in 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 (NFI) 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). Information between 2013 and 2020 was based on projections using the EFISCEN model (see Arets et al., 2018).

From plot-level data from the HOSP, MFV and NBI6 inventories, changes in carbon stocks in living biomass in forests were calculated. In addition, changes in activity data were assessed using several databases of tree biomass information, with allometric equations to calculate above-ground and below-ground biomass and forest litter.

More detailed descriptions of the methods and EFs used can be found in Arets et al. (2018).

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

and 2003 and between 2003 and 2012 are determined using linear interpolation.

An exception was made for units of Forest land remaining forest land that was afforested between 20 and 30 years ago. These are reported under FL-FL, but the calculation of carbon stock changes in these units follows the approach for Land converted to forest land (see Section 6.4.2.2).

Living biomass

For each plot measured during the NFIs, information is available on the dominant tree species, their standing stock (stem volumes) and the forest area they represent. Based on this information the following calculation steps are implemented (for more details see Arets et al., 2018):

1. On the basis of the growing stock information from the three NFIs and biomass expansion functions (BCEFs) for each plot in the NFIs, total tree biomass per hectare is calculated. Biomass is calculated using the dominant tree species group's specific BCEFs.
2. Average growing stocks (in m^3 ha^{-1}), average BCEFs (tonnes biomass m^{-3}) and average root-to-shoot ratios are calculated (Arets et al., 2018). These are weighted for the representative area of each of the NFI plots for each NFI.
3. On the basis of the distribution of total biomass per hectare between coniferous and broadleaved plots (determined by the dominant tree species), the relative share of coniferous and broadleaved forest is determined.
4. The average growing stock, average BCEFs, average root-to-shoot ratios and shares of coniferous and broadleaved forests are linearly interpolated between the NFIs to estimate those parameters for all the intermediate years.
5. Combining for each year average growing stock, BCEF and root-to-shoot ratios, the average above-ground and below-ground 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 below-ground biomass were converted to carbon amounts.
7. Losses from wood harvesting are not taken into account, as these 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-ground biomass (AGB) and below-ground biomass (BGB), and BCEF based on temporal interpolation between the inventories and/or model projections

Year	Growing stock (m^3 ha^{-1})	BCEF (tonne d.m. m^{-3})	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
2016	224	0.762	171	31

d.m.: dry matter

Dead wood

Dead wood volume is available from the three NFI datasets. The calculation of carbon stock changes in dead organic matter in forests follows the approach for the calculation of carbon emissions from living biomass and is done for lying and standing dead wood (see Arets et al., 2018).

Litter

Analysis of carbon stock changes based on collected data has shown that there is probably a build-up in litter in Dutch forest land. Data from around 1990, however, are extremely uncertain and, therefore, in order

to be conservative, this highly uncertain sink is not reported (see Arets et al., 2018).

Effects of wood harvests on biomass gains and losses
For each year, first the amount of timber recovered from deforestation is estimated. This is calculated as the area deforested multiplied by the average forest growing stock. This volume of wood is then subtracted from the overall nationally harvested wood volume. The remaining harvest is then allocated to Forest management activities. The fraction of harvest from Forest management in relation to the total harvest is then used in the calculations for harvested wood products (see Section 6.10).

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. See Arets et al. (2018) for more details.

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 to 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., 2018).

Emissions of CO_2, CH_4 and N_2O from forest fires are reported at Tier 2 level according the method described in the 2006 IPCC Guidelines (IPCC 2006: equation 2.27). The 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. Because burned sites are also part of the NFI, the loss of carbon due to forest fires is covered in the carbon stock changes derived from the NFI. Yet forest fires are very infrequent, mostly cover small areas and have a relatively mild impact on biomass. As a result, the NFI information probably does not fully cover emissions from forest fires. The approach followed may therefore include some double counting of these emissions and is therefore considered to be a conservative approach.

With the available data it is not possible to distinguish between forest fires in Forests remaining forests and Land converted to forest land. Therefore, total emissions from forest fires are reported in CRF Table 4(V) under 'wildfires 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 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 using a country-specific Tier 2 methodology. The approach chosen follows the IPCC 2006 Guidelines.

Living biomass
Changes in carbon stocks in above-ground biomass (AGB) and below-ground biomass (BGB) in Land converted to forest land are estimated using the following set of assumptions and calculation steps:

1. The EF 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 the time of afforestation, carbon stocks in AGB and BGB are zero.
3. The specific growth curve of new forests is unknown, but analyses of NFI plot data show that carbon stocks in newly planted forests reach the carbon stock of average forests in 30 years. Consequently, carbon stocks in AGB or BGB on units of newly established forest land annually increase by 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 Forest land remaining forest land, divided by the number of years left to reach an age of 30 years.

For Cropland and Grassland converted to forest land, biomass loss in the year of conversion is calculated using Tier 1 default values.

Conversion from Grassland (TOF) to Forest land may occur when areas surrounding units of Trees outside forests are converted to Forest land and the total forested area becomes larger than the lower limit of the forest definition (i.e. 0.5 ha). For these conversions from TOF to FL it is assumed that the biomass remains and the forest continues to grow as in Forest land remaining forest land.

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 carbon sink (see Arets et al., 2018). This sink is not reported, in order to be conservative.

Emissions from forest fires
All emissions from forest fires are included under Forest land remaining forest land and therefore are reported here 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 N_2O emissions from N inputs for Land converted to forest land are reported as NO.

6.4.2.3 Forest land converted to other land use categories

Living biomass

Total emissions from the tree component after deforestation are 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 in AGB and BGB 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 the annual increment exceeds the annual harvest.

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
2016	98.9	2.01	35.95

Conversion from Forest land to Grassland (TOF) occurs when surrounding forest is converted to other land uses and the remaining forest area becomes smaller than the lower limit of the forest definition (i.e. 0.5 ha). For these conversions from FL to TOF it is assumed that no loss of biomass occurs.

Dead wood
Total emissions from the dead wood component after deforestation are 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. This loss is also applied to Grassland (TOF).

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 in AGB and BGB 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 has been estimated at national level (Van den Wyngaert et al., 2012). Data for litter layer thickness and carbon in litter are available from five different datasets, but none of these could be used exclusively. Selected forest stands on poor and rich sands were also intensively sampled with the explicit purpose of providing conversion factors or functions. From these data, 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 NFIs (HOSP, MFV and NBI6).

The assessment of carbon stocks and changes thereto in litter in Dutch forests was based on extensive datasets on litter thickness and carbon content in litter (see Arets et al., 2018: section 4.2.1). Carbon stock changes per area of litter pool of the area of deforestation is relatively high compared to those reported by other Parties. These high values are related to the large share of the forest area that is on poor Pleistocene soils characterized by relatively thick litter layers. Additional information on geomorphological aspects is provided in Schulp et al. (2008) and de Waal et al. (2012) .

6.4.3 Uncertainties and time series consistency

Forest land remaining forest land (4A1)

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.3, provides estimates of uncertainty by IPCC source category. The Netherlands also applies an improved uncertainty assessment to the LULUCF sector with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for details). 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 range in CO_2 emissions from 4A1 (Forest land remaining forest land) is calculated at +10% to -12% and for Land converted to forest land at 26% to -21%. See Arets et al. (2018) for details.

Time series consistency
To ensure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emissions 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 Forest land remaining forest land beyond the latest NFI (i.e. from 2013 onwards) resulted in improved time series consistency between carbon stock changes.

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%. 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 ensure time series consistency, for all years the same approach for activity data, land use area and emissions calculation is used. More detailed information is provided in Section 6.4.2.2.

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%. See Olivier et al. (2009) for details.

Time series consistency
To ensure time series consistency, for all years the same approach for activity data, land use area and emissions 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 NFIs, specific QA/QC measures were implemented to prevent errors in measurements and reporting (see Arets et al., 2018).
- Previously, changes in forest area and mean carbon stocks in Dutch forests were verified by 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 described in Section 6.1. The distinction between Forest land and Trees outside forests resulted in a smaller forest area, affecting the total carbon stock changes in Forest land remaining forest land and conversions from Forest land to other land used. Similarly, changes in the carbon stocks in Grassland (non-TOF) resulted in differences in carbon stock changes in Grassland converted to forest land.

6.4.6 Category-specific planned improvements

In 2017 the Netherlands started its 7th National Forest Inventory (NBI7). This is expected to deliver results by 2021. The results will be used in the NIR 2022 and will then replace the currently projected changes in carbon stocks based on the EFISCEN model.

6.5 Cropland (4B)

6.5.1 Description

Emissions resulting from the lowering of the ground water table in organic soils under Cropland are significant, and are calculated separately for areas of Cropland remaining cropland and Land converted to cropland (see Arets et al., 2018).

However, over time no net accumulation of carbon stocks in biomass are expected to occur in Cropland (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, which is in line with the Tier 1 method detailed in the IPCC 2006 Guidelines (IPCC, 2006).

There are significant carbon stock changes in biomass in orchards, which in the Netherlands predominantly consist of fruit trees, but because of the usually grassy vegetation between the trees, orchards are included under Grassland (see Section 6.6).

Dead organic matter in annual cropland is expected to be negligible and, applying a Tier 1 method, it is assumed that dead wood and litter stocks (dead organic matter, DOM) are not present in Cropland (IPCC, 2016). Therefore, neither are carbon stock gains in DOM included in land use conversions to Cropland, nor are carbon stock losses included in conversions from Cropland to other land uses. Carbon stock losses for conversions to Cropland will depend on the carbon stocks in DOM in the ‘converted from’ land use category. Currently carbon stocks in DOM are included only under Forest land.

As with living biomass and DOM, no carbon stock changes in mineral soils are expected in Cropland remaining cropland. Therefore, for Cropland remaining cropland no net carbon stock changes in mineral soils are calculated or reported.

6.5.2 Methodological issues

With regard to soil emissions, a 20-year transition period is included, starting from 1990, while carbon stock changes in biomass are considered to be instantaneous on conversion. In the CRF table 4.B, 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 (4A2, 4C2, 4D2, 4E2, 4F2). Net carbon stock changes in both mineral and organic soils for land use changes involving Cropland are calculated using the methodology provided in Arets et al. (2018).

6.5.3 Uncertainties and time series consistency

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.3, provides estimates of uncertainties for each IPCC source category. The Netherlands also applies an improved uncertainty assessment to the LULUCF sector with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for more details). The uncertainties in the Dutch analysis of carbon levels depends 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 range in the CO_2 emissions for 4B1 (Cropland remaining cropland) is calculated at -60% to +61% and for 4B2 (Land converted to cropland) at -45% to +61%; see Arets et al. (2018) for details.

Time series consistency

To ensure time series consistency, for all years up to 2013 the same approach for activity data and land use area is used. For years after 2013 the trends from the period before are extrapolated. 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 1,873 Gg CO_2 in 2016.

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 described in Section 6.11.

6.5.6 Category-specific planned improvements

No improvements are planned.

6.6 Grassland (4C)

6.6.1 Description

From the NIR 2018 onwards the reporting of the class Grassland has changed from previous submissions. At the level of reporting two main categories are identified: (1) Trees outside forests (TOF) (see Section 6.2) and (2) Grassland (non-TOF). The previous class Grassland is now Grassland (non-TOF). Conversions of land use to, from and between Grassland (non-TOF) and TOF are separately monitored and the calculation of the carbon stock changes differs.

Grassland (non-TOF)

As for Cropland, emissions resulting from the lowering of the ground water table in organic soils under Grassland (non-TOF) are significant. Therefore, these are explicitly calculated for areas of Grassland remaining grassland (non-TOF) and Land converted to grassland (non-TOF) (see Arets et al., 2018).

For carbon stock changes in living biomass in grassland vegetation and nature remaining in those categories, a Tier 1 method is applied, assuming no change in carbon stocks (IPCC, 2006; for more details see Arets et al., 2018). In orchards an increase in carbon stocks can be expected with aging of the fruit trees. However, data on orchards indicate that the average age of trees in orchards remains relatively constant at 10.5 years (see chapter 6 in Arets et al., 2018). Therefore, it is assumed that at the national level average carbon stocks per unit of area of orchard will not change.

Emissions of CO_2 from carbon stock changes in living biomass for Land converted to grassland is calculated using a Tier 1 approach (see Section 6.6.2). Carbon stocks in Grassland (non-TOF) depend on carbon stocks per unit of area of grassland vegetation, nature and orchards and the relative contribution of these categories to the Grassland (non-TOF) area. This value is also used for determining emissions from Grassland converted to other land use categories.

Dead organic matter in grassland and orchards is expected to be negligible. While dead wood and litter may be formed in orchards, pruning and the removal of dead wood and litter will prevent build-up of large amounts of DOM. Therefore, the Tier 1 approach – assuming no build-up of DOM – is used (IPCC, 2006). This means that neither are carbon stock gains in DOM included in land use conversions to the Grassland (non-TOF), nor are carbon stock losses included in conversions from Grassland (non-TOF) to other land use categories. Carbon stock losses for conversions to Grassland (non-TOF) will depend on the carbon stocks in DOM in the ‘converted from’ land use category. Currently carbon stocks in DOM are included only under Forest land.

Following the IPCC Guidelines, no carbon stock changes in mineral soils are expected for Grassland (non-TOF) remaining grassland (non-TOF). However, since transitions between ‘nature’ and grassland vegetation are treated as Grassland (non-TOF) remaining grassland (non-TOF) and land is always reported under its last known use, a unit of land that is converted from another land use to ‘nature’ (or grassland vegetation)

and subsequently to grassland vegetation (or nature) will be reported under Land converted to grassland (non-TOF) until its conversion to grassland vegetation, and as Grassland (non-TOF) remaining grassland (non-TOF) thereafter. However, the soil carbon stock is still in the transition phase, causing a change in the mineral soil carbon stock in the Grassland (non-TOF) remaining grassland (non-TOF) category even if soil carbon under grassland is assumed to be stable.

Trees outside forests
The trees ouside forests (TOF) category is determined spatially explicit and experiences carbon stock changes similar to those of Forest land (see Section 6.4.2 and Arets et al., 2018). For land use conversion to TOF, the same biomass increase and associated changes in carbon stocks are assumed as for Land converted to forest land.
For conversions from TOF to other land uses, hoewever, no losses of dead wood or litter are assumed. As the patches are smaller and any edge effects therefore larger than in forests, the uncertainty on dead wood and litter accumulation is even higher for TOF than for Forest land. Moreover, for small patches and linear woody vegetation, the chance of dead wood removal may be very high. Disturbance effects on litter may prevent accumulation. Therefore the conservative estimate of no carbon accumulation in these pools is applied.

Conversion from Forest land to TOF may occur if connected surrounding units of Forest land are converted to other land uses and the remaining area no longer complies with the forest definition. Such units of land are considered to remain with tree cover but losses of carbon in dead wood and litter will occur.

Conversions between Grassland (non-TOF) and TOF
Whereas conversions between Grassland (non-TOF) and TOF are reported under Grassland remaining grassland, the two categories are considered as separate categories in the calculations.

Conversions from Grassland (non-TOF) to TOF will result in the loss of Grassland (non-TOF) biomass in the year of conversion and subsequent growth of biomass in TOF. The conversion from TOF to Grassland (non-TOF) will involve a loss of carbon stocks in biomass from TOF and increase in carbon stocks in Grassland (non-TOF), as with conversions from other land use categories.

6.6.2 *Methodological issues*

With regard to soil emissions, a 20-year transition period is included, starting from 1990, while carbon stock changes in biomass are considered to be instantaneous on conversion. In the CRF, the area associated with the transition period for soil is reported.

Living biomass
Grassland non-TOF
Carbon stock changes due to changes in biomass in land use conversions to and from Grassland (non-TOF) are calculated using Tier 1 default carbon stocks. For the whole Grasslands (non-TOF) category, including grassland vegetation, nature and orchards, an average carbon stock per unit of land is calculated from the carbon stocks per unit area

of grassland vegetation, nature and orchards weighted for their relative contribution to the Grassland (non-TOF) category. Therefore, average carbon stocks for Grassland (non-TOF) will vary over time as a result of varying relative contributions of the different vegetation types to the total Grassland (non-TOF) area (see Table 6.9).

Default values for dry matter and carbon factors were used to determine carbon stocks in living biomass in grassland vegetation and nature. These are 6.4 ton C ha^{-1} (see Arets et al., 2018). Carbon stocks in living biomass in orchards were based on the average age of trees in orchards of 10.5 years and a T1 biomass accumulation rate of 2.1 ton C ha^{-1} yr^{-1} (IPCC, 2003a). The average carbon stock in living biomass in orchards is thus estimated at 22 tons C ha^{-1}. Areas of orchards as published annually since 1992 by the CBS are used to assess the area-weighted average carbon stocks in Grassland non-TOF (Table 6.9).

Net carbon stock changes in both mineral and organic soils for land use changes involving Grassland are calculated using the methodology provided in Arets et al. (2018).

Table 6.9: Area and carbon stocks (CS) in living biomass for orchards and grass vegetation and combined average carbon stocks per area of Grassland non-TOF

	Orchard		Grass vegetation		Total		Average
Year	Area (kha)	CS (tC)	Area (kha)	CS (tC)	Area (kha)	CS (tC)	CS (tC/ha)
1990	24.1	529.6	1434.0	9166.3	1458.1	9707.8	6.66
1991	23.9	524.8	1427.2	9123.0	1451.1	9659.9	6.66
1992	23.6	520.0	1420.5	9079.6	1444.1	9610.4	6.65
1993	23.4	515.2	1413.7	9036.3	1437.1	9562.5	6.65
1994	23.4	514.1	1406.7	8991.9	1430.1	9517.7	6.66
1995	22.4	492.2	1400.7	8953.5	1423.1	9457.3	6.65
1996	22.2	488.2	1393.9	8910.0	1416.1	9409.4	6.64
1997	22.2	489.0	1386.9	8865.0	1409.1	9364.6	6.65
1998	21.6	476.0	1380.5	8824.0	1402.1	9310.4	6.64
1999	21.1	465.0	1374	8782.5	1395.1	9257.8	6.64
2000	19.8	434.7	1368.4	8746.6	1388.2	9193.4	6.62
2001	18.8	412.6	1362.4	8708.3	1381.2	9133.0	6.61
2002	18.5	407.1	1355.6	8665.2	1374.1	9082.8	6.61
2003	17.7	388.7	1349.5	8625.8	1367.2	9026.2	6.60
2004	17.6	387.3	1342.5	8581.5	1360.1	8979.2	6.60
2005	17.4	382.1	1339.2	8560.2	1356.6	8953.7	6.60
2006	17.4	382.2	1335.6	8537.5	1353.0	8930.6	6.60
2007	17.7	388.3	1331.8	8512.9	1349.5	8912.9	6.60
2008	17.8	391.0	1328.1	8489.4	1345.9	8891.4	6.61
2009	17.9	394.8	1324.4	8465.6	1342.3	8870.0	6.61
2010	17.7	389.6	1313	8392.4	1330.7	8792.6	6.61
2011	17.5	384.5	1301.5	8319.2	1319.0	8714.6	6.61

	Orchard		Grass vegetation		Total		Average
Year	Area (kha)	CS (tC)	Area (kha)	CS (tC)	Area (kha)	CS (tC)	CS (tC/ha)
2012	17.1	376.3	1290.2	8246.8	1307.3	8633.5	6.60
2013	17.4	382.9	1278.2	8170.2	1295.6	8563.3	6.61
2014	17.5	384.7	1278.1	8169.7	1295.6	8564.8	6.61
2015	17.9	394.8	1277.6	8166.7	1295.5	8570.4	6.62
2016	17.9	392.9	1277.7	8167.3	1295.6	8571.1	6.62

Trees outside forests
For TOF, no separate data on growth or increment are available. It is assumed that TOF grow at the same rates as forests under Forest land (see Section 6.4 and Arets et al., 2018). The only difference between the two categories is the size of the stand (<0.5 ha for TOF), so this seems to be a reasonable assumption. It is assumed that no build-up of dead wood or litter occurs. It is also assumed that no harvesting takes place. Instead, all wood included in the national harvest statistics is assumed to be harvested from Forest land.

Wildfires
There are no recent statistics available on the occurrence and intensity of wildfires in the Netherlands. Emissions of CO_2, CH_4 and N_2O from wildfires are reported according to the Tier 1 method described in the 2006 IPCC Guidelines (IPCC, 2006).

The area of wildfires is based on a historical series from 1980 to 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 Section 6.4.2). The average annual area of other wildfires is 210 ha (Arets et al., 2018). This includes all land use categories. Most wildfires in the Netherlands, however, are associated with heath and grassland. All other emissions from wildfires, except forest fires, are therefore included under Grassland remaining grassland. CO_2, CH_4 and N_2O emissions from wildfires are based on the default carbon stock in living biomass on Grassland (non-TOF).

6.6.3 *Uncertainties and time series consistency*

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.3, provides estimates of uncertainties by IPCC source category. The Netherlands also applies an improved uncertainty assessment to the LULUCF sector with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for more details). The uncertainty range for CO_2 emissions in category 4C1 Grassland (non-TOF) remaining grassland (non-TOF) is calculated at -60% to +68% and for 4C2 Land converted to grassland (non-TOF) at -220% to +340%; see Arets et al. (2018) for details. There is not yet a Monte Carlo uncertainty assessment based on the TOF category, but uncertainties are likely to be similar to those of Forest land – except that the uncertainty related to the land use map is possibly bigger as a result of the inherently small

patches of TOF. A new Monte Carlo uncertainty assessment including TOF is foreseen in the next NIR.

Time series consistency
To ensure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emissions calculation is used. Net annual emissions of CO_2 due to the conversion of land to Grassland show an increase from 218 Gg CO_2 in 1990 to 270 Gg CO_2 in 2016.

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 described in Section 6.1. Slightly increased carbon stocks in the Grassland (non-TOF) category (which was the whole Grassland class in previous submissions) has led to increases in carbon gains in Land converted to grassland (non-TOF) and increased carbon losses in Grassland (non-TOF) converted to other land uses. As a result of including Trees outside forests in the Grassland class, carbon stock gains in Grassland remaining grassland are now also included, resulting in large changes in the Grassland remaining grassland category. This change, however, has only limited effects on overall emissions and removals from all land use categories.

6.6.6 Category-specific planned improvements
No improvements are planned.

6.7 Wetland (4D)

6.7.1 Description
The land use category Wetland mainly comprises open water. Therefore for 4D1 (Wetland remaining wetland) no changes in carbon stocks in living biomass and soil are estimated. Similarly, for land use conversions from Wetland to other land uses no carbon stock changes in living biomass are assumed. For land use changes from Forest land, Cropland and Grassland to Wetland (4D2) losses in carbon stocks in living biomass and net carbon stock changes in soils are included.

Because the Wetland category is mainly open water, dead organic matter (DOM) is assumed to be negligible. Therefore, neither are carbon stock gains in DOM included in land use conversions to Wetland nor are carbon stock losses included in conversions from Wetland to other land use categories. Carbon stock losses for conversions to Wetland will depend on the carbon stocks in DOM in the ‘converted from’ land use category. Currently carbon stocks in DOM are included only under Forest land.

In the Netherlands land use on peat areas is mainly Grassland and Settlements. Emissions from drainage in peat areas are included in

carbon stock changes in organic soils in the relevant land use categories.

6.7.2 Methodological issues

Living biomass

Carbon stocks in living biomass and DOM on flooded land and in open water are considered to be zero. For conversion from other land uses to Wetland, 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 Wetland

The land use category Wetland mainly comprises open water, on which no direct nitrogen inputs occur. Therefore, in CRF Table 4(I) direct N_2O emissions from N inputs for Wetland are reported as NO.

6.7.3 Uncertainties and time series consistency

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.3, provides estimates of uncertainties according to IPCC source categories. The Netherlands also applies an improved uncertainty assessment to the LULUCF sector with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for details).
The uncertainty range in the CO_2 emissions for 4D2 Wetland converted to wetland is calculated at -67% to +76%; see Arets et al. (2018) for details.

Time series consistency

To ensure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emissions calculation is used. The time series shows a decrease in CO_2 emissions from 88 Gg CO_2 in 1990 to 64.4 Gg CO_2 in 2016.

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 described in Section 6.

6.7.6 Category-specific planned improvements

No improvements are planned.

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, due to the high resolution of the land use grid, areas of land of 25 x 25 m or more

within urban areas meeting the criteria for Forest land, Grassland or Trees outside forests will be reported under those land use categories and not under Settlements (see Arets et al., 2018). In other words, these major pools of carbon in urban areas are covered by other land use categories.

Since no additional data are available on carbon stocks in biomass and DOM in Settlements, the Netherlands applies the Tier 1 method, assuming no change in carbon stocks in biomass in 4E1 (Settlements remaining settlements). Similarly, it is assumed that no carbon stock changes occur in soils under Settlements remaining settlements. For conversions 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

The methodology for calculating carbon stock changes in biomass for Forest land converted to settlements is provided in Section 6.4. Sections 6.5 (Cropland) and 6.6 (Grassland) provide the methodology for calculating carbon stock changes in biomass for conversions from Cropland and Grassland to Settlements. Land use conversions from Wetland or Other Land to Settlements will result in no changes in carbon stocks in living biomass.

Emissions from fertilizer use in Settlements

Direct N_2O emissions from Settlements are reported under 3Da2c (other organic fertilizers applied to soils (including compost)). Therefore, in CRF Table 4(I) N_2O emissions from N inputs for Settlements are reported as IE.

6.8.3 Uncertainties and time series consistency

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.3, provides estimates of uncertainties for each IPCC source category. The Netherlands also applies an improved uncertainty assessment to the LULUCF sector with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for details).

The uncertainty range in CO_2 emissions for 4E1 (Settlements remaining settlements) is calculated at -64% to +53% and for 4E2 (Land converted to settlements) at -17% to +90%; see Arets et al. (2018) for details.

Time series consistency

To ensure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emissions calculation is used. The time series shows a consistent increase from 888 Gg CO_2 in 1990 to 1,650 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 described in Section 6.1.

6.8.6 Category-specific planned improvements

No improvements are planned.

6.9 Other land (4F)

6.9.1 Description

In the Netherlands the land use category 4F (Other land) is used to report areas of bare soil that are not included in any other category. These include coastal dunes and beaches with little or no vegetation, inland dunes and shifting sands, i.e. areas where the vegetation has been removed to create spaces for early succession species (and which are kept open by the wind). Inland bare sand dunes developed in the Netherlands as a result of heavy overgrazing. This was for a long time combated by forest planting. These inland dunes and shifting sands, however, provided a habitat to some species that have now become rare. As a conservation measure in certain areas, these habitats have now been restored by removing vegetation and topsoil.

No carbon stock changes occur on Other land remaining other land. For units of land converted from other land uses to the category Other land, the Netherlands assumes that all the carbon in living biomass and DOM that existed before conversion is lost and no gains on Other land exist. Carbon stock changes in mineral and organic soils on land converted to Other land are calculated and reported.

Similarly, land use conversions from Other land to the other land use categories will involve no carbon stock losses from biomass or DOM.

6.9.2 Methodological issues

The methodology for calculating carbon stock changes in biomass for Forest land converted to settlements is provided in Section 6.4. Sections 6.5 (Cropland) and 6.6 (Grassland) provide the methodology for calculating carbon stock changes in biomass in conversions from Cropland and Grassland to Other land. Land use conversions from Wetland or Settlements to Other Land will result in no changes in carbon stocks in living biomass.

6.9.3 Uncertainties and time series consistency

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.3, provides estimates of uncertainties for each IPCC source category. The Netherlands also applies an improved uncertainty assessment to the LULUCF sector with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for details).

The uncertainty range in CO_2 emissions for 4F2 (Land converted to other land) is calculated at -3% to +152%; see Arets et al. (2018) for details.

Time series consistency
To ensure time series consistency, for all years up to 2013 the same approach for activity data, land use area and emissions calculation is used. The time series shows a consistent slow increase from 26 Gg CO_2 in 1990 to 126 Gg CO_2 in 2016.

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 in other categories described in Section 6.1.

6.9.6 Category-specific planned improvements
No improvements are planned.

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., 2018). Under the convention, HWP emissions and removals are reported in the CRF using Approach B2.

6.10.2 Methodological issues
The approach taken to calculate the HWP pools and fluxes follows the guidance in chapter 2.8 of the 2013 IPCC KP guidance (IPCC, 2014). As required by the guidelines, carbon from HWP allocated to Deforestation is reported using instantaneous oxidation (Tier 1) as the method for calculations. The remainder of the carbon is allocated to Forest management and is subsequently added to the respective HWP pools. As no country-specific methodologies or half-life constants exist, the calculation 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) (Arets et al., 2018).

Four categories of HWP are taken into account: Sawn wood, Wood-based panels, Other industrial round wood, and Paper and paperboard. Emissions from wood harvested for energy purposes are included in carbon stock losses in living biomass under Forest management, but are not used as an inflow to the HWP pool. As a result, these emissions are accounted for on the basis of instantaneous oxidation.

The distribution of material inflow in the different HWP pools is based on the data reported from 1990 onwards to FAO-statistics on imports, production and exports of the different wood product categories (see Table 6.10), 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 from the 2013 IPCC KP guidance (see Table 6.11) have been used. For the category Other industrial round wood, the values for Sawn wood were used, as the latter category includes types of round wood use, such as the use of whole stems as piles in building foundations and road and waterworks, and as fences and poles. These are considered applications with a long to very long lifetime, for which the 35-year half-life is considered appropriate.

Table 6.10: Annual production, import and export statistics for Sawn wood, Wood-based panels, Other industrial round wood (only production, no import or export) and Paper and paperboard

	Sawn wood			**Wood-based panels**			**Other**	**Paper and paperboard**		
	Prod.	**Im.**	**Ex.**	**Prod.**	**Im.**	**Ex.**	**Prod.**	**Prod.**	**Im.**	**Ex.**
Year	1000 m^3							metric kt		
1990	455	3,450	413	97	1,621	141	115	2,770	2,420	2,099
1991	425	3,149	461	105	1,589	154	132	2,862	2,547	2,135
1992	405	3,222	440	111	1,532	167	95	2,835	2,579	2,224
1993	389	3,564	427	107	1,456	237	77	2,855	2,429	2,050
1994	383	3,771	426	110	1,593	312	100	3,011	2,366	2,204
1995	426	3,277	458	114	1,599	305	75	2,967	2,522	2,250
1996	359	3,322	389	96	1,531	318	70	2,987	2,798	2,438
1997	401	3,431	377	101	1,765	313	59	3,159	3,178	2,844
1998	349	3,534	415	59	1,813	299	39	3,180	3,523	2,810
1999	362	3,606	427	61	2,089	288	92	3,256	3,496	2,588
2000	390	3,705	380	61	1,727	275	110	3,332	3,210	3,001
2001	268	3,294	305	20	1,816	257	84	3,174	3,211	2,558
2002	258	3,022	356	23	1,631	254	116	3,346	3,306	2,819
2003	269	3,163	400	10	1,630	247	126	3,339	3,264	3,044
2004	273	3,175	388	8	1,597	308	33	3,459	3,055	2,957
2005	279	3,100	488	11	1,643	327	44	3,471	3,386	3,151
2006	265	3,399	555	10	1,871	363	32	3,367	3,367	3,169
2007	273	3,434	601	18	1,886	405	20	3,224	3,519	3,106
2008	243	3,101	423	33	1,894	411	31	2,977	3,413	2,374
2009	210	2,575	292	46	1,495	301	48	2,609	2,923	2,007
2010	231	2,750	314	51	1,483	274	52	2,859	3,036	2,270
2011	238	2,710	322	46	1,680	295	61	2,748	2,874	2,484
2012	190	2,557	432	58	1,431	329	20	2,761	2,570	1,941
2013	216	2,477	446	33	1,371	288	14	2,792	2,758	2,279
2014	228	2,506	508	29	1,404	290	14	2,767	2,789	2,268
2015	185	2,661	477	29	1,522	244	16	2,643	2,411	2,140
2016	185	2,661	477	29	1,522	244	16	2,643	2,411	2,140

Table 6.11: Tier 1 default carbon conversion factors and half-life 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 industrial round wood	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 estimate is currently available. The Netherlands, however, has included HWP in the improved uncertainty assessment of the LULUCF sector using Monte Carlo simulations for combining different types of uncertainties (see chapter 14 in Arets et al., 2018 for more details).

The uncertainty range in the CO_2 emissions for 4G (Harvested wood products) is calculated at -8% to +1%; see Arets et al. (2018) for details.

Time series consistency

Annual changes in carbon stocks in HWP are erratic by nature because they depend on highly variable inputs of wood production, imports and exports. Net CO_2 emissions and removals in the period 1990–2016 range 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 described in Section 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 Forest land remaining forest land beyond the latest NFI affected the calculated biomass in Forest land, which subsequently changed the calculated amounts of wood that would become available from deforestation, which is included in HWP, assuming instantaneous oxidation.

6.10.6 *Category-specific planned improvements*

No improvements are planned.

7 Waste (CRF sector 5)

Major changes in the Waste sector compared with the National Inventory Report 2017

Emissions:	In 2016, total GHG emissions from this sector decreased further.
Key sources:	Compared with the NIR 2017, subcategory 5D (Wastewater treatment and discharge) is now considered a key source of CH_4 emissions.
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.

CO_2 emissions from the anaerobic decay of waste in landfill sites are not included here, 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, either, 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 (Peek et al., 2018) and is available from Annex 7 or the website http://english.rvo.nl/nie.

