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

Greenhouse Gas Emissions *in the Netherlands* 1990-2013

National Inventory Report 2015

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

Greenhouse gas emissions in the Netherlands 1990–2013 National Inventory Report 2015

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Colophon

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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 2013].

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

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

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

Total greenhouse gas (GHG) emissions from the Netherlands in 2013 decreased by approximately 0.2%, compared with 2012 emissions. This decrease was mainly the result of decreased fuel combustion in the transport sector and in the petrochemical industry.

In 2013, total direct GHG emissions (excluding emissions from Land use, land use change and forestry (LULUCF)) in the Netherlands amounted to 195.8 Tg CO_2 eq. This is approximately 12% below the emissions in the base year[2] (221.1 Tg CO_2 eq).

This report documents the Netherlands' 2015 annual submission of its GHG emissions inventory in accordance with the guidelines provided by the United Nations Framework Convention on Climate Change (UNFCCC)[3] and the European Union's Greenhouse Gas Monitoring Mechanism. Implementation of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) meant the presentation of the emissions data changed in comparison with previous submissions.

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

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

[2] 1990 for CO_2, CH_4 and N_2O and 1995 for the F-gases.
[3] As the UNFCCC software that should be used for the reporting of emissions and removals under the Kyoto Protocol did not function adequately, it was not possible for the Netherlands, like all other EU Member States, to report these emissions and removals. It is foreseen that the next report will contain the supplementary information.

Publiekssamenvatting

In 2013 is de totale broeikasgasemissie van Nederland met ongeveer 0,2 procent gedaald ten opzichte van de emissie in 2012. Deze daling komt vooral door de afname van brandstofgebruik in de transportsector en de petrochemische industrie.

De totale broeikasgasemissie in 2013 bedraagt 195,8 teragram (megaton of miljard kilogram) CO_2 equivalenten. Ten opzichte van het basisjaar (221,1 Tg CO_2 equivalenten) is dit een afname van ongeveer 11,5 procent. Beide getallen zijn exclusief de emissies afkomstig uit het soort landgebruik en de verandering daarin, zoals natuurontwikkeling of ontbossing (land use, land use change and forestry, LULUCF).

Dit blijkt uit een inventarisatie van broeikasgasemissies die het RIVM op verzoek van het ministerie van Infrastructuur en Milieu (IenM) heeft opgesteld. Met deze inventarisatie voldoet Nederland aan de nationale rapportageverplichtingen voor 2015 van het Klimaatverdrag van de Verenigde Naties (UNFCCC)[4] en van het Bewakingsmechanisme Broeikasgassen van de Europese Unie. De emissiecijfers zijn in absolute zin gewijzigd ten opzichte van eerdere rapportages omdat de nu gerapporteerde cijfers berekend zijn conform de nieuwste UNFCCC 2006 Guidelines.

De inventarisatie bevat verder trendanalyses voor de emissies van broeikasgassen in de periode 1990-2013, een analyse van belangrijkste emissiebronnen (sleutelbronnen) evenals de onzekerheid in hun emissies. Daarnaast biedt de inventarisatie documentatie van de gebruikte berekeningsmethoden, databronnen en toegepaste emissiefactoren. Ten slotte bevat het een overzicht van het kwaliteitssysteem en de validatie van de emissiecijfers door de Nederlandse Emissieregistratie.

Kernwoorden: broeikasgassen, emissies, trends, methodiek, klimaat

[4] Doordat de UNFCCC software die gebruikt moet worden voor de rapportage onder het Kyoto protocol nog niet aan alle eisen voldeed, kon Nederland, net als alle landen in de Europese Unie, niet rapporteren over emissies onder het Kyoto Protocol. De verwachting is dat in de eerstvolgende rapportage ook de emissies onder het Kyoto Protocol weer gerapporteerd kunnen worden.

