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

Greenhouse Gas Emissions *in the Netherlands* 1990-2017

National Inventory Report 2019

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

Greenhouse gas emissions in the Netherlands 1990–2017
National Inventory Report 2019

15 April 2019 Version

RIVM Report 2019-0020

Colophon

DOI 10.21945/RIVM-2019-0020

P.G. Ruyssenaars, P.W.H.G. Coenen[1], P.J. Zijlema[2], E.J.M.M. Arets[6], K. Baas[3], R. Dröge[1], G. Geilenkirchen[5], M. 't Hoen[5], E. Honig, B. van Huet[7], E.P. van Huis[4], W.W.R. Koch[1], L.A. Lagerwerf, R. te Molder, J.A. Montfoort, C.J. Peek, J. Vonk, M.C. van Zanten,

[1] Netherlands Organization for Applied Scientific Research (TNO), P.O. Box 80015, NL-3508 TA Utrecht
[2] Netherlands Enterprise Agency (RVO.nl), P.O. Box 8242, NL-3503 RE Utrecht
[3] Statistics Netherlands (in Dutch: 'Centraal Bureau voor de Statistiek', CBS), P.O. Box 24500, NL-2490 HA Den Haag
[4] Dutch Emissions Authority (NEa), P.O. Box 91503, NL-2509 EC Den Haag
[5] PBL Netherlands Environmental Assessment Agency, P.O. Box 30314 NL-2500 GH Den Haag
[6] Wageningen Environmental Research (Alterra) Wageningen UR, P.O. Box 47 NL-6700 AA Wageningen
[7] Rijkswaterstaat, P.O. Box 2232, NL-3500 GE Utrecht

Contacts:
Margreet van Zanten (RIVM) (margreet.van.zanten@rivm.nl)
Peter Zijlema (NIE / Netherlands Enterprise Agency (RVO.nl)) (Peter.Zijlema@rvo.nl)

This report has been compiled by order and for the account of the Directorate-General for the Environment and International Affairs, within the framework of the project Emission Registration M/240037/15/NI, 'Netherlands Pollutant Release & Transfer Register'. Report prepared for submission in accordance with the United Nations Framework Convention on Climate Change (UNFCCC) and the European Union's Greenhouse Gas Monitoring Mechanism [including electronic Common Reporting Format (CRF) Excel spreadsheet files containing the data for 1990 to 2017].

This is a publication of:
National Institute for Public Health and the Environment
P.O. Box1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

Acknowledgements

Many colleagues from a number of organizations Statistics Netherlands (CBS), Wageningen Environmental Research (WUR), Netherlands Enterprise Agency (RVO.nl), Netherlands Environmental Assessment Agency (PBL), RIVM and TNO have been involved in the annual update of the Netherlands Pollutant Release & Transfer Register (NL-PRTR), also called the Emission Registration (ER) system, which contains emissions data on about 350 pollutants. The emissions calculations, including those for greenhouse gas (GHG) emissions, are performed by members of the ER Task Forces. This is a major task, since the Netherlands' inventory contains details of many emissions sources.

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), Bas van Huet (Waste), Gerben Geilenkirchen and Maarten 't Hoen (Transport), Romuald te Molder and Jolien van Huijstee (key sources and uncertainty analysis), Rianne Dröge (Energy and uncertainty assessment), Johanna Montfoort (Fugitive emissions), Kees Peek and Erik Honig (Industrial processes and product use, data control, chart production), Kees Baas (Wastewater handling), Lotte Lagerwerf and Jan Vonk (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, Dirk Wever and Jacqueline Wanders 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 1990–2017

Total greenhouse gas (GHG) emissions in the Netherlands in 2017 decreased by approximately 1.1%, compared with 2016 emissions. This decrease was mainly the result of decreased coal combustion for energy and heat production.

In 2017, 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 193.7 Tg CO_2 eq. This is approximately 12.6% below the emissions in the base year 1990 (221.7 Tg CO_2 eq.).

CO_2 emissions in 2017 were still above the level in the base year (+1.0%). 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 2019 of its GHG emissions inventory in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) prescribed by the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol (KP) and the European Union's Greenhouse Gas Monitoring Mechanism.

This 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. Per source category, methods, data sources and emission factors (EFs) are described; besides a description of the quality assurance system and the verification activities performed on the data. It also describes changes in methodologies compared to the former submission (NIR 2018), the results of recalculations and planned improvements.

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

Publiekssamenvatting

Emissies van broeikasgassen tussen 1990 en 2017

In 2017 is de totale uitstoot van broeikasgassen van Nederland met ongeveer 1,1 procent gedaald ten opzichte van 2016. Deze daling komt vooral doordat minder kolen zijn gebruikt om elektriciteit te produceren en ruimtes te verwarmen.

De totale uitstoot van broeikasgassen naar de lucht wordt uitgedrukt in CO_2-equivalenten en bedroeg in 2016 193,7 miljard kilogram. Het jaar 1990 geldt als referentiejaar (het zogeheten Kyoto-basisjaar) voor de te halen doelstellingen. De uitstoot in 1990 bedroeg 221,7 miljard kilogram CO_2-equivalenten. Ten opzichte van het basisjaar is de uitstoot gedaald met ongeveer 12,6 procent.

De uitstoot van CO2 ligt ongeveer 1 procent boven het niveau van het basisjaar. Omdat de uitstoot van de andere broeikasgassen (methaan, distikstofoxide en gefluoreerde gassen) sinds 1990 flink is gedaald, is de totale uitstoot van broeikasgassen lager dan in 1990.

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 analyses van ontwikkelingen in de uitstoot van broeikasgassen tussen 1990 en 2017, een analyse van de belangrijkste bronnen die broeikasgassen uitstoten (‘sleutelbronnen’), evenals de onzekerheid in hun uitstoot. Daarnaast zijn de gebruikte berekeningsmethoden en databronnen beschreven. Ten slotte bevat het een overzicht van het kwaliteitssysteem en de manier waarop de Nederlandse Emissieregistratie de berekeningen controleert.

Kernwoorden: broeikasgassen, emissies, trends, methodiek, klimaat

Contents

Samenvatting

Het National Inventory Report (NIR) 2019 bevat de rapportage van broeikasgasemissies (CO_2, N_2O, CH_4 en de F-gassen) over de periode 1990 tot en met 2017. De emissiecijfers in de NIR 2019 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) als voor de emissies in de periode tot en met 2017. 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 voor 2019 te voldoen aan de nationale rapportageverplichtingen 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.

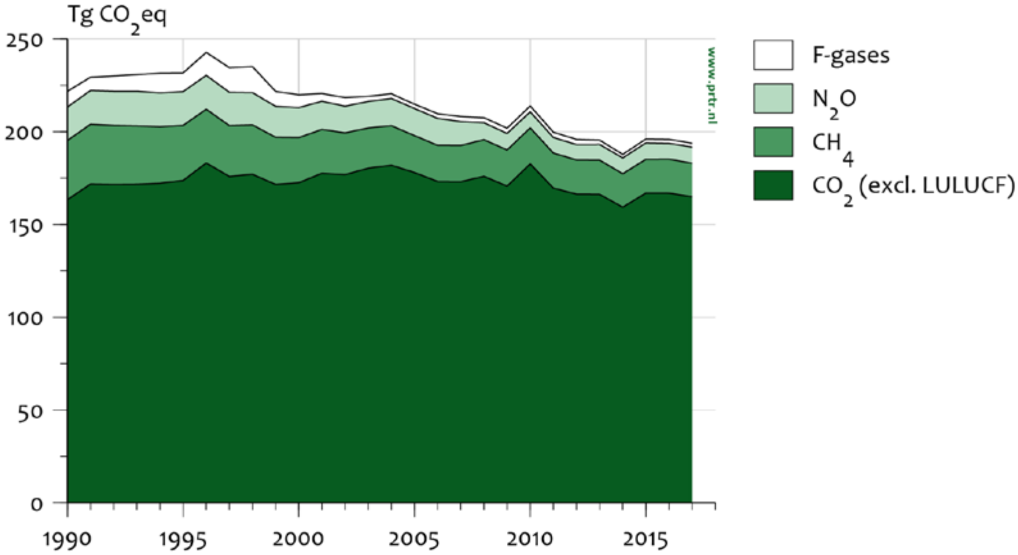
Dit rapport bevat de volgende informatie:
- trendanalyses voor de emissies van broeikasgassen in de periode 1990-2017;
- een analyse van zogenaamde sleutelbronnen en de onzekerheid in hun emissies volgens de ‘Benaderingen 1 en 2’-methodiek van de 2006 IPCC Richtlijnen;
- documentatie van gebruikte berekeningsmethoden, 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 ook de methodiek rapporten meegeleverd. In de bijlagen bij dit rapport is onder meer een overzicht van de belangrijkste bronnen (“sleutelbronnen”) en onzekerheden in de emissie opgenomen.

De NIR gaat niet specifiek in op de invloed van het gevoerde overheidsbeleid op de emissies van broeikasgassen; meer informatie hierover is te vinden in de Balans van de Leefomgeving 2018 (opgesteld door het Planbureau voor de Leefomgeving, PBL), de zevende Nationale

Communicatie onder het Klimaatverdrag (NC7; EZK, 2017a) en de derde Tweejaarlijkse Voortgangsrapportage (BR3; EZK, 2017b).



Figuur S.1 Broeikasgassen: emissieniveaus en emissietrends (exclusief LULUCF), 1990-2017

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 1990-2017 weer. De totale emissies bedroegen in 2017 circa 193,7 Tg (Mton ofwel miljard kg) CO_2 equivalenten en zijn daarmee circa 12,6 procent afgenomen in vergelijking met de emissies in het basisjaar (221,7 Tg CO_2 eq). In de in dit rapport gepresenteerde emissies worden de indirecte CO_2 emissies meegerekend. De emissies van landgebruik en bossen (LULUCF) worden echter niet meegeteld.

De emissie van CO_2 is sinds 1990 met circa 1,0 procent toegenomen, de emissies van de andere broeikasgassen zijn met 50,7 procent afgenomen ten opzichte van het basisjaar.

In 2017 daalde de CO_2 emissie met 1,1 procent ten opzichte van het jaar 2016. Deze daling komt vooral doordat er minder kolen zijn verbruikt voor elektriciteitsproductie en ruimteverwarming. De emissie van CH_4 daalde in 2017 licht ten opzichte van 2016, met 1,7 procent. De N_2O emissie steeg in 2017 met 2,8 procent. De emissie van F-gassen daalde in 2017 met 6,1 procent ten opzichte van 2016. De totale emissie van broeikasgassen in 2017 ligt daarmee 1,1 procent lager dan het niveau in 2016.

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 188 en 200 Tg (Mton).
De onzekerheid in de emissietrend tussen het basisjaar (1990) en 2017 is geschat op circa 2 procent; dat wil zeggen dat de emissietrend in die periode met 95 procent betrouwbaarheid ligt tussen de -11 en -15 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 2019 of its greenhouse gas (GHG) emissions inventory, as to fulfil the annual reporting requirements under the United Nations Convention on Climate Change (UNFCCC) and its Kyoto Protocol (KP). It is also prepared to fulfil part of the reporting requirements under the EU Monitoring Mechanism Regultation (EU 525/2013).

This report is prepared in line with the reporting guidelines as provided in Decisions by the UNFCCC Conference of the Parties (COP) and the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) as well as in line with the relevant (2006) IPCC reporting Guidelines.
The content of this report is as follows:

- Chapter 1 documents the "National System" as reviewed and approved upon UNFCCC review in 2007 (and reconfirmed in 2017);
- Chapter 2 summarises the emission trends, as further described and documented in the consecutive chapters;
- Chapter 3 – chapter 8 document emissions and trends for the following sectors, respectively:
    - Energy (sector 1)
    - Industrial Processes and Product Use (IPPU, sector 2)
    - Agriculture (sector 3)
    - Land Use, Land Use Change and Forestry (LULUCF, sector 4)
    - Waste (sector 5)
    - Other (sector 6)
- Chapter 9 describes Indirect CO_2 emissions
- Chapter 10 documents recalculations and improvements compared to the former report (NIR2018).

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

Note that this report provides no specific information on the effectiveness of government policies for reducing GHG emissions. This information can be found in 'Netherlands State of the Environment report2018' (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) 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 NIR2019 in PDF format and the methodology reports, are also available on the website http://english.rvo.nl/nie.

Base year
The Netherlands uses 1990 as the base year for all gases.

Key categories
To identify the 'key categories' (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 32 key categories and 95% of the national total trend is due to 38 key categories, out of a total of 107 source categories.
Next, the IPCC Approach 2 method for identifying the key categories is used; this requires incorporating the uncertainty in the emissions estimate of each of these categories before ranking them in relation to their share of total emissions. The result is a list of 35 key categories (both level and trend) from the total of 107 source categories.
Finally, after the inclusion of 10 Land use, land use change and forestry (LULUCF) source categories in the key category analysis, 4 more key categories are found in the LULUCF sector; except for the Approach 1 trend assessment (3 additional key categories).

Institutional arrangements for inventory preparation
The GHG emissions inventory process of the Netherlands is integrated part of the national Pollutant Release and Transfer Register (NL-PRTR). Figure ES.1 shows the structure/responsibilities in the inventory process.

The National Institute for Public Health and the Environment (RIVM) has been contracted by the Ministry of Infrastructure and Water Management, respectively the ministry of Economic Affairs and Climate policy (EZK) to compile and maintain the PRTR and to coordinate the annual preparation of the NIR and the completion of the CRF tables (see Figure ES.1). 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.

The inventory is compiled annually in accordance with the procedures applicable to National Systems, in accordance with the requirements of Article 5.1 of the Kyoto Protocol, the UNFCCC reporting guidelines and the EU MMR, while in accordance with these requirements the National Inventory Entity (NIE) is the designated single national entity with overall responsibility for the national inventories.

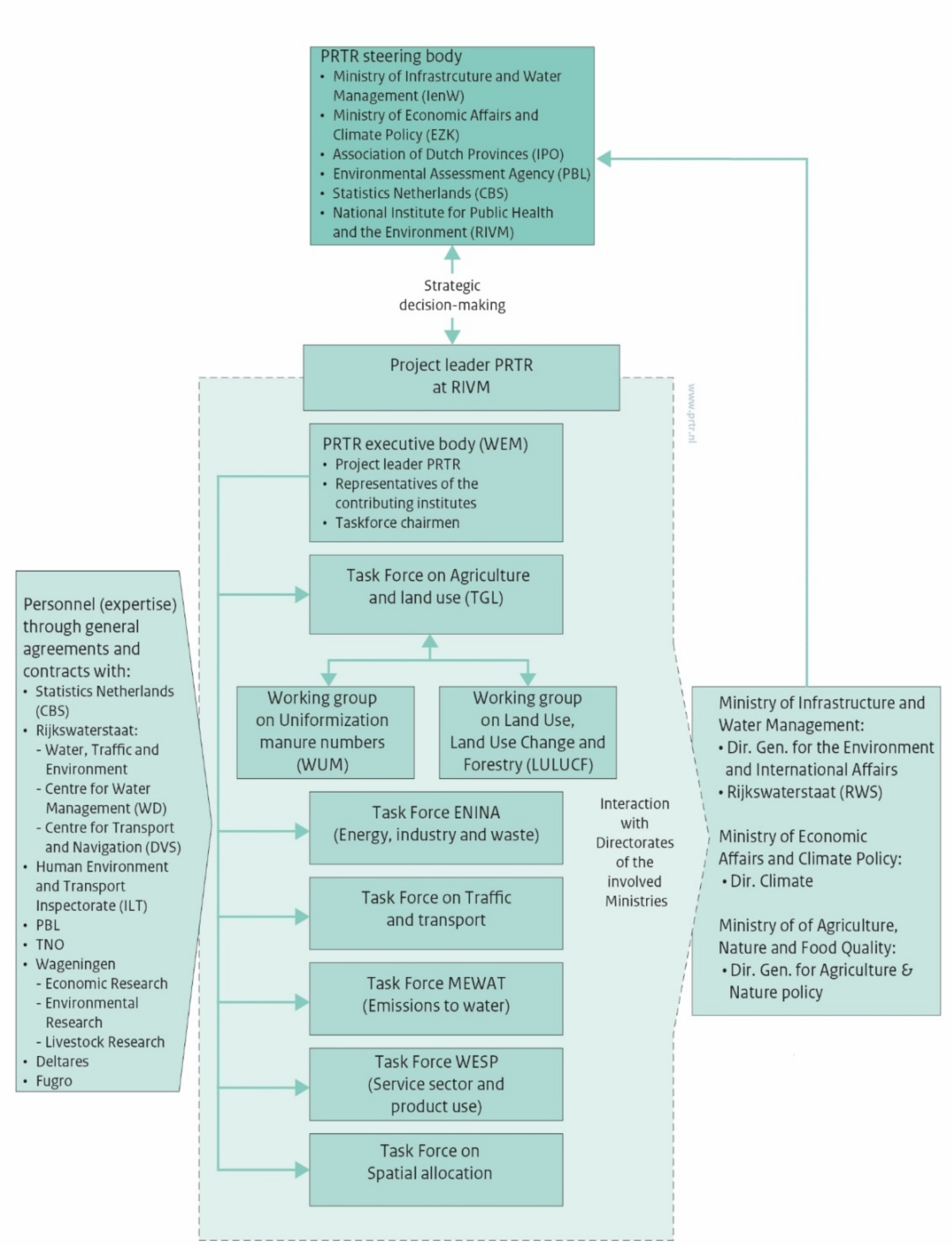


Figure ES.1: Main elements in the GHG emissions inventory compilation process

Methodology reports

Emissions data are reported in accordance with the 2006 IPCC Guidelines (IPCC, 2006)). Methodologies are described in methodology reports. The present CRF/NIR is based on these methodology reports, which are part of the National System.
The methodology reports are also part of the National GHG submission. References are included in Annex 7 and are available at the National System website http://english.rvo.nl/nie. (Any changes in) the methodology reports are reviewed and approved by the NIE and the PRTR project leader at RIVM.

ES2 Summary of trends in national emissions and removals

In 2017, total GHG emissions (including indirect CO_2 emissions and excluding emissions from LULUCF) in the Netherlands were estimated at 193.7 Tg CO_2 equivalents (CO_2 eq.). This is approximately 12.6% below total emissions in the base years (221.7 Tg CO_2 eq.).

The Netherlands uses 1990 as the base year for all greenhouse gas emissions. CO_2 emissions (excluding LULUCF) increased by about 1% between 1990 and 2017. CH_4 emissions in 2017 were 43.4% lower than 1990 levels, mainly due to decreases in emissions from the Waste sector and the Agricultural sector. N_2O emissions decreased by 51.7% in 2017 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. Compared to the base year, the emissions of F-gases (HFCs, PFCs and SF_6) decreased by 67.4%, 97.1% and 38.9%, respectively; see table ES.1. Total emissions of all F-gases were 76.1% lower than in 1990. Figure ES.2 shows a graphical representation of these trends.

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

	CO_2 excl. LULUCF	CH_4 excl. LULUCF	N_2O excl. LULUCF	HFCs	PFCs	SF_6	Total excl. LULUCF
1990 (base yr)	163.3	31.8	18.0	5.6	2.7	0.2	221.7
1995	173.7	29.7	18.2	7.6	2.3	0.3	231.7
2000	172.5	24.3	16.2	4.8	1.9	0.3	219.8
2005	178.0	19.9	14.6	1.7	0.4	0.2	214.7
2010	182.6	19.4	8.6	2.7	0.3	0.2	213.8
2015	166.9	18.2	8.8	1.8	0.1	0.1	196.0
2016	166.8	18.3	8.5	1.9	0.2	0.1	195.8
2017	164.9	18.0	8.7	1.8	0.1	0.1	193.7

Compared to 2016, the *overall GHG emissions* decreased by about 1.1%. The development for the specific gases was as follows:

- CO_2 emissons (excluding LULUCF) decreased by 1.1% (-1.9 Tg), mainly due to less coal combustion for electricity and heat production (1A1a);
- CH_4 emissions decreased by 1.7% (ca -0.3 Tg CO_2 eq.); mainly in category 3A (Enteric fermentation) and category 5A (Solid waste disposal on land);
- N_2O emissions increased by about 2.8% (ca 0.2 Tg CO_2 eq.), mainly due to an increase of emissions in category 3D (agricultural soils).
- F-gas emissions decreased by 6.1% (ca -0.1 Tg CO_2 eq.). This was primarily caused by a reduction of PFC emissions of 49.3% (-0.07 Tg CO_2 eq.).

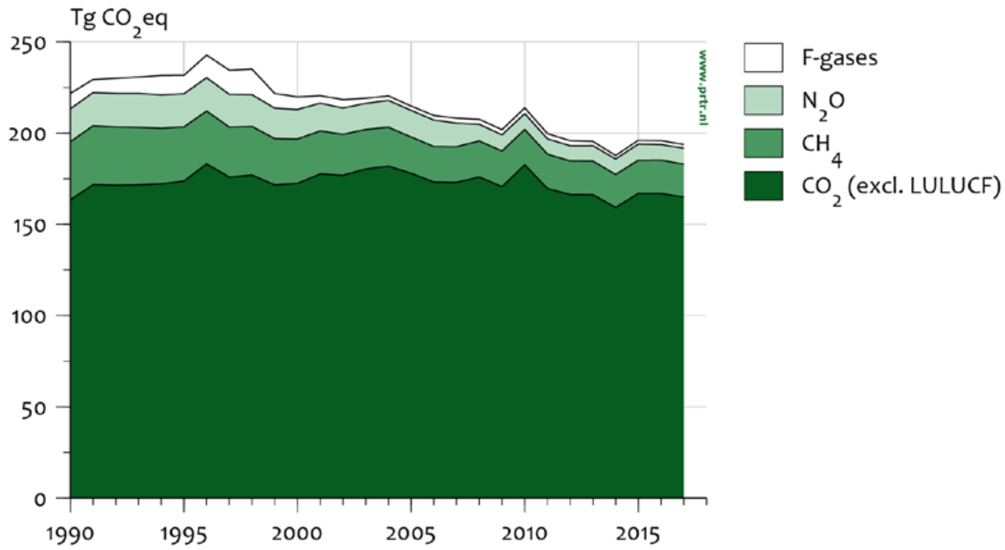


Figure ES.2: Overview of the trends in GHG emissions (excl. LULUCF) 1990–2017

ES3 Overview of source and sink category emissions estimates and trends

Table ES.2 and figure ES.3 provide an overview of the emissions trends (in CO_2 eq.) per IPCC sector. The Energy sector is by far the largest contributor to national total GHG emissions. Emissions from this sector were in 2017 ca 1% higher than in 1990. Emissions from all other sectors were lower than in the base year, the largest decreases being in Waste, IPPU (Industrial Production and Product Use) and Agriculture. Source categories showing the largest increase in CO_2-equivalent emissions since 1990 are Transport (1A3) and Energy industries (1A1) (+11% and +19%, respectively).

Table ES.2 Summary of emissions trends per sector (Tg CO2 equivalents, including indirect CO_2 emissions)

	Energy (1)	IPPU (2)	Agriculture (3)	LULUCF (4)	Waste (5)	Total incl. LULUCF	Total excl. LULUCF
1990 (base yr)	158.6	23.8	25.1	6.5	14.2	228.2	221.7
1995	169.3	25.6	24.2	6.4	12.6	238.1	231.7
2000	167.1	22.2	20.7	6.1	9.8	225.9	219.8
2005	173.0	17.0	18.4	5.7	6.4	220.4	214.7
2010	178.9	12.3	18.0	5.6	4.6	219.4	213.8
2015	162.5	11.4	18.7	5.6	3.4	201.7	196.0
2016	162.6	11.1	18.9	5.6	3.3	201.4	195.8
2017	160.2	11.5	18.9	5.6	3.1	199.3	193.7

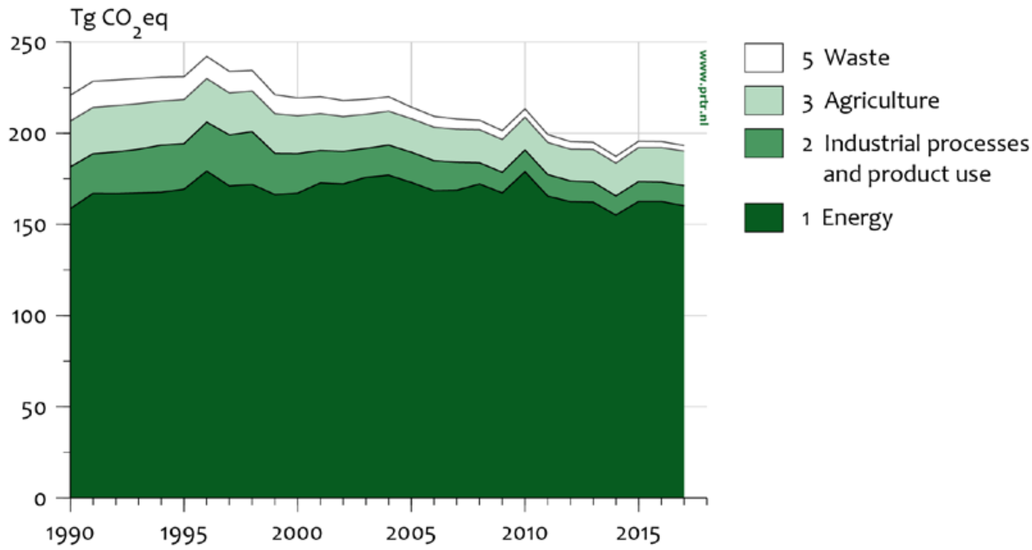


Figure ES.3: Overview of the trends in GHG emissions per sector (excl. LULUCF) 1990–2017

ES4 Other information

General uncertainty evaluation

The results of the uncertainty estimation according to the IPCC Approach 1 are summarized in Annex 2 of this report. The overall results are shown in Table ES3. IPCC Approach 2 also takes the correlation between source categories (such as cattle numbers for enteric fermentation and animal manure production) into account. The results of the Approach 2 uncertainty assessment (using Monte Carlo analysis) are also included in Annex 2. The overall results (see Table ES3) show that the calculated uncertainty in the national emissions is of the same order of magnitude as the Approach 1 uncertainty assessment. 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.

Table ES.3: Approach 1 and Approach 2 uncertainty assessment of 2017 emissions (without LULUCF)

Greenhouse gas	Approach 1 annual uncertainty	Approach 2 annual uncertainty (Monte Carlo)
Carbon dioxide	2%	3%
Methane	13%	9%
Nitrous oxide	36%	26%
F-gases	41%	34%
Total	3%	3%

The trend uncertainty in total CO_2-equivalent emissions (excluding LULUCF) for 1990–2017 is ±2%. This means that the trend in total CO_2-equivalent emissions between 1990 and 2017 (excluding LULUCF), which is calculated to be a 12.6% (rounded 13%) decrease, will be between a 11% decrease and a 15% 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 ±11%, respectively. More details of the trend uncertainty assessment can be found in Annex 2.

Completeness of the national inventory
The Netherlands GHG inventory includes almost all sources that, according to the 2006 IPCC Guidelines, should be included in the inventory. The following very minor sources are not included:

- 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 of poultry (3A4), due to missing EFs;
- N_2O from Industrial wastewater treatment (5D2) and septic tanks (5D3), due to negligible amounts;
- Part of CH_4 from Industrial wastewater (5D2 sludge), due to negligible amounts;
- Precursor emissions (i.e. CO, NOx, NMVOC and SO_2) from memo item 'International bunkers' (international transport).

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
Compared to the NIR2018, some improvements of the inventory (including recalculations) have been implemented and documented in this NIR2019. The rationale behind the recalculations is documented in Chapters 3–10. Table ES.4 shows the results of these recalculations in the NIR2019 compared with the NIR2018.

Table ES.4: Differences between the NIR2019 and NIR2018 due to recalculations (in Tg CO_2 eq. including indirect CO_2 emissions; F-gases in Gg CO_2 eq.)

	Source	**1990**	**2000**	**2010**	**2016**
CO_2	NIR 2019	169.8	178.5	188.1	172.2
Incl.	NIR 2018	169.2	178.3	188.5	172.3
LULUCF	*Difference*	*0.4%*	*0.1%*	*-0.2%*	*0.0%*
CO_2	NIR 2019	**163.3**	172.5	182.6	166.8
Excl.	NIR 2018	**163.1**	172.3	182.4	165.7
LULUCF	*Difference*	*0.1%*	*0.1%*	*0.1%*	*0.7%*
CH_4	NIR 2019	**31.9**	24.3	19.4	18.3
	NIR 2018	**32.0**	24.4	19.6	18.6
	Difference	*-0.3%*	*-0.5%*	*-1.0%*	*-1.3%*
N_2O	NIR 2019	**18.0**	16.2	8.6	8.5
	NIR 2018	**17.7**	15.9	8.4	8.4
	Difference	*1.7%*	*1.8%*	*3.4%*	*1.6%*
PFCs	NIR 2019	**2663**	1903	314	152
	NIR 2018	**2663**	1903	314	152
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*
HFCs	NIR 2019	**5606**	4765	2669	1876
	NIR 2018	**5606**	4764	2677	2418
	Difference	*0.0%*	*0.0%*	*-0.3%*	*-22.4%*
SF_6	NIR 2019	**207**	259	154	134
	NIR 2018	**207**	259	154	134
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*
Total	NIR 2019	228.2	225.9	219.4	201.4
Tg CO_2-eq.	*NIR 2018*	227.3	225.5	219.6	201.9
Incl.	*Difference*	*0.4%*	*0.2%*	*-0.1%*	*-0.3%*
LULUCF					
Total	NIR 2019	**221.7**	219.8	213.8	195.8
Tg CO_2 eq.	NIR 2018	**221.3**	219.4	213.4	195.2
Excl.	*Difference*	*0.2%*	*0.2%*	*0.2%*	*0.3%*
LULUCF					

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, 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 2017 by 54% and 66%, respectively. For SO_2, the reduction was 86%; for NO_x, the 2017 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	2017
Total NO_X	586	486	399	349	287	241	230	223
Total CO	1,248	976	905	747	677	597	586	579
Total NMVOC	519	375	272	210	206	185	177	178
Total SO_2	187	126	71	62	33	30	28	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 reporting

Climate Convention, Kyoto Protocol and EU Monitoring Mechanism Regulation

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. In 2005, the Kyoto Protocol (KP) under the Convention entered into force. Rules for Monitoring, Reporting and Verification (MRV), initially agreed under the Convention itself, have been further elaborated in the KP under the articles 5, 7 and 8; and have been implemented successively. The "National System" under article 5.1 of the KP, has been reviewed (art 8 of the KP) and accepted for the Netherlands in 2007. The Greenhouse gas (GHG) inventory is prepared on an annual basis under this national system (article 7.1 of the KP). The latest in country review of the inventory in 2017 confirmed that the Netherlands inventory and inventory process are still in line with the rules for national systems.

The inventory is accompanied by the Common Reporting Format (CRF), representing the national GHG emissions of the Netherlands. The methodologies applied for calculating the emissions, are in accordance with the Guidelines of the IPCC, as agreed upon in 2006.
Besides, both the inventory and this National Inventory Report are in line with the rules of the European Commission; as laid down in the EU Monitoring Mechanism Regulation (EU 525/2013).

This national inventory report (NIR), together with the Common Reporting Format (CRF), represents the 2019 national emissions inventory of GHGs under the UNFCCC and the KP (Part I of this report). Additional reporting requirements under the KP, other than inventory related issues, are included inPart 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

The NIR (and CRF) cover the seven direct GHGs included in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF3) (the last four are called the F-gases). NF_3 is included in the figure for PFCs. Emissions cannot be reported separately due to the confidentiality of the data. The Netherlands reports total greenhouse gas emissions including indirect CO_2 emissions. Besides, 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 period 1990–2017. It summarizes the methods and data sources used 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.

This inventory report does not include detailed assessments of the extent to which changes in emissions are due to the implementation of policy measures. This information can be found in: 'The Netherlands State of the Environment Report 2018' (biennial edition; in Dutch: 'Balans van de Leefomgeving') (PBL, 2018), the 7th Netherlands National Communication under the United Nations Framework Convention on Climate Change (NC7: EZK, 2017a) and the Third Biennial Report (BR3: EZK, 2017b).

The Netherlands also reports emissions under other international agreements, such as the United Nations Economic Commission for Europe (UNECE) 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 various cooperating organizations, as further described in box 1 and table 1.3 underneath. The GHG emissions inventory and the PRTR share underlying data, which ensures consistency between the inventories and other internationally reported data.

In line with the requirements of the National System and in accordance with Art 5.1 of the KP, both the National System and the methodologies for calculating the GHG emissions in the Netherlands are kept up to date on an annual basis. Information on the latest changes to the National System is reported in Chapter 13 of this report.

Since 2015, emissions data are calculated according to the 2006 IPCC Guidelines (IPCC, 2006).The methodologies applied in the Netherlands are documented in five methodology reports, one for each PRTR Task Force. The NIR2019 is based on these methodologies. The methodology 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 and any changes in methodologies are reviewed by the National Inventory Entity (NIE) and approved by the chairperson of the PRTR Task Force concerned. Changes in methodologies are also described in the NIR; both in the relevant chapters as well as in chapter 10 (documenting recalculations and improvements made following the recommendations of the latest reviews).

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. This information is included in Part II of the NIR.

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 (UNFCCC, 2013). 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.

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 elected not to include any other activities under Article 3, paragraph 4, of the Kyoto Protocol.
Information on the accounting of Kyoto units is also provided in the SEF file RREG1_NL_2018_2_1.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 GHG emissions documented in this NIR and for the completion of the CRF tables. RIVM is also coordinating the compilation of the National Inventory Report.

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, 2018). 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 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 (Netherlands Environmental Asssessment Agency), CBS, RIVM, Rijkswaterstaat- and TNO.

Task Force on Agriculture
Covers the calculation of emissions to soil and airfrom agriculture. Participating organizations include RIVM, PBL, Wageningen environmental Research (WenR), Wageningen economic Research (WecR) and CBS.

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 and TNO.

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. In addition, the Netherlands Enterprise Agency (RVO.nl) is involved in its role as NIE. RVO.nl also prepares most of the NIR Part II. RIVM integrates all information into the NIR. RVO.nl takes care of 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 7 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., 2019).

The calculated values were generated using the LULUCF bookkeeping model at Wageningen Environmental Research and checked by the LULUCF sectoral expert. Consecutively, they were sent to the NL-PRTR for entering the data into the CRF database for all sectors, and checked 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, 2018) are summarized in this chapter, notably those relating to the current NIR.

1.2.3.2 QA/QC procedures for the CRF/NIR2019

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 in 2017 providing more information in the NIR, and this is now included in the methodology reports (which are an integral part of this 2019 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 purposesThe Task Forces are eager to continuously 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 NIR 2019, changes were incorporated into both methodology reports and background documents. The methodology reports are available on the National System website (http://english.rvo.nl/nie) and are an integrated part of the NIR 2019 (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 1990–2017 (with the exception of LULUCF). After a first check of the data by the RIVM 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 (6 December 2018). The conclusions of this workshop (including how the Task Forces should resolve the clarity issues that had been identified) are documented at RIVM. Further improvements to the database were then implemented 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 NIR2019 includes the following activities:

- In preparing this NIR2019, the results of former UNFCCC reviews and ESD reviews are taken into account and the requested improvements were made;
- Usually the draft NIR is also subject to a public review in January/February. Due to problems encountered with the generation of CRF files, it was not possible to timely deliver a draft NIR for the planned public review. It was decided not to conduct a public review in 2019. For 2020, the Netherlands has planned the next public review;
- Due to organizational problems, the annual peer review has been postponed to April/May 2019. Results of the peer review will addressed in the NIR 2020;

The QA/QC system must operate within the available resources (both capacity and finance). Within those means, QA/QC activities especially focus on:

- *The QA/QC programme* (RVO.nl, 2018), 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).

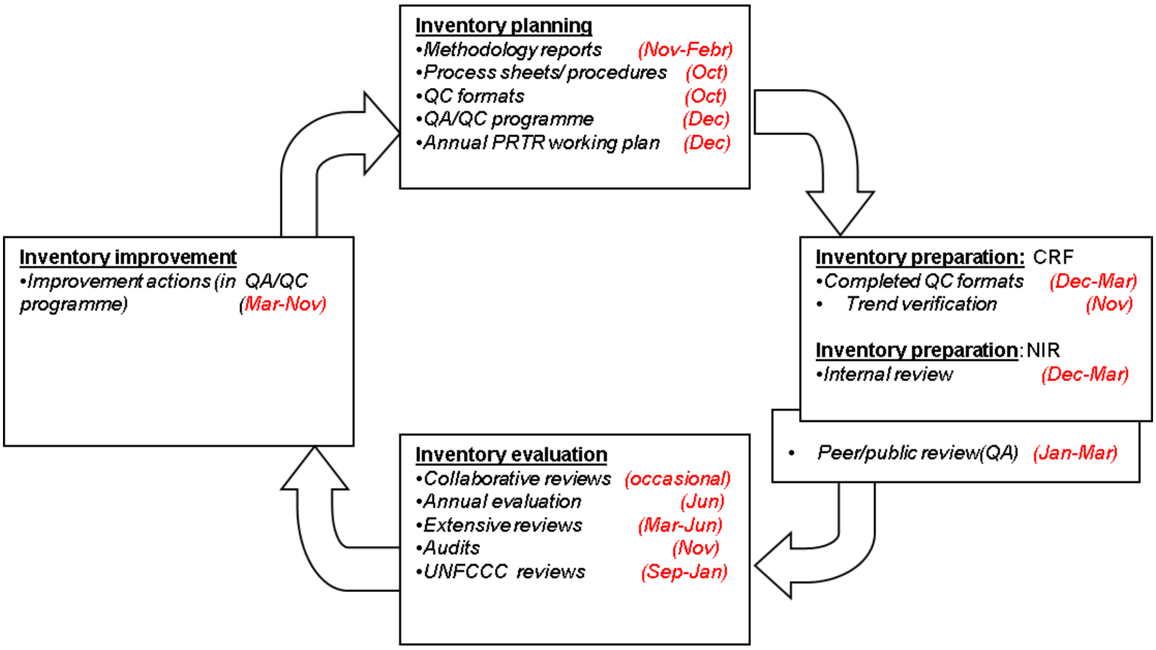


Figure 1.1: QA/QC cycle (including timeline)

- *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, 2018). 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).
- *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.
- Whenever a contributing institution cites or quotes data from the annually fixed database in their own reports, their own QA/QC procedures apply.

- *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/NIR2019

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.
During the trend analysis, the GHG emissions for all years between 1990 and 2017 were checked in two ways:

(1) The datasets from previous years’ submissions were compared with the current submission; emissions from 1990 to 2016 should be identical to those reported last year for all emissions for which no methodological changes have been announced.
(2) The data for 2017 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 2018 (RIVM, 2018). 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 2016 and 2017. In this table, differences of >5% at sector level were used to document trends;
- 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/NIR2019.

Table 1.1: Key actions for the NIR2019

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	4-07-2018	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten voorlopige cijfers 2017 v4 juli 2018. xls
Comparison sheets with final data	5-12-2017	RIVM	Input for trend analyses	Verschiltabel_LuchtIPCC_19-11-2018.xls
Trend analysis	6-12-2017	Task Forces	Updated action list	Actiepunten definitieve cijfers 1990-2017 v 7 december 2018.xls
Resolving the issues on the action list	Until 19-12-2017	Task Forces RIVM/NIC/TNO	Final dataset	Actiepunten definitieve cijfers 1990-2017 v 20 december 2018.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	15-01-2019 15-03-2019
Writing and checks of NIR	Until 15-3-2019	Task Forces/ NIC/TNO/NIE	Draft texts	R:\.\NI National Inventory Report\NIR2019\NIR redactie
Generation of tables for NIR from CRF tables	Until 15-3-2019	NIC/TNO	Final text and tables NIR	R:\....\NIR2019 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 Statistics Netherlands. The acceptance of the dataset was, furthermore, discussed 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.

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

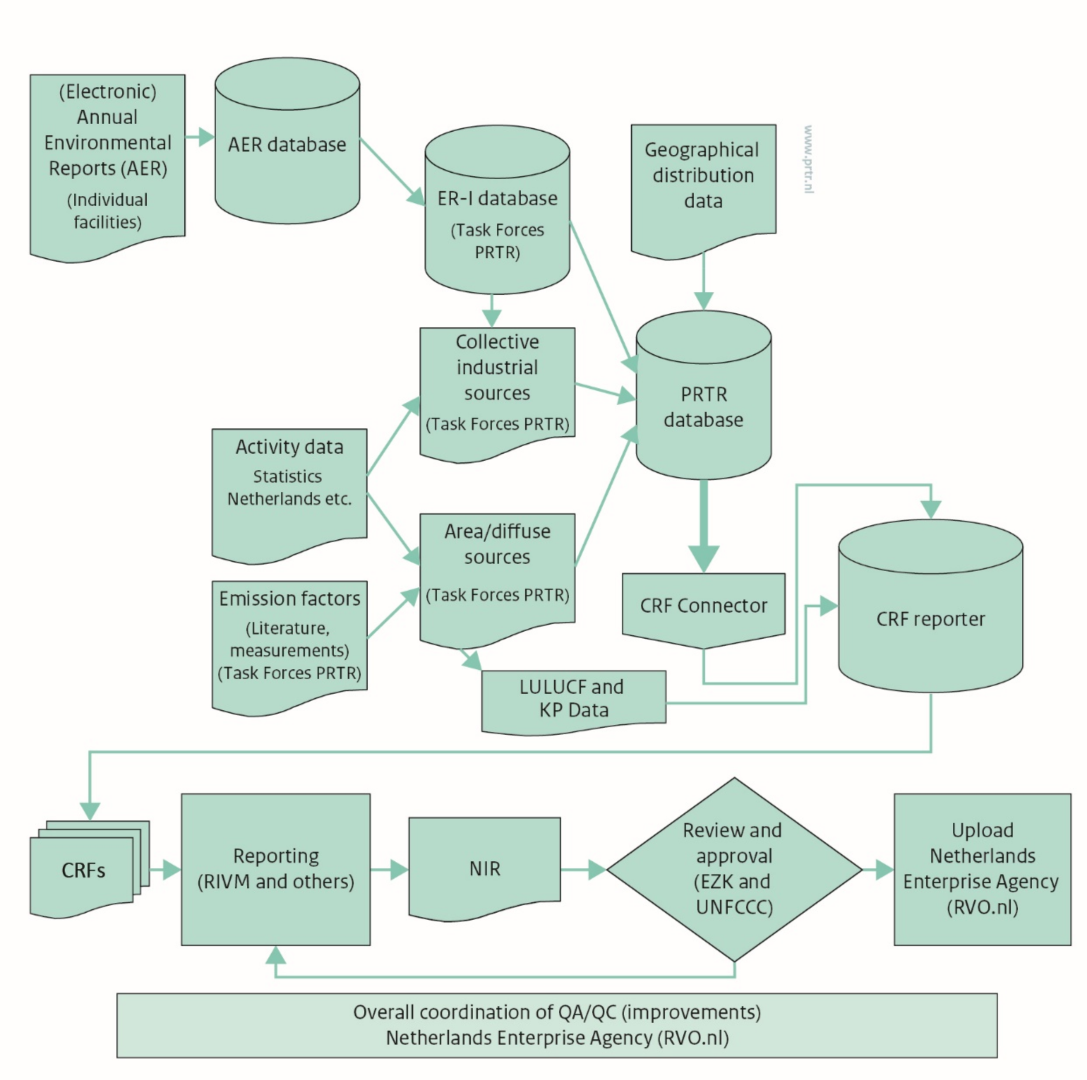


Figure 1.2: Main elements in the GHG emissions inventory process

1.3.2 *Data collection*

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

Statistical data

Statistical data are provided under various (not specifically GHG-related) obligations and legal arrangements. These include national statistics from Statistics Netherlands 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 Agriculture, Nature and Food Quality (LNV) 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, as described in section 1.2. 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).

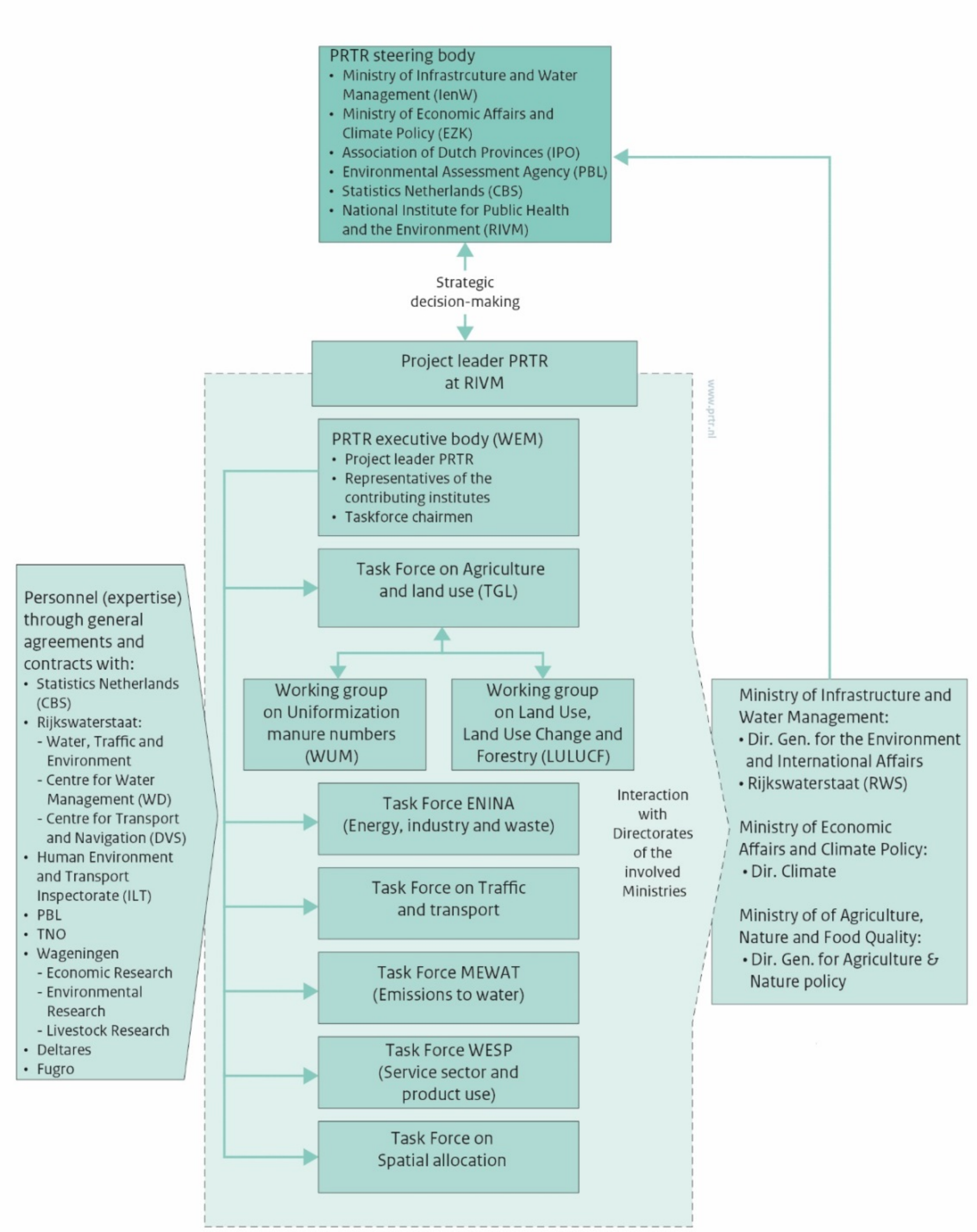


Figure 1.3: Organisational arrangements for PRTR project

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	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	CS,T1,T2,T3	CS,D,PS	T1,T1b,T2,T3	CS,D,PS		
1. Solid fuels	T3	CS				
2. Oil and natural gas	CS,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,T1,T2	CS,PS
A. Mineral industry	CS,T1,T3	CS,D,PS				
B. Chemical industry	CS,T1,T3	CS,D	CS	CS	T1,T2	CS,PS
C. Metal industry	T1a,T2	CS,D				
D. Non-energy products from fuels and solvent use	T1,T3	CS,D				
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	CS	CS	CS	CS	CS	CS
H. Other	T1	CS				
3. Agriculture	T1	D	T1,T2,T3	CS,D	T1,T1b,T2	CS,D
A. Enteric fermentation			T1,T2,T3	CS,D		
B. Manure management			T1,T2	CS,D		
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						
J. Other						
4. Land use, land-use change and forestry	CS,T1,T2	CS,D	CS,T1	CS,D	CS,D,T1	CS,D
A. Forest land	T1,T2	CS,D	T1	CS,D	T1	CS,D
B. Cropland	CS,T1	CS,D			D,T1	CS
C. Grassland	CS,T1,T2	CS,D	CS	D	CS,D,T1	CS,D
D. Wetlands	T1,T2	CS,D			D,T1	CS
E. Settlements	T1	CS,D			T1	CS
F. Other land	T1	CS,D			T1	CS
G. Harvested wood products	T1	D				
H. Other						

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
5. Waste	CS	CS	CS,T1,T2	CS,D	CS,T1,T2	CS,D
A. Solid waste disposal			T2	CS		
B. Biological treatment of solid waste			T1	CS	T1	CS
C. Incineration and open burning of waste	CS	CS	CS	CS	CS	CS
D. Waste water treatment and discharge			T1,T2	CS,D	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	T2	CS	T2	CS	T1,T3	CS
A. Mineral industry						
B. Chemical industry	T2	CS	T2	CS		
C. Metal industry			T2	CS		
D. Non-energy products from fuels and solvent use						
E. Electronic industry			T2	CS		
F. Product uses as ODS substitutes	T2	CS				
G. Other product manufacture and use					T1,T3	CS
H. Other						

1.4.2 Data sources

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

- Fossil fuel data: (1) national energy statistics from Statistics Netherlands (Energy Monitor); (2) natural gas and diesel consumption in the agricultural sector (Wageningen economic Research (WecR); (3) (residential) bio fuel data: national renewable energy statistics from Statistics Netherlands (Renewable Energy);
- Transport statistics: (1) monthly statistics for traffic and transport; (2) national renewable energy statistics from Statistics Netherlands (Renewable Energy);
- Industrial production statistics: (1) AERs from individual companies; (2) national statistics;
- Consumption of HFCs: annual reports from the accountancy firm PriceWaterhouseCoopers (only HFC data are used, due to inconsistencies for PFCs and SF6 with emissions reported elsewhere);
- Consumption/emissions of PFCs and SF6: 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 N2O: the Dutch Association of Aerosol Producers (Nederlandse Aerosol Vereniging, NAV);
- Animal numbers and Manure production and handling: Statistics Netherlands/WecR agricultural database and data from the annual agricultural census;
- Fertilizer statistics: Wageningen Economic Research agricultural statistics;
- Forest and wood statistics:
    - harvest data: FAO harvest statistics in combination with data from national forest inventories (NFI-5 and NFI-6);
    - stem volume, annual growth and fellings: Dirkse et al. (2003);
    - carbon balance: data from three National Forest Inventories: HOSP (1988–1992), fifth national forest inventory (NFI-5, 2001–2005) and sixth national forest inventory (NFI-6 2012–2013);
- Land use and land use change: based on digitized and digital topographical maps of 1990 (Kramer and van Dorland 2009), 2004 (Kramer et al., 2007), 2009 (Kramer and Clement, 2016) 2013 (Kramer and Clement, 2015) and 2017 (Kramer, 2019);
- Soil maps: Groot et al. (2005a and b) and 2014 update; Waste production and handling and CH_4 recovery from landfills: Working Group on Waste Registration (WAR), Rijkswaterstaat Environment and Statistics Netherlands.

Many recent statistics are available at Statistics Netherlands' statistical website StatLine and in Statistics Netherlands/PBL/RIVM 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, 2013 and 2017 were used (Kramer and van Dorland, 2009; Kramer et al., 2007; Kramer and Clement, 2016; Kramer and Clement, 2015; Kramer, 2019 and Arets et al., 2019). The results were national scale land use and land use change matrices (1990–2004, 2004–2009 and 2009–2013 and 2013-2017, see Arets et al., 2019).

To distinguish between mineral soils and peat soils, overlays were made with the Dutch Soil Map (Vries de et al., 2004) and its 2014 update of organic soils. 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 2017, whether it is located on a mineral soil or on an organic soil (peat or peaty) and, if on a mineral soil, what the aggregated soil type is. Land use changes after 2017 are extrapolated from the latest land use change matrix. These changes will then be updated once a new land use map becomes available. A future land use map is anticipated with a map date of 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 in combination with data from national forest inventories (NFI-5 and NFI-6);
  - stem volume, annual growth and fellings: Dirkse et al. (2003);
  - carbon balance: data from three National Forest Inventories: HOSP (1988–1992), fifth national forest inventory (NFI-5, 2001–2005) and sixth nationa forest inventory (NFI-6 2012–2013);
- Land use and land use change: based on digitized and digital topographical maps of (Kramer and van Dorland 2009), 2004 (Kramer et al., 2007), 2009 (Kramer and Clement, 2016) 2013 (Kramer and Clement, 2015) and 2017 (Kramer, 2019).

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 category analysis for the prioritization of possible inventory improvement actions.

In comparison with the key category analysis for the NIR2018 submission, following new key categories were identified:

2C3	Aluminium production	CO_2
2F6	Other	HFC
2B10	Other	CO_2
2G	Other product manufacture and use	N_2O
3B1	Mature dairy cattle	CH_4
3B1	Cattle	N_2O
3B1	Mature dairy cattle	N_2O
3B1	Growing cattle	N_2O

3B5	Indirect emissions	N_2O
3G	Liming	CO_2
5D	Wastewater treatment and discharge	N_2O

Compared to the NIR 2018, following source is no longer a key category:

5D	Wastewater treatment and discharge	CH_4

These changes are mostly the result of changing emissions and/or changing emission factors.

1.5.2 KP-LULUCF inventory

The smallest key category based on the Approach 1 level analysis including LULUCF is 647.0 Gg CO_2 (3Db Indirect N_2O emissions from managed soils; see Annex 1).
With net emissions of 602.1 Gg CO_2, the absolute annual contribution of afforestation/reforestation under the KP-LULUCF in 2017 is smaller than the smallest key category (Approach 1 level analysis including LULUCF). Deforestation under the KP-LULUCF in 2017 causes a net emission of 1,302.6 Gg CO_2, which is more than the smallest key category (Approach 1 level analysis including LULUCF). With a net figure of -990.0 Gg CO_2, removals 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 (RWS, 2014)

These data sources were supplemented by expert judgements by RIVM/PBL and Statistics Netherlands emissions experts. The expert judgements were based on independent uncertainty estimates from these experts. Their views were discussed to reach a consensus on the estimates. This was followed by an estimation of the uncertainty in the emissions in 1990 and 2017 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 2017, based on calculated uncertainties of 2%, 13%, 36% 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 2017, 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%	33%	29%		3%
2	9%	63%	23%	34%	10%
3	27%	9%	35%		13%
4	35%				35%
5		22%	37%		21%
Total	3%	9%	26%	34%	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 2017 emissions (without LULUCF)

Greenhouse gas	Approach 1 annual uncertainty	Approach 2 annual uncertainty
Carbon dioxide	2%	3%
Methane	13%	9%
Nitrous oxide	36%	26%
F-gases	41%	34%
Total	3%	3%

Table 1.4 shows, that taking into account the correlations between source categories increases the uncertainty of the national CO_2 emissions. 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 A2.1 of Annex 2 summarizes the estimates of the trend uncertainties 1990–2017 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 1990–2017 of ±2%. This means that the trend in total CO_2-equivalent emissions between 1990 and 2017 (excluding LULUCF), which is calculated to be a 12.6% (rounded 13%) decrease, will be between 11% and 15% 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 ±11%, respectively. More details on the level and trend uncertainty assessment can be found in Annex 2.
In the assessments described above (and in some more detail in Annex 2), 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 uncertainty analysis uses Monte Carlo simulations for combining different types of uncertainties and correctly representing the uncertainties

in the land-use matrix (see chapter 14 in Arets et al., 2019, 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 analysis is performed for Forest land and is based on the same data and calculations, 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 AR are estimated at +10% to -12%, which is equal to the uncertainty in Land converted to forest land. Similarly the uncertainty for total net removals from units of land under Article 3.4 FM is estimated at +26% to -21%, which is equal to the uncertainty of Forest land remaining forest land (see Chapter 6.4.3).

1.7 General assessment of completeness

1.7.1 GHG emissions inventory

At present the Netherlands GHG inventory includes almost all sources that, according to the 2006 IPCC Guidelines, should be included in the inventory. The following very minor sources are not included:

- 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.

Annex 6 presents the assessment of completeness and sources, potential sources and sinks for this submission of the NIR2019 and the CRF tables.

1.7.2 KP-LULUCF inventory

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

In the Netherlands, the conversion of non-forest to forest (AR) involves a build-up of carbon in litter. However, 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. Therefor, the conversion of non-forest to forest 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 in re/afforested areas and areas under Forest management does not occur in the Netherlands, so 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 1990–2017 by GHG and by sector. Detailed explanations of these trends are provided in Chapters 3–8.

In 2017, total GHG emissions (including indirect CO_2 emissions, excluding emissions from LULUCF) in the Netherlands were estimated at 193.7 Tg CO_2 eq. This is 12.6% lower than the 221.7 Tg CO_2 eq. reported in the base year (1990).

Figure 2.1 shows the trends and contributions of the different gases to the aggregated national GHG emissions. In the period 1990–2017, emissions of carbon dioxide (CO_2) increased by 1.0% (excluding LULUCF). Emissions of non-CO_2 GHGs methane (CH_4), nitrous oxide (N_2O) and F-gases decreased by 43.4%, 51.7% and 76.1%, respectively.

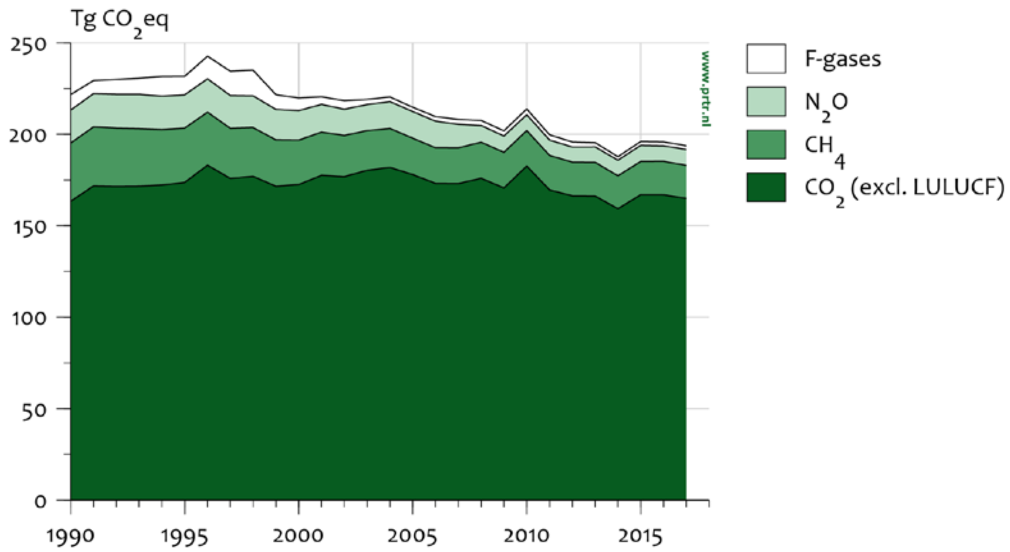


Figure 2.1: Greenhouse gases: trend and emissions levels (excl. LULUCF), 1990–2017

Emissions from LULUCF-related sources decreased over the period 1990–2017 by 13.7%. Total GHG emissions in the Netherlands for the year 2017 (including LULUCF) was 199.3 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 1990–2017, national CO_2 emissions increased by 1.0% (from 163.3 to 164.9 Tg). The Energy sector is by far the largest contributor to CO_2 emissions in the Netherlands (95.4%), the categories 1A1 Energy industries (38.2%), 1A4 Other sectors (20.1%) and 1A3 Transport (18.7%) being the largest contributors in 2017.

Compared with 2016, total CO_2 emissions decreased by 1.1% (1.9 Tg). One of the main reasons was a reduction in coal combustion for electricity and heat production (1A1a).

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 (0.45 Tg in 2017).
Carbon Capture and Storage (CCS) is not applied in the Netherlands.