The Waste sector accounted for 1.7% of total national emissions (without LULUCF) in 2016, compared with 6% in 1990, emissions of CH_4 and N_2O accounting for 95% and 5% of CO_2-equivalent emissions from the sector, respectively. Emissions of CH_4 from waste – almost all of which (86%) originates from landfills (5A1 Managed waste disposal on land) – accounted for 15% of total national CH_4 emissions in 2016. N_2O emissions from the Waste sector originate from biological treatment of solid waste and from wastewater treatment. Fossil fuel-related emissions from waste incineration, mainly CO_2, are included in 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% between 1990 and 2016 (see Figure 7.1), mainly due to a 78% reduction in CH_4 from landfills (5A1). Between 2015 and 2016, CH_4 emissions from landfills decreased by approximately 7%. 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 2016).

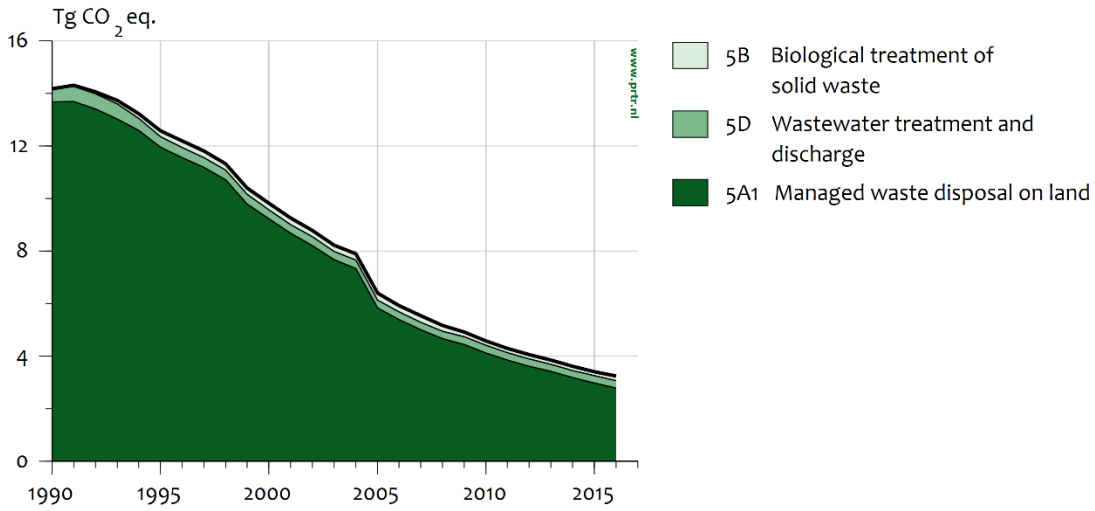


Figure 7.1: Sector 5 Waste – trend and emissions levels of source categories, 1990–2016

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 3.3 Tg CO_2 eq. in 2016.

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	2015	2016	Absolute 2016–2015	by sector	of total gas	of total CO_2 eq.
5 Waste	CH_4	-	14.0	3.3	3.1	-0.2	95.0	16.6	1.6
	N_2O	-	0.2	0.2	0.2	0.0	5.0	2.0	0.1
	All	-	14.2	3.5	3.3	-0.3	100.0		1.7
5A Solid waste disposal	CH_4	-	13.7	3.0	2.8	-0.2	85.5	15.0	1.4
5A1 Managed waste disposal on land	CH_4	L,T	13.7	3.0	2.8	-0.2	85.5	15.0	1.4
5B Biological treatment of solid waste	CH_4	-	0.0	0.1	0.1	0.0	2.7	0.5	0.0
	N_2O	-	0.0	0.1	0.1	0.0	2.8	1.1	0.0
5D Wastewater treatment and discharge	N_2O	-	0.2	0.1	0.1	0.0	2.2	0.9	0.0
	CH_4	-	0.3	0.2	0.2	0.0	6.8	1.2	0.1
	All	-	0.5	0.3	0.3	0.0	9.0		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 2016 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% (vol.) CH_4 and 50% (vol.) CO_2. Due to a light overpressure, landfill gas migrates into the atmosphere. CH_4 recovery takes place at 53 sites in the Netherlands. At several landfill sites, the gas is extracted before it is released into the atmosphere and is 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% in 1990 and 1.4% in 2016 – a decrease of 50%. This decrease is partly due to the increase in recovered CH_4, from about 4% in 1990 to 13% in 2016. A second cause is the decrease in methane

produced at SWDS and the decrease in the relative amount of methane in landfill gas from 57% to 50%.

In 2016, solid waste disposal on land accounted for 85.5% of total emissions from the Waste sector and 1.4% 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.[5] As a result of this policy, the amount of waste sent to landfills decreased from more than 14 million tons in 1990 to 2.8 million tons in 2016, thereby reducing emissions from this source category.

7.2.2 Methodological issues

A more detailed description of the method and EFs used can be found in Peek et al. (2018) and Annex 7.

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 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, 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 to 0.05 in 2005 (IPCC parameter) and remaining constant thereafter; this corresponds to a half-life of 14.0 years;
- CH_4 oxidation factor for managed landfills (IPCC parameter): 10%;

[5] In extreme circumstances, e.g. an increase in demand for incineration capacity due to unprecendented supply, the regional government can grant an exemption from these 'obligations'.

- Fraction of DOC actually dissimilated (DOCF): 0.58 until 2004 (see Oonk et al., 1994); decreasing to 0.5 in 2005 (IPCC parameter) and remaining constant thereafter;
- Methane correction factor (MCF): 1.0 (IPCC parameter);
- Fraction of methane in landfill gas produced. For the years up until 2004, the fraction of methane in landfill gas has been set at 57.4% (see Oonk, 2016); decreasing to 50% in 2005 (IPCC parameter) and remaining constant thereafter.
- Amount of recovered landfill gas, published in the annual report 'Waste processing in the Netherlands' (Rijkswaterstaat, 2017);
- Delay time when deposited waste starts to produce methane is set at 6 months (IPCC parameter). On average, waste landfilled in year x starts to contribute to the methane emissions in year x+1.

In our model, waste landfilled in 1945 started to contribute to current emissions. In the next section, a few parameters are discussed.

Amount of waste landfilled
Table 7.2 shows an overview of waste landfilled and its DOC content.

Table 7.2: Amounts of waste landfilled and degradable organic carbon content

Year	Amount landfilled (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
2016	2.8	52

Between 1945 and 1970 a number of municipalities already held detailed records of the collection of waste. In addition, information was available about which municipalities had their waste incinerated or composted. All other municipal waste was landfilled.
This information in combination with data on landfilling from various sources (SVA, 1973; CBS 1988, 1989; Nagelhout, 1989) data for the years 1950, 1955, 1960, 1965 and 1970 determined and published (Van Amstel et al., 1993) was used to complete the data, assuming that

during the Second World War hardly any waste was landfilled. These data are also used in the FOD model, while missing years (1945–1950, 1951–1954, 1956–1959, 1961–1964 and 1966–1969) are linearly extrapolated.
From 1970 on accurate data on production and waste treatment are available (Spakman et. al, 2003). Landfill site operators systematically monitor the amount of waste dumped (weight and composition) for each waste site. Since 1993 monitoring has occurred by weighing the amount of waste dumped, via weighing bridges, regulated by compulsory environmental permits.
Data concerning the amounts of waste dumped since 1991 are supplied by the Working Group for Waste Registration (WAR) and included in the annual report 'Waste processing in the Netherlands'. Information concerning the way in which these data are gathered and the scope of the information used can be found in these reports, available since 1991 from the WAR (Rijkswaterstaat).
Since 2005 landfill operators are obliged to register their waste according to European Waste List (EWL) codes. Landfill operators also use these EWL codes for the annual survey by the WAR, so that the WAR has a complete overview of the waste that is landfilled for every EWL code.

Fraction of degradable organic carbon
Rijkswaterstaat gathers information on the amounts and composition of a large number of waste flows, as part of its work to draw up the annual Netherlands Waste in Figures report (AgentschapNL, 2010). The results of several other research projects also help to determine the composition of the waste dumped. This method was used till 2004.
For each EWL code an amount of degradable carbon is determined (Tauw, 2011). DOC values are added to 10 different groups of waste streams. Each type of waste (corresponding to an EWL code) that is allowed to be landfilled (liquid waste may not be landfilled, for example) is divided into one of the groups. Each group has an individual DOC content. Table 7.3 gives an overview of the waste stream groups, with their DOC values and the amount landfilled in 2015 (where permitted).

Table 7.3: Amount of waste landfilled in 2015 and DOC value *of each group*

Waste stream group	**Amount landfilled (ton)**	**DOC value (kg/ton)**	**Total DOC landfilled (ton)**
Waste from households	153,056	182	27,856
Bulky household waste		192	
Commercial waste		182	
Cleansing waste	4,834	43.4	210
Fresh organic waste	79,597	112	8,915
Stabilized organic waste	167,280	130	21,746
Little organic waste	738,253	44	32,483
Contamined soil	217,855	11.5	2,505
Dredging spoils	140,244	42.4	5,946
Inert waste	841,051	0	0
Wood waste	19	430	8
Total	**2,342,188**		**99,670**

The DOC values were determined from the composition of mixed household waste (Tauw, 2011: table B3.2), the composition of other waste streams (Tauw, 2011: appendix 3) and expert judgement. The average DOC value of a ton of waste landfilled is calculated by dividing the total DOC landfilled by the amount landfilled.
From 2005 onwards all waste that is landfilled is included in the figures. This includes waste streams that have very low DOC content (contaminated soil, dredging spoils) or no DOC at all (inert waste). The result is that the average DOC value of a tonne of landfilled waste is low compared with the IPCC default values.

Degradable organic carbon that decomposes (DOCf)
The fraction of degradable organic carbon that decomposes (DOCf) is an estimate of the amount of carbon that is ultimately released from SWDS, and reflects the fact that some degradable organic carbon does not decompose, or degrades very slowly, under anaerobic conditions in the SWDS. The IPCC default value for DOCf is 0.5.
Materials never decompose completely. For waste streams considered to be 'biodegradable' like the 'organic wet fraction' (ONF), a conversion of about 70% seems to be the most achievable. Under landfill conditions the conversion is significantly lower. A practical test with the 'Bioreactor concept during the TAUW research shows that biogas production is approximately 25% of the potential maximum. In addition to the less favourable conditions in the landfill, the low value is explained by an overestimation of the landfill degradability (by 10–15 percentage points) and aerobic degradation in the first stage after deposition (about 15 percentage points, based on a laboratory test). If these values are taken into account, approximately 46% of the carbon is decomposed within the test period (aerobic + anaerobic). In the long term, degradation may increase and an f value of 0.58 can be approximated. This f value, however, relates only to anaerobic degradation; there is no correction for aerobic degradation in the initial stage of the landfill process (Tauw, 2011: pp. 89–90).
Therefore we assume that the IPCC default value of 0.5 is quite accurate for the amount of waste that actually decomposes.

k-value
Degradable waste is not landfilled in large quantities in the Netherlands. There is still a quantity of mixed municipal waste landfilled (EWL code 200301). In theory, this code applies to several waste streams, e.g. waste from households and commercial waste. In fact, in recent years only commercial waste is being landfilled, because waste from households is being incinerated. The problem with commercial waste is that an accurate composition of this waste stream is not available. Waste incinerator operators do not accept this stream, so an exemption of the landfill ban is permitted by the regional authorities. Waste incinerator operators must give an explanation why the waste cannot be incinerated at their plants. In most cases the waste incinerators give as explanation that the waste stream is not combustible or not suitable for their processes and therefore has to be landfilled.
The same problem applies to residues from waste treatment. If residues have to be landfilled, it is in most cases because they are not combustible or recyclable. In some cases waste incinerator operators argue that the caloric value is also too high, mainly due a high content

of plastics in the residues. Residues do not contain rapidly degrading waste such as food waste or sewage sludge.
Other waste streams that are landfilled in large quantities, such as contaminated soil (EWL code 170504) or sludges from physico-chemical treatment (EWL code 190206: in fact mainly residues from soil remediation) have a low DOC value. It is reasonable to assume that these residues contain only slowly degrading waste, because the organic content is stabilized.
The k-value is a value for slowly degrading waste (wood, paper, textiles) in a wet and temperate climate zone. The IPCC default value is between 0.03 and 0.06, but a k-value of 0.05 is used in the Dutch model.

Methane correction factor (MCF)
All sites that were in operation after World War II can be regarded as being managed as defined in the IPCC guidelines, according to which they must have controlled placement of waste (i.e. waste is directed to specific deposition areas, there is a degree of control over scavenging and over the outbreak of fire) and feature at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.

Many landfill sites were situated not far from urban areas. In order to prevent odour and scavenging animals (birds, rats) the management of landfill sites has attracted close attention since the beginning of the 20th century. A major study conducted in 2005 (NAVOS, 2005) investigated about 4,000 old landfill sites and concluded that:

- From 1930 a method of placing the waste in defined layers and covering it with ashes, soil, sand or dirt from street sweeping became common practice;
- In the early 1970s the waste sector introduced a ‘code of practice’ in which a method of environmentally friendly landfilling was described.
- During the 1970s and early 1890s national legislation introduced an obligation to landfill in a controlled manner. Some old permits for landfill sites (from the early 1970s) contain obligations to compact and cover the waste and to deposit waste in specific parts of the site of a certain maximum size instead of using the whole area simultaneously. Several permits also pay attention to fire-prevention.

On the basis of these findings, waste disposal sites can be generally considered as managed during the whole relevant period.

A few landfill sites are semi-aerobic.

On three selected landfills research is currently being undertaken into how the site should be managed after it is closed. This is the responsibility of the regional authorities. A few parts of these landfills are semi-aerobic, but all waste landfilled at these sites is included in the emissions from anaerobic landfills.

Fraction of methane generated in landfill gas
Most models of methane formation in landfills and emissions from landfills are based on landfills of municipal solid waste. This type of waste was landfilled in the Netherlands until the early 1990s, but since

then Dutch waste policy has changed. The landfilling of waste with large amounts of biodegradables (such as household waste) was first discouraged and then banned. Food and garden waste are now collected separately and composted. Other types of household wastes are nowadays mostly incinerated and or recycled. As a result, existing models are extrapolated to deal with this changed waste composition. Another explanation is that there is reduced methane content in the landfill gas being formed. Landfill gas is produced from a broad range of materials. Cellulose or hemicellulose, for example, produces gas with a theoretical methane concentration of about 50%. Proteins and fats, however, produce gas with a significantly higher methane concentration. When waste is landfilled it is conceivable that the more readily degradable components decompose first, resulting in a methane concentration that gradually declines from e.g. 57% to about 50%. Since, less and less readily degradable materialis landfilled in the Netherlands, it is possible that the observed decline is at least partially the result of a decline in methane concentration in the gas that is formed (Oonk, 2011: page 5).

Trend information on IPCC Tier 2 method parameters that change over time is provided in Table 7.3. 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% of the CO_2 was removed by the leachate. In the calculations 10% of the CO_2 is removed, resulting in a fraction of methane in landfill gas of 57.4% for the period 1990–2004.
From 2005 onwards the IPCC default value of 50% methane is used.

Table 7.4: Parameters used in the IPCC Tier 2 method that change over time (additional information on solid waste handling)

Parameter	1990	1995	2000	2005	2010	2015	2016
Fraction DOC in landfilled waste	0.13	0.13	0.11	0.06	0.03	0.04	0.05
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	54	53
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 A2.3 in Annex 2 provides estimates of uncertainties by IPCC source category and gas. The uncertainty in CH_4 emissions from SWDS is estimated to be approximately 24%. The uncertainty in the activity data and the EF are estimated to be less than 0.5% and 24%, 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 Category-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 the QA/QC of outside agencies (Wever, 2011).

7.2.5 Category-specific recalculations
Compared with the previous submission, several recalculations were made for this submission. In the last submission for several parameters (percentage of methane in landfill gas, DOCf, k-value) a transition period existed for the period 2000–2004. Because only activity data can be interpolated, a transition period for these parameters is not allowed. All changes in the values of these parameters therefore occur from 2005 onwards. The adjustment of the parameters causes emissions of methane from landfills to increase from 2000 onwards by about 1% (2016) compared with previous submissions. The main reason is that the value of the methane content of landfill gas does not decrease in the former transition period 2000–2004, but only since 2005. Emissions from waste that was landfilled in the period 2000–2004 have a higher amount of methane than in previous submissions.

7.2.6 Category-specific planned improvements
No improvements are planned.

7.3 Biological treatment of solid waste (5B)

7.3.1 Category description
This source category consists of 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. 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 4.1 million tons in 2016. In 2016, this treatment accounted for 5.5% of the emissions in the Waste sector (see Table 7.1) but the biological treatment of solid waste is not a key source of CH_4 or N_2O emissions.

7.3.2 Methodological issues
Activity data and EFs
Detailed information on activity data and EFs can be found in Peek et al. (2018) and Annex 7. The activity data for the amount of organic waste composted at industrial composting facilities derives mainly from the annual survey performed by the WAR at all industrial composting sites in the Netherlands (Rijkswaterstaat, 2017). Amounts of organic waste treated by green waste composting plants were collected from the Landelijk Meldpunt Afvalstoffen, which register waste numbers as obliged by Dutch legislation.

Table 7.5: Total amount of separately collected organic waste from households and green waste from gardens and companies

Year	Separatly collected organic waste from households (Mton)	Green waste from gardens and companies (Mton)
1990	228	-
1995	1,453	2,057
2000	1,567	2,475
2005	1,366	2,784
2009	1,258	2,648
2010	1,220	2,437
2011	1,273	2,409
2012	1,301	2,447
2013	1,273	2,341
2014	1,357	2,145
2015	1,356	2,077
2016	1,431	2,646

In 2010 an independent study on the EFs was carried out (DHV, 2010). To this end the EFs were compared with those in other, predominantly European, countries. The EF for CH_4 from composting was modified as of the NIR 2011 (2009 data). The EFs could not be modified retroactively on the basis of this study. All other EFs are unchanged.

7.3.3 Uncertainty and time series consistency

Uncertainty

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 Category-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 the 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 Category-specific recalculations

Compared with the previous submission, minor errors in the data were corrected in this submission.

7.3.6 *Category-specific planned improvements*

In 2017, 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 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 WAR 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, 2017).

A more detailed description of the method and the EFs used can be found in the methodology report (Peek et al., 2018) and Annex 7. Fossil-based and biogenic 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). 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 in terms of mass, energy, the fraction of biomass in energy and the corresponding amounts of fossil and biogenic carbon in the total waste incinerated.

Based on measurement data (Spoelstra, 1993), an EF of 20 g/ton waste is applied to N_2O from incineration with selective catalytic reduction (SCR). For incineration with selective non-catalytic reduction (SNCR), an EF of 100 g/ton is applied. The percentage of SCR increased from 6% in 1990 to 46% in 2016.

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. This is in line with IPCC, 2006 V5, §5.2.2.3 and §5.4.2. Emissions are reported in the CRF file with the code 'NO' (as the CRF cannot handle 0 (zero) values). More information can be found in the methodology report (Peek et al., 2018).

Open burning of waste does not occur in the Netherlands. It is prohibited by law.

Table 7.6: Composition of incinerated waste

	1990	1995	2000	2005	2010	2015	2016
Total waste incinerated (Gg)	2,780	2,913	4,896	5,503	6,459	7,564	7,796
Total waste incinerated (TJ)	22,746	27,903	51,904	55,058	63,818	75,299	77,392
Energy content (MJ/kg)	8.2	9.6	10.6	10.0	9.9	10	9,9
Fraction biomass (energy %)	58.2	55.2	50.4	47.8	53.1	54.2	53,8
Amount of fossil carbon (Gg)	164	221	433	561	675	780	809
Amount of biogenic carbon (Gg)	544	561	938	909	1,172	1,381	1,412

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, which provides estimates of uncertainties by IPCC source category and gas. The uncertainty in the CO_2 emissions for 2016 from waste incineration is estimated at 7%. 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 biogenic carbon in the waste (from their fossil and biogenic carbon fraction) and the corresponding amounts of fossil and biogenic 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 3.1% and 5.8%, 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

Consistent methodologies have been used throughout the time series for this source category. Time series consistency of the activity data is considered to be very good, due to the continuity of the data provided by the WAR.

7.4.4 *Category-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 the QA/QC of outside agencies 2011 (Wever, 2011).

7.4.5 *Category-specific recalculations*

There are no source-specific recalculations for this category.

7.4.6 *Category-specific planned improvements*

In 2017, 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.
The recommendations of the peer review carried out for the draft of this NIR (CE Delft, 2018) have been implemented insofar as they clarified the text. The other recommendations will be looked at for the next NIR.

7.5 Wastewater handling (5D)

7.5.1 Category description

This source category includes emissions from industrial wastewater, domestic (urban) wastewater and septic tanks. In 2016, only 0.55% 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 2016, urban wastewater (the mixture of domestic, industrial and commercial wastewater, including urban run-off) was treated aerobically in 327 public wastewater treatment plants (WWTP). The treatment of the resulting wastewater sludges is accomplished mainly by anaerobic digesters. During 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. As 0.55% 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) (2016: 53 plants).

N_2O emissions from the wastewater category (see Table 7.7) contributed about 0.87% of total N_2O emissions in 2016 and 0.037% in total CO_2-equivalent emissions. N_2O emissions from wastewater handling and effluents decreased by 58% during the period 1990–2016. This decrease is mainly the result of lower untreated discharges, resulting in lower effluent loads (see Table 7.7) 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 2016 was 1.18%, 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 29% during the period 1990–2016. 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 7.7 shows the trend in GHG emissions from the different types of wastewater handling.

Table 7.7: Wastewater handling emissions of CH_4 and N_2O (Gg/year)

	1990	2000	2010	2015	2016
CH_4 domestic wastewater[1)]	8.13	6.88	7.40	7.36	7.81
CH_4 industrial wastewater	0.29	0.39	0.38	0.38	0.38
CH_4 septic tanks	3.93	1.99	0.68	0.63	0.61
Net CH_4 emissions	12.35	9.25	8.46	8.37	8.81
CH_4 recovered[2)] and/or flared	33.0	40.6	40.0	44.4	48.0
N_2O domestic WWTP	0.076	0.076	0.079	0.082	0.084
N_2O effluents	0.501	0.302	0.174	0.157	0.157
Total N_2O emissions	0.577	0.378	0.253	0.240	0.240

1) Including emissions caused by venting of biogas at public WWTPs.
2) Used for energy purposes on site at public WWTPs and/or flared, so excludes CH_4 in external delivered biogas and vented amounts.

7.5.2 *Methodological issues*

Activity data and EFs

Most of the activity data on wastewater treatment is collected by the CBS (StatLine, 2017) 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 7.8 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 sewerage systems. In the method developed for calculating methane emissions, the DOC (or total organics in wastewater, TOW) is based on an organic load expressed in terms of chemical oxygen demand (COD). In the calculation of the COD of sewage sludge, the average content of 1.4 kg COD per kg organic dry solids is used. Organic dry solids weights are determined by measurements of sewage sludge at all public WWTPs. These data are inventoried by the CBS.

Table 7.8: Activity data of domestic and industrial wastewater handling

	Unit	1990	2000	2010	2015	2016
Domestic (urban) WWTPs:						
Treated volume	Mm^3/yr	1,711	2,034	1,934	1,957	1,902
TOW as COD[1)]	Gg/year	933	921	953	999	1,009
Sludge organic dry solids[2)]	Gg/year	260	308	340	360	359
Sludge DOC as COD[1)2)]	Gg/year	365	431	476	505	503
Biogas recovered [3)]	mio m^3/yr	74	87.9	98.5	107.0	115.2
Biogas flared	1,000 m^3/yr	8,961	6,150	7,360	7,405	10,092
Biogas vented	1,000 m^3/yr	2,524	284	1,066	82.3	578.8
Actual PE load WWTP[4)]	1,000	23,798	23,854	24,745	25,686	26,173
IWWTPs:						
TOW as COD[1)]	Gg/year	144	194	192	190	192
Energy produced with biogas[5)]	TJ/year	468	974	2,900	5,320	5,525
Septic tanks:						
Resident population [6)]	1,000	14,952	15,926	16,615	16,940	17,018
inhabitants with septic tank	% of pop.	4	1.9	0.62	0.57	0.55
Direct discharges of nitrogen:						
Nitrogen in effluents[7)], total	Gg/yr	63.79	38.45	22.13	19.99	19.99
Via effluents from UWWTP	Gg/yr	42.68	30.44	17.69	15.68	15.68
Via industrial discharges	Gg/yr	12.71	4.51	2.36	2.33	2.33
Via other direct discharges	Gg/yr	8.40	3.51	2.07	1.99	1.99

1) Expressed in terms of 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) PE = Pollution Equivalents, representing the total load of biodegradable substances in the mixture of domestic and industrial wastewater treated in urban WWTPs.
5) This is the total of energy produced with biogas from anaerobic IWWTPs as well as other biomass fermentation within industries.
6) Average population over a year.
7) Sum of domestic and industrial discharges of N in wastewater to surface water.

From Table 7.8 it can be concluded that the DOC of treated domestic 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 total amount of recovered biogas has increased steadily over the last years, because a larger fraction of sludge is digested.

Emissions from the source category Septic tanks have steadily decreased since 1990. This can be explained by the increased number of households connected to the sewerage system in the Netherlands (and therefore no longer using septic tanks; see Table 7.8).

Total direct discharges of N have also decreased steadily, due to improved wastewater treatment and prevention measures.

A full description of the methodology is provided in the methodology report (Peek et al., 2018).

In general, emissions are calculated according to the 2006 IPCC Guidelines, with country-specific activity data.

CH_4 emissions from domestic wastewater treatment (5D1)
In 2016, 99.4% of the population was connected to closed sewer systems, which were in turn connected to 327 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. Although according to IPCC (2006) methane emissions from advanced aerobic WWTPs are zero, small amounts of methane can be formed during certain wastewater treatment process steps and there can be small emissions from the influent cellars, anaerobic zones created for phosphorus removal and anaerobic pockets in zones with poor aeration, for example.
2. 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. The incidental venting of biogas produced in anaerobic sludge digesters can be a source of CH_4 emissions.

These steps are described in more detail below.

A more detailed description of the method and the EFs used can be found in the methodology report (Peek et al., 2018), in Annex 7 or on the website http://english.rvo.nl/nie.

1. Wastewater treatment process emissions
Methane emissions from the wastewater treatment process are calculated using the B0 from the 2006 IPCC Guidelines, a country-specific MCF and country-specific data for the TOW and sludge produced. The 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 the CBS among the Water Boards. Data are available for the years 1990 until the present for every treatment plant.

The COD of sludge is calculated using the conversion factor 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 7.8 gives the time series of the values of influent COD, organic solids weight of sludge and sludge COD.
2. Anaerobic sludge digestion emissions
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 recovered in the sludge digesters. The emissions are calculated per WWTP with sludge digestion facilities. In 2016, 78

WWTPs were equipped with sludge digesters. A more detailed description of the method and the EFs used can be found in the methodology report (Peek et al., 2018), in Annex 7 and 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 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 (-) (Hobson, 2001);
F_{CH4} = methane content of biogas = 440 g CH_4/m^3 biogas (Baltussen and Geurts van Kessel, 2015).

Since the EF is calculated on the 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 Section 7.5.5.

Country-specific activity data on volume of recovered biogas in all public WWTPs with sludge digesters is derived from the yearly survey conducted by the CBS among the Water Boards. Data is available for the years 1990 until the present for every treatment plant.

3. Emissions from incidental venting of biogas
Incidental venting of biogas at public WWTPs is recorded by the plant operators and subsequently reported to the CBS. In 2016, the amount of CH_4 emitted by the venting of biogas was 0.225 Gg CH_4, equalling 0.3% 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 2016 was moderate.

Recovered biogas is largely used for energy generation purposes, but a small amount is flared, vented or delivered to third parties. Table 7.7 provides data on the 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 (Peek et al., 2018).

In the Netherlands no information is available on the actual load of COD that is treated in the IWWTPs. The TOW thus has to be determined in an alternative way. The TOW is therefore estimated 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 (PE). One PE equals an amount of 40 kg COD per year. Data on the design capacity is available from the CBS (CBS, 2017). Table 7.8 provides the time series of total TOW for IWWTPs. In 2016, 62% of the anaerobic capacity was installed within the food and beverage industry. Other branches with anaerobic wastewater treatment are waste processing facilities (17%), the chemical industry (16%) and the paper and cardboard industry (4%).

The CBS has data on total biogas recovery from biomass fermentation plants within industrial companies, including anaerobic WWTPs, but in these statistics no distinction is made in the type of substrate or type of installation. So biogas recovery at anaerobic IWWTPs cannot be quantified separately (see also Section 7.5.4). In 2016, the total biogas recovery from biomass fermentation by industrial companies equals 5,525 TJ. It is not known which part stems from anaerobic industrial wastewater treatment.

CH_4 emissions from septic tanks (5D3)
Emissions of methane from septic tanks are calculated using IPCC default values for B0 and MCF and IPCC value of TOW of 60 g BOD (biological oxygen demand) 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 (Peek et al., 2018).

Table 7.5 shows the time series of the numbers of people 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 percentage of the population connected to septic tanks decreased from 4% in 1990 to 0.55% in 2016. These data derive from surveys and estimates by various organizations in the Netherlands, such as Rioned (Rioned, 2009, 2016) 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 people connected, including the extra fraction of industrial and commercial wastewater. This is determined by the number of PEs.

Rationale for using the Pollution Equivalent as activity data (response to 2016 review question)
The PEs, as measured and reported by all urban WWTPs (UWWTPs), reflect the total amount of organic degradable matter that is treated in

the plants. 1 PE equals the wastewater (and degradable substances in it) from one person. Its basis and method of calculation are anchored in Dutch water laws.
As the PE is calculated from influent data on COD and N-kjeldahl, it includes the loads from industrial and commercial activities as well as loads from urban run-off into the sewerage system. In formula 6.9, box 6.1 of the IPCC 2006 Guidelines, the total PE thus can replace the terms $P*T_{PLANT}*F_{IND-COM}$. For example, the PE value for 2016 is 26.2 million. With an average population of 17.0 million, this means that 9.1 million PE comes from industrial and commercial sources and urban run-off. With T_{PLANT} is almost 1, $F_{IND-COM}$ in 2016 is approximately equal to 1.5.

A description of the calculation of PE, the method and the EF used can also be found in the methodology report (Peek et al., 2018), see Annex 7.
Table 7.5 provides a times series of the PE. In 2016, the total PE equalled 26.2 million.

As wastewater treated at public WWTPs is a mixture of household wastewater, (urban) run-off rainwater and wastewater from industries and services, the N_2O emissions are reported under category 5D1 (Domestic and commercial wastewater).

Indirect N_2O emissions from surface water as a result of discharge of domestic and industrial effluents (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' PRTR.

Rationale for country-specific activity data and not using the 'Note' in box 6.1 in 2006 IPCC Guidelines (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 N discharged to surface water via effluents of UWWTP plus industrial effluents, instead of using equation 6.8 of the IPCC 2006 Guidelines. 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 discharged to wastewater. Instead, the Netherlands has chosen to use activity data derived from other sources, such as 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 include loads of N in (1) effluents of all UWWTPs, (2) direct discharges from companies and households (via septic tanks), (3) estimated incidental wastewater discharges such as those from sewer overflows.
As a consequence of using these data, the Netherlands does not take into account the Note in box 6.1 of IPCC (2006). 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 wastewater treatment is not needed.

A more detailed description of the method, the activity data and the EF used can be found in the methodology report (Peek et al., 2018).

Table 7.5 provides a time series of the activity data: total N discharges.

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 do not provide a method for calculating N_2O emissions from industrial sources, except for industrial wastewater that is co-discharged with domestic wastewater into the sewerage system. N_2O emissions from industrial sources are believed to be insignificant in comparison with emissions from domestic wastewater. In the Netherlands most industries discharge their wastewater into the sewerage system/WWTPs (emissions included in 5D1). Indirect emissions from surface water resulting from discharge of wastewater effluents are already included under 5D3 (other, wastewater effluents).

Direct N_2O emissions from septic tanks (5D3)
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 in CRF category 5D3 Indirect N_2O emissions 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 the CBS show that only 2 out of a total of 160 IWWTPs are equipped with anaerobic sludge digestion reactors. These data are 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, however, 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 expert judgement and is estimated to be >20%. The yearly loads of $DOC_{influent}$, DOC_{sludge} $N_{influent}$ and $N_{effluent}$ are calculated on the basis of wastewater and sludge sampling and analysis, as well as flow measurements at all WWTPs; all these measurements can involve 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 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 concluded 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 the CBS.

7.5.4 Category-specific QA/QC and verification
The source categories are covered by the general QA/QC procedures, as discussed in Chapter 1. Moreover, statistical data are covered by the specific QA/QC procedures of the CBS.

For annual CH_4 and N_2O emissions from domestic and commercial wastewater handling, the results of a study (GWRC, 2011) neither support 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 biogas recovery at anaerobic IWWTPs. This will not be possible, at least not in the short term. The CBS has data on total biogas recovery from biomass fermentation plants, including anaerobic WWTPs, 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 Category-specific recalculations
CH_4 emissions from domestic wastewater treatment (5D1)
Due to final activity data on the TOW and the DOC of sludge produced in 2015 the CH4 emissions of domestic wastewater treatment decreased with 0.025 Gg (-0.34%) compared to the previous submission.