Contents

References — 278

Samenvatting

Het National Inventory Report (NIR) 2015 bevat de rapportage van broeikasgasemissies (CO_2, N_2O, CH_4 en de F-gassen) over de periode 1990 tot en met 2013. De emissiecijfers in de NIR 2015 zijn berekend volgens de methoderapporten behorend bij het 'National System' dat is voorgeschreven in het Kyoto Protocol. In de methoderapporten zijn de berekeningswijzen vastgelegd voor zowel het basisjaar (1990 voor CO_2, CH_4 en N_2O en 1995 voor de F-gassen) als voor de emissies in de periode tot en met 2013. De methoderapporten zijn beschikbaar op de website www.rvo.nl/nie

National Inventory Report (NIR)
Dit rapport over de Nederlandse inventarisatie van broeikasgasemissies is op verzoek van het ministerie van Infrastructuur en Milieu (IenM) opgesteld om te voldoen aan de nationale rapportageverplichtingen in 2015 van het Klimaatverdrag van de Verenigde Naties (UNFCCC)[5] en het Bewakingsmechanisme Broeikasgassen van de Europese Unie. Belangrijk is te vermelden dat in de emissies in dit rapport zijn berekend conform nieuwste definities en richtlijn van de UNFCCC 2006. In het verleden werden de emissies volgens richtlijnen uit 1996 berekend. Door de definitieverschillen zijn de cijfers uit eerdere rapportages en deze NIR niet vergelijkbaar.

Dit rapport bevat de volgende informatie:

- trendanalyses voor de emissies van broeikasgassen in de periode 1990-2013;
- een analyse van zogenaamde sleutelbronnen en de onzekerheid in hun emissies volgens de 'Tier 1'-methodiek van de IPCC Good Practice Guidance;
- documentatie van gebruikte berekeningsmethoden, databronnen en toegepaste emissiefactoren;
- een overzicht van het kwaliteitssysteem en de validatie van de emissiecijfers voor de Nederlandse EmissieRegistratie;
- de wijzigingen die in de methoden voor het berekenen van broeikasgasemissies zijn aangebracht na de review van het Nationaal Systeem broeikasgassen vanuit het Klimaatverdrag. Op basis van de methoden die in de NIR en de Nederlandse protocollen broeikasgassen zijn vastgelegd, is de basisjaaremissie bepaald en de hoeveelheid broeikasgassen die Nederland in de periode 2008 t/m 2012 (volgens het Kyoto Protocol) mag uitstoten.

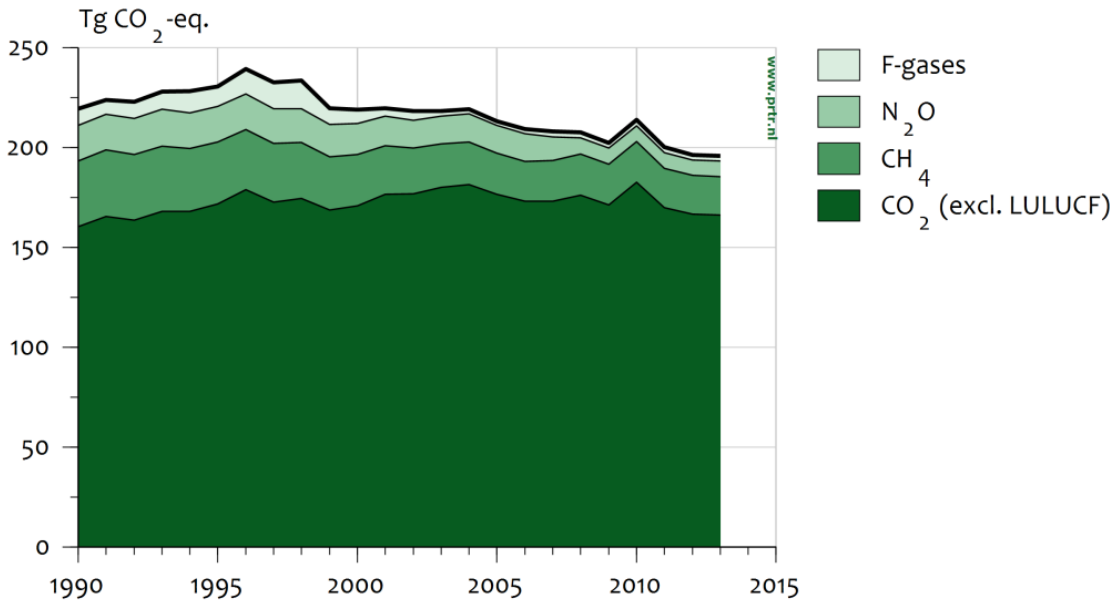
De NIR bevat dit jaar niet de informatie die voorgeschreven is volgens artikel 7 van het Kyoto protocol (deel 2 van dit rapport). Doordat de UNFCCC software die gebruikt moet worden voor de rapportage onder het Kyoto protocol nog niet aan alle eisen voldeed, kon Nederland, net