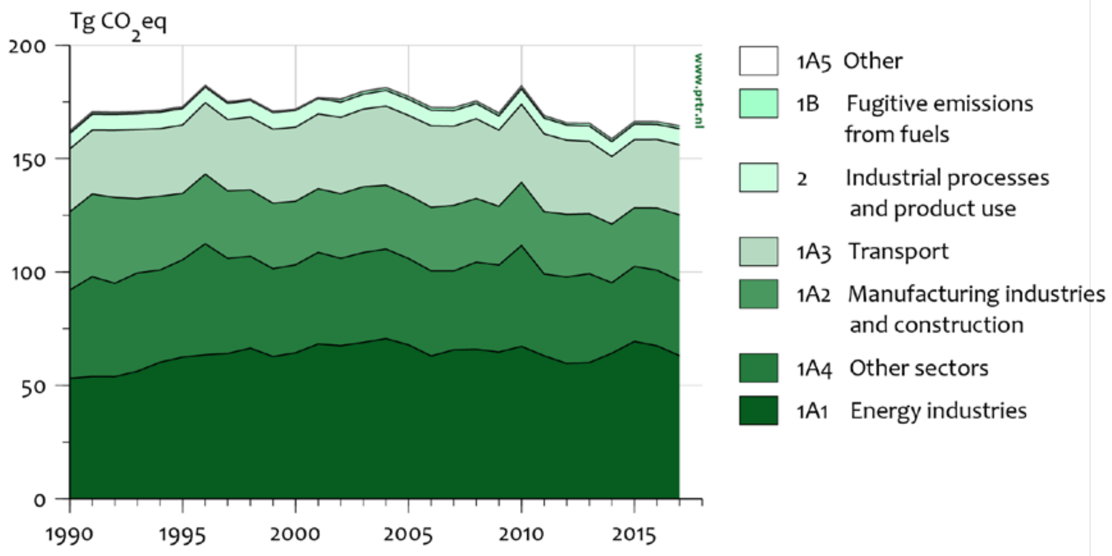


Figure 2.2: CO_2 – trend and emissions levels of sectors (excl. LULUCF), 1990–2017

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 43.4%, from 31.9 Tg in to 18.0 Tg CO_2 eq., between 1990 and 2017. The Agriculture and Waste sectors (69.5% and 16.2%, respectively) were the largest contributors in 2017.

Compared with 2016, national CH_4 emissions decreased by about 1.7% in 2017 (0.3 Tg CO_2 eq.). CH_4 emissions mainly decreased in the category 3A (Enteric fermentation) and category 5A (Solid waste disposal on land); ca 0.1 Tg CO_2 eq.and 0.2 Tg CO_2 eq., respectively.

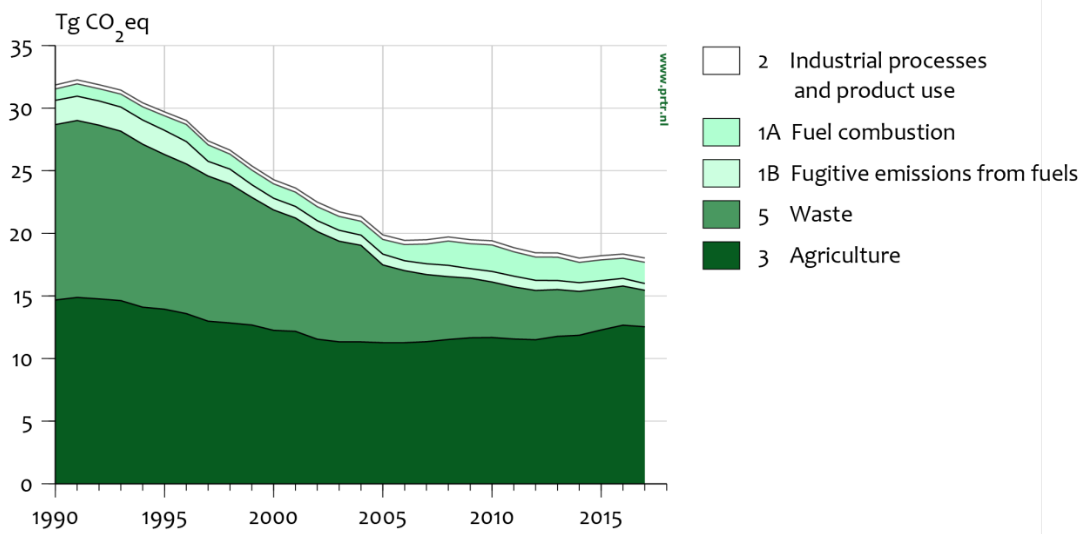


Figure 2.3: CH_4 – trend and emissions levels of sectors, 1990–2017

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 51.7%, from 18.4 Tg CO_2 eq. in 1990 to 8.7 Tg CO_2 eq. in 2017. The IPPU sector contributed the most to this decrease in N_2O emissions (emissions decreased by 78.4 % compared with the base year).

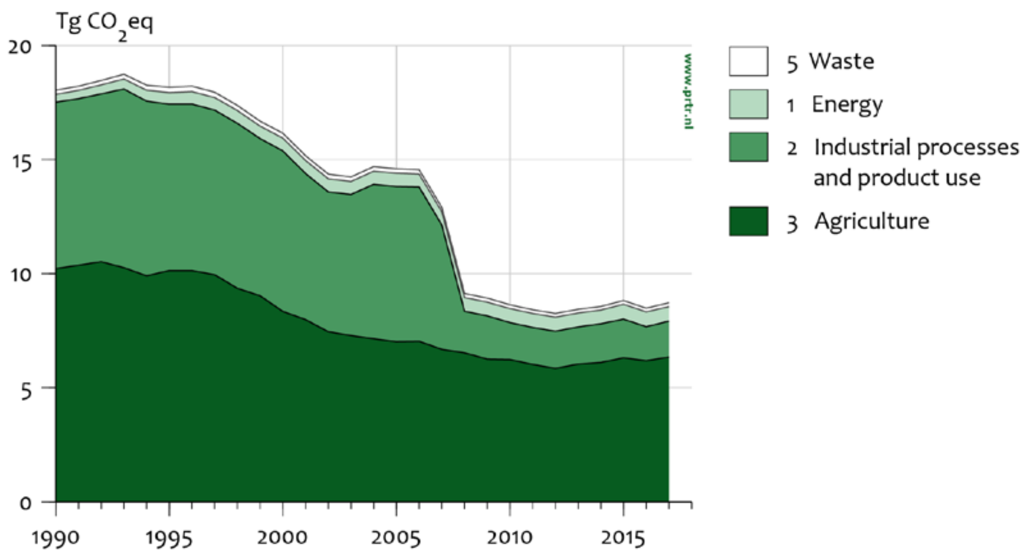


Figure 2.4: N_2O – trend and emissions levels of sectors, 1990–2017

Compared with 2016, total N_2O emissions increased by 2.8% in 2017 (0.2 Tg CO_2 eq.), mainly due to an increase of emissions in category 3D (agricultural soils).

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 76.1 % from 8.2 Tg CO_2 eq. in 1990 to 2.0 Tg CO_2 eq. in 2017. Emissions of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) decreased by 67.4% and 97.1%, respectively, during the same period, while sulphur hexafluoride (SF_6) emissions decreased by 38.9%. It should be noted that, due to the fact that there is no separate registration of NF_3 in the Netherlands, the emissions of NF3 are included in the PFC emissions.

Between 2016 and 2017, aggregated emissions of F-gases decreased by 6.1%. HFCs emissions decreased by 2.7% and PFCs emissions decreased by 49.3% between 2016 and 2017. The latter decrease was mainly a result of a further implementation of an intensive reduction scheme in category 2E1 (Integrated circuit or semiconductor). SF_6 emissions decreased by 5.8% over the same period.

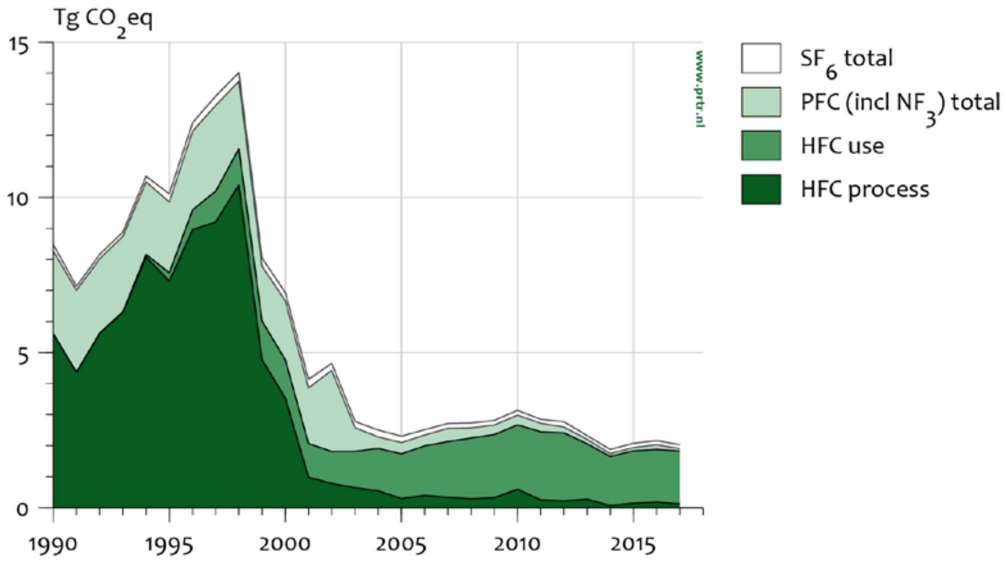


Figure 2.5: Fluorinated gases – trend and emissions levels of individual F-gases, 1990–2017

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 ±11%, respectively. For all GHGs taken together, the uncertainty estimate in annual emissions is ±3%. The uncertainty estimates in annual emissions of For CO_2, CH_4 and N_2O are ±2%, ±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.

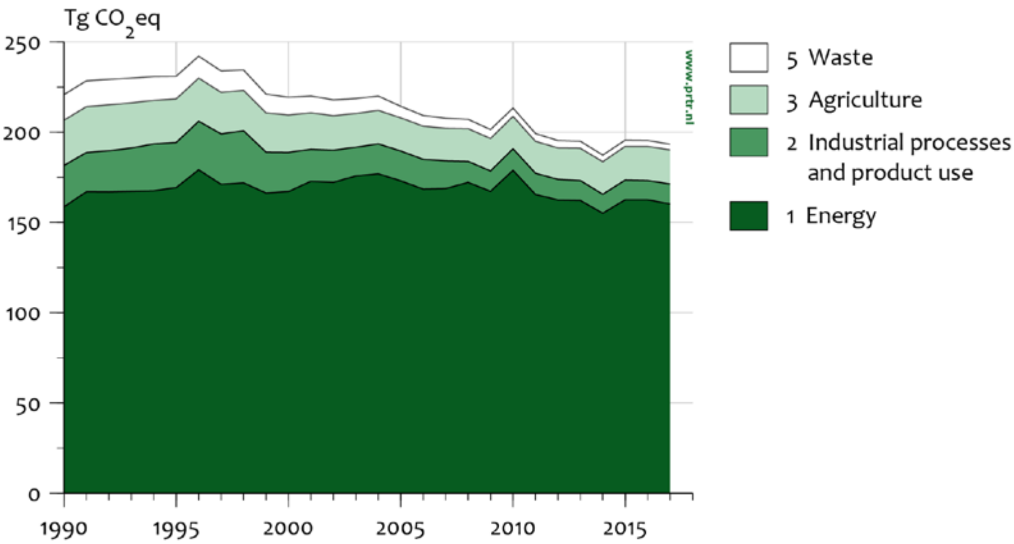


Figure 2.6: Aggregated GHGs – trend and emissions levels of sectors (excl. LULUCF), 1990–2017

The Energy sector is by far the largest contributor to total GHG emissions in the national inventory (contributing 71.5% in the base year and 82.7% in 2017. The emissions level of the Energy sector increased by approximately 1% in the period 1990–2017.
Total GHG emissions of all other sectors (IPPU, Agriculture, LULUCF and Waste) decreased by 51.7%, 24.5%, 13.7% and 78.3%, respectively, in 2017 compared with the base year.
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 ±3%, ±10%, ±13% and ±21%, respectively; for the LULUCF sector (4) the uncertainty is estimated at ±35%.
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 53% decrease, for sector 3 (Agriculture) at ±8% in the 25% decrease and for sector 5 (Waste) at ±1% in the 79% 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 2017 reduced by 54% and 66%, respectively. For SO_2, the reduction was 86%; and for NO_x, 2017 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.

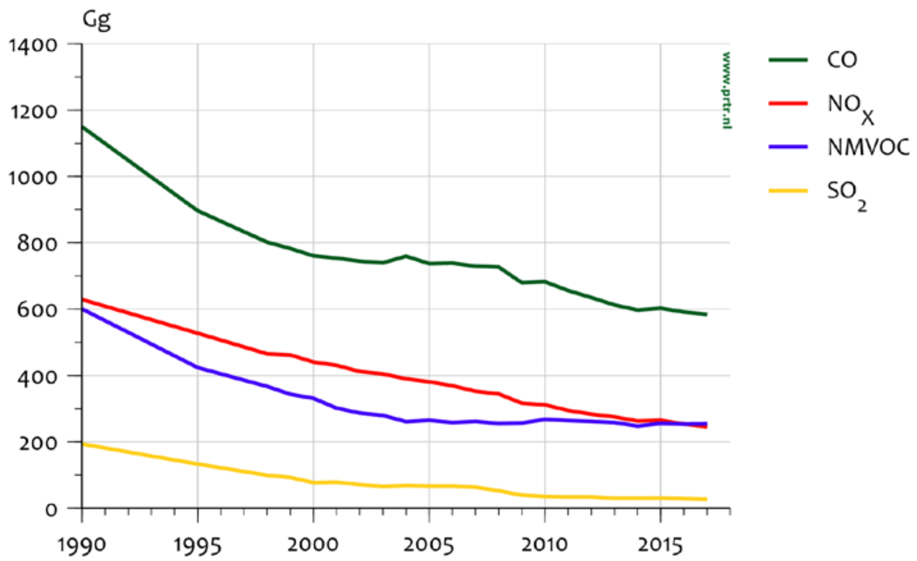


Figure 2.7: Emissions levels and trends of CO, NO_x, NMVOC and SO_2, 1990–2017 (Gg)

3. Energy (CRF sector 1)

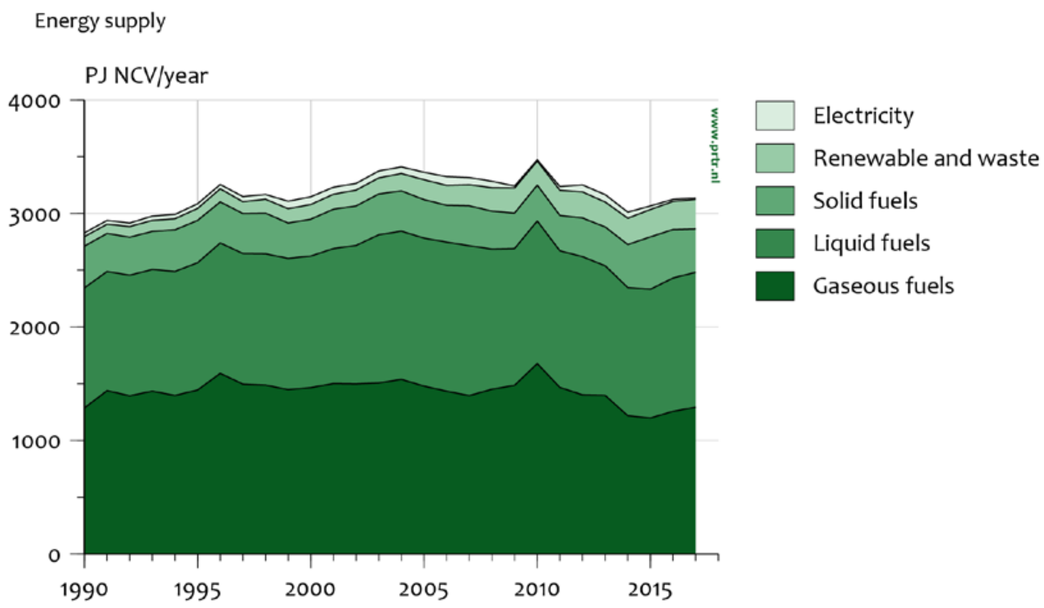
Major changes in the Energy sector compared with the National Inventory Report 2018

Emissions:	In 2017, GHG emissions decreased by 1.4% compared to 2016.
Key categories:	No changes
Methodologies:	New activity data for calculating the activity data of charcoal use in barbecues
Activity data:	• An error is corrected in the fuel use in the chemical sector (1A2c). For the years 2012-2016, fuel statistics for a few chemical companies were incomplete; • Energy statistics for the years 2015 and 2016 have been improved. • For road transport (1A3), some recalculations because of improvements in statistical data.

3.1 Overview of sector

3.1.1. Energy supply and energy demand

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.



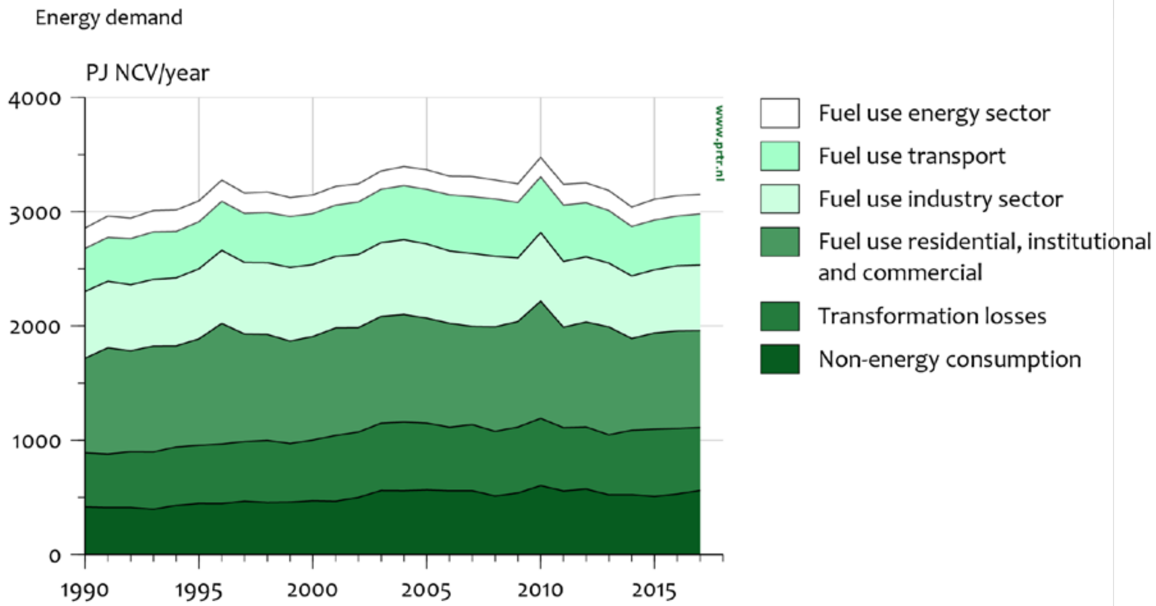


Figure 3.1: Overview of energy supply and energy demand in the Netherlands, 1990–2017 ('Electricity' refers to imported electricity only)

3.1.2 *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 1990–2017 period, total fossil fuel combustion increased by 6%, due to a 12% increase in liquid fuel consumption, a 4% increase in solid fuel consumption and a 1% increase in gaseous fuel consumption.
Total fossil fuel consumption for combustion increased by about 0.2% between 2016 and 2017, mainly due to a 2.9% and 1.1% increase in gaseous fuel and liquid fuel consumption, respectively. Use of solid fuels decreased by 10.4%.
Note that solid fuel consumption showed an increase in 2015, caused by the new coal-fired power plants, which started in 2014 and increased production in 2015. The decrease in solid fuel consumption in 2016 and 2017 is caused by the closure of three old coal fired power plants in these years

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. This caused a decrease in the use of gaseous fuel for space heating in that year.

3.1.3 *GHG emissions from the Energy sector*

Table 3.1 shows the emissions in the main categories in the Energy sector. 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; resulting from both combustion and fugitive emissions

Table 3.1 Overview of emissions in the energy sector in the base year and the last two years of the inventory (in Tg CO_2 eq

Sector / category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1 Energy	CO_2		155,4	159,7	157,3	1,2%	98,2%	95,4%	81,2%
	CH_4		2,9	2,2	2,2	-21,6%	1,4%	12,4%	1,2%
	N_2O		0,3	0,6	0,6	85,6%	0,4%	0,0%	0,3%
	all		158,6	162,6	160,2	1,0%	100,0%		82,7%
1A Fuel combustion	CO_2		154,5	158,6	156,2	1,1%	97,5%	94,7%	80,6%
	CH_4		0,9	1,6	1,7	86,4%	1,1%	9,4%	0,9%
	N_2O		0,3	0,6	0,6	85,6%	0,4%	0,0%	0,3%
	all		155,8	160,8	158,5	1,7%	99,0%		81,8%
1B Fugitive emissions	CO_2		0,9	1,1	1,1	26,4%	0,7%	0,7%	0,6%
	CH_4		1,9	0,6	0,5	-72,1%	0,3%	3,0%	0,3%
	all		2,8	1,7	1,7	-41,3%	1,0%		0,9%
Total national emissions	CO_2		163,3	166,8	164,9	1,0%			
(excl LULUCF)	CH_4		31,8	18,3	18,0	-43,4%			
	N_2O		18,0	8,5	8,7	-51,7%			
	total*		221,7	195,8	193,7	-12,6%			

** including f-gases*

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;
- distribution of fuels.

3.1.4 *Overview of shares and trends in emissions*

Figure 3.2 show the contributions of the source categories and emission trends in the Energy sector. 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.

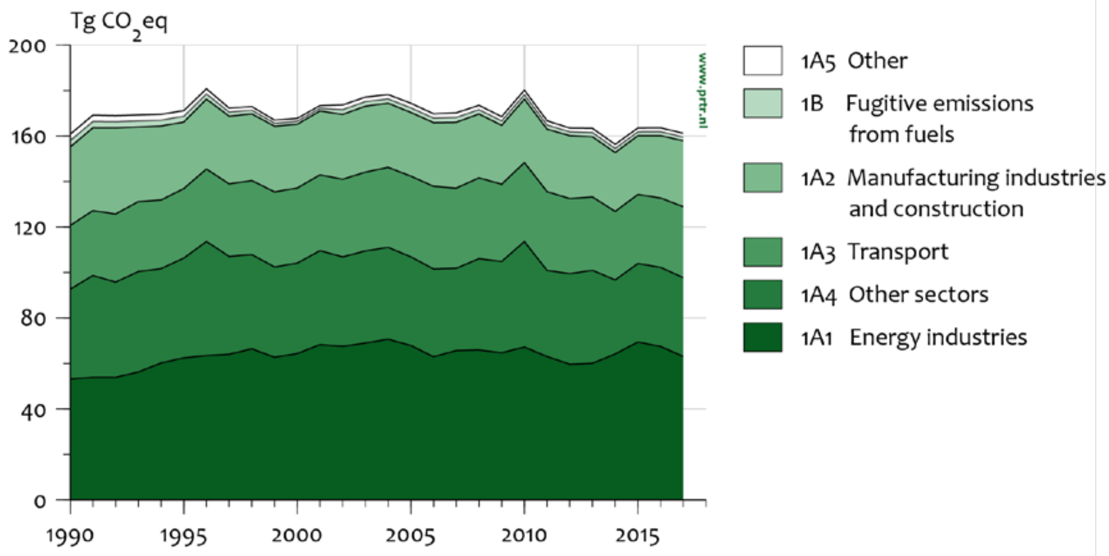


Figure 3.2: Sector 1 Energy – trend and emissions levels of total greenhouse gas emissions per source category, 1990–2017

3.2 Fuel combustion (1A)

Table 3.2 presents the source categories under category 1A in the Energy sector. 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).

Table 3.2 Overview of emissions in the fuel combustion sector (1A) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	**Gas**	**Key**	**1990**	**2016**	**2017**	**2017 vs 1990**	**Contribution to total in 2017 (%) by**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1A Fuel combustion	CO_2		154,5	158,6	156,2	1,1%	97,5%	94,7%	80,6%
	CH_4		0,9	1,6	1,7	86,4%	1,1%	9,4%	0,9%
	N_2O		0,3	0,6	0,6	85,6%	0,4%	0,0%	0,3%
	All		155,8	160,8	158,5	1,7%	99,0%	104,1%	81,8%
1A1 Energy Industries	CO_2		53,1	67,4	63,1	18,7%	39,4%	38,2%	32,6%
	CH_4	non key	0,1	0,1	0,1	47,4%	0,1%	0,6%	0,1%
	N_2O	non key	0,1	0,3	0,3	93,6%	0,2%	0,0%	0,1%
	All		53,4	67,9	63,5	18,9%	39,6%		32,8%
1A2 Manufacturing industries and construction	CO_2		34,5	27,4	29,0	-15,8%	18,1%	17,6%	15,0%
	CH_4	non key	0,1	0,1	0,1	-2,0%	0,0%	0,4%	0,0%
	N_2O	non key	0,0	0,0	0,0	17,6%	0,0%	0,0%	0,0%
	All		34,6	27,5	29,1	-15,8%	18,2%		15,0%
1A3. Transport	CO_2		27,7	30,2	30,9	11,3%	19,3%	18,7%	15,9%
	CH_4		0,2	0,1	0,1	-66,9%	0,0%	0,4%	0,0%
	N_2O		0,1	0,2	0,3	143,6%	0,2%	0,0%	0,1%
	All		28,0	30,5	31,2	11,3%	19,5%		16,1%
1A4. Other sectors	CO_2		38,9	33,4	33,1	-14,9%	20,7%	20,1%	17,1%
	CH_4		0,6	1,4	1,5	154,3%	0,9%	8,1%	0,8%
	N_2O	non key	0,1	0,1	0,1	5,0%	0,0%	0,0%	0,0%
	All		39,5	34,8	34,6	-12,4%	21,6%		17,9%
1A5 Other	CO_2	non key	0,3	0,2	0,1	-52,7%	0,1%	0,1%	0,1%
	CH_4	non key	0,0	0,0	0,0	-60,2%	0,0%	0,0%	0,0%
	N_2O	non key	0,0	0,0	0,0	-59,5%	0,0%	0,0%	0,0%
	All		0,3	0,2	0,2	-52,8%	0,1%		0,1%

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 2017 is shown in Table 3.3 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 3.3: 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	390	5358	85
		Stock change	-2	-8	0
		Total exports	-130	-3963	-1081
		Bunkers	0	-520	0
	Consumption	Gross inland consumption	-257	-1037	-1287
		whereof: Final non-energy consumption	*-11*	*-317*	*-88*
2017	Supply	Primary production	0	54	1594
		Total imports	394	8355	1384
		Stock change	3	-48	-75
		Total exports	-8	-6666	-1797
		Bunkers	0	-660	0
	Consumption	Gross inland consumption	-389	-1035	-1107
		whereof: Final non-energy consumption	*0*	*-432*	*-96*

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 Statistics Netherlands. National default, partly country-specific, CO_2 EFs are taken from Zijlema, 2019 (see Annex 5).

The fuels from the energy statistics are allocated to the fuels in the RA, as shown in Table 3.4.

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 3.4: 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)	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)	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	Antraciet	Anthracite
		Coking coal	Cokeskool	Coking coal
		Other bituminous coal	Totaal steenkool	Total coal
		Sub-bituminous coal	IE 2)	IE 2)
		Lignite	Bruinkool	Lignite
		Oil shale and tar sand	NO 1)	NO 1)
	Secondary fuels	BKB and patent fuel	Bruinkoolbriketten	BKB (Braunkohlenbriketts)
		Coke oven/gas coke	Cokesovencokes	Coke-oven cokes
		Coal tar	Steenkoolteer	Coal tar

Fuel types in the Reference Approach			**Fuel types in the Netherlands' energy statistics**	
Fuel type			**Dutch**	**English**
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)	NO 1)
Biomass total		Solid biomass	Vaste en vloeibare biomassa 4)	Solid and liquid biomass 4)
		Liquid biomass	Biobenzine	Biogasoline
			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) Sub-bituminous coal is included in other bituminous coal.
3) Ethane is included in LPG.
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 3.5 presents the results of the RA calculation for 1990–2017, compared with the official national total emissions reported as fuel combustion (source category 1A).

In 2018, a peer review on the Reference Approach calculation was performed by CE Delft. Parts of the comments have been used to improve the reporting in 2018. Furthermore, a meeting was scheduled with Statistics Netherlands (responsible for the national energy statistics) and the Dutch PRTR (responsible for the emission calculations and the Reference Approach calculation). In this meeting, the differences between the energy statistics and the data needs in the CRF were discussed. A few improvements have been included in the Reference Approach calculation in the NIR 2019:

- Coal has been split up between other bituminous coal, anthracite and coking coal
- Description in the NIR and the methodology report has been improved.

The annual difference calculated from the direct comparison varies between -1% and 0%.

Table 3.5: 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	56.0	53.0	48.2	49.0
Solid fuels [1)]	33.4	34.1	30.2	31.4	29.5	43.6	40.4
Gaseous fuels	68.1	76.3	77.5	78.7	87.5	61.9	65.6
Others	0.9	1.4	1.9	2.7	2.9	3.2	3.4
Total RA	153.0	164.5	163.3	168.8	172.9	156.9	158.4
SA							
Liquid fuels	50.4	52.7	55.0	56.2	53.6	48.5	49.8
Solid fuels	33.6	34.2	29.8	31.4	29.7	43.0	39.7
Gaseous fuels	69.9	77.4	77.7	79.5	88.4	64.1	66.2
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	158.5	158.6
Difference (%)							
Liquid fuels	0.2%	-0.1%	-2.3%	-0.3%	-1.2%	-0.6%	-1.5%
Solid fuels	-0.4%	-0.2%	1.3%	0.1%	-0.8%	1.2%	1.8%
Gaseous fuels	-2.6%	-1.4%	-0.3%	-1.1%	-0.9%	-3.4%	-0.9%
Other	49.3%	74.3%	18.6%	29.7%	16.8%	10.8%	13.0%
Total	-1.0%	-0.4%	-0.5%	-0.3%	-0.7%	-1.0%	-0.1%

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 -0.8% 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.
- The energy statistics contain production data for chemical waste gas and additives. These cannot be included in the Reference Approach tables and are therefore excluded from the RA (while combustion of these fuels is included in the SA). The CO_2 emissions from liquid fuels in the Reference Approach are therefore slightly underestimated.

3.2.2 International bunker fuels (1D)

3.2.2.1 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 3.3.

Fuel deliveries for international aviation more than doubled between 1990 and 1999, stabilised 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 18% to 168 PJ in 2017.
There are no deliveries of aviation gasoline or biomass for international aviation reported in the Energy Balance.

Fuel deliveries for international navigation increased by 51% between 1990 and 2008, but then decreased by 29% to 482 PJ in 2017. 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, followed by a decreased to 3.4 PJ in 2016. In 2017 there is an increase to 4.7 PJ.

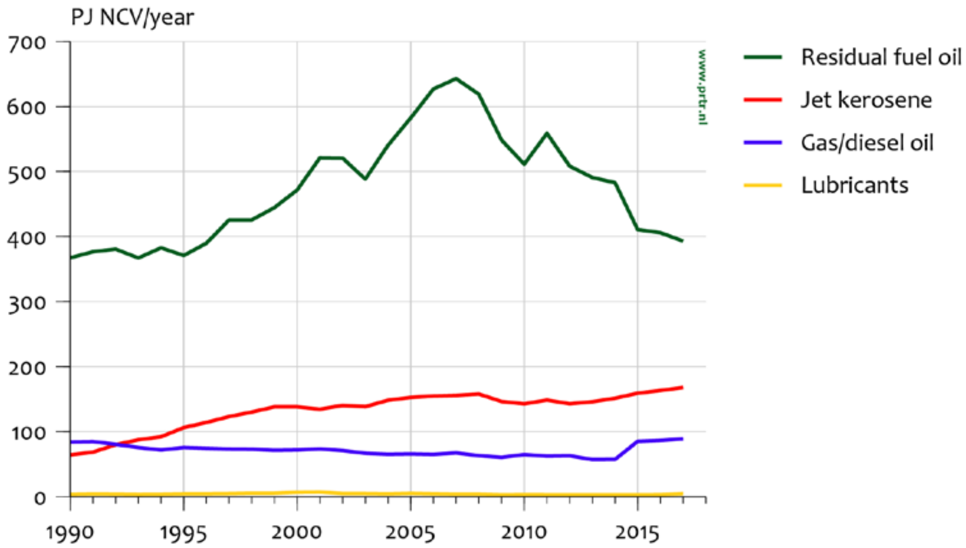


Figure 3.3: Marine and aviation bunker fuel exports, 1990–2016

3.2.2.2 Methodological issues

CO2 emissions from bunker fuels are calculated using a Tier 1 and 2 approach. Default heating values and CO2 EFs are used for heavy fuel oil, jet kerosene and lubricants, whereas country-specific heating values and CO2 EFs are used for diesel oil, derived from the Netherlands' list of fuels (Zijlema, 2019). 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. (2019).

3.2.2.3 Category-specific recalculations

Compared to the NIR 2018, bunker emissions for the years 2015 and 2016 have been recalculated (-5%or 20 PJ). The amount of navigation bunkers changed due the revision of the energy statistics For 2015 and 2016, 20 PJ fuel oil had abusively been to bunker fuels; where as in practice these 20 PJ were exported.

3.2.3 Feed stocks and non-energy use of fuels

Table 3.3 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

Table 3.6 provides an overview of the emissions in the energy industries sector (1A1), as well as the key categories. Figure 3.4 shows the development of total GHG emissions by sub-category of the energy industries, in the years 1990-2017.

Table 3.6 Overview of emissions in the energy industries sector (1A1) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1A1 Energy Industries	CO_2		53,1	67,4	63,1	18,7%	39,4%	38,2%	32,6%
	CH_4	non key	0,1	0,1	0,1	47,4%	0,1%	0,6%	0,1%
	N_2O	non key	0,1	0,3	0,3	93,6%	0,2%	0,0%	0,1%
	All		53,4	67,9	63,5	18,9%	39,6%		32,8%
1A1a Public Electricity and Heat Production, total	CO_2		40,0	55,0	51,4	28,4%	32,1%	31,2%	26,5%
1A1a liquids	CO_2	T	0,2	0,8	0,6	153,3%	0,4%	0,4%	0,3%
1A1a solids	CO_2	L,T	25,9	34,0	29,3	13,2%	18,3%	17,8%	15,1%
1A1a gas	CO_2	L,T	13,3	17,3	18,5	39,1%	11,6%	11,2%	9,6%
1A1a other fuels	CO2	L,T	0,6	3,0	3,0	394,2%	1,9%	1,8%	1,5%
1A1b. Petroleum refining, total	CO_2		11,0	9,6	9,0	-18,0%	5,6%	5,5%	4,7%
1A1b liquids	CO_2	L,T	10,0	9,6	6,6	-33,7%	4,1%	4,0%	3,4%
1a1b gases	CO_2	L,T	1,0	9,6	2,4	132,0%	1,5%	1,5%	1,2%
1A1c Manufacture of Solid Fuels and Other Energy Industries, total	CO_2		2,1	2,8	2,7	25,8%	1,7%	1,6%	1,4%
1A1c solids & liquid	CO_2		0,9	1,2	1,0	11,3%	0,6%	0,6%	0,5%
liquids	CO_2	non key	0,0	0,0	0,0	-100,0%	0,0%	0,0%	0,0%
solids	CO_2	L	0,9	1,2	1,0	12,5%	0,6%	0,6%	0,5%
1A1c gases	CO_2	L,T	1,2	1,6	1,6	37,1%	1,0%	1,0%	0,8%

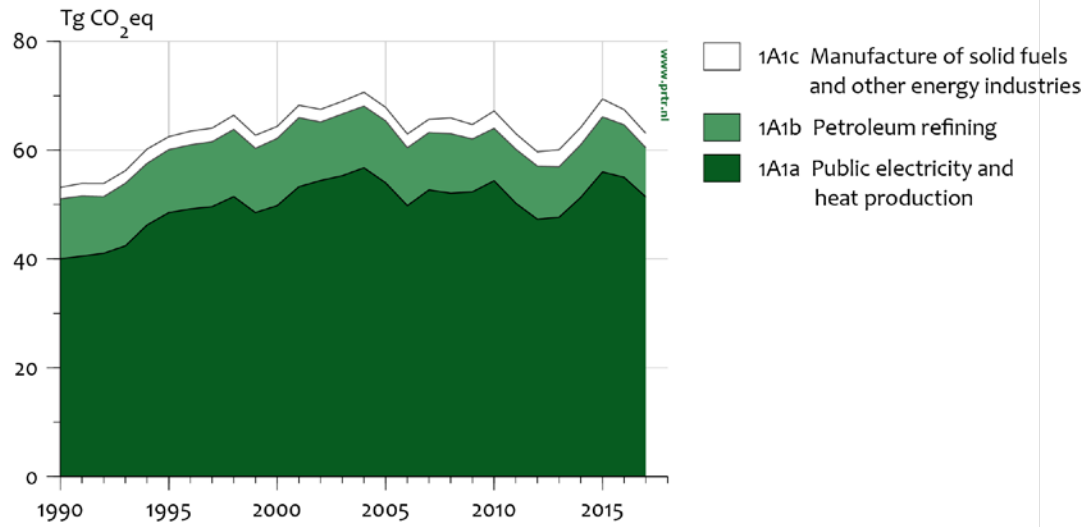


Figure 3.4: 1A1 Energy industries – trend in total GHG emission by sub-category, 1990–2017

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. The increasing trend in electric power production corresponds to a substantial increase in CO_2 emissions from fossil fuel combustion by power plants (see Figure 3.4).

Compared 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).

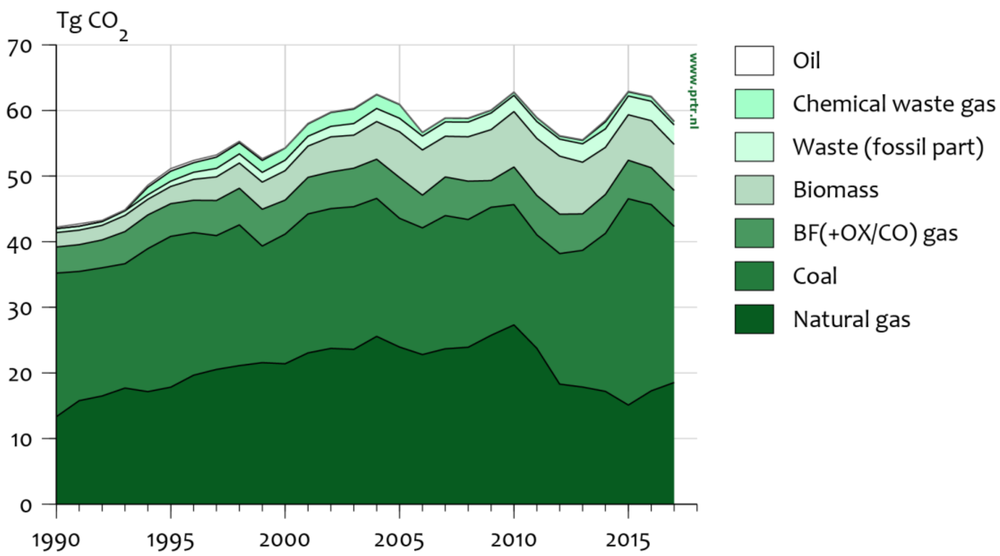


Figure 3.5: Trend in CO_2 emissions from fossil and biogenic fuel use in power plants, 1990–2017. The abbreviation BF/OX/CO refers to blast furnace gas, oxygen furnace gas, coke oven gas and phosphor oven gas. The biogenic part of waste is included in biomass.

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.

Emissions from waste incineration are included in 1A1a because they all waste incinerators 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. From 1990, an increasing amount of waste has been 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 until 2010 is due to the increase in the share of plastics (which have a high carbon content) in combustible waste.

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.

Over the years there has been a fluctuation in CO_2 emissions in 1A1a due to market circumstances. In some years the import of electricity was higher (e.g. 1999, 2000, 2006, 2010) than in other years.
Other influencing factors have been:

- a significant shift from coal to chemical waste gas and natural gas in 1999;
- New large power plants in 2004 and 2014

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 is the second largest emission source sub-category in the category 1A1. 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.

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.

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).

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 Annual Environmental Reports (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 emissions for coke production by the iron and steel plant are 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

Details of methodologies, data sources and country-specific source allocation issues are provided in Peek et al. (2019).

The emissions from this source category are calculated in two steps: First, emissions are calculated by multiplying fuel consumption with country-specific emission factors. Second, reported emissions of a select number of companies are used to refine the emission calculation. This paragraph provides a description of these two steps, and it provides a comparison of the country-specific emission factors and the implied emission factors (including an explanation of the differences).

Emission calculation step 1
The first step of the emission calculation consists of a multiplication of fuel consumption with country-specific emission factors.

Activity data are derived from the aggregated statistical data from national energy statistics published annually by Statistics Netherlands (see www.cbs.nl). The aggregated statistical data 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).
Emission factors are either IPCC default or country-specific emission factors (Tier 1 and Tier 2 method for CO_2, Tier 2 method for CH_4 and Tier 1 method for N_2O). 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. 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., 2019) for more details on the CH_4 EF of gas engines). For N_2O, IPCC default EFs are used.

For waste incineration the activity data and EFs are explained in section 7.4.

Emission calculation step 2
In the second step, reported emissions of a select number of companies are used to refine the emission calculation. 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 (Annual Environmental Report) 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, the CO_2 emissions data are not used for the emissions inventory. Country-specific EFs are used instead. This occurs only rarely, and the emissions are recalculated when the validated data from these companies become available in a later stage.

For each relevant company, 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 of a company are combined with energy use, as recorded in energy statistics for that specific company, to derive a company-specific EF. For each company, a different company-specific emission factor is derived and is used to calculate the emissions.

The following company-specific emission factors have been calculated:

- Natural gas: Since 2003, company-specific EFs have been derived for the combustion of ‘raw’ natural gas. For the years prior to 2003, EFs from the Netherlands’ list of fuels (Zijlema, 2019) are used.
- 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 2002, EFs from the Netherlands’ list of fuels (Zijlema, 2019) 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 years prior to 2007, EFs from the Netherlands' list of fuels (Zijlema, 2019) 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 years prior to 2007, EFs from the Netherlands' list of fuels (Zijlema, 2019) are used.
- Phosphor gas: Since 2006, company-specific EFs have been derived for the single company and are used in the emissions inventory. For years prior to 2006, EFs from the Netherlands' list of fuels (Zijlema, 2019) 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 years prior to 2006, EFs from the Netherlands list of fuels (Zijlema, 2019) 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 2006, a country-specific EF is used for all companies.

Comparison of emission factors
For the year 2017, approximately 97% of CO_2 emissions were calculated using country-specific or company-specific EFs. The remaining 3% 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 3.7. Since some emissions data in this sector originate from individual companies, some of the values (in Table 3.7) 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 these are available to the reviewers upon request.

Table 3.7: Overview of EFs used for the year 2017 in the category Energy industries (1A1)

Fuel	Amount of fuel used in 2017 (TJ NCV)	IEFs (g/GJ)		
		CO_2 (x1000)	N_2O	CH_4
Natural gas	391 945	57.6	0.20	8.08
Other bituminous coal	335 298	92.6	1.08	0.35
Waste gas	94 301	64.5	0.10	3.60
Waste (biogenic fractionmass)	40 484	125.3	6.17	0.00
Other fuels (not mentioned above)	22 764	NA	NA	NA

Explanation for the source-specific EFs

Natural gas

The standard CH_4 EF for natural gas is 5.7 g/GJ. Only in sub-category *1A1c 'other energy industries',* 'wet' natural gas (directly extracted from the wells) is 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 (56.6 kg CO_2/GJ and 0.1 g N_2O/GJ), because this category includes emissions from the combustion of crude 'wet' natural gas.

Coal

CO_2 emissions from coal are based on emissions data from the ETS, and the IEF is different from the country-specific EF.

Waste gas (refinery gas)

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.

Waste

The EF for N_2O emissions from waste combustion (both the fossil and biomass fraction) is either with SNCR or with SCR (100 g/ton and 20 g/ton, respectively), depending on choices made by the operator of an incinerator. The EF for CH_4 from waste incineration is 0 g/GJ as a result of a study on emissions from waste incineration (§2.3.2.1.2 of (Peek et al., 2019); DHV, 2010; and NL Agency, 2010). That this is possible is stated in 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 (§7.4 and Peek et al., 2019).

Blast furnace gas

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.

The methodology for calculation of Non-Road Mobile Machinery (NRMM) emissions is described in paragraph 3.2.7.2.

Trends in the IEF

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 103.1 and 111.8 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 74.9 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/Annex 2 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 category 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 kg 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. (2019).

3.2.4.5 Category-specific recalculations

The energy statistics for the years 2015 and 2016 have been improved (some corrections). This results in the following changes in CO_2 emissions (in Gg CO_2):

	2015	2016
1A1a	-36.5	+117.3
1A1b	-3.4	+43.9
1A1c	+3.6	+7.5

Also CH_4 and N_2O emissions have been recalculated with the improved energy statistics.

3.2.4.6 Category-specific planned improvements

Following the review recommendation of 2017, it is planned to study the CO_2 emission factor of chemical waste gas for the earlier years, using reported emission data from individual companies in ETS and AERs. If the data in the ETS and AERs prove to be representative to use for the earlier years as well, these will be used to calculate a new CO_2 emission factor for chemical waste gas.

3.2.5 Manufacturing industries and construction (1A2)

3.2.5.1 Source category description

Table 3.8 provides an overview of sub-source categories, emissions and key categories in the Manufacturing industries and construction sector (1A2).

Table 3.8. Overview of emissions in the manufacturing industries and construction sector (1A2) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1A2 Manufacturing industries and construction	CO_2		34,5	27,4	29,0	-15,8%	18,1%	17,6%	15,0%
	CH_4	non key	0,1	0,1	0,1	-2,0%	0,0%	0,4%	0,0%
	N_2O	non key	0,0	0,0	0,0	17,6%	0,0%	0,0%	0,0%
	All	-	34,6	27,5	29,1	-15,8%	18,2%		15,0%
1A2 liquids	*CO_2*	*L,T*	*8,8*	*9,3*	*9,4*	*6,5%*	*5,8%*	*5,7%*	*4,8%*
1A2 solids	*CO_2*	*L,T*	*6,6*	*4,4*	*5,2*	*-21,5%*	*3,2%*	*3,2%*	*2,7%*
1A2 gases	*CO_2*	*L,T*	*19,0*	*13,6*	*14,4*	*-24,2%*	*9,0%*	*8,8%*	*7,5%*
1A2a. Iron and steel	CO_2		5,6	4,7	5,4	-3,1%	*3,4%*	*3,3%*	*2,8%*
1A2b. Non-Ferrous Metals	CO_2		0,2	0,2	0,2	-18,3%	*0,1%*	*0,1%*	*0,1%*
1A2c. Chemicals	CO_2		17,3	13,9	14,5	-16,0%	*9,1%*	*8,8%*	*7,5%*
1A2d. Pulp, Paper and Print	CO_2		1,7	0,9	0,9	-46,0%	*0,6%*	*0,5%*	*0,5%*
1A2e. Food Processing, Beverages and Tobacco	CO_2		4,0	3,6	3,7	-6,9%	*2,3%*	*2,3%*	*1,9%*
1A2f. Non metalic minerals	CO_2		2,3	1,2	1,2	-46,8%	*0,8%*	*0,7%*	*0,6%*
1A2g. Other	CO_2		3,4	3,0	3,0	-10,5%	*1,9%*	*1,8%*	*1,6%*

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 CH4 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 (1A2c and 1A2e); 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 3.9).

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 1990–2017, 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 3.9: Fuel use in 1A2 Manufacturing industries and construction in selected years (PJ NCV/year)

	Amount of fuel used (PJ NCV/year)							
Fuel type/Sub-category	1990	1995	2000	2005	2010	2015	2016	2017
Gaseous fuels								
Iron and steel	11.7	13.0	13.7	12.5	12.0	11.1	10.8	11.4
Non-ferrous metals	3.8	4.3	4.2	4.0	3.6	2.8	2.8	3.1
Chemicals	170.7	139.0	117.8	105.3	97.6	94.7	98.2	118.7
Pulp, paper and print	29.2	24.4	27.4	29.7	21.0	15.6	15.4	15.9
Food processing, beverages and tobacco	63.7	68.5	73.7	67.1	57.0	61.6	62.7	63.7
Non-metallic minerals	26.1	23.8	26.5	23.5	22.6	17.9	18.5	17.8
Other	30.1	34.8	36.3	32.6	31.4	23.2	24.9	24.6
Liquid fuels								
Iron and steel	0.3	0.3	0.1	0.1	0.1	0.2	0.2	NO
Non-ferrous metals	NO	NO	NO	NO	NO	NO	NO	NO
Chemicals	96.2	77.6	82.6	93.2	112.7	94.4	109.8	119.8
Pulp, paper and print	0.0	0.0	NO	NO	NO	NO	NO	NO
Food processing, beverages and tobacco	2.2	0.6	0.2	0.2	NO	NO	NO	NO
Non-metallic minerals	5.6	4.2	1.9	0.8	0.7	0.2	0.2	0.2
Other	22.4	24.2	26.6	24.6	22.7	20.9	20.9	21.5
Solid fuels								
Iron and steel	73.4	80.6	68.5	81.0	70.5	80.7	81.2	85.6
Non-ferrous metals	0.0	NO	NO	NO	NO	NO	NO	NO
Chemicals	12.8	0.2	0.1	NO	NO	NO	NO	NO
Pulp, paper and print	0.1	NO	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	1.3
Non-metallic minerals	3.3	2.1	2.3	1.5	1.5	1.5	1.5	1.8
Other	0.4	0.2	0.3	0.5	1.6	0.5	0.9	0.9

The derivation of these figures, however, should also be considered 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.

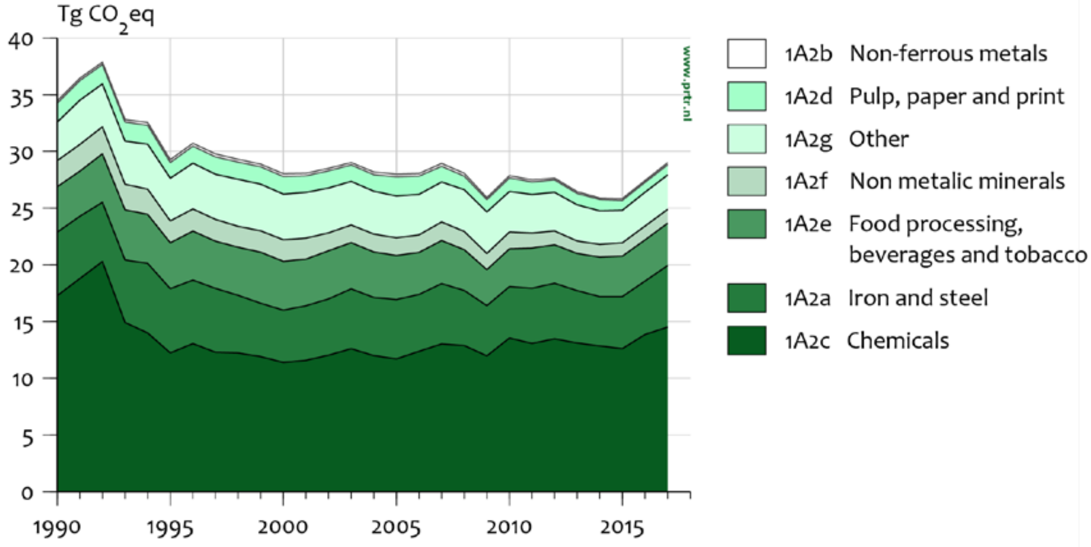


Figure 3.6: 1A2 Manufacturing industries and construction – trend and emissions levels of source categories, 1990–2017

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 3.10). 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 3.10 does not include the quantities of the in- and outputs. The figures can, however, be made available for review purposes.

Table 3.10: 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 3.10 (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).
The Energy Balance of Statistics Netherlands distinguishes between energy figures from the Cokes Plant and the summed fuel use of the rest of processes in the integrated steel plant Therefore, only combustion emissions from the Coke Plant and the rest of the integrated crude steel plant can be estimated. These combustion emissions (including 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.

Combining all CO_2 emissions from the sector, 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.

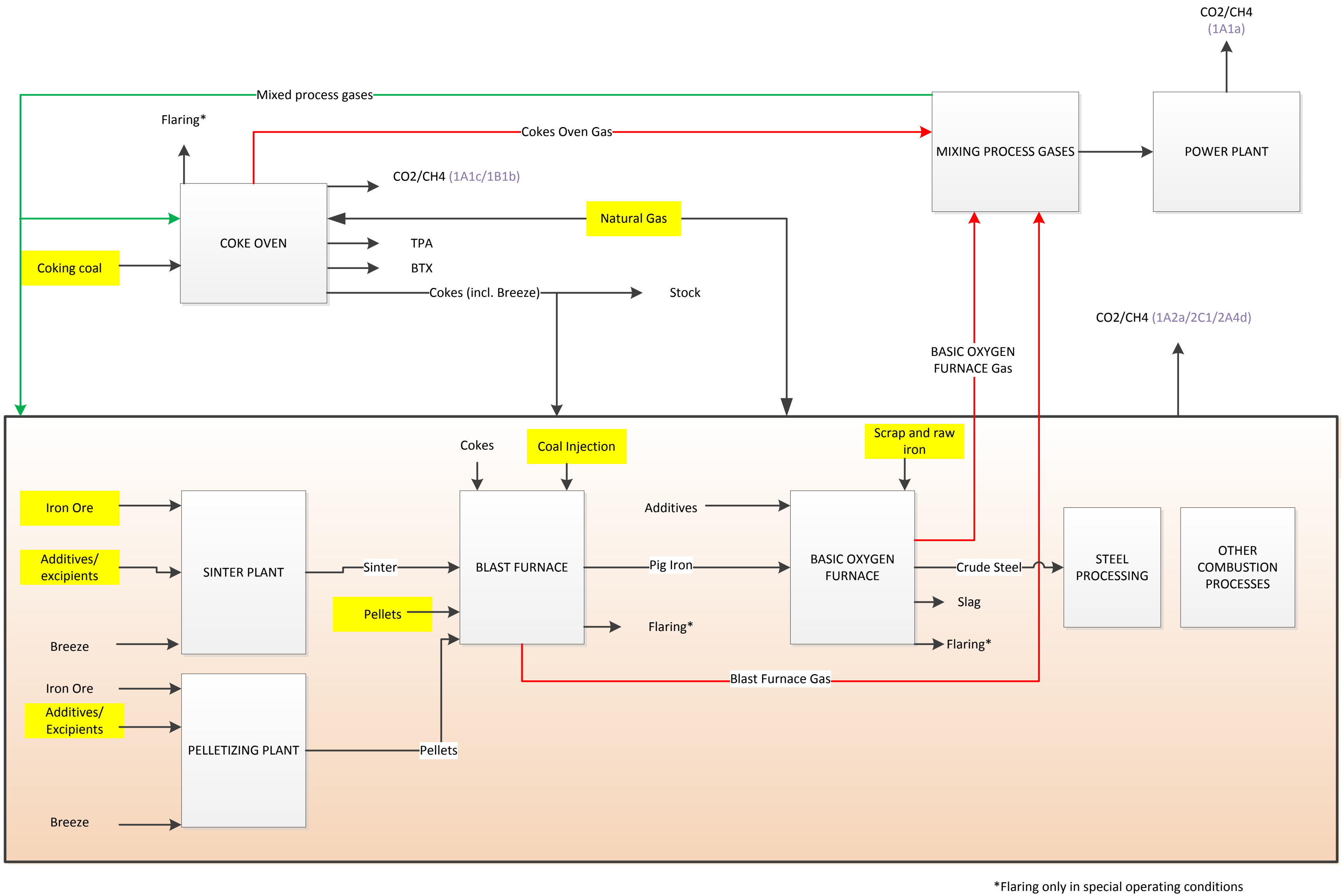


Figure 3.7: Production process of the Tata Steel integrated steel plant

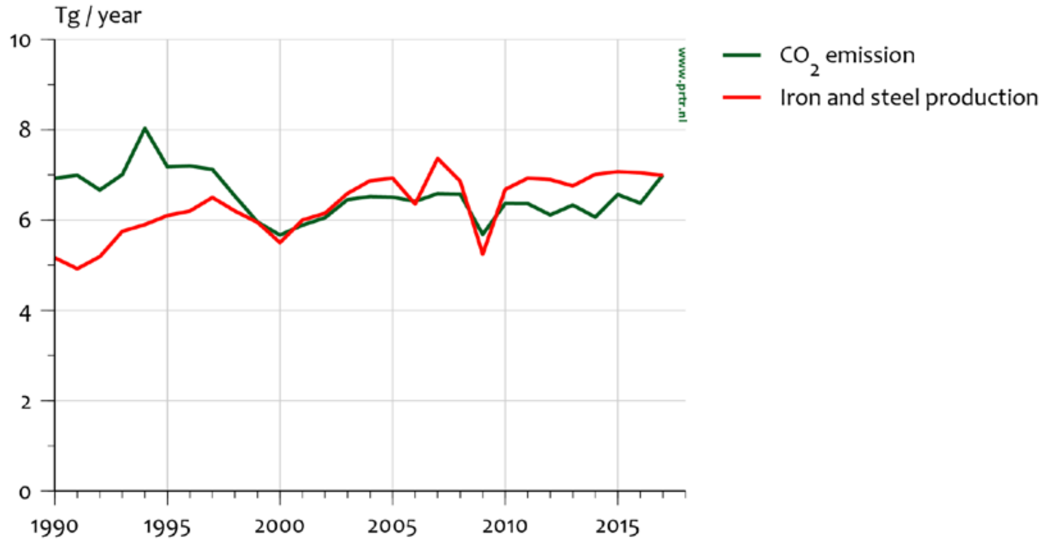


Figure 3.8: CO_2 emissions (Gg) from crude steel production compared with crude steel production, 1990–2017 (kton)

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.

There is a steady decrease in CO_2 emissions from the combustion of natural gas in this subcategory since 1990. This is mainly caused by a decrease 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 mainly due to a shift in the ownership of cogeneration plants to joint ventures, thus reallocating liquid fuel consumption 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 kg/GJ range, with exceptional values of 23 and 95 kg/GJ).
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 circa 55 to 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 since 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 (chemical waste gas) 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 relatively 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 relatively 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

Details of methodologies, data sources and country-specific source allocation issues are provided in Peek et al. (2019) and Klein et al. (2019). The Emission calculation for category 1A2 follows the same steps as the calculation applied for Energy industries (1A1). See section 3.2.4.2. (page 72).

Comparison of emission factors
For 2017, approximately 95% emissions were calculated using country-specific or company-specific EFs. The remaining 5% of CO_2 emissions were calculated with default IPCC EFs. These remaining emissions are mainly the result of the combustion of solid biomass, other oil, lignite, residual fuel oil and kerosene.

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 3.11 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 3.11: Overview of emission factors used (for the year 2017) in the category Manufacturing industries and construction (1A2)

Fuel	**Amount of fuel used in 2017 (TJ NCV)**	**Implied emission factors (g/GJ)**		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	255 083	56.6	0.10	6.3
Waste gas	119 755	65.1	0.10	3.6
Coke oven/gas coke	56 322	106.9	0.29	1.3
Gas/diesel oil	19 853	72.5	0.27	0.44
Other bituminous coal	46 988	92.9	0.27	0.44

Explanations for the IEFs
Natural gas
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.

Waste gas
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.

Gas/diesel oil
The EFs for CH_4 and N_2O from gas/diesel oil used in machinery are based on source-specific estimation methods, and these differ from the emission factors used in stationary combustion.

Other bituminous coal and coke oven / gas coke
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.

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 1A2.

The methodology for calculation of Non-Road Mobile Machinery (NRMM) emissions is described in paragraph 3.2.7.2.

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 and Annex 2 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 fuel quality analysis reported by Heslinga and Van Harmelen (2006) and further discussed in Olivier et al. (2009). The 25% uncertainty estimate in the CO_2 EF for liquids is based on an uncertainty of 30% in the EF for chemical waste gas in order to account for the quite variable composition of the gas and its more than 50% share in the total liquid fuel use in the sector. An uncertainty of 10% is assigned to solids, which reflects the uncertainty in the carbon content of blast furnace gas/oxygen furnace gas based on the standard deviation in a three-year average. BF/OX gas accounts for the majority of solid fuel use in this category.

3.2.5.4 Category-specific QA/QC and verification

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

CO_2 emissions reported by companies (both in AERs and as part of the ETS) are validated by the competent authority and then compared (see also Section 3.2.4.4).
More details on the validation of the energy data can be found in Peek et al. (2019).

3.2.5.5 Category-specific recalculations

An error is corrected in the fuel consumption in the chemical sector (1A2c). For the years 2012-2016, a large amount of fuel was missing from the energy statistics in this category. The energy statistics have been improved and the corresponding fuel consumption has been added to the emission inventory and emissions of CO_2, CH_4 and N_2O have been recalculated. Resulting changes (in Gg CO_2 eq.) are as follows:

	2012	**2013**	**2014**	**2015**	**2016**
1A2a				+155.6	-43.1
1A2b				-3.3	-0.8
1A2c	+580.5	+662.3	+889.0	+952.1	+1024.2
1A2d					
1A2e				+6.3	+6.5
1A2f				+4.3	+4.9
1A2gvii					-26.3

Also CH_4 and N_2O emissions have been recalculated with the improved energy statistics.