CH_4 emissions from septic tanks (5D3)
In 2017, Rioned published new estimates on the percentage of the population connected to septic tanks (Rioned, 2017). The value for 2015 was adjusted from 0.06% to 0.057%. As a result, CH_4 emissions from septic tanks in 2015 decreased by 0.033 Gg CH_4 (-5%) compared with the previous submission.

As a result of the two above-mentioned recalculations, total CH_4 emissions from category 5D decreased in 2015 by 0.058 Gg (-0.69%) compared with the previous submission.

N_2O emissions from centralized wastewater treatment (5D1)
Due to final activity data on PEs in 2015, the emission of N_2O from centralized wastewater treatment in 2015 decreased by 0.00034 Gg N_2O (-0.4%) compared with the previous submission.

7.5.6 Category-specific planned improvements
No improvements are planned.

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 emissions

9.1 Description of sources

Methane, carbon monoxide (CO) and NMVOC emissions are oxidized to CO_2 in the atmosphere. In this chapter indirect CO_2 emissions as a result of this atmospheric oxidation are described.

As the Netherlands already assumes 100% oxidation during the combustion of fuels, only process emissions of NMVOC (mainly from product use) are used to calculate indirect CO_2 emissions.

Indirect CO_2 emissions originate from the use and/or evaporation of NMVOC in the following sectors:

1. Energy (Energy, Traffic and transport and Refineries);
2. IPPU (Consumers, Commercial and governmental institutions, Industry, and Construction and building industries);
3. Agriculture;
4. Waste.

Indirect CO_2 emissions decreased from 0.68 Tg in 1990 to 0.21 Tg in 2016 as a result of the Dutch policy to reduce NMVOC emissions.

9.2 Methodological issues

Indirect CO_2 emissions are calculated as follows:

CO_2 (in Gg) = NMVOC emission (in Gg) * C * 44/12

Where:

C = default IPCC carbon content (C) of 0.6;

NMVOC emission 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% and the uncertainty in carbon content is estimated at 10%, resulting in an uncertainty in CO_2 emissions of approximately 27%.

Consistent methodologies and activity data have been used to estimate 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 changes in NMVOC emissions for the period 1990–2016, these changed indirect CO_2 emissions for the whole time series.

9.6 Category-specific planned improvements

No improvements are planned.

10 Recalculations and improvements

Major recalculations and improvements compared with the National Inventory Report 2017

For the NIR 2018, the data for the most recent year (2016) were added to the inventory and corresponding Common Reporting Format (CRF).

As a result of the recommendations of the in-country review several improvements were made to the inventory and the NIR. These include corrections of errors in previous submissions. These have resulted in minor changes in emissions over the entire 1990–2015 period.

Other recalculations were performed as a result of methodical changes and/or based on new, improved activity data and/ or improved EFs.

For details of 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 emissions inventory

For this submission (NIR 2018), the Netherlands uses the CRF Reporter software v6.0.5.
The in-country review of the UNFCCC from September 2017 suggested that we could improve the Dutch GHG emissions inventory. Following this suggestion we could improve both this NIR and the corresponding CRF. The review recommendations have also been incorporated into the methodology reports.
Besides these externally induced improvements, additional improvements were made as a result of our own QA/QC programme:

- Methodological changes and data improvements;
- Changes in source allocation;
- Error corrections.

Please note that we have not yet received the draft review report. In this version of the NIR the preliminary main findings were used.

Methodological changes and data improvements

The improvements to QA/QC activities in the Netherlands 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 relevant experts and information users) improves the peer review and timely documentation of the background to and justification for changes made.
The most significant recalculations in this submission (compared with the previous NIR) are:

- In the Energy sector:
  - recalculation of emissions from biomass due to revision of the renewable energy statistics (whole time series);
  - improved activity data for the years 1991–1994 due to revision of the energy statistics for this period (following the previous 2016 recalculation for the other years);

  - improved activity data for the year 2015 due to update of the 2015 energy statistics and some minor revisions in the energy statistics to align with international energy statistics;
  - improved activity data for diesel consumption in the 1A2, 1A3 and 1A4 categories to align former years to the latest knowledge on the division of the activity data over the sectors and to align the energy statistics to international definitions (whole time series). This also affected bunker emissions (memo item).
  - update of the heating values as well as the emission factors for CO_2 from gasoline and diesel in cars as a result of a measuring programme of carbon content;
  - additional estimates for CH_4 and N_2O emissions resulting from the reallocating of fuels from process emissions of Iron and steel production to combustion categories (whole time series; see also Reallocation section).
- In the IPPU sector:
  - recalculation of F-gas emissions from mobile air-conditioning based on improved activity data (1994–2014);
  - inclusion of CO_2 emissions from lime production as a result of the 2017 review.
- In the Agriculture sector:
  - revision of B0 and MCFs for total time series resulting in recalculation of CH_4 emissions from Manure management;
  - inclusion of N_2O emissions from additional follow-up crop residues for the total time series.
- In the LULUCF sector:
  - allocation of Trees outside forest to Grassland instead of Forest land;
  - calculation of carbon stock changes in orchards and revised estimates of carbon in dead wood (1990–2016) based on extrapolation instead of model estimates.
- In the Waste sector:
  - improvement of estimates of emissions from solid waste disposal from 1995 onwards as a result of the 2017 review, which asked for a fixed date for changes in relevant parameters (elimination of former transition period).

The sectoral sections describe some additional minor recalculations.

Changes in source allocation

During the in-country review recommendations were made to improve the transparency of the calculation of emissions from Iron and steel production. These recommendations were implemented and resulted in the reallocation of CO_2 emissions from categories 2C and 1B1b to 1A2a and 1A1c and 2A4d4..

Error correction

In general, the 2015 figures have been updated whenever improved statistical data have become available since the 2017 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 improvements are:

- Error correction in the process emissions from refineries in 2015;

- Correction of methane emissions from consumers(1A4) for 1998, 1999, 2007, 2008 and 2014;
- Error corrections in the data on biological treatment of solid waste

10.1.2 KP-LULUCF inventory

Some of the methodological changes in the LULUCF sector as reported in Section 6.2 have also resulted in recalculations in the KP-LULUCF inventory:

- As a result of the explicit identification of Trees outside forests as belonging to Grassland, the activity data and resulting emissions and removals for the accounting of A, D and FM have changed (see Section 11.3.2).
- The change in method for calculating carbon stocks in orchards under the UNFCCC category Grassland (non-TOF) (Section 6.6) increases carbon stock losses under Afforestation (loss of original biomass) and carbon stock gains under Deforestation (increase in carbon stock after conversion from Forest to Grassland).

10.2 Implications for emissions levels

10.2.1 GHG emissions inventory

This section summarizes the implications of the changes described in Section 10.1 for the emissions levels reported in the GHG emissions inventory.

Table 10.1 shows the changes in emissions per relevant sector in Gg CO_2 eq., compared with the 2017 submission, as a result of the recalculations.

Table 10.1: Summary of recalculations for the period 1990–2015 (Gg CO_2 eq)

		1990	1995	2000	2005	2010	2012	2013	2014	2015
CO_2, CH_4, N_2O	1A1 Energy industries	292.3	401.9	337.8	419.5	891.6	213.3	614.2	576.4	1489.6
CO_2, CH_4, N_2O	1A2 Manufacturing industries and construction	2437.0	1736.3	1250.3	1247.3	803.3	1218.9	856.1	776.5	696.3
CO_2, CH_4, N_2O	1A3 Transport	-108.9	-116.2	-79.5	-42.9	-640.2	-752.9	-763.6	-757.7	-808.6
CO_2, CH_4, N_2O	1A4 Other sectors	-117.6	-69.0	5.8	48.5	-46.5	-150.0	-166.2	-163.3	200.6
CO_2, CH_4, N_2O	1A5 Other	2.0	0.3	-3.3	0.7	0.9	3.7	0.5	-2.0	-14.1
CO_2, CH_4	1B Fugitive emissions from fuels	-292.1	-401.5	-337.5	-419.0	-891.1	-212.8	-613.7	-576.0	-1089.1
CO_2, CH_4, N_2O	2 Industrial processes	-2059.8	-1395.9	-908.1	-922.7	-506.8	-934.0	-770.1	-589.1	-601.6
HFC and PFCs	2F Product uses	0.0	0.6	-0.7	4.8	10.4	28.2	34.0	33.9	36.9
SF_6	2G Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.7	0.7
CH_4	3A Enteric Fermentation	4.0	3.4	1.5	0.9	-1.3	-2.6	-2.1	-1.1	-2.1
CH_4 , N_2O	3B Manure management	-371.7	-533.1	-702.9	-573.2	-577.8	-566.8	-566.0	-567.8	-584.3
N_2O	3D Agricultural soils	68.7	123.4	120.3	102.3	144.5	146.8	145.6	155.1	163.1
CO_2, CH_4, N_2O	4 LULUCF	-6.7	-21.5	20.9	-18.6	-4.4	-39.5	-67.5	-86.4	-53.4
CH_4	5A Solid waste disposal	0.0	0.2	0.0	117.6	62.7	47.2	40.5	34.5	29.1
CH_4, N_2O	5B Biological treatment of solid waste	-0.5	-0.1	-5.6	0.7	0.4	0.2	0.9	1.8	-1.7
CH_4 ,N_2O	5D Wastewater handling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.6
CO_2	Indirect emissions	16.8	17.1	17.7	19.0	19.5	19.8	19.7	19.9	20.1
Total Difference		**-136.3**	**-253.9**	**-283.4**	**-15.1**	**-734.9**	**-980.6**	**-1,237.5**	**-1,146**	**-520.2**

The relatively large changes in the emissions from Transport are due to revised EFs for CO_2 and the revision of fuel data from the energy statistics. The latter also influenced emissions reported in 1A4 and 1A2.

As it is difficult to interpret the described changes in terms of emissions of individual gases, Table 10.2 gives the changes per gas and per sector in 1990 and 2015.

Table 10.2: Summary of recalculations per gas and sector (Gg CO_2 eq)

CO_2	**1990**		**2015**
1 Energy	2,229		497.8
2 IPPU	-2,059		-595
3 Agriculture	-		-
4 LULUCF	-6.8		-53.2
5 Waste	-		-
CH_4	**1990**		**2015**
1 Energy	4.9		0.8
2 IPPU	-		-6.1
3 Agriculture	-363		-587.3
4 LULUCF	-		-
5 Waste	-		27.4
N_2O	**1990**		**2015**
1 Energy	-21.3		-23.9
2 IPPU	-		-0.4
3 Agriculture	64.4		164.0
4 LULUCF	-		-0.14
5 Waste	-0.6		-1.6

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 (2018). These recalculations (NMVOC) also induced the revision of the indirect CO_2 emissions.

10.2.2 KP-LULUCF inventory

The changes in the methodologies have resulted in recalculations in the whole time series. The differences between the previous and recalculated emissions and removals are shown in Table 10.3.

Table 10.3: Summary of recalculations for KP-LULUCF 2013–2015 in Gg CO_2-eq.

Activity	**2013**	**2014**	**2015**
AR	114.8	121.0	127.2
D	-273.2	-282.0	-290.2
FM	60.8	59.6	58.1
Total	-97.7	-101.5	-104.8

10.3 Implications for emissions trends, including time series consistency

10.3.1 GHG emissions inventory

The recalculations and error corrections further improved both the accuracy and the time series consistency of the estimated emissions.

Table 10.4 shows the changes made due to the recalculations for 1990, 1995, 2000, 2005, 2010 and 2015 (compared with the NIR 2017). From the table, it emerges that the recalculations changed national emissions only to a small extent (<0.3%) compared with the last NIR. More detailed explanations are given in the relevant Chapters 3–8.

Table 10.4: Differences between the NIR 2017 and NIR 2018 for the period 1990–2015 due to recalculations (Units: Tg CO_2 eq.; for F-gases: Gg CO_2 eq.)

	Source	1990	1995	2000	2005	2010	2015
CO_2 **Incl. LULUCF**	NIR 2018	169.2	179.7	178.3	183.7	188.5	171.8
	NIR 2017	169.0	179.5	178.0	183.3	188.8	171.9
	Difference	0.1%	0.1%	0.2%	0.2%	-0.2%	-0.3%
CO_2 **Excl. LULUCF**	NIR 2018	163.1	173.5	172.3	177.8	182.4	165.3
	NIR 2017	162.9	173.3	172.0	177.4	182.8	165.3
	Difference	0.1%	0.1%	0.2%	0.2%	-0.2%	-0.1%
CH_4	NIR 2018	32.0	29.8	24.4	20.0	19.6	18.4
	NIR 2017	32.3	30.3	25.1	20.5	20.1	19.0
	Difference	-1.1%	-1.7%	-2.8%	-2.2%	-2.6%	-3.0%
N_2O	NIR 2018	17.7	17.9	15.9	14.3	8.4	8.6
	NIR 2017	17.7	17.8	15.8	14.2	8.2	8.5
	Difference	0.2%	0.5%	0.6%	0.6%	1.5%	1.6%
PFCs	NIR 2018	2663	2280	1903	366	314	104
	NIR 2017	2663	2280	1903	366	314	104
	Difference	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HFCs	NIR 2018	5606	7572	4764	1733	2677	2373
	NIR 2017	5606	7571	4765	1728	2666	2336
	Difference	0.0%	0.0%	0.0%	0.3%	0.4%	1.6%
SF_6	NIR 2018	207	261	259	204	154	139
	NIR 2017	207	261	259	204	154	139
	Difference	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Total Tg CO_2-eq. **Incl. LULUCF**	NIR 2018	227.3	237.5	225.5	220.3	219.6	201.4
	NIR 2017	227.5	237.7	225.8	220.3	220.3	202.0
	Difference	-0.1%	-0.1%	-0.1%	0.0%	-0.3%	-0.3%
Total Tg CO_2 eq. **Excl. LULUCF**	NIR 2018	221.3	231.3	219.4	214.4	213.4	194.8
	NIR 2017	221.4	231.5	219.7	214.4	214.2	195.2
	Difference	-0.1%	-0.1%	-0.1%	0.0%	-0.3%	-0.2%

Note: Total emissions include indirect CO_2.

The above changes translate to changes in emissions trends. Table 10.5 shows the changes in emissions trends from the base year to 2015, compared with the trends as presented in the NIR 2017.

Table 10.5: Differences between the NIR 2017 and NIR 2018 with respect to emissions trends from the base year to 2015 (Units: Gg CO_2 eq.)

Gas	Trend base year–2015 (absolute)			Trend base year–2015 (percentage)		
CO_2 eq [Gg] [1)]	Reported in NIR 2018	Reported in NIR 2017	*Difference* [2)]	Reported in NIR 2018	Reported in NIR 2017	*Difference*
CO_2	2,133	2,397	-264	1.3%	1.5%	-0.2%
CH_4	-13,522	-13,316	207	-42.3%	-41.2%	1.1%
N_2O	-9,260	-9,355	-96	-52.2%	-52.9%	-0.7%
HFCs	-5,199	-5,236	-36	-68.7%	-69.2%	-0.5%
PFCs	-2,176	-2,176	0	-95.4%	-95.4%	0.0%
SF_6	-121	-122	-1	-46.5%	-46.8%	-0.3%
Total	-28,145	-27,807	338	-12.6%	-12.5%	0.2%

1) Including indirect CO_2 emissions, excluding LULUCF.
2) Negative sign indicates negative effect on declining emissions trend.

The table shows that the trends between the base year and 2015 in this submission have changed significantly for CO_2 and CH_4 emissions. The CO_2 emission increase is now greater than in the 2017 submission and for CH_4 the decrease is greater due to the recalculations. Overall, the percentage reduction in total emissions compared with the base year in this submission is higher than reported in the NIR 2017.

10.3.2 KP-LULUCF inventory

The implemented changes have no effect on the trends of emissions and removals in the KP-LULUCF inventory.

10.4 Recalculations, response to the review process and planned improvements

10.4.1 GHG emissions 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 of the draft NIR of January 2018, a few suggestions were made for the CO_2 calculations in industry and energy production, e.g. how statistics and CO_2 calculations are influenced by Carbon Capture Usage and the use of bio-based materials. The suggestion was also made to update some country-specific methods and emission factors. These issues will be considered in improvement actions on emissions calculations in the near future.

The peer review includes a general check on all chapters. In addition, special attention is given to a specific sector or topic each year. This year, a separate study (CE Delft, 2018) focused on the Reference Approach (RA) and waste incineration. The study concluded that, overall, the RA and the calculations on waste incineration in the Dutch NIR 2018 appear to be in line with the 2006 IPCC Guidelines (IPCC, 2006).

Specifically, the report stated that CO_2 emissions calculated using the RA seem to be accurate and complete. Suggestions were made for

improving transparency of the inventory by explaining methods, assumptions and calculations more clearly, in the NIR as well as in the ENINA methodology report and the CRF tables.
In relation to waste incineration, suggestions were made for improvement of the NIR and the ENINA methodology report, which would make the submission more transparent and more understandable by people not directly involved in the calculations. An important remark was that reporting transparency is good when the NIR and ENINA methodology report are considered together: general information is included in the NIR, while details are included in the ENINA methodology report. This was also a remark made by the 2017 ERT. Therefore, from 2018 the methodology reports are included in the annual submission by the Netherlands.
Finally, many of the suggestions for the RA and waste incineration have been incorporated in Chapters 3 and 7 of the NIR 2018.

Peer reviews in past years have focused on the following sectors and categories:

- N_2O and CO_2 emissions from Agriculture (Kuikman, 2017);
- Energy (excluding transport) (CE Delft, 2014);
- Industrial process emissions (Royal HaskoningDHV, 2013);
- LULUCF (Somogyi, 2012);
- Waste (Oonk, 2011);
- Transport (Hanschke et al., 2010);
- Combustion and process emissions in industry (Neelis and Blinde, 2009);
- 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 long delay in the inventory process due to severe problems with the CRF software.

UNFCCC review
The review reports for the 2015 and 2016 inventory submissions were finalized in June 2017, while in September 2017, an in-country review of the NIR 2017 took place. At the end of the review week the provisional main findings (PMF) were presented including some issues which the Netherlands should address in the next (2018) submission.
The follow-up on the recommendations of the 2015/2016 review as well as those stated in the preliminary main findings of the 2017 review are summarized in Table 10.6. It should be noted that this is a summarizing table, which includes references to the sectoral sections in this NIR, CRF tables and updated methodology reports (2018).

Table 10.6: Improvements made in response to the in-country UNFCCC review of September 2017

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
General	G.4. 2016	The ERT recommends that the Netherlands provide the level and trend uncertainty assessment as required by paragraphs 15 and 42 of the UNFCCC Annex I inventory reporting guidelines.	Uncertainty analysis including LULUCF and base year provided in the NIR	Annex 2		
General	G.6. 2016	The ERT recommends that the Netherlands update the publicly available information in the national registry in accordance with the recommendations in the SIAR	This information will be updated annually			
General	G.7. 2016	Include in the next annual submission the information on the application of decision 1/CMP.8, paragraphs 23–26, related to carry-over and the PPSR account.	Information included	Chapter 12		
General	G.8. 2016	Provide the calculated value of the CPR using the next annual submission.	Information included	Chapter 12		
General	G.11. 2016	Include in the NIR the information on the QA activities for the national inventory, including information on an independent peer review of the inventory and a description of the responsibilities of institutions involved in the national system for specific QA/QC activities.	Information included	Sections 3.2.1 and 7.4		
General	G.14. 2016	Ensure that all required documentation in support of the NIR is provided in the public domain in a timely manner and remove any obsolete documentation from the inventory website.	Methodology reports now part of the NIR submission and have been published on the website			
Energy	E.1. 2016	Ensure that all the information provided in the CRF tables and the NIR is consistent (e.g. regarding the methods used to estimate CO_2 emissions from the manufacture of solid fuels and other energy industries).	Additional checks performed to improve consistency	Amongst others in Table 3.1		

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
Energy	E.7. 2016	Add the following information in the table in Annex 5 to the NIR: (a) clarification on whether the carbon content factors are reported in terms of gross calorific value or net calorific value; (b) CH_4 and N_2O EFs.(c) direct references for each of the country-specific and plant-specific EFs provided	Annex 5 holds now a table with the EFs for N_2O and CH_4 Direct references for each emission factor (default and country-specific) are provided in the factsheets on fuels. The factsheets are still available on request and will not be included in annex 5 of the NIR 2018	Annex 5		
Energy	E.8. 2016	Notation keys NO en NE	Improved text on CSC Table 9.xls contains detailed information on sources that are reported as NE or IE. The notation key NO is used in the following situations: * Combustion categories: when a certain fuel type is not used in a CRF category. * Coal mining: there are no mines in operation anymore and the old mines are not gassy (flooded), so no emissions from coal mining occur. * Fugitives: CO2 from fugitives is not captured * CO2 capture and storage: is not done in the Netherlands	Section 3.4		
Energy	E.10.	Improve the QA/QC processes to ensure the use of	Revision of energy statistics is		1(A)b	

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
	2016	accurate and consistent fuel data throughout the GHG inventories. To improve transparency, the ERT also encourages the Party to identify discrepancies between the Party's submission and the IEA data and document them clearly in the NIR.	now fully completed and incorporated in the CRF		en 1D	
Energy	E.11. 2016	Specify in the NIR the allocation of all fuels used in the Reference Approach, and ensure that these allocations correspond with the fuel lists in the national balances and IEA data.	Table with links between RA and fuel list provided	Section 3.2.1		
Energy	E.13. 2016	Clarify the allocation of emissions from incinerated waste oils and solvents and justify the applicable AD, EFs and emissions trend.	Explanation of waste oils included	Section 3.2.4.1		
Energy	E.14. 2016	Provide the reasons behind the fluctuations in the CO_2 IEF for solids throughout the time series.	Most significant trends in IEFs are elaborated	Section 3.2.4.2		
Energy	E.16. 2016	Provide in the NIR the reasons behind the fluctuations in the CO_2 IEF throughout the gas combustion time series and explain how consistency of the time series and EFs is ensured in estimating CO_2 emissions from this category.	Most significant trends in IEFs are elaborated	Section 3.2.4.2		
Energy	E.17. 2016	Use more up-to-date data from the most recently available data sources, such as AERs or EU-ETS data, in order to improve the time series consistency of the estimates of CO_2, CH_4 and N_2O emissions from chemical waste gases (if the data are suitable to use for previous years) or, if that is not possible, include in the NIR a detailed category-specific improvement plan, and explain how time series consistency for the AD is ensured for the emissions estimates for this category.	We use the most recent available AER and ETS data in the QA/QC process. However, it is not always possible to use the most recent data in the annual inventory cycle as the processes are not aligned (time-wise).	Sections 3.2.4.2 and 3.2.4.4		
Energy	E.18.	Explain the reasons for the variation in the CH_4 IEF	Most significant trends in IEFs	Section		

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
	2016	for gaseous fuels, including the quantities of natural gas combusted in gas engines and other appliances for the whole time series.	are elaborated	3.2.7.2		
Energy	E.22. 2016	Change the relevant notation keys in CRF table '1.B.2.C. and 1s2 for this category from 'NE' to 'IE', and include the explanation of this in both the NIR and CRF table 9 in the next submission.	Notation keys changed and documentation box included		1.B.2.c	
IPPU	I.8 2016	Strengthen QA/QC procedures and institutional arrangements to: (a) ensure that the ENINA Task Force can access the commercially confidential data in order to assess the recalculations and determine the time series of IEFs on a production basis (where necessary for comparability); (b) where applicable, compare the annual EU-ETS and/or emissions reported in the Party's AERs with recalculated inventory estimates; and (c) report on all findings of QA/QC activities transparently in the NIR, or directly provide the information to the ERT, while protecting commercially sensitive data.	Improved text in NIR	Section 4.1		
IPPU	I.9. 2016	Provide AD, EFs and details of the methodology used to estimate emissions from lime production in the NIR.	Text in NIR provided and notation keys in CRF	Section 4.2.2	Table 2(I).A-Hs1	
IPPU	I.10. 2016	Resolve the inconsistencies in the information provided in the NIR, the ENINA report and the notation keys in the CRF tables on the allocation of emissions from lime production.	Improved text in NIR and methodology report	Section 4.2.1		2.2.3.2
IPPU	I.11. 2016	Work with industrial operators and competent authorities to obtain additional data to enable the correct allocation of the emissions from lime production under the lime production category, in	Improved text in NIR and methodology report	Section 4.2.1		2.2.3.2

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		order to report in accordance with the 2006 IPCC Guidelines and to improve comparability. In the event that these data are commercially confidential, the ERT encourages the Netherlands to prepare detailed justifications for the emissions estimates in order to maintain data confidentiality.				
IPPU	I.12. 2016	Include the explanation of methodology choices, provide references for all data used across the time series (including for extrapolations) along with examples of validation to justify the data and methods used for all of the sub-categories under other process uses of carbonates.	Improved text in NIR and methodology report	Section 4.2.5		2.2.3.2
IPPU	I.13. 2016	Conduct further research and consultation with industry and/or statistical agencies to either access additional AD and EFs or seek verification of the current method and emissions estimates. The ERT encourages the Party to report on progress in future NIRs. The ERT believes that this issue should be considered further in future reviews to confirm that there is not an underestimate of emissions.	Improved text in NIR and methodology report	Section 4.2.2		2.2.3.2
IPPU	I.14. 2016	Estimate emissions from ammonia production taking into account CO_2 emissions and sequestration from urea production by collecting new AD (annual urea production, urea imports and exports and urea application to soils) through research and/or consultation with industry and statistical agencies.	Improved text in NIR and methodology report	Section 4.3.2		2.2.3.1
IPPU	I.15. 2016	Document full details of the inventory data and methodologies for all categories affected in this cross-sectoral issue in future submissions. The IEF also encourages the Party to provide future ERTs	Improved text in NIR and methodology report	Section 4.3.2		2.2.3.1

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		with carbon balances for ammonia and urea production and urea application sources, while protecting commercially sensitive data.				
IPPU	I.16. 2016	Report CO_2 emissions from ammonia production using a method that is consistent with the 2006 IPCC Guidelines, reporting emissions from all natural gas uses (i.e. both fuel and feedstock use) within this category. The ERT also encourages the Party to work with chemical companies and national energy statistics compilers to avoid gaps or double counting in the natural gas energy balance data.	Improved text in NIR and methodology report	Section 4.1		2.2.3.1
IPPU	I.17. 2016	Review and strengthen the QA/QC procedures for this category, including by: (a) providing the ENINA Task Force with access to the confidential production data and deriving a time series of annual production-based IEFs; (b) comparing the annual inventory and EU-ETS estimates for ammonia production; and (c) reporting on the findings of QA/QC activities transparently in the next submission or directly to future ERTs while protecting commercially sensitive data,	Improved text in NIR and methodology report	Section 4.3.4		2.2.3.1
IPPU	I.18. 2016	Report emission estimates for ethylene, methanol and carbon black production under the category petrochemical and carbon black production. The ERT also encourages the Party to work with chemical companies and national energy statistics compilers to avoid gaps or double counting in the energy balance, and to obtain the product-specific data (production, emissions, IEFs), and, if the confidential data cannot be disclosed in the	Improved text in NIR and methodology report	Section 4.3.2		2.2.3.1

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		submission, make provisions such that the confidential data can be made available to the ERT well in advance of the review week in order to facilitate the review process.				
IPPU	I.19. 2016	document the QA/QC activities and outcomes for the chemical and petrochemical sources in the IPPU sector in the next submission	Improved text in NIR and methodology report	Section 4.3.4		2.2.3.1
IPPU	I.20. 2016	Include the procedural clarifications, provided during the review week, in the NIR to improve transparency. The ERT encourages the Party to overcome commercial confidentiality issues and describe the QA/QC procedures transparently in the NIR.	Improved text in NIR and methodology report	Sections 4.1 and 4.3.4		2.2.3.5
IPPU	I.21. 2016	Correct the notation key 'NA' to 'IE' in accordance with paragraph 37 of the UNFCCC Annex I inventory reporting guidelines.	Notation keys in 2.F improved and text in methodology report	Section 4.7.1	Table2(II)B-Hs2	2.2.3.9
IPPU	I.22. 2016	Conduct QA/QC and verification of the method used to estimate emissions from refrigeration and air-conditioning, in accordance with paragraph 41 of the UNFCCC Annex I inventory reporting guidelines, and report on the outcomes thereof.	Improved text in NIR and methodology report	Section 4.7.4		2.2.3.9
Agriculture	A.2. 2016	Continue and enhance efforts to improve consistency between the CH_4 and N_2O emissions estimates, and report correct values for the fractions of the different manure management systems in the NIR and the CRF tables.	Corrected CRF table and improved text in NIR	Section 5.3.1	Table 3.B(a)s 2	
Agriculture	A.4. 2016	Include the method and related parameters used to derive the country-specific N excretion and FracGRAZ.	The method and related parameters for the country-specific N excretion are described in CBS (2012). A			4.1.1

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
			yearly update in Dutch is published, van Bruggen (2017) being the most recent. FracGRAZ is no longer part of the CRF.			
Agriculture	A.6. 2016	Enhance the methodology description of this category by providing in the NIR additional information and references on MCFs and include the outcomes of the new research on B0 and MCFs as soon as they become available.	Recalculation and improved text in NIR and methodology report	Section 5.3	Tables 3.B(a)s 1 and 3.B(a)s 2	4
Agriculture	A.7. 2016	Include in the NIR an explanation of the different trends in CH_4 emissions and changes in the swine population.	Considered along with A.6, 2016			
Agriculture	A.8. 2016	Include numeric data on the annual removal of agricultural crop residues in the NIR.	Removal of agricultural crop residues has been included in the new methodology report			9.6
Agriculture	A.9. 2016	Include a section in the NIR with the information on the methodology used for the estimation of CO_2 emissions from urea application in the agriculture sector and the allocation of emissions in accordance with the 2006 IPCC Guidelines, and link with the reporting of emissions from ammonia production in the IPPU sector.	To be addressed in NIR2019			
LULUCF	L.1. 2016	Obtain the data and report the estimates for all mandatory categories CSC (currently reported as 'NE') for which methodologies and EFs are available.	Explanations for 'missing' CSC are now included in NIR	Sections 6.5.1, 6.6.1, 6.7.1, 6.8.1, 6.9.1		
LULUCF	L.5. 2016	Calibrate the 2013 and 2014 values, and take historical trends into account, to ensure the accuracy and timeseries consistency in the	New method described in methodology report			LULUCF 4.2.1

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		estimates of removals.				
LULUCF	L.6. 2016	Periodically update the carbon stock changes on land areas involving forest land as and when the new information from the next NFI becomes available.	Text on planned improvement included	Section 6.4.6		
LULUCF	L.7. 2016	Provide in its NIR an explanation of the implication of carbon stock change in forests and the assumptions made for their estimates and provide references to justify this assumption.	New graphics included			LULUCF 4.2.1
LULUCF	L.9. 2016	Correct the mistakes in reporting land use area data in the CRF tables and ensure complete and consistent coverage of land areas within the country.	Alignement with Agriculture		3D.6	
LULUCF	L.2. 2016	Obtain the data and report the estimates for the carbon pools (living biomass and DOM) reported as 'NE' for which methods and EFs are available.	Text improved and new method described	Section 6.6.1		LULUCF 6.1 en 6.2
LULUCF	L.10. 2016	Correct the errors in the allocation of areas and the estimates of emissions/removals between grassland remaining grassland and land converted to grassland, and enhance the QA/QC procedures to ensure accurate reporting on this issue in the NIR and the CRF tables.	Recalculation and improved text	Section 6.6.1	4.C	
LULUCF	L.11. 2016	Revise the notation key 'NE' to 'IE' for indirect N_2O emissions that are reported in the agriculture sector, and provide a more transparent explanation.	Changed notation keys		4.I	
Waste	W.2. 2016	Include important AD, such as the amount and composition of disposed waste, in the NIR.	Requested data included in NIR	Section 7.2.2, Table 7.3		
Waste	W.7. 2016	Provide in the NIR an explanation of the selection of the parameters used in the FOD method, including delay time and MCF.	Explanation now provided	Section 7.2.2		

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
Waste	W.8. 2016	Correct the notation key in CRF table 5.A in accordance with paragraph 37 of the UNFCCC Annex I inventory reporting guidelines.	Explanation included as node comment in CRF		Reporter node 5.A.1.b	
Waste	W.9. 2016	Include in the NIR background information on the use of country-specific values for the fraction of CH_4 in generated landfill gas.	Explanation now provided	Section 7.2.2		
Waste	W.10. 2016	If the Netherlands is unable to provide the justifications referred in the issue (W.10, 2016) and to obtain a country-specific value for the fraction of CH_4 in generated landfill gas for the period 2001–2014, it should continue to use the country-specific value (57.4%) for the fraction of CH_4 in generated landfill gas, and recalculate CH_4 emissions from waste disposal on land using the same country-specific value (57.4%) for the fraction of CH_4 in generated landfill gas for the entire time series, 1990–2014.	Explanation now provided	Sections 7.2.2 and 7.2.5		
Waste	W.3. 2016	Report a complete time series of AD of separately collected organic waste from households for CH_4 and N_2O emissions from composting and digesting for the period 2009–2012.	Requested data included in NIR	Section 7.3.2, Table 7.5		
Waste	W.11. 2016	Ensure the consistency of the reported time series for the CH_4 EF and include in the NIR the reason for the decrease in the CH_4 EF after 2009.	Explanation now provided	Section 7.3.2		
Waste	W.14. 2016	Provide the clearly documented country-specific methodology and the background information in the NIR to improve the transparency of the reporting.	Improved text in NIR and ENINA report	Section 7.5.2		2.3.2.4.6
Waste	W.6. 2016	Provide a numerical estimate of the recovered methane in anaerobic industrial wastewater treatment plants.	Partly resolved, text in NIR, some data in Table 7.5	Section 7.5.2, Table 7.5	No data availabl	