[5] Doordat de UNFCCC software die gebruikt moet worden voor de rapportage onder het Kyoto protocol nog niet aan alle eisen voldeed, kon Nederland, net als alle landen in de Europese Unie, niet rapporteren over emissies onder het Kyoto Protocol. De verwachting is dat in de eerstvolgende rapportage ook de emissies onder het Kyoto Protocol weer gerapporteerd kunnen worden.

als alle landen in de Europese Unie, niet rapporteren over emissies onder het Kyoto Protocol. De verwachting is dat in de eerstvolgende rapportage ook de emissies onder het Kyoto Protocol weer gerapporteerd kunnen worden.

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

De NIR gaat niet specifiek in op de invloed van het gevoerde overheidsbeleid op de emissies van broeikasgassen; meer informatie hierover is te vinden in de Balans van de Leefomgeving (opgesteld door het Planbureau voor de Leefomgeving, PBL) en de zesde Nationale Communicatie onder het Klimaatverdrag, die eind 2013 is verschenen.



Figuur ES.1 Broeikasgassen: emissieniveaus en emissietrends (exclusief LULUCF), 1990-2013.

Ontwikkeling van de broeikasgasemissies
De emissieontwikkeling in Nederland wordt beschreven en toegelicht in dit National Inventory Report (NIR 2015). Figuur ES.1 geeft het emissieverloop over de periode 1990-2013 weer. De totale emissies bedroegen in 2013 circa 195,8 Tg (Mton ofwel miljard kg) CO_2 equivalenten en zijn daarmee circa 11,5 procent afgenomen in vergelijking met de emissies in het basisjaar (221,1 Tg CO_2 eq). De hier gepresenteerde emissies zijn exclusief de emissies van landgebruik en bossen (LULUCF).

De emissie van CO_2 is sinds 1990 met circa 3 procent toegenomen, terwijl de emissies van de andere broeikasgassen met circa 49 procent zijn afgenomen ten opzichte van het basisjaar.
In 2013 daalde de CO_2 emissie met circa 1,7 procent (ten opzichte van het jaar 2012) ten gevolge van een daling van het brandstofgebruik in

transport sector, de petrochemische industrie. De emissie van CH_4 daalde in 2013 licht ten opzichte van 2012, met ongeveer 0,1 procent. De N_2O emissie steeg in 2013 met circa 2 procent ten gevolge verhoogde emissies in de chemische industrie. De emissie van F-gassen daalden in 2013 met circa 2,5 procent ten opzichte van 2012. De totale emissie van broeikasgassen in 2013 ligt daarmee 0,2 procent lager dan het niveau in 2012.

Box ES.1 Onzekerheden
De emissies van broeikasgassen kunnen niet exact worden gemeten of berekend. Onzekerheden zijn daarom onvermijdelijk. Het RIVM schat de onzekerheid in de jaarlijkse totale broeikasgasemissies op circa 3 procent. Dit is geschat op basis van informatie van emissie-experts in een eenvoudige analyse van de onzekerheid (volgens IPCC Tier 1). De totale uitstoot van broeikasgassen ligt daarmee met 95 procent betrouwbaarheid tussen de 189 en 200 Tg (Mton). De onzekerheid in de emissietrend tussen het basisjaar (1990/1995) en 2013 is geschat op circa 2 procent; dat wil zeggen dat de emissietrend in die periode met 95 procent betrouwbaarheid ligt tussen de -8 en -12 procent.