3.2.5.6 Category-specific planned improvements

Following the review recommendation of 2017, it is planned to study the CO_2 emission factor of chemical waste gas for the earlier years, using reported emission data from individual companies in ETS and Annual Environmental Reports (AERs). If the data in the ETS and AERs are representative to use for the earlier years as well, this will be used to calculate a new CO_2 emission factor for chemical waste gas.

3.2.6 *Transport (1A3)*

3.2.6.1 Source category description

Table 3.12. Overview of emissions in the sector Transport (1A3) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1A3. Transport	CO_2		27,7	30,2	30,9	11,3%	19,3%	18,7%	15,9%
	CH_4		0,2	0,1	0,1	-66,9%	0,0%	0,4%	0,0%
	N_2O		0,1	0,2	0,3	143,6%	0,2%	0,0%	0,1%
	All		28,0	30,5	31,2	11,3%	19,5%		16,1%
1A3a. Civil aviation	CO_2	non key	0,1	0,0	0,0	-62,0%	0,0%	0,0%	0,0%
1A3b. Road vehicles	CO_2		26,5	29,0	29,7	12,1%	18,5%	18,0%	15,3%
	CH4	non key	0,2	0,1	0,1	-68,3%	0,0%	0,3%	0,0%
	N2O	T	0,1	0,2	0,2	152,2%	0,2%	0,0%	0,1%
1a3b gasoline	CO_2	L,T	10,8	11,8	12,2	12,7%	7,6%	7,4%	6,3%
1a3b diesel oil	CO_2	L,T	13,0	16,7	17,0	31,0%	10,6%	10,3%	8,8%
1a3b LPG	CO_2	T	2,6	0,4	0,3	-86,9%	0,2%	0,2%	0,2%
1a3b Natural gas	CO_2	non key	0,0	0,1	0,1		0,1%	0,1%	0,1%
1A3c. Railways	CO_2	non key	0,1	0,1	0,1	-10,2%	0,1%	0,0%	0,0%
1A3d. Domestic Navigation	CO_2	L,T	0,7	1,0	1,0	32,6%	0,6%	0,6%	0,5%
1A3e Other Transportation	CO_2	non key	0,3	0,1	0,1	-72,1%	0,1%	0,1%	0,0%

Table 3.12 provides an overview of sources and emissions in this category in the Netherlands. CO_2 is by far the most important GHG within the transport sector.

Overview of shares and trends in energy use and emissions
Transport was responsible for 16.1% of GHG emissions in the Netherlands in 2017. 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 31.2 Tg CO_2 eq. in 2017.
Total energy use and resulting GHG emissions from transport are summarized in Figure 3.9 and Figure 3.10. As Figure 3.9 shows, road transport accounts for 95–97% of energy use and GHG emissions in this category over the time series.

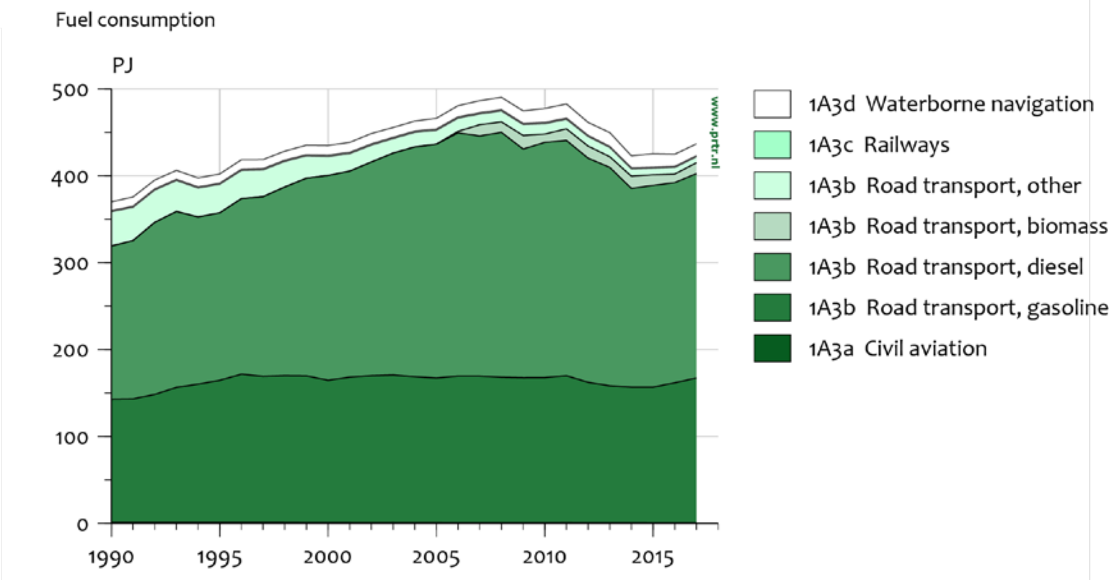


Figure 3.9: 1A3 Transport – energy use of source categories in PJ, 1990–2017

Figure 3.10 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 3.10).
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
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 3.10).
Between 2011 and 2014, CO_2 emissions decreased by 13%. This can for a major 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 2017, GHG emissions from transport were 2.2% higher than in 2016. This increase in emissions was caused by an increase in transport volumes in the Netherlands.

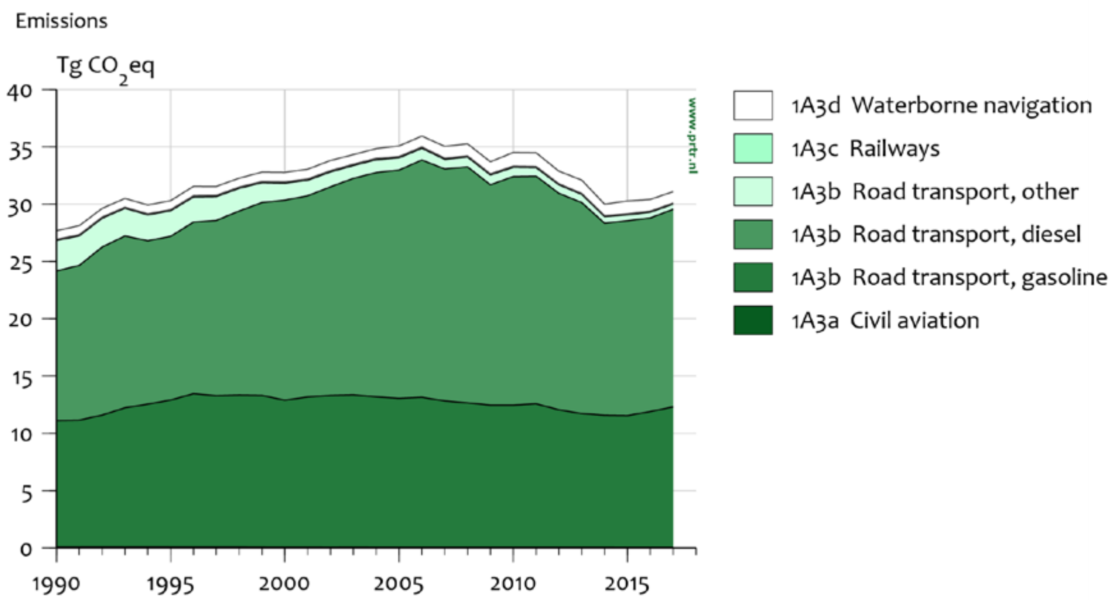


Figure 3.10: 1A3 Transport –emissions levels of source categories, 1990–2017

Civil aviation (1A3a)
The share of civil aviation (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) in GHG emissions in the Netherlands was less than 0.1% throughout the whole period 1990-2017. 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 2017, whereas the use of aviation gasoline decreased from 0.16 PJ in 1990 to 0.04 PJ in 2017. 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 15.5% in 2017. Between 1990 and 2017, GHG emissions from road transport increased from 26.7 to 30.0 Tg CO_2 eq., resulting for the most part from an increase in diesel fuel consumption. 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 17% to 235 PJ in 2017. 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 167 PJ in 2017. 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.

LPG consumption for road transport decreased steadily throughout the time series: from 40 PJ in 1990 to 5 PJ in 2017, 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 2017. The use of natural gas in road transport has increased in recent years, but is still very low. 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 2017, biofuel use for road transport amounted to 13 PJ, accounting for 3.0% of total energy use for road transport. Even though the legal obligation 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 2017). CH_4 emissions from road transport decreased by 66.9% between 1990 and 2017. 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 2017, 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 remained roughly stable between 2014 and 2017.

The share of N_2O in total GHG emissions from road transport (in CO_2 eq.) is also very small (0.8% in 2017). N_2O emissions from road transport increased from 0.3 Gg in 1990 to 0.9 Gg in 1997, but have slightly decreased since to 0.8 Gg in 2017. 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:

1. 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).
2. Recent generations of heavy-duty diesel trucks, equipped with selective catalytic reduction (SCR) catalysts to reduce NOx 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 2017 N_2O emissions from road transport increased by 3.5% compared to 2016, which is due to an increase in fuel consumption and IEF for gasoline passenger cars and an increase in fuel consumption for trucks and vans.

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 2017, diesel fuel consumption by railways amounted to 1.2 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)
(Domestic) 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. Because emissions from international navigation are reported under bunkers (1D, Section 3.5), 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 2017. These fluctuations can partially be explained by changes in offshore operations.

In line with the increase in fuel consumption, GHG emissions from domestic waterborne navigation increased from 0.7 Tg CO_2 eq. in 1990 to 1.2 Tg in 2011 and then decreased to 1.0 Tg in 2017.

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 2017.

Note that:

- Emissions from fuels delivered to international aviation and navigation companies (aviation and marine bunkers) are reported separately in the inventory (see Section 3.2.2);
- Emissions from military aviation and shipping are included in 1A5 (see Section 3.2.8).
- Energy consumption for pipeline transport is not recorded separately in national energy statistics but 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, in accordance with the 2006 IPCC Guidelines.
- Emissions from Non-Road Mobile Machineries (NRMM) are reported under different sub-categories, in line with the agreed CRF format:
    - industrial and construction machinery: 1A2g;
    - commercial and institutional machinery: 1A4a;
    - residential machinery: 1A4b;
    - agricultural machinery: 1A4c.

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. Table 3.13 summarises the methods and types of emission factors used for transport. More details on methodological issues can be found in Klein et al., 2019.

Table 3.13 Overview of methodologies for the Transport sector (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

CS: Country specific, D: Default

Civil aviation (1A3a)
GHG emissions from 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 (2019). Country-specific values are used for aviation gasoline, whereas for jet kerosene default values from the 2006 IPCC Guidelines are used. Also for N_2O and CH_4, default EFs are used. Since domestic civil aviation is not a key source in the inventory, the use of a Tier 1 methodology is deemed sufficient.

Emissions of precursor gases (NOx, CO, NMVOC and SO2), reported in the CRF under domestic aviation, are the uncorrected emissions values from the NL-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.

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. Table 2.1 of Klein et al. (2019) provides an overview of the methodology used to divide the Energy Balance data over the different CRF categories.

CO_2 emissions from road transport are calculated using a Tier 2 methodology. Country-specific heating values and CO_2 EFs are used. They were derived from two measurement programmes, the most recent being performed in 2016 and 2017. This is described in detail in the 2018 inventory report. An elaborate description of the methodology that is currently used for calculating GHG emissions for road transport is provided in Klein et al. (2019), chapter 2. The emission factors that were used are provided in Klein et al. (2019) in table 2.3 (for CH_4 and N_2O factors) and table 2.8 (CO_2 emission factors).

Figure 3.11 shows the implied N_2O and CH_4 emission factors for road transport. The CH_4 EFs have decreased steadily for all fuel types throughout the time series due to the EU emissions legislation for HC. The N_2O EFs for gasoline and LPG increased between 1990 and 1995 due to the increasing number of catalyst-equipped passenger cars in the car fleet, but have since decreased steadily, as is described in section

3.2.6.1. The IEF for diesel has increased in recent years, mainly due to the increasing number of heavy-duty trucks and buses equipped with an SCR catalyst.

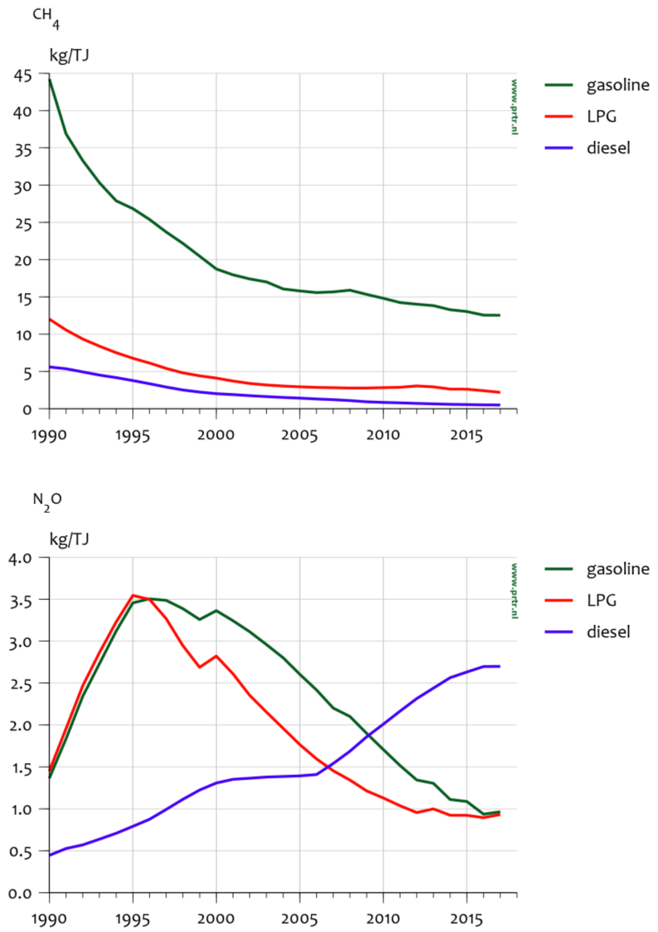


Figure 3.11 IEFs per fuel type for CH_4 and N_2O emissions by road transport, 1990–2017

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.

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 Deltares & TNO (2016). Gasoline sales data for road transport, as derived from the Energy Balance, are corrected accordingly (as shown in table 2.1 of Klein et al., 2019).

The fuel consumption from the energy balance is apportioned between international bunkers and inland navigation as follows: Each fuel supplier has to report their total fuel sales to Statistics Netherlands, and subsequently fills in a survey. In this survey, the fuel supplier indicates to which type(s) of shipping (inland navigation, fisheries, international shipping, etc) they deliver their fuels. Within inland navigation, the distinction between domestic inland navigation (included in 1A3d) and international inland navigation (included in 1D international bunker fuels) is uncertain. Based on the survey and expert judgement by Statistics Netherlands, the fuel sales of each fuel supplier for inland navigation are attributed to either national or international navigation. This methodology is used consistently throughout the time series.

A Tier 2 methodology is used to calculate CO_2 emissions from domestic waterborne navigation, using country-specific CO_2 EFs, while a Tier 1 method is used for CH_4 and N_2O emissions. A description of the country-specific EFs for CO_2 and CH_4 and N_2O EFs that are used and underlying methodology is provided in Klein et al. (2019). The emission factors are included in table 2.2.

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. (2019), which also shows the sources used to estimate uncertainties. Table 3.14 summarises the uncertainties for activity data and emission factors per source category, fuel type and gas. The estimations of uncertainties in activity data are all based on Statistics Netherlands.
The uncertainty estimates for N_2O and CH_4 for civil aviation, railways and waterborne navigation are from IPCC Defaults. The uncertainties in emission factors for road transport and CO_2 emission factors for other source categories are based on expert judgements, which were determined in workshops. See also table 2.6 of Klein et al (2019).

Table 3.14 uncertainties for activity data and emission factors, category 1A3

CRF	Source category	Fuel type	Gas	Activity data	Efs
1A3a	Civil aviation	Avgas	CO_2	+- 10%	+- 4%
		Avgas	N_2O		-70% - +150%
		Avgas	CH_4		-57% - +100%
		Kerosene	CO_2		+- 4%
		Kerosene	N_2O		-70% - +150%
		Kerosene	CH_4		-57% - +100%
1A3b	Road transportation	gasoline	CO_2	+- 2%	+- 2%
		diesel	CO_2	+- 2%	+- 2%
		LPG	CO_2	+- 2%	+- 2%
		CNG	CO_2	+- 10%	+- 2%
		all	CH_4	+- 2%	+- 50%
		all	N_2O	+- 2%	+- 50%
1A3c	Railways	all	CO_2	+- 1%	+- 2%
		all	N_2O		-50% - +300%
		all	CH_4		-40% - +251%
1A3d	Waterborne navigation	all	CO_2	+- 5%	+- 2%
		all	N_2O		-40% - +140%
		all	CH_4		+- 50%

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

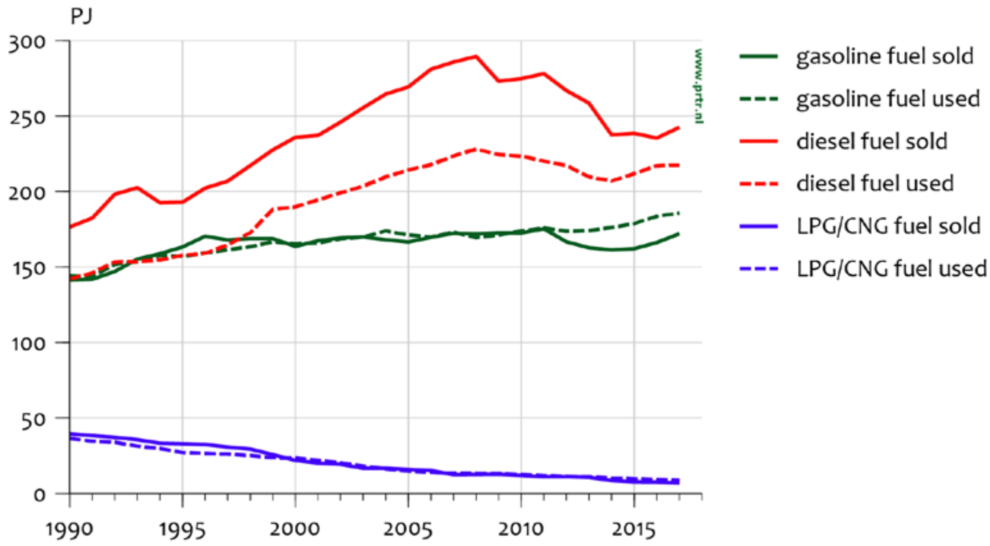


Figure 3.12: Fuel sold and fuel used for road transport in the Netherlands, 1990–2017

The bottom-up calculation of gasoline consumption in road transport closely corresponds with the (adjusted) sales data from the Energy Balance until 2011; differences between the figures are small throughout the time series. As of 2011, fuel sold had decreased compared to fuel used, due to an increase in cross-border refuelling, as was described in 3.2.6.1.
The same holds for LPG sales and consumption, as can be seen in Figure 3.12. 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 is 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.

CE Delft (2014) 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 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., 2019). 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

(Minor) changes in the GHG emissions in category 1A3 are:

- Energy statistics for gasoline consumption for road transport were corrected for 2014 and 2015, resulting in minor increases between 0,5% and 2%.
- The total fuel consumption of road transport throughout the time series has remained nearly the same, with minor changes. There has been a minor shift in allocation of fuel consumption between modes, with a slight increase for passenger cars and decrease for motorcycles and mopeds. Activity data for motorcycles and mopeds have been adjusted downwards, following the results of a recent measurement programme.
- Also, CH_4 emissions for mopeds and motorcycles were adjusted upwards from 2002, resulting in up to 25% higher emissions in 2014. This also results from the recent measure programme on mopeds.

Activity data for railways was adjusted downwards for 2015-2016 by 10% (0,2 PJ) due to an error correction. The emissions decreased accordingly.

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

Table 3.15 shows the subcategories under sector 1A4, as well as the key categories.

Table 3.15 Overview of emissions in the other sectors (1A4) in the base year and the last two years of the inventory (in Tg CO_2 eq).

Sector/category	**Gas**	**Key**	**1990**	**2016**	**2017**	**2017 vs 1990**	**Contribution to total in 2017 (%) by**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1A4. Other sectors	CO_2		38,9	33,4	33,1	-14,9%	20,7%	20,1%	17,1%
	CH_4		0,6	1,4	1,5	154,3%	0,9%	8,1%	0,8%
	N_2O	non key	0,1	0,1	0,1	5,0%	0,0%	0,0%	0,0%
	All		39,5	34,8	34,6	-12,4%	21,6%		17,9%
1A4a. Commercial/Institutional	CO_2		8,3	7,4	7,6	-8,3%	4,8%	4,6%	3,9%
	CH4	non key	0,0	0,0	0,0	6,5%	0,0%	0,3%	0,0%
1A4a Natural gas	CO_2	L,T	7,8	7,0	7,2	-7,0%	4,5%	4,4%	3,7%
1A4b. Residential	CO_2		20,7	17,0	16,5	-20,4%	10,3%	10,0%	8,5%
	CH4	L	0,5	0,4	0,4	-3,6%	0,3%	0,3%	0,2%
1A4b Natural gas	CO_2	L,T	19,9	16,8	16,3	-18,0%	10,2%	9,9%	8,4%
1A4c. Agriculture/Forestry/Fisheries	CO_2		9,8	9,0	9,0	-8,9%	5,6%	5,4%	4,6%
	CH4	L,T	0,1	0,9	1,0	1227,9%	0,6%	0,6%	0,5%
1A4c liquids	CO_2	L,T	2,5	1,8	1,8	-30,4%	1,1%	1,1%	0,9%
1A4c Natural gas	CO_2	L,T	7,3	7,1	7,2	-1,6%	4,5%	4,4%	3,7%

Subcategory 1A4a (commercial and institutional services) 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.

Subcategory 1A4b (residential) 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.

Subcategory 1A4c (agriculture, forestry and fisheries) 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).

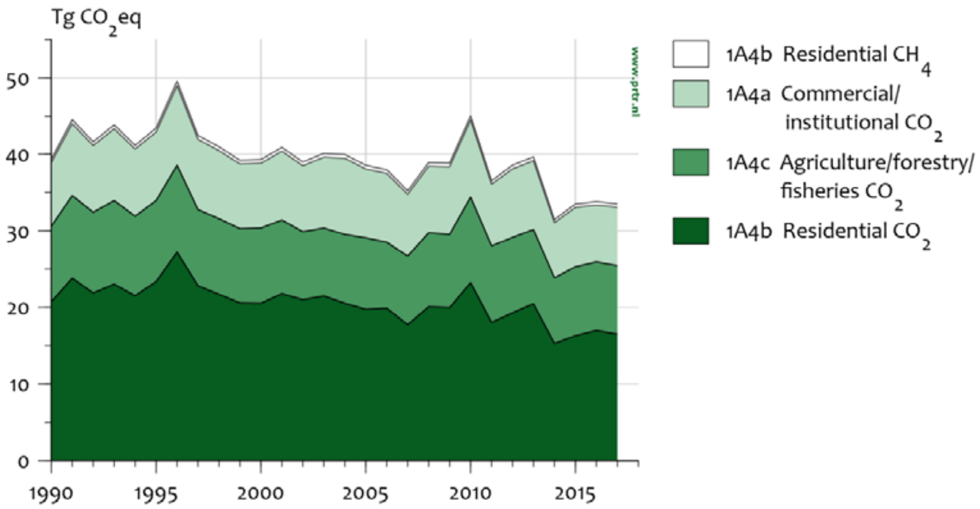


Figure 3.13: 1A4 (Other sectors) – trend and emissions levels of source sub-categories, 1990–2017

Commercial and institutional services (1A4a)
CO_2 emissions in the commercial and institutional services (1A4a) sub-category have decreased since 1990. The interannual variations in emissions 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 2017, 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 emissions (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, while the number of households has increased. This is mainly due to the improved insulation of dwellings and the increased use of high-efficiency boilers for central heating.

Energy use by NRMM used in trade increased from 0.5 PJ in 1990 to 1.0 PJ in 2017, 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.

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).
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 been 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 significantly decreased, from 1.3 Tg in 2000 to 0.6 Tg in 2017. 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
Details of methodologies, data sources and country-specific source allocation issues are provided in Peek et al. (2019), Jansen et al. (2019) and Klein et al (2019).

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).

Activity data
- The activity data for stationary combustion is from the energy statistics from Statistics Netherlands.
- The activity data for charcoal consumption in barbecues is based on energy statistics from Statistics Netherlands, and corrected for annual meat consumption.
- 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.

- The consumption of diesel oil and heavy fuel oil by fisheries is derived from the Energy Balance.

Emission factors

For stationary combustion, the following emission factors are used: 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, 2019), 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., 2019). 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 fisheries (1A4c iii) are calculated on the basis of IPCC Tier 2 methodologies. Fuel-use data are combined with country-specific EFs for CO_2. CH_4 and N_2O emissions from fisheries are derived using a Tier 1 methodology. The emission factors are shown in Klein et al (2019) in Table 2.2B

Table 3.16 Overview of methods used for calculation of emissions for NRMM and fisheries

CRF code	Source category description	Method	EF
1A2gii	Industry and construction	T2, T3	CS
1A4aii	Commercial/institutional	T2, T3	CS
1A4bii	Residential	T2, T3	CS
1A4cii	Agriculture/Forestry	T2, T3	CS
1A4aiii	National Fishing	T1, T2	CS, D

CS: Country specific, D: Default

- Fuel consumption by NRMM is derived from the Energy balance, which in turn uses the output of the EMMA model (Hulskotte and Verbeek, 2009). CO_2 emissions from NRMM are estimated using a Tier 2 methodology. Country-specific heating values and CO_2 emission factors are used similar to those for road transport.
- CH_4 and N_2O emissions from NRMM are estimated using a Tier 3 methodology, using country specific emission factors derived from the EMMA model. CH_4 emission factors are presented in Klein et al (2019) in Table 2.2C.

For 2017, 99% of the CO_2 emissions in 1A4 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 IEFs used for the most important fuels (up to 95% of the fuel use) in the other sectors (category 1A4) is provided in Table 3.17.

Table 3.17: Overview of IEFs used (for the year 2017) in Other sectors (1A4)

Fuel	Amount of fuel used in 2017 (TJ NCV)	IEFs (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	543 244	56.6	0.1	93.8
Gas / Diesel oil	27 452	72.5	0.9	2.5
Solid biomass	23 380	111.6	4.0	300.0
Biogas	7 634	88.4	0.1	5.0

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.

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 3.14 shows the trend in natural gas combusted in gas engines and in other plants, as well as the trend in the IEF.

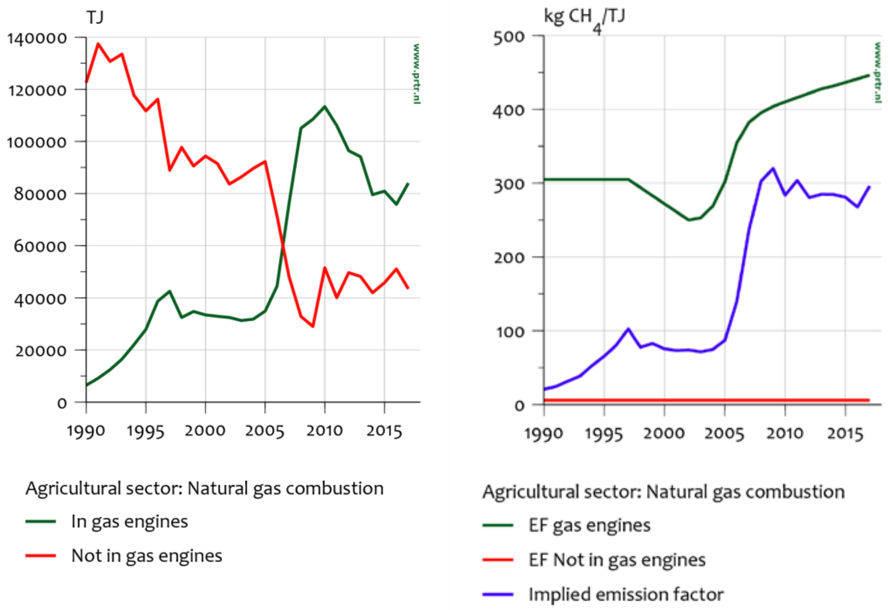


Figure 3.14: Trend in natural gas consumption in gas engines (with a relatively high emission factor) and other engines (with a relatively low emission factor) in the agricultural sector compared with the implied CH_4 emission factor from natural gas combustion in the agricultural sector, 1990–2017

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 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 Wageningen Economic Research 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).

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. (2019). 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.

3.2.7.4 Category-specific QA/QC and verification

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. (2019).

3.2.7.5 Category-specific recalculations

The energy statistics for the years 2015 and 2016 have been improved. This results in the following changes in CO_2 emissions:

	2015	**2016**
1A4a	-4.5	-450.8
1A4b	-0.4	-0.8
1A4c	-0.1	-65.2

Also CH_4 and N_2O emissions have been recalculated with the improved energy statistics.

The charcoal consumption in barbecues has been updated based on new statistics for meat consumption.

3.2.7.6 Category-specific planned improvements

There are no source-specific improvements envisaged.

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). .

Table 3.18: Overview of emissions in the sector Other (1A5) in the base year and the last two years of the inventory (in Tg CO_2 equivalents).

Sector/category	**Gas**	**Key**	**1990**	**2016**	**2017**	**2017 vs 1990**	**Contribution to total in 2017 (%) by**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1A5 Other	CO_2	non key	0,3	0,2	0,1	-52,7%	0,1%	0,1%	0,1%
	CH_4	non key	0,0	0,0	0,0	-60,2%	0,0%	0,0%	0,0%
	N_2O	non key	0,0	0,0	0,0	-59,5%	0,0%	0,0%	0,0%
	All		0,3	0,2	0,2	-52,8%	0,1%		0,1%

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 other countries. The EFs are presented in Table 3.19. 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 3.19 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 2017 (Gg)	148.49	0.01	0.01

Source: Hulskotte (2004).

3.2.8.3 Uncertainties and time series consistency

The uncertainty in total CO_2 emissions from this source category is approximately 80%, mainly determined by the uncertainty in the EFs.

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)

Table 3.20 Overview of emissions in the Fugitive emissions from fuels sector (1B) in the base year and the last two years of the inventory (in Tg CO_2 eq).

Sector/category	**Gas**	**Key**	**1990**	**2016**	**2017**	**2017 vs 1990**	**Contribution to total in 2017 (%) by**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1B Fugitive emissions from fuels	CO_2		0,9	1,1	1,1	26,4%	0,7%	0,7%	0,6%
	CH_4		1,9	0,6	0,5	-72,1%	0,3%	3,0%	0,3%
	All		2,8	1,7	1,7	-41,3%	1,0%		0,9%
1B1. Solid fuels transformation	CO_2	non key	0,1	0,1	0,1	-33,7%	0,0%	0,0%	0,0%
1B2. Fugitive emissions from oil and gas operations	CO_2	L,T	0,8	0,1	0,1	-93,1%	0,0%	0,0%	0,0%
1B2. venting/flaring	CH_4	T	1,5	0,3	0,3	-82,0%	0,2%	1,5%	0,1%

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).

Table 3.20 shows that total GHG emissions in 1B decreased from 2.8 Tg CO_2 eq. to 1.7 Tg CO_2 eq. between 1990 and 2017.

3.3.1 Solid fuels (1B1)

3.3.1.1 Source category description

Both the CO_2 and CH_4 emissions in this source category are small. The CH_4 emissions are, because of this, not reflected in table 3.20. Fugitive emissions of CH_4 from this category relate to coke manufacture. The decrease in CH_4 emissions over the time series is clarified by changes in charcoal production. 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 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.
Emission totals for the iron and steel industry 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.

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 Statistics Netherlands. For category 1B1, the production of coke oven coke as registered by Statistics Netherlands 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. (2019).

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
No category-specific recalculations

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).

Note that:

- 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 (AER) from the plant), these emissions were re-allocated from 1A1b to 1B2a4 from 2002 onwards.

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., 2019). 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 exploration, production and processing, venting and flaring (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 was 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 CH_4 per km of pipeline for grey cast iron, and 120 m^3 CH_4 per km of pipeline for other materials.
These 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 m3 CH_4 per km of pipeline for grey cast iron, 51 m^3 CH_4 per km of pipeline for other materials with a pressure of <=200 mbar, and 75 m3 CH_4 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 CH_4 for the whole time series 1990–2014.

Emissions of CO_2 and 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 applied for 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 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 CH_4 emissions for the smaller locations were based on measurements of a sample of those locations and added for the whole time series.

Fugitive emissions of CH_4 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., 2019). 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., 2019).

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 CH_4 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 category-specific recalculations have been made.

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 (CCS) 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.

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 2018

Emissions:	The total GHG emissions of the sector increased from 10.7 Tg CO_2 eq. in 2016 to 11.1 Tg CO_2 eq. in 2017.
Key categories:	New key categories: • 2B10 Other (CO_2) • 2C3 Aluminium production (CO_2); • 2F6 Other (HFC); • 2G Other product manufacture and use (N_2O);
Methodologies:	• Due to corrections the CO_2 and CH_4 emissions from Petrochemical and carbon black production (2B8) have been changed for a number of years (CO_2) and for $CH_4$for the whole time seriesCH_4; • A previously unknown N_2O source within the chemical industry is included in this submission (+0.38 Mton CO_2-eq in 2017);. • Through some corrections the HFC emissions from handling activities (2B9b3) have been changed for a number of years; • The current calculation method (via a stock model) of Stationary refrigeration (2F1) has been replaced by a new method. From 2013 onwards new emission figures are presented; • Because more detailed information on Mobile air-conditioning (2F1) became available, HFC emissions have been changed for the whole time series.
Activity data:	An error is corrected in the fuel use as feedstock in the chemical sector (2B10). For the years 2012-2016, fuel statistics for a few chemical companies were incomplete

4.1 Overview of the sector

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 treated as confidential, unless a company has no objection to publication. 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.

Table 4.1 Overview of emissions in the Industrial Production and Product Use sector, in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2. Total Industrial Processes	CO_2		7,8	7,1	7,6	-2,0%	65,8%	4,6%	3,9%
	CH_4		0,3	0,3	0,3	7,4%	3,0%	1,9%	0,2%
	N_2O		7,3	1,5	1,6	-78,4%	13,6%	18,0%	0,8%
	HFC		5,6	1,9	1,8	-67,4%	15,8%	100,0%	0,9%
	PFC		2,7	0,2	0,1	-97,1%	0,7%	100,0%	0,0%
	SF_6		0,3	0,1	0,1	-51,6%	1,1%	100,0%	0,1%
	All		23,9	11,1	11,5	-51,7%	100,0%		6,0%
2A. Mineral industry	CO_2		1,4	1,5	1,63	15,6%	14,1%	1,0%	0,8%
2B. Chemical industry	CO_2		4,7	4,8	5,1	8,4%	44,3%	3,1%	2,6%
	CH_4		0,3	0,3	0,3	11,2%	2,6%	1,7%	0,2%
	N_2O		7,1	1,4	1,5	-78,9%	12,9%	17,1%	0,8%
	HFC		5,6	0,2	0,1	-97,7%	1,1%	7,0%	0,1%
	PFC		0,0	0,0	0,0		0,2%	27,8%	0,0%
	All		17,7	6,7	7,0	-60,1%	61,0%		3,6%
2C. Metal Production	CO_2		0,5	0,1	0,1	-87,5%	0,5%	0,0%	0,0%
	PFC		2,6	0,0	0,0	-99,5%	0,1%	16,9%	0,0%
	All		3,1	0,1	0,1	-97,7%	0,6%		0,0%
2D. Non-energy products from fuels and solvent use	CO_2		0,2	0,3	0,3	73,1%	2,8%	0,2%	0,2%
	CH_4		0,0	0,0	0,0	103,0%	0,0%	0,0%	0,0%
	All		0,2	0,3	0,3	73,1%	2,8%		0,2%
2E. Integrated circuit or semiconductor	PFC	non key	0,0	0,1	0,0	69,4%	0,4%	55,4%	0,0%
2F. Product uses as substitutes for ODS	HFC	L, T	0,0	1,7	1,7		14,7%	93,0%	0,9%
2G. Other	CO_2	non key	0,0	0,0	0,0	239,2%	0,0%	0,0%	0,0%
	CH_4	non key	0,1	0,0	0,0	-13,3%	0,4%	0,2%	0,0%
	N_2O	T	0,2	0,1	0,1	-62,6%	0,7%	1,0%	0,0%
	All		0,5	0,3	0,3	-52,5%	1,1%		0,1%
2H. Other process emissions	CO_2	non key	0,1	0,0	0,0	-66,9%	0,2%	0,0%	0,0%
Indirect CO2 emissions	CO_2		0,9	0,5	0,5	-50,6%	3,9%	0,3%	0,2%

Sector / category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
National Total GHG emissions (excl. CO2 LULUCF)	CO_2		163,3	166,8	164,9				
	CH_4		31,8	18,3	18,0				
	N_2O		18,0	8,5	8,7				
	HFCs		5,6	1,9	1,8				
	PFCs		2,7	0,2	0,1				
	SF_6		0,2	0,1	0,1				
	All		221,7	195,8	193,7				

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).

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.

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.

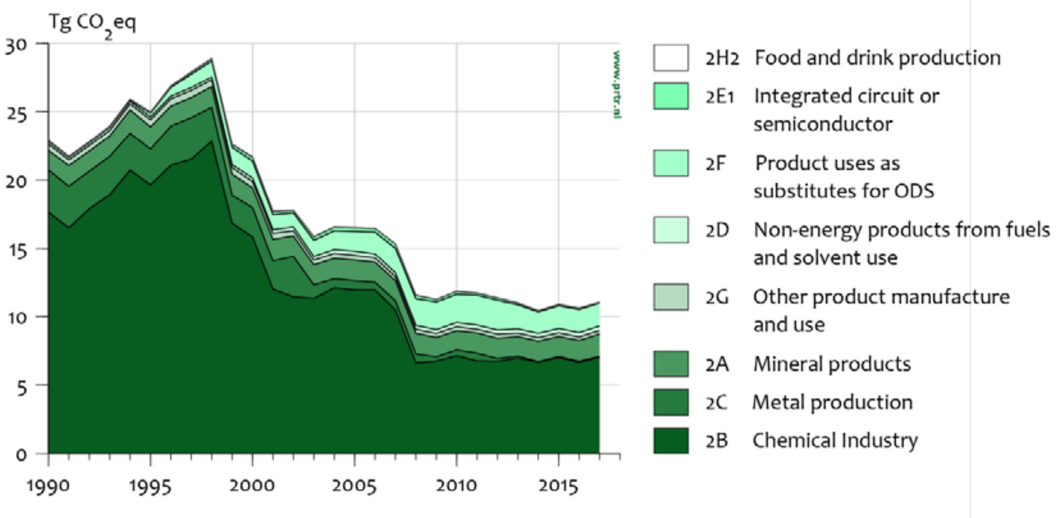


Figure 4.1: Sector 2 Industrial processes and product use – trend and emissions levels of source categories, 1990–2017

In 2017, IPPU contributed 6.0% of the total national GHG emissions (without LULUCF) in comparison with 10.8% in 1990. The sector is a major source of N_2O emissions in the Netherlands, accounting for 18.0% of total national N_2O emissions in 2017. Category 2B (Chemical industry) contributes most to the emissions from this sector with 1.5 Tg CO_2 eq. in 2017.

4.2 Mineral products (2A)

4.2.1 Source category description

Table 4.2 Overview of the sector Mineral Industry (2A), in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector / category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2A. Mineral industry	CO_2		1,41	1,50	1,63	15,6%	14,1%	1,0%	0,8%
2A1. Cement production	CO_2	non key	0,42	0,24	0,30	-28,3%	2,6%	0,2%	0,2%
2A2. Lime production	CO_2	non key	0,16	0,17	0,23	38,6%	2,0%	0,1%	0,1%
2A3. Glass production		non key	0,14	0,10	0,08	-44,0%	0,7%	0,0%	0,0%
2A4a Ceramics	CO_2	non key	0,14	0,12	0,12	-15,8%	1,0%	0,1%	0,1%
2A4b Other uses of Soda Ash	CO_2	non key	0,07	0,12	0,12	73,9%	1,0%	0,1%	0,1%
2A4d Other	CO_2	L,T	0,48	0,77	0,79	64,1%	6,8%	0,5%	0,4%

Table 4.2 presents the CO_2 emissions related to the sub-sectors in this category. In (2A4a), following processes are included: 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. 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).

4.2.2 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. (2019).

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. NEa 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 4.3 shows the trend in the CO_2 IEFs for clinker production during the period 2002–2017 (IPCC Default = 0.52 t/t clinker).

Table 4.3 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
2017	0.51

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;

EFls = EF limestone (0.440 ton CO_2/ton limestone);
EFd = EF dolomite (0.477 ton CO_2/ton dolomite).

Based on Olivier J.G.J. et al (2009). The fractions and EFs (both defaults) are obtained from the 2006 Guidelines.

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

Mc = Mclay x cc

Where:
Mclay = amount of clay consumed, 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 (Na_2CO_3) (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 the 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 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.

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 Approach 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.
The activity data for 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. This (annual) comparison is documented in a (confidential) document. This document is available for the ERT upon request and after signature of a confidentiality statement.

4.2.5 *Category-specific recalculations*

No recalculations have been made.

4.2.6 *Category-specific planned improvements*

No improvements are planned.

4.3 Chemical industry (2B)

4.3.1 Source category description

Table 4.4 Overview of the sector Chemical Industry (2B), in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2B. Chemical industry	CO_2		4,7	4,8	5,1	8,4%	44,3%	3,1%	2,6%
	CH_4		0,3	0,3	0,3	11,2%	2,6%	1,7%	0,2%
	N_2O		7,1	1,4	1,5	-78,9%	12,9%	17,1%	0,8%
	HFC		5,6	0,2	0,1	-97,7%	1,1%	7,0%	0,1%
	PFC		0,0	0,0	0,0		0,2%	27,8%	0,0%
	All		17,7	6,7	7,0	-60,1%	61,0%		3,6%
2B1. Ammonia production	CO_2	L,T	3,7	3,8	3,9	5,7%	34,1%	2,4%	2,0%
2B2. Nitric acid production	N_2O	T	6,1	0,3	0,3	-95,1%	2,6%	3,4%	0,2%
2B4. Caprolactam production	N_2O	L	0,7	0,8	0,8	8,4%	7,0%	9,2%	0,4%
2B7. Soda ash production	CO_2	non key	19,0	NO	NO	-100,0%	0,0%	0,0%	0,0%
2B8. Petrochemical and carbon black production	CO_2	L,T	0,3	0,5	0,5	36,7%	4,0%	0,3%	0,2%
	CH_4	L	0,3	0,3	0,3	11,2%	2,6%	1,7%	0,2%
2B9. Fluorochemical production	HFC	T	7,3	0,2	0,1	-98,2%	1,1%	7,0%	0,1%
	PFC	non key	0,0	0,0	0,0		0,2%	27,8%	0,0%
2B10. Other chemical industry	CO_2	L	0,6	0,5	0,7	21,5%	6,1%	0,4%	0,4%

The national inventory of the Netherlands includes emissions of GHGs of ten source categories reported in category 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 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 / CH_4 / N_2O (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).

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.

Overview of shares and trends in emissions
Table 4.4 gives an overview of the proportions of emissions from the main categories. Emissions from this category contributed 8.0% of total national GHG emissions (without LULUCF) in 1990 and 3.6% in 2017. Figure 4.2 shows the trend in CO_2-equivalent emissions from 2B (Chemical industry) in the period 1990–2017.

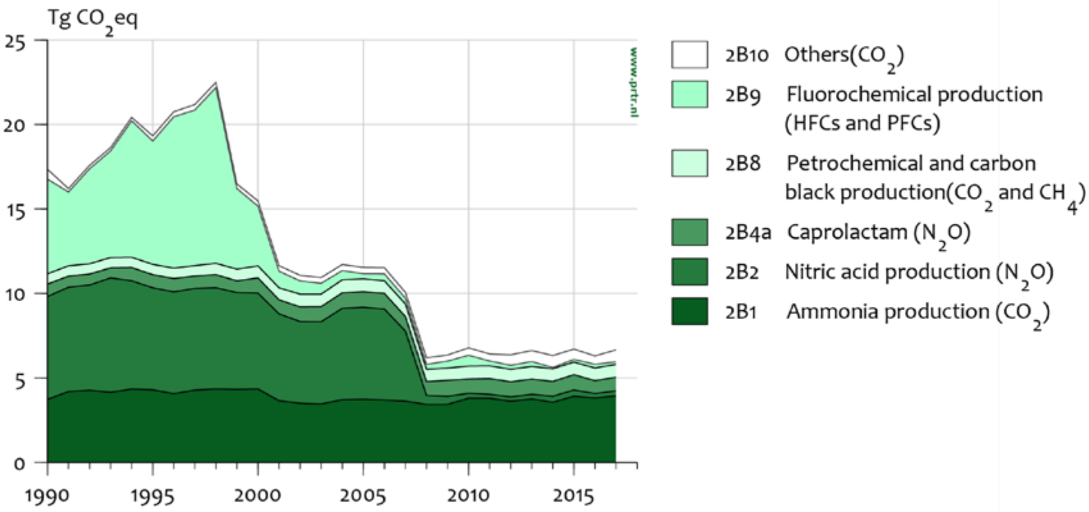


Figure 4.2: 2B Chemical industry – trend and emissions levels of source categories, 1990–2017

Mainly due to a reduction in HFC-23 emissions from HCFC-22 production total GHG emissions from 2B (Chemical industry) decreased from 1990 to 2001. From 2001 to 2008, total GHG emissions from 2B decreased mainly due to a reduction in N_2O emissions from the production of nitric acid. During the period 2009–2017, total GHG emissions from 2B remained rather stable. Table 4.5 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 4.5: Trend in N_2O emissions from Chemical industry (2B) (Gg CO_2 eq.)

Year	2B2 Nitric acid production	2B4a Caprolactam production	2B8e Acrylonitrile production	Total
1990	6,085	740	244	7,069
1991	6,169	657	244	7,070
1992	6,228	648	248	7,125
1993	6,765	598	245	7,608
1994	6,407	784	260	7,451
1995	6,035	777	268	7,080
1996	6,020	794	277	7,090
1997	6,020	733	285	7,037
1998	5,990	774	293	7,057
1999	5,731	691	301	6,723
2000	5,670	903	309	6,882
2001	5,134	833	317	6,284
2002	4,837	866	325	6,028
2003	4,864	890	333	6,088
2004	5,400	921	342	6,663
2005	5,440	917	350	6,707
2006	5,380	926	358	6,664
2007	4,138	861	366	5,366
2008	536	822	374	1,733
2009	473	941	382	1,796
2010	290	846	390	1,526
2011	234	926	364	1,524
2012	254	895	388	1,536
2013	274	898	368	1,539
2014	356	874	378	1,607
2015	370	902	336	1,609
2016	270	755	380	1,405
2017	299	802	387	1,489

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. During the period 2002-2006 the emission fluctuations were caused by the the production levels.

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 4.6, with detailed information per plant, explains the significant reductions in N_2O emissions from nitric acid production in 2007 and 2008.

Table 4.6: Overview with detailed information per nitric acid plant

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

1) As well as in two Dutch plants, EnviNOx process variant 1 systems are in operation – with similar, very high N_2O abatement rates (99% and above) – in nitric acid plants in Austria and elsewhere.
2) Abatement efficiency relates to IEFs. Because the IEFs are confidential, they are not included in this table.

From 2008 onwards, N_2O emissions from HNO_3 production in the Netherlands were included in the 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 2018, the companies' emissions reports (2017 emissions) were independently verified and submitted to the NEa, where they were checked against those reported in the CRF tables (2017).
No differences were found between the emissions figures in the CRF tables and those in the emissions reports under EU-ETS.

Caprolactam production (2B4a) and Acrylonitrile production (2B8e)
The emissions fluctuations from these source are both mainly caused by the production level.

Fluorochemical production (2B9)
Table 4.7 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 1992–2017 can be* explained by the large fluctuations in handling activities, which depend on the demand from customers.

Table 4.7: 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	0	5,606
1991	4,366	0	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	866	118	983
2002	569	215	784
2003	525	121	645
2004	448	97	546
2005	248	55	303
2006	355	57	412
2007	307	37	344
2008	268	23	291
2009	195	217	411
2010	494	148	642
2011	211	81	292
2012	159	76	235
2013	238	54	291
2014	45	28	73
2015	118	43	161
2016	158	66	224
2017	101	48	149

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., 2019), 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. (2019), 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; CH_4;N_2O
  - 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). The N_2O emissions from 2017 are based on measurements. For the period 1990-1994 and the period 2010-2016 the emissions are calculated with the help of the emission and the production level in 2017 and the production levels in both periods. Emissions for the period 1995–2009 have been determined by extrapolation between 1994 and 2010.
- 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:

- o 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.
- o 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.
- o 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 Statistics Netherlands.

4.3.3 *Uncertainty and time series consistency*

Uncertainty

The Approach 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- and acrylonitrile production are both 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 involves a certain amount of extrapolation with respect to emissions data for acrylonitrile production, thereby introducing further uncertainties for the period 1995–2009.

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 have been compared with the sector data from the Statistics Netherlands (AD) and the national inventory (emissions).
For both source categories no differences were found.
For the production of HCFC-22 (2B9a1) the operators' data in annual environmental reports (including the confidential information) are verified annually by the competent authority and the Dutch inventory IPPU expert, consecutively.
These (annual) comparisons are documented in a (confidential) document. This document is available and can be made available for the ERT upon request, after signature of a confidentiality statement.

4.3.5 *Category-specific recalculations*

Because of the correction of some AD the CO_2 emissions from Petrochemical and carbon black production (2B8) have been changed for the period 2011-2016. Due to the use of the correct EF the CH_4 emissions from 2B8 have been changed for the whole time series. Furthermore a previously unknown N_2O source within the chemical industry is included in this submission. The results of these changes can be found in Table 4.8.

Table 4.8: Effects of emissions changes (Gg CO_2 eq.) applied to Petrochemical and carbon black production (2B8), 1990-2016

Year	NIR 2019 2B8g CO_2	NIR 2018 2B8g CO_2	Difference CO_2	NIR 2019 2B8g CH_4	NIR 2018 2B8g CH_4	Difference CH_4	NIR 2019 2B8g N_2O	NIR 2018 2B8g N_2O	Difference N_2O
1990				269	380	-111	244	0	244
1991				269	380	-111	244	0	244
1992				269	380	-111	248	0	248
1993				267	380	-113	245	0	245
1994				267	380	-113	260	0	260
1995				267	380	-113	268	0	268
1996				267	380	-113	277	0	277
1997				267	380	-113	285	0	285
1998				270	376	-106	293	0	293
1999				284	389	-105	301	0	301
2000				285	396	-112	309	0	309
2001				284	396	-112	317	0	317
2002				320	438	-118	325	0	325
2003				320	458	-137	333	0	333
2004				323	410	-88	342	0	342

Year	NIR 2019 2B8g CO_2	NIR 2018 2B8g CO_2	Difference CO_2	NIR 2019 2B8g CH_4	NIR 2018 2B8g CH_4	Difference CH_4	NIR 2019 2B8g N_2O	NIR 2018 2B8g N_2O	Difference N_2O
2005				320	459	-139	350	0	350
2006				291	445	-154	358	0	358
2007				293	462	-169	366	0	366
2008				284	425	-140	374	0	374
2009				277	394	-118	382	0	382
2010				296	436	-140	390	0	390
2011	460	463	-3	291	411	-121	364	0	364
2012	445	452	-7	293	429	-136	388	0	388
2013	457	460	-3	290	404	-114	368	0	368
2014	454	457	-3	297	414	-117	378	0	378
2015	451	454	-3	293	403	-110	336	0	336
2016	455	458	-3	292	434	-141	380	0	380

Due to a correction in the fuel use as feedstock of a few chemical companies the CO_2 emissions from Other (2B10) have been changed for the period 2012-2016. The results of these changes can be found in Table 4.9.

Table 4.9: Effects of emissions changes (Gg CO_2 eq.) applied to Other (2B10), 2012-2016.

Year	NIR 2019: 2B10 CO_2	NIR 2018: 2B10 CO_2	Difference
2012	578	224	354
2013	610	259	351
2014	706	301	405
2015	610	280	330
2016	492	205	287

Through some corrections, the HFC emissions from Handling activities (2B9b3) have been changed for a number of years. The results of these changes can be found in Table 4.10.

Table 4.10: Effects of emissions changes (Gg CO_2 eq.) applied to Handling activities (2B9b3), 2001-2003 and 2006-2013

Year	NIR 2019: 2B9b3 HFC/PFC	NIR 2018: 2B9b3 HFC/PFC	Difference
2001	118	222	-105
2002	215	110	105
2003	121	78	43
2006	57	58	0
2007	37	38	-1
2008	23	25	-1
2009	217	222	-5
2010	148	156	-9
2011	81	89	-8

Year	NIR 2019: 2B9b3 HFC/PFC	NIR 2018: 2B9b3 HFC/PFC	Difference
2012	76	80	-4
2013	54	58	-4

4.3.6 *Category-specific planned improvements*
No improvements are planned.

4.4 Metal production (2C)
4.4.1 *Source category description*
Table 4.11 Overview of the sector Metal Production (2C), in the base year and the last two years of the inventory (in Tg CO_2 eq) update

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2C. Metal Production	CO_2		0,5	0,1	0,1	-87,5%	0,5%	0,0%	0,0%
	PFC		2,6	0,0	0,0	-99,5%	0,1%	16,9%	0,0%
	All		3,1	0,1	0,1	-97,7%	0,6%	0,0%	0,0%
2C1. Iron and steel production	CO_2	non key	0,0	0,0	0,0	-67,9%	0,1%	0,0%	0,0%
2C3. Aluminium production	CO_2	T	0,4	0,1	0,0	-89,6%	0,4%	0,0%	0,0%
	PFC	T	2,6	0,0	0,0	-99,5%	0,1%	16,9%	0,0%

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).

Overview of shares and trends in emissions

Table 4.11 provides an overview of emissions, by proportion, from the main source categories. From 2004 onwards, the level of the PFC emissions from aluminium production (2C3) (see Table 4.12) 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 4.12: Emissions of CF_4 and C_2F_6 from Aluminium production (2C3) (Gg CO_2 eq.)

Year	PFC14 (CF_4)	PFC116 (C_2F_6)	Total
1990	2,049	588	2,638
1991	2,034	577	2,611
1992	1,849	521	2,369
1993	1,876	518	2,394
1994	1,799	498	2,297
1995	1,746	485	2,230
1996	1,946	521	2,467
1997	2,079	549	2,628
1998	1,530	491	2,020
1999	1,134	433	1,567
2000	1,188	454	1,642
2001	1,135	434	1,570
2002	1,744	706	2,450
2003	389	129	518
2004	100	24	124
2005	82	20	102
2006	56	13	69
2007	92	21	113
2008	67	16	84
2009	40	10	50
2010	57	11	67
2011	79	17	96
2012	15	3	18
2013	9	2	11
2014	0.04	0.01	0.05
2015	5.4	1.1	6.5
2016	11.3	2.3	13.6
2017	10.8	2.2	13.0

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. (2019).

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 1990–2017. EFs are plant-specific and confidential and are based on measured data.

4.4.3 *Uncertainty and time series consistency*

Uncertainty

The Approach 1 uncertainty analysis explained in Annex 2, provides estimates of uncertainties per 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*

No category specific recalculations were made.

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 *Source category description*

Table 4.13 presents an overview of emissions related to to three sources in this category. 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.

Table 4.13 Overview of the sector Non-energy products from fuels and solvents use (2D), in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2D. Non-energy products from fuels and solvent use	CO_2		0,2	0,3	0,3	73,1%	2,8%	0,2%	0,2%
	CH_4		0,0	0,0	0,0	103,0%	0,0%	0,0%	0,0%
	All		0,2	0,3	0,3	73,1%	2,8%	0,0%	0,2%
2D1. Lubricant use	CO_2	non key	0,1	0,1	0,1	11,4%	0,8%	0,1%	0,0%
2D2. Paraffin wax use	CO_2	L,T	0,1	0,2	0,2	103,0%	1,8%	0,1%	0,1%
2D3. Other non specified	CO_2	non key	0,0	0,0	0,0		0,2%	0,0%	0,0%

CO_2 emissions from paraffin wax use are identified as a Approach 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 2017. CO_2 emissions from Urea use in diesel vehicles increased sharply during the period 2005–2017.

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. (2019).

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

4.5.3 *Uncertainty and time series consistency*
Uncertainty
The Approach 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*
Small corrections have been made for Lubricant use (2D1) in 2015 and 2016, Paraffin wax use (2D2) in 2016 and Urea use in SCR (2D3) for the period 2005-2016. This has led to minor corrections in CO_2 emissions for the period 2005-2016.

4.5.6 *Category-specific planned improvements*
No improvements are planned.

4.6 Electronics industry (2E)
4.6.1 *Source category description*

Table 4.14, Overview of the sector Integrated circuit or semiconductor (2E) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2E1. Integrated circuit or semiconductor	PFC	non key	0,0	0,1	0,0	69,4%	0,4%	55,4%	0,0%

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.

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 0.3% in 1990 and 2.1% in 2017. The latter figure corresponds to 0.04 Tg CO_2 eq. and accounts for 0.02% of the national total GHG emissions in 2017.

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 4.15).

Table 4.15: Emissions trend from the use of PFCs (incl. NF_3) in Electronics industry (2E1) (Gg CO_2 eq.)

Year	PFCs
1990	25
1995	50
2000	261
2005	254
2006	269
2007	305
2008	241
2009	168
2010	205
2011	140
2012	156
2013	115
2014	89
2015	85
2016	92
2017	43

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., 2019).

4.6.3 *Uncertainty and time series consistency*

Uncertainty
The Approach 1 uncertainty analysis outlined in Annex 2, provides estimates of the uncertainties per 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 *Source category description*

Table 4.16, Overview of the sector Product use as substitutes for ODS (2F) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2F. Product uses as substitutes for ODS	HFC		0	1,7	1,7		14,7%	93,0%	0,9%
2F1. Stationary refrigeration and Mobile air-conditioning	HFC	L,T	0	1,5	1,5		13,2%	83,4%	0,8%
2F6. Other	HFC	T	0	0,2	0,2		1,5%	9,6%	0,1%

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 commercial-, industrial- and transport refrigeration, stationary air-conditioning and mobile air-conditioning.

Overview of shares and trends in emissions
Due to increased HFC consumption as a substitute for (H)CFC use, the contribution of F-gas emissions from category 2F to the total national inventory of F-gas emissions was 0% in 1990 and 93% in 2017. The latter figure corresponds to 1.7 Tg CO2 eq. and accounts for 0.9% of the national total GHG emissions in 2017(see Table 4.17).
In this submission the current calculation method (via a stock model) of Stationary refrigeration (2F1) has been replaced by a new method. The new method uses a ‘Refrigerants registration system’ to estimate the emissions from 2013 onwards.

Table 4.17: Emissions trends per sub category from the use of HFCs as substitutes for ODS (Gg CO_2 eq.)

Year	2F1: Sationary refrigeration HFCs	2F1: Mobile air-conditioning: HFC134a	2F6: Other applications: HFCs	HFCs Total
1990	NO	NO	NO	NO
1991	NO	NO	NO	NO
1992	NO	NO	NO	NO
1993	NO	NO	NO	NO
1994	16	3	62	81
1995	63	9	201	273
1996	143	17	474	634
1997	217	31	746	994
1998	267	54	849	1,170
1999	311	84	849	1,243
2000	420	122	689	1,231
2001	537	163	386	1,086
2002	644	204	181	1,029

Year	2F1: Sationary refrigeration HFCs	2F1: Mobile air-conditioning: HFC134a	2F6: Other applications: HFCs	HFCs Total
2003	761	244	167	1,172
2004	870	282	214	1,366
2005	975	315	152	1,441
2006	1,077	344	171	1,592
2007	1,190	368	238	1,797
2008	1,307	389	261	1,958
2009	1,399	410	226	2,034
2010	1,447	417	205	2,068
2011	1,481	428	287	2,196
2012	1,533	437	222	2,191
2013	1,160	443	186	1,788
2014	955	450	175	1,580
2015	1,053	457	175	1,685
2016	1,053	470	175	1,698
2017	1,053	471	175	1,698

4.7.2 *Methodological issues*

To comply with the 2006 IPCC Guidelines, volume 3, IPCC Tier 2 methods are used to estimate emissions from the sub-categories of 2F. The activity data used to estimate emissions of F-gases derives from the following sources:

- Stationary refrigeration(2F1): Until the 2016 submission, consumption data of HFCs were obtained from the annual reports by PriceWaterhouseCoopers. From 2015 onwards no consumption data of HFCs are available. Therefore, emissions were kept equal to the emissions of 2014 till last submission.

From this submission onwards the figures from the ‘Refrigerants registration system’, that includes information about leakages, the filling of (new) installations and dismantling, are used. This system is the result of a European obligation, whereby building owners are required to register(see for more information page 25 of the attachement “NVKL-procedures stationaire koelinstallaties volgens VERORDENING (EU) Nr. 517/2014”).
Collecting of data within the ‘Refrigerants registration system’ takes place as follow:

- data at plant level level (amounts of leakages, filling of (new) installations and dismantling),are registered continuously by mechanics of the installation companies;
- the control of the figures happens once every two years by the inspection authorities;
- after approval, the figures are aggregated and delivered to the NL-PRTR;
- Next, the NL-PRTR can start the emission calculations.