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
					e for inclusion in CRF	
KP	KL.5. 2016	Include a justification for the high value of carbon stock change per area of litter pool for the area of deforestation in 1990 in the NIR.	Description included	Sections 6.4.2 and 11.3.1.1		LULUCF 4.2.3
KP	KL.6. 2016	When it conducts technical corrections of the FMRL, address the recommendation made in the report of the technical assessment of the FMRL submitted by the Netherlands and reflect historical emissions from natural disturbance (see also document FCCC/IRR/2016/NLD, table 3, ID# 5).	Will be included in technical correction of 2019	Section 11.5.2.3		
KP	KL.7. 2016	Provide: information on the methodologies, parameters (e.g. half lives) and assumptions used for the estimation of CO_2 emissions from HWP; an explanation of the treatment of HWP in the NIR, including what is included or excluded as emissions from HWP, and on which assumption the estimation is based, in accounting those emissions; and, in particular, an explanation of the adherence to IPCC guidance in terms of the exclusion of imports and deforestation, inherent HWP, and of the relationship between the reporting under the Convention and the projection of HWP in the FMRL.	Description included	Sections 6.10.2 and 11.4.5		LULUCF 10.2
KP	KL.8. 2016	Provide the reasons for the exclusion of direct and indirect N_2O emissions from N fertilization from the KP-LULUCF reporting, as explained during the review, in order to improve the transparency and completeness of the next submission.	Reason included in NIR	Section 11.3.1.2	-	-

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
General	MF 2017 Table 2 #1	Improve the archiving function in order to ensure that all information used to compile the inventory is kept at the most disaggregated level, together with the methods used and assumptions made, in order to be able to promptly retrieve the information in order to estimate emissions, perform the QA/QC functions and provide the information to the review teams in a timely manner.	Archive function is fit for purpose but it is up to the individual institutes to use this function or not. The current arrangements ensure fast responses to any review questions that need background information or data.			
General	MF 2017 Table 2 #2	Improve the description of the institutional arrangements in the NIR, moreover in relation to the roles of the agencies participating in the planning, preparation and management of the GHG emissions inventory, including Task Forces composition. The ERT also recommends that the Netherlands include more elements from the QA/QC programme in the NIR, particularly in relation to the timeline of the activities in an integrated way with the Work Plan timeline.	1) Additional information on the agencies participating in the Task Forces included; 2) Additional information on QA/QC programme included, including figure 1 QA/QC cycle (including timeline)	Section 1.2.2, Box 1 Section 1.2.3		
General	MF 2017 Table 2 #3	Improve the transparency of the NIR. If the Netherlands finds that the size of the NIR would become impossible to handle, an option is the use of methodological reports as part of Annex 3 of the NIR. These methodological reports would need to be officially submitted to the UNFCCC as addenda to the NIR. Clear cross-references between the main body of the NIR and the methodological reports would be essential.	Methodology reports are now part of the official NIR submission and they will not differ from those published on the website			
Energy	MF 2017 Table 2 #4	Include the reason why emissions from liquid fuel are reported only in 1990 in the NIR.	Explanation given in NIR	Section 3.2.4.1		

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
Energy	MF 2017 Table 2 #5	Fill all blank cells in manufacture of solid fuels (1A1ci) with notation key.	Activity data included	Activity data included		
Energy	MF 2017 Table 2 #6	Change the allocation of the emissions from the iron and steel industry according to the 2006 IPCC Guidelines in the next submission.	Improved and new text on iron and steel in the NIR and methodology report and improved CRF tables	Sections 3.2.5.1, 3.2.5.5, 4.4.2 and 4.2.5		2.2.3.1
Energy	MF 2017 Table 2 #7	Apply revised energy statistics for 1991–1994 in order to ensure time-series consistency.	For the years 1991–1994 in this submission we used revised energy statistics. A short explanation is given in the NIR, with a reference to a complete description in NIR2016.	Section 3.2		
Energy	MF 2017 Table 2 #8	Include an explanation of the recalculation of the energy balance.	See MF 2017 Table 2 #7			
Energy	MF 2017 Table 2 #9	Include the combustion emission of CH_4 from the natural gas transport network are also allocated to category 1A3ei (gaseous pipeline transport).	Not enough data available to make a consistent time series. So this recommendation cannot be followed.			
Energy	MF 2017 Table 2 #10	Include the detailed explanation of the trend in the next submission.	New figure added in NIR.	3.2.7.2		
Energy	MF 2017 Table 2 #11	Replace the correct value for AD	AD included in CRF		1.B.1.b	
Energy	MF 2017 Table 2 #12	Include the explanation that fugitive emissions of gas and oil exploration and production are included in fugitive emission of venting and flaring (1B2c) in the NIR and revise CRF table 9.	CRF table 9 is completed as a separate file		Table 9	

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
Energy	MF 2017 Table 2 #13	Change the notation keys applied to CO_2 emissions from 'NA' to 'IE' for 1990–2001, and include an explanation that fugitive CO_2 emissions from oil refining in 1990–2001 are included in 1A1b. The ERT also noted that a default EF for fugitive emissions from oil refining is not provided in the 2006 IPCC Guidelines, volume 2, chapter 4, table 4.2.4.	Notation keys changed		1.B.2.a.4	
Energy	MF 2017 Table 2 #14	Replace the emissions with correct values and enhance QA/QC procedure to ensure correct reporting. Furthermore, the ERT recommends that the Party conduct an assessment of completeness in the energy sector and report the result of this assessment in its NIR as suggested in para. 50 (f) of the UNFCCC reporting guidelines.	Error is corrected		1.B.2.a.4	
Energy	MF 2017 Table 2 #15	Enter appropriate notation keys in CRF table 1.b.2, ensuring time-series consistency,	All relevant notation keys on NO		1.B.2.b.6	
Energy	MF 2017 Table 2 #16	Include the methodology description of venting and flaring from oil and gas, such as AD and EF, with setting a chapter for this category.	This issue is now addressed in the NIR			
Energy	MF 2017 Table 2 #17	Include a chapter for 1C (Transport and storage).	This issue is now addressed in the NIR	Section 3.4		
IPPU	MF 2017 Table 2 #18	Take emissions from 2C1d and add to 2C1a so all steel CO_2 emissions are reported in the correct cell of CRF Table 2(I).A-Hs2 and this is clearly explained in NIR in the next submission in order to avoid misunderstanding by future ERTs. In addition, the ERT recommends that the Party inserts 'NO' in CRF	New text on iron and steel in the NIR and methodology report and improved CRF tables	Sections 3.2.5.5 and 4.2.5	Table2(I).A-Hs2	2.2.3.1

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		Table 2(I).A-Hs2 in cell G13, because there are no CO_2 emissions from iron produced by DRI technology route in the country.				
IPPU	MF 2017 Table 2 #19	Enhance QA/QC routine for this category and ensure that all emissions are reported along iron and steel making sub-categories in IPPU.	See MF 2017 Table 2 #18		2(I).A-Hs2	2.2.3.1
IPPU	MF 2017 Table 2 #20	Correct C balance by inserting C balance dry flows of reducing agents/fuels consumed, including fuel gases, as inputs and with by-products, products and residues dry mass outputs with their respective C-contents and emissions figures in order to presented to future ERT, when requested. Additionally, review NIR text to improve the sector description and present a qualitative C balance process by explaining the link with energy sector categories and its respective CRF tables, when -gases are reused for stationary combustion in both on-site or off-site applications.	New figure and table included in the NIR and improved methodology report			2.2.3.1
IPPU	MF 2017 Table 2 #21	Provide explanations in the NIR regarding the time series and premises behind EF used for N_2O emissions from caprolactam.	Improved text in NIR and methodology report	Section 4.3.2		2.2.3.4
IPPU	MF 2017 Table 2 #22	undertake QAQC activities for this particular category as it is a KC. Also NDL is recommended to document its QAQC findings in NIR for next inventory submission	Improved text in NIR and methodology report	Section 4.3.4		2.2.3.1
IPPU	MF 2017 Table 2 #23	Report the emissions separately in CRF Table2(II)B-Hs2 in order to bring transparency and comparability to the emissions reporting.	Improved text in NIR and methodology report	Section 4.7.1		2.2.3.9
IPPU	MF 2017 Table 2	Report 2F2–2F5 at a minimumlevel of aggregation in CRF Tables 2(II), Table 2(II)B-Hs2 and Table	Cannot be resolved. Because of the sensitivity of data from			2.2.3.11

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
	#24	10s5, enhance efforts to access primary data (per gas amount) and directly provide the information to the ERT, when requested during the review.	Foam blowing agents (2F2) the data per gas amount are not available. Therefore only the sum of HFC 245fa, HFC 227 ea and HFC365 mfc (expressed in CO_2 eq.) is delivered to the trade flows studies. This information can also be provided to the ERT.			
IPPU	MF 2017 Table 2 #25	Either report in the NIR the numbers of EF used for F-gases calculations in order to enhance reporting transparency or submit the ENINA report as an annex to the official NIR submission to comply with UNFCCC requirements and re-write the NIR text to make proper reference to the ENINA report and avoid duplicating text in the NIR and ENINA. The information has to be reported in one of the documents that are officially submitted to UNFCCC.	ENINA report will be a part of the submission (Annex 3)			
IPPU	MF 2017 Table 2 #26	Enhance efforts to obtain the missing primary data instead of using the CO_2 emissions directly from environmental reports in order to check that those emissions were properly calculated and have AD to present to the ERT in order to calculations reproduced during the review.	Improved text in NIR and methodology report	Section 4.2.2		2.2.3.2
IPPU	MF 2017 Table 2 #27	Correct the NIR text regarding the cement method and category description in order to delete sewage sludge.	Improved text in NIR and methodology report	Section 4.2.2		2.2.3.2
Agriculture	MF 2017 Table 2 #28	Collect the livestock data and estimate emissions from mules and asses for the period 1990–2009 or replace NO with NE and demonstrate that a	Notation key changed and improved text in NIR	Section 5.1	3	

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		disproportionate amount of effort would be required to collect livestock data, according to the provisions of paragraph 37 (b) of Decision 24/CP. 19.				
Agriculture	MF 2017 Table 2 #29	Improve the transparency of the inventory by including in the NIR complete descriptions of the evolution of AD, EFs and emissions estimates.	Improved text in NIR	Chapter 5		
Agriculture	MF 2017 Table 2 #30	Include in the NIR part of the next inventory submission the explanations provided during the review on the non-occurrence of the indirect N_2O emissions due to N leaching and run-off.	Included in new methodology report			7.2
Agriculture	MF 2017 Table 2 #31	Include in the NIR part of the next inventory submission the explanation provided during the review.	Improved text in NIR and new methodology report	Chapter 5		1.2
Agriculture	MF 2017 Table 2 #32	Include in the sections on category-specific QA/QC and verification in the NIR, at sub-sectoral level, detailed elements on the implementation of peer reviews: approach used, conclusions, recommendations and description of status and approaches used to implement recommendations.	Being addressed. To ensure consistency between all chapters, this could not be included in this year's NIR.			
Agriculture	MF 2017 Table 2 #33	In order to improve the comparability of the inventory, include in the CRF tables separate data for rabbits and minks, as part of the next inventory submission.	Proposed as planned improvement			
Agriculture	MF 2017 Table 2 #34	In order to improve comparability in respect of the estimates of CO_2 emissions from urea application, collect the necessary data and reallocate emissions on the basis of the categories included in the agreed CRF tables.	To be addressed in NIR2019 (see also A.9, 2016)			
LULUCF	MF 2017 Table 2	Continually improve transparency and use higher tiers for all pools of all mandatory key categories, as	See 38		CRF 9	LULUCF 1.3

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
	#35	required by paragraph 13 of the UNFCCC inventory reporting guidelines.				
LULUCF	MF 2017 Table 2 #36	Add this explanation and the graphs shown during the review to the NIR and demonstrate that emissions from land use changes in 1990–2009 are not underestimated for all significant pools from key categories by not considering inherited emissions due to land use changes before 1990.	Description included in NIR	Section 6.3		
LULUCF	MF 2017 Table 2 #37	Include this documentation with respect to land use changes (1) in total, (2) from non-forest land to forest land, and (3) from forest land to non-forest land, and rotations between grassland and cropland in the NIR.	Description included in NIR	Section 6.3		
LULUCF	MF 2017 Table 2 #38	Extend and improve the description in the NIR. This could be done by adding an explanation and some figures shown during the in-country review.	Methodology description improved. A new approach has been described. This has no effects on land use changes.			LULUCF 3.6
LULUCF	MF 2017 Table 2 #39	Correct the description of the calculation steps, extend the description of the calculation of carbon stock changes in living biomass and provide additional information on the primary data sets used (e.g. tables of graphs containing gains and losses of biomass for the whole time series). Furthermore, add a qualitative description or an interpretation of the values shown in table 4.2 of Arets et al. (2018), specifically explaining the temporal development of growing stock, the net annual increment and carbon stock in dead wood and the policies related to these processes.	We disagree that the steps taken are not straightforward. However, we agree that the term ‘biomass expansion factor’ is used twice and should be explained better. This description has been improved in section 4.2 of the methodological background report.			LULUCF 4.2
LULUCF	MF 2017	Take into account carbon stock changes from	A methodological change,	Section 6.6		LULUCF 6.1

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
	Table 2 #40	orchards in the Grassland category by improving the applied EFs and methodology and add this information to the NIR.	including orchards under grassland, has been implemented.			and 6.2
LULUCF	MF 2017 Table 2 #41	Add an explanation of these inter-annual changes in IEF to the NIR.	Information included in the NIR	Section 6.6.3		
LULUCF	MF 2017 Table 2 #42	Estimate the area of forest on organic soils as proposed by the Party during the review, report CO_2 and N_2O emissions in the CRF tables and describe the applied methodology and IEF in the NIR.	This comment asks for additional analysis and a methodology change. During the remainder of 2017 there were no resources available for doing this. Improvements may be planned for a forthcoming NIR.			
LULUCF	MF 2017 Table 2 #43	Include the argumentation provided during the review in the NIR.	Explanation included in the NIR	Section 6.4.2.1		
Waste	MF 2017 Table 2 #44	Report in the NIR of the next annual submission that CH_4 emissions from semi-aerobic landfills are included in those of managed solid waste disposal sites to clarify the use of the notation key IE.	Explanation included as node comment in CRF		Reporter node 5.A.1.b	
Waste	MF 2017 Table 2 #45	Provide in the next submission information on the types, composition and amount of waste landfilled and how the AD were compiled.	Requested data included in NIR	Section 7.2.2, Table 7.3		
Waste	MF 2017 Table 2 #46	Include in the next submission the data used for the estimation of emissions only together with a detailed explanation.	Requested data included in NIR	Section 7.2.2, Table 7.3		
Waste	MF 2017 Table 2 #47	Include in the NIR of the next submission data on waste composition and the method applied to derive the DOC values.	Requested data included in NIR	Section 7.2.2, Table 7.3		
Waste	MF 2017	Report in the NIR of the next submission the	Requested details included in	Section 7.2.2,		

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
	Table 2 #48	reasons for the decrease in DOC values throughout the time series, in particular between 2000 and 2001, and an explanation for the low values reported for the period 2000–2015.	NIR	Table 7.3		
Waste	MF 2017 Table 2 #49	Include in the next submission an explanation of the use of k-values throughout the time series 1990–2016.	Explanation provided	Section 7.2.2		
Waste	MF 2017 Table 2 #50	Include in the NIR of the next submission an explanation of the use of DOCf values throughout the time series, 1990–2016.	Explanation provided	Section 7.2.2		
Waste	MF 2017 Table 2 #51	Include in the NIR of the next submission and explanation of the use of the fraction of methane in landfill gas generated throughout the time series, 1990–2016.	Explanation provided	Section 7.2.2		
Waste	MF 2017 Table 2 #52	Include in the NIR of the next submission detailed data on DOC for domestic and industrial wastewater and sludge and an explanation of how the data were derived (see Table 7.5, page 223 of the 2017 NIR).	Text and table included in the NIR and text in ENINA	Section 7.5.2, Table 7.5		2.3.2.4.2
KP	MF 2017 Table 2 #53	Extend the information provided during the review to the NIR such that the calculation process is documented transparently showing that the calculation is based on area-specific emissions and that the background value and margin for both AR and FM are provided separately (not summed).	Explanation and split between background level and margin included in the NIR	Section 11.4.4		
KP	MF 2017 Table 2 #54	Ensure consistency between the values provided in the CRF tables and in the NIR and correct errors where needed. Also improve the use of notation keys and use them consequently throughout the NIR, i.e. use ‘NR’ (similarly as ‘NE’ under the Convention) for pools where zero carbon stock	Table 11.3 and accompanying text has been improved in the NIR	Section 11.3.1.1		

Sector	Number	Recommendation	Response NLD	Paragraph or table number in:		
				NIR	CRF	Methodology report
		changes apply and for which a justification has been given in the NIR.				
KP	MF 2017 Table 2 #55	Add this information to the NIR.	Explanation on other round wood has been included in the NIR and background report	Sections 6.10.2 and 11.4.5		LULUCF 10.2
KP	MF 2017 Table 2 #56	Include this information in the NIR.	Added	Section 6.10.2, Table 6.10		
KP	MF 2017 Table 2 #57	Periodically update the internal document Mol et al. (2011) with regard to the screening of the reporting methods applied by other countries and especially with regard to provided arguments from international literature on soil modelling, since some of the references can be replaced by more recent studies (e.g. Liski et al., 2002).	Results of the Monte Carlo assessment showing that litter under Forest land remaining forest land and Forest management is not a source have been added to the methodological background report.			LULUCF 4.2
KP	MF 2017 Table 2 #58	Estimate the area of A and FM on organic soils as proposed by the Party during the review, report CO_2 and N_2O emissions in the CRF tables and describe the applied methodology and IEF in the NIR.	This is the same as main finding 100, requiring additional analysis and a methodology change. During the remainder of 2017 there were no resources available for doing this. Improvements may be planned for a forthcoming NIR.			

10.4.1.2 Completeness of NIR

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 (2A4d), due to missing activity data;
- CO_2 from road paving (2A4d), due to missing activity data;
- CH_4 from enteric fermentation in poultry (3A4), 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. CO, NO_x, NMVOC) and SO_2) from memo item 'International bunkers' (international transport).

For more detailed information on this issue, see Annex 6.

The recommendation of the review team to document the 'NE' notation key in the CRF will be implemented in the next submission. Due to technical problems with the CRF we included a copy of Table 9 as Excell sheet to this submission.

10.4.1.3 Completeness of CRF tables

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 are confidential and not reported when a source category comprises three or fewer companies. During in-country reviews, however, these data can be made available to the ERT.

10.4.1.4 Planned improvements

The Netherlands' National System was established at 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 set out in 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 as 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 and EU reviews, peer reviews and audits. Where needed, improvements are included in the annual update of the QA/QC programme (RVO.nl, 2017).

QA/QC programme

The QA/QC programme for this year (RVO.nl, 2017) continues the assessment of long-term improvement options 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 2018 and are governed by the annual Work Plan.

10.4.2 KP-LULUCF inventory

The following future improvements are foreseen:

- In the NIR 2019 an updated land use change matrix 2013–2017 is expected.
- An updated soil map is currently being implemented. This will allow improved future calculation of emissions from soil associated with land use changes. This is also expected to be implemented in the NIR 2019.
- A new forest inventory (NBI7) has begun and will provide results by 2021. Results will be included in the NIR 2022.

Part II: 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., 2018).

This year under the UNFCCC reporting (Chapter 6) a sub-category Trees outside forests (TOF) has been introduced under Grassland. TOF consists of units of land with trees that do not meet the minimum area requirement for the forest definition. Until the NIR 2014 these areas of TOF were included as a separate category under Forest land, and were excluded from accounting under KP-LULUCF, except for deforestation from Forest to TOF. This, however, appeared to be confusing when

comparing UNFCCC and KP reporting and accounting and resulted in continuing questions and recommendations during the review process. In the NIRs 2015 to 2017 these areas were therefore included under Forest land without making a distinction between units of Forest land that did comply with the definition and those that did not comply. Due to new insights and to improve transparency, the separate reporting of Trees outside forests is reinstated in this NIR. To prevent the previously observed confusion between emissions and removals as reported under UNFCCC and KP, however, the category TOF is now included under Grassland.

As a result, compared with the NIR 2017, this has had an effect on reported activity data and emissions and removals for:

1) Afforestation and reforestation (AR), as conversions from TOF to Forest land are now included under this activity. In the NIR 2017 these units of land were included mostly under Forest management (FM) for those areas of TOF that were TOF since 1990. At the same time, conversions from other land uses to TOF are no longer included under AR.
2) Deforestation (D), because conversions from Forest land to TOF are now included under this activity. In the NIR 2017 these units of land were included mostly under FM for those areas of Forest land that were Forest land since 1990. At the same time, conversions from TOF to other land uses are no longer included under D.
3) FM, as conversions between TOF and Forest land are now excluded from this activity and included under AR and D, and because the overall FM area has decreased due to the exclusion of the area under TOF that remained TOF since 1990.

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 but did so at any moment before 31 December 2016. 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 subsequently reforested and thus complies with the forest definition again.

Units of land subject to Article 3.4 *Forest management* (FM) are units of land meeting the definition of forest that are managed for stewardship and use of forest land and that have not been classified under AR or D. Here, the Netherlands applies the broad interpretation of FM. As a result, all Forest land under the UNFCCC that is not classified as AR or D land will be classified as FM land. 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 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 later reconverted to Forest land. CRF Table 4(KP-I)A.2 provides the information for D land disaggregated for the land use categories in the reporting year, including Forest land, which refers to units of land that were reforested 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 (IPCC, 2014: para. 2.2.2). AR, D and FM 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 D, 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 continue to do so over the full time period since 1990 are treated as FM.

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, 2009), 1 January 2009 (Van den Wyngaert et al., 2012) and 1 January 2013 (Kramer and Clement, 2015); see also Section 11.2.3 below. An overlay was made of those four maps plus a map with mineral soil types and a

map with organic soil locations (Arets et al., 2018). 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 2004–1 January 2009 and a third matrix covering the period 1 January 2009–1 January 2013. Together the three 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 between the map years were calculated by linear interpolation. From 2013 onwards the annual changes as obtained from the matrix 2009–2013 are used to extrapolate land use changes. These values will be used until a new land use map is available (provisionally planned to be included in the NIR 2019 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 FM.

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 Convention subcategory 4A2 (Land converted to forest land) for the respective years up to 2003. From 2004 onwards these start to differ because part of the afforestation that is included in Convention category 4A2 is on land that was deforested between 1990 and 2003. Additionally, due to the 20-year transition period for forests, from 2010 onwards, land reported under 4A2 that was converted to Forest land 20 years earlier will be reported under Convention category 4A1 (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 consecutive land use change matrices, from 2009 onwards, i.e. 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 Table 11.1 they are included under ‘D remaining D’ since the first deforestation event on the particular unit of land.

Table 11.1: Results of the calculations of the area change (in kha) of afforestation/reforestation (AR), deforestation (D) and Forest management (FM) in the period 1990–2016

Year	Land to AR	AR remaining AR	AR to D	FM to D	D remaining D	FM remaining FM	Other (not in KP Article 3.3 or FM)
1990	2.6		0	2.0	0	360.1	3,786.8
1991	2.6	2.6	0	2.0	2.0	358.1	3,784.3
1992	2.6	5.1	0	2.0	4.0	356.1	3,781.7
1993	2.6	7.7	0	2.0	6.0	354.1	3,779.1
1994	2.6	10.2	0	2.0	7.9	352.1	3,776.6
1995	2.6	12.8	0	2.0	9.9	350.1	3,774.0
1996	2.6	15.3	0	2.0	11.9	348.1	3,771.5
1997	2.6	17.9	0	2.0	13.9	346.2	3,768.9
1998	2.6	20.4	0	2.0	15.9	344.2	3,766.4
1999	2.6	23.0	0	2.0	17.9	342.2	3,763.8
2000	2.6	25.5	0	2.0	19.9	340.2	3,761.3
2001	2.6	28.1	0	2.0	21.9	338.2	3,758.7
2002	2.6	30.7	0	2.0	23.8	336.2	3,756.2
2003	2.6	33.2	0	2.0	25.8	334.2	3,753.6
2004	2.5	34.9	0.9	1.6	27.8	332.6	3,751.1
2005	2.5	36.6	0.9	1.6	30.3	331.0	3,748.6
2006	2.5	38.2	0.9	1.6	32.8	329.3	3,746.0
2007	2.5	39.9	0.9	1.6	35.3	327.7	3,743.5
2008	2.5	41.5	0.9	1.6	37.8	326.1	3,741.0
2009	2.9	42.7	1.3	1.9	40.3	324.2	3,738.1
2010	2.9	44.3	1.3	1.9	43.5	322.3	3,735.2
2011	2.9	45.8	1.3	1.9	46.8	320.4	3,732.3
2012	2.9	47.4	1.3	1.9	50.0	318.6	3,729.4
2013	3.7	49.7	0.6	2.6	53.2	315.9	3,725.7
2014	3.7	52.8	0.6	2.6	56.4	313.3	3,722.0
2015	3.7	55.9	0.6	2.6	59.6	310.6	3,718.3
2016	3.7	59.0	0.6	2.6	62.9	308.0	3,714.6

11.2.3 Maps and/or database to identify geographical locations and the system of identification codes for geographical locations

The land use information reported under both the Convention (see also Section 6.3) and the Kyoto Protocol is based on four land use maps specifically monitoring nature development in the Netherlands: 'Basiskaart Natuur' (Base Map Nature, BN) for 1 January 1990, 1 January 2004 (Kramer et al., 2007, 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., 2018).

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, Water, Reed marsh, Sand, Built-up area, Greenhouses	Grassland, Nature, Grassland, Arable land, Heath land, Forest, Built-up area and infrastructure, Water, Reed marsh, Drifting sands, Dunes and beaches	Grassland, Nature Grassland, Arable land, Heath land, Forest, Built-up area and infrastructure, Water, Reed marsh, Drifting sands, Dunes and beaches	Grassland, Nature Grassland, Arable land, Heath land, Forest, Built-up area and infrastructure, Water, Reed marsh, Drifting sands, Dunes and beaches

To distinguish between mineral soils and organic soils, an overlay is also made of 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 or D or remained 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 intervals between the different land use maps, it is unknown for each individual location in which year exactly AR or D occurred. A mean annual rate for the Netherlands as a whole is derived from the aforementioned analysis by interpolation.

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and GHG emissions 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 (NFIs) 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 NFI becomes available, by 2020, the development of carbon stocks in forests is based on projections using the EFISCEN model (see Arets et al., 2018).

Using 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 of tree biomass information, with allometric equations to calculate above-ground biomass (AGB) and below-ground biomass (BGB) and forest litter.

More detailed descriptions of the methods used and EFs can be found in Arets et al. (2018).

Afforestation / reforestation

Reporting of AR is linked to the following land use categories 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., 2018).

Carbon stock losses due to changes in above-ground and below-ground biomass in land use conversions from Cropland and Grassland (non-TOF) were calculated on the basis of Tier 1 default carbon stocks. Carbon stock changes in litter and dead wood follow the approach for Land converted to forest land (Section 4.2.2 in Arets et al., 2018) during the first 20 years after establishment, which are not estimated due to lack of data. Twenty years after establishment, the carbon stock changes in litter and dead wood are calculated using the methods for Forest land remaining forest land (Section 4.2.1 and Arets et al., 2018). The analysis for litter in this category consistently showed a carbon sink in litter, but the magnitude was very uncertain. Therefore, assuming

zero accumulation of carbon in litter was considered to be conservative (Section 4.2.1 and Arets et al., 2018). For KP-LULUCF reporting, this translates to applying the 'not a source principle' for litter, and carbon stock changes in dead wood are included. Methods for calculating 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 (CSC) (in Gg C) from afforestation/reforestation activities during the second commitment period

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
2013	152.6	16.9	NO	6.12	-0.37	-1.25
2014	163.8	18.9	NO	7.0	-0.97	-1.25
2015	175.2	20.9	NO	7.8	-.1.55	-1.25
2016	186.9	23.0	NO	8.6	-2.12	-1.25

CSC: carbon stock change, AG: above ground, BG: below ground

Deforestation

Reporting of D is linked to the following land use categories 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, 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 6.5–6.9 and Arets et al. (2018).

Carbon stock changes due to changes in forest biomass were differentiated into AGB and BGB using data available from the bookkeeping model used (Arets et al., 2018). Data from the 6th NFI 2012–2013, in combination with data from the previous NFI (MFV) in 2000, allowed the calculation of actual carbon stock changes from deforestation (see EF in Table 6.8 in Section 6.4.2.3). Carbon stock changes due to changes in AGB and BGB in land use conversions to Cropland and Grassland were calculated on the basis of Tier 1 default carbon stocks for Cropland and average carbon stocks as assessed for Grassland (non-TOF) (see Section 6.6.2 and Arets et al., 2018).

Deforestation to TOF may occur when surrounding units of Forest land are deforested. As a result, the remaining area no longer conforms to the minimum area of the forest definition. Tree biomass is, however, assumed to remain the same. As a result, deforestation to TOF will not result in loss of biomass, while in the years after the deforestation event, carbon stock gains will continue as a result of the growing biomass of TOF (see Section 6.6.2 and Arets et al., 2018). Net carbon stock changes in the different carbon pools are given in Table 11.4.

Table 11.4: Net carbon stock changes (CSC) (in Gg C) of deforestation activities during the second commitment period

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
2013	-195.21	-27.89	-99.02	-4.86	1.84	-11.16
2014	-198.30	-28.47	-99.85	-5.49	1.59	-12.25
2015	-201.62	-29.03	-100.69	-6.13	1.34	-13.35
2016	-204.83	-29.62	-101.52	-6.78	1.09	-14.45

CSC: carbon stock change, AG: above ground, BG: below ground

Carbon stock changes in mineral soils are reported using a 20-year transition period. Carbon stock changes in organic soils are reported for all organic soils under Article 3.3 activities. The methods are presented below.

Deforestation of AR land involves an emission of all accumulated carbon stocks up to the time of deforestation that have been calculated following the methodologies for AR.

Carbon stock changes per area for the litter pool under deforestation is found to be higher in the Netherlands than in other countries. As a result of a characteristic combination of geomorphological and climate conditions, a large share of Forest land in the Netherlands is on poor Pleistocene soils, characterized by relatively thick litter layers, which may explain the differences with other countries. The assessment of the carbon stocks and changes thereto in litter in Dutch forests is based on extensive datasets on litter thickness and carbon content in litter (see Section 4.2.1 and Arets et al., 2018). Additional information on geomorphological aspects is provided in Schulp et al. (2008) and de Waal et al. (2012).

Forest management

Reporting of FM is linked to the category 4A1 Forest land remaining forest land used for reporting under the Convention. Yet the area and total figures of carbon stock changes differ due to the fact that, under Convention reporting, from 2009 onwards land that was afforested after 1990 exceeds the 20-year transition period and is included in the category Forest land remaining forest land, while under KP reporting such land is still reported under AR.

The calculation of carbon stock changes and resulting EFs is the same as used under the Convention (see Section 6.4.2.1 and Arets et al., 2018). Net carbon stock changes are given in Table 11.5.

Table 11.5: Net carbon stock changes (CSC) (in Gg C) in Forest management during the second commitment period

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
2013	276.14	49.71	NO	69.63	NO	NO
2014	273.46	49.22	NO	69.07	NO	NO
2015	270.78	48.74	NO	68.51	NO	NO
2016	268.11	48.26	NO	67.95	NO	NO

CSC: carbon stock change, AG: above ground, BG: below ground

Carbon stock changes in litter in Forest land remaining forest land were estimated but a Monte Carlo uncertainty assessment showed that while litter consistently remained a carbon sink, the magnitude of it was very uncertain. Therefore, it was considered conservative to set the accumulation of carbon in FM to zero (see Arets et al., 2018).

Method of estimating carbon stock changes in AR or D land in mineral soils

Carbon stock changes in mineral and organic soils are reported for all soils changing land use under Article 3.3. Carbon stock changes in mineral soils were 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 in the Netherlands. Combined with land use at the time of sampling, this led to a new soil/land use-based classification of all points (see Arets et al., 2018 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. For the remaining land use categories, separate estimates were made. For Settlements, which constitute about 32% of deforested land, the estimates make use of information in the IPCC 2006 Guidelines. An average soil carbon stock under Settlements of 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 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 class 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 AR or D is then estimated from the difference between land use classes divided by 20 years (the IPCC default transition period):

$$E_{\min\_xy} = \sum_{1}^{i}\left(\frac{C_{yi} - C_{xi}}{T} \cdot A_{\min\_xyi}\right)$$

Where:

$E_{\min\_xy}$	annual emissions from 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 (i.e. <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:

$$C_{\Delta yi_t} = C_{xi} + t \cdot \frac{C_{yi} - C_{xi}}{T}$$

Where (as above plus):

$C_{\Delta yi_t}$	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.