Methoden
De methoden die Nederland hanteert voor de berekening van de broeikasgasemissies waren tot en met 2014 vastgelegd in protocollen voor de vaststelling van de emissies. Ten gevolge van de implementatie van de 2006 IPCC Guidelines zijn de protocollen in 2015 vervangen door zogenaamde methoderapporten. De methoderapporten 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) in nauwe samenwerking met de Rijksdienst voor Ondernemend Nederland (voorheen Agentschap NL)
De methoden rapporten omvatten alle informatie die tot voorheen was opgenomen in de protocollen en zijn te vinden op www.rvo.nl/nie.

Executive summary

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

This report documents the Netherlands' 2015 annual submission of its greenhouse gas (GHG) emissions inventory in accordance with the guidelines provided by the United Nations Framework Convention on Climate Change (UNFCCC)[6] and the European Union's Greenhouse Gas Monitoring Mechanism. These guidelines, which relate to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), provide a format for the definition of source categories and for the calculation, documentation and reporting of emissions. The Guidelines are aimed at facilitating verification, technical assessment and expert review of the inventory information by the independent Expert Review Teams (ERTs) of the UNFCCC. The inventories should, therefore, be transparent, consistent, comparable, complete and accurate, as specified in the UNFCCC Guidelines for reporting, and be prepared using good practice.

This National Inventory Report 2015 (NIR 2015), therefore, provides explanations of the trends in GHG emissions, activity data and (implied) emission factors (EFs) for the period 1990–2013. It also summarizes the methods and data sources used in Tier 1 assessments of uncertainty in annual emissions and in emissions trends; it presents an assessment of key sources of emissions following the Tier 1 and Tier 2 approaches of the 2006 IPCC Guidelines and describes quality assurance and quality control (QA/QC) activities.

This report provides no specific information on the effectiveness of government policies for reducing GHG emissions. This information can be found in *Environmental balance* (biennial edition; in Dutch: 'Balans van de Leefomgeving') prepared by the Netherlands Environmental Assessment Agency (PBL) and the *6th National Communication* (NC6) prepared by the Government of the Netherlands.

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

Please note that the presentation of the figures in this report differs from that of earlier NIR*s* as a result of the implementation of the 2006 IPCC Guidelines in this submission. Previous NIR*s* were based on the Revised 1996 IPCC Guidelines (IPCC, 1997).

[6] As the UNFCCC software that should be used for the reporting of emissions and removals under the Kyoto Protocol did not function adequately, it was not possible for the Netherlands, like all other EU Member States, to report these emissions and removals. It is foreseen that the next report will contain the supplementary information.

Climate Convention and Kyoto Protocol
This NIR is prepared as part of the Netherlands' commitment under the UNFCCC and under the Kyoto Protocol. One of its obligations is establishment of a National System for GHG emissions (Art. 5.1 of the Protocol). This National System, developed in the period 2000–2005, was reviewed by an ERT of the UNFCCC in April 2007 and found to be in compliance with the requirements.