Because the system is working in this way, it takes more time before the data comes available. This means that in this submission final figures will be provided up to and including 2015. The 2016 and 2017 figures will be kept equal to the last year (2015). In the 2020 submission, the 2016 figures from the 2019 submission will be replaced by the final figures for 2016.

- For mobile air-conditioning (2F1), the number of cars (by year of construction) and the number of scrapped cars (by year of construction) were obtained from Statistics Netherlands. The amounts of recycled and destroyed refrigerants were obtained from ARN, a waste-processing organization.
- Other applications (2F6); HFC emissions from 2F2, 2F3, 2F4 and 2F5:
- Until the 2016 submission, consumption data of HFCs were obtained from the annual reports by PriceWaterhouseCoopers. From 2015 onwards no consumption data of HFCs are available. Therefore, emissions from these sources were kept equal to the emissions of 2014.

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

- Stationary refrigeration: Until the 2016 submission annual leak rates from surveys (Baedts et al., 2001). From this submission onwards figures from the ‘Refrigerants registration system’ are used that includes information about leakages, the filling of new installations and dismantling.
- Mobile air-conditioning: Annual leak rates from surveys (Baedts et al., 2001) and other literature (Minnesota Pollution Control Agency, 2009; YU & CLODIC, 2008).
- Other applications (2F6); IPCC default EFs.

More detailed descriptions of the methods and EFS used can be found in the methodology report (Peek et al., 2019), 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 Approach 1 uncertainty analysis outlined in Annex 2, provides estimates of uncertainties per IPCC source category. Based on expert judgement, the uncertainty in HFC emissions from HFC consumption is estimated to be in the range of 50%, mostly determined by uncertainties in activity data.

Time series consistency

Consistent methodologies have been used to estimate emissions from Mobile air-conditioning (2F1) and Other applications (2F6).

For Stationary refrigeration (2F1), two methods have been used to estimate emissions. The stock model-method has been used for the period 1990-2012 and the method with the use of the ‘Refrigerants registration system’ from 2013 onwards.
For the stock-model method, activity data were derived from the sales figures of individual HFCs to the total cooling sector in the Netherlands. Until the 2016 submission, these were available annually via a trade

flow study. However, the trade flow study stopped after the 2016 submission. So, from 2015 onwards no sales figures of HFCs are available. The annual sales figures were not sufficiently reliable to be split into the annual filling of new installations and the refilling of existing installations. It was also not possible to divide the sales among the diferent subsectors.
Therefore, a stock model for the complete sector has been set up to determine the refilling of existing installations, the filling of new installations and other figures. To determine the different figures, a fixed leakage percentage has been used. The starting year of the stock-model was the year in which a certain HFC is used for the first time as cooling agent. So, the only input variables were the sales figures from HFCs. The other parameters (the filling of new installations, total stock, dismantling-amounts, emissions) were calculated using the model.

The new method uses figures from the 'Refrigerants registration system' to calculate emisions. In this system data about leakages, filling of new installation, dismantling, etc. are collected from commercial-, industrial- and transport refrigeration and stationary air-conditioning. Leakages, filling of new installation, dismantling, etc. are not calculated but taken directly from the system.
This new method provides more accurate data than the stock-model method. All equipments with a content >= 3 kg are covered by the 'Refrigerants registration system'. This makes it the best source we have and as complete as possible. In addition, the emissions calculated with the new method are lower than those calculated with the old stock-model method. That the stock-model gave higher emissions was probably due to the assumption that the usage figures were the same as the sales figures and that a fixed leakage percentage of 5.8% was used, while according to the new method the average leakage rate during the period 2013-2015 was approximately 4%.
Figures from the 'Refrigerants registration system' are available from 2013 onwards.

As described above, the two methods are completely different. For that reason it is not possible to construct a realistic consistent time series for the whole period 1990-2017.

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*

For Stationary refrigeration (2F1) the current calculation method (via a stock model) has been replaced by a new method that uses a 'Refrigerants registration system'.

For the 2018 submission, the stock model has been used to calculate the emissions for the period 1990-2016. In current submission, the stock model has been used to calculate emissions for the period 1990-2012 and from 2013 onwards the ‘Refrigerants registration system’. This resulted in new emission figures for the period 2013-2016 (see Table 4.18).

Table 4.18: Effects of emissions changes (Gg CO_2 eq.) applied to Stationary refrigeration (2F1): 2013-2016

Year	NIR 2019 2F1: Stationary refrigeration HFCs	NIR 2018 2F1: Stationary refrigeration HFCs	Difference HFCs
2013	1,160	1,574	-415
2014	955	1,591	-637
2015	1,053	1,591	-539
2016	1,053	1,591	-539

Because more detailed information on Mobile air-conditioning (2F1) became available, the HFC 134a emissions have been changed for the whole time series. The results of these changes can be found in Table 4.19.

Table 4.19: Effects of emissions changes (Gg CO_2 eq.) applied to Mobile airconditioning(2F1): 1994-2016

Year	NIR 2019 2F1: Mobile airconditioning: HFC134a	NIR 2018 2F1: Mobile airconditioning: HFC134a	Difference HFC134a
1994	3	3	-0.63
1995	9	10	-1.54
1996	17	20	-2.41
1997	31	34	-3.40
1998	54	58	-4.54
1999	84	84	0.01
2000	122	122	0.86
2001	163	162	1.40
2002	204	203	1.75
2003	244	242	1.50
2004	282	280	2.24
2005	315	313	1.75
2006	344	342	1.60
2007	368	367	1.31
2008	389	388	1.17
2009	410	409	0.88
2010	417	416	0.86
2011	428	427	0.75
2012	437	436	0.63
2013	443	443	0.06
2014	450	450	-0.05
2015	457	458	-0.23
2016	470	473	-2.48

4.7.6 *Category-specific planned improvements*

The Netherlands is working on a new method for "Other applications" (2F6); as well as an update of the uncertainty estimates for HFC emissions from HFC consumption (2F1).

4.8 Other product manufacture and use (2G)

4.8.1 *Source category description*

Table 4.20, Overview of the sector Other product manufacture and use (2G) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector / category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2G. Other	CO_2	non key	0,000	0,001	0,001	239,2%	0,0%	0,0%	0,0%
	CH_4	non key	0,05	0,04	0,04	-13,3%	0,4%	0,2%	0,0%
	N_2O	T	0,22	0,09	0,08	-62,6%	0,7%	1,0%	0,0%
	All		0,54	0,27	0,25	-52,5%	1,1%	0,0%	0,1%
2G2. SF6 and PFCs from other product use	SF6	non key	0,3	0,1	0,1	-51,6%	1,1%	100,0%	0,1%
2G3. N2O from product uses	N_2O		0,2	0,1	0,1	-66,6%	0,6%	0,8%	0,0%

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):
  - o Fireworks: CO_2, CH_4 and N_2O emissions;
  - o 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).

Overview of shares and trends in emissions

Table 4.21 shows the trend in emissions from the use of SF_6 during the period 1990–2017.

Table 4.21: Emissions from the use of SF_6, 1990–2017 (Gg CO_2 eq.)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
SF_6	207	261	259	204	154	125	173	120	135	139	134	126

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 67% during the period 1990–2017. N_2O emissions from anaesthesia fell by 94% between 1990 and 2017 due to better dosing in hospitals and other medical institutions. Domestic sales of cream in aerosol cans increased sharply between 1990 and 2017. For this reason, emissions of N_2O from food aerosol cans increased by 122% during the period 1990–2017.

The small CO_2 and CH_4 emissions remained fairly constant between 1990 and 2017. CO_2, CH_4 and $_{N2O}$ 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., 2019.
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 Statistics Netherlands.

The EFs used in 2G4 are based on the following:
- Fireworks: CO_2: 43 kg/t; CH_4: 0.78 kg/t; N_2O: 1.96 kg/t (Jansen et al., 2019);
- Production of drinking water: 2.47 tons CH_4/106 m^3 (Jansen et al., 2019).

4.8.3 *Uncertainty and time series consistency*

Uncertainty

The Approach 1 uncertainty analysis outlined in Annex 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 2G1 the uncertainty is estimated to be approximately 30% and 15%, respectively.
Uncertainties for the other source categories under 2G vary from 50-70%

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
The 2016 AD for Fireworks and Degassing of drinking water have been corrected. This has led to some minor changes in the CO_2, CH_4 and N_2O emissions from Fireworks in 2016 and a minor change in CH_4 emissions from Degassing of drinking water in 2016.

4.8.6 Category-specific planned improvements
No improvements are planned.

4.9 Other (2H)
4.9.1 Source category description
Table 4.22 Overview of the sector Other process emissions (2H) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector / category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2H. Other process emissions	CO_2	non key	0,1	0,0	0,0	-66,9%	0,2%	0,0%	0,0%

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.
Overview of shares and trends in emissions
Emissions are very small (see Table 4.22).

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

4.9.3 Uncertainty and time series consistency
Uncertainty
The Approach 1 uncertainty analysis outlined in Annex 2, provides estimates of the uncertainties per IPCC source category. The uncertainty

in the emissions of this category is estimated to be 6% (respectively 3% and 5% uncertainty in activity data and EF)

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*

The energy statistics for the years 2015 and 2016 have been improved. This has led to some minor corrections for CO_2 emissions in 2015 and 2016.

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 2018

Emissions:	Methane (CH_4) emissions decreased by 1.0% from 2016 to 2017, due to a decrease in animal numbers, resulting in a lower enteric fermentation emission. Nitrous oxide (N_2O) emissions increased by 2.6% from 2016 to 2017, this is because the amount of N in manure increased in 2017, which compensated the decrease in animal numbers. Carbondioxide (CO_2) emissions increased by 15.6% from 2016 to 2017, caused by an increased usage of liming products. In CO2 equivalents, overall emissions increased 0.2% in 2017 compared to 2016.
Key categories:	New Key categories: • 3B1 Mature dairy cattle (CH_4) • 3B1 Cattle (N_2O) • 3B1 Mature dairy cattle (N_2O) • 3B1 Growing cattle (N_2O) • 3B5 Indirect emissions (N_2O) • 3G Liming (CO_2 (Key(L2,T));
Methodologies:	The **emissions of manure treatment** are now included in the calculations, resulting in a decrease of 0.04 kton CH_4 (-1.0 kton CO_2 eq.) in 1990 and 5.6 kton CH_4 (-140.7 kton CO_2 eq.) in 2016. N_2O emissions from this category have increased by 0.06 kton N_2O (37.0 kton CO_2 eq.) in 1990 and 0.24 kton N_2O (90.8 kton CO_2 eq.) in 2016. These emissions are reported under category 3, with the exception of CH_4 from manure digestion; these emissions are reported in category 5B2 Biological treatment of waste – anaerobic digestion at biogas facilities. The **N_2O emissions from manure management** will from now on be reported per animal category. In itself this will not change the total N_2O emissions, differences in emissions compared to the previous submission are entirely due to the inclusion of manure treatment. The **production of organic substances (volatile solids)** will be calculated yearly from now on, instead of irregular updates and extrapolation between these years. The **information source of the synthetic fertilizer statistics** has been changed. Before 2016 the information was collected through a survey among the wholesalers and the fertilizer companies, but - due to a lower response to the survey - Wageningen

Economic Research has chosen to switch to the fertilizer data as collected for the Farm Accountancy Data Network (FADN; or BIN in Dutch). Consistency between both data sources has been investigated and was confirmed.

5.1 Overview of the sector

Table 5.1 provides an overview of the contribution of the sector Agriculture, subdivided in the relevant subcategories, to the total greenhouse gas emissions in the Netherlands.

Table 5.1: Overview of emissions in Agriculture sector, in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3. Agriculture	CO_2		0,2	0,0	0,0	-74,4%	0,2%	0,0%	0,0%
	CH_4		14,7	12,7	12,5	-14,6%	66,2%	69,5%	6,5%
	N2O		10,2	6,2	6,3	-37,9%	33,5%	72,7%	3,3%
	All		25,1	18,9	18,9	-24,5%	100,0%		9,8%
3A. Enteric fermentation	CH_4		9,2	8,8	8,7	-6,2%	45,8%	48,0%	4,5%
3B. Manure management	CH_4		5,4	3,9	3,9	-28,8%	20,5%	21,5%	2,0%
	N_2O	L	0,9	0,8	0,8	-17,7%	4,1%	8,9%	0,4%
	All		6,4	4,6	4,6	-27,2%	24,6%		2,4%
3D. Agriculture soils	N_2O		9,3	5,4	5,6	-40,0%	29,4%	63,8%	2,9%
3G. Liming	CO_2	T	0,2	0,0	0,0	-74,4%	0,2%	0,0%	0,0%
National Total GHG emissions (excl. CO2 LULUCF)	CO_2		163,3	166,8	164,9	1,0%			
	CH_4		31,8	18,3	18,0	-43,4%			
	N_2O		18,0	8,5	8,7	-51,7%			
	total*		221,7	195,8	193,7	-12,6%			

**including f-gases*

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. Throughout the whole period 1990-2017, Field burning of agricultural residues was prohibited in the Netherlands (article 10.2 of the Environmental Management Act, or *'Wet Milieubeheer'* in Dutch).

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 emissions through land use in agriculture (CRF sector 4 Land use, land use change and forestry; see Chapter 6). 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).

Overview of trends in emissions and activity data

Figure 5.1 shows the trend in total GHG emissions from the sector Agriculture.

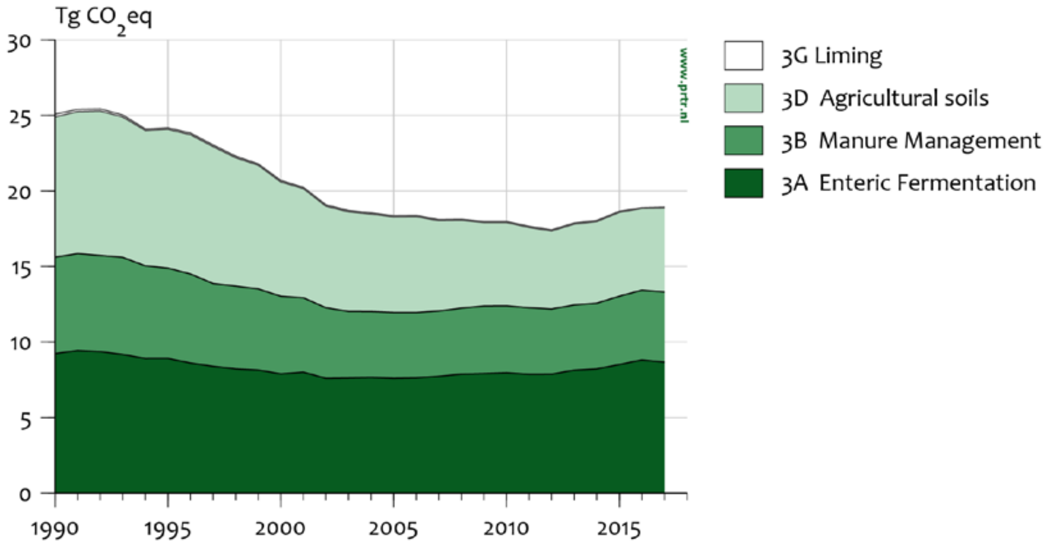


Figure 5.1: Sector 3 Agriculture – trend and emission levels of source categories, 1990–2017

Animal numbers are the primary activity data used in emission calculations for Agriculture. Animal numbers come from the annual agricultural census, performed by Statistics Netherlands. . Table 5.2 presents an overview. The animal numbers decreased between 1990 and 2017 for total cattle, swine and sheep numbers by 18%, 11% and 48%, respectively. For poultry, horses and goats the animal numbers increased by 11%, 10% and 777%. The number of rabbits decreased by 56%, while the number of fur-bearing animals increased by 66%. Higher production rates per animal and restrictions via quotas resulted in a decreasing trend in the animal numbers of cattle, sheep and swine.

The methodology to calculate the CH_4 and N_2O emissions are based on different activity data (see section 5.2 and 5.3). This includes sometimes differing animal numbers, since for N_2O the combined N excretion data for swine, sheep and goats and their young offspring/male animals is estimated by the Working group on Uniformity of calculations of Manure and mineral data (WUM). Whereas for CH_4 calculations, default IPCC emission factors for average animals present are used.

Between 1990 and now several outbreaks of animal diseases have taken place. These outbreaks have had an impact on the animal numbers, and on the related emissions. In the years with an outbreak the animal numbers have been corrected (CBS, 2012). More detailed information on animal numbers can be found in the background document (Van Bruggen *et al.*, in prep.).

Table 5.2: Animal numbers in 1990–2017 (x 1,000) (www.cbs.nl)

Animal type	1990	1995	2000	2005	2010	2015	2016	2017
Cattle								
Mature dairy cattle	1,878	1,708	1,504	1,433	1,479	1,622	1,745	1,672
Other mature cattle	120	146	163	151	115	80	68	65
Growing cattle	2,929	2,800	2,402	2,213	2,381	2,432	2,438	2,287
Sheep	790	771	680	647	558	523	493	491
Young stock/males	913	903	625	714	571	423	399	402
Swine	8,724	8,801	8,015	6,749	7,131	7,005	6,883	6,789
Young stock	5,191	5,596	5,102	4,563	5,124	5,598	5,595	5,612
Goats	37	43	98	172	222	292	306	322
Young stock/males	23	33	80	120	131	178	194	211
Horses	370	400	417	433	441	417	406	408
Mules and asses	IE	IE	IE	IE	1	1	1	1
Poultry	94,902	91,637	106,517	95,190	103,371	108,558	107,312	105,771
Other livestock								
Rabbits	105	64	52	48	39	48	45	43
Young stock	681	424	340	312	260	333	319	300
Fur-bearing animals	554	463	589	697	962	1,023	923	919

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 (-11%) was associated with an increase in milk production per cow between 1990 and 2017. The increase in milk production per cow is the result of genetic changes (due to breeding programs 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. This increase has been stopped by the introduction of the phosphate quotain January 2018. This limits the amount of dairy cattle a farmer can keep, resulting in reduction of animal numbers in 2017 in anticipation of introduction of the phosphate quota, for mature dairy cattle this was 8% and for growing cattle 12% (CBS, 2018). Since the yearly agricultural census is done in April, the amount of cattle present on the farms at that time was not representative for the yearly average. Therefore the number of animals is adjusted, with the help of the Identification and Registration system (I&R rundvee; data from the Netherlands Enterprise Agency).

The other mature cattle show the same trend as the mature dairy cattle. However, in 2016 the other mature dairy cattle show a larger decrease that continues into 2017. This can be explained by the phosphate quotas, which make it less profitable to have large numbers of other mature cattle and growing cattle. The total decrease between 1990 and 2017 is 46% in the number of other mature cattle. Between 1990 and 2013, the number of young dairy cattle followed the same decreasing trend as the number of mature dairy cattle. Overall, from 1990 to 2017 the number of growing cattle decreased by 22%. In veal calves a small shift was seen from formula-fed production (white veal) towards non-formula-fed production (rosé veal).

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. Sheep numbers remained almost at the same level between 2016 and 2017.

Swine
The number of swine was stable in the early 1990s. In 1997 there was an outbreak of classical swine fever, this led to an overestimation of the sow and fattening pig numbers during the agricultural census; this overestimation was corrected in the VS and N excretion, leading to a decrease in emissions. This decreasing trend continued to 2004, followed by a relatively small increasing trend up until 2011. Due to the Netherlands' manure and fertilizer policy, in which 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, from 2012 onwards swine numbers were fairly stable. In 2017 adult swine numbers decreased by 1% compared with 2016.

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 2017, total goat numbers increased by 7% compared with 2016.

Horses
From 1990 to 2009 the number of horses and ponies kept on farms increased by 108%. From 2010 onwards the number of horses on farms decreased as an effect of the economic crisis. 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 (Productschappen Vee Vlees en Eieren, 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. Between 1990 and 2017, 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 emission inventory. For the years 1990–2009 the notation key IE is used, because prior to 2010 mules and asses were included in the category horses of the Agricultural Census. In 2017 the total number increased with 2% compared to 2016.

Poultry
An increase in the number of poultry was observed between 1990 and 2002. As a direct result of the avian flu outbreak in 2003 the poultry numbers decreased by almost 30%. In 2004 poultry numbers increased 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 2017 fipronil was found in eggs in the Netherlands, this led to the culling of the contaminated farms and vacancy of the poultry houses during the remaining months of 2017. This resulted in fewer animals present in 2017 (-1%).

Other livestock
This category includes rabbits and fur-bearing animals. The number of rabbits showed a continuous decreasing trend from 1990 to 2017 (-56%).
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). For 2016 and 2017, a drop of 10% in animal numbers is observed, probably because farmers are already anticipating on 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 to be kept from 2008 onwards.

5.2 Enteric fermentation (3A)

5.2.1 Source 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. Detailed information on activity data sources and EFs can be found in chapter 2 of the methodology report Lagerwerf *et al.* (2019).
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.

CH_4 emissions from enteric fermentation decreased from 9.2 Mton CO_2 eq. to 8.7 Mton (-6.2%) between 1990 and 2017 (table 5.3), which is almost entirely explained by the decrease in CH_4 emissions from cattle. Cattle accounted for the majority (90%) of CH_4 emissions from enteric fermentation in 2017. Swine contributed 5% and the animal categories sheep, goats, horses and mules and asses accounted for the remaining 5%.

Table 5.3: Overview of the sector Enteric fermentation (3A) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector / category	**Gas**	**Key**	**1990**	**2016**	**2017**	**2017 vs 1990**	**Contribution to total in 2017 (%) by**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
3A. Enteric fermentation	CH_4		9,2	8,8	8,7	-6,2%	45,8%	48,0%	4,5%
3A1. Cattle	CH_4		8,2	7,9	7,8	-5,2%	41,0%	43,1%	4,0%
3A1. Mature dairy cattle	CH_4	L,T	5,2	5,6	5,6	8,5%	29,7%	31,2%	2,9%
3A1. Other mature cattle	CH_4	non key	0,2	0,1	0,1	-40,4%	0,7%	0,7%	0,1%
3A1. Growing cattle	CH_4	L,T	2,8	2,1	2,0	-28,0%	10,7%	11,2%	1,0%
3A2. Sheep	CH_4		0,3	0,2	0,2	-47,6%	0,9%	1,0%	0,1%
3A3. Swine	CH_4	L	0,5	0,5	0,5	-10,9%	2,5%	2,6%	0,2%
3A4. Other livestock	CH_4	non key	0,2	0,2	0,3	44,0%	1,3%	1,4%	0,1%

5.2.2 *Methodological issues*

Calculation method for cattle emissions

The EFs for cattle are calculated annually for the different sub-categories. For mature dairy cattle a country-specific Tier 3 method is used. The Tier 3 approach used 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. Detailed information on activity data sources and EFs can be found in chapter 2 and 3 of the methodology report (Lagerwerf et al., 2019).

For the other cattle categories, the calculation is based on a country-specific Tier 2 methodology. 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. 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 for the Netherlands, because GE intake is calculated with a country-specific method.

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, 2012a). For example, 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, 2018). Data on the chemical nutrient composition of individual roughages is provided by Eurofins Agro, a leading laboratory in the Dutch agricultural and horticultural sector with roughage sampling, analytical and advisory activities that is able to deliver data that can be taken as representative of average Dutch farming conditions.

The Netherlands is split in two regions, because of differences in diets. Where the north-west (NW) has a diet that contains mainly grass and south-east (SE) has a large fraction of maize in diet. Data used between 1990 and 2012 are published in an annex to Van Bruggen *et al.* (2014), a yearly update is published on the specific yearly diet (CBS, 2008 through 2018).

Trends in cattle EFs
Table 5.4 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, 2018).

Table 5.4: EFs for methane emissions from enteric fermentation specified according to CRF animal category (kg CH_4/animal/year)

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**
Mature dairy cattle	110.4	114.4	120.0	125.0	128.0	129.0	129.3	134.6
of which NW region	111.0	115.4	121.7	126.4	129.9	131.2	130.9	135.1
of which SE region	109.9	113.5	118.4	123.6	126.7	127.5	128.2	134.3
Other mature dairy cattle	70.3	71.3	72.1	76.7	78.1	79.1	78.6	77.6
Growing cattle	38.3	38.6	35.4	34.4	35.0	36.4	35.2	35.3

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). Also the average weight of mature dairy cattle and the average milk production has increased, , while the animal numbers decreased (Van Bruggen, 2018). Both will lead to an increase in the gross energy intake of the mature dairy cattle.

For growing cattle, the decrease of EF between 1990 and 2017 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 5.5 shows that the mature dairy cattle EF has the same increasing trend as the 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 (134.6/8,674)*6,000 = 93.1 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). The increase in 2017 of the EF can be explained by the changes in feed composition and increase of average body weight of the mature dairy cattle.

Table 5.5: Milk production (kg milk/cow/year) and EF (kg CH_4/cow/year) for mature dairy cattle

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**
Milk production	6,003	6,596	7,416	7,568	8,075	8,338	8,328	8,674
EF for methane	110.4	114.4	120.0	125.0	128.0	129.0	129.3	134.6

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.

EFs of other livestock
For sheep, swine, goats, horses and mules and asses the IPCC 2006 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 sub source category is less than 25% of the total emission from a key source category. The animal categories sheep, swine, goats, horses and mules and asses, have a combined share in total CH_4 emissions from enteric fermentation of ca. 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.

5.2.3 *Uncertainty and time series consistency*

Uncertainty
The Approach 1 uncertainty analysis explained in Annex 2 provides estimates of uncertainty according to IPCC source categories. The uncertainty of CH_4 emissions from the enteric fermentation emissions vary between 15% and 50%, mostly determined by the uncertainties in the emission factors (uncertainty in the EF for 3A3 (swine) estimated at

50%; for mature dairy cattle however, at 15%). Uncertainties for the activity data are estimated about 5%.

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 Statistics Netherlands. Consistent methods are used in compiling the census to ensure continuity in the collected data. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected through an annual survey.

5.2.4 *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 1997 there was an outbreak of classical swine fever, this led to an overestimation of the sow and fattening pig numbers during the agricultural census. It was then chosen to correct this overestimation in the VS excretion. However, over the years this correction on the VS excretion was not included anymore, because of its exception on the method of correction. The VS excretion for sows decreased 4.2% and for fattening pigs 17.2%.

With a redefinition of what is and what is not “an active agricultural farm animal”, adjustments were made to the animal numbers between 2000 and 2004 in the national statistics (largest number of 619 sheep).
To keep the animal numbers in line with the national statistics small changes were made in the animal categories: mature dairy cattle, other mature cattle, growing cattle, sheep, swine and horses. See table 5.6. Note that these changes have been incorporated in the NIR/CRF2018 already; included here for reason of transparency.

Table 5.6. Adjustment in animal numbers to agree with the national statistics.

	2000	2001	2002	2003	2004
3A1 Cattle					
3A1a Mature dairy cattle	0	0	-11	0	0
3A1b Other mature cattle	-60	-38	-41	-32	-17
3A1c Growing cattle	-86	-40	-46	-18	-28
3A2 Sheep	-619	-518	-468	-330	-296
3A3 Swine	-3	0	0	0	0
3A4 Other livestock					
Horses	-9	-7	-8	-5	-5

5.2.6 *Category-specific planned improvements*

No improvements are planned.

5.3 Manure management (3B)

5.3.1 Source category description

Overview of shares and trends in emissions

In the Netherlands, CH_4 emissions from manure management contribute 2.0% to total GHG emissions in the Netherlands and 20.5% to the sector. In 2017, N_2O emissions from manure management contributed 0.4% to the national total and 4.1% of the total GHG emissions of the Agriculture sector (see table 5.7).

CH_4 from manure management are particularly related to cattle and swine manure. Cattle and swine manure management contributed 10.9% and 9.0%, respectively, to the total GHG emissions of the Agriculture sector in 2016. Based on the trend, CH_4 emissions from manure management of poultry is a minor key source (-82.4% from 1990 to 2017). N_2O emissions from manure management from cattle contribute 1.9% to the sector total.

Table 5.7: Overview of the sector Manure Management (3B) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3B. Manure management	CH_4		5,4	3,9	3,9	-28,8%	20,5%	21,5%	2,0%
	N_2O	L	0,9	0,8	0,8	-17,7%	4,1%	8,9%	0,4%
	All		6,4	4,6	4,6	-27,2%	24,6%		2,4%
3B1. Cattle (total)	CH4	L,T	1,6	2,1	2,1	27,8%	10,9%	11,4%	1,1%
3B2. Sheep	CH4	non key	0,0	0,0	0,0	-47,6%	0,0%	0,0%	0,0%
3B3. Swine	CH4	L,T	3,4	1,6	1,7	-49,3%	9,0%	9,5%	0,9%
3B4. Poultry	CH4	T	0,4	0,1	0,1	-82,4%	0,4%	0,4%	0,0%
3B4. Other livestock	CH4	non key	0,0	0,0	0,0	32,7%	0,2%	0,2%	0,0%
3B1-4. Direct emissions	N_2O		0,9	0,8	0,8	-17,7%	4,1%	8,9%	0,4%
3B1. Cattle (total)	N_2O	L	0,3	0,4	0,4	7,0%	1,9%	4,2%	0,2%
3B2. Sheep	N_2O	non key	0,0	0,0	0,0	-79,3%	0,0%	0,0%	0,0%
3B3. Swine	N_2O	non key	0,1	0,1	0,1	-35,7%	0,5%	1,0%	0,0%
3B4. Other livestock	N_2O	non key	0,1	0,1	0,1	33,3%	0,4%	0,9%	0,0%
3B5. Indirect emissions	N_2O	L,T	0,4	0,2	0,2	-39,8%	1,2%	2,7%	0,1%

Both CH_4 and N_2O are emitted during the handling and storage of manure from cattle, sheep, swine, goats, horses, mules and asses, poultry 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.

Four different manure management systems are used in the Netherlands and included in the calculations:

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

Animal numbers were distributed over the various housing types using information from the Agricultural Census. In accordance with the IPCC 2006 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).

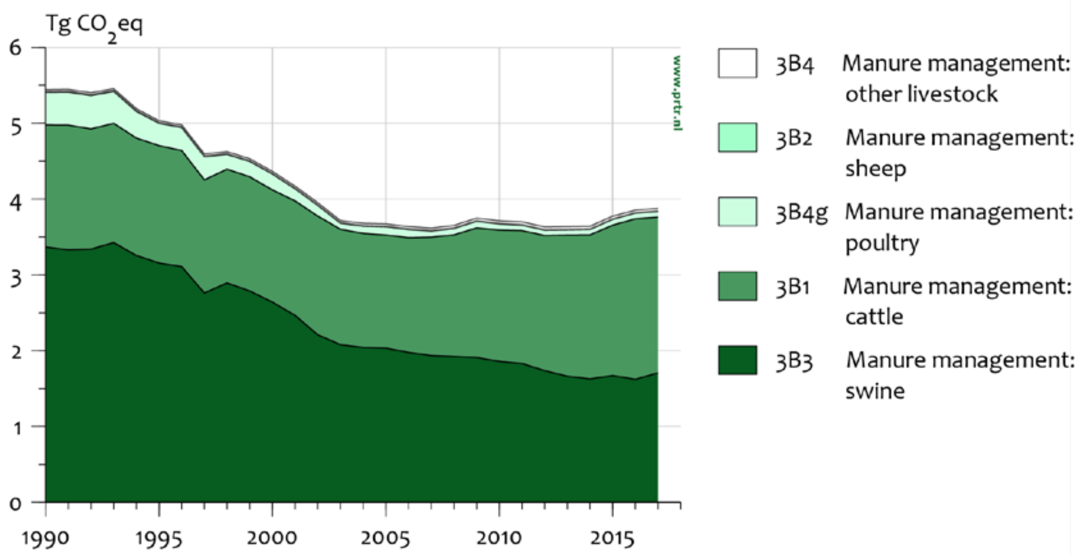


Figure 5.2: Category 3B Manure management – trend and emissions levels of source categories CH_4, 1990–2017

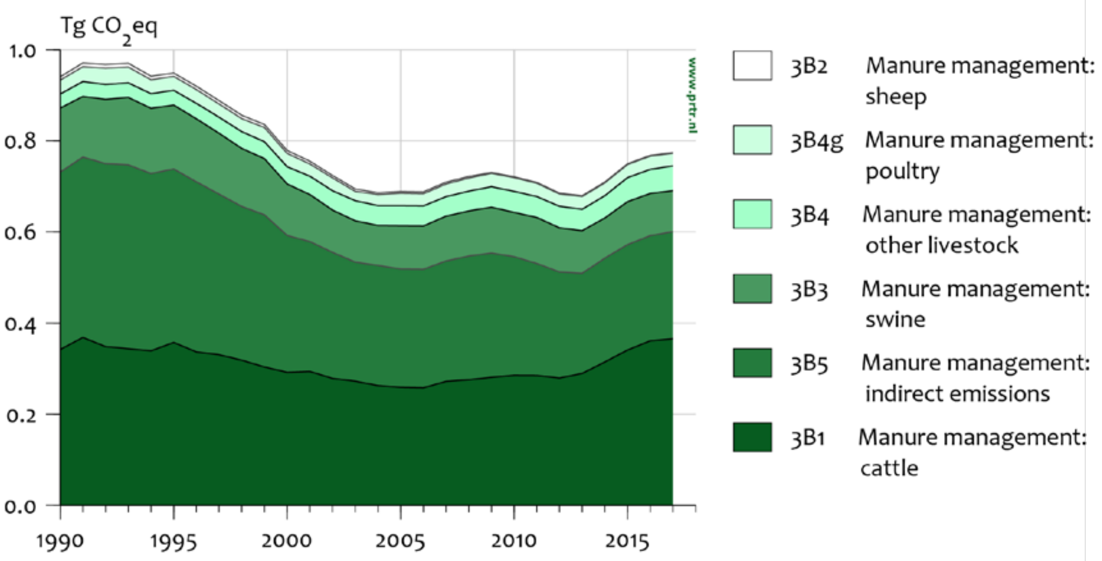


Figure 5.3: Category 3B Manure management – trend and emissions levels of source categories N_2O, 1990–2017

CH_4 from manure management
Between 1990 and 2017, emissions of CH_4 from manure management decreased by 29%. Emissions from cattle increased by 27.8%, while swine and poultry emissions decreased by 49.3% and 82.4% 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 of emissions is associated with the change from battery cage systems with liquid manure, to floor housing systems or aviary systems with solid manure. This lowered the CH_4 emissions, since the solid manure systems have a lower EF. Also the increase of manure treatment, shortening the storage time of the manure had an effect.

The decreasing VS excretions for swine resulted in a decreasing trend in CH_4 emissions from swine during the time series (CBS, 2018). The decrease was somewhat softened by an increase in livestock numbers in the first part of the time series (up to 1997).

CH_4 emissions from manure management have decreased from 1990 to 2017 as a result of more manure being treated. As the policy amount the application manure became stricter, it became more feasible to treat the manure. Also, when manure is treated (digested) it is stored shorter then untreated manure, resulting in lower CH_4 manure storage emissions.

N_2O from manure management
N_2O emissions are calculated using an N-flow model, the National Emission Model for Agriculture (NEMA; Lagerwerf et al., 2019). 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 NH_3, NOx, N_2 and N_2O 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.

The direct N_2O emissions from manure management have decreased by 2.1% between 1990 and 2017. Decreasing livestock numbers and lower N excretions per animal influence this trend. Manure treatment also influences this trend, from 1990 to 1998 only manure nitrification and denitrification took place. With manure separation more N_2O is emitted during the processing than is reduced with the shortening of the manure storage. However, since 1998 more manure is treated (also different techniques), resulting in an increase in N_2O emissions.

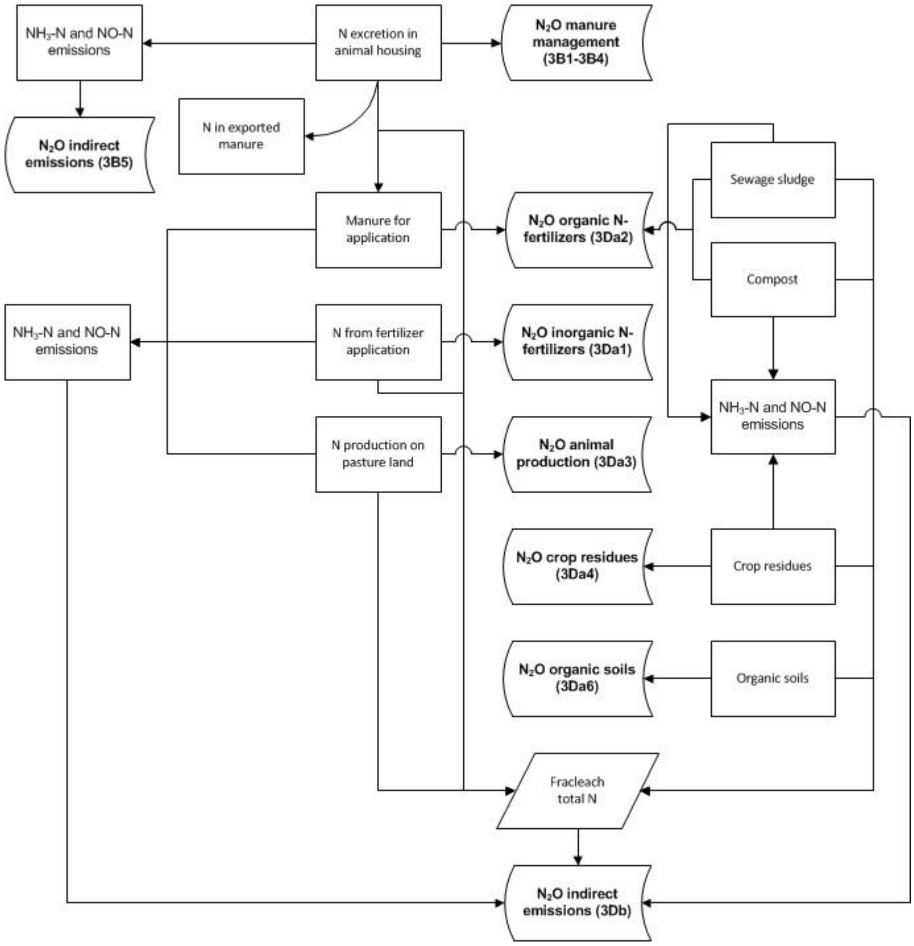


Figure 5.4: Schematic representation of N flows in agriculture and the allocation of emissions to source categories

Indirect N_2O emissions following atmospheric deposition of NH_3 and NOx emitted during the handling of animal manure decreased 39.8% from 1990 to 2017. This decrease is explained by reduction measures for NH_3 and NOx emissions from animal housing systems and manure storages over the years.

5.3.2 *Methodological issues*

Activity data and (implied) EFs

Detailed information on sources of activity data and EFs is found in chapters 4 (CH_4) and 7 (N_2O) of the methodology report (Lagerwerf *et al.*, 2019). Van Bruggen *et al.* (in prep.) 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 VS) and maximum CH_4 producing potential (B0, in m3 CH_4/kg VS).
- Manure management system conditions (storage temperature and period) for liquid manure systems, which determine the MCF.

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 for liquid manure since the manure management systems are different from the circumstances on which the default is based, as demonstrated in Groenestein et al. (2016). For solid manure systems and manure produced on pasture while grazing, IPCC default values are used. The time spent on pasture is calculated yearly by the Working group on Uniformity of calculations of Manure and mineral data (CBS, 2008 through 2018). If the manure is treated, it is assumed that the storage time is shortened since it is beneficial for the farmer to treat the manure as soon as possible.

For comparison, table 5.8 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 5.8: CH_4 implied emission factor (kg/animal/year) for manure management specified by animal category, 1990–2017

Animal type	1990	1995	2000	2005	2010	2015	2016	2017
Cattle								
- dairy cattle	23.07	24.10	27.97	31.07	34.87	36.72	37.23	37.85
- non-dairy cattle	7.42	7.53	7.50	7.84	8.04	8.01	8.01	6.85
- young cattle	6.87	7.04	6.62	6.30	7.05	7.88	7.86	8.07
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	IE	IE	IE	IE	0.76	0.76	0.76	0.76
Swine*	9.68	8.77	8.05	7.19	6.07	5.31	5.20	5.51
Swine excl. piglets	15.44	14.34	13.18	12.06	10.43	9.55	9.43	10.06
- fattening pigs	12.87	11.81	10.76	9.70	8.40	7.53	7.48	7.87
- breeding swine	26.09	25.08	23.60	22.47	20.18	19.27	19.09	20.68
Poultry	0.18	0.13	0.08	0.05	0.03	0.03	0.03	0.03
Other animals*	0.33	0.37	0.44	0.48	0.54	0.52	0.51	0.52

* The IEF is calculated on total animal numbers, including young stock. Manure production of young stock is accounted for in manure production by adult animals.

The manure treatments common in the Netherlands are manure separation, nitrification/denitrification, the creation of mineral concentrates, incineration of manure, drying of manure and/or digesting of manure. The emissions associated with the digesting of manure are reported in 5B2 Biological treatment of waste – anaerobic digestion at biogas facilities, all other manure treatment emissions are included in 3B. The amount of manure that is treated is based on the registered manure transports (data from the Netherlands Enterprise Agency; RVO).

Comparison with IPCC default EF for CH_4
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. For all other animal categories emissions are estimated using a Tier 1 approach. Detailed descriptions of the methods are given in the methodology report (Lagerwerf *et al.*, 2019). 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 Van Bruggen (2018).

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.

Mature dairy cattle
The IEF for the manure management of mature dairy cattle increased between 1990 and 2017 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 2017 (Van Bruggen, 2018). 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 der Hoek and Van Schijndel, 2006; Van Bruggen, 2018).

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 2013, when the liquid manure system was fully replaced by the solid manure system. The increase in poultry numbers by 11% since 1990 is counteracted by the shift towards solid manure management systems with a lower EF. This lead to an overall decrease in CH_4 emissions of poultry (Van der Hoek and Van Schijndel, 2006). The increase in manure treatment led to a decrease in CH_4 emissions through less storage time.

Swine
Between 1990 and 2017, 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. The VS excretion decreases, because the feed composition changes over the years, increasing the overall digestibility. 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.

N_2O IEF for manure management

Emissions of N_2O from manure management are calculated using the 2006 IPCC default EFs. As presented in Table 5.9, N_2O emissions from manure management decreased between 1990 and 2013 due to a decrease in total N excretion, as a result of more efficient production. The increase of IEF between 2013 and 2017 is a result of increased N excretion. This is caused by an increased feed intake, as a result of a higher average weight of mature dairy cattle (CBS, 2018) and an higher average milk production.

Table 5.9: N_2O IEFs for manure management and total N excretion per management system, 1990–2017 (mln kg/year and kg N_2O/kg manure)

	1990	1995	2000	2005	2010	2015	2016	2017
Cattle								
dairy cattle	0,34	0,36	0,32	0,34	0,34	0,35	0,35	0,39
non-dairy cattle	0,19	0,22	0,20	0,18	0,17	0,18	0,17	0,21
young cattle	0,14	0,15	0,13	0,11	0,11	0,12	0,12	0,12
Sheep	0,03	0,03	0,03	0,02	0,01	0,01	0,01	0,01
Goats	0,31	0,34	0,30	0,28	0,28	0,29	0,29	0,29
Horses	0,04	0,05	0,06	0,06	0,06	0,06	0,04	0,04
Mules and asses	IE	IE	IE	IE	0,10	0,10	0,08	0,08
Swine	0,05	0,05	0,05	0,05	0,04	0,03	0,03	0,03
Poultry	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Rabbits	0,07	0,06	0,06	0,06	0,06	0,07	0,07	0,07
Furbearing animals	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01

Comparison with IPCC default EF for N_2O

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 Approach 1 uncertainty analysis, detailed in Annex 2, provides estimates of uncertainty according to IPCC source categories.
The uncertainty for CH_4 varies between 20% and 40%, mostly determined by the estimated uncertainties in the EF (20% for 3B1 growing cattle; 40% for poultry (3B4). Uncertainties in Activity data vary between 1% and 10%.
The uncertainty in the annual N_2O emissions from manure management is much higher; estimated at 100% - 190% , attributable to the uncertainties in the EFs.

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 Statistics Netherlands. Consistent methods are used in compiling the census to ensure continuity in the collected data. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected through an annual survey.

5.3.4 *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*

Manure treatment emissions are added for all years. A detailed description of the methodology can be found in the methodology report (Lagerwerf et al., 2019). It is assumed that storage emissions for treated manure are half that of untreated manure for CH_4, and zero for N_2O. On the other hand, new emissions occur both during the process itself and storage of products. Combined effect on reference years and 2016 as reported in the NIR2018 are shown in table 5.10.

For this NIR2019, it is assumed that the treated manure does not lead to other storage emissions. Therefore the emissions reported in table 10.1, showing the effect of recalculations of emissions compared for the years up to 2016, differ slightly from the figures in table 5.10.

Table 5.10: Combined effect of change in storage emissions compared to the NIR2018 and addition of manure treatment to the inventory (ton CH_4 or N_2O, in Gg CO_2-eq.)

	Gg	1990	1995	2000	2005	2010	2015	2016
Mature dairy cattle	CH_4	0	0	0	0	-772	-699	-809
	N_2O	0	0	0	0	-13	11	14
Young cattle	CH_4	-39	-98	-103	-112	-336	-322	-292
	N_2O	61	132	149	119	158	210	225
Swine	CH_4	0	0	0	0	-2,214	-4,251	-4,661
	N_2O	0	0	0	0	-12	0	3
Poultry	CH_4	0	0	10	18	115	145	137
	N_2O	0	0	0	0	0	0	0
Total	CH_4	-39	-98	-92	-94	-3,208	-5,127	-5,627
	N_2O	61	132	149	119	133	221	242
	CO_2-eq	17	37	42	33	-41	-62	-69
5B2 manure digestion	CH_4	0	0	0	0	814	1,145	1,270
	CO_2-eq	0	0	0	0	20	29	32

In 1997 there was an outbreak of classical swine fever, this led to an overestimation of the sow and fattening pig numbers during the agricultural census, it was then chosen to correct this overestimation in the VS excretion. However, over the years this correction on the VS excretion was lost, since with all the other disease outbreaks the animal number was corrected. The VS excretion for sows decreased 4.2% and for fattening pigs 17.2%.

With a redefinition of what is and what is not an agricultural farm animal small adjustments were made to the animal numbers between 2000 and 2004 in the national statistics. To keep the animal numbers in line with the national statistics small changes were made in the animal categories: mature dairy cattle, other mature cattle, growing cattle, sheep, swine and horses. For more details see table 5.6, section 5.2.5)

5.3.6 Category-specific planned improvements
No improvements are planned.

5.4 Agricultural soils (3D)
5.4.1 Source category description
In 2017 agricultural soils were responsible for 29.4% of total GHG emissions in the Agriculture sector. Total N_2O emissions from agricultural soils decreased by 40% between 1990 and 2017 (see Table 5.11). 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; see figure 5.5). This was partly counteracted 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.

Methane emissions from agricultural soils are regarded as natural, non-anthropogenic emissions and are therefore not estimated.

Table 5.11 Overview of the sector Agricultural Soils (3D) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3D. Agriculture soils	N_2O		9,3	5,4	5,6	-40,0%	29,4%	63,8%	2,9%
3Da. Direct N2O emissions from agricultural soils	N_2O	L,T	7,7	4,8	4,9	-35,7%	26,0%	56,4%	2,5%
3Da1. Inorganic ferilizers	N_2O		2,5	1,5	1,6	-36,7%	8,4%	18,2%	0,8%
3Da2. Organic N fertilizers	N_2O		0,8	1,3	1,4	75,2%	7,2%	15,5%	0,7%
3Da3. Urine and dung from grazing animals	N_2O		3,0	0,9	0,9	-69,0%	5,0%	10,8%	0,5%
3Da4. Crop residues	N_2O		0,5	0,3	0,3	-28,3%	1,8%	3,9%	0,2%
3Da6. Cultivation of organic soils	N_2O	-	0,9	0,7	0,7	-19,6%	3,7%	8,0%	0,4%
3Db. Indirect N2O Emissions from managed soils	N_2O	L,T	1,6	0,6	0,6	-60,2%	3,4%	7,4%	0,3%

In 2017, N_2O emissions from grazing increased by about 1.3% compared to 2016 and emissions from synthetic N fertilizers increased by 3.5%. Emissions from crop residues have increased by 9.8% as a result of more grassland renovation (which varies considerably from year to year depending on weather conditions).

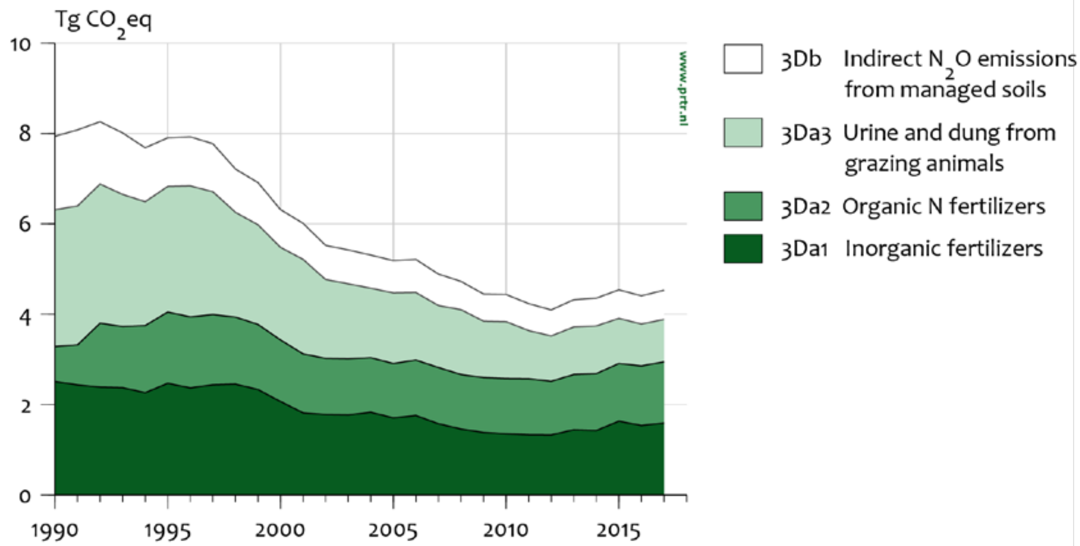


Figure 5.5: Category 3D Agricultural soils – trend and emissions levels of source categories, 1990–2017

Between 69% and 80% of the N excreted in animal housing is eventually applied to soils. A growing proportion of the manure N is exported, from 1% in 1990 to 10% in 2017. However this increasing trend stagnated in recent years. Approximately 10–16% of the N is emitted as ammonia or nitrous oxide during storage. Other N losses, mainly N_2 and NO, account for the remaining difference.

The N in manure applied to the soil emitted as NH_3, has decreased from 41% to 11% between 1990 and 2017, as a result of the Netherlands' policy to reduce ammonia emissions. This policy restricted the broadband application of manure, shifting the manure application to manure incorporation into the soil (i.e. shallow injection or ploughing-in) in 1991, resulting in lower NH_3 emissions. Ultimately, between 1990 and 2017, NH_3-N emission (from animal housing, storage, manure treatment, grazing and application to the field) decreased from 37% to 16% of total N in manure. In combination with lower synthetic N fertilizer application (-39%) and lower nitrogen excretion by animals (-26%), this resulted in a reduction of 64% in the amount of N deposited atmospherically over the 1990–2017 period.

The total N supply to soil was taken into account for calculating leaching and run-off: manure production in animal housing and on pasture (including treated manure), the application of synthetic N fertilizer, sewage sludge and compost, corrected for the net export of manure. In accordance with the IPCC 2006 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 33% between 1990 and 2017. This can be explained by the Netherlands' manure and fertilizer policy, aimed at reducing N leaching and run-off. This policy regulates the amount of manure production and its application by the introduction of measures such as restrictions on the numbers of swine and poultry per farm (so called 'manure production rights') and maximum application limits for manure and synthetic N fertilizer, all part of the Dutch ‘Manure and Fertilizers Act’ conform the Nitrates Directive. Since the leaching fraction has also decreased over time, the amount of nitrogen leached or run off has been reduced by 42% since 1990.

The emissions of crop residues decrease between 1990 and 2017 by 28%, the same decreasing trend can be seen in the amount of crop residues left on the field. This is mainly because of a decrease in grassland renewal.

5.4.2 *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 IPCC 2006 Guidelines. A description of the methodologies used and data sources is presented in Lagerwerf *et al.* (2019).

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 chapter 12 of the methodology report (Lagerwerf *et al.*, 2019) or the background document by (Van der Hoek *et al.*, 2007). The activity data and characteristics for crops are presented in Van Bruggen *et al.* (in prep.)

Emission factors
For synthetic N fertilizer application the EF for direct N_2O emissions from agricultural soils is based on a weighted mean of different synthetic 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 5.12, with default IPCC EFs included for comparison.

Table 5.12: 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	

Source	Default IPCC	EF used	Reference
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 5.13 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 1990–2017. 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 19% decrease in N manure input to soil, this explains the 76% 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 5.13: N_2O IEFs from animal manure applied to agricultural soils (kg N/kg N-input)

	1990	1995	2000	2005	2010	2015	2016	2017
IEF from manure applied to soils	0.004	0.008	0.009	0.009	0.009	0.009	0.009	0.009

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; Van Schijndel and Van der Sluis, 2011; Velthof and Mosquera, 2011).

There is insufficient information on the amount of urea made, imported, exported and used in the Netherlands. Therefore are all the emissions are reported in 2B1. For more information, consult section 4.3.1.

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 'FRACleach' 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 Approach 1 uncertainty analysis, outlined in Annex 2, provides estimates of uncertainty per IPCC source category. The uncertainty in direct N_2O emissions from synthetic 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 206% (leaching and run-off) and 414% (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 Statistics Netherlands (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*

Manure treatment emissions are added for all years (see section 5.3). The emissions associated with manure treatment are subtracted from the amount of N available for manure application on soils. A detailed description of the methodology can be found in the methodology report (Lagerwerf *et al.*, 2019).
New data was available for inorganic N-fertilizers from 2016 onwards, resulting in lower emissions from synthetic N fertilizer.

5.4.6 *Category-specific planned improvements*

No improvements are planned.

5.5 Liming (3G)

5.5.1 Source 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.

Table 5.14: Overview of the sector Liming (3G) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3G. Liming	CO_2	T	0,2	0,0	0,0	-74,4%	0,2%	0,0%	0,0%

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 1990–2017 period, the amounts of limestone used decreased by 53% and the amounts of dolomite decreased by 78%.

Overview of shares and trends in emissions
CO_2 emissions from liming decreased by ca. 74% from 1990 to 2017 as a result of a decrease in limestone and dolomite use (see table 5.14 and 5.15).

Table 5.15: CO_2 emissions from the use of limestone and dolomite in agriculture (in Gg CO_2)

	1990	1995	2000	2005	2010	2015	2016	2017
3G Liming	183	98	98	75	60	69	41	47

5.5.2 Methodological issues

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.

Trends in EFs
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 Lagerwerf *et al.* (2019).

5.5.3 Uncertainty and time series consistency

Uncertainty
The Approach 1 analysis, outlined in Annex 2, provides estimates of uncertainties by IPCC source category. The uncertainty in CO_2 emissions from Liming of soils is calculated to be 100%. The uncertainty in the

activity data is estimated to be 100% and the uncertainty in the EFs is 10%. 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 1990–2017 is consistent over time. Statistics on calcium-containing 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*
New data was available for calcareous fertilizers from 2016 onwards, resulting in lower emissions from liming.

5.5.6 *Category-specific planned improvements*
Emissions from liming are to be reconsidered. If necessary changes to methodology or activity data will be made in the next submission.

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

Major changes in the LULUCF sector compared with the National Inventory Report 2018

Emissions:	CO_2 emissions from LULUCF for 2017 slightly increased compared with the year 2016 (0.3%). Due to methodological changes and use of new data, emissions along the whole time series changed compared with the NIR 2018; GHG emissions in the LULUCF sector for the year 1990 increased by 7% while for 2016 they decreased by 16 %.
Key categories:	No changes.
Methodologies:	This year, two methodological changes have been implemented. First, the addition of a new soil map for 2014 allowed a better assessment of the development of organic (peat and peaty) soil area in the Netherlands. The results indicated that previously the area of organic soil in 1990 was underestimated by 22 kha and hence emissions from organic soils as result of drainage were underestimated. At the same time the results showed that as a result of continuing oxidation and subsequent loss of peat, the area of organic soil decreased by 64 kha over time between 1990 and 2014. As a result the total annual emissions from organic soils have decreased since 1990. Second, in response to the recommendation by the review team the areas of forest land and 'trees outside forest' on organic soils where drainage might still be occurring have been estimated and associated emissions have been calculated using country specific emission factors.
Data:	Additionally new data have been included, resulting in recalculations of part of the time series. First a new land-use map representing land-use on 1 January 2017 was included. As a result now the actual land-use changes observed between the previous land-use map of 1 January 2013 and the new map have been used. This replaces the previous estimates of land-use changes from 2013 onwards that were based on the extrapolation of changes observed in the land-use change matrix 2009-2013. Second, data from the 6th Nationals Forest Inventory (NFI-6) have been included to calculate the average carbon stocks in litter in forest land

from 2003 onwards. These average carbon stocks are used to calculate the carbon stock losses from litter under conversions from Forest land to other land use categories.

Third, data on wood harvests partly have been obtained partly from a new source, resulting in adjusted total round wood harvests from 1990 onwards and updated amounts of fuel wood from 1990 onwards. The amount of harvested industrial round wood remained the same as before.

Additionally the average carbon stocks in forests is estimated using only data from plots from the NFI-6 that actually represent represents Forest land remaining forest land (FL-FL)FL-FL. In the previous NIRs the average carbon stocks in forests by mistake were estimated based on all NFI-6 plots instead of the subset that represents Forest land remaining forest land (FL-FL).

In the NIR 2018 the methodology change for the extrapolation of carbon stocks in dead wood in forest from 2013 (until data from a new Forest Inventory are available) was reported. But due to an input error this was not effectuated in the CRF values for carbon stock changes in dead wood in Forest land remaining Forest land. This error has now been corrected.

6.1 Overview of sector

Overview and trends in the 2017 results

This chapter describes the 2017 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 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 (9%); 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.

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 includes six categories: Forest Land (4A); Cropland (4B); Grassland (4C); Wetlands (4D) (including open water); Settlements (4E) and Other land (4F). There is also a category Harvested wood products (HWP) (4G), providing information on carbon gains and losses from the HWP carbon pool. Emissions from land use-related activities such as liming are reported under the agriculture sector (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 category Grassland is subdivided in two sub-categories, Grassland (non-TOF) and Trees outside forests (TOF) (see Section 6.2 and Arets et al., 2019). 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 fulfil 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 their changes, the TOF category is similar to Forest land.

Conversions of land use from, to and between Grassland (non-TOF) and TOF are separately monitored, and subsequent calculations of carbon stock changes differ (see Arets et al., 2019).

An overview of the completeness of reporting by the Netherlands is provided in Table 6.1. In this table, pools for which carbon stock changes are reported, are indicated in bold, with either tier level in brackets. "NO" is used for pools for which carbons stock changes are not occurring or "IE" if carbon stock changes are included elsewhere. Pools for which carbon stock changes are not estimated are indicated with

“NE”, besides an indication of the significance of the respective source or sink (“s”: significant, “n.s.” not significant, and reference to the section where this is justified in this NIR).