Method of estimating carbon stock change in AR and D land in organic soils

The area of organic soils under forests in 2016 is small: 22.8 kha, which is 4.5% of the total area of organic soil. The area of AR land on organic soils was 7.7 kha in 2016 (12.3% of total AR area) and the area of D land on organic soils was 6.5 kha in 2014 (9.9% of deforested area). In 2016 the majority of this area of AR (88%) and D (66%) 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 into peat soils, which have a peat layer of at least 40 cm within the first 120 cm, and peaty soils (in Dutch: ‘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 EFs for peat and peaty soils have been developed (see Arets et al., 2018).

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. Estimated total annual emissions from cultivated peat soils were then converted to an annual EF of 19.03 tonnes CO_2 per ha peat soil to report emissions from peat soils for land use (change) categories involving Grassland (non-TOF), Cropland and Settlements (see Arets et al., 2018: chapter 11.3).

For peaty soils, a different approach was used, based on a large data set of soil profile descriptions over time (de Vries et al., 2016, in press). om This data set holds information on the change in thickness of the peat layer over time and from these data the average loss rate of peat was calculated. This resulted in an average overall EF of 13.02 tonnes CO_2 per ha per year for peaty soils under agriculture. For Settlements no data were available, but the same average EF was used. Detailed information on the calculations for peat and peaty soils is provided in Arets et al. (2018).

For organic soils under deforestation, the assumption that emissions are equal to the emissions of cultivated organic soils is realistic. For AR, 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 AR, emissions remain equal to the emissions on cultivated organic soils before AR.

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 (N_2O) emissions from soils by disturbance associated with land use conversions are calculated with a Tier 2 methodology, using equation 11.8 of the 2006 IPCC Guidelines for each aggregated soil type (see Arets et al., 2018: chapter 11.2). The default EF 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, chapter 11.16). For aggregated soil types where conversion of land use led to a net gain of carbon, N_2O emissions were set to zero.

GHG emissions due to biomass burning in units of land subject to Article 3.3 (AR and D) and Article 3.4 (FM)

Emissions of 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, emissions of 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., 2018) and are reported in Table 4(KP-II)4.

The 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 wildfires 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. Other wildfires in the Netherlands are assumed to be burned nature grasslands.

The average annual area of D land burned is then estimated from the fraction of natural grasslands that is D land. In the Netherlands, wildfires 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 NIF 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, the age of the trees does not necessarily represent the time since AR. This is reflected in a very weak relation between tree age and carbon in litter (Figure 11.1) and a large variation in dead wood, even for plots with young trees (Figure 11.2).

Apart from Forest land, no land use class 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 AR conservatively as zero.

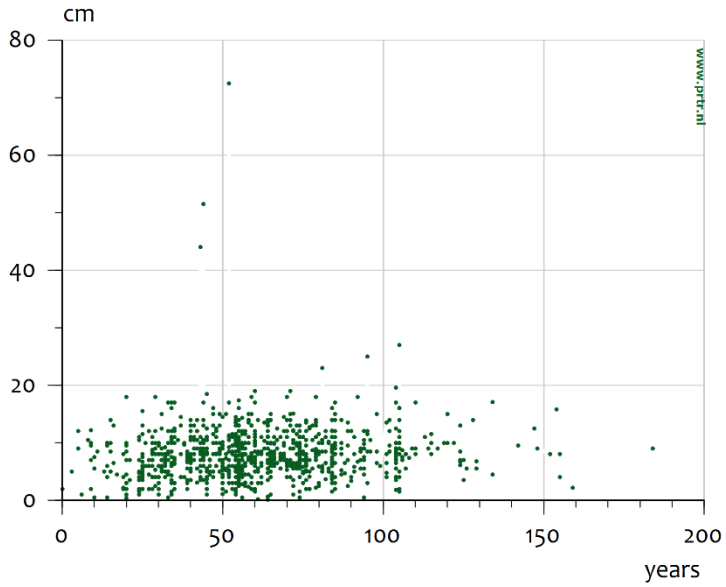


Figure 11.1: Thickness of litter layer (litter fermented humus,LFH) in Dutch NFI plots in relation to tree age. LFH measurements were conducted only in plots on sandy soils.

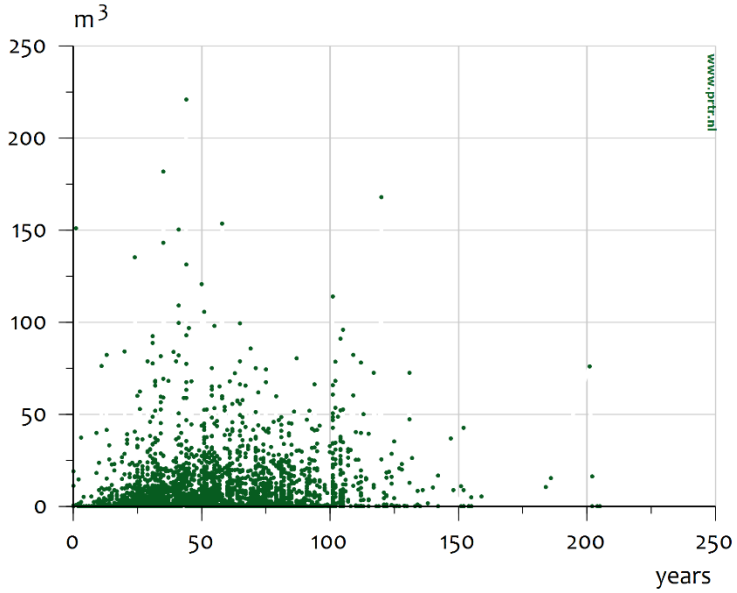


Figure 11.2: Volume of dead wood (standing and lying) in Dutch NFI plots in relation to tree age

Similarly, no other land use class 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 (regenerated in 1990 or later), the accumulation of carbon in dead wood in AR 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 becomes older (>20 years), changes in carbon stocks in dead

wood are estimated in the same way as for Forest land remaining forest land under the Convention (see Arets et al., 2018).

N_2O emissions due to N fertilization in units of land subject to Article 3.3 (AR and D) and Article 3.4 (FM)
Fertilization does not occur in forests in the Netherlands. Therefore, fertilization in AR and FM areas is reported as NO. In the Netherlands there is no law prohibiting use of fertilizers on A or FM land. The application of fertilizers in forests is not common practice because maximizing wood production is not a high priority in FM. Moreover, given the high background levels of N deposition in the Netherlands, the application of additional N in forests is not considered to be economically valuable.

Nitrogen fertilization of Grassland and Cropland on units of D land 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 stocks 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 to what extent each factor contributes. There has been no factoring-out of indirect GHG emissions and removals due to the effects of elevated CO_2 concentrations or N deposition.
This increase in mean carbon stocks 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)
As a result of the explicit identification of Trees outside forests under Grassland, the activity data and resulting emissions and removals for accounting of AR, D and FM have changed. Compared with the NIR 2017 this will have an effect on reported activity data and emissions and removals for:

1) Afforestation, as conversions from TOF to Forest land are now included under this activity while in the NIR 2017 these units of land were included mostly under FM for those areas of TOF that were TOF since 1990. At the same time, conversions from other land uses to TOF are no longer included under AR.
2) Deforestation, because conversions from Forest land to TOF are now included under this activity, while in the NIR 2017 these units of land were included mostly under FM for those areas of Forest land that were Forest land since 1990. At the same time, conversions from TOF to other land uses are no longer included under D. Conversions from Forest land to TOF may occur when surrounding units of area are deforested. Now these units of land are also included under the activity D because the remaining area does not comply with the minimum area in the forest definition.

Tree biomass is, however, assumed to remain the same. As a result, deforestation to TOF will not result in loss of biomass, and in the years after the deforestation event, carbon stock gains will continue as a result of the growing biomass of TOF.

3) Forest management, as conversions between TOF and Forest land are now excluded from this activity and included under AR and D, and because the overall FM area has decreased due to the exclusion of the area under TOF that remained TOF since 1990.

Afforestation and Deforestation deforestation from/to Grassland (non-TOF)
The change in method for calculating carbon stocks in orchards under the UNFCCC category Grassland (non-TOF) (Section 6.6) increases carbon stock losses under A (loss of original biomass) and carbon stock gains under D (increase in carbon stock after conversion from Forest to Grassland (non-TOF)).

Forest management
Under FM, alterations to the calculation of changes in carbon stock in dead wood after 2013 (see Chapter 6.4) have a small effect.

HWP and wildfires
The above-mentioned changes will affect emissions and removals in all categories in which carbon stocks in biomass on Forest land are included, i.e. carbon stock losses from D and 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 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 the KP Article 3.3 categories and FM. Thus, the uncertainty for total net emissions from units of land under Article 3.3 AF are estimated at 63%, which is equal to the uncertainty in Land converted to forest land. The uncertainty for total net emissions from units of land under Article 3.3 D is estimated at 56%, which is 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 FM is estimated at 67%, which is 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, paragraphs 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 dated 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 all land use changes between 1 January 1990 and 31 December 2020 to be taken into account.

In the Netherlands, forests are protected by the Forest Law (1961), which stipulates that 'The owner of ground on which a forest stands, other than through pruning, [or] 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 land 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., 2018).

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 NFIs, however, it can be estimated that approximately 0.3% of Forest land 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 AR under Article 3, paragraph 3, of the Kyoto Protocol and/or FM 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 a 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 natural disturbances for the calibration period is provided in Table 11.6. Based on the total extent of forest fires, GHG 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 on a proprietary database that is maintained at Wageningen Environmental Research in which damage from major storm events is collected. Part of this data set 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 disturbances for calibration.

Background level and margin
The background level and margin are calculated on the basis of the area-specific emissions using the step-wise and iterative approach as provided in chapter 2.3.9.6 of the IPCC 2013 revised supplementary methods for KP (IPCC, 2014). In five iterative steps all outliers (e.g. wind storms in 1990 and 2007) have been removed. The resulting annual background level and margin (twice the standard error) are the following:
FM: background level 2.377 Gg CO_2 eq., margin 2.004 Gg CO_2 eq.
AR: background level 0.0067 Gg CO_2 eq., margin 0.0055 Gg CO_2 eq.

Table 11.6: Time series of total annual emissions for disturbance types included under FM and AR

		Inventory year during the calibration period																			
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Activity	Disturbance type	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

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 in chapter 2.8 of IPCC (2014). As required by the guidelines, carbon from harvests allocated to deforestation is reported using instantaneous oxidation (Tier 1) as the calculation method. The remainder of the harvests is allocated to FM and is subsequently 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 follow the Tier 2 approach outlined in the 2013 IPCC KP guidance by applying equations 2.8.1–2.8.6 (Arets et al., 2018).

Four categories of HWP are taken into account: Sawn wood, Wood-based panels, Other industrial round wood, and Paper and paperboard. Emissions from wood harvested for energy purposes is included in the carbon stock losses in living biomass under FM, but is not used as an inflow in the HWP pool. As a result, these emissions are accounted on the basis of instantaneous oxidation. Emissions from harvested wood products in solid waste disposal sites (SWDS) are not separately accounted.

From the land use change calculations under Forest land (see Arets et al., 2018), 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 from 1990 onwards to FAO-stat as import, production and export for the different wood product categories (see Table 6.10), including those for industrial round wood and wood pulp as a whole (equations 2.8.1–2.8.4.). Equation 2.8.4 from the 2013 IPCC KP guidance (IPCC, 2014) is used to obtain the annual fractions of HWP from domestic harvests and to exclude imported HWP.

Material inflow is included from 1990 onwards. Consequently, inherited emissions since 1990 are taken into consideration in the accounting. The dynamics of the HWP pools are 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., 2018).

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 11.8). For the category Other industrial round wood, the values for Sawn wood were used. This category includes a variety of round wood use, like the use of whole stems as piles in building foundations, roads and waterworks, and as fences and poles. These are considered applications with a long to very long lifetime, for which the 35-year half life is considered appropriate.

Table 11.8: Tier 1 default carbon conversion factors and half life 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 industrial round wood	0.229	35
Paper and paperboard	0.386	2

Because the statistics on the production, import and export of industrial round wood in 1990 appeared not to be correct in the FAO forestry statistics database, the data for the base year 1990 were adjusted on the basis of the statistics reported by PROBOS, the Dutch national correspondent to the Joint Forest Sector Questionnaire, reporting national forestry statistics to the FAO and other international organizations (see Arets et al., 2018).

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 changes in Forest land use to be followed 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 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 into the information on carbon stocks in Forest land available from the NFIs. Therefore, emissions arising from the possible conversion of (natural) forest to plantations are already included in the carbon stock changes calculated from the NFIs and are already reported under FM.

11.5.2.2 Forest Management Reference Levels (FMRLs)

The 'Submission of information on forest management reference levels by the Netherlands' of 20 April 2011 contains the information on the FMRLs 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 HWP model, changes in the submission of information on FMRLs 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 contains updated values of the proposed reference levels.

During the subsequent technical assessment of the submission mentioned above, the ERT noticed discrepancies in area data used by the models. As result, the Netherlands reran 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 to 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, 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 GHG emissions excluding LULUCF, taking into account the corrected amount after the review of the NIR 2015 and the 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 to FMRLs

A number of changes in the Netherlands inventory cause methodological inconsistencies between the inventory and the FMRLs. Partly this is because the accounting of HWP as agreed in decision 2/CMP.7 was not yet available at the time the FMRLs were submitted: natural disturbances were not yet included at the time of submission of the FMRLs. Moreover, new NFI statistics became 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 FMRLs 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 Tier 1 level analysis including LULUCF is 2B4 Caprolactam production, with emissions of 755.2 Gg CO_2 (see Annex 1). With net removals of 783.4 Gg CO_2, the absolute annual contribution of AR under the KP in 2016 is larger than the emissions from the smallest key category (Tier 1 level analysis including LULUCF). Deforestation under the KP in 2016 causes an emission of 1,1311.24 Gg CO_2, which is more than the smallest key category (Tier 1 level analysis including LULUCF). Removals from FM without HWP, at 1,319.63 Gg

CO_2, are also larger than the smallest key category (Tier 1 level analysis including LULUCF).

Table 11.9 shows the net emissions from AR, D and FM for the years 2013–2016.

Table 11.9: Net emissions from AR, D and FM (Gg CO_2)

Activities	**Net emissions (Gg CO_2)**			
	2013	2014	2015	2016
A. Article 3.3 activities				
A1 Afforestation and Reforestation	-632.77	-681.92	-732.11	-783.40
A2 Deforestation	1,237.66	1,261.72	1,286.64	1,311.24
B. Article 3.4 activities				
B1 Forest management	-1,364.39	-1,355.75	-1,332.66	-1,319.63

11.7 Information relating to Article 6

The Netherlands is not buying or selling emissions rights from Joined Implementation 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 (SEF) report for 2017 containing the information required by 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 (ITL_RREG1_NL_2017_CP2.xlsx).

12.1.2 Summary of information reported in the SEF tables

There were 3,548,366 CERs in the registry at the end of 2017: 501,598 CERs were held in the Party holding accounts, 2,923,456 CERs were held in entity holding accounts and 123,312 CERs were held in the voluntary cancellation account.

There were 5,346,075 Emission Reduction Units (ERUs) in the registry at the end of 2017: 5,336,075 ERUs were held in entity holding accounts and 10,000 ERUs were held in the voluntary cancellation account.

The total amount of the units (CERs and ERUs) in the registry corresponded to 8,894,441 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 2017 has been submitted to the UNFCCC Secretariat electronically (ITL_RREG1_NL_2017_CP2.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 2017.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2017.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2017.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units existed as at 31 December 2017.
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: www.emissionsauthority.nl/topics/public-information-kyoto All required information for a Party with an active Kyoto registry is provided, with the following exceptions: <u>paragraph 46</u> Article 6 Project Information. The Netherlands does not host JI projects, as laid down in national legislation. This fact is stated in the information available at the above-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 these would only increase the existing shortage of emissions allowances/assigned amount units. <u>paragraph 47a/d/f/l in/out/current</u> 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, which states: '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.' <u>paragraph 47c</u> The Netherlands does not host JI projects, as laid down in national legislation (ref. submission paragraph 46 above). <u>paragraph 47e</u> The Netherlands does not perform LULUCF activities and therefore does not issue RMUs. <u>paragraph 47g</u> No ERUs, CERs, AAUs or RMUs have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4, to date. <u>paragraph 47h</u> No ERUs, CERs, AAUs or RMUs have been cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1, to date.

Annual submission item	Submission
	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. As suggested by the review team, the Netherlands has included further information about carry-over and PPSR account below.

12.1.5 Calculation of the commitment period reserve (CPR)

The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

For the purposes of the joint fulfilment, the commitment period reserve (CPR) applies to the EU, its Member States and Iceland individually.

The calculations of the CPR for the Netherlands are follows.
Method 1 (90% of assigned amount) results in:
0.90 * 924,777,902 = 832,300,112 tonnes of CO_2 equivalent.

Method 2 (100% of most recently reviewed inventory): taking the 2018 submission as the most recently reviewed inventory an multiplying by 8 results in:
221,287,124 * 8 = 1,770,296,989 tonnes of CO_2 equivalent.

The CPR consequently amounts to 832,300,112 tonnes of CO_2 equivalent.

12.1.6 KP-LULUCF accounting

Not applicable, because the Netherlands has opted for end-of-period accounting for KP-LULUCF.

12.1.7 Carry-over and PPSR

Carry-over
The Netherlands will not make use of the carry-over possibility. It will not carry over any Kyoto Protocol Units from commitment period 1 to commitment period 2.

PPSR
Since 16 November 2016 the Union Registry has provided the technical facility to open a PPSR account. However, the PPSR account type must first be first introduced into the EU legislative framework. This was done by the Annex of Commission Delegated Regulation 2015/1844. This

provision, however, will become applicable, according to Article 2 of the Delegated Regulation, on ‘the date of publication by the Commission in the Official Journal of the European Union of a communication on the entry into force of the Doha Amendment to the Kyoto Protocol’. Consequently, for the moment and until the Doha Amendment comes into force, we are not in a position to open the PPSR account in our National Registry. When the Doha Amendment comes into force, the Netherlands will open the PPSR account in our National Registry.

13 Information on changes in the 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 7th National Communication, the 3rd 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 coordination of the Emission Registration Project, in which emissions of about 350 substances are annually calculated, was performed until 1 January 2010 by the PBL. As of 1 January 2010, coordination has been assigned to the RIVM. Processes, protocols and methods remain unchanged. Many of the former experts from the PBL have moved to the 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) changed as of 1 January 2014 to Netherlands Enterprise Agency (RVO.nl).
- In 2010 the Ministry of Economic Affairs and the Ministry of Agriculture, Nature and Food Quality (LNV) merged into the Ministry of Economic Affairs, Agriculture and Innovation (EL&I). In 2012 the name of this ministry was changed to the Ministry of Economic Affairs (EZ).
- 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.
- Finally, in 2017, responsibility for climate policy shifted from the Ministry of Infrastructure and the Environment to the Ministry of Economic Affairs. The latter has been renamed the Ministry of Economic Affairs and Climate Policy (EZK). Other Ministries retain their responsibilities for integrating environmental policy targets and endorsing environmental policies within their respective fields (e.g.

the Ministry of Infrastructure and Water Management is responsible for climate adaptation).

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 2017

The following changes to the national registry of Netherlands have occurred in 2017.

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 Email: 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 Email: 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 Email: alexander.brandt@emissieautoriteit.nl
15/CMP.1 annex II.E paragraph 32.(a)	None

Reporting item	Description
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and affected only EU-ETS functionality. No change was required to the database and application back-up plan or to the disaster recovery plan. The database model is provided in Annex A. No change to the capacity of the national registry occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.7 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). No other change in the registry's conformance to the technical standards occurred for the reporting period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change to discrepancies procedures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No change regarding security occurred during the reporting period.
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 to the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change regarding 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 8.0.7 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.

15 Information on minimization 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 NIRs 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 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 minimized.

Since the submission of the NIR 2017, there have been limited changes in the activities on minimizing 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 have reflected market prices for many years. With (increasing) environmental taxation the externalities of energy use related to GHG emissions are increasingly reflected in energy prices. Examples are: environmental taxes on the use of natural gas up to 170,000 m^3 increased from €0.1639 per m^3 in 2011 to €0.26001 in 2018; excise duty on gasoline increased in the same period from €0.71827 per litre to €0.778961 per litre. 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
and on excise duties at:
https://download.belastingdienst.nl/douane/docs/tarievenlijst_accijns_acc0552z75fol.pdf.

For many years, there have been 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.

To promote Policy Coherence for Development, the Netherlands has adopted an Action Plan. One of its focus areas is climate change. In addition to integrating climate action into development cooperation, and increasing support for climate change adaptation and mitigation in developing countries, we have taken a number of other actions:

- We no longer provide public support, including export credits, to coal-fired power plants.
- In the international financial institutions we advocate more investment in renewable energy and support investment in fossil fuels only in exceptional circumstances, where no realistic alternatives are available.
- In climate funds such as the Green Climate Fund and the Climate Investment Funds we seek to ensure that funding benefits the poor.
- To halt deforestation in highly relevant supply chains such as timber, soy and palm oil, the Netherlands has initiated and promoted the Amsterdam Declarations. The two Declarations – one on stopping deforestation and one on sustainable palm oil – were launched on 7 December 2015 with the intention of achieving fully sustainable and deforestation-free agro-commodity supply chains in Europe by 2020. To date, in addition to the Netherlands, Denmark, Germany, Norway, the United Kingdom and France have signed. The Declarations are intended to stimulate private sector commitment and progress on agricultural commodities associated with deforestation (such as palm oil, soy and cocoa) for which Europe has a significant market share. By expanding market demand for sustainable commodities in the signatory European countries, the Declarations aim to incentivize sustainable production in producer countries.

The Netherlands also strives to accelerate the transition to renewable energy worldwide. The Netherlands is a founding member of the International Renewable Energy Agency (IRENA), an intergovernmental organization that supports countries in their transition to a sustainable energy future. Through the Energy Sector Management Assistance Program (ESMAP) of the World Bank and the Friends of Fossil Fuel subsidy reform, the Netherlands supports countries (mostly) in the MENA region to reform fossil fuel subsidies while maintaining social safety nets.

The Netherlands has decided to integrate development and climate action budgets, policies and activities for maximum impact and best results, especially for the poorest and most vulnerable. Committed to supporting developing countries in their climate action, we have been scaling up our climate finance. While public climate finance amounted in 2013 to €286 million, it reached €395 million in 2014, €416 million in 2015 and €472 million in 2016. In addition, in 2015 the Netherlands mobilized €73 million private finance in 2015 and €171 million in 2016. We have provided support to multilateral climate funds such as the Least Developed Countries Fund, the Green Climate Fund, the GEF and the Scaling up Renewable Energy Program of the Strategic Climate Fund, one of the Climate Investment Funds. Furthermore, we focus our support on access to renewable energy, halting deforestation, climate-

smart agriculture, integrated water resource management and the provision of climate-resilient water and sanitation (WASH) services. Disaster risk reduction is an integral part of our integrated water resource management programmes and receives support through Partners for Resilience. Gender is an important cross-cutting issue, as climate action is most effective when it builds on the capacities of both genders and addresses both their needs and their vulnerabilities.

There is no Dutch policy related to cooperating in the technological development of non-energy uses of fossil fuels (action c).

The Netherlands will continue to support and cooperate with developing country parties in relation to actions d–f. Examples include the following:

- 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) and 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 helped to use domestic biogas as a climate-friendly energy energy and organic fertilizer and in 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, aimed at eliminating structural constraints such as feed-in tariff hurdles for electricity generated by geothermal sources.
- The National Geothermal Capacity-Building Programme in Indonesia works to develop Indonesia’s geothermic potential at various locations, calculated to be 27,000 MW, of which only 1,052 MW (4%) was being used in 2008. The objective of this public–private partnership is to develop and strengthen the structure of human resources development, which is needed to provide the workforce for the development and implementation of the planned infrastructure for geothermal energy in Indonesia.
- The 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.

Collaboration between authorities, business and knowledge institutions
the Netherlands will be working more and 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 customization and to let everyone make an appropriate contribution.

Market Mechanisms
The flexible mechanisms under the Protocol – (1) Emissions Trading (i.e. the European Union Emissions Trading Scheme EU-ETS), (2) Joint Implementation and (3) Clean Development – 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 GHG-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 Clean Development Mechanism (CDM) projects with several countries worldwide. The Netherlands is supporting the World Bank's 'Partnership for Market Readiness' (PMR), which will help countries use the carbon market. The PMR will promote new market instruments as well as adjustments or expansion of the CDM.
To buy carbon credits under the CDM, the Dutch Ministry of Infrastructure spent €151 million between 2005 and 2008 and €132.6 million in the period 2009–2012. The Ministry of Economic Affairs purchased carbon credits under Joint Implementation for €53.4 million between 2005 and 2008 and for €109.1 million for the period 2009–2012.

In total, the Netherlands has contracted 33.2 million tonnes of carbon credits from CDM projects, 17.1 million tonnes from JI projects, 3 million tonnes from Latvia (Green Investment Scheme) and 2.2 million tonnes from Participation in Carbon Funds (PCF) in order to realize its obligations under the Kyoto Protocol.

Minimizing 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 biofuels are sustainable are they allowed to be used to fulfil 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 eq.). 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 key sources, the total of whose emissions adds up to 95% of the national total (excluding LULUCF): 29 sources for annual level assessment (emissions in 2016) and 35 sources for the trend assessment out of a total of 92 sources. The two lists are 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 46 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, 8 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);
- 2B8 Petrochemical and carbon black production: CO_2 (Tier 2 Level and Trend);
- 2D2 Paraffin wax use: CO_2 (Tier 2 level and trend);

- 2B8 Petrochemical and carbon black production: CH_4 (Tier 2 Level);
- 3A3 Swine: CH_4 (Tier 2 Level);
- 3B4 Poultry: CH_4 (Tier 2 Level);
- 3B Emissions from manure management: N_2O (Tier 2 Level and Trend);
- 5D Wastewater treatment and discharge: CH_4 (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 50 key sources; see also Table A1.2.

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.

Table A1.1: Key source list identified by the Tier 1and 2 level and trend assessments for 2016 emissions (excluding LULUCF sources)

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 (T)	0	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,T1)	1	1	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,T)	1	1	1	1
1A2	Manufacturing Industries and Construction: solids	CO_2	Key (L,T)	1	1	1	1
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 (,T1)	0	1	0	0
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
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

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
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 excl 1A3b	Other	CH_4	Non-key	0	0	0	0
1A3 excl 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	Non-key	0	0	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

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
2A4b	Other uses of soda ash	CO_2	Non-key	0	0	0	0
2A4d	Other	CO_2	Key (L,T)	1	1	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	Non-key	0	0	0	0
2C3	Aluminium production	CO_2	Non-key	0	0	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 air-conditioning	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
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	Non-key	0	0	0	0

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
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 (T2)	0	0	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	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	Key (T2)	0	0	0	1
5D	Wastewater treatment and discharge	N_2O	Non-key	0	0	0	0
			SUM	29	35	30	29

Table A1.2 Key source list identified by the Tier 1 level and trend assessments. Level assessment for 2016 emissions (including LULUCF sources)

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 (T)	0	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,T1)	1	1	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,T)	1	1	1	1
1A2	Manufacturing Industries and Construction: solids	CO_2	Key (L,T)	1	1	1	1
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 (T1)	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
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH_4	Key (L,T)	1	1	1	1

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
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 excl 1A3b	Other	CH_4	Non-key	0	0	0	0
1A3 excl 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	Non-key	0	0	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

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
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 (L,T)	1	1	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	0	0
2B8	Petrochemical and carbon black production	CO_2	Key (L2,T2)	0	0	1	1
2C1	Iron and steel production	CO_2	Non-key	0	0	0	0
2C3	Aluminium production	CO_2	Non-key	0	0	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 air-conditioning	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	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	Non-key	0	0	0	0

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
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	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 (T2)	0	0	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	Non-key	0	0	0	0
	LAND USE, LAND USE CHANGE AND FORESTRY		Non-key				
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	Wetland	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

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
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	Key (T2)	0	0	0	0
5D	Wastewater treatment and discharge	N_2O	Non-key	0	0	0	0
		SUM	33	40	32	33	50

1.2 Changes in key sources compared with previous submission

Due to the use of emissions data for 2016 and new uncertainty data on mobile combustion, the following changes in key sources have taken place in comparison with the previous NIR:

- One new key source was identified:
  - 5D Wastewater treatment and discharge (CH_4).

- The following key sources in the previous submission are no longer key sources:
  - 1B1b Solid fuel transformation (CO_2);
  - 2C1 Iron and steel production (CO_2);
  - 2C3 Aluminium production (CO_2);
  - 2G Other product manufacture and use (N_2O).

A1.3 Tier 1 key source and uncertainty assessment

In Table A1.3 the source ranking is done according to the contribution to the 2016 annual emissions total and in Tables A1.4 according to the base-year-to-2016 trend. This results in 29 level key sources and 33 trend key sources. Inclusion of LULUCF sources in the analysis adds four Tier 1 level and trend key sources (see Table A1.2).

Table A1.3: Source ranking using IPCC Tier 1 level assessment 2016 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	34,006.9	17 %	17 %
1A1a	Public Electricity and Heat Production: gaseous	CO_2	17,178.7	8 %	25 %
1A4b	Residential gaseous	CO_2	16,793.3	8 %	33 %
1A3b	Road transportation: diesel oil	CO_2	16,709.1	8 %	41 %
1A2	Manufacturing Industries and Construction: gaseous	CO_2	13,184.1	6 %	48 %
1A3b	Road transportation: gasoline	CO_2	11,755.1	6 %	53 %
1A2	Manufacturing Industries and Construction, liquids	CO_2	8,819.3	4 %	57 %
1A4a	Commercial / Institutional: gaseous	CO_2	7,462.2	4 %	61 %
1A4c	Agriculture / Forestry / Fisheries: gaseous	CO_2	7,173.0	3 %	65 %
1A1b	Petroleum Refining: liquids	CO_2	7,077.0	3 %	68 %
3A1	Mature dairy cattle	CH_4	5,641.6	3 %	71 %
3Da	Direct emissions from agricultural soils	N_2O	4,967.8	2 %	73 %
1A2	Manufacturing Industries and Construction: solids	CO_2	4,457.6	2 %	75 %
4C	Grassland	CO_2	4,168.3	2 %	77 %
2B1	Ammonia production	CO_2	3,814.8	2 %	79 %
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	2,966.7	1 %	81 %
5A	Solid waste disposal	CH_4	2,781.6	1 %	82 %
4B	Cropland	CO_2	2,751.3	1 %	83 %
1A1b	Petroleum Refining: gaseous	CO_2	2,528.0	1 %	85 %
4A	Forest Land	CO_2	2,272.4	1 %	86 %
3B1	Cattle	CH_4	2,144.1	1 %	87 %
3A1	Young cattle	CH_4	2,144.1	1 %	88 %
2F1	Refrigeration and air-conditioning	HFC	2,064.4	1 %	89 %
1A4c	Agriculture / Forestry / Fisheries: liquids	CO_2	1,860.5	1 %	90 %
3B3	Swine	CH_4	1,739.0	1 %	91 %
4E	Settlements	CO_2	1,623.1	1 %	91 %
1A1c	Manufacture of Solid Fuels: gaseous	CO_2	1,602.2	1 %	92 %
1A1c	Manufacture of Solid Fuels: solids	CO_2	1,184.7	1 %	93 %
1B2	Fugitive emissions from oil and gas operations	CO_2	1,027.3	0 %	93 %
1A3d	Domestic navigation	CO_2	1,009.7	0 %	94 %
1A4c	Agriculture / Forestry / Fisheries: all fuels	CH_4	867.9	0 %	94 %

IPCC Category		Gas	Latest year estimate (CO_2 eq.)	Level assessment	Cumulative total
2A4d	**Other**	**CO_2**	**766.7**	**0%**	**94%**
2B4	**Caprolactam production**	**N_2O**	**755.2**	**0%**	**95%**
1A1a	Public Electricity and Heat Production: liquids	CO_2	728.7	0%	95%
3B	Emissions from manure management	N_2O	686.5	0%	95%
3Db	Indirect emissions from managed soils	N_2O	639.1	0%	96%
1A4	Liquids excl. 1A4c	CO_2	572.0	0%	96%
3A3	Swine	CH_4	467.9	0%	96%
2B8	Petrochemical and carbon black production	CO_2	457.8	0%	97%
1A4b	Residential: all fuels	CH_4	446.3	0%	97%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	433.6	0%	97%
3A4	Other	CH_4	423.8	0%	97%
1A3b	Road transportation: LPG	CO_2	405.4	0%	97%
1B2b	Natural gas	CH_4	313.6	0%	98%
1A1	Energy Industries: all fuels	N_2O	308.0	0%	98%
1B2c	Venting and flaring	CH_4	285.9	0%	98%
2B2	Nitric acid production	N_2O	269.7	0%	98%
2A1	Cement production	CO_2	239.0	0%	98%
1A3b	Road transportation	N_2O	238.0	0%	98%
5D	Wastewater treatment and discharge	CH_4	220.3	0%	98%
2D2	Paraffin wax use	CO_2	207.8	0%	98%
2B10	Other	CO_2	204.9	0%	98%
2B	Fluorochemical production	HFC	178.2	0%	99%
2F6	Other	HFC	175.1	0%	99%
1A5	Military use: liquids	CO_2	162.5	0%	99%
3A1	Other mature cattle	CH_4	134.3	0%	99%
2G2	SF_6 use	SF_6	134.2	0%	99%
4F	Other Land	CO_2	129.2	0%	99%
2A4b	Other uses of soda ash	CO_2	118.0	0%	99%
2A4a	Ceramics	CO_2	116.1	0%	99%
1A1	Energy Industries: all fuels	CH_4	105.3	0%	99%
1A3b	Road transportation: gaseous	CO_2	101.9	0%	99%
1A3c	Railways	CO_2	98.5	0%	99%

IPCC Category		Gas	Latest year estimate (CO_2 eq.)	Level assessment	Cumulative total
2A3	Glass production	CO_2	95.6	0%	99%
2E	Electronic Industry	PFC	92.4	0%	99%
1A3e	Other	CO_2	91.7	0%	99%
5B	Biological treatment of solid waste: composting	N_2O	91.4	0%	99%
2D1	Lubricant use	CO_2	90.0	0%	99%
5B	Biological treatment of solid waste: composting	CH_4	87.3	0%	99%
2G	Other product manufacture and use	N_2O	87.3	0%	99%
4B	Cropland	N_2O	84.0	0%	100%
3B4	Poultry	CH_4	73.0	0%	100%
5D	Wastewater treatment and discharge	N_2O	71.8	0%	100%
1B1b	Solid fuel transformation	CO_2	71.7	0%	100%
3G	Liming	CO_2	68.7	0%	100%
1A4a	Commercial/Institutional: all fuels	CH_4	63.5	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	CH_4	59.1	0%	100%
4D	Wetland	CO_2	58.2	0%	100%
1A3b	Road transportation	CH_4	57.2	0%	100%
1A4	Other Sectors: all fuels	N_2O	52.6	0%	100%
2C3	Aluminium production	CO_2	52.1	0%	100%
2B	Fluorochemical production	PFC	45.8	0%	100%
4H	Other	N_2O	45.3	0%	100%
2G	Other product manufacture and use	CH_4	42.5	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	N_2O	38.6	0%	100%
3B2, 3B4	Other	CH_4	38.1	0%	100%
1A3a	Domestic aviation	CO_2	30.1	0%	100%
2D3	Other	CO_2	21.3	0%	100%
2H	Other industrial	CO_2	21.2	0%	100%
1B2a	Oil	CH_4	13.6	0%	100%
2C3	Aluminium production	PFC	13.6	0%	100%
1A4	Solids	CO_2	12.6	0%	100%
2C1	Iron and steel production	CO_2	11.0	0%	100%
1A3 excl 1A3b	Other	N_2O	8.5	0%	100%
4C	Grassland	N_2O	6.9	0%	100%

IPCC Category		Gas	Latest year estimate (CO_2 eq.)	Level assessment	Cumulative total
1A3 excl 1A3b	Other	CH_4	3.5	0%	100%
1A5	Military use: liquids	N_2O	2.6	0%	100%
2G	Other product manufacture and use	CO_2	0.7	0%	100%
1A5	Military use: liquids	CH_4	0.4	0%	100%
4	LULUCF: CH_4	CH_4	0.3	0%	100%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0.3	0%	100%
2B7	Soda ash production	CO_2	0.0	0%	100%
4G	Harvested wood products	CO_2	0.0	0%	100%

Lines in bold represent the key sources.