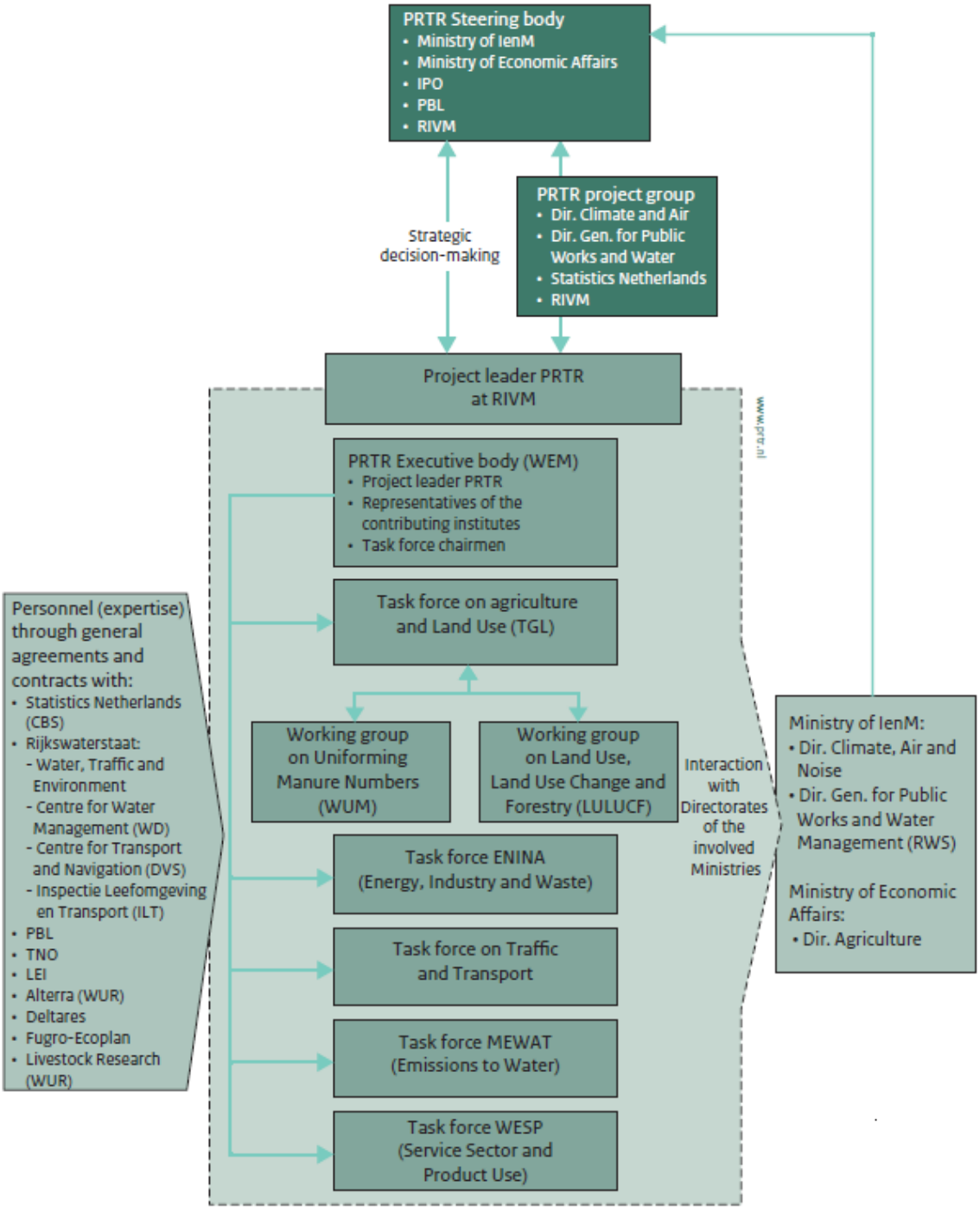


Figure ES.2 Main elements in the GHG inventory compilation process

Key categories
To identify the 'key categories' (the source categories which constitute 95% of the national emissions) according to the definition of the 2006 IPCC Guidelines, national emissions are categorized according to the IPCC potential key category list wherever possible. The IPCC Tier 1 method consists of ranking this list of source categories according to their contribution to both national total annual emissions and the national total trend. The results of this ranking are presented in Annex 1: 95% of the national total annual emissions derive from 33 sources and 95% of the national total trend is due to 34 sources, out of a total of 72 sources. The two lists can be combined to give an overview of sources that meet either or both of these two criteria. Next, the IPCC Tier 2 method for identifying the key sources is used; this requires incorporating the uncertainty in the emission estimate of each of these sources before ranking them in relation to their share of total emissions. The result is a list of 45 source categories from the total of 72 that are identified as 'key sources'. Finally, after inclusion of ten Land use, land use change and forestry (LULUCF) sub-categories in the key category analysis, four more key sources are found in the LULUCF sector.

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

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

Methodology reports
Under the National System, in accordance with Article 5.1 of the Kyoto Protocol, the methodologies for calculating GHG emissions in the Netherlands were reassessed in 2005 and compared with UNFCCC and IPCC requirements. For all sources and for sinks, the methodologies and processes were elaborated into (about 40) monitoring protocols. These protocols, which described the methodologies according to Revised 1996 IPCC Guidelines (IPCC, 1997), were annually revised, where necessary, and were used until 2014. Revisions to the protocols required an official announcement in the *Government gazette* (*Staatscourant*). This requirement was laid down in the Act on the Monitoring of Greenhouse Gases, which took effect in December 2005.