Forest land, Cropland, Grassland and Settlements are key sources. The latter three are key categories due to their significant emissions from peat soils (see 6.5.1, 6.6.1 and 6.8.1)

Table 6.1: Carbon stock changes reported in the national inventory per land-use (conversion) category

From→ **To↓**	**FL**	**CL**	**GL**	**WL**	**Sett**	**OL**
FL	**BG** (T2), **BL** (T2), **DW** (T2), **Litt** (T2), **MS** (NO) **OS** (T2) **FF** (T1)	**BG** (T2), **BL** (T2), DW (NE[1]), Litt (NE[1]), **MS** (T2) **OS** (T2) FF (IE)	**BG** (T2), **BL** (T2), DW (NE[1]), Litt (NE[1]), **MS** (T2) **OS** (T2) FF (IE)	**BG** (T2), **BL** (T2), DW (NE[1]), Litt (NE[1]), **MS** (T2) **OS** (T2) FF (IE)	**BG** (T2), **BL** (T2), DW (NE[1]), Litt (NE[1]), **MS** (T2) **OS** (T2) FF (IE)	**BG** (T2), **BL** (T2), DW (NE[1]), Litt (NE[1]), **MS** (T2) **OS** (T2) FF (IE)
CL	**BG** (T1), **BL** (T2), **DM** (T2), **MS** (T2) **OS** (T2) WF (IE)	BG (NE, n.s. 6.5.1), BL (NE, n.s., 6.5.1), DM (NE, n.s., 6.5.1), **MS** (NO) **OS** (T2) WF (IE)	**BG** (T1), **BL** (T1), DM (NE, n.s., 6.5.1, 6.61), **MS** (T2) **OS** (T2) WF (IE)	**BG** (T1), **BL** (NO), DM (NE, n.s., 6.5.1, 6.7.1), **MS** (T2) **OS** (T2) WF (IE)	**BG** (T1), **BL** (NO), DM (NE, n.s. 6.5.1, 6.8.1), **MS** (T2) **OS** (T2) WF (IE)	**BG** (T1), **BL** (NO), DM (NE, n.s. 6.5.1, 6.9.1), **MS** (T2) **OS** (T2) WF (IE)
GL	**BG** (T1, T2), **BL** (T2), **DM** (T2), **MS** (T2) **OS** (T2) WF (IE)	**BG** (T1, T2), **BL** (T1, T2), DM (NE, 6.5.1, 6.6.1), **MS** (NO) **OS** (T2) WF (IE)	**BG** (T2), **BL** (T1, T2), **DM** (NO, NE, n.s 6.6.1), **MS** (T2) **OS** (T2) **WF** (T1)	**BG** (T1, T2), **BL** (NO), DM (NE, n.s 6.6.1, 6.7.1), **MS** (T2) **OS** (T2) WF (IE)	**BG** (T1, T2), **BL** (NO), DM (NE, n.s 6.6.1, 6.8.1), **MS** (T2) **OS** (T2) WF (IE)	**BG** (T1, T2), **BL** (NO), DM (NE, n.s. 6.6.1, 6.9.1), **MS** (T2) **OS** (T2) WF (IE)
WL	BG (NE, n.s. 6.7.1), **BL** (T2), **DM** (T2), **MS** (T2) **OS** (T2) WF (IE)	BG (NE, n.s. 6.7.1), **BL** (T1), DM (NE, 6.5.1, 6.7.1), **MS** (T2) **OS** (T2) WF (IE)	BG (NE, n.s. 6.7.1), **BL** (T1, T2), DM (NE, 6.6.1, 6.7.1), **MS** (T2) **OS** (T2) WF (IE)	BG (NE, n.s. 6.7.1), BL (NE, n.s. 6.7.1), DM (NE, n.s. 6.7.1), **MS** (T2) **OS** (NO) WF (IE)	BG (NE, n.s. 6.7.1), **BL** (NO), DM (NE, n.s 6.7.1, 6.8.1), **MS** (T2) **OS** (NO) WF (IE)	BG (NE, n.s. 6.7.1), **BL** (NO), DM (NE, n.s 6.7.1, 6.9.1), **MS** (T2) **OS** (NO) WF (IE)
Sett	BG (NE, n.s. 6.8.1), **BL** (T2), **DM** (T2), **MS** (T2) **OS** (T2) WF (NO)	BG (NE, n.s. 6.8.1), **BL** (T1), DM (NE, 6.5.1, 6.8.1), **MS** (T2) **OS** (T2)	BG (NE, n.s. 6.8.1), **BL** (T1, T2), DM (NE, 6.6.1, 6.8.1), **MS** (T2) **OS** (T2)	BG (NE, n.s. 6.8.1), **BL** (NO), DM (NE, 6.7.1, 6.8.1), **MS** (T2) **OS** (T2)	BG (NE, n.s. 6.8.1), BL (NE, n.s. 6.8.1), DM (NE, 6.8.1), **MS** (NO)	BG (NE, n.s. 6.8.1), **BL** (NO), DM (NE, 6.8.1, 6.9.1), **MS** (T2)

From→ To↓	FL	CL	GL	WL	Sett	OL
		WF (NO)	WF (NO)	WF (NO)	**OS** (T2) WF (NO)	**OS** (T2) WF (NO)
OL	BG (NE, n.s. 6.9.1), **BL** (T2), **DM** (T2), **MS** (T2) **OS** (NO) WF (NO)	BG (NE, n.s. 6.9.1), **BL** (T1), DM (NE, 6.5.1, 6.9.1), **MS** (T2) **OS** (T2) WF (NO)	BG (NE, n.s. 6.9.1), **BL** (T1, T2), DM (NE, 6.6.1, 6.9.1), **MS** (T2) **OS** (T2) WF (NO)	BG (NE, n.s. 6.9.1), **BL** (NO), DM (NE, 6.7.1, 6.9.1), **MS** (T2) **OS** (NO) WF (NO)	BG (NE, n.s. 6.9.1), **BL** (NO), DM (NE, 6.8.1, 6.9.1), **MS** (T2) **OS** (T2) WF (NO)	NA

Carbon stock changes included are:
BG: Biomass Gain; BL: Biomass Loss; DW: Dead Wood; Litt: Litter; DM: Dead organic Matter; MS: Mineral Soils; OS: Organic Soils; FF: Forest Fires; WF: Other Wildfires;.
Land-use types are: FL: Forest Land; CL: Cropland; GL: Grassland; TOF: Trees outside Forests; WL: Wetland; Sett: Settlements; OL: Other Land.
[1] not a source, see Chapter 4.2.2 in Arets et al., 2019

Carbon stock changes in mineral soils

The Netherlands has developed a Tier 2 approach for calculating 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 2014 update of the Dutch soil map, combined with the soil carbon stocks that have been quantified for each land use and soil type combination (see Section 3.5 in Arets et a., 2019).

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 overlays of two soil maps, the initial map with the average year of sampling dated at 1977 and a 2014 update on the spatial extent of organic soils, the development of organic soil area between 1990 and 2014 was assessed (see Arets et al., 2019 for more details). As a result of oxidation and subsequent loss of peat the total area of organic soils decreases from 500 kha in 1990 to 437 kha in 2014. Developments in organic soil area are uncertain and currently receive a lot of policy attention, but are not yet monitored on a regular basis. Therefore, after 2014 the area of organic soils is kept constant. Because the current trend shows a decreasing area of organic soil and also a decrease of the associated emissions, this is considered to be a conservative approach. Overlays with the land-use maps provide information on areas of organic soils under the different land-use categories. Detailed information is provided in Arets et al. (2019).

Based on the available data sets, two different approaches for calculating the EFs for peat soils and for peaty soils have been developed (see Arets et al., 2019). 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 soils were then converted to an annual EF per ha peat soil to report emissions from peat soils for land-use (change) categories 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.

Drainage of organic soils is usually not applied in forestry in the Netherlands. However, since afforestation usually occurs on land with previously agricultural land use, it cannot be completely excluded that the old drainage systems from the agricultural sites are still active. Therefore, to account for possible emissions, the area of forest that are planted on organic soils that were in agricultural use before and where drainage systems may still be (partially) functioning was estimated at 24.2% of the total forest area on peat soils and 22.0% of the total forest area on peaty soils. Subsequently to these areas the same country specific emission factors are applied as used for drained peat and peaty soils under Grassland, Cropland and Settlements.

Detailed information on calculations for peat and peaty soils is provided in Arets et al. (2019).

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., 2019). The default emission factor 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., 2019). 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
This year, two methodological changes have been implemented and in addition new data were included in the existing methodologies, resulting in changes in the carbon stock changes and associated emissions and removals along the whole time series.

Implementation of an additional soil map 2014
Previously the area of organic soils was based on one soil map (dated 1990) with some minor adaptations based on an additional map indicating peat and peaty soils in the year 2000 (see Arets et al, 2018). This estimated area of organic soils was kept constant over time. The addition of a new soil map for 2014 allowed a better assessment of the development of organic (peat and peaty) soil area in the Netherlands. Based on overlays of the two soil maps dated at 1977 (average year of sampling of the map previously used at 1990) and 2014, the development of organic soil area over time was assessed (see Figure 6.1, and Arets et al., 2019 for more details). As a result of oxidation and subsequent loss of peat the total area of organic soils decreases from 500 kha in 1990 to 437 kha in 2014 (Figure 6.1)

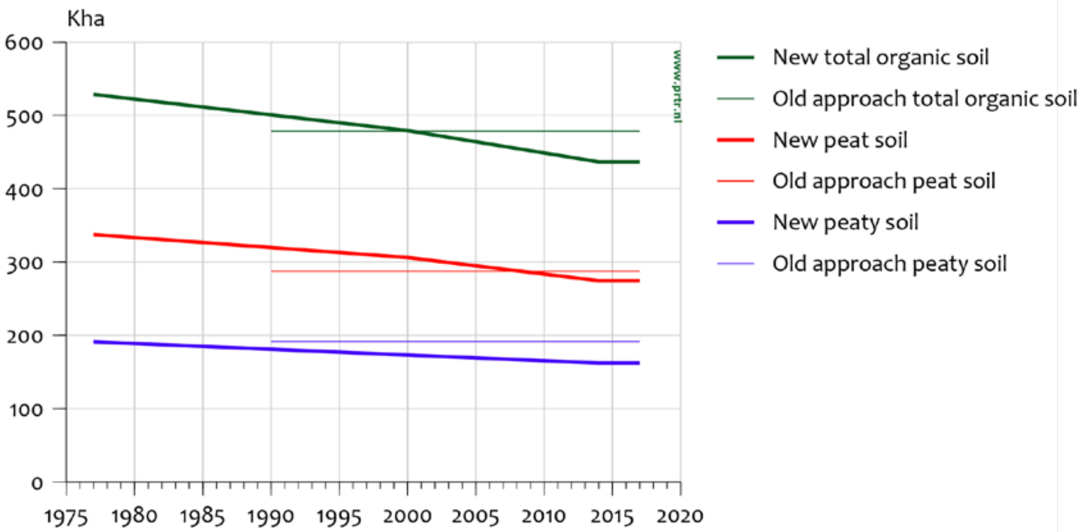


Figure 6.1. Development of the area organic soils in the Netherlands (for peat soils, peaty soils and total organic soils, based on one soil map (old approach) and based on two soil maps (new approach).

A comparison between the old and new approach showed that previously the area of organic soil in 1990 was underestimated by 22 kha and hence emissions from organic soils were underestimated (Figure 6.2) by the old approach. At the same time the results showed that as a result of continuing oxidation of peat and peaty soils the area of organic soil decreased by 64 kha over time between 1990 and 2014 and so also decreasing emissions. As a result the total annual emissions from organic soils are higher in the new approach compared to the old one in 1990 and then decrease over time to 2014 (Figure 6.2). As a result of the smaller area of (drained) organic soils in 2014 also the reported emissions from organic soils are lower in the new approach. From 2013 onwards, additionally the updated land-use matrix and the resulting update of land-use transitions has an effect on the emissions from mineral and organic soils.

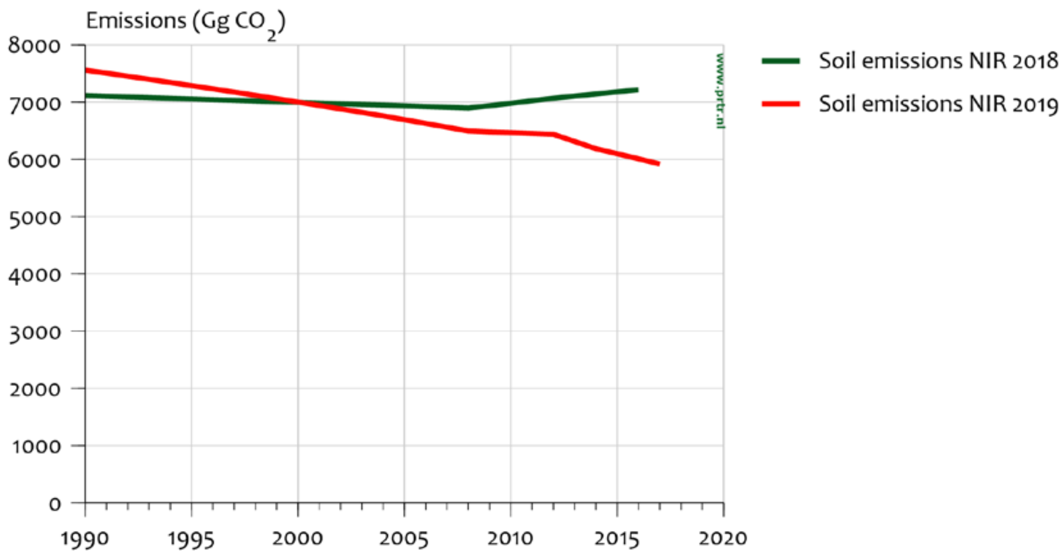


Figure 6.2. Emissions (Gg CO_2) from mineral and organic soils as reported in the NIR 2018 with the old apprach and the NIR 2019 with the new approach.

Emissions from organic soils under Forest land
In response to the recommendation in finding L.18 in the ARR2017 the areas of forest land and 'trees outside forest' on organic soils where drainage might still be occurring have been estimated and associated emissions have been calculated using country specific emission factors.

The total area of forest on peat soils in the 2017 map was 11.3 kha. Out of this area, 2.7 kha (24.2% of the forest area on peat soils) was listed as being Cropland, Grassland or Settlement in at least one of the earlier maps. For each year we therefore assume that 24.2% of the forest area on peat soil has an emission factor equal to that of agriculture on peat soil.

The total area of forest on peaty soil in the 2017 map was 9.1 kha. Out of this area, 2 kha (22.0% of the forest area on peaty soils) was listed as being Cropland, Grassland or Settlement in at least one of the earlier land-use maps. For each year we assume that 22.0% of the forest area on peat soil has an emission factor equal to that of agriculture on peaty soils.

Dead wood
While in the NIR2018 the methodology for the extrapolation of carbon stocks in dead wood in forest from 2013 (until data from a new Forest Inventory are available) was adjusted, as a result of an input error this was not effectuated in the CRF values for carbon stock changes in dead wood in Forest land remaining Forest land. This error has now been corrected in the CRF with the NIR2019 and affects the reported values for carbon stock changes in dead wood in Forest land remaining forest land from 2013 onwards.

Additionally new data sources have been included, also resulting in recalculations of part of the time series.

New land use map 2017
As already announced in previous NIRs in the NIR2019 a new land-use map representing land-use on 1 January 2017 was included. As a result now the actual land-use changes observed between the previous land-use map of 1 January 2013 and the new map have been used. This replaces the previous estimates of land-use changes from 2013 onwards that were based on the extrapolation of changes observed in the land-use change matrix 2009-2013. The results show that between 2013 and 2017 gross deforestation remains relatively high but that the rate of conversions of land to forest land have strongly decreased. As a result from 2013 onwards the long-term trend of increasing forest area in The Netherlands has been reversed into a net loss of forest area. Additionally the decreasing trend of Grassland area has been reversed to an increase of Grassland area, mainly at the cost of Cropland area.

Average carbon stocks in forest litter
Data from the 6th Nationals Forest Inventory (NFI-6) have been included to calculate the average carbon stocks in litter in forest land from 2003 onwards. These average carbon stocks are used to calculate the carbon stock losses from litter under conversions from Forest land to other land use categories. The results are included in Table 6.9 in section 6.4. The average carbon stocks show a slight decrease over time, resulting in smaller losses in carbon stocks resulting from deforestation.

Update of historic carbon stocks in above and belowground biomass in FL-FL
While doing additional analysis on the data from the NFI-6, it was found that the average carbon stocks in forests as used in the calculations in the previous NIRs was based on all NFI-6 plots instead of the subset that represents Forest land remaining forest land. For the NIR 2019 this was corrected to only include data from NFI-6 plots that actually represent Forest land remaining forest land. The average growing stock of all NFI-6 plots was 217 m^3/ha, but this also included plots that were not yet classified as forest in 2003 (NFI-5) and hence do not represent Forest land remaining forest land. If only the plots from NFI-6 were used that actually represent Forest land remaining forest land, the average growing stock in 2013 was calculated at 221 m^3/ha (see Table 6.2). From 2003 onwards, this has an effect on carbon stock gains in living biomass under Forest land remaining forest land, and carbon stock losses in biomass under Forest land converted to other land uses.

The parameters are average growing stock (GS; m^3 ha^{-1}), aboveground biomass (AGB; tonnes ha^{-1}), biomass conversion and expansion factors (BCEF, tonne dry matter per m^3 stemwood volume), belowground biomass (BGB; tonnes ha^{-1}), root to shoot ratio (R), share of conifer biomass in the total forest biomass, mass of standing deadwood (DWs, tonnes ha^{-1}) and lying deadwood (DWl, tonnes ha^{-1}). The new data replace the values for 2013 as used in section 4.2.1 in Arets et al 2018 (see Arets et al., 2019).

Table 6.2. Corrected state of the forest in 2013 based on NFI-6 data.

	Year	GS	AGB	BCEF	BGB	R	Share Conifers	DWs	DWl
NIR 2018 (Arets et al., 2018)	2013	217	165.5	0.764	29.9	0.18	0.367	1.88	1.93
NIR 2019 (Arets et al., 2019)	2013	221	165.5	0.744	29.9	0.18	0.404	1.97	2.03

The parameters are:
average growing stock (GS; m^3 ha^{-1}), aboveground biomass (AGB; tonnes ha^{-1}), biomass conversion and expansion factors (BCEF, tonne dry matter per m^3 stemwood volume), belowground biomass (BGB; tonnes ha^{-1}), root to shoot ratio (R), share of conifer biomass in the total forest biomass, mass of standing deadwood (DWs, tonnes ha^{-1}) and lying deadwood (DWl, tonnes ha^{-1}).

Wood harvests

Up until the NIR 2018, FAO statistics were used for harvesting of roundwood. From 2015 onwards, however, these statistics include large amounts of wood fuel that are not exclusively based on wood from forest land, but also includes other wood sources. Additionally a comparison between the wood balance based on forest inventory data (NFI-5 and NFI-6) and the current FAO statistics indicate that FAO statistics up to 2015 underestimate the amount of harvested round wood (see Figure 6.3 and for additional details see Arets et al., 2019). In the new approach total round wood harvests from forests are based on the wood balance from the NFI data. Additionally the FAO estimates for industrial roundwood were considered to be reliable and were kept the same. The difference between total roundwood harvests from the NFI wood balance and FAO industrial roundwood statistics were then used as updated estimates for fuel wood harvesting. In figure 6.3 the dark bars represent production of industrial roundwood from FAO statistics, light coloured bars represent the amount of wood fuel from FAO statistics. The two together are the total amount of roundwood from FAO statistics. The dots represent the corrected total roundwood production with application of the improved approach using NFI data

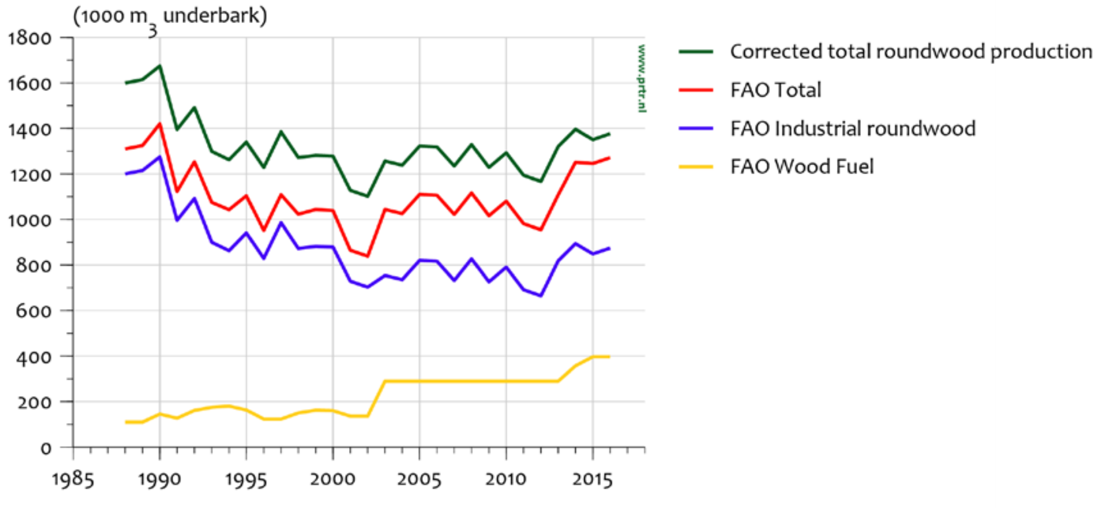


Figure 6.3. Annual production of round wood in the Netherlands.

Contribution of the sector to GHG emissions and removals
Table 6.3 shows the sources and sinks in the LULUCF sector in 1990, 2016 and 2017. For 1990 and 2017, total net emissions are estimated to be approximately 6.5 Tg CO_2 eq. and 5.6 Tg CO_2 eq., respectively. The results for 2016 have been added to give insight in annual changes. Sector 4 (LULUCF) accounted for about2.8% 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 6.4 Tg CO_2 in 2017 (7.6 Tg CO_2 in 1990). 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: -1.8 Tg CO_2, which includes Forest land remaining forest land (4A1) and Land converted to forest land (4A2).

Table 6.3: Overview of the sector Land Use, Land Use change and Forestry (LULUCF) (4) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector / category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
4. Total Land use Categories	CO_2		6,5	5,5	5,5	-15,1%	98,3%	3,2%	2,8%
	CH_4	non key	0,0	0,0	0,0	32,0%	0,0%	0,0%	0,0%
	N_2O		0,0	0,1	0,1	1581,0%	1,7%	0,1%	0,0%
	All		6,5	5,6	5,6	-13,7%	100,0%		2,8%
4A. Forest land	CO_2	L, T	-1,7	-1,8	-1,8	5,3%	-32,6%	-1,1%	-0,9%
4A1. Forest land remaining Forest Land	CO_2		-1,8	-1,3	-1,3	-24,1%	-23,9%	-0,8%	-0,7%
4A2. Land converted to Forest Land	CO_2		0,0	-0,5	-0,5	-1601,3%	-8,7%	-0,3%	-0,2%
	All		-1,7	-1,8	-1,8	5,3%	-32,6%	-1,1%	-0,9%
4B. Cropland	CO_2	non key	1,8	1,7	1,8	-3,5%	31,3%	1,0%	0,9%
4B1. Cropland remaining Cropland	CO_2		1,6	0,6	0,6	-64,2%	10,5%	0,3%	0,3%
4B2. Land converted to Cropland	CO_2		0,2	1,1	1,2	547,6%	20,8%	0,7%	0,6%
	All		1,8	1,7	1,8	-3,5%	31,3%	1,0%	0,9%
4C. Grassland	CO_2	L,T	5,5	3,8	3,7	-32,9%	66,3%	2,2%	1,9%
4C1. Grassland remaining Grassland	CO_2		5,3	3,8	3,8	-29,3%	67,2%	2,2%	1,9%

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
4C2. Land converted to Grassland	CO_2		0,2	0,0	0,0	-121,3%	-0,8%	0,0%	0,0%
	All		5,5	3,8	3,7	-32,9%	66,3%	2,2%	1,9%
4D. Wetlands	CO_2	non key	0,1	0,0	0,0	-55,9%	0,7%	0,0%	0,0%
4D1. Wetlands remaining Wetlands	CO_2		NO,NE,IE	0,0	0,0		0,0%	0,0%	0,0%
4D2. Land converted to Wetlands	CO_2		0,1	0,0	0,0	-53,8%	0,7%	0,0%	0,0%
	All		0,1	0,0	0,0	-55,9%	0,7%	0,0%	0,0%
4E. Settlements	CO_2	L, T	0,9	1,5	1,5	68,6%	27,4%	0,9%	0,8%
4E1. Settlements remaining Settlements	CO_2		0,4	0,4	0,4	-1,3%	7,3%	0,2%	0,2%
4E2. Land converted to Settlements	CO2		0,5	1,1	1,1	127,6%	20,1%	0,7%	0,6%
	All		0,9	1,5	1,5	68,6%	27,4%	0,9%	0,8%
4F. Other land	CO_2	non key	0,0	0,2	0,2	516,5%	2,8%	0,1%	0,1%
4F1. Other land remaing other Land	CO_2								
4F2. Land converted to Other Land	CO_2		0,0	0,2	0,2	516,5%	2,8%	0,1%	0,1%
	All		0,0	0,2	0,2	516,5%	2,8%	0,1%	0,1%
4G. Harvested wood products	CO_2	non key	-0,2	0,1	0,1	-184,8%	2,4%	0,1%	0,1%
National Total GHG emissions (incl. CO2 LULUCF)	CO_2		168,9	171,9	170,0	0,6%			
	N_2O		18,0	8,6	8,8	-51,1%			
	total*		228,2	201,4	199,3	-12,7%			
National Total GHG emissions (excl. CO2 LULUCF)	CO_2		163,3	166,8	164,9	1,0%			
	CH_4		31,8	18,3	18,0	-43,4%			
	N_2O		18,0	8,5	8,7	-51,7%			
	total*		221,7108	195,835	193,713	-12,6%			

** including f-gases*

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., 2019).

6.2 Land-use definitions and the classification systems used and their correspondence to the land use, land use change and forestry categories

The Netherlands has defined the different land-use categories in line with the descriptions given in the 2006 IPCC Guidelines (IPCC, 2006). Below are the definitions the Netherlands uses for the six main land-use categories that need to be covered. For more detailed information see Arets et al. (2019). Following definitions are applied.

Forest land (4A)
The Netherlands has chosen to define the land-use category Forest land as ‘all land with woody vegetation, now or expected in the near future (e.g. clear-cut areas to be replanted, young afforestation areas)’. The following criteria define this category:
- forests are patches of land exceeding 0.5 ha, with a minimum width of 30 m;
- a tree crown cover of at least 20%; and
- a tree height of at least 5 meters, or, if this is not the case, these thresholds are likely to be achieved at the particular site.

This definition is in conformity with the 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 the NIR 2018 onwards two distinct sub-categories are identified within the Grassland category, and these are spatially explicitly assessed. These are (1) Grassland (non-TOF) and 2) Trees outside forests (TOF). 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 category. 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 grassland vegetation. This mainly consists of heathland and peat moors and may have the occasional tree as part of the typical vegetation structure.
- 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). 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., 2019).

In the calculations orchards are not spatially explicitly included. Instead, statistics on areas of orchards are used. See Arets et al. (2019) 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 process. 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 wetlands (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 category. This includes natural open water in rivers, but also man-made open water in channels, ditches and artificial lakes. It includes bare areas which are under water only part of the time, as a result of tidal influences, and very wet areas without vegetation. It also includes 'wet' infrastructure for boats, i.e. waterways as well as the water in harbours and docks.

Settlements (4E)
In the Netherlands, the main categories included under the category 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 categories 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 category to report surfaces of bare soil that are not included in any other category. In the Netherlands, this means mostly almost bare sands and the earliest stages of succession on sand in coastal areas (beaches, dunes and sandy roads) or uncultivated land alongside rivers. It does not include bare areas that emerge from shrinking and expanding water surfaces, which are included in Wetland. In general, the amount of carbon in Other land is limited.

6.3 Information on approaches used to representing land areas and land-use databases used for the inventory preparation

One consistent approach was used for all land-use categories. 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, 2013 and 2017 were used for wall-to-wall map overlays (Arets et al., 2019; Kramer and Clement, 2015; Kramer et al., 2007, 2009a,b; Van den Wyngaert et al., 2012), resulting in four national scale land use and land-use change matrices covering the periods 1990–2004 (Table 6.4), 2004–2009 (Table 6.5),2009–2013 (Table 6.6) and 2013-2017 (Table 6.7). The information used, concerning the activities and land-use categories, covers the entire territorial (land and water) surface area of the Netherlands. The sum of all land-use categories is constant over time. For more details see Arets et al. (2019).

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 to support the classification.

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 declining slightly. 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 6.4: 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 6.5: 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 6.6: 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*

Table 6.7: Projected land use and land-use change matrix for the six UNFCCC land-use categories for the period 2013–2017 using the land-use data available on 1-1-2017 (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF).

	BN 2017							
BN 2013	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	356,633	1,662	9,345	2,012	804	4,886	404	*375,744*
CL	902	762,447	170,184	245	1,674	8,865	24	*944,340*
GL-non TOF	4,816	103,116	1,197,036	1,500	9,185	28,661	1,394	*1,345,709*
GL-TOF	1,143	205	1,658	16,549	146	1,834	41	*21,576*
WL	837	291	6,711	191	805,948	4,306	2,678	*820,962*
Sett	1,034	2,582	21,372	710	1,559	578,065	191	*605,512*
OL	215	7	736	34	1,399	429	34,838	*37,657*
Total	*365,579*	*870,310*	*1,407,040*	*21,240*	*820,715*	*627,046*	*39,570*	*4,151,500*

Annual land-use changes are derived from these land-use change matrices. The matrix 2013–2017 (Table 6.7) 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 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 2013 and 2017 maps) the earlier observed increase in conversion of Grassland to Cropland was reversed, with more grassland being converted to cropland.

When comparing the four land-use change matrices, however, the different lengths 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 period 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 time wise and thus are better able to 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 regulation 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 land use.

Despite the relatively high deforestation rates in the previous periods, until 2013 the rate of afforestation was higher than deforestation. From the most recent matrix 2013-2017, it can be inferred, however, that afforestation rates have decreased considerably, resulting in a net decrease in forest area since 2013. In principle, deforestation needs to be compensated with afforestation of an equal area elsewhere. The exception to these rules is when conversion to priority nature takes place on the basis of ecological arguments, like on the basis of Natura 2000 development or management plans. In such cases forest conversion can take place without compensation. There are also signs that there is a lack of monitoring and enforcement of the compensation rule at local government level. Recently, however, this issue has received more attention and is currently addressed. Therefore, it is expected that this trend of net loss of forest cover will be reversed again in the next years.

A new land-use map will be implemented and used in the NIR in 2022.

6.4 Forest land (4A)

6.4.1 Source category description

Reported in this category 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[2]). 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.

[2] 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

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.

The category 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 chosen approach 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., 2019). 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 (NFI-5 data: Daamen and Dirkse, 2005) and 2012–2013 (NFI-6: 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 (NFI-5) and 2012 (NFI-6). Information between 2013 and 2020 was based on projections using the EFISCEN model (see Arets et al., 2019).

From plot-level data from the HOSP, NFI-5 and NFI-6 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. (2019).

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 were 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., 2019):

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., 2019). 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 6.8).
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, NFI-5 and NFI-6.

Table 6.8: 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. d.m.: dry matter

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	0.737	145	26
2005	200	0.738	148	27
2006	203	0.738	150	27
2007	206	0.739	152	27
2008	209	0.74	154	28
2009	211	0.741	156	28
2010	214	0.742	159	29
2011	217	0.742	161	29
2012	220	0.743	163	29
2013	222	0.744	165	30
2014	224	0.745	167	30
2015	226	0.747	169	30
2016	228	0.748	171	31
2017	230	0.75	172	31

Dead wood
Dead wood volume is available from the three NFI datasets (up to 2013). The calculation of carbon stock changes in dead wood 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., 2019). From 2013 onwards, carbon stock changes in dead wood are extrapolated from the trend of the last two forest inventories. Once new data are available from the NFI-7 in 2021 (see 6.4.6), these carbon stock changes will be recalculated based on the actual data.

Litter
Analysis of carbon stock changes based on collected data has shown that there is probably a build-up in litter in D utch 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., 2019).

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. (2019) 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., 2019).

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 6.9). 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. Both management practices are not 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., 2019). 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. Both management practice are not 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. It is therefore assumed that, with deforestation, all carbon stored in AGB and BGB is lost to the atmosphere. National averages are used for the emission factors (see Table 6.9), 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 6.9: 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	1.46	35.63
2005	85.8	1.52	35.32
2006	87.1	1.58	35
2007	88.3	1.63	34.68
2008	89.6	1.69	34.37
2009	90.9	1.74	34.05
2010	92.2	1.8	33.73
2011	93.5	1.86	33.41
2012	94.8	1.91	33.1
2013	96.1	1.97	32.78
2014	97.1	2.02	32.46
2015	98.1	2.08	32.15
2016	99.1	2.13	31.83
2017	100.1	2.19	31.51

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 for the emission factors, 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, NFI-5 and NFI-6).

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., 2019: 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*

Uncertainties
The Approach 1 analysis in Annex 2, shown in Table A2.4, 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., 2019 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. (2019) for details.

Time series consistency
To ensure time series consistency in Forest land remaining forest land, 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.

To ensure time series consistency in land converted to forest land , 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.

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., 2019).
- 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*

A number of the methodological changes and updated data sources have resulted in recalculations in the Forest land categories. The estimate of possible drainage of organic forest soils resulted in increased carbon stock losses in organic soils in the Forest land categories. Additionally the correction of the dead wood extrapolation from 2013 resulted in decreased carbon stock gains in dead wood in all years from 2013 onwards. The correction of historic carbon stocks in above and belowground biomass in Forest land remaining forest land based on NFI-6 data resulted in limited changes in the net carbon stock gains under Forest land remaining forest land from 2003 onwards. Although the improvements in the harvest statistics resulted in changes in biomass gains and losses in Forest land remaining forest land this had no effect on net carbon stock changes in Forest land remaining forest land (see section 4.3.1 in Arets et al., 2019 for the effects of wood harvests on biomass gains and losses and net carbon stock changes in biomass.
See also the methodological changes described in Section 6.1.

6.4.6 *Category-specific planned improvements*

In 2017 the Netherlands started its 7th National Forest Inventory (NFI-7). 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 Source category description

Emissions resulting from disturbance of mineral soils due to land-use changes to cropland and 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., 2019). As a result of these high emissions from mineral drained organic soils the Cropland categories is a key source. Also the carbon stock gains and losses in living biomass in Grassland converted to Cropland strongly contribute to the emissions and removals in the Cropland category, but this contribution stays below the threshold of 25% to be a significant pool under the Cropland category.

Because Cropland in the Netherlands mainly consists of annual cropland were annual biomass gains are harvested each year, over time no net accumulation of carbon stocks in biomass are expected to occur in Cropland (IPCC, 2006). Based on estimates using the Tier 1 emissions factors the carbon pools biomass gains and DOM in Cropland remaining Cropland and land converted to Cropland can be considered not significant. Therefore, following the Tier 1 method in the IPCC 2006 Guidelines (IPCC, 2006), carbon stock changes in living biomass are not estimated for Cropland remaining Cropland.
Even if we apply the unrealistically high average implied emission factor for biomass gains and losses of Land converted to cropland to the area of Cropland remaining cropland, the resulting carbon stock changes stay well below the significance level (i.e. 25% of gains/losses in the category). Therefore in the CRF Table 4.B. these carbon stock changes are reported with the notation key “NE”.

There are significant carbon stock changes in biomass in orchards, which in the Netherlands predominantly consist of fruit trees. 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 carbon stock gains in DOM are estimated in land-use conversions to Cropland, nor carbon stock losses 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. (2019).

6.5.3 *Uncertainties and time series consistency*

Uncertainties

The Approach 1 analysis in Annex 2, shown in Table A2.4, 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., 2019 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. (2019) 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.

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 organic soils in this category were recalculated for the whole time series due to the methodological changes in organic soil emissions described in Section 6.1. Additionally the update of the land-use matrix 2013-2017 resulted in recalculation of all pools from 2013 onwards.

6.5.6 *Category-specific planned improvements*

No improvements are planned.

6.6 Grassland (4C)

6.6.1 *Source category description*

Under the Grassland category, two main sub-categories are identified: (1) Grassland (non-TOF), and (2) Trees outside forests (TOF) (see Section 6.2). Conversions of land use to, from and between Grassland (non-TOF) and TOF are separately monitored and the approach to calculate the carbon stock changes differs between them.

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., 2019).

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., 2019). 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., 2019). Therefore, it is assumed that at the national level average carbon stocks per unit of area of orchard will not change. As a result of changing areas of grassland vegetation and orchards the average carbon stocks in Grassland remaining grassland (non-TOF) changes between years, which is reflected in the carbon stock changes in biomass in Grassland remaining grassland (non-TOF).
Carbon stock gains in living biomass for Land converted to grassland (non-TOF) 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 carbon stock losses in biomass for 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, common orchard management that includes pruning and the removal of dead wood and litter will prevent build-up of large amounts of DOM. Even if we would apply a value of 10% of annual carbon stock gains in biomass as an estimate of carbon stock gains in DOM in the same sub-category for which now NE is used, this only makes up 1% to the carbon stock gains and losses in the Grassland category. Therefore, the Tier 1 approach – assuming no build-up of DOM – is used (IPCC, 2006), which is reported as 'NE'.

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 outside forests (TOF) category is determined in a spatially explicit way and experiences carbon stock changes similar to those of Forest land (see Section 6.4.2 and Arets et al., 2019). 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, however, 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 6.10).

Default values for dry matter and carbon factors were used to determine carbon stocks in living biomass in grassland vegetation and nature. Combined these give 6.4 ton C per ha (see Arets et al., 2019). 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 per ha. 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 6.10).

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. (2019).

Table 6.10: 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

	Orchard		Grass vegetation		Total		Average
Year	**Area (kha)**	**CS (tC)**	**Area (kha)**	**CS (tC)**	**Area (kha)**	**CS (tC)**	**CS (tC/ha)**
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
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
2017	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., 2019). 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., 2019). 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 A2.4, 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., 2019 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.

(2019) 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 2017 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 decrease from 220 Gg CO_2 in 1990 to -47 Gg CO_2 in 2017. Inter-annual changes in implied emission factors in mineral soils are the result of changes in trends of land-use changes. Carbon stock changes in mineral soils are based on combinations of land-use change and soil type. The mix of combinations of land-use changes and soil types included therefore changes over time. Moreover, actual annual land-use changes, mixed with the timing of the 20 year transition periods for carbon stock changes in soils further affects the inter annual changes in the implied emission factors calculated based on the total area in a certain conversion category (eg. Cropland converted to Grassland).

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 losses in organic soils in this category were recalculated for the whole time series due to the methodological changes in organic soil emissions described in Section 6.1. Additionally the update of the land-use matrix 2013-2017 resulted in recalculation of all pools from 2013 onwards. Also the estimate of possible drainage of organic forest soils resulted in increased carbon stock losses in organic soils in the TOF sub-categories.

6.6.6 *Category-specific planned improvements*
No improvements are planned.

6.7 Wetland (4D)
6.7.1 *Source category 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. For land-use conversions from Wetland to other land uses no carbon stock losses in living biomass are assumed to occur. These will be reported as not occurring, 'NO'. 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, Cropland or Settlements. Emissions from drainage in peat areas are included in carbon stock changes in organic soils for these 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 A2.4, 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., 2019 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. (2019) 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 87 Gg CO_2 in 1990 to 38 Gg CO_2 in 2017.

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 6.1.

6.7.6 *Category-specific planned improvements*

No improvements are planned.

6.8 Settlements (4E)

6.8.1 *Source category description*

As a result of lowering of the groundwater table also in peat soils under Settlements oxidation of peat results in high emissions. Together with loss of carbon stocks in biomass resulting from conversion of Forest land to Settlement and Grassland to Settlement these are significant sources of carbon stock changes.

Although Settlements also include areas with grass and trees, biomass gains and losses are expected to be in balance. Therefore the Netherlands applies the Tier 1 method, assuming no change in carbon stocks in biomass in 4E1 (Settlements remaining settlements). 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., 2019). 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, and because conversions to Settlements are more frequent than conversions from Settlements to other land uses, it is considered to be the more conservative approach to not report carbon stock gains and losses for biomass and DOM in Settlement resulting from conversions to and from Settlements.
Also it is assumed that no carbon stock changes occur in mineral 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 losses 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 losses in biomass for conversions from Cropland and Grassland to Settlements. Land-use conversions from Wetlands or Other Land to Settlements will result in no changes in carbon stocks in living biomass.

Emissions from fertilizer use in Settlements

Under Settlements direct N_2O emissions from the use of fertilizers and compost by private consumers and hobby farms are reported under 3Da1 (inorganic N fertilizers) and 3Da2 (organic N fertilizers). 3Da1 and 3Da2 also include fertilizers used outside agriculture. 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 A2.4, 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., 2019 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. (2019) 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 911 Gg CO_2 in 1990 to 1535 Gg CO_2 in 2017.

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 *Source category 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., 2019 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. (2019) 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 157 Gg CO_2 in 2017.

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 *Source category 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., 2019). 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., 2019).

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 6.11), 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 6.12) 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 6.11. 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

	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		
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
2017	185	2,661	477	29	1,522	244	16	2,643	2,411	2,140

Table 6.12: 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 Approach 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., 2019 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. (2019) 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 1990–2017 range between -157 Gg CO_2 (removals) and 133 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 correction of growing stock, carbon stocks in above and belowground biomass in Forest land remaining forest land based on NFI-6 data resulted in limited changes in the HWP category from 2003 onwards. This is because these parameters have an effect on the calculation of amounts of wood that are provided from deforestation, and hence the remaining harvests contributing to HWP.

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 2017, total GHG emissions from this sector decreased further.
Key categories:	New: 5D (Wastewater treatment and discharge) (N_2O). No longer Key category: 5D (Wastewater treatment and discharge) (CH_4).
Methodologies:	The CH_4 emissions of manure treatment (5B2) are now included in the inventory, resulting in 34 Gg CO_2 eq. emissions in 2017. CH_4 and N_2O emissions of bonfires are included in the inventory (5C Incineration and open burning of waste), resulting in ca.7 Gg higer CO_2 eq. emissions in 2017.

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 biomass waste (including manure) (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., 2019) and is available from Annex 7 or the website http://english.rvo.nl/nie.

The Waste sector accounted for 1.6% of total national emissions (without LULUCF) in 2017, compared with 6.4% in 1990, emissions of CH_4 and N_2O accounting for about 95% and 5% of CO_2-equivalent emissions from the sector, respectively. Emissions of CH_4 from waste – almost all of which (83%) originates from landfills (5A1 Managed waste disposal on land) – accounted for 14.2% of total CH_4 emissions in 2017. 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 78.3% between 1990 and 2017 (see Figure 7.1, from from 14.2 Tg CO_2 eq. in 1990 to 3.1 Tg CO_2 eq.), mainly due to a 81.2% reduction in CH_4 from landfills (5A1). Between 2016 and 2017, CH_4 emissions from landfills decreased by 7.7%. 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 2017).

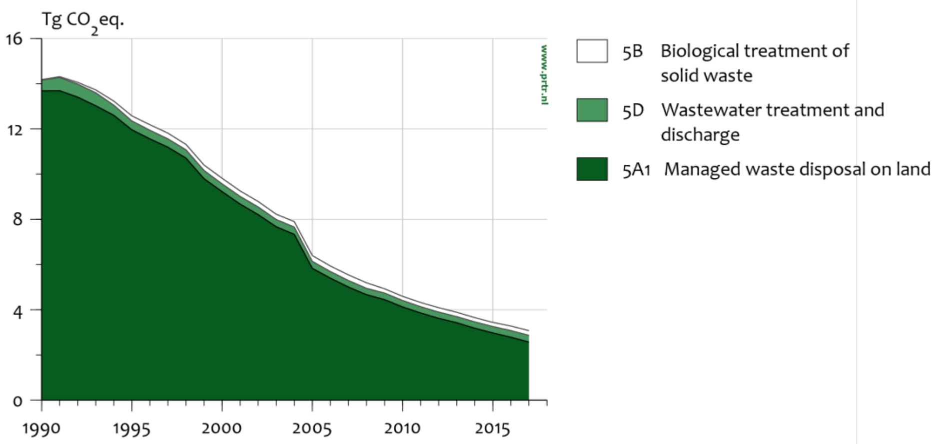


Figure 7.1: Sector 5 Waste – trend and emissions levels of source categories, 1990–2017

Table 7.1 shows the contribution of the emissions from the Waste sector to total GHG emissions in the Netherlands, as well as the key sources in this sector by level, trend or both. The list of all (key and non-key) sources in the Netherlands is included in Annex 1.

Table 7.1: Overview of the sector Waste (5) in the base year and the last two years of the inventory (in Tg CO_2 eq)

Sector/category	Gas	Key	1990	2016	2017	2017 vs 1990	Contribution to total in 2017 (%) by		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
5 Waste	CH_4		14,0	3,1	2,9	-79,2%	94,6%	16,2%	1,5%
	N_2O		0,2	0,2	0,2	-8,3%	5,4%	1,9%	0,1%
	All		14,2	3,3	3,1	-78,3%	100,0%		1,6%
5A. Solid Waste Disposal	CH_4		13,7	2,8	2,6	-81,2%	83,4%	14,2%	1,3%
5A1. Managed Waste Disposal on Land	CH_4	L,T	13,7	2,8	2,6	-81,2%	83,4%	14,2%	1,3%
5B. Biological treatment of solid waste	CH_4	non key	0,0	0,1	0,1	764,5%	3,8%	0,7%	0,1%
	N_2O	non key	0,0	0,1	0,1	1253,7%	2,9%	1,0%	0,0%
	All		0,0	0,2	0,2	922,5%	6,7%		0,1%
5D. Wastewater treatment and discharge	N_2O	T	0,2	0,1	0,1	-56,5%	2,4%	0,9%	0,0%
	CH_4	non key	0,3	0,2	0,2	-27,9%	7,2%	1,2%	0,1%
	All		0,5	0,3	0,3	-38,1%	9,7%		0,2%
National Total GHG emissions (excl. CO2 LULUCF)	CH_4		31,8	18,3	18,0	-43,4%			
	N_2O		18,0	8,5	8,7	-51,7%			
	total*		221,7	195,8	193,7	-12,6%			

* including f-gases

As indicated above, emission of waste incineration (5C), are included in category 1A1ai "other fossil fuels". Emissions from waste incineration accounted for ca 0.6 Tg CO_2 eq. in 1990 (601 Gg CO_2 and 0.03 Gg N_2O emissions, respectively). In 2017, emissions accounted for approximately 3.0 Tg CO_2 eq. (2,972 Gg CO_2 and 0.18 Gg N_2O); see also table 7.7.

7.2 Solid waste disposal on land (5A)

7.2.1 Category description

In 2017 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 6.1% in 1990 and 1.3% in 2017.
This decrease is partly due to the increase in recovered CH_4, from about 4% in 1990 to 13% in 2017. 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 2017, solid waste disposal on land accounted for 83.4% of total emissions from the Waste sector and 1.3% of total national CO_2-equivalent emissions (see Table 7.1).

Dutch policies directly aim 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.[3] As a result of this policy, the amount of waste sent to landfills decreased from 14 million tons in 1990 to 2.9 million tons in 2017, 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. (2019) and Annex 7.

Data on the amount of waste disposed of at landfillsites 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 (2017). 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

[3] 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’.

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%;
- 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, 2018);
- 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 degradable organic carbon content (DOC).

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
2017	2.9	56

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.
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.

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. As an illustration of this approach, Ttable 7.3 shows the waste stream groups, with their DOC values and the amount landfilled in 2016 (where permitted).

Table 7.3: Amount of waste landfilled in 2016 and DOC value *of each group*

Waste stream group	**Amount landfilled (ton)**	**DOC value (kg/ton)**	**Total DOC landfilled (ton)**
Waste from households	273,049	182	49,695
Bulky household waste		192	
Commercial waste		182	
Cleansing waste	18,126	43.4	787
Fresh organic waste	79,571	112	8,912
Stabilized organic waste	242,533	130	31,529
Little organic waste	919,533	44	40,459
Contamined soil	316,598	11.5	3,641
Dredging spoils	105,290	42.4	4,464
Inert waste	860,250	0	0
Wood waste	19,087	430	8,207
Total	2,834,038	52	147,695

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.

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 physic-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 CH_4 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 materials landfilled in the Netherlands, it is possible that the observed decline is at least partially the result of a decline in CH_4 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 7.4. 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 CH_4 in landfill gas has been adapted, as a result of the UNFCCC review in 2016. In earlier research the amount 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	2017
Fraction DOC in landfilled waste	0.13	0.13	0.11	0.06	0.03	0.04	0.05	0.06
CH_4 generation rate constant (k)	0.09	0.07	0.07	0.05	0.05	0.05	0.05	0.05
Number of SWDS recovering CH_4	45	50	55	50	53	54	53	54
Fraction CH_4 in landfill gas	0.57	0.57	0.57	0.5	0.5	0.5	0.5	0.5

7.2.3 *Uncertainty and time series consistency*

Uncertainty
The Approach 1 uncertainty analysis shown 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).

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.

7.2.5 *Category-specific recalculations*
No source-specific recalculations were made for this category in this inventory.

7.2.6 *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 were selected to be implemented.

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 horticulture; and manure from agriculture. 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 2017, this treatment accounted for 6.7% of the emissions in the Waste sector (see Table 7.1). The biological treatment of solid waste is not a key source of CH_4 or N_2O emissions.

7.3.2 Methodological issues

Detailed information on activity data and EFs can be found in Peek et al. (2019).

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.
The amount of animal manure used in digesters is based on the registered manure transports (data from the Netherlands Enterprise Agency; RVO). The emissions are calculated using the National Emissions Model Agriculture (NEMA), as described in chapter 5 and the methodology report for agricultural emissions (Lagerwerf et al. 2019).

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	1,454	2,057
2000	1,568	2,475
2005	1,367	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	1,357	2,077
2016	1,431	2,400
2017	1,492	2,442

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 63% and 50%, respectively, with an uncertainty in the activity data of 5%, and in the EF of 63% and 50%. 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.
Also CH_4 emissions from digesting of manure (category 5B2) are added from 2006 onwards (year of introduction), for an amount of 4 Gg CO_2 eq. in 2006 to 34 Gg CO_2 eq. in 2017)

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*

In this section the emissions of the activities of the waste incineration facilities that can process municipal solid waste and other waste streams are taken into account.
Open burning of waste does not occur in the Netherlands. It is prohibited by law. So there are no emissions for open burning of waste. However, bonfires (wood burning) are allowed occasionally, and as of this year included in the inventory. Bonfires occur mainly during New Year’s Eve and Easter. They are fuelled by biomass waste (wooden pallets, organic degradable waste). Municipalities grant permits for these

bonfires, so it is well known where the bonfires occur. In the permits it's often described how much biomass waste is allowed to be burned in open air. During the process of open burning emissions of N_2O and CH_4 occur. This is a minor source.

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, 2018).

Fossil-based and biogenic CO_2, CH_4 and N_2O emissions from waste incineration are country specific (Tier 2) and 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 7.6 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. As the amount and composition of incinerated waste varies annually this has also an effect on the emissions.

Fossil-based CO_2 is calculated based on the fossil-based carbon content of the incinerated waste. De fossil based carbon content is calculated based on the carbon content of the different components in the different waste streams. As stated above for some waste stream the composition is updated yearly.

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 significant since 1990.

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. That an EF of 0 g/GJ is possible is stated in 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).

A more detailed description of the method and the EFs used can be found in the methodology report (Peek et al., 2019). A comparison between the country specific EF's and the IPCC defaults can also be found in this report.

Table 7.6: Composition of incinerated waste

	1990	1995	2000	2005	2010	2015	2016	2017
Total waste incinerated (Gg)	2,780	2,913	4,896	5,503	6,459	7,564	7,796	7,627
Total waste incinerated (TJ)	22,746	27,903	51,904	55,058	63,818	75,299	77,392	76,311
Energy content (MJ/kg)	8.2	9.6	10.6	10.0	9.9	10	9,9	10.0
Fraction biomass (energy %)	58.2	55.2	50.4	47.8	53.1	54.2	53,8	53,1
Amount of fossil carbon (Gg)	164	221	433	561	675	780	809	811
Amount of biogenic carbon (Gg)	544	561	938	909	1,172	1,381	1,412	1,383

Table 7.7 shows the emissions for the waste incinerations plants. The increase in emissions from 1990 until 2016 is directly related to the increase of processed waste. In 2017 there was a minor decrease of processed waste compared with 2016, see also table 7.6. This does not give a decrease in the emissions because the composition of the waste differs yearly. The fraction of fossil waste increased slightly which gave an overall minor increase in the fossil CO_2 emissions and the total emissions in CO_2 eq.

Table 7.7: Emissions of incinerated waste

	1990	1995	2000	2005	2010	2015	2016	2017
Total CO_2 emission (Gg)	2,596	2,867	5,025	5,392	6,770	7,924	8,146	8,044
Fossil CO_2 emissions (Gg)	601	810	1,586	2,058	2,473	2,861	2,967	2,972
N_2O emissions (Gg)	0	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Total GHG emissions (Gg CO_2 eq)	622	843	1,655	2,138	2,573	2,989	3,098	3,101

7.4.3 *Uncertainty and time series consistency*

Uncertainty

The Approach 1 uncertainty analysis is shown in Annex 2, which provides estimates of uncertainties by IPCC source category and gas. The uncertainty in the CO_2 emissions for 2017 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% and 6%, 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).

The reporting on waste incineration under 5C has been extended since this NIR 2019 with an additional source: bonfires. Uncertainties in the related emissions (both CH_4 and N_2O) are high, in the range of 315%. This relates to uncertainties in activity data as well as in EF's; estimated at 100% and 300%, respectively, for both gases.

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*
Bonfires have been added to the inventory as of this NIR2019; leading to higher emissions over the whole time series under category 5C Incineration and open burning of waste, varying from 6.1 Gg CO_2 eq. in 1990; up to 6.9 Gg CO_2 eq. in 2017.

7.4.6 *Category-specific planned improvements*
In 2018, 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 the NIR 2018 (CE Delft, 2018) have been implemented in sofar as they seemed necessary.

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 2017, only 0.5% 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 2017, urban wastewater (the mixture of domestic, industrial and commercial wastewater, including urban run-off) was treated aerobically in 326 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 0.5% 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) (2017: 52 plants).

N_2O emissions from the wastewater treatment (see Table 7.1 and 7.8) contributed about 0.9% of total N_2O emissions in 2017 and 0.04% in total CO_2-equivalent emissions. During the period 1990–2017 N_2O emissions from wastewater handling and effluents decreased by 56.5%. This decrease is mainly the result of lower untreated discharges, resulting in lower effluent loads (see Table 7.8) 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 2017 was 1.2%, or 0.1% 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. During the period 1990–2017 CH_4 emissions from wastewater handling decreased by ca 28%. The amount of wastewater and sludge being treated does not change much over time. Therefore, the annual 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 7.8 shows the trend in GHG emissions from the different types of wastewater handling.

Table 7.8: Wastewater handling emissions of CH_4 and N_2O (Gg/year)

	1990	2000	2010	2015	2016	2017
CH_4 domestic wastewater[1)]	8.13	6.88	7.40	7.36	7.88	7.97
CH_4 industrial wastewater	0.29	0.39	0.38	0.38	0.38	0.38
CH_4 septic tanks	3.93	1.99	0.68	0.63	0.62	0.56
Net CH_4 emissions	12.35	9.25	8.46	8.37	8.88	8.91
CH_4 recovered[2)] and/or flared	33.0	40.6	40.0	44.4	48.0	49.1
N_2O domestic WWTP	0.076	0.076	0.079	0.082	0.084	0.085
N_2O effluents	0.501	0.302	0.174	0.168	0.167	0.167
Total N_2O emissions	0.577	0.378	0.253	0.250	0.251	0.251

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 Statistics Netherlands and presented in StatLine (CBS, 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 7.9 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 Statistics Netherlands.

From Table 7.9 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., 2019).

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

Table 7.9: Activity data of domestic and industrial wastewater handling

	Unit	1990	2000	2010	2015	2016	2017
Domestic (urban) WWTPs:							
Treated volume	Mm^3/yr	1,711	2,034	1,934	1,957	1,902	1,921
TOW as COD[1)]	Gg/year	933	921	953	999	1,011	1,021
Sludge organic dry solids[2)]	Gg/year	260	308	340	360	359	359
Sludge DOC as COD[1)2)]	Gg/year	365	431	476	505	503	503
Biogas recovered [3)]	mio m^3/yr	74	87.9	98.5	107.0	115.2	116.8
Biogas flared	1,000 m^3/yr	8,961	6,150	7,360	7,405	10,092	12,717
Biogas vented	1,000 m^3/yr	2,524	284	1,066	82.3	578.8	678.3
Actual PE load WWTP[4)]	1,000	23,798	23,854	24,745	25,686	26,239	26,427
IWWTPs:							
TOW as COD[1)]	Gg/year	144	194	192	190	192	192
Total biogas converted[5)]	TJ/year	468	974	2,900	5,320	5,385	5,594
Septic tanks:							
Resident population [6)]	1,000	14,952	15,926	16,615	16,940	17,030	17,133
inhabitants with septic tank	% of pop.	4	1.9	0.62	0.57	0.55	0.50
Direct discharges of nitrogen:							
Nitrogen in effluents[7)], total	Gg/yr	63.79	38.45	22.13	21.35	21.20	21.20
Via effluents from UWWTP[8)]	Gg/yr	42.68	30.44	17.69	17.05	16.91	16.91
Via industrial discharges	Gg/yr	12.71	4.51	2.36	2.29	2.26	2.26
Via other direct discharges	Gg/yr	8.40	3.51	2.07	2.01	2.03	2.03

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) Total amount of biogas from anaerobic IWWTPs as well as other biomass fermentation within industries, converted into energy. Flared amounts are not included.
6) Average population over a year.
7) Sum of domestic and industrial discharges of N in wastewater to surface water.
8) Including discharges from combined sewer overflows and storm water sewers.

CH_4 emissions from domestic wastewater treatment (5D1)
In 2017, 99.5% of the population was connected to closed sewer systems, which were in turn connected to 326 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 is also 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., 2019), 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 Statistics Netherlands among the Water Boards. Data on influent COD are available for the years 1990 until the present for every treatment plant.

For data on sludge produced, data are available on an annual basis for the years 1990 until 2016. Due to a re-evaluation of the statistical programme this data in future will only be inventoried for the even years. For odd years (starting 2017) the data of the previous year will be used as best estimate. See also (Peek et al., 2019).

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. The total dry solids are measured at each public WWTP; the inorganic fraction is calculated on basis of measurements of the 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 2017, 74 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.

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 2017, the amount of CH_4 emitted by the venting of biogas was 0.298 Gg CH_4, equalling 3.8% 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 2017 was moderate.

Recovered biogas is largely used for energy generation purposes, but a small amount is flared, vented or delivered to third parties. Table 7.8 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., 2019).

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 Statistics Netherlands (CBS, 2018). Table 7.9 provides the time series of total TOW for IWWTPs. In 2017, 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 activity data and CH_4 emissions of 2017 are a copy of the 2016 values, since the inventory on industrial wastewater treatment is no longer continued, starting 2017.
For the next submission (NIR 2020) an alternative source for these activity data or other activity data will be needed, which also could implicate that the method for calculating CH_4 emissions from anaerobic

industrial waste water treatment will be changed (see also section 7.5.6).

Statistics Netherlands has data on total biogas produced within biomass fermentation plants, 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 2017, the total biogas converted into energy from biomass fermentation by industrial companies equals 5,594 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., 2019).

Table 7.9 shows the time series of the percentage of the population connected to septic tanks. The percentage of the population connected to septic tanks decreased from 4% in 1990 to 0.5% in 2017. 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 Population Equivalents (PE's).

Rationale for using the Pollution Equivalent (PE) as activity data (response to 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 2017 is 26.4 million. With an average population of 17.1 million, this means that 9.3 million PE comes from industrial and commercial sources and urban run-off. With T_{PLANT} is almost 1, $F_{IND-COM}$ in 2017 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., 2019), see Annex 7. Table 7.9 provides a time series of the PE. In 2017, the total PE equalled 26.4 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' Emissions Inventory System.

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 , combined sewer overflows, plus industrial effluents and other direct discharges to surface water. The Netherlands does not make use of 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 other wastewater discharges such as those from combined 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., 2019).

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) or not occurring (NO):

N_2O emissions from industrial wastewater treatment (5D2: NE)
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: NO)
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: NE)
From a recent survey among IWWTPs conducted by the Statistics Netherlands it can be concluded that anaerobic sludge digestion within industries is not significant. These data are not published on www.cbs.statline.nl for reasons of confidentiality. Forthcoming CH_4 emissions are therefore not estimated (NE). 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 Approach 1 uncertainty analysis shown 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 Statistics Netherlands.

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 Statistics Netherlands.

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. Statistics Netherlands 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 CH_4 emissions of domestic wastewater treatment increased with 0.066 Gg (+0.85%) compared to 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 increased by 0.00021 Gg N_2O (+0.25%) compared with the previous submission.

CH_4 emissions from septic tanks (5D3)
Due to final activity data on number of people connected to septic tanks in 2016 the CH_4 emissions of septic tanks increased with 0.00043 Gg (+0.07%) compared to the previous submission.

Indirect N_2O emissions from surface water as a result of discharge of domestic and industrial effluents (5D3, Wastewater effluents)
Due to final activity data on total Nitrogen discharges in 2014, 2015 and 2016, the emission of N_2O from surface water as a result of discharge of domestic and industrial effluents increased for these years. This increase is 0.0093 Gg N_2O (+6.1%) for 2014, 0.011 Gg N_2O (+6.8%) for 2015 and 0.010 Gg N_2O (+6.1%) for 2016, compared with the previous submission.

7.5.6 *Category-specific planned improvements*

Starting 2017, activity data on anaerobic industrial wastewater treatment (IWWTP), needed to calculate CH_4 emissions from this source, will not be available anymore due to a re-evaluation of the statistical programme of Statistics Netherlands. For 2017 it is chosen to copy the data of 2016, but for future years 2018 and later this will no longer be possible. For the inventory of 2018 emissions (Submission 2020) an alternative source or estimate using expert judgement for these activity data will be needed. This will be elaborated in the course of 2019.