Table A1.4: Source ranking using IPCC Tier 1 trend assessment 2016, 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	25,862.2	34,006.9	6%	13%	13%
5A	Solid waste disposal	CH_4	13,679.2	2,781.6	5%	11%	24%
2B	Fluorochemical production	HFC	7,297.7	178.2	3%	8%	32%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13,330.2	17,178.7	3%	6%	38%
1A3b	Road transportation: diesel oil	CO_2	13,014.1	16,709.1	3%	6%	44%
2B2	Nitric acid production	N_2O	6,084.7	269.7	3%	6%	50%
1A2	Manufacturing Industries and Construction: gaseous	CO_2	19,045.8	13,184.1	2%	4%	55%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601.5	2,966.7	1%	3%	58%
1A3b	Road transportation: gasoline	CO_2	10,814.3	11,755.1	1%	3%	60%
2F1	Refrigeration and air-conditioning	HFC	73.4	2,064.4	1%	2%	63%
2C3	Aluminium production	PFC	2,230.2	13.6	1%	2%	65%
1A3b	Road transportation: LPG	CO_2	2,642.0	405.4	1%	2%	67%
3Da	Direct emissions from agricultural soils	N_2O	7,620.8	4,967.8	1%	2%	70%
1A1b	Petroleum Refining: liquids	CO_2	9,968.2	7,077.0	1%	2%	72%
1A1b	Petroleum Refining: gaseous	CO_2	1,042.3	2,528.0	1%	2%	74%
1A2	Manufacturing Industries and Construction: solids	CO_2	6,623.4	4,457.6	1%	2%	75%
4B	Cropland	CO_2	1,647.0	2,751.3	1%	2%	77%
3B3	Swine	CH_4	3,368.6	1,739.0	1%	1%	78%
1B2c	Venting and flaring	CH_4	1,501.9	285.9	1%	1%	79%
3A1	Mature dairy cattle	CH_4	5,183.2	5,641.6	1%	1%	81%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8,788.1	8,819.3	1%	1%	82%
1A4b	Residential gaseous	CO_2	19,895.7	16,793.3	0%	1%	83%
4E	Settlements	CO_2	870.2	1,623.1	0%	1%	84%
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH_4	73.1	867.9	0%	1%	85%
3Db	Indirect emissions from managed soils	N_2O	1,615.3	639.1	0%	1%	86%
3B1	Cattle	CH_4	1,608.9	2,144.1	0%	1%	87%
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO_2	7,329.3	7,173.0	0%	1%	88%
4A	Forest Land	CO_2	1,812.2	2,272.4	0%	1%	88%
4C	Grassland	CO_2	5,388.6	4,168.3	0%	1%	89%
1A4a	Commercial/Institutional: gaseous	CO_2	7,758.4	7,462.2	0%	1%	90%

IPCC Category		Gas	Base Year Estimate (CO_2 eq.)	Latest Year Estimate (CO_2 eq.)	Trend Assessment	% Contribution to trend	Cumulative Total
1A1c	Manufacture of Solid Fuels: gaseous	CO_2	1,184.2	1,602.2	0%	1%	90%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233.2	728.7	0%	1%	91%
1A4	Liquids excl. 1A4c	CO_2	1,223.8	572.0	0%	1%	92%
2B1	Ammonia production	CO_2	3,730.1	3,814.8	0%	1%	92%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2,516.9	1,860.5	0%	0%	93%
1A1c	Manufacture of Solid Fuels: solids	CO_2	924.6	1,184.7	0%	0%	93%
1A3d	Domestic navigation	CO_2	742.6	1,009.7	0%	0%	94%
3A1	Young cattle	CH_4	2,801.8	2,144.1	0%	0%	94%
1B2	Fugitive emissions from oil and gas operations	CO_2	774.6	1,027.3	0%	0%	94%
2A4d	Other	CO_2	481.2	766.7	0%	0%	95%
2B10	Other	CO_2	583.3	204.9	0%	0%	95%
3B4	Poultry	CH_4	432.1	73.0	0%	0%	95%
2C3	Aluminium production	CO_2	408.4	52.1	0%	0%	96%
1A3e	Other	CO_2	342.2	91.7	0%	0%	96%
1A1	Energy Industries: all fuels	N_2O	148.1	308.0	0%	0%	96%
2B8	Petrochemical and carbon black production	CO_2	335.6	457.8	0%	0%	97%
1A3b	Road transportation	N_2O	97.8	238.0	0%	0%	97%
4G	Harvested wood products	CO_2	157.2	0.0	0%	0%	97%
3B	Emissions from manure management	N_2O	921.9	686.5	0%	0%	97%
1A4	Solids	CO_2	162.7	12.6	0%	0%	97%
2A1	Cement production	CO_2	415.8	239.0	0%	0%	97%
2D2	Paraffin wax use	CO_2	102.9	207.8	0%	0%	97%
1A5	Military use: liquids	CO_2	314.0	162.5	0%	0%	98%
1A3b	Road transportation	CH_4	193.2	57.2	0%	0%	98%
2G	Other product manufacture and use	N_2O	224.7	87.3	0%	0%	98%
4F	Other Land	CO_2	25.4	129.2	0%	0%	98%
1A3b	Road transportation: gaseous	CO_2	0.0	101.9	0%	0%	98%
2B4	Caprolactam production	N_2O	739.9	755.2	0%	0%	98%
2G2	SF_6 use	SF_6	261.0	134.2	0%	0%	98%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380.0	433.6	0%	0%	98%
3G	Liming	CO_2	183.2	68.7	0%	0%	99%

IPCC Category		Gas	Base Year Estimate (CO_2 eq.)	Latest Year Estimate (CO_2 eq.)	Trend Assessment	% Contribution to trend	Cumulative Total
5B	Biological treatment of solid waste: composting	N_2O	6.5	91.4	0%	0%	99%
4B	Cropland	N_2O	3.1	84.0	0%	0%	99%
5D	Wastewater treatment and discharge	N_2O	172.1	71.8	0%	0%	99%
5B	Biological treatment of solid waste: composting	CH_4	13.7	87.3	0%	0%	99%
1B2b	Natural gas	CH_4	421.1	313.6	0%	0%	99%
2A4b	Other uses of soda ash	CO_2	68.6	118.0	0%	0%	99%
2B7	Soda ash production	CO_2	63.8	0.0	0%	0%	99%
5D	Wastewater treatment and discharge	CH_4	308.8	220.3	0%	0%	99%
3A1	Other mature cattle	CH_4	210.2	134.3	0%	0%	99%
2E	Electronic Industry	PFC	49.7	92.4	0%	0%	99%
2B	Fluorochemical production	PFC	0.0	45.8	0%	0%	99%
1A3a	Domestic aviation	CO_2	84.8	30.1	0%	0%	99%
2H	Other industrial	CO_2	72.5	21.2	0%	0%	100%
4H	Other	N_2O	2.4	45.3	0%	0%	100%
1A1	Energy Industries: all fuels	CH_4	71.7	105.3	0%	0%	100%
1A4b	Residential: all fuels	CH_4	456.8	446.3	0%	0%	100%
3A4	Other	CH_4	514.4	423.8	0%	0%	100%
2A3	Glass production	CO_2	142.4	95.6	0%	0%	100%
2C1	Iron and steel production	CO_2	43.7	11.0	0%	0%	100%
1B1b	Solid fuel transformation	CO_2	110.4	71.7	0%	0%	100%
1A4a	Commercial/Institutional: all fuels	CH_4	42.6	63.5	0%	0%	100%
2D3	Other	CO_2	0.0	21.3	0%	0%	100%
4D	Wetland	CO_2	86.4	58.2	0%	0%	100%
1A3c	Railways	CO_2	90.7	98.5	0%	0%	100%
2D1	Lubricant use	CO_2	84.6	90.0	0%	0%	100%
2A4a	Ceramics	CO_2	140.1	116.1	0%	0%	100%
3B2, 3B4	Other	CH_4	33.7	38.1	0%	0%	100%
1A4	Other Sectors: all fuels	N_2O	50.1	52.6	0%	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	N_2O	35.9	38.6	0%	0%	100%
4C	Grassland	N_2O	0.3	6.9	0%	0%	100%
3A3	Swine	CH_4	521.8	467.9	0%	0%	100%

IPCC Category		Gas	Base Year Estimate (CO_2 eq.)	Latest Year Estimate (CO_2 eq.)	Trend Assessment	% Contribution to trend	Cumulative Total
1B2a	Oil	CH_4	20.3	13.6	0%	0%	100%
2F6	Other	HFC	201.0	175.1	0%	0%	100%
1A3 excl 1A3b	Other	N_2O	6.9	8.5	0%	0%	100%
1A5	Military use: liquids	N_2O	5.5	2.6	0%	0%	100%
2G	Other product manufacture and use	CH_4	50.1	42.5	0%	0%	100%
1A3 excl 1A3b	Other	CH_4	2.5	3.5	0%	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	CH_4	67.4	59.1	0%	0%	100%
2G	Other product manufacture and use	CO_2	0.2	0.7	0%	0%	100%
1A5	Military use: liquids	CH_4	0.8	0.4	0%	0%	100%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0.2	0.3	0%	0%	100%
4	LULUCF: CH_4	CH_4	0.2	0.3	0%	0%	100%

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 A1.5 (contribution to the 2016 annual emissions total) and A1.6 (contribution to the trend).
Six LULUCF sources are identified as key sources: 4A Forest land, 4B Cropland, 4C Grassland, 4D Wetland, 4E Settlements and 4F Other Land.

Table A1.5: Source ranking using IPCC Tier 2 level assessment 2016 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	4,968	2%	61%	1.5%	9%	9%
4C	Grassland	CO_2	4,168	2%	56%	1.1%	7%	16%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8,819	4%	25%	1.1%	7%	22%
3B1	Cattle	CH_4	2,144	1%	100%	1.0%	6%	29%
1A1b	Petroleum Refining: liquids	CO_2	7,077	3%	25%	0.9%	5%	34%
3B3	Swine	CH_4	1,739	1%	100%	0.8%	5%	39%
4B	Cropland	CO_2	2,751	1%	56%	0.7%	5%	44%
4A	Forest Land	CO_2	2,272	1%	67%	0.7%	4%	48%
3Db	Indirect emissions from managed soils	N_2O	639	0%	206%	0.6%	4%	52%
2F1	Refrigeration and air-conditioning	HFC	2,064	1%	54%	0.5%	3%	55%
1A1a	Public Electricity and Heat Production: solids	CO_2	34,007	17%	3%	0.5%	3%	59%
4E	Settlements	CO_2	1,623	1%	56%	0.4%	3%	61%
3A1	Mature dairy cattle	CH_4	5,642	3%	16%	0.4%	3%	64%
1A4b	Residential gaseous	CO_2	16,793	8%	5%	0.4%	2%	66%
1A4a	Commercial/Institutional: gaseous	CO_2	7,462	4%	10%	0.4%	2%	69%
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO_2	7,173	3%	10%	0.3%	2%	71%
3B	Emissions from manure management	N_2O	687	0%	100%	0.3%	2%	73%
5A	Solid waste disposal	CH_4	2,782	1%	24%	0.3%	2%	75%
1B2	Fugitive emissions from oil and gas operations	CO_2	1,027	0%	50%	0.2%	2%	76%
1A3b	Road transportation: diesel oil	CO_2	16,709	8%	3%	0.2%	1%	78%
1A2	Manufacturing Industries and Construction: solids	CO_2	4,458	2%	10%	0.2%	1%	79%
3A1	Young cattle	CH_4	2,144	1%	21%	0.2%	1%	80%
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH_4	868	0%	50%	0.2%	1%	81%
2B1	Ammonia production	CO_2	3,815	2%	10%	0.2%	1%	83%
2A4d	Other	CO_2	767	0%	50%	0.2%	1%	84%
1A3b	Road transportation: gasoline	CO_2	11,755	6%	3%	0.2%	1%	85%
1A1c	Manufacture of Solid Fuels: gaseous	CO_2	1,602	1%	21%	0.2%	1%	86%

IPCC Category		Gas	CO_2 eq. latest year abs	Share	Uncertainty estimate	Level * uncertainty	Share L*U	Cum. Share L*U
2B8	**Petrochemical and carbon black production**	**CO_2**	**458**	**0%**	**71%**	**0.2%**	**1%**	**87%**
2B8	**Chemical industry: Petrochemical and carbon black production**	**CH_4**	**434**	**0%**	**71%**	**0.1%**	**1%**	**88%**
1A2	**Manufacturing Industries and Construction: gaseous**	**CO_2**	**13,184**	**6%**	**2%**	**0.1%**	**1%**	**88%**
1A4b	**Residential: all fuels**	**CH_4**	**446**	**0%**	**55%**	**0.1%**	**1%**	**89%**
3A3	**Swine**	**CH_4**	**468**	**0%**	**50,2%**	**0.1%**	**1%**	**90%**
2B4	Caprolactam production	N_2O	755	0%	30%	0.1%	1%	90%
2D2	Paraffin wax use	CO_2	208	0%	102%	0.1%	1%	91%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	2,967	1%	7%	0.1%	1%	92%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	1,860	1%	10%	0.1%	1%	92%
1A3b	Road transportation	N_2O	238	0%	70%	0.1%	0%	93%
1B2b	Natural gas	CH_4	314	0%	50%	0.1%	0%	93%
1A1a	Public Electricity and Heat Production: liquids	CO_2	729	0%	20%	0.1%	0%	94%
1A1c	Manufacture of Solid Fuels: solids	CO_2	118,474,746	1%	10,9%	0.1%	0%	94%
3A4	Other	CH4	423,812	0%	30%	0.1%	0%	94%
1A4	Liquids excl. 1A4c	CO_2	572	0%	20%	0.1%	0%	95%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	1,717,869,999	8%	1%	0.0%	0%	95%
2F6	Other	HFC	175	0%	54%	0.0%	0%	95%
5D	Wastewater treatment and discharge	CH_4	220	0%	38%	0.0%	0%	96%
3B4	Poultry	CH_4	73,03375	0%	100%	0.0%	0%	96%
5D	Wastewater treatment and discharge	N_2O	71,764	0%	102%	0.0%	0%	96%
4F	Other Land	CO_2	129	0%	56%	0.0%	0%	96%
1B2c	Venting and flaring	CH_4	286	0%	25%	0.0%	0%	96%
3G	Liming	CO_2	69	0%	100%	0.0%	0%	97%
2G	Other product manufacture and use	N_2O	87	0%	71%	0.0%	0%	97%
2B10	Other	CO_2	205	0%	30%	0.0%	0%	97%
2A4b	Other uses of soda ash	CO_2	118	0%	50%	0.0%	0%	97%
2A4a	Ceramics	CO_2	116	0%	50%	0.0%	0%	97%
1A1	Energy Industries: all fuels	N_2O	308	0%	19%	0.0%	0%	97%
5B	Biological treatment of solid waste: composting	CH_4	87	0%	63%	0.0%	0%	98%

IPCC Category		Gas	CO_2 eq. latest year abs	Share	Uncertainty estimate	Level * uncertainty	Share L*U	Cum. Share L*U
1A3d	Domestic navigation	CO_2	1010	0%	5%	0.0%	0%	98%
4B	Cropland	N_2O	84	0%	63%	0.0%	0%	98%
2D1	Lubricant use	CO_2	90	0%	58%	0.0%	0%	98%
5B	Biological treatment of solid waste: composting	N_2O	91	0%	50%	0.0%	0%	98%
2G2	SF_6 use	SF_6	134	0%	34%	0.0%	0%	98%
2B	Fluorochemical production	HFC	178	0%	22%	0.0%	0%	98%
3B2, 3B4	Other	CH_4	38	0%	100%	0.0%	0%	99%
1A5	Military use: liquids	CO_2	162,463,753	0%	20%	0.0%	0%	99%
4D	Wetland	CO_2	58	0%	56%	0.0%	0%	99%
1A4a	Commercial/Institutional: all fuels	CH_4	63	0%	49%	0.0%	0%	99%
1A3b	Road transportation	CH_4	57	0%	50%	0.0%	0%	99%
3A1	Other mature cattle	CH_4	134	0%	21%	0.0%	0%	99%
2A1	Cement production	CO_2	239	0%	11%	0.0%	0%	99%
1A4	Other Sectors: all fuels	N_2O	53	0%	47%	0.0%	0%	99%
2A3	Glass production	CO_2	96	0%	25%	0.0%	0%	99%
2E	Electronic Industry	PFC	92	0%	25%	0.0%	0%	99%
1A2	Manufacturing Industries and Construction: all fuels	N_2O	39	0%	59%	0.0%	0%	99%
1A3b	Road transportation: LPG	CO_2	405	0%	5%	0.0%	0%	99%
2G	Other product manufacture and use	CH_4	42	0%	50%	0.0%	0%	100%
2B2	Nitric acid production	N_2O	270	0%	8%	0.0%	0%	100%
1A1	Energy Industries: all fuels	CH_4	105	0%	19%	0.0%	0%	100%
1A1b	Petroleum Refining: gaseous	CO_2	2,528	1%	1%	0.0%	0%	100%
4H	Other	N_2O	45	0%	25%	0.0%	0%	100%
1B1b	Solid fuel transformation	CO_2	72	0%	15%	0.0%	0%	100%
2B	Fluorochemical production	PFC	46	0%	22%	0.0%	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	CH_4	59	0%	16%	0.0%	0%	100%
1A3a	Domestic aviation	CO_2	3,010	0%	30%	0.0%	0%	100%
1B2a	Oil	CH_4	14	0%	54%	0.0%	0%	100%
1A4	Solids	CO_2	13	0%	51%	0.0%	0%	100%
1A3 excl	Other	N_2O	9	0%	70%	0.0%	0%	100%

IPCC Category		Gas	CO_2 eq. latest year abs	Share	Uncertainty estimate	Level * uncertainty	Share L*U	Cum. Share L*U
1A3b								
2D3	Other	CO_2	21	0%	27%	0.0%	0%	100%
1A3b	Road transportation: gaseous	CO_2	102	0%	5%	0.0%	0%	100%
1A3c	Railways	CO_2	99	0%	5%	0.0%	0%	100%
4C	Grassland	N_2O	7	0%	56%	0.0%	0%	100%
2C3	Aluminium production	CO_2	52	0%	5%	0.0%	0%	100%
2C3	Aluminium production	PFC	14	0%	20%	0.0%	0%	100%
1A5	Military use: liquids	N_2O	3	0%	82%	0.0%	0%	100%
1A3 excl 1A3b	Other	CH_4	4	0%	50%	0.0%	0%	100%
2H	Other industrial	CO_2	21	0%	6%	0.0%	0%	100%
2C1	Iron and steel production	CO_2	11	0%	6%	0.0%	0%	100%
1A3e	Other	CO_2	92	0%	1%	0.0%	0%	100%
2G	Other product manufacture and use	CO_2	1	0%	54%	0.0%	0%	100%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0	0%	112%	0.0%	0%	100%
1A5	Military use: liquids	CH_4	0	0%	60%	0.0%	0%	100%
4	LULUCF: CH_4	CH_4	0	0%	17%	0.0%	0%	100%
2B7	Soda ash production	CO_2	0	0%	7%	0.0%	0%	100%
4G	Harvested wood products	CO_2	0	0%	56%	0.0%	0%	100%

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 at the top of the list when uncertainty estimates are included. As Table A1.5 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 25–100%, an order of magnitude higher than the 3% uncertainty for CO_2 from the Energy industries.

Table A1.6: 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 assessment latest year	trend assessment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
5A	Solid waste disposal	CH_4	13,679	2,782	1%	5%	24%	1%	14%	14%
3Db	Indirect emissions from managed soils	N_2O	1,615	639	0%	0%	206%	1%	10%	24%
2B	Fluorochemical production	HFC	7,298	178	0%	4%	22%	1%	9%	33%
3B3	Swine	CH_4	3,369	1,739	1%	1%	100%	1%	8%	40%
2F1	Refrigeration and air-conditioning	HFC	73	2,064	1%	1%	54%	1%	7%	47%
3Da	Direct emissions from agricultural soils	N_2O	7,621	4,968	3%	1%	61%	1%	7%	54%
3B1	Cattle	CH_4	1,609	2,144	1%	0%	100%	0%	5%	58%
1A1b	Petroleum Refining: liquids	CO_2	9,968	7,077	4%	1%	25%	0%	3%	61%
5D	Wastewater treatment and discharge	CH_4	309	220	0%	0%	38%	0%	3%	64%
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH_4	73	868	0%	0%	50%	0%	3%	66%
2B2	Nitric acid production	N_2O	6,085	270	0%	3%	8%	0%	2%	69%
2C3	Aluminium production	PFC	2,230	14	0%	1%	20%	0%	2%	71%
1A1a	Public Electricity and Heat Production: solids	CO_2	25,862	34,007	17%	7%	3%	0%	2%	73%
3B4	Poultry	CH_4	432	73	0%	0%	100%	0%	2%	75%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8,788	8,819	5%	1%	25%	0%	2%	77%
1B2c	Venting and flaring	CH_4	1,502	286	0%	1%	25%	0%	2%	79%
1B2	Fugitive emissions from oil and gas operations	CO_2	775	1,027	1%	0%	50%	0%	1%	80%
2A4d	Other	CO_2	481	767	0%	0%	50%	0%	1%	81%
3A1	Mature dairy cattle	CH_4	5,183	5,642	3%	1%	16%	0%	1%	82%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601	2,967	2%	1%	7%	0%	1%	83%
1A3b	Road transportation: diesel oil	CO_2	13,014	16,709	9%	3%	3%	0%	1%	84%
1A2	Manufacturing Industries and Construction: solids	CO_2	6,623	4,458	2%	1%	10%	0%	1%	85%
3B	Emissions from manure management	N_2O	922	687	0%	0%	100%	0%	1%	85%
2D2	Paraffin wax use	CO_2	103	208	0%	0%	102%	0%	1%	86%
1A1c	Manufacture of Solid Fuels: gaseous	CO_2	1,184	1,602	1%	0%	21%	0%	1%	87%

IPCC Category		Gas	CO_2 eq base year abs	CO_2 eq latest year abs	level assessment latest year	trend assessment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
2B8	Petrochemical and carbon black production	CO_2	336	458	0%	0%	71%	0%	1%	88%
1A3b	Road transportation	N_2O	98	238	0%	0%	70%	0%	1%	88%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233	729	0%	0%	20%	0%	1%	89%
1A3b	Road transportation: LPG	CO_2	2,642	405	0%	1%	5%	0%	1%	90%
1A4	Liquids excl. 1A4c	CO_2	1,223,834,159	571,954,924	0%	0%	20%	0%	1%	90%
3G	Liming	CO_2	183	69	0%	0%	100%	0%	1%	91%
2B10	Other	CO_2	583	205	0%	0%	30%	0%	1%	91%
2G	Other product manufacture and use	N_2O	225	87	0%	0%	71%	0%	0%	92%
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO_2	7,329	7173	4%	0%	10%	0%	0%	92%
1A2	Manufacturing Industries and Construction: gaseous	CO_2	19,046	13184	7%	2%	2%	0%	0%	93%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	380	434	0%	0%	71%	0%	0%	93%
1A4	Solids	CO_2	163	13	0%	0%	51%	0%	0%	94%
1A4a	Commercial/Institutional: gaseous	CO_2	7,758	7,462	4%	0%	10%	0%	0%	94%
3A1	Young cattle	CH_4	2,802	2,144	1%	0%	21%	0%	0%	95%
1A3b	Road transportation: gasoline	CO_2	10,814	11,755	6%	1%	3%	0%	0%	95%
1A3b	Road transportation	CH_4	193	57	0%	0%	50%	0%	0%	95%
2B1	Ammonia production	CO_2	3,730	3,815	2%	0%	10%	0%	0%	96%
5D	Wastewater treatment and discharge	N_2O	172	72	0%	0%	102%	0%	0%	96%
5B	Biological treatment of solid waste: composting	CH_4	14	87	0%	0%	63%	0%	0%	96%
5B	Biological treatment of solid waste: composting	N_2O	7	91	0%	0%	50%	0%	0%	97%
1A1c	Manufacture of Solid Fuels: solids	CO_2	925	1,185	1%	0%	11%	0%	0%	97%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2,517	1,860	1%	0%	10%	0%	0%	97%
1A4b	Residential gaseous	CO_2	19,896	16,793	9%	0%	5%	0%	0%	97%
1A1	Energy Industries: all fuels	N_2O	148	308	0%	0%	19%	0%	0%	97%
2B4	Caprolactam production	N_2O	740	755	0%	0%	30%	0%	0%	98%

IPCC Category		Gas	CO_2 eq base year abs	CO_2 eq latest year abs	level assessment latest year	trend assessment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
2G2	SF_6 use	SF_6	261	134	0%	0%	34%	0%	0%	98%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13,330	17,179	9%	3%	1%	0%	0%	98%
2A4b	Other uses of soda ash	CO_2	69	118	0%	0%	50%	0%	0%	98%
1B2b	Natural gas	CH_4	421	314	0%	0%	50%	0%	0%	98%
1A4b	Residential: all fuels	CH_4	457	446	0%	0%	55%	0%	0%	99%
1A5	Military use: liquids	CO_2	314	162	0%	0%	20%	0%	0%	99%
1A3d	Domestic navigation	CO_2	743	1,010	1%	0%	5%	0%	0%	99%
2C3	Aluminium production	CO_2	408	52	0%	0%	5%	0%	0%	99%
2A1	Cement production	CO_2	416	239	0%	0%	11%	0%	0%	99%
1A3a	Domestic aviation	CO_2	85	30	0%	0%	30%	0%	0%	99%
1A4a	Commercial/Institutional: all fuels	CH_4	43	63	0%	0%	49%	0%	0%	99%
2E	Electronic Industry	PFC	50	92	0%	0%	25%	0%	0%	99%
3A1	Other mature cattle	CH_4	210	134	0%	0%	21%	0%	0%	99%
2B	Fluorochemical production	PFC	0	46	0%	0%	22%	0%	0%	99%
2D1	Lubricant use	CO_2	85	90	0%	0%	58%	0%	0%	99%
1A1b	Petroleum Refining: gaseous	CO_2	1,042	2,528	1%	1%	1%	0%	0%	99%
3B2, 3B4	Other	CH_4	34	38	0%	0%	100%	0%	0%	100%
3A4	Other	CH_4	514	424	0%	0%	30%	0%	0%	100%
1A1	Energy Industries: all fuels	CH_4	72	105	0%	0%	19%	0%	0%	100%
2A3	Glass production	CO_2	142	96	0%	0%	25%	0%	0%	100%
2D3	Other	CO_2	0	21	0%	0%	27%	0%	0%	100%
1A3b	Road transportation: gaseous	CO_2	0	102	0%	0%	5%	0%	0%	100%
3A3	Swine	CH_4	522	468	0%	0%	50%	0%	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	N_2O	36	39	0%	0%	59%	0%	0%	100%
1A4	Other Sectors: all fuels	N_2O	50	53	0%	0%	47%	0%	0%	100%
2B7	Soda ash production	CO_2	64	0	0%	0%	7%	0%	0%	100%

IPCC Category		Gas	CO_2 eq base year abs	CO_2 eq latest year abs	level assessment latest year	trend assessment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative
1B1b	Solid fuel transformation	CO_2	110	72	0%	0%	15%	0%	0%	100%
2A4a	Ceramics	CO_2	140	116	0%	0%	50%	0%	0%	100%
2H	Other industrial	CO_2	72	21	0%	0%	6%	0%	0%	100%
1B2a	Oil	CH_4	20	14	0%	0%	54%	0%	0%	100%
1A5	Military use: liquids	N_2O	6	3	0%	0%	82%	0%	0%	100%
1A3 ex. 1A3b	Other	N_2O	7	9	0%	0%	70%	0%	0%	100%
2C1	Iron and steel production	CO_2	44	11	0%	0%	6%	0%	0%	100%
1A3e	Other	CO_2	342	92	0%	0%	1%	0%	0%	100%
1A3c	Railways	CO_2	91	99	0%	0%	5%	0%	0%	100%
2G	Other product manufacture and use	CH_4	50	42	0%	0%	50%	0%	0%	100%
2F6	Other	HFC	201	175	0%	0%	54%	0%	0%	100%
1A3 ex. 1A3b	Other	CH_4	3	4	0%	0%	50%	0%	0%	100%
2G	Other product manufacture and use	CO_2	0	1	0%	0%	54%	0%	0%	100%
1A5	Military use: liquids	CH_4	1	0	0%	0%	60%	0%	0%	100%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0	0	0%	0%	112%	0%	0%	100%
1A2	Manufacturing Industries and Construction: all fuels	CH_4	67	59	0%	0%	16%	0%	0%	100%

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, an Approach 1 uncertainty assessment was made to estimate the uncertainty in total national GHG emissions and in emissions trends. Approach 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 A2.3 were also used for an Approach 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.

An Approach 2 uncertainty assessment (Monte Carlo) is performed as a check of the Approach 1 uncertainty assessment and the results are similar to the results from the Approach 1 uncertainty assessment (see Tables A2.1 and A2.2).

Table A2.1: Approach 1 level and trend uncertainty estimates

	Uncertainty in emissions level	**Uncertainty in emissions trend**
CO_2	±2%	±1% of 2% increase
CH_4	±17%	±6% of 42% decrease
N_2O	±41%	±7% of 54% decrease
F-gases	±41%	±12% of 73% decrease
Total	±3%	±2% of 12.5% decrease

Table A2.2: Approach 2 level uncertainty estimates

	Uncertainty in emissions level
CO_2	±3%
CH_4	±10%
N_2O	±27%
F-gases	±25%
Total	±3%

As in earlier studies, a comparison with the Approach 1 uncertainty estimate based on similar data showed that, in the Dutch circumstances, the errors made in the simplified Approach 1 to estimating uncertainties

are quite small (see Olsthoorn and Pielaat, 2003; Ramírez-Ramírez et al., 2006).

Details of the Approach 1 calculation can be found in Table A2.3.