From 2015 onwards, emissions data must be reported according to the 2006 IPCC Guidelines (IPCC, 2006), implemented in accordance with the UNFCCC Reporting Guidelines. Therefore, the methodologies have been aligned with those Guidelines. At the same time, for reasons of

efficiency, the monitoring protocols have been replaced by five methodology reports, one for each PRTR Task Force. The present CRF/NIR is based on these methodology reports, which are part of the National System. The reports are available at the National System website http://english.rvo.nl/nie. The update of five methodology reports is simpler than the update of about 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 now checked by the National Inventory Entity and approved by the chairperson of the PRTR Task Force concerned.

Organization of the report

This report is organised in line with the prescribed NIR format, starting with an introductory chapter, Chapter 1, which contains background information on the Netherlands' process of inventory preparation and reporting; key categories and their uncertainties; a description of methods, data sources and emission factors (EFs); and a description of the quality assurance system, along with verification activities applied to the data. Chapter 2 provides a summary of trends in aggregated GHG emissions by gas and by principal source. Chapters 3 to 9 present detailed explanations of emissions in the different CRF sectors. Chapter 10 presents information on recalculations, improvements and responses to issues raised in former reviews and the UNFCCC centralised review of the NIR 2014. In addition, the report provides detailed information on key categories and methodologies and other relevant reports in eight annexes.

This year's report does not include the usual Part II, containing the supplementary information required under Article 7, paragraph 1 of the Kyoto Protocol, as the UNFCCC CRF reporter software that should be used for reporting of emissions and removals did not function adequately. It is expected that next year's report will contain the supplementary information.