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 0.92 Tg in 1990 to 0.45 Tg in 2017 as a result of the Dutch policy to reduce NMVOC emissions. Please note that the indirect emissions reported in this submission are higher than in previous submission due the addition of a new source for NMVOC in the agricultural sector (Silage).

9.2 Methodological issues

Indirect CO_2 emissions are calculated as follows:

$$CO_2 \text{ (in Gg)} = \text{NMVOC emission (in Gg)} * C * 44/12$$

Where:

C = default IPCC carbon content (C) of 0.6;

NMVOC 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

Due to the inclusion of an additional NMVOC source in the agriculture inventory (silage) the indirect CO_2 emissions increased for the whole time series (234 Gg CO_2 eq. in 1990; 238 Gg CO_2 eq. in 2016).

9.6 Category-specific planned improvements

No improvements are planned.

10. Recalculations and improvements

Major recalculations and improvements compared with the National Inventory Report 2018

For the NIR 2019, the data for the most recent year (2017) were added to the inventory and corresponding Common Reporting Format (CRF).

As a result of the recommendations of the in-country review of 2017 several improvements were made to the inventory and the NIR. These include corrections of errors in previous submissions. These have resulted in changes in emissions over the entire 1990–2016 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 NIR 2019, the Netherlands uses the CRF Reporter software v6.0.6.
The in-country review 2017 of the UNFCCC suggested in their review report of May 2018 that there is room for improvement of the Dutch GHG inventory. Following their recommendations 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.

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 (so: *not all*) recalculations in this submission (compared with the previous NIR) are:
- *Energy sector:*
    - improved energy statistics data for the years 2015 and 2016 for the categories 1.A.1 and 1.A.4;
    - correction of the energy statistics for natural gas and chemical waste gas for the years 2012-2016 in category 1.A.2.c. During comparison of the energy statistics and the ETS data from some major chemical companies, it was

detected that the energy statistics were incomplete. The error is now corrected which increased the CO_2 emissions in the order of magnitude of 0.5 to 1 Gg per year.
    - In the transport sector: some minor changes as a result of the correction of the energy statistics for gasoline consumption for road transport. The correction of the energy statistics also decreased the navigation bunker emissions in 2015 and 2016. Besides, activity data for motorcycles and mopeds were adjusted (downwards) as a result of a recent measurement programme.
- *IPPU sector:*
    - A previously unknown N_2O source (production of Acrylonitril) within the chemical industry is now included in the inventory;
    - Minor corrections in 2B8 for CO_2 and CH_4 for the total time series;
    - Based on new activity data the HFC emissions from Handling activities reported under 2B9b3 have changed for selected years;
    - The method for the calculation of the emissions from refrigeration (2F1) had to be adapted to the new registry system of refrigerants. The application of the new methodology changed emission data as of 2012.
- *Agriculture sector:*
    - The manure management methodology now includes the calculation of the emissions from Manure treatment and manure digestion (the latter reported under category 5B2). Emissions added to both 3B and 3D;
    - New data available (from 2016 onwards) for N-fertilizers (3D)
    - Redefinition of the term “agricultural farm animal” lead to some changes in the animal statistics.
- *LULUCF sector:*
    - New method to assess the emissions from peat soils;
    - Use of improved land use maps.
- *Waste sector:*
    - Inclusion of the emissions from institutionalised bonfires in 5.C.2 (biogenic).
- *Indirect CO_2 emissions:*
    - Inclusion of the NMVOC emissions from agricultural silage raised the indirect CO_2 emissions for the total time series.

The sectoral sections describe some additional minor recalculations.

Changes in source allocation
As a result of recommendations of the 2017 review, following source allocations changed:
- We differentiated the allocation of composting and digestion of wastes in 5B1 and 5B2.
- The N_2O emissions from Manure Management are now to the extent possible (limited by the CRF reporter) differentiated per animal species under 3B4.

Error correction
In general, the 2016 and in some cases 2015 figures have been updated whenever improved statistical data have become available since the latest submission. Furthermore, as a result of internal QA/QC procedures, corrections have been made in activity data and emission figures..

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. The addition of a new soil map for 2014 allowed for a better assessment of the development of organic (peat and peaty) soil area in the Netherlands. The area of of organic soil in 1990 was underestimated by 22 kha and hence emissions from organic soils as result of drainage were underestimated. At the same time the results showed that, as a result of continuing oxidation and subsequent loss of peat, the area of organic soil decreased by 64 kha over time between 1990 and 2014. Therefor, total annual emissions from organic soils have decreased since 1990.
Besides, in response to the recommendation by the review team the areas of forest land and 'trees outside forest' on organic soils where drainage might still be occurring have been estimated and associated emissions have been calculated using country specific emission factors.

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 2018 submission, as a result of the recalculations.

For 1990 the recalculations resulted in an increased emission total compared to the latest submission (+0.3%). For 2016 the recalculated emissions are decreased compared to the last submission (-0.4%).

Table 10.1: Summary of recalculations for the period 1990–2016 (Gg CO_2 eq)

Gas(es)		1990	1995	2000	2005	2010	2015	2016
CO_2, CH_4, N_2O	1.A.1 Energy industries	0.0	0.0	0.0	0.0	0.0	-15.0	189.0
CO_2, CH_4, N_2O	1.A.2 Manufacturing industries and construction	0.0	0.0	0.1	0.1	0.1	1117.7	971.8
CO_2, CH_4, N_2O	1.A.3 Transport	-12.4	0.0	8.3	1.2	9.9	20.4	-8.2
CO_2, CH_4, N_2O	1.A.4 Other sectors	-0.1	-0.1	-0.2	-0.2	-0.1	-44.6	-537.0
CO_2, CH_4, N_2O	2 Industrial processes	133.6	155.8	197.3	210.9	250.2	556.4	526.3
HFC	2.B.9 Flurochemical production	0.0	0.0	0.0	0.0	-8.8	0.0	0.0
HFC and PFC	2.F Product uses	0.0	-1.5	0.9	1.8	0.9	-539.0	-541.3
CH_4	3.A Enteric Fermentation	0.0	0.0	-0.3	0.0	0.0	0.0	0.0
CH_4 , N_2O	3.B Manure management	17.6	37.6	42.9	33.8	-38.6	-53.6	-59.5
N_2O	3.D Agricultural soils	44.0	18.3	-6.9	-29.5	-48.8	-73.7	-191.8
CO_2	3.G Liming	0.0	0.0	0.0	0.0	0.0	0.0	-28.2
CO_2, CH_4, N_2O	4 LULUCUF	437.8	234.2	6.4	-302.1	-561.7	-1,012.0	-1,101.2
CH_4								
CH_4	5.B Biological treatment of solid waste	0.5	-0.1	-0.6	-0.7	20.0	30.3	22.4
CH_4, N_2O	5.C Incineration and open burning of waste	6.1	6.2	6.3	6.4	7.0	6.8	6.8
CH_4, N_2O	5.D Waste water Handling	0.0	0.0	0.0	0.0	0.0	3.2	4.6
CO_2	Indirect emissions	234.4	165.5	178.1	166.0	202.2	224.5	238.5
Total Difference		861.5	615.8	432.3	87.6	-167.8	221.2	-507.8

As it is difficult to interpret the described changes in terms of emissions of individual gases, Table 10.2 shows the changes per gas and per sector in 1990 and 2016.

Table 10.2: Summary of recalculations per gas and sector (Gg CO_2 eq)

CO_2	**1990**	**2016**
1 Energy	-12.65	606.05
2 IPPU	0.00	287.07
3 Agriculture	0.00	-28.19
4 LULUCF	437.88	-1059.34
5 Waste	0.00	0.00
Indirect emissions	234.42	238.45
CH_4		
1 Energy	-0.23	8.62
2 IPPU	-10.55	-140.60
3 Agriculture	-0.96	-140.66
4 LULUCF	0.00	-0.01
5 Waste	3.70	32.68
N_2O		
1 Energy	0.37	0.92
2 IPPU	244.19	379.83
3 Agriculture	62.54	-110.65
4 LULUCF	-0.09	-41.83
5 Waste	2.88	1.16
HFC's		
2 IPPU	0.00	-541.29
PFC's		
2 IPPU	0.00	0.00

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 (2019).
The addition of a new NMVOC source in the agricultural sector 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 2013–2016 in Gg CO_2-eq.

Activity	**2013**	**2014**	**2015**	**2016**
A. Article 3.3 activities				
A1 Afforestation and Reforestation	32.5	80.9	131.1	182.8
A2 Deforestation	-127.2	-111.1	-94.5	-77.6
B. Article 3.4 activities				
B1 Forest management	294.4	285.7	292.8	265.5
Total	**199.8**	**255.4**	**329.4**	**370.6**

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, 2000, 2010 and 2016 (compared with the NIR 2018). From the table, it emerges that the recalculations changed national emissions only to a small extent (<0.4%) compared with the last NIR.

Table 10.4: Differences between the NIR 2018 and NIR 2019 for the period 1990–2016 due to recalculations (Units: Tg CO_2 eq.; for F-gases: Gg CO_2 eq.)

	Source	1990	2000	2010	2016
CO_2	NIR 2019	169.8	178.5	188.1	172.2
Incl.	NIR 2018	169.2	178.3	188.5	172.3
LULUCF	*Difference*	*0.4%*	*0.1%*	*-0.2%*	*0.0%*
CO_2	NIR 2019	163.3	172.5	182.6	166.8
Excl.	NIR 2018	163.1	172.3	182.4	165.7
LULUCF	*Difference*	*0.1%*	*0.1%*	*0.1%*	*0.7%*
CH_4	NIR 2019	31.9	24.3	19.4	18.3
	NIR 2018	32.0	24.4	19.6	18.6
	Difference	*-0.3%*	*-0.5%*	*-1.0%*	*-1.3%*
N_2O	NIR 2019	18.0	16.2	8.6	8.5
	NIR 2018	17.7	15.9	8.4	8.4
	Difference	*1.7%*	*2.2%*	*3.4%*	*1.6%*
PFCs	NIR 2019	2663	1903	314	152
	NIR 2018	2663	1903	314	152
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*
HFCs	NIR 2019	5606	4765	2669	1876
	NIR 2018	5606	4764	2677	2418
	Difference	*0.0%*	*0.0%*	*-0.3%*	*-22.4%*
SF_6	NIR 2019	207	259	154	134
	NIR 2018	207	259	154	134
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*
Total	NIR 2019	228.2	225.9	219.4	201.4
Tg CO_2-eq.	*NIR 2018*	227.3	225.5	219.6	201.9
Incl. LULUCF	*Difference*	*0.4%*	*0.2%*	*-0.1%*	*-0.3%*
Total	NIR 2019	221.7	219.8	213.8	195.8
Tg CO_2 eq.	NIR 2018	221.3	219.4	213.4	195.2
Excl. LULUCF	*Difference*	*0.2%*	*0.2%*	*0.2%*	*0.3%*

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. The peer review includes a general check on all chapters and pays special attention to a specific sector or topic. The peer review checks on transparency, readability and consistency with 2006 IPCC Guidelines (IPCC, 2006).

In 2019, due to organizational problems, the annual peer review has been postponed to April/May 2019. Results of the peer review will be addressed in the NIR 2020. The peer review in 2019 will focus on the transport sector. Usually the draft NIR is also subject to a public review in January/February. Due to problems encountered with the generation of CRF files, it was not possible to timely deliver a draft NIR for the planned public review. It was decided not to conduct a public review in 2019. For 2020, the Netherlands has planned the next public review.

Peer reviews in past years have focused on the following sectors and categories:

- Reference approach and Waste Incineration (CE, 2018)
- 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.

A peer review on the Reference Approach calculation conducted by CE Delft in 2018, has been used to improve the Reference Approach in 2018. A meeting was scheduled with Statistics Netherlands (responsible for the national energy statistics) and the Dutch PRTR (responsible for the emission calculations and the Reference Approach calculation) to discuss the differences between the energy statistics and the data needs in the CRF. A few improvements have been included in the Reference Approach calculation in the NIR 2019:

- Coal has been split up between other bituminous coal, anthracite and coking coal;
- Description in the NIR and the methodology report has been improved.

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. In May 2018 we received the final review report and the recommendations are included in Annex 10. It should be noted that the recommendations are summarized. The full text of the recommendations can be found in the review report via the reference number given in the first three columns of the table (Sector, ARR table number and Issue indication). Furthermore the table does not include the issues which, according to the review report were already solved. The non-issues are represented neither.
The table in Annex 10 also gives references to the sectoral sections in this NIR, the CRF tables and updated methodology reports (2019) in which the follow-up of the recommendations is detailed.

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.

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). A conclusion of the initial review (2007) was, 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. This was reconfirmed in the in country review in 2017.

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, 2018).

QA/QC programme
The QA/QC programme for this year (RVO.nl, 2018) 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
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 this definition 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., 2019).

Under the UNFCCC reporting (Chapter 6) a sub-category Trees outside forests (TOF) is included under Grassland. TOF consists of units of land with trees that do not meet the minimum area requirement for the forest definition. Conversions from TOF to Forest land are included under Afforestation and reforestation (AR), while conversions from Forest land to TOF are included under Deforestation (D).

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 2017. 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),1 January 2013 (Kramer and Clement, 2015), 1 January 2017, (Arets et al., 2019); see also Section 11.2.3 below. An overlay was made of those five land-use maps plus two maps with soil types (Arets et al., 2019). 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 a third matrix covering the period 1 January 2009–1 January 2013 and a fourth matrix covering the period 1 January 2013–1 January 2017. Together the three matrices thus cover the period 1 January 1990–1 January 2017, which ensures 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 2017 onwards the annual changes as obtained from the matrix 2013–2017 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 2022 with a map date of 1 January 2021).

Table 11.1 gives the annual area change 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 four consecutive land-use change matrices, 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 1990–2017

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	8.0	352.1	3,776.6
1995	2.6	12.8	0	2.0	10.0	350.1	3,774.0
1996	2.6	15.3	0	2.0	12.0	348.2	3,771.5
1997	2.6	17.9	0	2.0	13.9	346.2	3,768.9
1998	2.6	20.5	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	25.6	0	2.0	19.9	340.2	3,761.2
2001	2.6	28.2	0	2.0	21.9	338.2	3,758.7
2002	2.6	30.7	0	2.0	23.9	336.2	3,756.1
2003	2.6	33.3	0	2.0	25.9	334.2	3,753.6
2004	2.5	35.0	0.9	1.6	27.9	332.6	3,751.0
2005	2.5	36.6	0.9	1.6	30.4	330.9	3,748.5
2006	2.5	38.3	0.9	1.6	32.9	329.3	3,746.0
2007	2.5	39.9	0.9	1.6	35.4	327.7	3,743.5
2008	2.5	41.6	0.9	1.6	37.9	326.0	3,740.9
2009	2.9	42.7	1.4	1.9	40.5	324.1	3,738.0
2010	2.9	44.3	1.4	1.9	43.7	322.3	3,735.1
2011	2.9	45.9	1.4	1.9	46.9	320.4	3,732.2
2012	2.9	47.5	1.4	1.9	50.1	318.5	3,729.2
2013	1.6	48.1	2.3	2.0	53.4	316.5	3,727.7
2014	1.6	47.3	2.3	2.0	57.7	314.4	3,726.1
2015	1.6	46.6	2.3	2.0	62.1	312.4	3,724.5
2016	1.6	45.9	2.3	2.0	66.4	310.4	3,722.9
2017	2.0	45.4	2.0	2.0	70.8	308.4	3,720.9

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 five 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),1 January 2013 (Kramer and Clement, 2015) and 1 January 2017 (Arets et al., 2019).

To distinguish between mineral soils and organic soils and to include the temporal developments in organic soil, an overlay is also made with two versions of the soil maps. These are the initial version of the Dutch Soil Map (De Vries et al., 2003), dated at 1977, and a 2014 update based on the latest information on organic soils from the soil information system Netherlands (BIS), (see https://www.wur.nl/nl/show/Bodemkundig-Informatie-Systeem-BIS.htm). As a result detailed land-use information with national coverage is available. For each pixel, it identifies whether it was subject to AR or D or remained as FM between 1990 and 2004, 2004 and 2009, 2009 and 2013, and 2013 and 2017 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 linear 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 (NFI-5 data, Daamen and Dirkse, 2005) and 2012–2013 (NFI-6, 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 (NFI-5) and 2012 (NFI-6). Until a new NFI becomes available, in 2020, the development of carbon stocks in forests is based on projections using the EFISCEN model (see Arets et al., 2019).

Using plot-level data from the HOSP, NFI-5 and NFI-6, 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. (2019).

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 (see Section 6.4.2.2 and Arets et al., 2019).

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., 2019) 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., 2019). 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., 2019). 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 11.2.

Table 11.2: 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	144.3	21.3	NO	4.4	1.63	-6.61
2014	144.5	21.3	NO	4.5	1.32	-6.47
2015	144.6	21.3	NO	4.6	1.00	-6.38
2016	144.5	21.3	NO	4.6	0.70	-6.29
2017	146.0	20.4	NO	4.7	0.57	-6.36

CSC: carbon stock change, AG: above ground, BG: below ground, DW: dead wood

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. (2019). 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., 2019). Data from the 6th NFI

2012–2013, in combination with data from the previous NFI (NFI-5) in 2003, allowed the calculation of actual carbon stock changes from deforestation (see EF in Table 6.9 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., 2019).

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., 2019). Net carbon stock changes in the different carbon pools are given in Table 11.3.

Table 11.3: 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	-187.4	-22.9	-79.0	-4.5	4.2	-12.0
2014	-194.6	-24.2	-80.2	-4.7	4.7	-13.4
2015	-202.2	-25.5	-81.4	-5.0	5.2	-14.9
2016	-209.7	-26.9	-82.5	-5.3	5.7	-16.3
2017	-222.6	-29.5	-84.1	-5.6	5.8	-17.7

CSC: carbon stock change, AG: above ground, BG: below ground, DW: dead wood

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 Sections 4.2.1 and 4.2.3 in Arets et al., 2019). 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., 2019). Net carbon stock changes are given in Table 11.4.

Table 11.4: 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	264.7	47.6	NO	17.7	NO	-15.1
2014	263.8	47.5	NO	17.5	NO	-14.9
2015	262.8	47.3	NO	17.4	NO	-14.7
2016	261.9	47.1	NO	17.3	NO	-14.6
2017	261.0	47.0	NO	17.2	NO	-14.4

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 this sink was very uncertain. Therefore, it was considered conservative to set the accumulation of carbon in FM to zero (see Arets et al., 2019).

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., 2019 for more details).

The LSK dataset contains only data on soil carbon stocks for the land uses Grassland, Cropland and Forest land. 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 category Wetland, which makes up 5% of deforested land, no change in carbon stocks in mineral soils is assumed upon conversion to or from Forest. For the category ‘Other land’, a carbon stock of zero is assumed. This is a conservative estimate, yet in many cases very realistic. (‘Other land’ in the Netherlands comprises mainly sandy beaches and inland (drifting) sandy areas.)
The estimated annual C flux associated with 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 with:

$$C_{\Delta yi_t} = C_{xi} + t \cdot \frac{C_{yi} - C_{xi}}{T}$$

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 2017 is small: 20.24 kha, which is 4.5% of the total area of organic soil. The area of AR land on organic soils was 5.6 kha in 2017 (11.8% of total AR area) and the area of D land on organic soils was 7.0 kha in 2017 (9.3% of deforested area). In 2017 the majority of this area of D (58%) on organic soils was on agricultural land (Cropland or Grassland).

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., 2019).

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., 2019: 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). 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. (2019).

For organic soils under deforestation for which the current land use is Cropland, Grassland or Settlements, these emissions from organic soils are applied.

Drainage of organic soils is usually not applied in forestry in the Netherlands. However, since afforestation often occurs on land with previously agricultural land use, it cannot be completely excluded that the old drainage systems from the agricultural sites are still active. Therefore, to account for possible emissions, the area of forests that are planted on organic soils, that were in agricultural use before and where drainage systems may still be (partially) functioning, was estimated at 24.2% of the total forest area on peat soils and 22.0% of the total forest area on peaty soils. Subsequently to 24.2% of the FM land and AR land on peat soils, the same country specific emission factors are applied as used for drained peat soils under Grassland, Cropland and Settlements. Similarly, to 22.0% of the FM land and AR land on peaty soils, the same country specific emission factors are applied as used for drained peaty soils under Grassland, Cropland and Settlements

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., 2019: 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 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 in the Netherlands; they are therefore reported as not occurring (NO).

Because wildfires in the Netherlands are infrequent and relatively small-scale, there is no active 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., 2019) 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 in a year.

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 category 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.

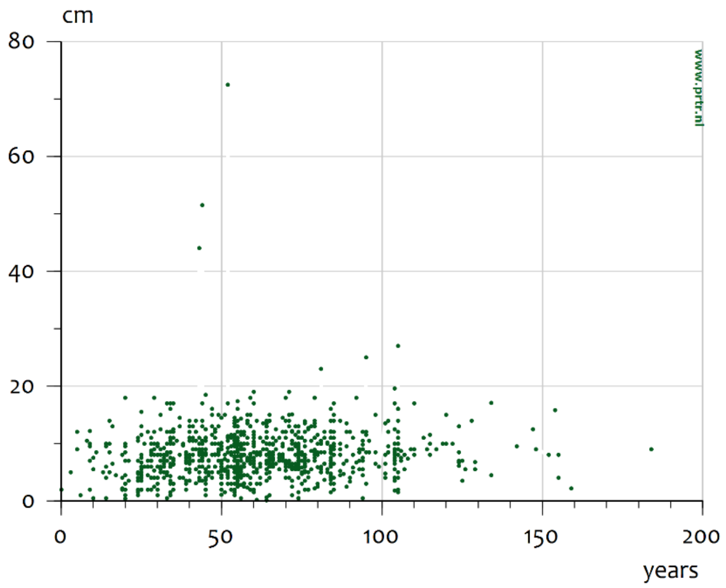


Figure 11.1: Thickness of litter layer in Dutch NFI plots in relation to tree age. Measurements were conducted only in plots on sandy soils.

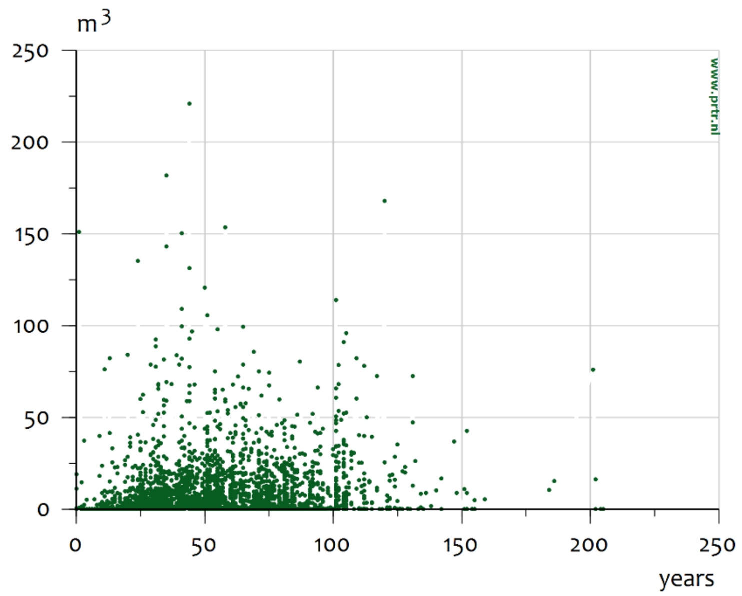


Figure 11.2: Volume of dead wood (standing and lying) in Dutch NFI plots in relation to tree age

Similarly, no other land-use category 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., 2019).

N_2O emissions due to nitrogen fertilization in units of land subject to Article 3.3 (AR and D) and Article 3.4 Forest Management

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 AR or FM land. Nevertheless. 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 economically valuable.

N2O emissions from the use of nitrogen fertilizers on units of D land used as grassland, cropland or settlements are included under categories 3Da1 (inorganic N fertilizers) and 3Da2 (organic N fertilizers) 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)

This year, two methodological changes have been implemented and additionally new data were included in existing methodologies and two errors were corrected, resulting in changes in various carbon stock changes and associated emissions and removals along the whole time series (see Chapter 6.1). These also resulted in recalculations for AR, D and FM. Because the separate changes may interact with each other, the effects of the separate changes cannot be quantified. The changes are briefly explained below. More extensive descriptions are included in Chapter 6.1.

Implementation of an additional soil map

As a result adding a second soil map for the year 2014, the development in the areas of peat and peaty soils in the Netherlands can be taken into consideration from 1990 onwards (see Chapter 6.1 for more details). The result is that in the relevant time period (i.e from 2013 onwards) overall the area of land with organic soils has become smaller compared to the old approach (using only one soil map) that was used in previous NIRs. The loss of area of organic soils is the result of continuing oxidation of organic matter resulting in loss of peat. As a result part of the land that was classified as organic soils before now is classified as mineral soil. Due to this decrease in the area also emissions from organic soils have decreased while on the other hand the increase of the area of mineral soils has an effect on the overall emissions and removals in mineral soils.

As a result of the changes in area of organic soils, the emissions from organic soils for AR and D have changed. Additionally this also changes the emissions and removals for mineral soils for AR and D land.

Emissions from organic soils under Forest land

Although drainage of organic soils is usually not actively applied in forestry in the Netherlands, afforestation often occurs on land with previously agricultural land use that may have been drained. In the previous NIR's it therefore was assumed that there are no emissions from organic soils in Forest land. Nevertheless, it cannot be ruled out that the old drainage systems from the agricultural sites are still active.

Therefore the relative areas of forest land and ’trees outside forest’ on organic soils where drainage might still be occurring were estimated (see Chapter 6.1 for more details).

The total area of forest on peat soils in the 2017 map was 11.3 kha. Out of this area, 2.7 kha was listed as being cropland, grassland or settlement in at least one of the earlier maps. This is equal to 24.2% of the forest area on peat soils. The same percentage was applied to the area of AR and FM on peat soils. For each year we therefore assume that 24.2% of AR and FM land on peat soil has an emission factor equal to that of agriculture on peat soil.

The total area of forest on peaty soil in the 2017 map was 9.1 kha. Out of this area, 2 kha was listed as being cropland, grassland or settlement in at least one of the earlier land-use maps. This is equal to 22.0% of the forest area on peaty soils. The same percentage was applied to the area of AR and FM on peaty soils. For each year we assume that 22.0% of AR and FM land on peaty soil has an emission factor equal to that of agriculture on peaty soils.

As a result of this change in method, emissions from organic soils in AR and FM have been recalculated for the full time series in this NIR. In the case of FM this implies that emissions from organic soils no longer are reported as NO.

In addition, new data sources have been included, also resulting in recalculations of part of the time series.

New land-use map 2017
In this NIR2019 a new land-use map representing land-use on 1 January 2017 was included (see Chapter 6.1 and Table 6.7). As a result, now the actual land-use changes observed between the previous land-use map of 1 January 2013 and the new map have been used. This replaces the previous estimates of land-use changes from 2013 onwards that were based on the extrapolation of changes observed in the land-use change matrix 2009-2013.

The results show that between 2013 and 2017 gross deforestation remains relatively high but that the rate of afforestation strongly decreased.

As a result of the updated land-use matrix the activity data for all pools in AR, D and FM have changed and this leads to recalculations of the emissions and removals for all pools in AR, D and FM.

Average carbon stocks in forest litter
Data from the 6th Nationals Forest Inventory (NFI-6) have been included to calculate the average carbon stocks in litter in forest land from 2003 onwards. These average carbon stocks are used to calculate the carbon stock losses from litter for deforestation. As a result this changes the emission factor for litter for deforestation, resulting in recalculations of the emissions from D.

Error correction for carbon stock changes in *dead wood*
While in the NIR2018 the methodology for the extrapolation of carbon stocks in dead wood in forest from 2013 (until data from a new Forest Inventory are available) was adjusted, as a result of an input error this was not effectuated in the CRF values for carbon stock changes in dead wood under FM and AR. This error has now been corrected, resulting in recalculation of the carbon stock changes in dead wood in AR and FM.

Error correction in estimating carbon stocks in above and belowground biomass in FL-FL
While doing additional analysis on the data from the NFI-6, it was found that the average carbon stocks in forests as used in the calculations in the previous NIRs was based on all NFI-6 plots instead of the subset that represents Forest land remaining forest land. This was adjusted to only include data from plots that actually represent Forest land remaining forest land (see Chapter 6.1 for more details).

The resulting changes in carbon stock changes in living biomass result in recalculations of the removals in the living biomass pool for AR and FM and the direct emissions resulting from the deforestation event for D land.

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 uncertainty analysis uses Monte Carlo simulations for combining different types of uncertainties and correctly representing the uncertainties in the land-use matrix (see chapter 14 in Arets et al., 2019 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 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 AR are estimated at +10% to -12%, which is equal to the uncertainty in Land converted to forest land. Similarly the uncertainty for total net removals from units of land under Article 3.4 FM is estimated at +26% to -21%, which is equal to the uncertainty of Forest land remaining forest land (see Chapter 6.4.3).

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, 2013 and 2017 have been used to track changes in land use on units of land. All observed AR and D activities between 1 January 1990 and 31 December 2016 have been taken into account. Subsequent land use changes are extrapolated from changes in the last period for which maps are available (2013–2017). A new land-use map and corresponding land-use matrix are foreseen for 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., 2019).

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 11.5. 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.

Total areas of FM and AR land are provided in Table 11.6.

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 11.5: 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 11.6: 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)	360	358	356	354	352	350	348	346	344	342	340	338	336	334	333	331	329	328	326	324
Area under AR (kha)	3	5	8	10	13	15	18	21	23	26	28	31	33	36	38	39	41	42	44	46

11.4.5 *Information on harvested wood products under Article 3.3*

The approach used 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., 2019).
During the first commitment period the Netherlands did not account for FM and HWP. Since no harvests from AR are included in the HWP, no emissions from harvested wood products originating from forests prior to the start of the second commitment period have been included in the accounting.

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., 2019), 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 forestry production and trade data reported to FAOSTAT[4] as import, production and export for the different wood product categories (see Table 6.11), 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., 2019).

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 11.7). 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.

[4] http://www.fao.org/faostat/en/#data/FO

Table 11.7: 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., 2019).

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 paragraph 11.4.1. The land-use mapping approach used allows changes in Forest land to be monitored 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, 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 the Approach 1 level analysis including LULUCF is 647.0 Gg CO_2 (3Db Indirect N_2O emissions from managed soils; see Annex 1).

With net emissions of 602.1 Gg CO_2, the absolute annual contribution of afforestation/reforestation under the KP-LULUCF in 2017 is smaller than the smallest key category (Approach 1 level analysis including LULUCF).

Deforestation under the KP-LULUCF in 2017 causes a net emission of 1,302.6 Gg CO_2, which is more than the smallest key category (Approach 1 level analysis including LULUCF).

With a net figure of -990.0 Gg CO_2, removals from Forest management are also larger than the smallest key category

Table 11.8 shows the net emissions from AR, D and FM for the years 2013–2017.

Table 11.8: Net emissions from AR, D and FM (including HWP) (Gg CO_2).

Activities	Net emissions (Gg CO_2)				
	2013	2014	2015	2016	2017
A. Article 3.3 activities					
A1 Afforestation and Reforestation	-600.3	-601.0	-601.0	-600.6	-602.1
A2 Deforestation	1110.5	1150.6	1192.1	1233.6	1302.6
B. Article 3.4 activities					
B1 Forest management	-1070.0	-1070.1	-1039.9	-1054.1	-990.0

11.7 Information relating to Article 6

The Netherlands is not buying or selling any emission reduction from Joint 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 2018

12.1.1 Background information

The Netherlands' Standard Electronic Format (SEF) report for 2018 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 (RREG1_NL_2018_2_1.xlsx) and (RREG1_NL_2018_2_1.xml).

12.1.2 Summary of information reported in the SEF tables

There were 3,785,277 CERs in the registry at the end of 2018: 544,246 CERs were held in the Party holding accounts, 2,921,358 CERs were held in entity holding accounts and 319,673 CERs were held in the voluntary cancellation account.

There were 10,000 Emission Reduction Units (ERUs) in the registry at the end of 2018: All 10,000 were held in the voluntary cancellation account.
The total amount of the units (CERs and ERUs) in the registry corresponded to 3,795,277 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 2018 has been submitted to the UNFCCC Secretariat electronically (RREG1_NL_2018_2_1.xlsx) and (RREG1_NL_2018_2_1.xml).

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 2018.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2018.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2018.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units existed as at 31 December 2018.
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 addresses: www.emissionsauthority.nl/topics/public-information-kyoto and/or here: https://unionregistry.ec.europa.eu/euregistry/NL/public/reports/publicReports.xhtml All required information for a Party with an active Kyoto registry is provided, with the following exceptions: paragraph 46 Article 6 Project Information. The Netherlands does not host JI projects, as laid down in national legislation. This fact is stated 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. paragraph 47a/d/f/l in/out/current Holding and transaction information is provided on a holding type level, due to more detailed information being declared confidential by EU regulation. This follows from Article 110 of Commission Regulation (EU) no 389/2013. paragraph 47c The Netherlands does not host JI projects, as laid down in national legislation (ref. submission paragraph 46 above). paragraph 47e The Netherlands does not perform LULUCF activities and therefore does not issue RMUs. paragraph 47g No ERUs, CERs, AAUs or RMUs have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4, to date. paragraph 47h 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. paragraph 47i The number of other ERUs, CERs, AAUs and RMUs that have been cancelled is published by means of the SEF report.

Annual submission item	Submission
	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 before, 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 2019 submission as the most recently reviewed inventory and multiplying by 8 results in: 221,710,817*8 = 1,773,368,536 tonnes of CO2 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 (NL-PRTR), 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 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 more simple 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;
- In 2017, the Ministry of Economic Affairs (EZ) was split into the Ministry of Economic Affairs and Climate Policy (EZK) and the Ministry of Agriculture, Nature and Food Quality (LNV). At the same time the responsibility for climate policy shifted from the (former) Ministry of Infrastructure and the Environment to the Ministry of Economic Affairs and Climate Policy.

These changes do not have any impact on the functions of the National System.

14. Information on changes in national registry in 2018

The following changes to the national registry of Netherlands have occurred in 2018. Note that the 2018 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Reporting item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	During the reported period the manager, who is also the main contact, changed. 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: https://www.emissionsauthority.nl/ **Main contact** Mrs. Maaike Breukels Manager Emissions Trading Dutch Emissions Authority P.O. Box 91503 NL-2509 EC The Hague Tel.: +31 70 456 8311 Fax: +31 70 456 8247 Email: maaike.breukels@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

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 versions of the EUCR released after 8.0.8 (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 only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.8 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 reported 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	A change to the registry internet address occurred during the reporting period. The new URL is https://unionregistry.ec.europa.eu/euregistry/NL/index.xhtml
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.

Reporting item	Description
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.8 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 2018, 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 €0.29313 in 2019; excise duty on gasoline increased in the same period from €0.71827 per litre to €0.78773 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-acc0552z78fd.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 increased to €395 million in 2014, €416 million in 2015 and topping at €472 million in 2016. In 2017 the public climate finance amounted €405 million. In addition, in 2015 the Netherlands mobilized €73 million private finance in 2015, €171 million in 2016 and €335 million in 2017. 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 source 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).

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 Approach 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): 32 sources for annual level assessment (emissions in 2017) and 38 sources for the trend assessment out of a total of 107 sources.

The IPCC Approach 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 Approach 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 Approach 1 and Approach 2 level and trend assessments are summarized in Table A1.1. A combination of Approach 1 and 2 and level and trend assessments, shows a total of 56 key categories (excluding LULUCF).

As expected, the Approach 2 level and trend assessments increase the importance of highly uncertain sources.
It can be concluded, that in using the results of a Approach 2 key category assessment, 14 categories are added to the list of 42 Approach 1 level and trend key categories (excluding LULUCF):

Table A1.0: Approach 2 additional key categories

1A4b	Residential: all fuels	CH_4	Key(L2,)
1A3b	Road transportation	N_2O	Key(,T2)
2B8	Petrochemical and carbon black production	CO_2	Key(L2,T2)
2F6	Other	HFC	Key(,T2)
2D2	Paraffin wax use	CO_2	Key(L2,T2)
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	Key(L2,)
2G	Other product manufacture and use	N_2O	Key(,T2)
3A3	Swine	CH_4	Key(L2,)
3B1	Cattle	N_2O	Key(L2,)
3B1	Mature dairy cattle	N_2O	Key(L2,)
3B1	Growing cattle	N_2O	Key(L2,)
3B5	Indirect emissions	N_2O	Key(L2,T2)
3G	Liming	CO_2	Key(,T2)
5D	Wastewater treatment and discharge	N_2O	Key(,T2)

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 Approach 1 and Approach 2 key source calculations, this results in 4 additional key categories, giving an overall total of 60 key categories; see also Table A1.2.

Note that the key category analysis for the base year (now 1990 for all gases) is included in the CRF Reporter and not in this annex.

*Table A1.1: Key category list identified by the Approach 1 and 2 level and trend assessments for 2017 emissions (**excluding** LULUCF sources)*

IPCC	Source category	Gas	Key source?	Approach 1 level recent year without LULUCF	Approach 1 trend without LULUCF	Approach 2 level recent year without LULUCF	Approach 2 trend without LULUCF
1A1a	Public Electricity and Heat Production: liquids	CO2	Key(,T)	0	1	0	1
1A1a	Public Electricity and Heat Production: solids	CO2	Key(L,T)	1	1	1	1
1A1a	Public Electricity and Heat Production: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	Key(L1,T)	1	1	0	1
1A1b	Petroleum Refining: liquids	CO2	Key(L,T)	1	1	1	1
1A1b	Petroleum Refining: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A1c	Manufacture of Solid Fuels: liquids	CO2	Non key	0	0	0	0
1A1c	Manufacture of Solid Fuels: solids	CO2	Key(L1,)	1	0	0	0
1A1c	Manufacture of Solid Fuels:.gaseous	CO2	Key(,T)	0	1	0	1
1A2	Manufacturing Industries and Construction, liquids	CO2	Key(L,T)	1	1	1	1
1A2	Manufacturing Industries and Construction, solids	CO2	Key(L,T1)	1	1	1	0
1A2	Manufacturing Industries and Construction, gaseous	CO2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	Key(L1,T1)	1	1	0	0
1A4	Liquids excl. 1A4c	CO2	Key(,T)	0	1	0	1
1A4	Solids	CO2	Non key	0	0	0	0
1A4a	Commercial/Institutional:gaseous	CO2	Key(L,T1)	1	1	1	0
1A4b	Residential gaseous	CO2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO2	Key(L,T)	1	1	1	1
1A5	Military use:liquids	CO2	Non key	0	0	0	0
1A1	Energy Industries:all fuels	CH4	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	CH4	Non key	0	0	0	0

IPCC	Source category	Gas	Key source?	Approach 1 level recent year without LULUCF	Approach 1 trend without LULUCF	Approach 2 level recent year without LULUCF	Approach 2 trend without LULUCF
1A4a	Commercial/Institutional:all fuels	CH4	Non key	0	0	0	0
1A4b	Residential:all fuels	CH4	Key(L2,)	0	0	1	0
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH4	Key(L,T)	1	1	1	1
1A5	Military use:liquids	CH4	Non key	0	0	0	0
1A1	Energy Industries:all fuels	N2O	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	N2O	Non key	0	0	0	0
1A4	Other Sectors:all fuels	N2O	Non key	0	0	0	0
1A5	Military use:liquids	N2O	Non key	0	0	0	0
1A3b	Road transportation: gasoline	CO2	Key(L,T1)	1	1	1	0
1A3b	Road transportation: diesel oil	CO2	Key(L,T)	1	1	1	1
1A3b	Road transportation: LPG	CO2	Key(,T)	0	1	0	1
1A3b	Road transportation:gaseous	CO2	Non key	0	0	0	0
1A3d	Domestic navigation	CO2	Key(L1,T1)	1	1	0	0
1A3a	Domestic aviation	CO2	Non key	0	0	0	0
1A3c	Railways	CO2	Non key	0	0	0	0
1A3e	Other	CO2	Non key	0	0	0	0
1A3 exl 1A3b	Other	CH4	Non key	0	0	0	0
1A3 exl 1A3b	Other	N2O	Non key	0	0	0	0
1A3b	Road transportation	CH4	Non key	0	0	0	0
1A3b	Road transportation	N2O	Key(,T2)	0	0	0	1
1B2c	Venting and flaring	CH4	Key(,T)	0	1	0	1
1B2b	Natural gas	CH4	Non key	0	0	0	0
1B2a	Oil	CH4	Non key	0	0	0	0
1B1b	Solid fuel transformation	CO2	Non key	0	0	0	0
1B2	Fugitive emissions from oil and gas operations	CO2	Key(L,T)	1	1	1	1

IPCC	Source category	Gas	Key source?	Approach 1 level recent year without LULUCF	Approach 1 trend without LULUCF	Approach 2 level recent year without LULUCF	Approach 2 trend without LULUCF
2A1	Cement production	CO2	Non key	0	0	0	0
2A3	Glass production	CO2	Non key	0	0	0	0
2A4a	Ceramics	CO2	Non key	0	0	0	0
2A4b	Other uses of soda ash	CO2	Non key	0	0	0	0
2A4d	Other	CO2	Key(L,T)	1	1	1	1
2B1	Ammonia production	CO2	Key(L,T1)	1	1	1	0
2B2	Nitric acid production	N2O	Key(,T)	0	1	0	1
2B4	Caprolactam production	N2O	Key(L,)	1	0	1	0
2B8	Petrochemical and carbon black production	CO2	Key(L2,T2)	0	0	1	1
2B10	Other	N2O	Non key	0	0	0	0
2C1	Iron and steel production	CO2	Non key	0	0	0	0
2C3	Aluminium production	CO2	Key(,T1)	0	1	0	0
2C3	Aluminium production	PFC	Key(,T)	0	1	0	1
2G2	SF6 use	SF6	Non key	0	0	0	0
2F1	Refrigeration and airconditioning	HFC	Key(L,T)	1	1	1	1
2F6	Other	HFC	Key(,T2)	0	0	0	1
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	CO2	Key(L,)	1	0	1	0
2D1	Lubricant use	CO2	Non key	0	0	0	0
2D2	Paraffin wax use	CO2	Key(L2,T2)	0	0	1	1
2D3	Other	CO2	Non key	0	0	0	0
2G	Other product manufacture and use	CO2	Non key	0	0	0	0
2H	Other industrial	CO2	Non key	0	0	0	0
2B8	Chemical industry: Petrochemical and carbon	CH4	Key(L2,)	0	0	1	0

IPCC	Source category	Gas	Key source?	Approach 1 level recent year without LULUCF	Approach 1 trend without LULUCF	Approach 2 level recent year without LULUCF	Approach 2 trend without LULUCF
	black production						
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH4	Non key	0	0	0	0
2G	Other product manufacture and use	CH4	Non key	0	0	0	0
2G	Other product manufacture and use	N2O	Key(,T2)	0	0	0	1
2B7	Soda ash production	CO2	Non key	0	0	0	0
3A1	Mature dairy cattle	CH4	Key(L,T)	1	1	1	1
3A1	Other mature cattle	CH4	Non key	0	0	0	0
3A1	Young cattle	CH4	Key(L,T)	1	1	1	1
3A3	Swine	CH4	Key(L2,)	0	0	1	0
3A4	Other	CH4	Non key	0	0	0	0
3B	Emissions from manure management	N2O	Key(L,)	1	0	1	0
3B1	Cattle	CH4	Key(L,T)	1	1	1	1
3B1	Mature dairy cattle	CH4	Key(L,T)	1	1	1	1
3B1	Other mature cattle	CH4	Non key	0	0	0	0
3B1	Growing cattle	CH4	Non key	0	0	0	0
3B3	Swine	CH4	Key(L,T)	1	1	1	1
3B4	Poultry	CH4	Key(,T)	0	1	0	1
3B2, 3B4	Other	CH4	Non key	0	0	0	0
3B1	Cattle	N2O	Key(L2,)	0	0	1	0
3B1	Mature dairy cattle	N2O	Key(L2,)	0	0	1	0
3B1	Other mature cattle	N2O	Non key	0	0	0	0
3B1	Growing cattle	N2O	Key(L2,)	0	0	1	0
3B2	Sheep	N2O	Non key	0	0	0	0
3B3	Swine	N2O	Non key	0	0	0	0
3B4	Other livestock	N2O	Non key	0	0	0	0

IPCC	Source category	Gas	Key source?	Approach 1 level recent year without LULUCF	Approach 1 trend without LULUCF	Approach 2 level recent year without LULUCF	Approach 2 trend without LULUCF
3B5	Indirect emissions	N2O	Key(L2,T2)	0	0	1	1
3Da	Direct emissions from agricultural soils	N2O	Key(L,T)	1	1	1	1
3Db	Indirect emissions from managed soils	N2O	Key(L,T)	1	1	1	1
3G	Liming	CO2	Key(,T2)	0	0	0	1
5A	Solid waste disposal	CH4	Key(L,T)	1	1	1	1
5B	Biological treatment of solid waste: composting	CH4	Non key	0	0	0	0
5B	Biological treatment of solid waste: composting	N2O	Non key	0	0	0	0
5D	Wastewater treatment and discharge	CH4	Non key	0	0	0	0
5D	Wastewater treatment and discharge	N2O	Key(,T2)	0	0	0	1
5D	Open burning of waste	CH4	Non key	0	0	0	0
5D	Open burning of waste	N2O	Non key	0	0	0	0
			SUM	32	38	35	35

*Table A1.2 Key source list identified by the Approach 1 and Approach 2 level and trend assessments for 2017 emissions (**including** LULUCF sources)*

IPCC	Source category	Gas	Key source?	Approach 1 level recent year with LULUCF	Approach 1 trend with LULUCF	Approach 2 level recent year with LULUCF	Approach 2 trend with LULUCF
1A1a	Public Electricity and Heat Production: liquids	CO2	Key(,T)	0	1	0	1
1A1a	Public Electricity and Heat Production: solids	CO2	Key(L,T)	1	1	1	1
1A1a	Public Electricity and Heat Production: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	Key(L1,T)	1	1	0	1
1A1b	Petroleum Refining: liquids	CO2	Key(L,T)	1	1	1	1
1A1b	Petroleum Refining: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A1c	Manufacture of Solid Fuels: liquids	CO2	Non key	0	0	0	0
1A1c	Manufacture of Solid Fuels: solids	CO2	Key(L1,)	1	1	0	0
1A1c	Manufacture of Solid Fuels:.gaseous	CO2	Key(,T)	1	1	1	1
1A2	Manufacturing Industries and Construction, liquids	CO2	Key(L,T)	1	1	1	1
1A2	Manufacturing Industries and Construction, solids	CO2	Key(L,T1)	1	1	1	0
1A2	Manufacturing Industries and Construction, gaseous	CO2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	Key(L1,T1)	1	1	0	0
1A4	Liquids excl. 1A4c	CO2	Key(,T)	0	1	0	1
1A4	Solids	CO2	Non key	0	0	0	0
1A4a	Commercial/Institutional:gaseous	CO2	Key(L,T1)	1	1	1	0
1A4b	Residential gaseous	CO2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO2	Key(L,T)	1	1	1	1
1A5	Military use:liquids	CO2	Non key	0	0	0	0
1A1	Energy Industries:all fuels	CH4	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	CH4	Non key	0	0	0	0

IPCC	Source category	Gas	Key source?	Approach 1 level recent year with LULUCF	Approach 1 trend with LULUCF	Approach 2 level recent year with LULUCF	Approach 2 trend with LULUCF
1A4a	Commercial/Institutional:all fuels	CH4	Non key	0	0	0	0
1A4b	Residential:all fuels	CH4	Key(L2,)	0	0	1	0
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH4	Key(L,T)	1	1	1	1
1A5	Military use:liquids	CH4	Non key	0	0	0	0
1A1	Energy Industries:all fuels	N2O	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction:all fuels	N2O	Non key	0	0	0	0
1A4	Other Sectors:all fuels	N2O	Non key	0	0	0	0
1A5	Military use:liquids	N2O	Non key	0	0	0	0
1A3b	Road transportation: gasoline	CO2	Key(L,T1)	1	1	1	1
1A3b	Road transportation: diesel oil	CO2	Key(L,T)	1	1	1	1
1A3b	Road transportation: LPG	CO2	Key(,T)	0	1	0	1
1A3b	Road transportation:gaseous	CO2	Non key	0	0	0	0
1A3d	Domestic navigation	CO2	Key(L1,T1)	1	1	0	0
1A3a	Domestic aviation	CO2	Non key	0	0	0	0
1A3c	Railways	CO2	Non key	0	0	0	0
1A3e	Other	CO2	Non key	0	0	0	0
1A3 exl 1A3b	Other	CH4	Non key	0	0	0	0
1A3 exl 1A3b	Other	N2O	Non key	0	0	0	0
1A3b	Road transportation	CH4	Non key	0	0	0	0
1A3b	Road transportation	N2O	Key(,T2)	0	0	0	1
1B2c	Venting and flaring	CH4	Key(,T)	0	1	0	1
1B2b	Natural gas	CH4	Non key	0	0	0	0
1B2a	Oil	CH4	Non key	0	0	0	0
1B1b	Solid fuel transformation	CO2	Non key	0	0	0	0
1B2	Fugitive emissions from oil and gas operations	CO2	Key(L,T)	1	1	1	1

IPCC	Source category	Gas	Key source?	Approach 1 level recent year with LULUCF	Approach 1 trend with LULUCF	Approach 2 level recent year with LULUCF	Approach 2 trend with LULUCF
2A1	Cement production	CO2	Non key	0	0	0	0
2A3	Glass production	CO2	Non key	0	0	0	0
2A4a	Ceramics	CO2	Non key	0	0	0	0
2A4b	Other uses of soda ash	CO2	Non key	0	0	0	0
2A4d	Other	CO2	Key(L,T)	1	1	1	1
2B1	Ammonia production	CO2	Key(L,T1)	1	1	1	0
2B2	Nitric acid production	N2O	Key(,T)	0	1	0	1
2B4	Caprolactam production	N2O	Key(L,)	1	0	1	0
2B8	Petrochemical and carbon black production	CO2	Key(L2,T2)	0	0	1	1
2B10	Other	N2O	Non key	0	0	0	0
2C1	Iron and steel production	CO2	Non key	0	0	0	0
2C3	Aluminium production	CO2	Key(,T1)	0	1	0	0
2C3	Aluminium production	PFC	Key(,T)	0	1	0	1
2G2	SF6 use	SF6	Non key	0	0	0	0
2F1	Refrigeration and airconditioning	HFC	Key(L,T)	1	1	1	1
2F6	Other	HFC	Key(,T2)	0	0	0	1
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	CO2	Key(L,)	1	0	1	0
2D1	Lubricant use	CO2	Non key	0	0	0	0
2D2	Paraffin wax use	CO2	Key(L2,T2)	0	0	1	1
2D3	Other	CO2	Non key	0	0	0	0
2G	Other product manufacture and use	CO2	Non key	0	0	0	0
2H	Other industrial	CO2	Non key	0	0	0	0
2B8	Chemical industry: Petrochemical and carbon	CH4	Key(L2,)	0	0	1	0

IPCC	Source category	Gas	Key source?	Approach 1 level recent year with LULUCF	Approach 1 trend with LULUCF	Approach 2 level recent year with LULUCF	Approach 2 trend with LULUCF
	black production						
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH4	Non key	0	0	0	0
2G	Other product manufacture and use	CH4	Non key	0	0	0	0
2G	Other product manufacture and use	N2O	Key(,T2)	0	0	0	1
2B7	Soda ash production	CO2	Non key	0	0	0	0
3A1	Mature dairy cattle	CH4	Key(L,T)	1	1	1	1
3A1	Other mature cattle	CH4	Non key	0	0	0	0
3A1	Young cattle	CH4	Key(L,T)	1	1	1	1
3A3	Swine	CH4	Key(L2,)	0	0	1	0
3A4	Other	CH4	Non key	0	0	0	0
3B	Emissions from manure management	N2O	Key(L,)	1	0	1	0
3B1	Cattle	CH4	Key(L,T)	1	1	1	1
3B1	Mature dairy cattle	CH4	Key(L,T)	1	1	1	1
3B1	Other mature cattle	CH4	Non key	0	0	0	0
3B1	Growing cattle	CH4	Non key	0	0	0	0
3B3	Swine	CH4	Key(L,T)	1	1	1	1
3B4	Poultry	CH4	Key(,T)	0	1	0	1
3B2, 3B4	Other	CH4	Non key	0	0	0	0
3B1	Cattle	N2O	Key(L2,)	0	0	1	0
3B1	Mature dairy cattle	N2O	Key(L2,)	0	0	1	0
3B1	Other mature cattle	N2O	Non key	0	0	0	0
3B1	Growing cattle	N2O	Key(L2,)	0	0	0	0
3B2	Sheep	N2O	Non key	0	0	0	0
3B3	Swine	N2O	Non key	0	0	0	0
3B4	Other livestock	N2O	Non key	0	0	0	0

IPCC	Source category	Gas	Key source?	Approach 1 level recent year with LULUCF	Approach 1 trend with LULUCF	Approach 2 level recent year with LULUCF	Approach 2 trend with LULUCF
3B5	Indirect emissions	N2O	Key(L2,T2)	0	0	1	1
3Da	Direct emissions from agricultural soils	N2O	Key(L,T)	1	1	1	1
3Db	Indirect emissions from managed soils	N2O	Key(L,T)	1	1	1	1
3G	Liming	CO2	Key(,T2)	0	0	0	1
4	LULUCF: CH4	CH4	Non key	0	0	0	0
4A	Forest Land	CO2	Key(L,T)	1	1	1	1
4B	Cropland	N2O	Non key	0	0	0	0
4B	Cropland	CO2	Key(L,)	1	0	1	0
4C	Grassland	CO2	Key(L,T)	1	1	1	1
4C	Grassland	N2O	Non key	0	0	0	0
4G	Harvested wood products	CO2	Non key	0	0	0	0
4D	Wetlands	CO2	Non key	0	0	0	0
4E	Settlements	CO2	Key(L,T)	1	1	1	1
4F	Other Land	CO2	Non key	0	0	0	0
4H	Other	N2O	Non key	0	0	0	0
5A	Solid waste disposal	CH4	Key(L,T)	1	1	1	1
5B	Biological treatment of solid waste: composting	CH4	Non key	0	0	0	0
5B	Biological treatment of solid waste: composting	N2O	Non key	0	0	0	0
5D	Wastewater treatment and discharge	CH4	Non key	0	0	0	0
5D	Wastewater treatment and discharge	N2O	Key(,T2)	0	0	0	1
5D	Open burning of waste	CH4	Non key	0	0	0	0
5D	Open burning of waste	N2O	Non key	0	0	0	0
			SUM	37	42	39	39

1.2 Changes in key sources compared with previous submission

Due to the use of emissions data for 2017, the following changes in key sources have taken place in comparison with the previous NIR.

Following categories are identified as new key sources:

2C3	Aluminium production	CO_2
2F6	Other	HFC
2B10	Other	CO_2
2G	Other product manufacture and use	N_2O
3B1	Mature dairy cattle	CH_4
3B1	Cattle	N_2O
3B1	Mature dairy cattle	N_2O
3B1	Growing cattle	N_2O
3B5	Indirect emissions	N_2O
3G	Liming	CO_2
5D	Wastewater treatment and discharge	N_2O

The following key category in the previous submission is no longer key category:

5D	Wastewater treatment and discharge	CH_4

A1.3 Approach 1 key source and uncertainty assessment

In Table A1.3 the source ranking is done according to the contribution to the 2017 annual emissions total and in Tables A1.4 according to the base-year-to-2017 trend. This results in 29 level key sources and 33 trend key sources. Inclusion of LULUCF sources in the analysis adds four Approach 1 level and trend key sources (see Table A1.2).

*Table A1.3: Source ranking using IPCC Approach 1 **level** assessment for 2017 emissions, 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	29284.5	14.3%	14%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	18539.5	9.0%	23%
1A3b	Road transportation: diesel oil	CO_2	17048.3	8.3%	32%
1A4b	Residential gaseous	CO_2	16315.9	8.0%	40%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	14437.7	7.0%	47%
1A3b	Road transportation: gasoline	CO_2	12174.5	5.9%	53%
1A2	Manufacturing Industries and Construction, liquids	CO_2	9359.8	4.6%	57%
1A4a	Commercial/Institutional:gaseous	CO_2	7216.2	3.5%	61%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7215.4	3.5%	64%
1A1b	Petroleum Refining: liquids	CO_2	6612.7	3.2%	67%
3A1	Mature dairy cattle	CH_4	5624.9	2.7%	70%
1A2	Manufacturing Industries and Construction, solids	CO_2	5201.6	2.5%	73%
3Da	Direct emissions from agricultural soils	N_2O	4921.3	2.4%	75%
2B1	Ammonia production	CO_2	3941.7	1.9%	77%
4C	Grassland	CO_2	3713.7	1.8%	79%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	2972.4	1.4%	80%
5A	Solid waste disposal	CH_4	2568.6	1.3%	81%
1A1b	Petroleum Refining: gaseous	CO_2	2418.3	1.2%	83%
3B1	Cattle	CH_4	2054.1	1.0%	84%
3A1	Young cattle	CH_4	2018.0	1.0%	85%
4A	Forest Land	CO_2	1826.5	0.9%	86%
4B	Cropland	CO_2	1752.3	0.9%	86%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	1751.2	0.9%	87%
3B3	Swine	CH_4	1707.4	0.8%	88%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	1623.5	0.8%	89%
3B1	Mature dairy cattle	CH_4	1581.7	0.8%	90%
4E	Settlements	CO_2	1534.9	0.7%	90%
2F1	Refrigeration and airconditioning	HFC	1523.4	0.7%	91%
1B2	Fugitive emissions from oil and gas operations	CO_2	1045.1	0.5%	92%
1A1c	Manufacture of Solid Fuels: solids	CO_2	1030.8	0.5%	92%
1A3d	Domestic navigation	CO_2	985.8	0.5%	93%

IPCC Category		Gas	Latest year estimate (CO_2 eq.)	Level assessment	Cumulative total
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	970.3	0.5%	93%
2B4	Caprolactam production	N_2O	802.4	0.4%	94%
2A4d	Other	CO_2	789.6	0.4%	94%
3B	Emissions from manure management	N_2O	774.1	0.4%	94%
2B10	Other	CO_2	708.6	0.3%	95%
3Db	Indirect emissions from managed soils	N_2O	647.0	0.3%	95%
1A1a	Public Electricity and Heat Production: liquids	CO_2	590.7	0.3%	95%
1A4	Liquids excl. 1A4c	CO_2	573.5	0.3%	95%
3A3	Swine	CH_4	465.0	0.2%	96%
3B1	Growing cattle	CH_4	461.4	0.2%	96%
2B8	Petrochemical and carbon black production	CO_2	458.8	0.2%	96%
1A4b	Residential:all fuels	CH_4	440.1	0.2%	96%
3A4	Other	CH_4	429	0.2%	97%
3B1	Cattle	N_2O	365.7	0.2%	97%
1A3b	Road transportation: LPG	CO_2	346.1	0.2%	97%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	299.5	0.1%	97%
2B2	Nitric acid production	N_2O	299.4	0.1%	97%
2A1	Cement production	CO_2	298.0	0.1%	97%
1A1	Energy Industries:all fuels	N_2O	286.8	0.1%	98%
1B2c	Venting and flaring	CH_4	272.8	0.1%	98%
1B2b	Natural gas	CH_4	255.8	0.1%	98%
1A3b	Road transportation	N_2O	247.4	0.1%	98%
3B5	Indirect emissions	N2O	234.7	0.1%	98%
5D	Wastewater treatment and discharge	CH_4	222.8	0.1%	98%
2D2	Paraffin wax use	CO_2	208.9	0.1%	98%
3B1	Mature dairy cattle	N_2O	205.3	0.1%	98%
2F6	Other	HFC	175.1	0.1%	98%
4F	Other Land	CO_2	157.4	0.1%	98%
3B1	Growing cattle	N_2O	156.4	0.1%	99%
1A5	Military use:liquids	CO_2	148.5	0.1%	99%
4G	Harvested wood products	CO_2	133.2	0.1%	99%
2B	Fluorochemical production	HFC	127.9	0.1%	99%

IPCC Category		Gas	Latest year estimate (CO_2 eq.)	Level assessment	Cumulative total
2G2	SF6 use	SF_6	126.3804	0.1%	99%
3A1	Other mature cattle	CH_4	125.3	0.1%	99%
2A4b	Other uses of soda ash	CO_2	119.2	0.1%	99%
5B	Biological treatment of solid waste: composting	CH_4	118.3	0.1%	99%
2A4a	Ceramics	CO_2	118.1	0.1%	99%
1A1	Energy Industries:all fuels	CH_4	105.7	0.1%	99%
1A3b	Road transportation:gaseous	CO_2	98.5	0.0%	99%
1A3e	Other	CO_2	95.5	0.0%	99%
2D1	Lubricant use	CO_2	94.2	0.0%	99%
3B3	Swine	N_2O	90.2	0.0%	99%
5B	Biological treatment of solid waste: composting	N_2O	88.3	0.0%	99%
2G	Other product manufacture and use	N_2O	84.0	0.0%	99%
3B4	Other livestock	N_2O	82.0	0.0%	99%
1A3c	Railways	CO_2	81.5	0.0%	99%
2A3	Glass production	CO_2	79.7	0.0%	99%
3B4	Poultry	CH_4	76.0	0.0%	100%
5D	Wastewater treatment and discharge	N_2O	74.8	0.0%	100%
1B1b	Solid fuel transformation	CO_2	73.2	0.0%	100%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	66.0	0.0%	100%
1A3b	Road transportation	CH_4	61.2	0.0%	100%
1A4	Other Sectors:all fuels	N_2O	52.7	0.0%	100%
4B	Cropland	N_2O	47.5	0.0%	100%
3G	Liming	CO_2	46.9	0.0%	100%
1A4a	Commercial/Institutional:all fuels	CH_4	45.4	0.0%	100%
2G	Other product manufacture and use	CH_4	43.4	0.0%	100%
2E	Electronic Industry	PFC	42.6	0.0%	100%
2C3	Aluminium production	CO_2	42.5	0.0%	100%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42.3	0.0%	100%
4H	Other	N_2O	41.6	0.0%	100%
4D	Wetlands	CO_2	38.4	0.0%	100%
3B2, 3B4	Other	CH_4	38.2	0.0%	100%
1A3a	Domestic aviation	CO_2	32.2	0.0%	100%

IPCC Category		Gas	Latest year estimate (CO_2 eq.)	Level assessment	Cumulative total
2H	Other industrial	CO_2	24.0	0.0%	100%
2D3	Other	CO_2	21.4	0.0%	100%
2B	Fluorochemical production	PFC	21.4	0.0%	100%
1B2a	Oil	CH_4	14.3	0.0%	100%
2C1	Iron and steel production	CO_2	14.0	0.0%	100%
1A4	Solids	CO_2	13.3	0.0%	100%
2C3	Aluminium production	PFC	13.0	0.0%	100%
3B1	Other mature cattle	CH_4	11.1	0.0%	100%
1A3 exl 1A3b	Other	N_2O	8.3	0.0%	100%
4C	Grassland	N_2O	7.1	0.0%	100%
5D	Open burning of waste	CH_4	4.5	0.0%	100%
3B1	Other mature cattle	N_2O	4.0	0.0%	100%
1A3 exl 1A3b	Other	CH_4	3.4	0.0%	100%
5D	Open burning of waste	N_2O	2.8	0.0%	100%
1A5	Military use:liquids	N_2O	2.2	0.0%	100%
3B2	Sheep	N_2O	1.5	0.0%	100%
2B10	Other	N_2O	1.3	0.0%	100%
2G	Other product manufacture and use	CO_2	0.7	0.0%	100%
4	LULUCF: CH4	CH_4	0.3	0.0%	100%
1A5	Military use:liquids	CH_4	0.3	0.0%	100%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0.3	0.0%	100%
1A1c	Manufacture of Solid Fuels: liquids	CO_2	0.0	0.0%	100%
2B7	Soda ash production	CO_2	0.0	0.0%	100%

Lines in bold represent the key sources.