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 be 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 Approach 1 key source assessment discussed above.

During the 2017 review it was recommended to perform an Approach 1 assessment of the uncertainty for the year 1990 emissions. As the Netherlands uses consistent methodologies over the complete time series, the uncertainties in AD and EFs for the year 1990 are equal to those in the data for 2016, as presented in Table A2.3.

Table A2.3: Approach 1 level and trend uncertainty assessment 1990–2016 (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 uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
3Da	Direct emissions from agricultural soils	N2O	7.519	4.860	10,0%	60,0%	61%	1,4%	-0,8%	2%	-0,5%	0,3%	0,6%
4C	Grassland	CO2	5.483	4.420	25,0%	50.0%	56%	1,2%	-0,2%	2%	-0,1%	0,7%	0,7%
3B1	Cattle	CH4	1.823	2.260	10.0%	100.0%	100%	1,1%	0,3%	1%	0,3%	0,1%	0,3%
3B3	Swine	CH4	3.489	2.113	10.0%	100.0%	100%	1,0%	-0,4%	1%	-0,4%	0,1%	0,4%
1A2	Manufacturing Industries and Construction, liquids	CO2	8.569	7.769	1,0%	25,0%	25%	0,9%	0,1%	3%	0.0%	0.0%	0,1%
1A1b	Petroleum Refining: liquids	CO2	9.968	6.797	5,0%	25,0%	25%	0,8%	-0,9%	3%	-0,2%	0,2%	0,3%
4A	Forest Land	CO2	1.911	2.434	25,0%	61,8%	67%	0,8%	0,3%	1%	0,2%	0,4%	0,4%
4B	Cropland	CO2	1.637	2.667	25,0%	50.0%	56%	0,7%	0,5%	1%	0,3%	0,4%	0,5%
3Db	Indirect emissions from managed soils	N2O	1.649	609	50.0%	200.0%	206%	0,6%	-0,4%	0%	-0,7%	0,2%	0,8%
1A1a	Public Electricity and Heat Production: solids	CO2	25.862	37.297	1,0%	3,0%	3%	0,6%	6,2%	16%	0,2%	0,2%	0,3%
2F1	Refrigeration and air-conditioning	HFC	73	2.041	20.0%	50.0%	54%	0,5%	0,8%	1%	0,4%	0,2%	0,5%
4E	Settlements	CO2	888,3	1.650	25,0%	50.0%	56%	0,4%	0,4%	1%	0,2%	0,3%	0,3%
3A1	Mature dairy cattle	CH4	5.179	5.233	5,0%	15,0%	16%	0,4%	0,3%	2%	0.0%	0,2%	0,2%
1A4b	Residential gaseous	CO2	19.896	16.117	5,0%	0,3%	5%	0,4%	-0,7%	7%	0.0%	0,5%	0,5%

IPCC category		Gas	CO_2 eq. base year	CO_2 eq. last year	AD uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO2	7.329	7.170	10.0%	0,3%	10%	0,3%	0,3%	3%	0.0%	0,4%	0,4%
1A4a	Commercial/Institutional: gaseous	CO2	7.758	7.108	10.0%	0,3%	10%	0,3%	0,1%	3%	0.0%	0,4%	0,4%
5A	Solid waste disposal	CH4	13.679	2.945	0,4%	24,0%	24%	0,3%	-4,0%	1%	-0,9%	0.0%	0,9%
3B	Emissions from manure management	N2O	926	674	10.0%	100.0%	100%	0,3%	-0,1%	0%	-0,1%	0.0%	0,1%
1B2	Fugitive emissions from oil and gas operations	CO2	775	1.315	50.0%	2,0%	50%	0,3%	0,3%	1%	0.0%	0,4%	0,4%
1A3b	Road transportation: diesel oil	CO2	13.025	17.134	2,0%	2,0%	3%	0,2%	2,4%	7%	0.0%	0,2%	0,2%
3A1	Young cattle	CH4	2.802	2.211	5,0%	20.0%	21%	0,2%	-0,1%	1%	0.0%	0,1%	0,1%
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH4	71	911	9,8%	48,8%	50%	0,2%	0,4%	0%	0,2%	0,1%	0,2%
2B1	Ammonia production	CO2	3.730	3.921	2,0%	10.0%	10%	0,2%	0,3%	2%	0.0%	0.0%	0,1%
1A1c	Manufacture of Solid Fuels: gaseous	CO2	1.184	1.792	20.0%	5,0%	21%	0,2%	0,3%	1%	0.0%	0,2%	0,2%
1A2	Manufacturing Industries and Construction: solids	CO2	4.401	3.371	2,0%	10.0%	10%	0,2%	-0,2%	1%	0.0%	0.0%	0.0%
1A3b	Road transportation: gasoline	CO2	10.785	11.742	2,0%	2,0%	3%	0,2%	0,9%	5%	0.0%	0,1%	0,1%
2B8	Petrochemical and carbon black production	CO2	336	458	50.0%	50.0%	71%	0,2%	0,1%	0%	0.0%	0,1%	0,1%
2A4d	Other	CO2	481	586	50.0%	5,0%	50%	0,1%	0,1%	0%	0.0%	0,2%	0,2%
2B8	Chemical industry:	CH4	380	409	50.0%	50.0%	71%	0,1%	0.0%	0%	0.0%	0,1%	0,1%

IPCC category		Gas	CO_2 eq. base year	CO_2 eq. last year	AD uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
	Petrochemical and carbon black production												
2B4	Caprolactam production	N2O	740	902	20.0%	23,0%	30%	0,1%	0,1%	0%	0.0%	0,1%	0,1%
1A2	Manufacturing Industries and Construction: gaseous	CO2	19.046	12.882	2,0%	0,3%	2%	0,1%	-1,7%	6%	0.0%	0,2%	0,2%
1A4b	Residential: all fuels	CH4	456	431	38,4%	39,9%	55%	0,1%	0.0%	0%	0.0%	0,1%	0,1%
3A3	Swine	CH4	522	473	5,0%	50.0%	50%	0,1%	0.0%	0%	0.0%	0.0%	0.0%
2D2	Paraffin wax use	CO2	103	207	100.0%	20.0%	102%	0,1%	0.0%	0%	0.0%	0,1%	0,1%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	601	2.861	3,2%	5,7%	7%	0,1%	1,0%	1%	0,1%	0,1%	0,1%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	2.519	1.859	10.0%	0,3%	10%	0,1%	-0,2%	1%	0.0%	0,1%	0,1%
1A3b	Road transportation	N2O	98	241	2,0%	70.0%	70%	0,1%	0,1%	0%	0.0%	0.0%	0.0%
1B2b	Natural gas	CH4	421	323	2,0%	50.0%	50%	0,1%	0.0%	0%	0.0%	0.0%	0.0%
1A1a	Public Electricity and Heat Production: liquids	CO2	233	739	0,5%	20.0%	20%	0,1%	0,2%	0%	0.0%	0.0%	0.0%
3A4	Other	CH4	514	436	5,0%	30.0%	30%	0,1%	0.0%	0%	0.0%	0.0%	0.0%
1B1b	Solid fuel transformation	CO2	403	811	2,0%	15,0%	15%	0,1%	0,2%	0%	0.0%	0.0%	0.0%
1A4	Liquids excl. 1A4c	CO2	1.329	601	20.0%	2,0%	20%	0,1%	-0,2%	0%	0.0%	0,1%	0,1%
2B10	Other	CO2	583	278	1,0%	30.0%	30%	0.0%	-0,1%	0%	0.0%	0.0%	0.0%
1A1a	Public Electricity and Heat Production: gaseous	CO2	13.330	14.727	0,5%	0,3%	1%	0.0%	1,2%	6%	0.0%	0.0%	0.0%

IPCC category		Gas	CO_2 eq. base year	CO_2 eq. last year	AD uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
1A1c	Manufacture of Solid Fuels: solids	CO2	633	743	2,0%	10,7%	11%	0.0%	0,1%	0%	0.0%	0.0%	0.0%
5D	Wastewater treatment and discharge	CH4	309	211	20.0%	32,0%	38%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1B2c	Venting and flaring	CH4	1.502	314	2,0%	25,0%	25%	0.0%	-0,4%	0%	-0,1%	0.0%	0,1%
2F6	Other	HFC	201	146	20.0%	50.0%	54%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
3B4	Poultry	CH4	464	73	10.0%	100.0%	100%	0.0%	-0,1%	0%	-0,1%	0.0%	0,1%
5D	Wastewater treatment and discharge	N2O	172	71	20.0%	100.0%	102%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4F	Other Land	CO2	26,296	126	25,0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
3G	Liming	CO2	183	69	10.0%	100.0%	100%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3d	Domestic navigation	CO2	857	1.241	5,0%	2,0%	5%	0.0%	0,2%	1%	0.0%	0.0%	0.0%
2G	Other product manufacture and use	N2O	225	86	50.0%	50.0%	71%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A1	Energy Industries: all fuels	N2O	147	312	2,5%	18,4%	19%	0.0%	0,1%	0%	0.0%	0.0%	0.0%
2A4b	Other uses of soda ash	CO2	69	114	50.0%	5,0%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2A4a	Ceramics	CO2	140	112	50.0%	5,0%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2C1	Iron and steel production	CO2	2.266	905	3,0%	5,0%	6%	0.0%	-0,5%	0%	0.0%	0.0%	0.0%
4B	Cropland	N2O	3	78	25,0%	57,9%	63%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4G	Harvested wood products	CO2	157,198	88	25,0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A4a	Commercial/Institutional: all fuels	CH4	42	97	10,4%	47,6%	49%	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 uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
2G2	SF_6 use	SF_6	261	139	30.0%	15,0%	34%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2D1	Lubricant use	CO2	85	80	50.0%	29,2%	58%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
5B	Biological treatment of solid waste: composting	CH4	14	74	5,0%	62,7%	63%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
3B2, 3B4	Other	CH4	34	40	10.0%	100.0%	100%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
5B	Biological treatment of solid waste: composting	N2O	7	77	5,0%	49,4%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4D	Wetland	CO2	88,042	64	25,0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A5	Military use: liquids	CO2	312	175	20.0%	2,0%	20%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2B	Fluorochemical production	HFC	7.298	148	10.0%	20.0%	22%	0.0%	-2,7%	0%	-0,5%	0.0%	0,5%
3A1	Other mature cattle	CH4	210	159	5,0%	20.0%	21%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A4	Other Sectors: all fuels	N2O	64	68	17,8%	43,1%	47%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2B2	Nitric acid production	N2O	6.085	370	5,0%	6,0%	8%	0.0%	-2,2%	0%	-0,1%	0.0%	0,1%
1A3b	Road transportation	CH4	193	57	2,0%	50.0%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A2	Manufacturing Industries and Construction: all fuels	N2O	43	48	3,3%	58,6%	59%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2A1	Cement production	CO2	416	249	5,0%	10.0%	11%	0.0%	-0,1%	0%	0.0%	0.0%	0.0%
2A3	Glass production	CO2	142	95	25,0%	5,0%	25%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3b	Road transportation: LPG	CO2	2.654	411	5,0%	2,0%	5%	0.0%	-0,8%	0%	0.0%	0.0%	0.0%
2E	Electronic Industry	PFC	50	85	5,0%	25,0%	25%	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 uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
2G	Other product manufacture and use	CH4	50	43	9,9%	49,5%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A1	Energy Industries: all fuels	CH4	72	112	2,5%	18,4%	19%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A1b	Petroleum Refining: gaseous	CO2	1.042	2.976	0,5%	0,3%	1%	0.0%	0,9%	1%	0.0%	0.0%	0.0%
4H	Other	N2O	2,483	45	25,0%	1,0%	25%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A2	Manufacturing Industries and Construction: all fuels	CH4	65	60	2,0%	15,8%	16%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3a	Domestic aviation	CO2	85	31	30.0%	4,0%	30%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3 excl 1A3b	Other	N2O	8	10	2,0%	70.0%	70%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1B2a	Oil	CH4	20	12	20.0%	50.0%	54%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2D3	Other	CO2	0	22	25,0%	9,4%	27%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3c	Railways	CO2	91	100	5,0%	2,0%	5%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3b	Road transportation: gaseous	CO2	0	95	5,0%	2,0%	5%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4C	Grassland	N2O	0	6	25,0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A4	Solids	CO2	163	6	50.0%	10.0%	51%	0.0%	-0,1%	0%	0.0%	0.0%	0.0%
2B	Fluorochemical production	PFC	0	12	10.0%	20.0%	22%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A5	Military use: liquids	N2O	6	3	7,2%	82,0%	82%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2C3	Aluminium production	CO2	408	40	2,0%	5,0%	5%	0.0%	-0,1%	0%	0.0%	0.0%	0.0%
1A3 excl	Other	CH4	3	4	2,0%	50.0%	50%	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 uncertainty	EF uncertainty	Uncertainty estimate	Combined Uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
1A3b													
2H	Other industrial	CO2	72	25	2,8%	5,0%	6%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2C3	Aluminium production	PFC	2.230	7	2,0%	20.0%	20%	0.0%	-0,8%	0%	-0,2%	0.0%	0,2%
1A3e	Other	CO2	342	93	0,5%	0,3%	1%	0.0%	-0,1%	0%	0.0%	0.0%	0.0%
2G	Other product manufacture and use	CO2	0	1	50.0%	20.0%	54%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH4	0	0	100.0%	50.0%	112%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A5	Military use: liquids	CH4	1	0	7,6%	59,9%	60%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4	LULUCF: CH_4	CH4	0	0	1,0%	17,0%	17%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2B7	Soda ash production	CO2	64	0	5,0%	5,0%	7%	0.0%	0.0%	0%	0.0%	0.0%	0.0%

Annex 3 Detailed methodological descriptions of individual sources 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.

These methodology reports are also integral part of this submission (see Annex 7).

Annex 4 CO_2 : the national energy balance for the most recent inventory year

The national energy balance for 2016 in the Netherlands (as used for this submission) can be found on the following pages.

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 2016	Hard coal	Lignite	Coke-oven cokes	BKB (Braunkohlen briketts)	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)	430.5	0.7	-1.6	0.8	-3.1			2322.5	292.4	22.3	12.6	83.3	154.6	-409.6	-2.8
Indigenous production								40.8	12.8	14.1	12.6				
Imports	1438.5	0.7	20.9	0.8	0.1			4101.8	306.7	26.1		166.5	713.5	418.8	
Exports	1047.4	0.0	21.8	0.0	3.1			1841.8	24.3	17.8		87.4	557.7	827.1	2.9
Bunkers															
Stock change	39.3	0.0	-0.7		0.0			21.7	-2.8	-0.1		4.2	-1.3	-1.2	0.0
Energy consumption															
Net energy consumption	430.5	0.7	-1.6	0.8	-3.1			2322.5	292.4	22.3	12.6	83.3	154.6	-409.6	-2.8
Energy transformation															
Total energy transformation input	429.3		55.0			1.7	24.4	2322.5	180.2	22.3	34.4	42.2	426.9	1.8	
Electricity and CHP transformation input	304.7					1.7	24.4				15.5				
Other transformation input	124.7		55.0					2322.5	180.2	22.3	18.9	42.2	426.9	1.8	
Total energy transformation output			58.0		3.1	15.5	35.6	0.0	0.0		206.2	80.7	493.6	579.9	2.9
Electricity/CHP transformation output															
Other transformation output			58.0		3.1	15.5	35.6	0.0	0.0		206.2	80.7	493.6	579.9	2.9
Total net energy transformation	429.3		-3.0		-3.1	-13.9	-11.2	2322.5	180.2	22.3	-171.8	-38.5	-66.7	-578.2	-2.9
Net electricity/CHP transformation	304.7					1.7	24.4				15.5				
Net other transformation	124.7		-3.0		-3.1	-15.5	-35.6	2322.5	180.2	22.3	-187.3	-38.5	-66.7	-578.2	-2.9
Energy sector own use															
Total energy sector own use						6.0	1.8				80.4	1.5			
Extraction of crude petroleum and gas												0.0			

Energy balance sheet the Netherlands 2016	Hard coal	Lignite	Coke-oven cokes	BKB (Braunkohlen briketts)	Coal tar	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Residual gas	Lpg	Naphtha	Motor gasoline	Aviation gasoline
Coke-oven plants						6.0	1.8								
Oil refineries											80.4	1.5			
Electricity and gas supply															
Distribution losses															
Distribution losses															
Final consumption															
Total final consumption	1.1	0.7	1.4	0.8		7.8	9.4		112.2		104.0	120.3	221.2	168.6	0.0
Total final energy consumption	0.9	0.7	1.3	0.8		7.8	9.4				104.0	14.1		168.6	0.0
Total industry	0.9	0.7	1.3	0.7		7.8	9.4				104.0	2.2		0.0	
Iron and steel			0.3			7.8	9.4					0.0		0.0	
Chemical and petrochemical											104.0	2.0			
Non-ferrous metals												0.0			
Non-metallic minerals	0.0	0.5	1.0									0.0			
Transport equipment												0.0			
Machinery												0.1			
Mining and quarrying		0.2										0.0			
Food and tobacco	0.9											0.0			
Paper, pulp and printing												0.0			
Wood and wood products												0.0			
Construction			0.1												
Textile and leather												0.0			
Non-specified				0.7								0.0			
Total transport												7.6		168.6	0.0
Domestic aviation															0.0
Road transport												7.6		168.6	
Rail transport															
Pipeline transport															
Domestic navigation															
Non-specified															
Total other sectors	0.0			0.1								4.3			

Energy balance sheet the Netherlands 2016	Hard coal	Lignite	Coke-oven cokes	BKB (Braunkohlen briketts)	Coal tar	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Residual gas	Lpg	Naphtha	Motor gasoline	Aviation gasoline
Services, waste, water and repair				0.1								1.9			
Households	0.0			0.0								1.0			
Agriculture												1.4			
Fishing															
Non-specified															
Total non-energy use	0.2		0.1						112.2			106.2	221.2		
Industry (excluding the energy sector)	0.2		0.1						112.2			106.2	221.2		
Of which chemistry and pharmaceuticals									112.2			106.2	221.2		
Transport															
Other sectors															
Statistical difference															
Statistical differences												0.0			

The table below consists of two parts (part two)

Energy balance sheet the Netherlands 2016	Kerosene type jet fuel	ther 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)	-321.7	-20.7	-554.0	-398.9	46.6	4.8	-3.5	2.5	16.4	-28.9	1251.9	42.3	63.3	13.3	40.4	2.7
Indigenous production											1671.3	33.2	111.3	13.3	32.7	2.7
Imports	194.4	9.9	812.9	1296.6	91.9	77.2	17.0	6.8	42.7	102.3	1312.1	10.5	10.5		8.9	
Exports	356.3	29.8	1300.3	1275.5	45.0	72.0	20.6	4.9	26.3	119.4	1747.5	1.4	57.9		1.2	
Bunkers	163.3		86.9	432.5		3.4					0.0					
Stock change	3.5	-0.8	20.3	12.5	-0.3	3.1	0.1	0.6	0.0	-11.8	.		-0.7			
Energy consumption																
Net energy consumption	-321.7	-20.7	-545.2	-398.9	46.6	4.8	-3.5	2.5	16.4	-28.9	1238.5	42.3	63.3		40.4	2.7
Energy transformation																
Total energy transformation input	6.2	9.8	173.5	239.2	90.6	2.4	0.1	0.6	0.0	76.1	472.8	42.3	35.9	12.7	37.7	2.0
Electricity and CHP transformation input			0.6	0.0							454.2	42.3	22.2	10.1	36.0	2.0
Other transformation input	6.2	9.8	172.8	239.2	90.6	2.4	0.1	0.6	0.0	76.1	18.7		13.7	2.6	1.7	
Total energy transformation output	329.5	32.8	1017.7	639.0	46.0	3.7	9.4	0.6	14.2	113.1	9.4					
Electricity/CHP transformation output																
Other transformation output	329.5	32.8	1017.7	639.0	46.0	3.7	9.4	0.6	14.2	113.1	9.4					
Total net energy transformation	-323.3	-23.0	-844.2	-399.8	44.6	-1.3	-9.3	0.0	-14.2	-36.9	463.4	42.3	35.9	12.7	37.7	2.0
Net electricity/CHP transformation			0.6	0.0							454.2	42.3	22.2	10.1	36.0	2.0
Net other transformation	-323.3	-23.0	-844.8	-399.8	44.6	-1.3	-9.3	0.0	-14.2	-36.9	9.2		13.7	2.6	1.7	
Energy sector own use																
Total energy sector own use			0.0	0.0			0.0		10.7	0.0	39.8					
Extraction of crude petroleum and gas											24.2					

Energy balance sheet the Netherlands 2016	Kerosene type jet fuel	ther 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
Coke-oven plants																
Oil refineries			0.0	0.0			0.0		10.7	0.0	14.2					
Electricity and gas supply											1.4					
Distribution losses																
Distribution losses											0.0					
Final consumption																
Total final consumption	1.5	2.3	299.0	1.0	1.9	6.1	5.7	2.5	19.9	8.0	735.3		27.4	0.8	2.7	0.7
Total final energy consumption	1.5	0.3	299.0	1.0						0.0	653.6		27.4	0.8	2.7	0.7
Total industry		0.0	18.7	0.2						0.0	172.4		4.4	0.5	2.7	0.4
Iron and steel			0.2								9.7					
Chemical and petrochemical			0.0							0.0	61.8				1.5	
Non-ferrous metals			0.0								2.8				1.2	
Non-metallic minerals			0.2	0.2							18.2					
Transport equipment		0.0	0.2								2.1					
Machinery		0.0	0.1								10.7					
Mining and quarrying			0.2								1.9					
Food and tobacco			0.3								45.4					
Paper, pulp and printing			0.0								6.5					0.0
Wood and wood products											1.0					
Construction			17.4								4.5					
Textile and leather											2.5					
Non-specified			0.0								5.3					
Total transport	0.4		249.8								1.8					

Energy balance sheet the Netherlands 2016	Kerosene type jet fuel	ther 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			235.4								1.8					
Rail transport			1.2													
Pipeline transport																
Domestic navigation			13.2													
Non-specified																
Total other sectors	1.2	0.3	30.5	0.8							479.4		23.0	0.3	0.0	0.3
Services, waste, water and repair			4.9	0.0							131.0		1.2	0.3	0.0	0.3
Households		0.3	0.3								297.2		19.0			
Agriculture			16.8								51.1		2.8			
Fishing			6.8	0.8												
Non-specified	1.2		1.7								0.1					
Total non-energy use		2.0			1.9	6.1	5.7	2.5	19.9	8.0	81.7					
Industry (excluding the energy sector)		1.9			1.9	2.0	5.7	2.5	19.9	8.0	81.7					
Of which chemistry and pharmaceuticals		1.9			1.0			1.8	19.9	8.0	81.7					
Transport						2.6										
Other sectors		0.1				1.4										
Statistical difference																
Statistical differences			-8.8								.			-0.1		

Annex 5 The Netherlands' fuel list, version January 2018

Colophon

Project name: Annual update of fuel list for the Netherlands
Project number: 113569/BL2018
Version number : January 2018
Project leader: P.J. Zijlema

Enclosures: 0
Author: P.J. Zijlema

The initial version of this fuel list was approved by the Steering Committee Emission Registration (SCER) in 2004, and the list was subsequently updated on the basis of decisions of the Steering Committee concerning the CO_2 emission factor for natural gas at meetings held on 25 April 2006 and 21 April 2009. The Steering Committee Emission Registration delegated the authority for approving this list to the ER/Working Group on Emission Monitoring (WEM) on 21 April 2009.
The present document (the version of January 2018) is approved by WEM, after detailed discussions with the Dutch Emission Authority (NEa) and several institutes that participate in the Emission Register (ER/PRTR) project, a.o:

- CBS, Statistics Netherlands,
- PBL, Netherlands Environmental Assessment Agency,
- RIVM, National Institute for Public Health and the Environment,
- RWS, Rijkswaterstaat, an agency of the Dutch Ministry of Infrastructure and the Environment responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands,
- TNO, the Dutch organization for Applied Scientific Research (TNO).

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2016	2017	2018	Ref [1)]	2016	2017	2018	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	43.0	43.0	43.0	CS	73.0	73.0	73.0	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	43.2	43.2	43.2	CS	72.5	72.5	72.5	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
Terpentine	White spirit and SBP	kg	43.6	43.6	43.6	CS	73.3	73.3	73.3	IPCC

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2016	2017	2018	Ref [1)]	2016	2017	2018	Ref [1)]
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	25.2	25.2 [2)]	25.2 [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	Nm^3	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)]	Nm^3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.6[3)]	56.6[3)]	CS
Compressed natural gas (CNG) [3)]	Compressed natural gas (CNG) [3)]	Nm^3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.6[3)]	56.6[3)]	CS
Liquified natural gas (LNG) [3)]	Liquified natural gas (LNG) [3)]	Nm^3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.6[3)]	56.6[3)]	CS

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2016	2017	2018	Ref [1)]	2016	2017	2018	Ref [1)]
Koolmonoxide	Carbon monoxide	Nm^3	12.6	12.6	12.6	CS	155.2	155.2	155.2	CS
Methaan	Methane	Nm^3	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)]									
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	Nm^3	21.8	21.8	21.8	CS	90.8	90.8	90.8	CS
RWZI biogas	Wastewater biogas	Nm^3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
Stortgas	Landfill gas	Nm^3	19.5	19.5	19.5	CS	100.7	100.7	100.7	CS
Industrieel fermentatiegas	Industrial organic waste gas	Nm^3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
	D. Other fuels									
Afval [2)]	Waste [2)]	Kg	9.9	9.9[2)]	9.9[2)]	CS	105.3	105.3[2)]	105.3 [2)]	CS

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 2017 and 2018 are not yet known, they are set equal to the value for 2016. 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 a memo item, using the emission factors mentioned.
   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.

Notes on the fuel list

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 2018) these values have been updated. In 2018 also the country specific heating values and emission factors of gasoline and gas/diesel oil have been updated (CBS, 2017).

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 2018), the years in question are 2016, 2017 and 2018. The values in these columns are used for the following purposes:

1. **2016**: these values are used in 2018 for calculations concerning the calendar year 2016, 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 2018 (NIR 2018) gives full details of greenhouse gas emissions in the Netherlands up to and including 2016. The fuel list forms an integral part of the NIR 2018.
2. **2017**: these values are used in 2018 for reports on energy consumption and CO_2 emission for the calendar year 2017 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).
1. **2018**: these values will be used in 2019 in emission reports for the calendar year 2018 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 Approach 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 2018.

Tabel A5.2 CH_4 and N_2O emission factors

Name (Dutch)	Name (English)	Unit	CH4 EF		N2O EF		Notes
			2016	Ref	2016	Ref	
	A. Liquid Fossil, Primary Fuels						
Ruwe aardolie	Crude oil	g/GJ	1,4	Scheffer 1997	0,6	IPCC 2006	
Orimulsion	Orimulsion						1)
Aardgascondensaat	Natural Gas Liquids	g/GJ	1,9	Scheffer 1997	0,6	IPCC 2006	
Fossiele additieven	Fossil fuel additives	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
	Liquid Fossil, Secondary Fuels/ Products						
Motorbenzine	Gasoline	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
Vliegtuigbenzine	Aviation gasoline	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
Kerosine luchtvaart	Jet Kerosene	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
Petroleum	Other kerosene	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	
Leisteenolie	Shale oil						1)
Gas-/dieselolie	Gas/Diesel oil	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
Zware stookolie	Residual Fuel oil	g/GJ	1,6	Scheffer 1997	0,6	IPCC 2006	
LPG	Liquefied Petroleum Gas (LPG)	g/GJ	0,7	Scheffer 1997	0,1	IPCC 2006	
Ethaan	Ethane	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	8)
Nafta's	Naphta	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	
Bitumen	Bitumen	g/GJ	1,6	Scheffer 1997	0,6	IPCC 2006	
Smeeroliën	Lubricants	g/GJ	1	Scheffer 1997	0,6	IPCC 2006	2)
Petroleumcokes	Petroleum Coke	g/GJ	3,8	Scheffer 1997	1,5	IPCC 2006	
Raffinaderij grondstoffen	Refinery Feedstocks	g/GJ	1,4	Scheffer 1997	0,6	IPCC 2006	
Raffinaderijgas	Refinery Gas	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	
Chemisch restgas	Chemical Waste Gas	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	
Overige oliën	Other oil	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	
Paraffine	Paraffin Waxes	g/GJ	1,5	Scheffer 1997	0,6	IPCC 2006	
Terpentine	White Spirit and SBP	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	
Overige aardolie producten	Other Petroleum Products	g/GJ	1,6 / 3,4 / 7,5	Scheffer 1997	0,6	IPCC 2006	4)
	B. Solid Fossil, Primary Fuels						

Name (Dutch)	Name (English)	Unit	CH4 EF		N2O EF		Notes
			2016	Ref	2016	Ref	
Antraciet	Anthracite	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	
Cokeskolen	Coking Coal	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	
Cokeskolen	Coking Coal (used in coke oven)	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	
Cokeskolen	Coking Coal (used in blast furnaces)	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	
Overige bitumineuze steenkool	Other Bituminous Coal	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	
Sub-bitumineuze kool	Sub-Bituminous Coal	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	
Bruinkool	Lignite	g/GJ	4,4	Scheffer 1997	1,5	IPCC 2006	
Bitumineuze Leisteen	Oil Shale						1)
Turf	Peat						1)
	Solid Fossil, Secondary Fuels						
Steenkool- and bruinkoolbriketten	BKB & Patent Fuel	g/GJ	4,4	Scheffer 1997	1,5	IPCC 2006	
Cokesoven/ gascokes	Coke Oven/Gas Coke	g/GJ	44,4	Scheffer 1997	1,5	IPCC 2006	
Cokesovengas	Coke Oven gas	g/GJ	2,8	Scheffer 1997	0,1	IPCC 2006	
Hoogovengas	Blast Furnace Gas	g/GJ	0,35	Scheffer 1997	0,1	IPCC 2006	
Oxystaalovengas	Oxy Gas	g/GJ	0,35	Scheffer 1997	0,1	IPCC 2006	
Fosforovengas	Fosfor Gas	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	
Steenkool bitumen	Coal tar	g/GJ	1,6	Scheffer 1997	0,6	IPCC 2006	
	C. Gaseous Fossil Fuels						
Aardgas	Natural Gas (dry)	g/GJ	5,7	Scheffer 1997	0,1	IPCC 2006	5)
Compressed natural gas (CNG)	Compressed natural gas (CNG)						3)
Liquified natural gas (LNG)	Liquified natural gas (LNG)						3)
Koolmonoxide	Carbon Monoxide	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	8)
Methaan	Methane	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	8)
Waterstof	Hydrogen	g/GJ	3,6	Scheffer 1997	0,1	IPCC 2006	8)
	Biomass						
Biomassa vast	Solid Biomass	g/GJ	30 / 300	Scheffer 1997	4	IPCC 2006	6)
Houtskool	Charcoal	g/GJ	200	IPCC 2006	1	IPCC 2006	
Biobenzine	Biogasoline	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
Biodiesel	Biodiesels	g/GJ	3,4	Scheffer 1997	0,6	IPCC 2006	2)
Overige vloeibare biobrandstoffen	Other liquid biofuels	g/GJ	30	Scheffer 1997	4	IPCC 2006	
Biomassa gasvormig	Gas Biomass	g/GJ	5	Scheffer 1997	0,1	IPCC 2006	
RWZI biogas	Wastewater biogas	g/GJ	5	Scheffer 1997	0,1	IPCC 2006	
Stortgas	Landfill gas	g/GJ	5	Scheffer 1997	0,1	IPCC 2006	

Name (Dutch)	Name (English)	Unit	CH4 EF		N2O EF		Notes
			2016	Ref	2016	Ref	
Industrieel fermentatiegas	Industrial organic waste gas	g/GJ	5	Scheffer 1997	0,1	IPCC 2006	
	D Other fuels						
Afval	Waste	g/ton	0	Rijkswaterstaat, 2013	20 / 100	Spoelstra, 1993 & Oonk, 1995	7)

Notes:

1) This fuel is not used in the Netherlands, and therefore no CH4 and N2O emission factors have been derived.
2) The emission factors presented in this table are only valid for stationary combustion. See 3.2.6 for more information on CH4 and N2O emissions from mobile combustion.
3) This fuel is only used for mobile combustion. See 3.2.6 for more information on CH4 and N2O emissions from mobile combustion.
4) The CH4 emission factor for other oil products differs per product. The emission factor of 1.6 g/GJ is used for raw materials for carbon black, the emission factor of 3.4 g/GJ is used for other crude oil products and the emission factor of 7.5 g/GJ is used for anti-knock preparations and additives for lubricants
5) CH4 emission factors for natural gas are only valid for natural gas not combusted in gas engines. For gas engines, the emission factors are presented in Table A5.3. Residential gas leakage before ignition in cooking, hot water and space heating are not included in the CH4 emission factor for natural gas; these are separately estimated to be 35 g/GJ.
6) CH4 emission factors for wood are 30 kg/TJ for CRF categories 1A1 and 1A2 and 300 kg/TJ for CRF category 1A4.
7) The N2O emission factor differs per DeNOx plant type. The emission factor of 20 g/GJ is used for SCR plants and the emission factor of 100 g/GJ s used for SNCR plants.
8) Ethane, carbon monoxide, methane and hydrogen are not reported separately, but as part of chemical waste gas.