*Table A1.4: Source ranking using IPCC Approach 1 **trend** assessment for 2017 emissions compared to the base year, 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
5A	Solid waste disposal	CH_4	13679.2	2568.5	5%	12%	12%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13330.2	18539.5	4%	9%	21%
1A1a	Public Electricity and Heat Production: solids	CO_2	25862.2	29284.5	4%	8%	29%
1A3b	Road transportation: diesel oil	CO_2	13011.7	17048.3	3%	7%	36%
2B2	Nitric acid production	N_2O	6084.7	299.4	3%	6%	42%
2B	Fluorochemical production	HFC	5606.3	127.9	3%	6%	48%
1A3b	Road transportation: gasoline	CO_2	10805.2	12174.5	1%	3%	52%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601.5	2972.4	1%	3%	55%
2C3	Aluminium production	PFC	2637.7	13.0	1%	3%	58%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	19045.8	14437.7	1%	3%	61%
1A1b	Petroleum Refining: liquids	CO_2	9968.2	6612.7	1%	3%	63%
1A3b	Road transportation: LPG	CO_2	2640.1	346.1	1%	2%	66%
3Da	Direct emissions from agricultural soils	N_2O	7653.7	4921.3	1%	2%	68%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8788.1	9359.8	1%	2%	70%
2F1	Refrigeration and airconditioning	HFC	0.0	1523.4	1%	2%	72%
1A1b	Petroleum Refining: gaseous	CO_2	1042.3	2418.3	1%	2%	74%
3B3	Swine	CH_4	3368.6	1707.4	1%	2%	76%
1A4b	Residential gaseous	CO_2	19895.7	16315.9	1%	1%	77%
4C	Grassland	CO_2	5537.2	3713.7	1%	1%	79%
3A1	Mature dairy cattle	CH_4	5183.2	5624.9	1%	1%	80%
1B2c	Venting and flaring	CH_4	1501.9	272.8	1%	1%	81%
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	73.1	970.3	1%	1%	82%
3Db	Indirect emissions from managed soils	N_2O	1626.4	647.0	0%	1%	83%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7329.3	7215.4	0%	1%	84%
4E	Settlements	CO_2	910.5	1534.9	0%	1%	85%
2B1	Ammonia production	CO_2	3730.1	3941.7	0%	1%	86%
3B1	Cattle	CH_4	1607.9	2054.1	0%	1%	87%
3B1	Mature dairy cattle	CH_4	1082.8	1581.7	0%	1%	88%
1A2	Manufacturing Industries and Construction, solids	CO_2	6623.4	5201.6	0%	1%	89%

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	1184.2	1623.5	0%	1%	89%
1A4	Liquids excl. 1A4c	CO_2	1223.8	573.5	0%	1%	90%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2516.9	1751.2	0%	1%	91%
3A1	Young cattle	CH_4	2801.8	2018.0	0%	1%	91%
1A4a	Commercial/Institutional:gaseous	CO_2	7758.4	7216.2	0%	1%	92%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233.2	590.7	0%	0%	92%
2A4d	Other	CO_2	481.2	789.6	0%	0%	93%
1B2	Fugitive emissions from oil and gas operations	CO_2	774.6	1045.1	0%	0%	93%
1A3d	Domestic navigation	CO_2	743.2	985.8	0%	0%	93%
2C3	Aluminium production	CO_2	408.4	42.5	0%	0%	94%
4A	Forest Land	CO_2	1734.2	1826.5	0%	0%	94%
3B4	Poultry	CH_4	432.1	76.0	0%	0%	95%
1A1c	Manufacture of Solid Fuels: solids	CO_2	916.3	1030.8	0%	0%	95%
1A3e	Other	CO_2	342.2	95.5	0%	0%	95%
2B10	Other	CO_2	583.3	708.6	0%	0%	95%
2F6	Other	HFC	0.0	175.1	0%	0%	96%
2B8	Petrochemical and carbon black production	CO_2	335.6	458.8	0%	0%	96%
1A3b	Road transportation	N_2O	98.1	247.4	0%	0%	96%
4B	Cropland	CO_2	1816.4	1752.3	0%	0%	96%
1A1	Energy Industries:all fuels	N_2O	148.1	286.8	0%	0%	96%
2B4	Caprolactam production	N_2O	739.9	802.4	0%	0%	97%
4F	Other Land	CO_2	25.5	157.4	0%	0%	97%
1A4	Solids	CO_2	162.7	13.3	0%	0%	97%
1A5	Military use:liquids	CO_2	314.0	148.5	0%	0%	97%
2D2	Paraffin wax use	CO_2	102.9	208.9	0%	0%	97%
3G	Liming	CO_2	183.2	46.9	0%	0%	97%
1B2b	Natural gas	CH_4	421.1	255.8	0%	0%	98%
2G	Other product manufacture and use	N_2O	224.7	84.0	0%	0%	98%
1A3b	Road transportation	CH_4	193.1	61.2	0%	0%	98%
3B5	Indirect emissions	N_2O	389.6	234.7	0%	0%	98%
5B	Biological treatment of solid waste: composting	CH_4	13.7	118.3	0%	0%	98%

IPCC Category		Gas	Base Year Estimate (CO_2 eq.)	Latest Year Estimate (CO_2 eq.)	Trend Assessment	% Contribution to trend	Cumulative Total
1A3b	Road transportation:gaseous	CO_2	0.0	98.5	0%	0%	98%
5B	Biological treatment of solid waste: composting	N_2O	6.5	88.3	0%	0%	98%
5D	Wastewater treatment and discharge	N2O	172.1	74.8	0%	0%	98%
2A1	Cement production	CO_2	415.8	298.0	0%	0%	98%
3B1	Cattle	N_2O	341.8	365.7	0%	0%	99%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	269.5	299.5	0%	0%	99%
3A1	Other mature cattle	CH_4	210.2	125.3	0%	0%	99%
2A4b	Other uses of soda ash	CO_2	68.6	119.2	0%	0%	99%
2B7	Soda ash production	CO_2	63.8	0.0	0%	0%	99%
2G2	SF6 use	SF_6	206.7	126.4	0%	0%	99%
3B	Emissions from manure management	N_2O	940.4	774.1	0%	0%	99%
5D	Wastewater treatment and discharge	CH_4	308.8	222.8	0%	0%	99%
2A3	Glass production	CO_2	142.4	79.7	0%	0%	99%
4B	Cropland	N_2O	3.0	47.5	0%	0%	99%
1A1	Energy Industries:all fuels	CH_4	71.7	105.7	0%	0%	99%
1A3a	Domestic aviation	CO_2	84.8	32.2	0%	0%	99%
2H	Other industrial	CO_2	72.5	24.0	0%	0%	99%
4H	Other	N_2O	2.4	41.6	0%	0%	99%
1A4b	Residential:all fuels	CH_4	456.7	440.1	0%	0%	99%
3B1	Mature dairy cattle	N_2O	190.1	205.3	0%	0%	99%
4D	Wetlands	CO_2	87.2	38.4	0%	0%	100%
3B3	Swine	N_2O	140.2	90.2	0%	0%	100%
3B1	Growing cattle	N_2O	144.8	156.5	0%	0%	100%
3B4	Other livestock	N_2O	61.5	82.1	0%	0%	100%
2C1	Iron and steel production	CO_2	43.7	14.0	0%	0%	100%
1B1b	Solid fuel transformation	CO_2	110.4	73.2	0%	0%	100%
3A4	Other	CH_4	514.4	429.0	0%	0%	100%
2D3	Other	CO_2	0.0	21.4	0%	0%	100%
2B	Fluorochemical production	PFC	0.0	21.4	0%	0%	100%
2E	Electronic Industry	PFC	25.2	42.6	0%	0%	100%
2D1	Lubricant use	CO_2	84.6	94.2	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
3B1	Growing cattle	CH_4	502.9	461.4	0%	0%	100%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	35.9	42.3	0%	0%	100%
1A1c	Manufacture of Solid Fuels: liquids	CO_2	9.9	0.0	0%	0%	100%
1A4	Other Sectors:all fuels	N_2O	50.1	52.7	0%	0%	100%
3B2, 3B4	Other	CH_4	33.7	38.2	0%	0%	100%
3B1	Other mature cattle	CH_4	22.2	11.1	0%	0%	100%
1A4a	Commercial/Institutional:all fuels	CH_4	42.6	45.4	0%	0%	100%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	67.4	66.0	0%	0%	100%
3A3	Swine	CH_4	521.8	465.0	0%	0%	100%
4C	Grassland	N_2O	0.3	7.1	0%	0%	100%
2A4a	Ceramics	CO_2	140.1	118.1	0%	0%	100%
3B2	Sheep	N_2O	7.2	1.5	0%	0%	100%
4G	Harvested wood products	CO_2	157.2	133.2	0%	0%	100%
1B2a	Oil	CH_4	20.3	14.3	0%	0%	100%
1A5	Military use:liquids	N_2O	5.5	2.2	0%	0%	100%
1A3 exl 1A3b	Other	N_2O	6.9	8.3	0%	0%	100%
3B1	Other mature cattle	N_2O	6.9	4.0	0%	0%	100%
1A3c	Railways	CO_2	90.8	81.5	0%	0%	100%
1A3 exl 1A3b	Other	CH_4	2.5	3.4	0%	0%	100%
5D	Open burning of waste	CH_4	3.8	4.5	0%	0%	100%
5D	Open burning of waste	N_2O	2.3	2.8	0%	0%	100%
2B10	Other	N_2O	0.8	1.3	0%	0%	100%
2G	Other product manufacture and use	CH_4	50.1	43.4	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	0.3	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: CH4	CH_4	0.2	0.3	0%	0%	100%

Lines in bold represent the key sources.

A1.4 Approach 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 Approach 2 key source assessment. The results of this assessment are presented in Tables A1.5 (contribution to the 2017 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 Approach 2 **level** assessment for 2017 emissions, 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	4921.3	2%	61%	1.5%	9%	9%
1A2	Manufacturing Industries and Construction, liquids	CO_2	9359.8	5%	25%	1.1%	7%	17%
4C	Grassland	CO_2	3713.7	2%	57%	1.0%	7%	23%
3B1	Cattle	CH_4	2054.1	1%	100%	1.0%	6%	30%
1A1b	Petroleum Refining: liquids	CO_2	6612.7	3%	25%	0.8%	5%	35%
3Db	Indirect emissions from managed soils	N_2O	647.0	0%	206%	0.7%	4%	39%
1A1a	Public Electricity and Heat Production: solids	CO_2	29284.5	14%	3%	0.5%	3%	42%
3A1	Mature dairy cattle	CH_4	5624.9	3%	16%	0.4%	3%	45%
2F1	Refrigeration and airconditioning	HFC	1523.4	1%	54%	0.4%	3%	48%
1A4b	Residential gaseous	CO_2	16315.9	8%	5%	0.4%	3%	50%
3B	Emissions from manure management	N_2O	774.1	0%	100%	0.4%	2%	53%
1A4a	Commercial/Institutional:gaseous	CO_2	7216.2	4%	10%	0.4%	2%	55%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7215.4	4%	10%	0.4%	2%	57%
4B	Cropland	CO_2	1752.3	1%	41%	0.4%	2%	60%
5A	Solid waste disposal	CH_4	2568.5	1%	24%	0.3%	2%	61%
3B1	Mature dairy cattle	CH_4	1581.7	1%	38%	0.3%	2%	63%
4E	Settlements	CO_2	1534.9	1%	39%	0.3%	2%	65%
1A2	Manufacturing Industries and Construction, solids	CO_2	5201.6	3%	10%	0.3%	2%	67%
1B2	Fugitive emissions from oil and gas operations	CO_2	1045.1	1%	50%	0.3%	2%	69%
4A	Forest Land	CO_2	1826.5	1%	26%	0.2%	2%	70%
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	970.3	0%	50%	0.2%	2%	72%
1A3b	Road transportation: diesel oil	CO_2	17048.3	8%	3%	0.2%	2%	73%
3B3	Swine	CH_4	1707.4	1%	27%	0.2%	1%	75%
3A1	Young cattle	CH_4	2018.0	1%	21%	0.2%	1%	76%
2B1	Ammonia production	CO_2	3941.7	2%	10%	0.2%	1%	77%
2A4d	Other	CO_2	789.6	0%	50%	0.2%	1%	78%

IPCC Category		Gas	CO_2 eq. latest year abs	Share	Uncertainty estimate	Level * uncertainty	Share L*U	Cum. Share L*U
3B1	Cattle	N_2O	365.7	0%	100%	0.2%	1%	80%
3B1	Mature dairy cattle	N_2O	205.3	0%	178%	0.2%	1%	81%
1A3b	Road transportation: gasoline	CO_2	12174.5	6%	3%	0.2%	1%	82%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	1623.5	1%	21%	0.2%	1%	83%
2B8	Petrochemical and carbon black production	CO_2	458.8	0%	71%	0.2%	1%	84%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	14437.7	7%	2%	0.1%	1%	85%
2B4	Caprolactam production	N_2O	802.4	0%	30%	0.1%	1%	85%
1A4b	Residential:all fuels	CH_4	440.1	0%	55%	0.1%	1%	86%
3B5	Indirect emissions	N_2O	234.7	0%	100%	0.1%	1%	87%
3A3	Swine	CH_4	465.0	0%	50%	0.1%	1%	88%
2D2	Paraffin wax use	CO_2	208.9	0%	102%	0.1%	1%	88%
2B10	Other	CO_2	708.6	0%	30%	0.1%	1%	89%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	299.5	0%	71%	0.1%	1%	90%
3B1	Growing cattle	N_2O	156.5	0%	130%	0.1%	1%	90%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	2972.4	1%	7%	0.1%	1%	91%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	1751.2	1%	10%	0.1%	1%	92%
1A3b	Road transportation	N_2O	247.4	0%	70%	0.1%	1%	92%
3A4	Other	CH_4	429.0	0%	30%	0.1%	0%	93%
1B2b	Natural gas	CH_4	255.8	0%	50%	0.1%	0%	93%
1A1a	Public Electricity and Heat Production: liquids	CO_2	590.7	0%	20%	0.1%	0%	93%
1A4	Liquids excl. 1A4c	CO_2	573.5	0%	20%	0.1%	0%	94%
1A1c	Manufacture of Solid Fuels: solids	CO_2	1030.8	1%	11%	0.1%	0%	94%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	18539.5	9%	1%	0.1%	0%	94%
2F6	Other	HFC	175.1	0%	54%	0.0%	0%	95%
3B1	Growing cattle	CH_4	461.4	0%	20%	0.0%	0%	95%
3B3	Swine	N_2O	90.2	0%	100%	0.0%	0%	95%

IPCC Category		Gas	CO_2 eq. latest year abs	Share	Uncertainty estimate	Level * uncertainty	Share L*U	Cum. Share L*U
5D	Wastewater treatment and discharge	CH_4	222.8	0%	38%	0.0%	0%	95%
3B4	Other livestock	N_2O	82.1	0%	100%	0.0%	0%	96%
5D	Wastewater treatment and discharge	N_2O	74.8	0%	102%	0.0%	0%	96%
5B	Biological treatment of solid waste: composting	CH_4	118.3	0%	63%	0.0%	0%	96%
1B2c	Venting and flaring	CH_4	272.8	0%	25%	0.0%	0%	96%
4F	Other Land	CO_2	157.4	0%	43%	0.0%	0%	97%
2A4b	Other uses of soda ash	CO_2	119.2	0%	50%	0.0%	0%	97%
2G	Other product manufacture and use	N_2O	84.0	0%	71%	0.0%	0%	97%
2A4a	Ceramics	CO_2	118.1	0%	50%	0.0%	0%	97%
2D1	Lubricant use	CO_2	94.2	0%	58%	0.0%	0%	97%
1A1	Energy Industries:all fuels	N_2O	286.8	0%	19%	0.0%	0%	98%
1A3d	Domestic navigation	CO_2	985.8	0%	5%	0.0%	0%	98%
3G	Liming	CO_2	46.9	0%	100%	0.0%	0%	98%
5B	Biological treatment of solid waste: composting	N_2O	88.3	0%	50%	0.0%	0%	98%
2G2	SF6 use	SF_6	126.4	0%	34%	0.0%	0%	98%
4G	Harvested wood products	CO_2	133.2	0%	25%	0.0%	0%	98%
2A1	Cement production	CO_2	298.0	0%	11%	0.0%	0%	98%
3B4	Poultry	CH_4	76.0	0%	41%	0.0%	0%	98%
1A3b	Road transportation	CH_4	61.2	0%	50%	0.0%	0%	99%
1A5	Military use:liquids	CO_2	148.5	0%	20%	0.0%	0%	99%
2B	Fluorochemical production	HFC	127.9	0%	22%	0.0%	0%	99%
3A1	Other mature cattle	CH_4	125.3	0%	21%	0.0%	0%	99%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	42.3	0%	59%	0.0%	0%	99%
1A4	Other Sectors:all fuels	N_2O	52.7	0%	47%	0.0%	0%	99%
2B2	Nitric acid production	N_2O	299.4	0%	8%	0.0%	0%	99%
4D	Wetlands	CO_2	38.4	0%	60%	0.0%	0%	99%
1A4a	Commercial/Institutional:all fuels	CH_4	45.4	0%	49%	0.0%	0%	99%
2G	Other product manufacture and use	CH_4	43.4	0%	50%	0.0%	0%	99%

IPCC Category		Gas	CO_2 eq. latest year abs	Share	Uncertainty estimate	Level * uncertainty	Share L*U	Cum. Share L*U
2A3	Glass production	CO_2	79.7	0%	25%	0.0%	0%	99%
1A1	Energy Industries:all fuels	CH_4	105.7	0%	19%	0.0%	0%	99%
4B	Cropland	N_2O	47.5	0%	41%	0.0%	0%	99%
1A3b	Road transportation: LPG	CO_2	346.1	0%	5%	0.0%	0%	99%
5D	Open burning of waste	CH_4	4.5	0%	316%	0.0%	0%	100%
1A1b	Petroleum Refining: gaseous	CO_2	2418.3	1%	1%	0.0%	0%	100%
3B2, 3B4	Other	CH_4	38.2	0%	34%	0.0%	0%	100%
1B1b	Solid fuel transformation	CO_2	73.2	0%	15%	0.0%	0%	100%
2E	Electronic Industry	PFC	42.6	0%	25%	0.0%	0%	100%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	66.0	0%	16%	0.0%	0%	100%
4H	Other	N_2O	41.6	0%	25%	0.0%	0%	100%
1A3a	Domestic aviation	CO_2	32.2	0%	30%	0.0%	0%	100%
5D	Open burning of waste	N_2O	2.8	0%	316%	0.0%	0%	100%
1B2a	Oil	CH_4	14.3	0%	54%	0.0%	0%	100%
3B1	Other mature cattle	N_2O	4.0	0%	192%	0.0%	0%	100%
1A4	Solids	CO_2	13.3	0%	51%	0.0%	0%	100%
1A3 exl 1A3b	Other	N_2O	8.3	0%	70%	0.0%	0%	100%
2D3	Other	CO_2	21.4	0%	27%	0.0%	0%	100%
1A3b	Road transportation:gaseous	CO_2	98.5	0%	5%	0.0%	0%	100%
2B	Fluorochemical production	PFC	21.4	0%	22%	0.0%	0%	100%
1A3c	Railways	CO_2	81.5	0%	5%	0.0%	0%	100%
4C	Grassland	N_2O	7.1	0%	57%	0.0%	0%	100%
3B1	Other mature cattle	CH_4	11.1	0%	33%	0.0%	0%	100%
2C3	Aluminium production	PFC	13.0	0%	20%	0.0%	0%	100%
2C3	Aluminium production	CO_2	42.5	0%	5%	0.0%	0%	100%
1A5	Military use:liquids	N_2O	2.2	0%	82%	0.0%	0%	100%
1A3 exl	Other	CH_4	3.4	0%	50%	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								
3B2	Sheep	N_2O	1.5	0%	100%	0.0%	0%	100%
2H	Other industrial	CO_2	24.0	0%	6%	0.0%	0%	100%
2C1	Iron and steel production	CO_2	14.0	0%	6%	0.0%	0%	100%
1A3e	Other	CO_2	95.5	0%	1%	0.0%	0%	100%
2G	Other product manufacture and use	CO_2	0.7	0%	54%	0.0%	0%	100%
2B10	Other	N_2O	1.3	0%	30%	0.0%	0%	100%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0.3	0%	112%	0.0%	0%	100%
1A5	Military use:liquids	CH_4	0.3	0%	60%	0.0%	0%	100%
4	LULUCF: CH4	CH_4	0.3	0%	17%	0.0%	0%	100%
1A1c	Manufacture of Solid Fuels: liquids	CO_2	0.0	0%	11%	0.0%	0%	100%
2B7	Soda ash production	CO_2	0.0	0%	7%	0.0%	0%	100%

Lines in bold represent the key sources.

With respect to Approach 2 level key sources, and perhaps surprisingly, the Energy industries, with the highest share 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);
- 4C Grassland
- 3B1 Cattle (CH_4).

The uncertainty in these emissions is estimated at 57–100%, an order of magnitude higher than the 3% uncertainty for CO_2 from the Energy industries.

Table A1.6: Source ranking using IPCC Approach 2 ***trend*** *assessment for 2017 emissions compared to the base year, 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	13679	2569	1%	5%	24%	1%	14%	14%
3Db	Indirect emissions from managed soils	N_2O	1626	647	0%	0%	206%	1%	10%	24%
3Da	Direct emissions from agricultural soils	N_2O	7654	4921	2%	1%	61%	1%	7%	31%
2B	Fluorochemical production	HFC	5606	128	0%	3%	22%	1%	7%	38%
2F1	Refrigeration and airconditioning	HFC	0	1523	1%	1%	54%	0%	5%	43%
4C	Grassland	CO_2	5537	3714	2%	1%	57%	0%	4%	47%
3B1	Cattle	CH_4	1608	2054	1%	0%	100%	0%	4%	51%
1A1b	Petroleum Refining: liquids	CO_2	9968	6613	3%	1%	25%	0%	3%	55%
2C3	Aluminium production	PFC	2638	13	0%	1%	20%	0%	3%	58%
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	73	970	0%	1%	50%	0%	3%	60%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8788	9360	5%	1%	25%	0%	3%	63%
2B2	Nitric acid production	N_2O	6085	299	0%	3%	8%	0%	2%	65%
3B3	Swine	CH_4	3369	1707	1%	1%	27%	0%	2%	68%
4E	Settlements	CO_2	911	1535	1%	0%	39%	0%	2%	69%
1B2c	Venting and flaring	CH_4	1502	273	0%	1%	25%	0%	2%	71%
3B1	Mature dairy cattle	CH_4	1083	1582	1%	0%	38%	0%	2%	73%
1A1a	Public Electricity and Heat Production: solids	CO_2	25862	29284	14%	4%	3%	0%	1%	74%
2A4d	Other	CO_2	481	790	0%	0%	50%	0%	1%	75%
1B2	Fugitive emissions from oil and gas operations	CO_2	775	1045	1%	0%	50%	0%	1%	76%
3A1	Mature dairy cattle	CH_4	5183	5625	3%	1%	16%	0%	1%	77%
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601	2972	1%	1%	7%	0%	1%	78%
1A3b	Road transportation: diesel oil	CO_2	13012	17048	8%	3%	3%	0%	1%	79%

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
3B4	Poultry	CH_4	432	76	0%	0%	41%	0%	1%	80%
2D2	Paraffin wax use	CO_2	103	209	0%	0%	102%	0%	1%	81%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	1184	1623	1%	0%	21%	0%	1%	82%
2B8	Petrochemical and carbon black production	CO_2	336	459	0%	0%	71%	0%	1%	82%
3G	Liming	CO_2	183	47	0%	0%	100%	0%	1%	83%
1A3b	Road transportation	N_2O	98	247	0%	0%	70%	0%	1%	84%
3B5	Indirect emissions	N_2O	390	235	0%	0%	100%	0%	1%	84%
1A3b	Road transportation: LPG	CO_2	2640	346	0%	1%	5%	0%	1%	85%
1A4	Liquids excl. 1A4c	CO_2	1224	573	0%	0%	20%	0%	1%	86%
2F6	Other	HFC	0	175	0%	0%	54%	0%	1%	86%
3A1	Young cattle	CH_4	2802	2018	1%	0%	21%	0%	1%	87%
4A	Forest Land	CO_2	1734	1826	1%	0%	26%	0%	1%	87%
2G	Other product manufacture and use	N_2O	225	84	0%	0%	71%	0%	1%	88%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7329	7215	4%	0%	10%	0%	0%	88%
5D	Wastewater treatment and discharge	N_2O	172	75	0%	0%	102%	0%	0%	89%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233	591	0%	0%	20%	0%	0%	89%
1A3b	Road transportation: gasoline	CO_2	10805	12175	6%	1%	3%	0%	0%	90%
3B1	Mature dairy cattle	N_2O	190	205	0%	0%	178%	0%	0%	90%
2B1	Ammonia production	CO_2	3730	3942	2%	0%	10%	0%	0%	91%
5B	Biological treatment of solid waste: composting	CH_4	14	118	0%	0%	63%	0%	0%	91%
1A4	Solids	CO_2	163	13	0%	0%	51%	0%	0%	91%
3B1	Cattle	N_2O	342	366	0%	0%	100%	0%	0%	92%
4B	Cropland	CO_2	1816	1752	1%	0%	41%	0%	0%	92%
1A2	Manufacturing Industries and Construction, solids	CO_2	6623	5202	3%	0%	10%	0%	0%	93%

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
2B10	Other	CO_2	583	709	0%	0%	30%	0%	0%	93%
4F	Other Land	CO_2	26	157	0%	0%	43%	0%	0%	93%
1A4b	Residential gaseous	CO_2	19896	16316	8%	1%	5%	0%	0%	94%
1B2b	Natural gas	CH_4	421	256	0%	0%	50%	0%	0%	94%
1A3b	Road transportation	CH_4	193	61	0%	0%	50%	0%	0%	94%
3B	Emissions from manure management	N_2O	940	774	0%	0%	100%	0%	0%	95%
2B4	Caprolactam production	N_2O	740	802	0%	0%	30%	0%	0%	95%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	19046	14438	7%	1%	2%	0%	0%	95%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2517	1751	1%	0%	10%	0%	0%	96%
2B8	Chemical industry: Petrochemical and carbon black production	CH_4	269	300	0%	0%	71%	0%	0%	96%
5B	Biological treatment of solid waste: composting	N_2O	7	88	0%	0%	50%	0%	0%	96%
1A4a	Commercial/Institutional:gaseous	CO_2	7758	7216	4%	0%	10%	0%	0%	96%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13330	18540	9%	4%	1%	0%	0%	97%
3B1	Growing cattle	N_2O	145	156	0%	0%	130%	0%	0%	97%
3B3	Swine	N_2O	140	90	0%	0%	100%	0%	0%	97%
2A4b	Other uses of soda ash	CO_2	69	119	0%	0%	50%	0%	0%	97%
1A1	Energy Industries:all fuels	N_2O	148	287	0%	0%	19%	0%	0%	98%
3B4	Other livestock	N_2O	62	82	0%	0%	100%	0%	0%	98%
1A5	Military use:liquids	CO_2	314	148	0%	0%	20%	0%	0%	98%
1A1c	Manufacture of Solid Fuels: solids	CO_2	916	1031	1%	0%	11%	0%	0%	98%
4D	Wetlands	CO_2	87	38	0%	0%	60%	0%	0%	98%
1A4b	Residential:all fuels	CH_4	457	440	0%	0%	55%	0%	0%	98%
2G2	SF6 use	SF_6	207	126	0%	0%	34%	0%	0%	98%
4B	Cropland	N_2O	3	48	0%	0%	41%	0%	0%	99%

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
5D	Wastewater treatment and discharge	CH_4	309	223	0%	0%	38%	0%	0%	99%
1A3d	Domestic navigation	CO_2	743	986	0%	0%	5%	0%	0%	99%
2C3	Aluminium production	CO_2	408	43	0%	0%	5%	0%	0%	99%
1A3a	Domestic aviation	CO_2	85	32	0%	0%	30%	0%	0%	99%
3A1	Other mature cattle	CH_4	210	125	0%	0%	21%	0%	0%	99%
2D1	Lubricant use	CO_2	85	94	0%	0%	58%	0%	0%	99%
2A3	Glass production	CO_2	142	80	0%	0%	25%	0%	0%	99%
4H	Other	N_2O	2	42	0%	0%	25%	0%	0%	99%
1A1b	Petroleum Refining: gaseous	CO_2	1042	2418	1%	1%	1%	0%	0%	99%
1A1	Energy Industries:all fuels	CH_4	72	106	0%	0%	19%	0%	0%	99%
2A1	Cement production	CO_2	416	298	0%	0%	11%	0%	0%	99%
3A4	Other	CH_4	514	429	0%	0%	30%	0%	0%	99%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	36	42	0%	0%	59%	0%	0%	99%
2D3	Other	CO_2	0	21	0%	0%	27%	0%	0%	99%
1A3b	Road transportation:gaseous	CO_2	0	98	0%	0%	5%	0%	0%	100%
2E	Electronic Industry	PFC	25	43	0%	0%	25%	0%	0%	100%
3B2	Sheep	N_2O	7	1	0%	0%	100%	0%	0%	100%
2B	Fluorochemical production	PFC	0	21	0%	0%	22%	0%	0%	100%
3B1	Other mature cattle	N_2O	7	4	0%	0%	192%	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%
3B1	Growing cattle	CH_4	503	461	0%	0%	20%	0%	0%	100%
1A4a	Commercial/Institutional:all fuels	CH4	43	45	0%	0%	49%	0%	0%	100%
4C	Grassland	N_2O	0	7	0%	0%	57%	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
5D	Open burning of waste	CH_4	4	4	0%	0%	316%	0%	0%	100%
1B1b	Solid fuel transformation	CO_2	110	73	0%	0%	15%	0%	0%	100%
3A3	Swine	CH_4	522	465	0%	0%	50%	0%	0%	100%
3B2, 3B4	Other	CH_4	34	38	0%	0%	34%	0%	0%	100%
3B1	Other mature cattle	CH_4	22	11	0%	0%	33%	0%	0%	100%
2A4a	Ceramics	CO_2	140	118	0%	0%	50%	0%	0%	100%
5D	Open burning of waste	N_2O	2	3	0%	0%	316%	0%	0%	100%
2H	Other industrial	CO_2	72	24	0%	0%	6%	0%	0%	100%
1A5	Military use:liquids	N_2O	6	2	0%	0%	82%	0%	0%	100%
1B2a	Oil	CH_4	20	14	0%	0%	54%	0%	0%	100%
1A3 exl 1A3b	Other	N_2O	7	8	0%	0%	70%	0%	0%	100%
2C1	Iron and steel production	CO_2	44	14	0%	0%	6%	0%	0%	100%
4G	Harvested wood products	CO_2	157	133	0%	0%	25%	0%	0%	100%
1A3e	Other	CO_2	342	96	0%	0%	1%	0%	0%	100%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	67	66	0%	0%	16%	0%	0%	100%
1A1c	Manufacture of Solid Fuels: liquids	CO_2	10	0	0%	0%	11%	0%	0%	100%
1A3 exl 1A3b	Other	CH_4	3	3	0%	0%	50%	0%	0%	100%
2G	Other product manufacture and use	CO_2	0	1	0%	0%	54%	0%	0%	100%
2G	Other product manufacture and use	CH_4	50	43	0%	0%	50%	0%	0%	100%
1A5	Military use:liquids	CH_4	1	0	0%	0%	60%	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
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0	0	0%	0%	112%	0%	0%	100%
2B10	Other	N_2O	1	1	0%	0%	30%	0%	0%	100%
1A3c	Railways	CO_2	91	81	0%	0%	5%	0%	0%	100%
4	LULUCF: CH4	CH_4	0	0	0%	0%	17%	0%	0%	100%

Lines in bold represent the key sources.

Annex 2 Assessment of uncertainty

2.1 Description of methodology used for estimating uncertainty

Both an Approach 1 uncertainty assessment (based on error propagation) and an Approach 2 (Monte Carlo) uncertainty assessment were done to estimate the uncertainty in total national GHG emissions and in emissions trends as reported in this NIR 2019.

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 emissions. 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.

The uncertainty estimates for the activity data and EFs listed in Table A2.4 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 have 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 category assessment of the NIR.

An Approach 2 uncertainty assessment (Monte Carlo) is performed as a check of the Approach 1 uncertainty assessment.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 related to 2017 emissions (trend: 1990 – 2017)

	Uncertainty in emissions level	**Uncertainty in emissions trend**
CO_2	±2%	±2% of 1% increase
CH_4	±13%	±6% of 42% decrease
N_2O	±36%	±7% of 54% decrease
F-gases	±41%	±11% of 76% decrease
Total	**±3%**	**±2% of 12.6% decrease**

Table A2.2: Approach 2 level uncertainty estimates related to 2017 emissions

	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 A2.4. It should be stressed that most uncertainty estimates in Table A2.4 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 category 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 2017, as presented in Table A2.4.

Table A2.4 is ranked in the order of categories contributing most to the annual uncertainty in 2017 (based on the Approach 1 uncertainty assessment. In addition, table A2.3 ranks the ten sources contributing most to the trend uncertainty in the national total emisssions in 2017 (based on the Approach 1). Note that 5 of the categories included in table A2.3, are also among the 10 sources contributing most to the total annual uncertainty in 2017 (based on Approach 1).

Table A2.3: Ten sources contributing most to trend uncertainty in the national total in 2017 emissions (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	1.0%
3Db	Indirect emissions from managed soils	N_2O	0.7%
3Da	Direct emissions from agricultural soils	N_2O	0.6%
1A4b	Residential gaseous	CO_2	0.5%
1A4a	Commercial/Institutional:gaseous	CO_2	0.5%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	0.5%
2B	Fluorochemical production	HFC	0.4%
2F1	Refrigeration and airconditioning	HFC	0.4%
1B2	Fugitive emissions from oil and gas operations	CO_2	0.3%
3B1	Cattle	CH_4	0.3%

Table A2.4: Approach 1 level and trend uncertainty assessment 1990–2017 with the categories of the IPCC potential key source list (without adjustment for correlation sources)

IPCC category		**Gas**	**CO_2 eq. base year (Gg)**	**CO_2 eq. last year (Gg)**	**AD uncertainty**	**AD uncertainty**	**Uncertainty estimate**	**Uncertainty estimate**	**Combined Uncertainty estimate**	**Combined Uncertainty estimate**	**Contribution to variance in last year**	**Inventory trend in national emissions compared to base year**	**Uncertainty introduced into the trend in total national emissions**
					(-)	(+)	(-)	(+)	(-)	(+)		(% BY)	(-) and (+)
3Da	Direct emissions from agricultural soils	N_2O	7,653.7	4,921.3	10.0%	10.0%	60.0%	60.0%	60.8%	60.8%	0.28280	-35.7%	0.6%
1A2	Manufacturing Industries and Construction, liquids	CO_2	8,788.1	9,359.8	1.0%	1.0%	25.0%	25.0%	25.0%	25.0%	0.17307	6.5%	0.2%
3B1	Cattle	CH_4	1,607.9	2,054.1	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.13449	27.8%	0.3%
1A1b	Petroleum Refining: liquids	CO_2	9,968.2	6,612.7	5.0%	5.0%	25.0%	25.0%	25.5%	25.5%	0.08970	-33.7%	0.3%
3Db	Indirect emissions from managed soils	N_2O	1,626.4	647.0	50.0%	50.0%	200.0%	200.0%	206.2%	206.2%	0.05614	-60.2%	0.7%
1A1a	Public Electricity and Heat Production: solids	CO_2	25,862.2	29,284.5	1.0%	1.0%	3.0%	3.0%	3.2%	3.2%	0.02706	13.2%	0.2%
3A1	Mature dairy cattle	CH_4	5,183.2	5,624.9	5.0%	5.0%	15.0%	15.0%	15.8%	15.8%	0.02496	8.5%	0.2%
2F1	Refrigeration and airconditioning	HFC	0.0	1,523.4	20.0%	20.0%	50.0%	50.0%	53.9%	53.9%	0.02124	-	0.4%
1A4b	Residential gaseous	CO_2	19,895.7	16,315.9	5.0%	5.0%	0.3%	0.3%	5.0%	5.0%	0.02106	-18.0%	0.5%
3B	Emissions from manure management	N_2O	940.4	774.1	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.01910	-17.7%	0.1%
1A4a	Commercial/Institutional:gaseous	CO_2	7,758.4	7,216.2	10.0%	10.0%	0.3%	0.3%	10.0%	10.0%	0.01644	-7.0%	0.5%
1A4c	Agriculture/Forestry/Fisheries:gaseous	CO_2	7,329.3	7,215.4	10.0%	10.0%	0.3%	0.3%	10.0%	10.0%	0.01644	-1.6%	0.5%
5A	Solid waste disposal	CH_4	13,679.2	2,568.5	0.4%	0.4%	24.0%	24.0%	24.0%	24.0%	0.01200	-81.2%	1.0%
3B1	Mature dairy cattle	CH_4	1,082.8	1,581.7	2.0%	2.0%	38.0%	38.0%	38.1%	38.1%	0.01143	46.1%	0.1%
1A2	Manufacturing Industries and Construction, solids	CO_2	6,623.4	5,201.6	2.0%	2.0%	10.0%	10.0%	10.2%	10.2%	0.00888	-21.5%	0.1%
1B2	Fugitive emissions from oil and gas	CO_2	774.6	1,045.1	50.0%	50.0%	2.0%	2.0%	50.0%	50.0%	0.00863	34.9%	0.3%

IPCC category		Gas	CO_2 eq. base year (Gg)	CO_2 eq. last year (Gg)	AD uncertainty	AD uncertainty	Uncertainty estimate	Uncertainty estimate	Combined Uncertainty estimate	Combined Uncertainty estimate	Contribution to variance in last year	Inventory trend in national emissions compared to base year	Uncertainty introduced into the trend in total national emissions
	operations												
1A4c	Agriculture/Forestry/Fisheries:all fuels	CH_4	73.1	970.3	9.8%	9.8%	48.8%	48.8%	49.8%	49.8%	0.00736	1227.9%	0.2%
1A3b	Road transportation: diesel oil	CO_2	13,011.7	17,048.3	2.0%	2.0%	2.0%	2.0%	2.8%	2.8%	0.00734	31.0%	0.2%
3B3	Swine	CH_4	3,368.6	1,707.4	10.0%	10.0%	25.0%	25.0%	26.9%	26.9%	0.00667	-49.3%	0.2%
3A1	Young cattle	CH_4	2,801.8	2,018.0	5.0%	5.0%	20.0%	20.0%	20.6%	20.6%	0.00546	-28.0%	0.1%
2B1	Ammonia production	CO_2	3,730.1	3,941.7	2.0%	2.0%	10.0%	10.0%	10.2%	10.2%	0.00510	5.7%	0.1%
2A4d	Other	CO_2	481.2	789.6	50.0%	50.0%	5.0%	5.0%	50.2%	50.2%	0.00497	64.1%	0.3%
3B1	Cattle	N_2O	341.8	365.7	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.00426	7.0%	0.0%
3B1	Mature dairy cattle	N_2O	190.1	205.3	2.0%	2.0%	178.0%	178.0%	178.0%	178.0%	0.00421	8.0%	0.0%
1A3b	Road transportation: gasoline	CO_2	10,805.2	12,174.5	2.0%	2.0%	2.0%	2.0%	2.8%	2.8%	0.00374	12.7%	0.2%
2B8	Petrochemical and carbon black production	CO_2	335.6	458.8	50.0%	50.0%	50.0%	50.0%	70.7%	70.7%	0.00332	36.7%	0.2%
1A2	Manufacturing Industries and Construction, gaseous	CO_2	19,045.8	14,437.7	2.0%	2.0%	0.3%	0.3%	2.0%	2.0%	0.00267	-24.2%	0.2%
2B4	Caprolactam production	N_2O	739.9	802.4	20.0%	20.0%	23.0%	23.0%	30.5%	30.5%	0.00189	8.4%	0.1%
1A4b	Residential:all fuels	CH_4	456.7	440.1	38.4%	38.4%	39.9%	39.9%	55.4%	55.4%	0.00187	-3.6%	0.1%
3B5	Indirect emissions	N_2O	389.6	234.7	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.00176	-39.8%	0.1%
3A3	Swine	CH_4	521.8	465.0	5.0%	5.0%	50.0%	50.0%	50.2%	50.2%	0.00172	-10.9%	0.0%
2D2	Paraffin wax use	CO_2	102.9	208.9	100.0%	100.0%	20.0%	20.0%	102.0%	102.0%	0.00143	103.0%	0.1%
2B10	Other	CO_2	583.3	708.6	1.0%	1.0%	30.0%	30.0%	30.0%	30.0%	0.00143	21.5%	0.0%
2B8	Chemical industry: Petrochemical and carbon black production	CH4	269.5	299.5	50.0%	50.0%	50.0%	50.0%	70.7%	70.7%	0.00142	11.2%	0.1%
3B1	Growing cattle	N_2O	144.8	156.5	1.0%	1.0%	130.0%	130.0%	130.0%	130.0%	0.00131	8.1%	0.0%

IPCC category		Gas	CO_2 eq. base year (Gg)	CO_2 eq. last year (Gg)	AD uncertainty	AD uncertainty	Uncertainty estimate	Uncertainty estimate	Combined Uncertainty estimate	Combined Uncertainty estimate	Contribution to variance in last year	Inventory trend in national emissions compared to base year	Uncertainty introduced into the trend in total national emissions
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO_2	601.5	2,972.4	3.2%	3.2%	5.7%	5.7%	6.5%	6.5%	0.00119	394.2%	0.1%
1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2	2,516.9	1,751.2	10.0%	10.0%	0.3%	0.3%	10.0%	10.0%	0.00097	-30.4%	0.1%
1A3b	Road transportation	N_2O	98.1	247.4	2.0%	2.0%	70.0%	70.0%	70.0%	70.0%	0.00095	152.2%	0.1%
3A4	Other	CH_4	514.4	429.0	5.0%	5.0%	30.0%	30.0%	30.4%	30.4%	0.00054	-16.6%	0.0%
1B2b	Natural gas	CH_4	421.1	255.8	2.0%	2.0%	50.0%	50.0%	50.0%	50.0%	0.00052	-39.2%	0.0%
1A1a	Public Electricity and Heat Production: liquids	CO_2	233.2	590.7	0.5%	0.5%	20.0%	20.0%	20.0%	20.0%	0.00044	153.3%	0.0%
1A4	Liquids excl. 1A4c	CO_2	1,223.8	573.5	20.0%	20.0%	2.0%	2.0%	20.1%	20.1%	0.00042	-53.1%	0.1%
1A1c	Manufacture of Solid Fuels: solids	CO_2	916.3	1,030.8	2.0%	2.0%	10.7%	10.7%	10.9%	10.9%	0.00040	12.5%	0.0%
1A1a	Public Electricity and Heat Production: gaseous	CO_2	13,330.2	18,539.5	0.5%	0.5%	0.3%	0.3%	0.6%	0.6%	0.00034	39.1%	0.1%
2F6	Other	HFC	0.0	175.1	20.0%	20.0%	50.0%	50.0%	53.9%	53.9%	0.00028	-	0.0%
3B1	Growing cattle	CH_4	502.9	461.4	1.0%	1.0%	20.0%	20.0%	20.0%	20.0%	0.00027	-8.3%	0.0%
3B3	Swine	N_2O	140.2	90.2	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.00026	-35.7%	0.0%
5D	Wastewater treatment and discharge	CH_4	308.8	222.8	20.0%	20.0%	32.0%	32.0%	37.7%	37.7%	0.00022	-27.9%	0.0%
3B4	Other livestock	N_2O	61.5	82.1	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.00021	33.3%	0.0%
5D	Wastewater treatment and discharge	N_2O	172.1	74.8	20.0%	20.0%	100.0%	100.0%	102.0%	102.0%	0.00018	-56.5%	0.0%
5B	Biological treatment of solid waste: composting	CH_4	13.7	118.3	5.0%	5.0%	62.7%	62.7%	62.9%	62.9%	0.00017	764.5%	0.0%
1B2c	Venting and flaring	CH_4	1,501.9	272.8	2.0%	2.0%	25.0%	25.0%	25.1%	25.1%	0.00015	-81.8%	0.1%
2A4b	Other uses of soda ash	CO_2	68.6	119.2	50.0%	50.0%	5.0%	5.0%	50.2%	50.2%	0.00011	73.9%	0.0%
2G	Other product manufacture and use	N_2O	224.7	84.0	50.0%	50.0%	50.0%	50.0%	70.7%	70.7%	0.00011	-62.6%	0.0%

IPCC category		Gas	CO_2 eq. base year (Gg)	CO_2 eq. last year (Gg)	AD uncertainty	AD uncertainty	Uncertainty estimate	Uncertainty estimate	Combined Uncertainty estimate	Combined Uncertainty estimate	Contribution to variance in last year	Inventory trend in national emissions compared to base year	Uncertainty introduced into the trend in total national emissions
2A4a	Ceramics	CO_2	140.1	118.1	50.0%	50.0%	5.0%	5.0%	50.2%	50.2%	0.00011	-15.8%	0.0%
2D1	Lubricant use	CO_2	84.6	94.2	50.0%	50.0%	29.2%	29.2%	57.9%	57.9%	0.00009	11.4%	0.0%
1A1	Energy Industries:all fuels	N_2O	148.1	286.8	2.5%	2.5%	18.4%	18.4%	18.6%	18.6%	0.00009	93.6%	0.0%
1A3d	Domestic navigation	CO_2	743.2	985.8	5.0%	5.0%	2.0%	2.0%	5.4%	5.4%	0.00009	32.6%	0.0%
3G	Liming	CO_2	183.2	46.9	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.00007	-74.4%	0.1%
5B	Biological treatment of solid waste: composting	N_2O	7	88	5%	5%	49%	49%	50%	50%	0.00006	1253.7%	0.0%
2G2	SF6 use	SF6	206.7	126.4	30.0%	30.0%	15.0%	15.0%	33.5%	33.5%	0.00006	-38.9%	0.0%
2A1	Cement production	CO_2	415.8	298.0	5.0%	5.0%	10.0%	10.0%	11.2%	11.2%	0.00004	-28.3%	0.0%
3B4	Poultry	CH_4	432.1	76.0	10.0%	10.0%	40.0%	40.0%	41.2%	41.2%	0.00003	-82.4%	0.1%
1A3b	Road transportation	CH_4	193.1	61.2	2.0%	2.0%	50.0%	50.0%	50.0%	50.0%	0.00003	-68.3%	0.0%
1A5	Military use:liquids	CO_2	314.0	148.5	20.0%	20.0%	2.0%	2.0%	20.1%	20.1%	0.00003	-52.7%	0.0%
2B	Fluorochemical production	HFC	5,606.3	127.9	10.0%	10.0%	20.0%	20.0%	22.4%	22.4%	0.00003	-97.7%	0.4%
3A1	Other mature cattle	CH_4	210.2	125.3	5.0%	5.0%	20.0%	20.0%	20.6%	20.6%	0.00002	-40.4%	0.0%
1A2	Manufacturing Industries and Construction:all fuels	N_2O	35.9	42.3	3.3%	3.3%	58.6%	58.6%	58.7%	58.7%	0.00002	17.6%	0.0%
1A4	Other Sectors:all fuels	N_2O	50.1	52.7	17.8%	17.8%	43.1%	43.1%	46.6%	46.6%	0.00002	5.0%	0.0%
2B2	Nitric acid production	N_2O	6,084.7	299.4	5.0%	5.0%	6.0%	6.0%	7.8%	7.8%	0.00002	-95.1%	0.1%
1A4a	Commercial/Institutional:all fuels	CH_4	42.6	45.4	10.4%	10.4%	47.6%	47.6%	48.7%	48.7%	0.00002	6.5%	0.0%
2G	Other product manufacture and use	CH_4	50.1	43.4	9.9%	9.9%	49.5%	49.5%	50.5%	50.5%	0.00002	-13.3%	0.0%
2A3	Glass production	CO_2	142.4	79.7	25.0%	25.0%	5.0%	5.0%	25.5%	25.5%	0.00001	-44.0%	0.0%
1A1	Energy Industries:all fuels	CH_4	71.7	105.7	2.5%	2.5%	18.4%	18.4%	18.6%	18.6%	0.00001	47.4%	0.0%
1A3b	Road transportation: LPG	CO2	2,640.1	346.1	5.0%	5.0%	2.0%	2.0%	5.4%	5.4%	0.00001	-86.9%	0.0%

IPCC category		Gas	CO_2 eq. base year (Gg)	CO_2 eq. last year (Gg)	AD uncertainty	AD uncertainty	Uncertainty estimate	Uncertainty estimate	Combined Uncertainty estimate	Combined Uncertainty estimate	Contribution to variance in last year	Inventory trend in national emissions compared to base year	Uncertainty introduced into the trend in total national emissions
5D	Open burning of waste	CH_4	3.8	4.5	100.0%	100.0%	300.0%	300.0%	316.2%	316.2%	0.00001	18.1%	0.0%
1A1b	Petroleum Refining: gaseous	CO_2	1,042.3	2,418.3	0.5%	0.5%	0.3%	0.3%	0.6%	0.6%	0.00001	132.0%	0.0%
3B2, 3B4	Other	CH_4	33.7	38.2	10.0%	10.0%	32.0%	32.0%	33.5%	33.5%	0.00001	13.4%	0.0%
1B1b	Solid fuel transformation	CO_2	110.4	73.2	2.0%	2.0%	15.0%	15.0%	15.1%	15.1%	0.00000	-33.7%	0.0%
2E	Electronic Industry	PFC	25.2	42.6	5.0%	5.0%	25.0%	25.0%	25.5%	25.5%	0.00000	69.4%	0.0%
1A2	Manufacturing Industries and Construction:all fuels	CH_4	67.4	66.0	2.0%	2.0%	15.8%	15.8%	15.9%	15.9%	0.00000	-2.0%	0.0%
1A3a	Domestic aviation	CO_2	84.8	32.2	30.0%	30.0%	4.0%	4.0%	30.3%	30.3%	0.00000	-62.0%	0.0%
5D	Open burning of waste	N_2O	2.3	2.8	100.0%	100.0%	300.0%	300.0%	316.2%	316.2%	0.00000	20.3%	0.0%
1B2a	Oil	CH_4	20.3	14.3	20.0%	20.0%	50.0%	50.0%	53.9%	53.9%	0.00000	-29.8%	0.0%
3B1	Other mature cattle	N_2O	6.9	4.0	2.0%	2.0%	192.0%	192.0%	192.0%	192.0%	0.00000	-42.8%	0.0%
1A4	Solids	CO_2	162.7	13.3	50.0%	50.0%	10.0%	10.0%	51.0%	51.0%	0.00000	-91.8%	0.0%
1A3 exl 1A3b	Other	N_2O	6.9	8.3	2.0%	2.0%	70.0%	70.0%	70.0%	70.0%	0.00000	20.8%	0.0%
2D3	Other	CO_2	0.0	21.4	25.0%	25.0%	9.4%	9.4%	26.7%	26.7%	0.00000	-	0.0%
1A3b	Road transportation:gaseous	CO_2	0.0	98.5	5.0%	5.0%	2.0%	2.0%	5.4%	5.4%	0.00000	-	0.0%
2B	Fluorochemical production	PFC	0.0	21.4	10.0%	10.0%	20.0%	20.0%	22.4%	22.4%	0.00000	-	0.0%
1A3c	Railways	CO_2	90.8	81.5	5.0%	5.0%	2.0%	2.0%	5.4%	5.4%	0.00000	-10.2%	0.0%
3B1	Other mature cattle	CH_4	22.2	11.1	2.0%	2.0%	33.0%	33.0%	33.1%	33.1%	0.00000	-50.1%	0.0%
2C3	Aluminium production	PFC	2,637.7	13.0	2.0%	2.0%	20.0%	20.0%	20.1%	20.1%	0.00000	-99.5%	0.2%
2C3	Aluminium production	CO_2	408.4	42.5	2.0%	2.0%	5.0%	5.0%	5.4%	5.4%	0.00000	-89.6%	0.0%

IPCC category		Gas	CO_2 eq. base year (Gg)	CO_2 eq. last year (Gg)	AD uncertainty	AD uncertainty	Uncertainty estimate	Uncertainty estimate	Combined Uncertainty estimate	Combined Uncertainty estimate	Contribution to variance in last year	Inventory trend in national emissions compared to base year	Uncertainty introduced into the trend in total national emissions
1A5	Military use:liquids	N_2O	5.5	2.2	7.2%	7.2%	82.0%	82.0%	82.3%	82.3%	0.00000	-59.5%	0.0%
1A3 exl 1A3b	Other	CH_4	2.5	3.4	2.0%	2.0%	50.0%	50.0%	50.0%	50.0%	0.00000	37.3%	0.0%
3B2	Sheep	N_2O	7.2	1.5	10.0%	10.0%	100.0%	100.0%	100.5%	100.5%	0.00000	-79.3%	0.0%
2H	Other industrial	CO_2	72.5	24.0	2.8%	2.8%	5.0%	5.0%	5.7%	5.7%	0.00000	-66.9%	0.0%
2C1	Iron and steel production	CO_2	43.7	14.0	3.0%	3.0%	5.0%	5.0%	5.8%	5.8%	0.00000	-67.9%	0.0%
1A3e	Other	CO_2	342.2	95.5	0.5%	0.5%	0.3%	0.3%	0.6%	0.6%	0.00000	-72.1%	0.0%
2G	Other product manufacture and use	CO_2	0.2	0.7	50.0%	50.0%	20.0%	20.0%	53.9%	53.9%	0.00000	239.2%	0.0%
2B10	Other	N_2O	0.8	1.3	20.0%	20.0%	23.0%	23.0%	30.5%	30.5%	0.00000	58.6%	0.0%
2D2	Non-energy products from fuels and solvent use: Paraffin wax use	CH_4	0.2	0.3	100.0%	100.0%	50.0%	50.0%	111.8%	111.8%	0.00000	103.0%	0.0%
1A5	Military use:liquids	CH_4	0.8	0.3	7.6%	7.6%	59.9%	59.9%	60.4%	60.4%	0.00000	-60.2%	0.0%
1A1c	Manufacture of Solid Fuels: liquids	CO_2	9.9	0.0	2.0%	2.0%	10.7%	10.7%	10.9%	10.9%	0.00000	-100.0%	0.0%
2B7	Soda ash production	CO_2	63.8	0.0	5.0%	5.0%	5.0%	5.0%	7.1%	7.1%	0.00000	-100.0%	0.0%
1A1c	Manufacture of Solid Fuels:.gaseous	CO_2	0.0	0.0	20.0%	20.0%	5.0%	5.0%	20.6%	20.6%	0.00000	-	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 2017 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.

Please note that because of the size, the table underneath has been split up in four parts.

Energy Balance the Netherlands 2017, The table below consists of two parts (part one)

Energy balance sheet the Netherlands 2017 (PJ)	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braun-kohlenbrikets)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg	Naphtha
Energy supply																		
Total Primary Energy Supply (TPES)	1,4	125,8	256,5	1	0,4	0,8		-3				2285,5	320,3	16,5		18,3	53,5	176,6
Indigenous production												40,6	10,6	12,2		18,3		
Imports	1,4	131,7	256,1	1	3,1	0,8						4175,3	313,2	20,9			145,4	766,7
Exports					5			3				1929,4	10,1	18,4			92,9	582,1
Bunkers																		
Stock change	0	-5,9	0,4	0	2,3			0				-0,9	6,6	1,8			0,9	-8
Energy consumption																		
Net energy consumption	1,4	125,8	256,5	1	0,4	0,8		-3				2285,5	320,3	16,5		18,3	53,5	176,6
Energy transformation																		
Total energy transformation input		125,8	256,5		55,1					2,1	25,2	2285,5	230,2	16,2		30,1	44,2	444,9
Electricity and CHP transformation input			256,5							2,1	25,2					15,1		
Other transformation input		125,8			55,1							2285,5	230,2	16,2		15	44,2	444,9
Total energy transformation output					56			3		15,9	37					201,2	77,5	506,4
Electricity / CHP transformation output																		
Other transformation output					56			3		15,9	37					201,2	77,5	506,4
Total net energy transformation		125,8	256,5		-0,9			-3		-13,8	-11,8	2285,5	230,2	16,2		- 171,1	-33,3	-61,4
Net electricity / CHP transformation			256,5							2,1	25,2					15,1		
Net other		125,8			-0,9			-3		-15,9	-37	2285,5	230,2	16,2		-	-33,3	-61,4

Energy balance sheet the Netherlands 2017 (PJ)	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braun-kohlenbrikets)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg	Naphtha
transformation																186,2		
Energy sector own use																		
Total energy sector own use										5,9	1,8					74,2	2	
Extraction of crude petroleum and gas																	0	
Coke-oven plants										5,9	1,8							
Oil refineries																74,2	2	
Electricity and gas supply																		
Distribution losses																		
Distribution losses																		
Final consumption																		
Total final consumption	1,4			1	1,3	0,8				7,9	10		90,1	0,3		115,2	84,7	238
Total final energy consumption	1,3			1	1,2	0,8				7,9	10					115,2	11,4	
Total industry	1,3			1	1,2	0,7				7,9	10					115,2	0,3	
Iron and steel					0,1					7,9	10						0	
Chemical and petrochemical																115,2	0	
Non-ferrous metals																	0	
Non-metallic minerals	0			0,8	1												0	
Transport equipment																	0	
Machinery																	0,1	
Mining and quarrying				0,2													0	
Food and tobacco	1,3																0	
Paper, pulp and printing																	0	

Energy balance sheet the Netherlands 2017 (PJ)	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braun-kohlenbrikketts)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg	Naphtha
Wood and wood products																		
Construction					0,1													
Textile and leather																	0	
Non-specified						0,7											0	
Total transport																	6,8	
Domestic aviation																		
Road transport																	6,8	
Rail transport																		
Pipeline transport																		
Domestic navigation																		
Non-specified																		
Total other sectors	0					0,1											4,4	
Services, waste, water and repair						0,1											2	
Households	0					0											1	
Agriculture																	1,4	
Fishing																		
Non-specified																		
Total non-energy use	0,1				0,1								90,1	0,3			73,3	238
Industry (excluding the energy sector)	0,1				0,1								90,1	0,3			73,3	238
Of which chemistry and pharmaceuticals													90,1	0,3			73,3	238
Transport																		
Other sectors																		
Statistical difference																		
Statistical differences																		

Energy Balance the Netherlands 2017, The table below consists of two parts (part two)

Energy balance sheet the Netherlands 2017 (PJ)	**Motor gasoline**	**Gasoline type jet fuel**	**Aviation gasoline**	**Kerosene type jet fuel**	**Other kerosene**	**Heating and other gasoil**	**Fuel oil**	**White spirit and industrial spirit (SBP)**	**Lubricants**	**Bitumen**	**Paraffin waxes**	**Petroleum coke**	**Other petroleum products**	**Natural gas**	**Municipal waste; renewable fraction**	**Solid and liquid biomass**	**Biogas**	**Non-rene.municipal waste + residual heat**
Energy supply																		
Total Primary Energy Supply (TPES)	-398		-2,8	-326,8	-6,7	-565,1	-308,8	56,7	4,9	-3,9	1,8	18,9	-153,7	1294	40,4	70,1	13,4	41,6
Indigenous production														1388,5	32	131,5	13,4	34,1
Imports	455,2			157,7	16,9	724,6	658,5	96,7	77,6	19,2	6	45,3	665,3	1624,4	10,1	9,7		9
Exports	855,9		2,7	325,7	22,4	1262,6	617,6	42,4	66	23,1	3,9	26,3	788,8	1681,5	1,7	67		1,5
Bunkers				168		90	393		4,7					0,1				
Stock change	2,7		-0,1	9,2	-1,2	62,9	43,3	2,4	-2	0	-0,4	-0,1	-30,2	-37,2		-4		
Energy consumption																		
Net energy consumption	-398		-2,8	-326,8	-6,7	-556,3	-308,8	56,7	4,9	-3,9	1,8	18,9	-153,7	1299,3	40,4	70,1	13,4	41,6
Energy transformation																		
Total energy transformation input	1,3			4	9	127,1	293,8	87,7	1,7	0,2	1,4		85,6	508,5	40,4	41,8	12,5	41,6
Electricity and CHP transformation input						0,6								488,2	40,4	23,8	9,4	35,8
Other transformation input	1,3			4	9	126,5	293,8	87,7	1,7	0,2	1,4		85,6	20,4		18	3,1	5,8
Total energy transformation output	573,7		2,8	332,2	18,3	988,8	603,6	32,4	3,3	9,1	4	13,6	247,9	4,5				
Electricity/CHP transformation output																		
Other transformation output	573,7		2,8	332,2	18,3	988,8	603,6	32,4	3,3	9,1	4	13,6	247,9	4,5				
Total net energy	-		-2,8	-	-9,2	-861,7	-	55,3	-1,6	-9	-2,6	-13,6	-	504,1	40,4	41,8	12,5	41,6

Energy balance sheet the Netherlands 2017 (PJ)	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Heating and other gasoil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Municipal waste; renewable fraction	Solid and liquid biomass	Biogas	Non-rene.municipal waste + residual heat
transformation	572,4			328,2			309,8						162,3					
Net electricity/CHP transformation						0,6								488,2	40,4	23,8	9,4	35,8
Net other transformation	- 572,4		-2,8	- 328,2	-9,2	-862,3	- 309,8	55,3	-1,6	-9	-2,6	-13,6	- 162,3	15,9		18	3,1	5,8
Energy sector own use																		
Total energy sector own use						0				0		9,3		40,7				
Extraction of crude petroleum and gas						0								23,9				
Coke-oven plants																		
Oil refineries						0				0		9,3		14,9				
Electricity and gas supply														2				
Distribution losses																		
Distribution losses																		
Final consumption																		
Total final consumption	174,4		0	1,4	2,5	305,4	1	1,4	6,5	5	4,4	23,2	8,6	754,5		28,2	0,9	
Total final energy consumption	174,4		0	1,4	0,3	305,4	1						0	647,4		28,2	0,9	
Total industry					0	19,4	0,2						0	186,8		4,2	0,6	
Iron and steel						0,2								10				
Chemical and petrochemical					0	0							0	74,3				
Non-ferrous metals						0								3,1				
Non-metallic minerals						0,3	0,2							17,4				

Energy balance sheet the Netherlands 2017 (PJ)	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Heating and other gasoil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Municipal waste; renewable fraction	Solid and liquid biomass	Biogas	Non-rene.municipal waste + residual heat
Transport equipment						0,2								2,1				
Machinery					0	0,1								11,1				
Mining and quarrying						0,1								2				
Food and tobacco						0								46,5				
Paper, pulp and printing						0								7,4				
Wood and wood products														0,5				
Construction						18,5								4,3		0,2		
Textile and leather														2,6				
Non-specified						0								5,6				
Total transport	174,4		0	0,4		256,4								1,9				
Domestic aviation			0	0,4														
Road transport	174,4					242,5								1,9				
Rail transport						1,2												
Pipeline transport																		
Domestic navigation						12,7												
Non-specified																		
Total other sectors				1	0,2	29,5	0,8							458,7		24	0,4	
Services, waste, water and repair						5								126,8		1,3	0,4	
Households					0,2	0,3								288,3		19,5		
Agriculture						16,8								43,5		3,3		
Fishing						5,7	0,8											
Non-specified				1		1,7								0,1				
Total non-energy use					2,3			1,4	6,5	5	4,4	23,2	8,6	107,1				

Energy balance sheet the Netherlands 2017 (PJ)	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Heating and other gasoil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Municipal waste; renewable fraction	Solid and liquid biomass	Biogas	Non-rene.municipal waste + residual heat
Industry (excluding the energy sector)					2,2			1,4	2,2	5	4,4	23,2	8,6	107,1				
Of which chemistry and pharmaceuticals					2,2			0,7	0		3,7	23,2	8,6	107,1				
Transport									2,8									
Other sectors					0,1				1,5									
Statistical difference																		
Statistical differences						-8,8								-5,2			0,1	

Annex 5 The Netherlands' fuel list and standard CO_2 emission factors. Version January 2019

Colophon

Project name	Annual update of fuel list for the Netherlands
Project number	113569/BL2019
Version number	January 2019
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 CO2 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 2019) is approved by WEM, after detailed discussions with the Dutch Emission Authority (NEa) and several institutes that participate in the Pollutant Release and Transfer Register (NL-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).

Fuel list, version of January 2019

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2017	2018	2019	Ref [1)]	2017	2018	2019	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
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	kg	28.6	28.6	28.6	CS	89.8	89.8	89.8	CS

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2017	2018	2019	Ref [1)]	2017	2018	2019	Ref [1)]
	(used in blast furnaces)									
Overige bitumineuze steenkool [2)]	Other Bituminous Coal [2)]	Kg	25.0	25.0 [2)]	25.0 [2)]	CS	94.7	94.7	94.7	CS
Sub-bitumineuze kool	Sub-Bituminous Coal	kg	18.9	18.9	18.9	IPCC	96.1	96.1	96.1	IPCC
Bruinkool	Lignite	kg	20.0	20.0	20.0	CS	101.0	101.0	101.0	IPCC
Bitumineuze Leisteen	Oil Shale	kg	8.9	8.9	8.9	IPCC	107.0	107.0	107.0	IPCC
Turf	Peat	kg	9.76	9.76	9.76	IPCC	106.0	106.0	106.0	IPCC
	Solid Fossil, Secondary Fuels									
Steenkool- and bruinkoolbriketten	BKB & Patent Fuel	kg	20.7	20.7	20.7	IPCC	97.5	97.5	97.5	IPCC
Cokesoven/ gascokes	Coke Oven/Gas Coke	kg	28.5	28.5	28.5	CS	106.8	106.8	106.8	CS
Cokesovengas	Coke Oven gas	MJ	1.0	1.0	1.0	CS	42.8	42.8	42.8	CS
Hoogovengas	Blast Furnace Gas	MJ	1.0	1.0	1.0	CS	247.4	247.4	247.4	CS
Oxystaalovengas	Oxy Gas	MJ	1.0	1.0	1.0	CS	191.9	191.9	191.9	CS
Fosforovengas	Fosfor Gas	Nm3	11.0	11.0	11.0	CS	143.9	143.9	143.9	CS
Steenkool bitumen	Coal tar	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
	C. Gaseous Fossil Fuels									
Aardgas [3)]	Natural Gas (dry) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.6[3)]	56.6[3)]	56.6[3)]	CS
Compressed natural gas (CNG) [3)]	Compressed natural gas (CNG) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.6[3)]	56.6[3)]	56.6[3)]	CS
Liquified natural gas (LNG) [3)]	Liquified natural gas (LNG) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.6[3)]	56.6[3)]	56.6[3)]	CS
Koolmonoxide	Carbon Monoxide	Nm3	12.6	12.6	12.6	CS	155.2	155.2	155.2	CS
Methaan	Methane	Nm3	35.9	35.9	35.9	CS	54.9	54.9	54.9	CS
Waterstof	Hydrogen	Nm3	10.8	10.8	10.8	CS	0	0	0	CS
	Biomass [4)]									
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	70.7	70.7	70.7	CS
Biodiesel	Biodiesels	kg	37.0	37.0	37.0	CS	76.8	76.8	76.8	CS
Overige vloeibare biobrandstoffen	Other liquid biofuels	kg	36.0	36.0	36.0	CS	79.6	79.6	79.6	IPCC

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2017	2018	2019	Ref 1)	2017	2018	2019	Ref 1)
Biomassa gasvormig	Gas Biomass	Nm3	21.8	21.8	21.8	CS	90.8	90.8	90.8	CS
RWZI biogas	Wastewater biogas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
Stortgas	Landfill gas	Nm3	19.5	19.5	19.5	CS	100.7	100.7	100.7	CS
Industrieel fermentatiegas	Industrial organic waste gas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
	D Other fuels									
Afval 2) 5)	Waste 2) 5)	Kg	10.0	10.0 2)	10.0 2)	CS	105.4	105.4 2)	105.4 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 memo-item, using the mentioned emission factors
   b. Under the Kyoto Protocol the emission factor for biomass is always zero.
   c. Under EU ETS the emission factor for biomass is zero, with exception of liquid biomass for which additional criteria have to be met to be allowed to use an emission factor of zero.
5) The percentage biogenic in the heating value is 53%. The percentage biogenic in the emission factor is 63%.

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 2019) these values have been updated. In 2019 also the country specific emission factors of biogasoline and biodiesel have been updated (CBS, 2017b).

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 2019), the years in question are 2017, 2018 and 2019. The values in these columns are used for the following purposes:

1. **2017**: these values are used in 2019 for calculations concerning the calendar year 2017, 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 2019 (NIR 2019) gives full details of greenhouse gas emissions in the Netherlands up to and including 2017. The fuel list forms an integral part of the NIR 2019.
2. **2018**: these values are used in 2019 for reports on energy consumption and CO_2 emission for the calendar year 2018 in the Electronic Environmental Annual Report (e-MJV), in the monitoring of MJA3/LTA3 (Long Term Agreement on energy efficiency for the period 2005-2020) and the monitoring of the MEE/LEE covenant (Long Term Agreement on Energy-Efficiency for ETS Companies).
3. **2019**: these values will be used in 2020 in emission reports for the calendar year 2019 by companies participating in the EU Emission Trading Scheme (ETS) that are allowed to report the emission factor and calorific value for a given source flow in accordance with Tier 2a (country-specific values), as laid down in Art. 31-1, MRR EU No. 601/2012. The country-specific values in question may be taken from those quoted in the last-published National Inventory Report, in this case NIR 2019.

Table A5.2 CH4 and N_2O emission factors

Name (Dutch)	**Name (English)**	**Unit**	**CH_4 EF**		**N_2O EF**		**Notes**
			2017	**Ref**	**2017**	**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						

Name (Dutch)	Name (English)	Unit	CH_4 EF		N_2O EF		Notes
			2017	Ref	2017	Ref	
	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						
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	g/GJ	0,44	Scheffer 1997	1,5	IPCC 2006	

Name (Dutch)	Name (English)	Unit	CH_4 EF		N_2O EF		Notes
			2017	**Ref**	**2017**	**Ref**	
	furnaces)						
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)

Name (Dutch)	**Name (English)**	**Unit**	**CH_4 EF**		**N_2O EF**		**Notes**
			2017	**Ref**	**2017**	**Ref**	
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	
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 CH_4 and N_2O 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 CH_4 and N_2O emissions from mobile combustion.
3) This fuel is only used for mobile combustion. See 3.2.6 for more information on CH_4 and N_2O emissions from mobile combustion.
4) The CH_4 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) CH_4 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 CH_4 emission factor for natural gas; these are separately estimated to be 35 g/GJ.
6) CH_4 emission factors for wood are 30 kg/TJ for CRF categories 1A1 and 1A2 and 300 kg/TJ for CRF category 1A4.
7) The N_2O 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 CH_4 gas engines in agriculture	EF CH_4 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
2017	446.1	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 (2A4d) and CO_2 from road paving (2A4d), 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 (3A4), due to missing EFs: for this source category, no IPCC default EF is available.
- N_2O emissions from industrial wastewater treatment (5D2): 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 Statistics Netherlands 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 2019. These reports are to be considered as an integrated part of this NIR2019.

A7.1 List of methodology reports

ENINA: (Energy, IP, Waste)
Methodologies on the calculations of emissions from the sectors Energy, Industry and Waste - Update 2019
RIVM Report 2019-0018
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 - 2019
J. Klein, H. Molnár-in ‘t Veld, M. Sijstermans, G. Geilenkirchen, M. ’t Hoen, J. Hulskotte, N. Ligterink, S. Dellaert, R. de Boer

IPPU
Methods used for the Dutch Emission Inventory. Product usage by consumers, construction and services
RIVM Report 2019-0017
B.I. Jansen, J.A.J. Meesters, M.M. Nijkamp

Agriculture:
Methodology for estimating emissions from agriculture in the Netherlands - 2019
Calculations of CH_4, NH_3, N_2O, NO_x, PM10, PM2.5 and CO_2 with the National Emission Model for Agriculture (NEMA)
L.A. Lagerwerf, A. Bannink, C. van Bruggen, C. Groenestein, J. Huijsmans, J. van der Kolk, H. Luesink, S. Sluis, G. Velthof, and J. Vonk

LULUCF
Greenhouse gas reporting for the LULUCF sector in the Netherlands
Methodological background, update 2019, WOt-technical report 146
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 CO_2 is not included.
3) The GWP-100 of emissions reported as 'HFC-unspecified' and 'PFC-unspecified' differ per reported year. They are in the order of magnitude of 3,000 and 8,400, respectively.

Source: UNFCCC (2013).

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
NIC	National Inventory Compiler
NIE	National Inventory Entity
NIR	National Inventory Report (annual GHG inventory report to UNFCCC)
NL-PRTR	Netherlands'Pollutant Release and Transfer Register
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)
WenR	Wageningen Environmental Research
WecR	Waegningen Economic Research
WWTP	wastewater treatment plant

ANNEX 10 Improvements made in response to the in-country UNFCCC review of September 2017

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
General	3	G.1.	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	NIR: Annex 2
General	3	G.3.	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	NIR: Chapter 12
General	3	G.4.	Provide the calculated value of the CPR using the next annual submission.	Information included	NIR: Chapter 12
General	3	G.5.	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	NIR: Section 1.2.3.2
General	3	G.6.	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	NIR: Annex 7 and http://english.rvo.nl/nie

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
General	3	G.8.	Update the publicly available information in the national registry in accordance with the recommendations in the standard independent assessment report.	The website www.emissionsauthority.nl/topics/public-information-kyoto will be updated annually.	NIR: Section 12.1.4
General	3	G.9.	The ERT recommends that the Netherlands improve the archiving and documentation procedures in order to ensure that all necessary information used to compile the inventory is kept at the most disaggregated level in the inventory team's archiving system, together with the methods and assumptions used, and in order for the inventory team to be able to promptly retrieve the information, perform the QA/QC functions and provide the information to the ERT in a timely manner.	Archive function is fit for purpose but it is up to the individual contributing institutes to use this function or not. The current arrangements ensure fast responses to any review questions that need background information or data. See also the response to I.2 on checks and archiving of the checks of ETS information.	
General	5	G.10.	The ERT recommends that the Netherlands improve the general transparency of the NIR. If, in implementing recommendations in this report, the Netherlands finds that the size of the NIR would become impossible to handle, an option would be to use methodological reports as part of annex 3 to the NIR and officially submit these reports to the UNFCCC as addenda to the NIR with clear cross-references between the main body of the NIR and the methodological reports.	Methodology reports are now part of the official NIR submission and they will not differ from those published on the website	NIR: Annex 7 and RVO website: http://english.rvo.nl/nie as well as on the UNFCCC website: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
					parties/national-inventory-submissions-2019
General	5	G.11.	The ERT recommends that the Netherlands improve the description of the institutional arrangements in the NIR, particularly in relation to the roles of the agencies participating in the planning, preparation and management of the GHG inventory, including task force composition. The ERT also recommends that the Netherlands include more elements of the QA/QC programme in the NIR, particularly in relation to the timeline of activities integrated with the workplan timeline.	1) Additional information on the agencies participating in the Task Forces included; 2) Additional information on QA/QC programme included, including figure 1.1 QA/QC cycle (including timeline)	NIR: Section 1.2.2, Box 1 and Section 1.2.3
General	5	G.13.	The ERT concluded that, taking into account the confirmed changes in the reporting, the information provided (related to Article 3, paragraph 14, of the Kyoto Protocol) was complete. The ERT recommends that the Netherlands improve the transparency of the information in its	The Netherlands endeavour to continue the provision of complete information, to the extent possible. In this submission there are a few changes compared to the 2018 submission.	NIR: Chapter 15

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
			NIR by describing all changes that have occurred, compared with information reported in the last annual submission.		
Energy	4	E.1.	Improve the QC procedures to 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 manufacture of solid fuels and other energy industries).	Additional checks performed to improve consistency	Chapter 3
Energy	3	E.2.	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 2019	NIR: Annex 5

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Energy	3	E.3.	Include explanations in the NIR to describe the categories or sources and sinks that are reported as “NO” or “NE” and any other relevant information for all categories for which methodologies are provided in the 2006 IPCC Guidelines.	Improved text on CCS. 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: CO_2 from fugitives is not captured * CO_2 capture and storage: is not done in the Netherlands	NIR: Section 3.4
Energy	3	E.4.	Improve the QA/QC processes to ensure the use of 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.	Revision of energy statistics is fully completed and incorporated in the CRF. The recommended comparison with IEA data has been made several years ago. This recommendation will not be implemented/elaborated in this NIR 2019.	CRF: 1(A)b and 1D

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Energy	3	E.5.	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. RA is updated for better compliance with international reporting. This is documented in section 3.2.1.	NIR: Section 3.2.1
Energy	3	E.7.	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	NIR: Section 3.2.4.1
Energy	3	E.8.	Provide the reasons behind the fluctuations in the CO_2 IEF for solids throughout the time series.	Most significant trends in IEFs are elaborated	NIR: Section 3.2.4.2
Energy	3	E.10.	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	NIR: Section 3.2.4.2
Energy	3	E.11.	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.	Checking (and improving, if necessary) the time-series consistency of chemical waste gas is included in the list of planned improvements. It still needs to be decided whether this improvement will be prioritised for the NIR 2020.	NIR: Sections 3.2.4.2 and 3.2.4.4

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Energy	3	E.12.	Explain the reasons for the variation in the CH_4 IEF for gaseous fuels, including the quantities of natural gas combusted in gas engines and other appliances for the whole time series.	Most significant trends in IEFs are elaborated	NIR: Section 3.2.7.2
Energy	3	E.15.	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. Also documented in the NIR.	CRF: 1.B.2.c and 9 NIR: Section 3.3.2.1
Energy	5	E.16	The ERT recommends that the Party include the reason why emissions from liquid fuels are reported for 1990 only in the NIR.	Explanation given in NIR	NIR: Section 3.2.4.1
Energy	5	E.17.	The ERT recommends that the Party either estimate emissions or fill with notation keys all cells for reporting on manufacture of solid fuels (1.A.1.c.i).	Notation keys are now included	CRF: 1.A.1.c.i
Energy	5	E.18	The ERT recommends that the Netherlands include the explanation of the allocation (e.g. mass balance of carbon in coke ovens and blast furnaces) of the emissions from iron and steel industry in its NIR.	Improved and new text on iron and steel in the NIR and methodology report and improved CRF tables	NIR: Sections 3.2.5.1, 3.2.5.5, 4.4.2 Method. : 2.2.3.1
Energy	5	E.19	The ERT recommends that the Party apply the revised energy statistics for 1991–1994 in order to ensure time-series consistency.	Revised energy statistics for the years 1991–1994, are used since the NIR report 2018. A short explanation is included in the NIR2018, with a reference	NIR: Section 3.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
				to a complete description in the NIR2016.	
Energy	5	E.20.	The ERT recommends that the Party include in the NIR an explanation for how it apportions fuel consumption from the energy balance between international bunkers and inland navigation.	Explanation is given in the NIR	NIR: Section 3.5
Energy	5	E.21.	The ERT recommends that the Party allocate combustion emissions of CH_4 from the natural gas transport network to category 1.A.3.e.i gaseous pipeline transport.	There is not enough data available to make a consistent time series. So this recommendation cannot be followed.	
Energy	5	E.23.	The ERT recommends that the Party correct the AD reported for 2013–2015 and ensure that AD are updated annually.	AD included in CRF	CRF: 1.B.1.b
Energy	5	E.24.	The ERT recommends that the Party report emissions from gas lost by leakage under category 1.B.2.b or, if that is not possible for the annual submission in 2018, include the explanation that fugitive emissions from gas and oil exploration and production were included with fugitive emissions from venting and flaring (1.B.2.c) in the NIR and revise CRF table 9.	CRF table 9 is completed	CRF: Table 9

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Energy	5	E.25.	The ERT recommends that the Party report CO_2 emissions for the whole time series or, if that is not possible for the annual submission in 2018, change the notation keys applied to report these CO_2 emissions from "NA" to "IE" for 1990–2001 and include the explanation that CO_2 fugitive emissions from oil refining were included in category 1.A.1.b for 1990–2001.	Notation keys changed	CRF: 1.B.2.a.4
Energy	5	E.26.	The ERT recommends that the Netherlands correct the CO_2 and CH_4 emission estimates for 2015 to remove the combustion-related CO_2 and CH_4 emissions and enhance QA/QC procedures to ensure correct reporting.	Error is corrected	CRF: 1.B.2.a.4
Energy	5	E.27.	The ERT recommends that the Party report the appropriate notation keys in CRF table 1.b.2 for AD and CO_2 and CH_4 emissions, ensuring time-series consistency	All relevant notation keys on NO	CRF: 1.B.2.b.6
Energy	5	E.28.	The ERT recommends that the Party include in the NIR a section on this category, including the methodological description of venting and flaring from oil and gas, as well as the AD and EFs.	Venting and flaring are now more explicitely addressed in the NIR. The same methodology is applied as for "production and processing", that was already described in the NIR.	NIR: Section 3.3.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Energy	5	E.29.	The ERT recommends that the Party investigate the existence of CO_2 emissions from CO_2 transport, injection and storage and either estimate emissions or document that they do not occur. The ERT further recommends that the Party include a section for this category in the NIR.	This issue is now addressed in the NIR	NIR: Section 3.4
IPPU	3	I.2.	In the event that recalculations affect emission sources where the underlying data are commercially confidential, 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 on QA/QC activities and the access and use of confidential data in these activities.	NIR: Section 4.1, 4.2.4, 4.3.4
IPPU	3	I.3.	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	NIR: Section 4.2.2 CRF: 2(I).A-Hs1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	3	I.4.	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	NIR: Section 4.2.1 Method: 2.2.3.2
IPPU	3	I.5.	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 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.	Improved text in NIR and methodology report	NIR: Section 4.2.1 Method: 2.2.3.2
IPPU	3	I.7.	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	NIR: Section 4.2.2 Method: 2.2.3.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	3	I.8.	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 in order to improve accuracy and the comparability of emission estimates.	Improved text in NIR and methodology report	NIR: Section 4.3.2 Method: 2.2.3.1
IPPU	3	I.9.	Document full details of the inventory data and methodologies for all categories affected in this cross-sectoral issue.	Improved text in NIR and methodology report	NIR: Section 4.3.2 Method: 2.2.3.1
IPPU	3	I.10.	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.	Improved text in NIR and methodology report	NIR: Section 4.1 Method: 2.2.3.1
IPPU	3	I.11.	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	NIR: Section 4.3.4 Method: 2.2.3.1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	3	I.13.	Document the QA/QC activities and outcomes for the chemical and petrochemical sources in the IPPU sector.	Improved text in NIR and methodology report	NIR: Section 4.3.4 Method: 2.2.3.
IPPU	3	I.14.	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	NIR: Sections 4.1 and 4.3.4 Method: 2.2.3.5
IPPU	3	I.15.	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	NIR: Section 4.7.1 CRF: Table2(II)B-Hs2 Method: 2.2.3.9
IPPU	3	I.16.	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	NIR: Section 4.7.4 Method: 2.2.3.9
IPPU	5	I.17.	The ERT recommends that the Party correct the NIR text regarding the method for estimating emissions from cement and correct the category description by deleting methodological information regarding the use of sewage sludge.	Improved text in NIR and methodology report	NIR: Section 4.2.2 Method: 2.2.3.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	5	I.18.	The ERT recommends that the Party enhance efforts to obtain the missing primary data on limestone consumption for the two coal-fired power plants (or confirm that carbonates are not consumed in FGD) in order to check if emissions were properly calculated and have AD to show to the ERT (in accordance with paragraph 13 of the annex to decision 13/CP.20 and paragraph 16(b) of the annex to decision 19/CMP.1) in order for the ERT to assess the estimation, including replicating the calculations, in accordance with the definition of transparency in the UNFCCC Annex I inventory reporting guidelines.	Data on limestone use from all coal fired plants are obtained from the ETS reports.	NIR: Section 4.2.2
IPPU	5	I.20.	The ERT recommends that the Netherlands provide explanations in the NIR regarding the time series and assumptions behind the derivation of the N_2O EF used for estimating N_2O emissions from caprolactam for the two distinct time periods 1990–2004 and 2005 to the latest year.	Improved text in NIR and methodology report.	NIR: Section 4.3.2 Method: 2.2.3.4

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	5	I.21	The ERT recommends that the Party report the HFC-23 load in the untreated flow based on flow meter results and stream composition in its NIR or in ENINA report, and report the type of HFCs separately in the CRF tables or, if it is difficult to conduct this recommendation soon, the ERT also recommends that the Party investigate ways to present information on AD in the NIR which demonstrate the completeness of reporting until such a time when the recommendation can be implemented.	Because of the sensitivity of data from the only producer in the Netherlands, only total emissions are reported (according to the Aarhus Convention). The HFC-23 load in the untreated flow, the removal efficiency of the Thermal Converter and production data are 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).	NIR: Section 4.3.1.1 Method: 2.2.3.4

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	5	I.22	The ERT recommends that the Party report CO_2 emissions from EAF steel production under category 2.C.1.a steel and clearly explain in the NIR that CO_2 emissions from EAF steel production are reported under that category in order to avoid misunderstanding. In addition, the ERT recommends that the Party report CO_2 emissions from direct reduced iron as “NO” because there are no CO_2 emissions from iron produced using that technology in the country.	New text on iron and steel in the NIR and methodology report and improved CRF tables	NIR: Sections 3.2.5.5 and 4.2.5 CRF: 2(I).A-Hs2 Method: 2.2.3.2
IPPU	5	I.23	The ERT recommends that the Netherlands assess the carbon flow and carbon balance in each process in iron and steel industry in order to ensure the completeness and transparency of the reporting. Further, the ERT recommends that the Netherlands conduct QA/QC activities for the AD, as described in the 2006 IPCC Guidelines (volume 3, chapter 4.2.4.1), and provide a quantitative summary of QA/QC activities in order to demonstrate that the reporting is correct (e.g. QA/QC procedure for subcategories 2.C.1.d sinter and 2.C.1.e pellet (see issue ID# I.24 below) and for reporting the allocation to the	New figure and table included in the NIR and improved methodology report	CRF: 2(I).A-Hs2 Method: 2.2.3.1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	5	I.24.	The ERT recommends that the Party ensure that all emissions are reported under iron and steel making subcategories in the IPPU sector, in accordance with the 2006 IPCC Guidelines.	All process emissions are reported under iron and steel making subcategories in the IPPU sector. They are obtained from the C mass balance of Tata Steel.	NIR: Section 4.4.2
IPPU	5	I.25.	The ERT recommends that the Party ensure all relevant emissions are reported under this category and clearly explain which emissions have been allocated in the energy sector and which have been allocated in the IPPU sector under iron and steel making subcategories.	All process emissions are reported under iron and steel making subcategories in the IPPU sector(2.A.4.d, 2.C1) and the combustion and fugitive emissions under the energy sector(1.A.1.c.i, 1.A.2.a and 1.B.1.b.)	NIR: Sections 3.2.5.1 and 3.2.5.5
IPPU	5	I.26.	The ERT recommends that the Party report categories 2.F.2–2.F.5 at a minimum level of aggregation in CRF tables 2(II), 2(II)B-Hs2 and 10s5 and enhance efforts to have access to primary data (per gas amount) and directly provide the information to the ERT when requested during the review or if it is difficult to conduct this recommendation soon, investigate ways to present information on AD in the NIR that demonstrates the completeness of reporting until such a time as the recommendation can be implemented.	Cannot be resolved. Because of the sensitivity of data from 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.	Method: 2.2.3.11

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
IPPU	5	I.27.	The ERT recommends that the Party either report in the NIR the EFs used for each subcategory in order to enhance transparency, or submit the ENINA report annexed to the NIR as an official submission and revise the NIR text to make proper reference to the ENINA report, while avoiding completely duplicating text in the NIR and the ENINA report.	Improved text in NIR and methodology report. The Enina methodology report (Peek, 2019) is submitted as an integrated part of the NL submission since 2018	NIR: Section 4.3.2 and 4.7.2 Method: 2.2.3.1 and 2.2.3.9
Agriculture	4	A.1.	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	NIR: Section 5.3.1 CRF: Table 3.B(a)s2
Agriculture	3	A.3.	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	NIR: Section 5.3 CRF: Tables 3.B(a)s1 and 3.B(a)s2 Method: 4
Agriculture	3	A.4.	Include in the NIR an explanation of the different trends in CH_4 emissions and changes in the swine population.	Considered along with A.3. detailing the relation between swine population and relevant parameters.	NIR: Section 5.3
Agriculture	3	A.5.	Include numeric data on the annual removal of agricultural crop residues in the NIR.	Removal of agricultural crop residues has been included in the methodology report	Method: The numeric data on the removal on annual if agricultural crop residues can be found in van Bruggen et al. 2017 in

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
					table 3.4 page number 44
Agriculture	4	A.6.	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 yearly update in Dutch is published, van Bruggen (2017) being the most recent. FracGRAZ is no longer part of the CRF.	Method: Country specific method that is used to calculate the N-excretion is described in CBS (2012; https://www.cbs.nl/nl-nl/publicatie/2012/29/standardised-calculation-methods-for-animal-manure-and-nutrients) with yearly updated from van Bruggen (2017; https://www.cbs.nl/nl-nl/publicatie/2017/33/dierlijke-mest-en- mineralen-2016 and 2018; https://www.cbs.nl/nl-nl/publicatie/2018/37/dierlijke-mest-en-mineralen-2017) . The manure of calculating the emissions based using the data described in van Bruggen (2017;2018). The method is elaborated in the methodology report

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
					chapter 10 (Lagerwerf et al., 2019)
Agriculture	5	A.7	Include a section in the NIR with the information on the methodology used for the estimation of CO_2 emissions from urea application under the agriculture sector, allocation of emissions in accordance with the 2006 IPCC Guidelines and link with the reporting of emissions from ammonia production under the IPPU sector.	Updated text in NIR2019	NIR: Section 5.1 and 5.4.2
Agriculture	5	A.8.	The ERT recommends that the Party collect livestock data and estimate emissions associated with mules and asses for the period 1990–2009, or, alternatively, use an extrapolation technique to ensure time-series consistency. In a comment on the draft review report, the Netherlands stated that the underestimation for the years 1990–2009 might be below the level of insignificance defined in decision 24/CP.19, annex I, paragraph 37(b).	Notation key changed and improved text in NIR. It is assumed that these animals were included into the animal category of horses before the category for mules and asses was included into the agricultural census in the Netherlands. Therefore is the NO now changed into IE.	NIR: Section 5.1 CRF: 3.A Method: 3
Agriculture	5	A.9.	The ERT recommends that the Party include in the NIR complete descriptions of the AD and EF trends and emission estimates for other mature cattle.	Updated in the text in the NIR 2019.	NIR: Section 5.2.1 and 5.2.2
Agriculture	5	A.11.	The ERT recommends the Party, in order to improve the transparency of the inventory, include the data in the CRF tables distinctly for rabbits and mink as part of the inventory submission.	Updated in the CRF of 2019.	CRF: 3.B

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Agriculture	5	A.12.	The ERT recommends that the Netherlands explain in the NIR the implementation of national policies and how this results in the non-occurrence of indirect N_2O emissions due to N leaching and run-off.	Updated in the text in the NIR 2019.	Method: 7.2
Agriculture	5	A.13.	The ERT recommends that the Netherlands include in the NIR the explanation that Article 10.2 of the Netherlands Environmental Law prohibits field burning of agriculture residues.	Updated in the text in the NIR 2019.	NIR: Section 5.1
LULUCF	4	L.1.	Obtain the data and report the estimates for all mandatory categories CSC (currently reported as 'NE') for which methodologies and EFs are available: (a) CSC in living biomass (gains and losses) under cropland remaining cropland; (b) CSC in DOM under land converted to cropland, except for forest land converted to cropland; (c) CSC in living biomass (losses) under wetlands, settlements and other land converted to cropland; (d) CSC in DOM under cropland, wetlands, settlements and other land converted to grassland; (e) CSC in living biomass (losses) under wetlands, settlements and other land converted to grassland; (f) CSC in living biomass (gains) under land converted to other wetlands; (g) CSC in living biomass (gains) under land converted to settlements;	In the NIR 2018 these points were already addressed by providing more complete information on the significance of the different pools in NIR sections 6.5.1 (Cropland), 6.6.1 (Grassland), 6.7.1 (Wetland), 6.8.1 (Settlements) and 6.9.1. (Other land). In the NIR 2019 the Netherlands added some further explanations and justification of the significant pools. Additionally in the NIR2019 the Netherlands adjusted Table 6.1 in the NIR (which was the same as Table 1.1 in Arets et al., 2017), which now shows all pools per	NIR Table 6.1, and: (a) See 6.5.1 (b) Since only FL is considered to have significant amounts of DOM, only CSC in DOM for FL converted to CL are included. See 6.5.1, 6.6.1, 6.7.1, 6.8.1 and 6.9.1 for reasoning of not estimating DOM in the other categories. (c) now reported as 'not occuring' (NO), see 6.7.1, 6.8.1 and 6.9.1 (d) see (b) (e) now reported as 'not occuring' (NO), see 6.7.1, 6.8.1 and 6.9.1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
			(h) CSC in living biomass (losses) under wetlands and other land converted to settlements; (i) CSC in living biomass (gains) under land converted to other land; (j) CSC in DOM under land converted to settlements, except for forest land converted to settlements; (k) CSC in DOM under cropland, grassland, wetlands and settlements converted to other land.	category, marking which ones are significant and indicating which tier has been used, as suggested by the ERT (2017).	(f) now reported as ‘not occuring’ (NO), see 6.7.1 (g) see 6.8.1 (h) now reported as ‘not occuring’ (NO), see 6.7.1 and 6.9.1 (i) now reported as ‘not occuring’ (NO), see 6.9.1 (j) and (k) see (b)
LULUCF	3	L.2.	Correct the notation key “NE” to “NO” for those pools in which the Party considers no CSC occurs, provide estimates for those pools and categories for which it believes zero carbon change does not apply, or provide the justification for reporting “NE” for the pools in which the amount of CSC is insignificant in line with paragraph 37 of the UNFCCC Annex I inventory reporting guidelines.	The Other land category is used to report areas of bare soil that are not included in any other category, including coastal dunes and beaches with little or no vegetation, inland dunes and shifting sands. Therefore no significant gains in carbon stocks in living biomass are to be expected. Therefore from the NIR 2019 onwards these gains are reported as not occurring ‘NO’. See L.1 for reasoning of notation key NE	NIR: Sections 6.5.1, 6.6.1, 6.7.1, 6.8.1, 6.9.1 NIR tabel 6.1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
LULUCF	3	L.3.	Transparently report in the NIR which pools of key categories are significant, and obtain the data and report the estimates of emissions and removals for those significant pools under the key categories, using higher-tier methodologies.	Table 6.1 in the NIR (which was the same as Table 1.1 in Arets et al., 2017), which now showing all pools per category, marking which ones are significant and indicating which tier has been used, as suggested by the ERT (2017).	NIR: Sections 6.5.1, 6.6.1, 6.7.1, 6.8.1, 6.9.1 NIR table 6.1
LULUCF	3	L.4.	Calibrate the 2013 and 2014 values, and take historical trends into account, to ensure the accuracy and time-series consistency in the estimates of removals.	This issues was addressed in the NIR 2018. Instead of using the EFISCEN model to estimate development of deadwood from the last national Forest Inventory (NFI6, 2013) census onwards, now the trend between the last two NFI's was extrapolated. In 2021 the data from the 7th National Forest Inventory will become available. The extrapolated data on CSC in deadwood then will be replaced by the actually observed CSC in deadwood, leading to a recalculation for the period from 2013 onwards.	Instead of using the EFISCEN model to estimate development of deadwood from the last national Forest Inventory (NFI6, 2013) census onwards, now the trend between the last two NFI's was extrapolated Method: 4.2.1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
LULUCF	3	L.5.	Periodically update the carbon stock changes on land areas involving forest land as and when the new information from the next NFI becomes available.	Since the NIR 2018 section 6.4.6 contains an explicit reference to the 7th NFI and that the results from this NFI will be used to replace the currently projected CSC in land areas involving forest land.	NIR: Section 6.4.6
LULUCF	3	L.6.	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.	The Netherlands has improved the test in the NIR2018 and following and in the LULUCF methodology background report (now Arets et al., 2019). Moreover the methodology for assessing and using national wood harvest statistics has been changed (see Arets et al., 2019)	NIR section: 6.4 Method: 4.2.1
LULUCF	3	L.8.	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.	The double counting of nature grassland, resulting in reporting different areas for cultivated organic soils in category 3.D.6 cultivation of organic soils and in CRF table 4.C has been corrected since the NIR 2018	CRF: 3.D.6
LULUCF	4	L.9.	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.	Since the NIR 2018 perennial fruit orchards and Trees outside forests have been included explicitly under Grassland.	NIR: Section 6.6.1 Method: 6.1 and 6.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
LULUCF	3	L.10.	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.	We have addressed this issue and now explicitly explain this issue. In the bookkeeping model It was not possible to correct this allocation issue without introducing new allocation errors, or abandoning the differences between nature grassland and other grassland which would have consequences for total carbon stock changes. Because it concerns a small allocation error, but does not affect the total net carbon stock changes reported, it was considered the best solution to keep it this way.	NIR: Section 6.6.1 CRF: 4.C
LULUCF	3	L.11.	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.	Notation keys for fertilizer use in Settlements have been changed to IE in CRF Table 4.(I).	NIR: 6.8.2. CRF: 4.I

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
LULUCF	5	L.12.	The ERT recommends that the Party add to the NIR the explanation of the lack of AD for before 1990 and extend the description by adding graphs showing the problem of the extrapolation of the AD back from 1990. The ERT also recommends that the Party make further efforts or explore alternative ways to derive appropriate data (e.g. through extrapolation based on surrogate data).	Lack of spatially explicit activity data before 1990 has been explained in the NIR Chapter 6.3. In the same chapter also observed trends in land use and land use changes are described and explained (since NIR 2018).	NIR: 6.3.
LULUCF	5	L.13.	The ERT recommends that the Party provide an explanation on the increase in total land-use change in 2009–2013, including in the NIR an explanation about the inter-survey period of the AD and the rotation frequency, and provide a qualitative description referring to relevant policies (e.g. Natura 2000 or the European Union Common Agricultural Policy) with respect to annual land-use change in total, from non-forest land to forest land and from forest land to non-forest land and rotations between grassland and cropland. The ERT also recommends that the Party use the same format for the land-use change matrices as in CRF table 4.1 and CRF table NIR-2 in order to avoid confusion in future annual submissions.	Also in Chapter 6.3 the observed trends in land use and land use changes are described and explained (since NIR 2018). The format of the Tables 6.3 to 6.5 has been changed to better match the format of CRF Table 4.1 and CRF Table NIR-2 (since NIR 2018).	NIR: 6.3 CRF: 4.I and NIR-2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
LULUCF	5	L.15.	The ERT recommends that the Netherlands correct and extend the description of the calculation steps for CSC in living biomass and provide additional information on the primary data sets used (e.g. tables or graphs containing gains and losses of biomass for the whole time series). Further the ERT encourages the Party to add a qualitative description or an interpretation of the values shown in table 4.2 of Arets et al. (2017), more specifically explaining the temporal development of growing stock, net annual increment and carbon stock in deadwood and the policies related to those processes.	The description in section 4.2 of the methodology background report (now Arets et al., 2019) has been improved. Explanation of the use of the biomass expansion factors has been improved. Graphs of the temporal development of average carbon stock and carbon stock changes in biomass based on the NFI data have been included.	Method: 4.2
LULUCF	5	L.16.	The ERT recommends that the Party estimate CSC in orchards according to methods provided in the 2006 IPCC Guidelines and provide information in the NIR on the method applied.	Carbon stock changes in orchards have been included since the NIR 2018. Information on the method are provided in the NIR and in the LULUCF methodology background report (now Arets et al., 2019) See also L9.	NIR: 6.6.1 and 6.6.2. Method: 6
LULUCF	5	L.17.	The ERT welcomes the information provided during the review and recommends that the Party include an explanation of the inter-annual changes in the IEF for mineral soils in cropland converted to grassland in the NIR.	Inter annual changes in IEF for mineral soils are now explained in Chapter 6.6.3 of the NIR.	NIR: 6.6.3

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
LULUCF	5	L.18.	The ERT recommends that the Party provide estimates of the areas of forest land on organic soils where drainage might still be occurring, report the associated CO_2 and N_2O emissions in the CRF tables using IPCC default or country-specific EFs and describe the applied methodology and IEF transparently in the NIR.	In the NIR 2019 the area of forest on organic soils where old drainage may still be active is estimated and emissions from organic soils for those areas is calculated using the emission factors for organic soils. The approach is indicated in the NIR and described in more detail in the LULUCF methodological background document.	NIR: 6.1 Method: 11.3
LULUCF	5	L.19.	The ERT agrees with this explanation and recommends that the Party include the methodological description in the NIR, providing information on how the NFI covers forest fires, showing how this is marginally reflected in the calculation of the available fuel and explaining the unlikeliness of double counting.	Explanation is included in the NIR	NIR: 6.4.2.1
Waste	4	W.1.	Include important AD, such as the amount and composition of disposed waste, in the NIR.	Requested data included in NIR	NIR: Section 7.2.2 Table 7.3
Waste	3	W.2.	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	NIR: Section 7.2.2
Waste	3	W.3.	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	CRF: 5.A.1.b

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Waste	3	W.5	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	NIR: Sections 7.2.2 and 7.2.5
Waste	4	W.6.	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	NIR: Section 7.3.2, Table 7.5
Waste	3	W.7.	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	NIR: Section 7.3.2
Waste	3	W.9.	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	NIR: Section 7.5.2 Method: 2.3.2.4.6
Waste	4	W.10.	Provide a numerical estimate of the recovered methane in anaerobic industrial wastewater treatment plants.	Partly resolved, text in NIR, some data in Table 7.8. Data for 2017 on recovered methane are constructed. In statistics no distinction is made in the type of substrate or	NIR:Section 7.5.2 Table 7.8 CRF: NA replaced by IE

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
				type of installation. This is why biogas recovery at anaerobic IWWTPs cannot be quantified separately.	
Waste	5	W.11.	The ERT recommends that the Party report in the NIR that CH_4 emissions from semi-aerobic landfills are included with the emissions from managed solid waste disposal sites to clarify the use of the notation key “IE”.	Explanation included as node comment in CRF	CRF: 5.A.1.b
Waste	5	W.12.	The ERT recommends that the Netherlands provide in the NIR information describing the types, composition and amount of waste landfilled and how the AD for the time series 1945–2015 were compiled.	Explanation now provided	NIR: Section 7.2.2
Waste	5	W.13.	The ERT recommends that the Party include in the NIR the data used for the estimation of emissions only (e.g. exclude the waste generation rate reported in NIR table 7.3), together with a detailed explanation.	Table 7.4 (was table 7.3) has been adjusted. Only relevant components are shown.	NIR: Section 7.2.2
Waste	5	W.14.	The ERT recommends that the Netherlands include in the NIR data on waste composition and the method applied to derive the DOC values.	Explanation now provided	NIR: Section 7.2.2 under 'Fraction of degradable organic carbon' and table 7.3

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
Waste	5	W.15.	The ERT recommends that the Netherlands report in the NIR the reasons for the decrease in DOC values throughout the time series, in particular between 2000 and 2001, and explain the low values reported for the period 2000–2015.	Explanation now provided	NIR: Section 7.2.2 under 'Fraction of degradable organic carbon' and table 7.3
Waste	5	W.16.	The ERT recommends that the Netherlands apply: (a) The country-specific value for k (0.0693) for the period 1990–2004; (b) The IPCC default value (0.05) for k for 2005 onward until new country-specific data are available. Furthermore, the ERT recommends that the Netherlands explain in the NIR the use of the k values throughout the time series.	The recommendations of the ERT are applied in the national model	NIR: Section 7.2.2 under 'k-value'
Waste	5	W.17.	The ERT recommends that the Party derive country-specific DOCf values for the period 2001 onward in order to ensure time-series consistency and, until the studies for obtaining these country-specific DOCf values are concluded, the ERT recommends that the Netherlands apply:	The recommendations of the ERT are applied in the national model	NIR: Section 7.2.2 under 'Degradable organic carbon that decomposes (DOCf)'

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
			(a) The country-specific value for DOCf (0.58) for the period 1990–2004; (b) The IPCC default value (0.5) for DOCf only for 2005 onwards. Furthermore, the ERT recommends that the Netherlands explain in the NIR the use of the DOCf values throughout the time series.		
Waste	5	W.18.	The ERT recommends that the Party derive country-specific fraction of CH_4 in generated landfill gas values for the period 2001 onwards in order to ensure time-series consistency and, until the studies for obtaining these country-specific values are concluded, the ERT recommends that the Netherlands apply: (a) the country-specific value (57.4 per cent) for the period 1990–2004; (b) the IPCC default value (50 per cent) for 2005 onwards. Furthermore, the ERT recommends that the Party explain in the NIR the use of the fraction of CH_4 in generated landfill gas value throughout the time series from 1990.	The recommendations of the ERT are applied in the national model	NIR: Section 7.2.2 under 'Fraction of methane generated in landfill gas'
Waste	5	W.19.	The ERT recommends that the Party include in the NIR detailed data on DOC for domestic and industrial wastewater and sludge and describe how the data were derived (see table 7.5, p.223, of the NIR).	Resolved: Data added in table 7.8 in chapter 7.5. Explanation provided in Section 7.5.2	NIR: Table 7.8 and text in section 7.5.2
KP	3	KL.4.	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.	Justification of the high value of carbon stock change per area of litter pool for the area of deforestation is included in the NIR (since NIR 2018) and the	NIR: Sections 6.4.2 and 11.3.1.1 Method: 4.2.3

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
				methodology background report (Arets et al, 2019)	
KP	3	KL.5.	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).	When conducting the Technical Correction, the recommendations made in the report of the technical assessment of the FMRL submitted by the Netherlands will be addressed and historical emissions from natural disturbance will be considered. A technical correction of the FMRL is foreseen for the NIR 2020.	
KP	3	KL.6.	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.	The description of HWP in the NIR has been extended and improved, and now explicitly addresses the issues of inherited emissions, emissions accounted for in the first commitment period and exclusion of imported HWP (since NIR 2018, with some additional improvements in the description in the NIR 2019) .	NIR: Sections 6.10.2 and 11.4.5 Method: 10.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
KP	3	KL.7.	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.	Reasons for the exclusion of direct and indirect N_2O emissions from N fertilization from the KP- LULUCF reporting have been included in the NIR (since NIR 2018).	NIR: Section 11.3.1.2
KP	5	KL.8.	The ERT recommends that the Party extend the information provided in the NIR such that the calculation process for the background level and margin to exclude natural disturbances is documented transparently showing that the calculation is based on area-specific emissions and that the background value and margin for both afforestation and FM were provided separately (not summed).	The requested explanation and differentiation between background level and margin have been included in the NIR	NIR: Section 11.4.4
KP	5	KL.9.	The ERT recommends that the Party ensure consistency between the values provided in the CRF tables and in the NIR and correct errors where needed. The ERT also recommends that the Party correct the use of the notation keys and use them consistently throughout the NIR (i.e. use “NR” (“not reported”) for pools where the tier 1 ‘not a source principle’ applies and for which a justification has be given in the NIR).	Consistency now has been ensured by correcting and improving Table 11.3 and accompanying text in the NIR.	NIR: Section 11.3.1.1

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
KP	5	KL.10.	The ERT recommends that the Party improve the description in the NIR of the applied methodology and IEF, differentiating between afforestation of forest younger than 20 years and afforestation of forest older than 20 years for litter and deadwood. Similarly, the ERT recommends that the Party transparently reported in the NIR the estimation method applied and the IEF for living biomass for afforestation of forest younger and older than the applied conversion time of 30 years.	Description on the calculation of carbon stock changes in AR land has been improved in the NIR.	NIR: Section 11.3.1.1
KP	5	KL.11.	The ERT recommends that the Party include in the NIR the definition of the category other and the provided justification for the applied half-life.	An explanation for the category other roundwood and a justification for the applied half-life value have been included in the NIR (since 2018) and in the LULUCF methodology background document (Arets et al, 2019).	NIR: 6.10.2 and 11.4.5 Method: 10.2

Sector	ARR 2017	No	Recommendation ERT	NLD Response	Paragraph or table number in: NIR, CRF and or Methodology report
KP	5	KL.13.	The ERT welcomes the justification provided for both carbon pools and recommends that the Party include reference documents in the NIR (in section 11.3.1.2) in order to demonstrate that for litter and mineral soils in Dutch forests the 'not a source' approach can be applied. The ERT encourages the Party to periodically update the internal document (Mol et al., 2011) with regard to the screening of the applied reporting methods of other countries and especially with regard to provided arguments from international literature on soil modelling, since some of the references (e.g. Liski et al., 2002) can be replaced by more recent studies.	Results of the Monte Carlo assessment that justify the use of not a source for litter under FL remaining FL (and FM) have been added in the LULUCF methodology background document (Arets et al, 2019).	Method: 4.2
KP	5	KL.14.	The ERT recommends that the Party provide estimates of the areas of afforestation and FM on organic soils where drainage might still be active, report the associated CO_2 and N_2O emissions in the CRF tables using IPCC default or country-specific EFs and describe the applied methodology and IEF transparently in the NIR.	In the NIR 2019 the area of forest on organic soils where old drainage may still be active is estimated and emissions from organic soils for those areas is calculated using the emission factors for organic soils. The approach is indicated in the NIR and described in more detail in the LULUCF methodological background document	NIR: 11.3.1.1 Method: 11.3

References

AgentschapNL, 2010. Nederlands afval in cijfers: gegevens 2000-2008 *(Dutch waste statistics, data on 2000-2008*), Agentschap NL Uitvoering Afvalbeheer, Utrecht. ISBN 978-90-5748-084-3. (In Dutch).

Amstel, van et al., 1993. Methane, the other greenhouse gas. Research and policy in the Netherlands. RIVM report 481507-001, Bilthoven, the Netherlands, 1993

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 113. Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu), Wageningen UR, Wageningen.

Arets, E. J. M. M., J. W. H. van der Kolk, G. M. Hengeveld, J. P. Lesschen, H. Kramer, P. J. Kuikman and M. J. Schelhaas, 2019: Greenhouse gas reporting of the LULUCF sector in the Netherlands. Methodological background, update 2019. WOt Technical report 146. 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).

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).

Van Bruggen, C., A. Bannink, C.M. Groenestein, B.J. De Haan, J.F.M. Huijsmans, H.H. Luesink, S.M. Van der Sluis, G.L. Velthof, and J. Vonk (2014). Emissies naar lucht uit de landbouw in 2012: Berekeningen met het model NEMA (in Dutch). WOt-technincal report 3. *Wettelijke Onderzoekstaken Natuur & Milieu, Wageningen UR, Wageningen, the Netherlands.*

Van Bruggen, C., A. Bannink, C.M. Groenestein, J.M. Huijsmans, L.A. Lagerwerf, H.H. Luesink, S.M. Van der Sluis, G.L. Velthof, and J. Vonk (in prep.). Emissies naar lucht uit de landbouw in 2017: Berekeningen met het model NEMA (in Dutch). WOt-technical report. *Wettelijke Onderzoekstaken Natuur & Milieu, Wageningen UR, Wageningen, the Netherlands.*

CBS, 1988. Bedrijfsafvalstoffen, 1986. Kwartaalbericht Milieustatistieken (CBS), 5:14-18.

CBS, 1989. Bedrijfsafvalstoffen 1986. Voorburg, the Netherlands.

CBS (2008-2018). Dierlijke mest en mineralen 2006 t/m 2018 (C. van Bruggen; in Dutch). Statistics Netherlands, Den Haag/Heerlen, the Netherlands.

CBS (2012). Standardised calculation methods for animal manure and nutrients. Standard data 1990-2008. Statistics Netherlands, The Hague/Heerlen, the Netherlands.

CBS, 2012a: Uncertainty analysis of mineral excretion and manure production. CBS, The Hague.

CBS, 2017: Statline. Landbouw; gewassen, dieren en grondgebruik naar regio. Website, accessed 1 December 2017 (in Dutch).

CBS, 2017b: Otto Swertz (team Energy), Sander Brummelkamp (team Energy), John Klein (team Environment), Norbert Ligterink (TNO), Adjustment of heating values and CO2 emission factors of petrol and diesel, 13 December 2017

CE Delft (2014): Sample check of transport chapter of Netherlands National Inventory Report (NIR), Delft

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, 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.

Deltares & TNO (2016): Engine emissions from recreational boats (in Dutch), Utrecht.

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

EZK, 2017a: Seventh Netherlands national communication under the United Nations Framework Convention on Climate Change (NC7). The Hague.

EZK, 2017b: The Netherlands third biennial report under the United Nations Framework Convention on Climate Change (BR3), The Hague

Finke, P.A., J.J. de Gruijter and R. Visschers. (2001). Status 2001 landelijke steekproef kaarteenheden en toepassingen. Alterra-rapport 389. Alterra, Wageningen. http://edepot.wur.nl/27713. (In Dutch)

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)

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.

Heslinga, D.C. & A.K. van Harmelen, 2006. Vaststellingsmethodieken CO2 emissiefactoren voor aardgas in Nederland. TNO, Rapport no. R.2006/ Project no. 64101, Apeldoorn

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

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), 2017a, The Seventh Netherlands National Communication under the United Nations Framework Convention on Climate Change (2017a)

Ministry of Economic Affairs and Climate Policy (EZK), 2017b, The Netherlands Third Biennial Report under the United Nations Framework Convention on Climate Change (2017b)

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, 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 al, 2019: Methods used for the Dutch Emission Inventory. Product usage by consumers, construction and services. RIVM Report 2019-0017. Bilthoven

KIWA, 2015. Evaluatie emissiefactoren, GT-1402019. Evaluation of emission factors Gas distribution commissioned by Netbeheer Nederland. (In Dutch)

Klein J., G. Geilenkirchen, J. Hulskotte, A. Hensema, P. Fortuin & H. Molnár-in 't Veld, 2019: Methods for calculating the emissions of transport in the Netherlands. PBL Environmental Assessment Agency Netherlands, The Hague

Kramer, H., 2019: Basiskaart Natuur 2017; Een landsdekkend basisbestand voor de terrestrische natuur in Nederland. WOt-technical report. Wettelijke Onderzoekstaken Natuur & Milieu Wageningen, The Netherlands.

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. and J. Clement 2016: Basiskaart Natuur 2009 : een landsdekkend basisbestand voor de terrestrische natuur in Nederland. 2352-2739. Wettelijke Onderzoekstaken Natuur & Milieu, Wageningen. http://edepot.wur.nl/392811

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., 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).

Lagerwerf, L.A., A. Bannink, C. van Bruggen, C. Groenestein, J. Huijsmans, J. van der Kolk, H. Luesink, S. Sluis, G. Velthof, and J. Vonk (2019). Methodology for estimating emissions from agriculture in the Netherlands. *Wettelijke Onderzoekstaken Natuur & Milieu, Wageningen UR, Wageningen, the Netherlands.*

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).

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.

Monteny, G.J. (Monteny Milieu Advies), 2008: Peer review Dutch NIR 2008. Renkum, March.

Nagelhout, D., Wieringa, K. and Joosten, J.M., 1989. Afval 2000. National Institute of Public Health and Environment (RIVM), the Netherlands.

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., 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.

PBL, 2018: Balans van de Leefomgeving 2018.Nederland duurzaam vernieuwen. Den Haag: PBL (in Dutch). www. pbl.nl

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., 2019: Methodologies on the calculations of emissions from the sectors Energy, Industry and Waste - Update 2019, RIVM Report 2019-0018. Bilthoven

Productschappen Vee Vlees en Eieren (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 composteren en vergisten. - Utrecht : RWS Water, Verkeer en Leefomgeving, 2014. Rapport 978-94-91750-08-3. (Dutch only).

Rijkswaterstaat, 2017: Afvalverwerking in Nederland, gegevens 2016, Werkgroep Afvalregistratie, Utrecht (ISBN 978-94-91750-18-2) (in Dutch).

Rijkswaterstaat, 2018: Afvalverwerking in Nederland, gegevens 2017, Werkgroep Afvalregistratie, Utrecht (ISBN 978-94-91750-21-2) (in Dutch).

Rioned, 2001. Riool in cijfers 2000-2001 *(Urban Drainage Statistics 2000-2001)*. Stichting Rioned, Ede. Available via www.riool.net. 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, 2018: Werkplan 2018–2019 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, 2018: The Netherlands National System: QA/QC programme 2018/2019, version 13.0, December 2018 (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.

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.

SVA, 1973. Inventarisatie benodigde stortruimte. Amersfoort.

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.

Tauw, 2005. Achtergronden bij het advise Nazorg Voormalige Stortplaatsen (NAVOS). Deventer, 2005 (in Dutch).

Tauw, 2011. Validatie van het nationale stortgas emissiemodel *(Validation of the national landfill gas emission model)*. Deventer, 2011. (In Dutch.

UNFCCC 2013: Decision 24/CP.19 Annex III Global Warming Potential Values

Van den Wyngaert, I.J.J., E.J.M.M. Arets, H. Kramer, P.J. Kuikman and J.P. Lesschen. (2012). Greenhouse gas reporting of the LULUCF sector: background to the Dutch NIR 2012. Alterra-report 1035.9. Alterra, Wageningen UR, Wageningen.

Van Harmelen, A.K. & W.W.R. Koch, 2002. CO_2 emission factors for fuels in the Netherlands. TNO report R2002/174

Velthof, G.L., J. Mosquera, and E.W.J. Hummelink (2010). Effect of manure application technique on nitrous oxide emission from agricultural soils. Alterra report 1992. *Alterra Wageningen UR, Wageningen, the Netherlands.*

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.

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., 2019: The Netherlands: list of fuels and standard CO_2 emission factors, version January 2019, RVO.nl.

P.G. Ruyssenaars | P.W.H.G. Coenen | P.J. Zijlema | E.J.M.M. Arets | K. Baas | R. Dröge | G. Geilenkirchen | M. 't Hoen | E. Honig | B. van Huet | E.P. van Huis | W.W.R. Koch | L.A. Lagerwerf | R. te Molder | J.A. Montfoort | C.J. Peek | J. Vonk | M.C. van Zanten

RIVM Report 2019-0020

Total greenhouse gas (GHG) emissions in the Netherlands in 2017 decreased by approximately 1.1%, compared with 2016 emissions. This decrease was mainly the result of decreased coal combustion for energy and heat production.

In 2017, 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 193.7 Tg CO_2 eq. This is approximately 12.6% below the emissions in the base year 1990 (221.7 Tg CO_2 eq.).

CO_2 emissions in 2017 were still above the level in the base year (+1.0%). 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 2019 of its GHG emissions inventory in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) prescribed by the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol (KP) and the European Union's Greenhouse Gas Monitoring Mechanism.

This 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. Per source category, methods, data sources and emission factors (EFs) are described; besides a description of the quality assurance system and the verification activities performed on the data. It also describes changes in methodologies compared to the former submission (NIR 2018), the results of recalculations and planned improvements.

Published by:

National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

April 2019

011310

Committed to *health and sustainability*