Table A5.3: CH_4 emission factors for natural gas combusted in gas engines (g/GJ).

Year	EF CH4 gas engines in agriculture	EF CH4 gas engines in other sectors
1990	305.0	305.0
1991	305.0	305.0
1992	305.0	305.0
1993	305.0	305.0
1994	305.0	305.0
1995	305.0	305.0
1996	305.0	305.0
1997	305.0	305.0
1998	294.0	294.0
1999	283.0	283.0
2000	272.0	272.0
2001	261.0	261.0
2002	250.0	250.0
2003	250.0	250.0
2004	268.9	250.0
2005	301.5	250.0
2006	354.6	250.0
2007	382.3	250.0
2008	395.3	250.0
2009	403.9	250.0
2010	410.1	250.0
2011	416.0	250.0
2012	421.8	250.0
2013	427.0	250.0
2014	431.7	250.0
2015	436.5	250.0
2016	441.3	250.0

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 were 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 ends in 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 15 in 1990 to fewer than 5 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 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 do not provide a method for estimating N_2O emissions from industrial sources, except for industrial wastewater that is co-discharged with domestic wastewater into the sewerage system. N_2O emissions from industrial sources are believed to be insignificant compared with emissions from domestic wastewater. In the Netherlands most industries discharge their wastewater into the sewerage system/WWTPs

(emissions included in 5D1). Indirect emissions from surface water resulting from discharges of wastewater effluent 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 effluent 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 the CBS shows that only 2 out of a total of 160 IWWTPs are equipped with anaerobic sludge digestion reactors. These data are 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 or 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 Additional information to be considered as part of the NIR submission

List A7.1 contains the list of methodology reports that have been submitted to the UNFCCC (in a separate ZIP file) as part of the submission of 15 April 2018. These reports are to be considered as an integral part of this NIR.

A7.1 List of methodology reports

ENINA: (Energy, IP, Waste)
Methodologies on the calculations of emissions from the sectors Energy, Industry and Waste - Update 2017
RIVM Report 2018-0007
C.J. Peek, J.A. Montfoort, R. Dröge1, B. Guis, C. Baas, B. van Huet, O.R. van Hunnik, A.C.W.M. van den Berghe

Transport
Methods for calculating the emissions of transport in the Netherlands - 2018
John Klein, Hermine Molnár-in 't Veld, Gerben Geilenkirchen, Jan Hulskotte, Norbert Ligterink, Stijn Dellaert, Riekele de Boer

IPPU
Methodology on the calculation of emissions from Product usage by consumers, construction and services.
RIVM Report 2018-0011
B.I. Jansen, J.A.J. Meesters, M.M. Nijkamp

Agriculture:
Methodology for estimating emissions from agriculture in the Netherlands – Update 2018
Calculations of CH_4, NH_3, N_2O, NO_x, PM10, PM2.5 and CO_2 with the National Emission Model for Agriculture (NEMA)
J. Vonk, S.M. van der Sluis, A. Bannink, C. van Bruggen, C.M. Groenestein, J.F.M. Huijsmans, J.W.H. van der Kolk, L.A. Lagerwerf, H.H. Luesink, S.V. Oude Voshaar & G.L. Velthoff

LULUCF
Greenhouse gas reporting for the LULUCF sector in the Netherlands
Methodological background, update 2018, WOt-technical report 11
E.J.M.M. Arets, J.W.H van der Kolk, G.M. Hengeveld, J.P. Lesschen, H. Kramer, P.J. Kuikman & M.J. Schelhaas

These reports are also available at the website http://english.rvo.nl/nie

Annex 8 Chemical compounds, GWP, units and conversion factors

A8.1 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)

A8.2 GWP of selected GHGs

Table A8.1 lists the 100-year GWP of selected GHGs. Gases shown in italics are not emitted in the Netherlands.

Table A8.1: 100-year GWP 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

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 CO2 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.

Source: IPCC (2014).

A8.3 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)

A8.4 Conversion factors for emissions

From element basis to full molecular mass:		From full molecular mass to element basis	
C → CO_2:	x 44/12 = 3.67	CO_2 →C:	x 12/44 = 0.27
C → CH_4:	x 16/12 = 1.33	CH_4 →C:	x 12/16 = 0.75
C → CO:	x 28/12 = 2.33	CO → C:	x 12/28 = 0.43
N → N_2O:	x 44/28 = 1.57	N_2O → N:	x 28/44 = 0.64
N → NO:	x 30/14 = 2.14	NO → N:	x 14/30 = 0.47
N → NO_2:	x 46/14 = 3.29	NO_2 → N:	x 14/46 = 0.30
N → NH_3:	x 17/14 = 1.21	NH_3 → N:	x 14/17 = 0.82
N → HNO_3:	x 63/14 = 4.50	HNO_3 → N:	x 14/63 = 0.22
S → SO_2:	x 64/32 = 2.00	SO_2 → S:	x 32/64 = 0.50

Annex 9 List of abbreviations

AD	activity data
AGB	above-ground biomass
AR	afforestation and reforestation
AER	Annual Environmental Report
BCEF	biomass expansion function
BF	blast furnace gas
BGB	below-ground biomass
BOD	biological oxygen demand
C	Carbon or Confidential information(notation code in CRF)
CO	coke oven gas
COD	chemical oxygen demand
CBS	Statistics Netherlands
CDM	Clean Development Mechanism
CHP	combined heat and power
CLRTAP	Convention on Long-Range Transboundary Transport of Air Pollutants
COD	chemical oxygen demand
CPR	commitment period reserve
CRF	Common Reporting Format (of emissions data files, annexed to an NIR)
CSC	carbon stock changes
D	deforestation
DM	dry matter
DOC	degradable organic carbon
DOCf	degradable organic carbon fraction
DOM	dead organic matter
DW	dead wood
e-AER	electronic Annual Environmental Report
EEA	European Environment Agency
EF	emission factor
ENINA	Task Group Energy, Industry and Waste Handling
ER	Emission Registration (system)
ERT	Expert Review Team
ERU	Emission Reduction Unit
ETS	Emission Trading System
EU	European Union
EWL	European Waste List
EZ	Ministry of Economic Affairs
EZK	Minisery of Economic Affairs and Climate Policy (EZK)
FAO	Food and Agricultural Organization (UN)
F-gases	group of fluorinated compounds comprising HFCs, PFCs and SF_6
FGD	flue gas desulphurization

FM	forest management
FMRL	Forest Management Reference Level
GE	gross energy
GHG	greenhouse gas
GWP	global warming potential
HOSP	Timber Production Statistics and Forecast (in Dutch: 'Hout Oogst Statistiek en Prognose oogstbaar hout')
HWP	Harvested wood products
IE	included elsewhere (notation code in CRF)
IEA	International Energy Agency
IEF	implied emission factor
IPPU	Industrial processes and product use (sector)
IWWTP	industrial wastewater treatment plant
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
KP-LULUCF	Land use, land use change and forestry according the Kyoto Protocol definitions
LDAR	Leak Detection and Repair
LEI	Agricultural Economics Institute
LPG	liquefied petroleum gas
LULUCF	Land use, land use change and forestry (sector)
MCF	methane conversion factor
MFV	Measuring Network Functions (in Dutch: 'Meetnet Functievervulling')
MR	methane recovery
MSW	municipal solid waste
MW	mega watt
N	nitrogen
NA	not available/not applicable (notation code in CRF)
NAV	Dutch Association of Aerosol Producers
NEa	Dutch Emissions Authority
NE	not estimated (notation code in CRF)
NEa	Netherlands Emission authority (Dutch Emission Authority)
NFI	National Forest Inventory
NIE	National Inventory Entity
NIR	National Inventory Report (annual GHG inventory report to UNFCCC)
NO	not occurring (notation code in CRF)
NRMM	non-road mobile machinery
ODS	ozone depleting substances
ODU	oxidation during use (of direct non-energy use of fuels or of petrochemical products)
OECD	Organisation for Economic Co-operation and Development
OX	oxygen furnace gas
PBL	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
RVO.nl	Netherlands Enterprise Agency
SA	sectoral approach
SCR	selective catalytic reduction
SEF	Standard Electronic Format
SNCR	selective non-catalytic reduction
SWDS	solid waste disposal site
TNO	Netherlands Organization for Applied Scientific Research
TOF	trees outside forest
TOW	total organics in wastewater
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UWWTP	urban wastewater treatment plant
VOC	volatile organic compound
VS	volatile solids
WAR	Working Group for Waste Registration
WBCSD	World Business Council for Sustainable Development
WEM	Working Group Emission Monitoring
WRI	World Resources Institute
WUR	Wageningen University and Research Centre (or: Wageningen UR)
WWTP	wastewater treatment plant

References

Amstel van, A.R., J.G.J. Olivier & P.G. Ruyssenaars (eds), 2000: Monitoring of greenhouse gases in the Netherlands: Uncertainty and priorities for improvement. Proceedings of a national workshop held in Bilthoven, the Netherlands, 1 September 1999. WIMEK report/RIVM report 773201003. Bilthoven.

Arets, E.J.M.M., J.W.H. van der Kolk, G.M. Hengeveld, J.P. Lesschen, H. Kramer, P.J. Kuikman & M.J. Schelhaas, 2018: Greenhouse gas reporting of the LULUCF sector in the Netherlands. Methodological background, update 2018. WOt Technical report. Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu), Wageningen UR, Wageningen.

Baedts de, E.E.A. et al., 2001: Koudemiddelgebruik in Nederland. STEK, Baarn (in Dutch).

Baltussen, J.J.M. & Geurts van Kessel, M.S.M., 2015: Luchtgerelateerde emissies vanuit RWZI's in het kader van I-PRTR. STOWA Report 2014-09. STOWA, Amersfoort (in Dutch).

Bannink, A., 2011: Methane emissions from enteric fermentation by dairy cows, 1990–2008. Background document on the calculation method and uncertainty analysis for the Dutch National Inventory Report on Greenhouse Gas emissions. ASG report, Lelystad.

Bannink, A., J. Dijkstra, J.A.N. Mills, E. Kebreab & J. France, 2005: Nutritional strategies to reduce enteric methane formation in dairy cows. Pp. 367–376. In: T. Kuczynski, U. Dämmgen, J. Webb and A. Myczko (eds), Emissions from European agriculture. Wageningen Academic Publishers, Wageningen.

Berdowski, J.J.M., G.P.J. Draaijers, L.H.J.M. Janssen, J.C.T. Hollander, M. van Loon, M.G.M. Roemer, A.T. Vermeulen, M. Vosbeek & H. Visser, 2001: Sources, regional scaling and validation of methane emissions from the Netherlands and Northwest Europe. NOP, NOP-MLK Series, RIVM report 410200084. Bilthoven.

Boonekamp, P.G.M., H. Mannaerts, H.H.J. Vreuls & B. Wesselink, 2001: Protocol Monitoring Energiebesparing. ECN, ECN Report ECN-C-01-129, Petten; RIVM report 408137005. Bilthoven (in Dutch).

Broeke ten, H.M. & J.H.J. Hulskotte, 2009: Actuele VOS- en PAK-profielen van het wegverkeer. TNO Bouw en Ondergrond, Utrecht (in Dutch).

Bruggen van, C., 2017: Dierlijke mest en mineralen 2016, www.cbs.nl. CBS, The Hague/Heerlen (in Dutch).

CBS, 2012a: Uncertainty analysis of mineral excretion and manure production. CBS, The Hague.

CBS, 2012b: Standardised calculation methods for animal manure and nutrients. Standard data 1990–2008. CBS, The Hague/Heerlen.

CBS, 2015: Revision Energy Balance 1995–2013. CBS, The Hague. Available via: https://www.cbs.nl/-/media/_pdf/2018/03/heating%20values%20and%20co2%20of%20petroldiesel_14-12-17-2.pdf.

CBS, 2017: Otto Swertz (team Energy), Sander Brummelkamp (team Energy), John Klein (team Environment), Norbert Ligterink (TNO), Adjustment of heating values and CO_2 emission factors of petrol and diesel, 13 December.

CE Delft, 2018: Peer review Dutch NIR 2018 (Focus on Reference Approach and waste incineration).

Daamen, W. & G.M. Dirkse, 2005: Veldinstructie. Meetnet Functie Vervulling (in Dutch).

DHV, 2000: Overview and explanation of results of project 'Identification of unknown sources of other GHGs'. NOVEM, Utrecht, December; Project 3743990070; DHV, DHV-Report ML-TB2000 0178. Amersfoort (in Dutch).

DHV, 2010: Update of emission factors for N_2O and CH_4 for composting, anaerobic digestion and waste incineration. Report MD-AF20100263/mk, July. DHV, Amersfoort.

Dirkse, G.M., W.P. Daamen, H. Schoonderwoerd & J.M. Paasman, 2003: Meetnet Functievervulling bos – Het Nederlandse bos 2001–2002. Expertisecentrum LNV, Report EC-LNV 2003/231. Ede (in Dutch).

Dijkstra, J., H.D.St.C. Neal, D.E. Beever & J. France, 1992: Simulation of nutrient digestion, absorption and outflow in the rumen: model description. Journal of Nutrition, 122: 2239–2256.

Dröge, R, 2014: Update of the Netherlands list of fuels for the National Inventory Report 2015 and later. TNO 2014 R11919.

EPA, 2001: Candles and incense as potential sources of indoor air pollution: Market analysis and literature review. Report EPA-600/R-01-001. US EPA, Washington, DC.

EZK, 2017a: Seventh Netherlands national communication under the United Nations Framework Convention on Climate Change. The Hague.

EZK, 2017b: The Netherlands third biennial report under the United Nations Framework Convention on Climate Change, The Hague.

Geilenkirchen, G., M. 't Hoen & M. Traa, 2017: Verkeer en vervoer in de Nationale Energieverkenning 2016. PBL Environmental Assessment Agency Netherlands, The Hague (in Dutch).

Gense, N.J.L. & R.J. Vermeulen, 2002: N_2O emissions from passenger cars. TNO report 02.OR.VM.016.1/NG. TNO Automotive, Delft.

Gerrits, W.J.J., J. Dijkstra & A. Bannink, 2014: Methaanproductie bij witvleeskalveren. Livestock Research Report 813. Wageningen UR Livestock Research, Wageningen (in Dutch).

Groenestein, C.M., J. Mosquera & R.W. Melse, 2016: Methaanemissie uit mest. Schatters voor biochemisch methaan potentieel (BMP) en methaanconversiefactor (MCF). Livestock Research Report 961. Wageningen UR Livestock Research, Wageningen (in Dutch).

Groot, W.J.M. de, R. Visschers, E. Kiestra, P.J. Kuikman & G.J. Nabuurs, 2005a: National system to report to the UNFCCC on carbon stock and change of carbon stock related to land use and changes in land use in the Netherlands. Alterra report 1035-3.r. Alterra, Wageningen (in Dutch).

Groot, W.J.M. de, E. Kiestra, F. de Vries & P.J. Kuikman, 2005b: National system of greenhouse gas reporting for land use and land use change: Carbon stock changes in the Netherlands due to land use changes 1990–2000. Alterra report 1035-III. Alterra, Wageningen.

GWRC, 2011: N_2O and CH_4 emission from wastewater collection and treatment systems, Technical report 30-2011, STOWA/GWRC, London. ISBN 978.90.77622.24.7.

Hanschke, C.B. et al., 2010: Peer review of the Dutch NIR 2010 for the category transport. ECN_BS—10-06, February. ECN, Petten.

Hobson, J., 2001: CH_4 and N_2O emissions from wastewater handling. Background paper of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC-TSU.

Hoek van der, K.W. & M.W. van Schijndel, 2006: Methane and nitrous oxide emissions from animal manure management, 1990–2003. Background document on the calculation method for the Dutch NIR. RIVM report 680125002; MNP report 500080002. Bilthoven.

Hoek van der, K.W., M.W. van Schijndel & P.J. Kuikman, 2007: Direct and indirect nitrous oxide emissions from agricultural soils, 1990–2003. Background document on the calculation method for the Dutch NIR. RIVM report 680125003; MNP report 500080003. Bilthoven.

Hoeksma, P., J. Mosquera & R.W. Melse, 2012: Monitoring methane and nitrous oxide reduction by manure treatment. Report 627. Wageningen UR Livestock Research, Lelystad.

Hulskotte, J., 2004: Protocol voor de jaarlijkse bepaling van de emissies van specifieke defensie-activiteiten conform de IPCC-richtlijnen. TNO-MEP, Apeldoorn (in Dutch).

Hulskotte, J.H.J. & R.P. Verbeek, 2009: Emissiemodel Mobiele Machines gebaseerd op machineverkopen in combinatie met brandstof Afzet (EMMA). TNO-034-UT-2009-01782_RPT-MNL. TNO Bouw en Ondergrond, Utrecht (in Dutch).

Huurman, J.W.F., 2005: Recalculation of Dutch stationary greenhouse gas emissions based on sectoral energy statistics 1990–2002. CBS, Voorburg.

Ministry of Economic Affairs and Climate Policy (EZK), 2017, The Netherlands Third Biennial Report under the United Nations Framework Convention on Climate Change (2017).

IPCC, 1997: Revised 1996 IPCC guidelines for national greenhouse gas emission inventories. Three volumes: Reference manual, Reporting guidelines and Workbook. IPCC/OECD/IEA. IPCC WG1 Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell.

IPCC, 2001: Good practice guidance and uncertainty management in national greenhouse gas inventories. IPCC-TSU NGGIP, Japan.

IPCC, 2003a: LUCF sector good practice guidance. In: Penman, J. (ed.), IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry. IPCC NGGIP Programme. IGES, Japan.

IPCC, 2003b: Good practice guidance for land use, land use change and forestry. IPCC National Greenhouse Gas Inventories Programme. Published by the Institute for Global Environmental Strategies (IGES), Kanagawa, Japan.

IPCC, 2006: 2006 IPCC Guidelines for national greenhouse gas inventories, prepared by the National Greenhouse Gas Inventories Programme. H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara & K. Tanabe (eds). IGES, Japan.

IPCC, 2014: 2013 Revised supplementary methods and good practice guidance arising from the Kyoto Protocol. T. Hiraishi, T. Krug, K. Tanabe, N. Srivastava, J. Baasansuren, M. Fukuda & T.G. Troxler (eds). IPCC, Switzerland.

Jansen et.all., 2018: Methods used for the Dutch Emission Inventory. Product usage by consumers, construction and services. RIVM Report 2018-3980. Bilthoven.

Klein J., G. Geilenkirchen, J. Hulskotte, A. Hensema, P. Fortuin & H. Molnár-in 't Veld, 2018: Methods for calculating the emissions of transport in the Netherlands. PBL Environmental Assessment Agency Netherlands, The Hague

Kramer, H. & J. Clement, 2015: Basiskaart Natuur 2013; Een landsdekkend basisbestand voor de terrestrische natuur in Nederland. WOt-technical report 41. Wettelijke Onderzoekstaken Natuur & Milieu Wageningen. Available via: http://edepot.wur.nl/356218.

Kramer, H. & G. van Dorland, 2009: Historisch Grondgebruik Nederland 1990. Een landelijke reconstructie van het grondgebruik rond 1990. Alterrarapport 1327. Alterra, Wageningen.

Kramer, H., G.W. Hazeu & J. Clement, 2007: Basiskaart Natuur 2004. Vervaardiging van een landsdekkend basisbestand terrestrische natuur in Nederland. WOt-werkdocument 40. WOt Natuur & Milieu, Wageningen. Available via: http://edepot.wur.nl/39219.

Kramer, H., G.J. van den Born, J.P. Lesschen, J. Oldengarm & I.J.J. van den Wyngaert, 2009: Land Use and Land Use Change for LULUCF-reporting under the Convention on Climate Change and the Kyoto Protocol. Alterra report 1916. Alterra, Wageningen.

Kuikman, P.J., 2017: Peer review Dutch draft NIR 2017 on N_2O and CO_2 emissions from the sector agriculture. Wageningen Environmental Research (Alterra).

Kuikman, P.J., J.J.H. van den Akker & F. de Vries, 2005: Emissions of N_2O and CO_2 from organic agricultural soils. Alterra report 1035-2. Alterra, Wageningen.

Kuiper, E. & A. Hensema, 2012: N_2O emissies van wegverkeer. TNO-060-DTM-2012-02977. TNO, Delft (in Dutch).

Lesschen J.P., H. Heesmans, J. Mol-Dijkstra, A.M. van Doorn, E. Verkaik, I.J.J. van den Wyngaert & P.J. Kuikman, 2012: Mogelijkheden voor koolstofvastlegging in de Nederlandse landbouw en natuur [Possibilities for carbon sequestration in agriculture and nature in the Netherlands]. Alterra report 2396. Alterra, Wageningen (in Dutch).

Ligterink, N.E., 2016: Dutch market fuel composition for GHG emissions, TNO report 2016 R10700, TNO, Utrecht.

Mills, J.A.N., J. Dijkstra, A. Bannink, S.B. Cammell, E. Kebreab & J. France, 2001: A mechanistic model of whole-tract digestion and methanogenesis in the lactating dairy cow: Model development, evaluation and application. Journal of Animal Science, 79: 1584–1597.

Minnesota Pollution Control Agency, 2009: Minnesota air conditioner leak rate database, Model Year 2009. Minnesota Pollution Control Agency, September. Minnesota.

MNP, 2008: Evaluatie natuur- en landschapsbeleid. Achtergrondrapport bij de Natuurbalans 2008. PBL-publicatienummer 500402012. Planbureau voor de Leefomgeving (in Dutch).

Monteny, G.J. (Monteny Milieu Advies), 2008: Peer review Dutch NIR 2008. Renkum, March.

Neelis, M. & P. Blinde, 2009: Emission from industrial processes: Expert review of the draft Dutch NIR 2009. Ecofys International BV, Utrecht.

Neelis, M.L., M.K. Patel, P.W. Bach & W.G. Haije, 2005: Analysis of energy use and carbon losses in the chemical and refinery industries. Report ECN-I-05-008. Energy Research Centre of the Netherlands, Unit Energy Efficiency in Industry, Petten, August.

NL Agency (S. te Buck, B. van Keulen, L. Bosselaar & T. Gerlagh), 2010: Renewable Energy Monitoring Protocol Update 2010 (Methodology for the calculation and recording of the amounts of energy produced from renewable sources in the Netherlands), July. 2DENB1014. Utrecht.

Olivier, J.G.J., 2004: Note on Netherlands' CO_2 emission factors for petrol, diesel and LPG. Version 2, December 2004. MNP document No. M/773201/01/NI, Bilthoven.

Olivier, J.G.J., L.J. Brandes & R.A.B. te Molder, 2009: Estimate of annual and trend uncertainty for Dutch sources of GHG emissions using the IPCC Tier 1 approach. PBL report 500080013. PBL, Bilthoven.

Olsthoorn, X. & A. Pielaat, 2003: Tier 2 uncertainty analysis of the Dutch GHG emissions 1999. IVM report R03-06. Institute for Environmental Studies (IVM), Free University, Amsterdam.

Oonk, H., 2004: Methaan- en lachgasemissies uit afvalwater [Methane and nitrous oxide emissions from wastewater], TNO report R2004/486 (in Dutch).

Oonk, H., 2011: Peer review 2011 Dutch NIR. Apeldoorn.

Oonk, H., 2016. Correction factor F for adsorption CO_2 in leachate. Oonkay, Apeldoorn.

Oonk, H., A. Weenk, O. Coops & L. Luning, 1994: Validation of landfill gas formation models, TNO Institute of Environmental and Energy Technology, December, reference number 94-315.

Peek, C.J., Montfoort, J.A., Dröge, R., Guis, B., Baas, C., van Huet, B., van Hunnik O.R. & van den Berghe, A.C.W.M.
Methodologies on the calculations of emissions from the sectors Energy, Industry and Waste - Update 2017, RIVM Report 2018-0007. Bilthoven

PRTR, 2014: Emissions data 1990–2013. Available via: www.prtr.nl.

PVE, 2005: Productie en afvoer van paardenmest in Nederland (in Dutch).

PWC, 2014: Handelstromenonderzoek 2013. Onderzoek naar het gebruik van fluorverbindingen in Nederland [Trade flow study 2013: Research into the use of fluor-based compounds in the Netherlands]. Utrecht, the Netherlands (in Dutch).

Rail Cargo, 2007: Spoor in Cijfers 2007. Statistisch overzicht railgoederenvervoer. Rail Cargo, Hoogvliet (in Dutch).

Rail Cargo, 2013: Spoor in Cijfers 2013. Rail Cargo, Hoogvliet (in Dutch).

Ramírez-Ramírez, A., C. de Keizer & J.P. van der Sluijs, 2006: Monte Carlo analysis of uncertainties in the Netherlands' greenhouse gas emission inventory for 1990–2004. Report NWS-E-2006-58. Department of Science, Technology and Society, Copernicus Institute for Sustainable Development and Innovation, Utrecht University, Utrecht, July.

Reumermann, P.J. & B. Frederiks, B., 2002: Proceedings 12th European conference on Biomass for Energy, Industry and Climate protection. Amsterdam.
Rijkswaterstaat, 2014: Onzekerheid emissies afval voor stortplaatsen, AVI's en gft-verwerking, February (in Dutch).

Rijkswaterstaat, 2017: Afvalverwerking in Nederland, gegevens 2016, Werkgroep Afvalregistratie, Utrecht (ISBN 978-94-91750-18-2) (in Dutch).

Rioned, 2009: Urban drainage statistics 2009–2010. Available via: http://www.riool.net/riool/binary/retrieveFile?itemid=1089.

Rioned, 2016: Het nut van stedelijk waterbeheer; Monitor gemeentelijke watertaken. Stichting Rioned, November (ISBN 97-890-73645-57-8, in Dutch).

RIVM, 1999: Meten, rekenen en onzekerheden. De werkwijze van het RIVM Milieuonderzoek. RIVM report 408129 005 (main report and addendum). Bilthoven (in Dutch).

RIVM, 2017: Werkplan 2017–2018 RIVM, Bilthoven (in Dutch).

Roemer, M. & O. Tarasova, 2002: Methane in the Netherlands – an exploratory study to separate time scales. TNO report R2002/215. TNO, Apeldoorn.

Roemer, M., Th. Thijsse & T. van der Meulen, 2003: Verificatie van methaan emissies. ArenA, Journal of the Netherlands Association of Environmental Professionals (VVM), Den Bosch (in Dutch).

Royal HaskoningDHV, 2013: Greenhouse gas emissions industrial processes NIR 2013, Peer review, BB4392-100-100/R/900425/Rott.

RVO.nl, 2017: The Netherlands National System: QA/QC programme 2017/2018, version 13.0, December 2017 (available at Netherlands Enterprise Agency (RVO.nl) for review purposes).

Scheffer, C.B. & W.J. Jonker, 1997: Uittreksel van interne TNO-handleiding voor het vaststellen van verbrandingsemissies, herziening January 1997 (in Dutch).

Schelhaas M.J., A. Schuck, S. Varis, S. Zudin, 2003. Database on Forest Disturbances in Europe (DFDE) – Technical Description. European Forest

Institute, Joensuu Finland. Internal report 14. Available via: http://dataservices.efi.int/dfde/.

Schelhaas, M., A.P.P.M. Clerkx, W.P. Daamen, J.F. Oldenburger, G. Velema, P. Schnitger, H. Schoonderwoerd & H. Kramer, 2014: Zesde Nederlandse bosinventarisatie: methoden en basisresultaten. Alterra-rapport 2545. Alterra Wageningen UR, Wageningen. Available via: http://edepot.wur.nl/307709 (in Dutch).

Schijndel van, M. & Van der Sluis, S., 2011: Emissiefactoren voor de berekening van directe lachgasemissies uit landbouwbodems en als gevolg van beweiding. Achtergrondnotitie bij de National Inventory Report 2011 (in Dutch).

Schoonderwoerd, H. & W.P. Daamen, 1999: Houtoogst en bosontwikkeling in het Nederlandse bos: 1984–1997. Reeks: HOSP, Bosdata nr 3. Stichting Bosdata, Wageningen (in Dutch).

Schulp, C.J.E., G.-J. Nabuurs, P.H. Verburg & R.W. de Waal, 2008: Effect of tree species on carbon stocks in forest floor and mineral soil and implications for soil carbon inventories. Forest Ecology and Management 256:482-490. Available via: http://dx.doi.org/10.1016/j.foreco.2008.05.007.

Seegers, R., 2015: Herziening Hernieuwbare Energie 2015. CBS, The Hague (in Dutch).

Smink, W., 2005: Calculated methane production from enteric fermentation in cattle excluding dairy cows. FIS background document. SenterNovem, Utrecht.

Spakman, J., M.M.J. Van Loon, R.J.K. Van der Auweraert, D.J. Gielen, J.G.J. Olivier & E.A. Zonneveld, 2003: Method for calculating GHG emissions. Emission Registration Report 37b, March, electronic update of original report 37 of July 1997. VROM-HIMH, The Hague (only available electronically in Dutch and in English at: http://english.rvo.nl/nie).

Spoelstra, H., 1993: N_2O emissions from combustion processes used in the generation of electricity. NOP report 410100049KEMA. Arnhem/RIVM, Bilthoven.

Spreen, J.S., G. Kadijk, R.J. Vermeulen, V.A.M. Heijne, N.E. Ligterink, U. Stelwagen, R.T.M. Smokers, P.J. van der Mark & G. Geilenkirchen, 2016: Assessment of road vehicle emissions: methodology of the Dutch in-service testing programmes, TNO, Delft.

Stelwagen, U. & N.E. Ligterink, 2014: CO_2 emission from urea consumption in SCR after-treatment in heavy-duty vehicles, TNO R11513, TNO, Delft.

Swertz, O., S. Brummelkamp, J. Klein & N. Ligterink, 2018: Adjustment of heating values and CO_2 emission factors of petrol and diesel, Statistics Netherlands, The Hague.

Velthof, G.L. & J. Mosquera, 2011: Calculation of nitrous oxide emission from agriculture in the Netherlands. Update of emission factors and leaching fraction. Alterra report 2151. Alterra, Wageningen.

Visser, H., 2005: The significance of climate change in the Netherlands. An analysis of historical and future trends (1901–2020) in weather conditions, weather extremes and temperature-related impacts. MNP report 550002007. Bilthoven.

Vonk, J., A. Bannink, C. van Bruggen, C.M. Groenestein, J.F.M. Huijsmans, J.W.H. van der Kolk, H.H. Luesink, S.V. Oude Voshaar, S.M. van der Sluis & G.L. Velthof, 2018: Methodology for estimating emissions from agriculture in the Netherlands. Calculations of CH_4, NH_3, N_2O, NO_x, PM10, PM2.5 and CO_2 with the National Emission Model for Agriculture (NEMA). WOt-report 2018.53. WOT Nature and Environment, Wageningen.

Vries de, F., 2004: The expansion of peat soils (In Dutch: De verbreiding van veengronden). In: A.J. van Kekem (ed.), Veengronden en stikstofleverend vermogen. Alterra report 965. Alterra, Wageningen.

Vries de F., J.P. Lesschen & J. van der Kolk, 2016: Conditie van moerige gronden in Nederland - Broeikasgasemissies door het verdwijnen van veenlagen. Alterra rapport. Alterra Wageningen UR, Wageningen(in Dutch).

Waal de, R.W., F.K. van Evert, J.G.J. Olivier, B. van Putten, C.J.E. Schulp and G.J. Nabuurs, 2012: Soil carbon dynamics and variability at the landscape scale: its relation to aspects of spatial distribution in national emission databases. Programme office Climate changes Spation Planning http://edepot.wur.nl/289947.

WBCSD/WRI (World Business Council for Sustainable Development/World Resources Institute), 2004: Calculating direct GHG emissions from primary aluminium metal production. Guide to calculation worksheets. Available at GHG Protocol Initiative website: www.ghgprotocol.org/standard/tools.htm.

Wever, D., 2011: QA/QC of outside agencies in the Greenhouse Gas Emission Inventory. Update of the background information in the Netherlands National System. RIVM report 680355005/2011. Bilthoven.

Wijdeven, S.M.J., M.J. Schelhaas, A.F.M. Olsthoorn, R.J. Bijlsma & K. Kramer, 2006: Bosbrand en terreinbeheer – een verkenning. Alterra, Wageningen (in Dutch).

YU & CLODIC, 2008: Generic approach of refrigerant HFC-134a emission modes from MAC systems. Laboratory tests, fleet tests and correlation factor. Centre for energy and processes, Ecole des Mines de Paris. 23 October.

Zijlema, P.J., 2018: The Netherlands: list of fuels and standard CO_2 emission factors, version January 2018, RVO.nl.

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RIVM Report 2018-0006

Total greenhouse gas (GHG) emissions from the Netherlands in 2016 increased by approximately 0.4%, compared with 2015 emissions. This increase was mainly the result of increased natural gas consumption for space heating. On the other hand, the emission of electricity production has declined.

In 2016, total GHG emissions (including indirect CO2 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 12.4% below the emissions in the base years[1] (222.9 Tg CO_2 eq.).

CO_2 emissions were still above the level in the base year in 2016 (+1.8%). This increase was offset by the reduction since 1990 in emissions of methane, nitrous oxide and fluorinated gases (CH_4, N_2O and F-gases).

This report documents the Netherlands' annual submission for 2018 of its GHG 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 (KP) 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 total 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.

[1] 1990 for CO_2, CH_4 and N_2O and 1995 for F-gases.

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