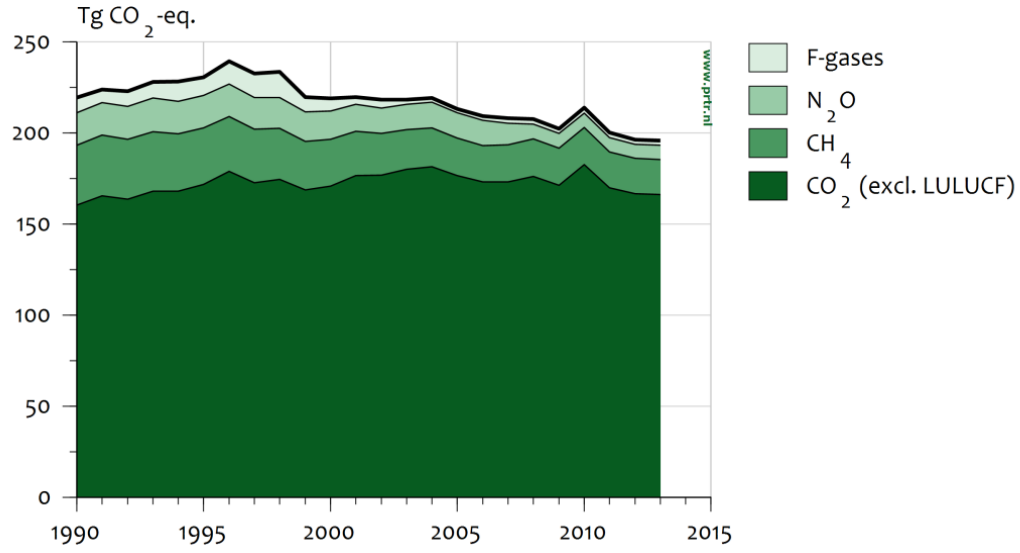


Figure ES.3 Overview of the trends in GHG emissions (excl. LULUCF) 1990–2013

ES2 Summary of trends in national emissions and removals

In 2013, total direct GHG emissions (excluding emissions from LULUCF) in the Netherlands were estimated at 195.8 Tg CO_2 equivalents (CO_2 eq). This is approximately 11.5% below the emissions in the base years (221.1 Tg CO_2 eq). In the Netherlands, the base year for emissions of CO_2, CH_4 and N_2O is 1990, and the base year for emissions of fluorinated gases (F-gases) is 1995. CO_2 emissions (excluding LULUCF) increased by about 3.5% from 1990 to 2013, mainly due to an increase in emissions in the Public Electricity and Transport) categories. CH_4 emissions in 2013 decreased by 42% compared with 1990 levels, mainly due to decreases in emissions from the Waste sector and the Agricultural sector and in fugitive emissions from the Energy sector. N_2O emissions decreased by 56% in 2013 compared with 1990, mainly due to decreases in emissions from Agriculture and from Industrial processes, which partly compensated for N_2O emissions increases from fossil fuel combustion (mainly from Transport). The emissions of F-gases (HFCs, PFCs and SF_6) decreased in the period 1995 (chosen as the base year) to 2013 by 70%, 94% and 52%, respectively. Total emissions of all F-gases were approximately 75% lower than in 1995.

Between 2012 and 2013, CO_2 emissions (excluding LULUCF) decreased by 2.9 Tg. Emissions of CH_4 also showed a decrease – of just under 0.2 Tg – between 2012 and 2013. In the same period, N_2O emissions increased by nearly 0.2 Tg CO_2 eq. Emissions of HFCs, PFCs and SF_6 did not change significantly in 2013. Total F-gas emissions decreased by 0.05 Tg CO_2 eq.

Overall, total GHG emissions decreased by about 0.24% in comparison with 2012.

Total CO_2-eq emissions including LULUCF decreased between 2012 and 2013 by 0.4 Tg to the level of 202.0 Tg CO_2 eq.

ES3 Overview of source and sink category emissions estimates and trends

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

Categories showing the largest increase in CO_2-equivalent emissions since 1990 are Transport (1A3) and Energy industries (1A1) (+34% and +18%, respectively). It should be noted that half the increase of almost 30% in the Public electricity category (1A2) between 1990 and 1998 was caused by a shift of cogeneration plants from Manufacturing industries to the Public electricity and heat production sector due to a change of ownership (joint ventures), which simultaneously caused a 15% decrease in Industry emissions in the early 1990s.

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

	CO_2 incl. LULUCF	CO_2 excl. LULUCF	CH_4	N_2O	HFCs	PFCs	SF_6	Total (incl. LULUCF)	Total (excl. LULUCF)
Base year	**166.1**	**160.5**	**32.9**	**17.6**	**7.6**	**2.3**	**0.3**	**226.8**	**221.1**
1990	166.1	160.5	32.9	17.6	5.6	2.7	0.2	225.1	219.5
1991	171.9	165.5	33.3	17.8	4.4	2.6	0.1	230.2	223.8
1992	170.0	163.6	32.9	18.1	5.6	2.4	0.1	229.1	222.8
1993	174.5	168.0	32.7	18.4	6.3	2.4	0.1	234.4	228.0
1994	174.4	167.9	31.6	17.9	8.2	2.3	0.2	234.6	228.1
1995	178.2	171.9	30.9	17.7	7.6	2.3	0.3	236.9	230.6
1996	185.3	178.9	30.1	17.7	9.6	2.5	0.3	245.6	239.2
1997	179.0	172.7	29.2	17.5	10.2	2.8	0.3	239.0	232.7
1998	180.8	174.5	28.0	16.9	11.5	2.2	0.3	239.7	233.4
1999	175.0	168.8	26.7	16.2	6.0	1.8	0.3	225.9	219.6
2000	177.1	170.9	25.5	15.7	4.7	1.9	0.3	225.2	219.0
2001	182.8	176.6	24.4	14.7	1.8	1.8	0.3	225.9	219.6
2002	183.0	176.8	22.9	13.9	1.9	2.6	0.2	224.6	218.3
2003	186.5	180.1	21.8	13.8	1.7	0.8	0.2	224.8	218.3
2004	187.7	181.6	21.1	14.1	1.8	0.4	0.2	225.4	219.2
2005	182.8	176.7	20.5	13.8	1.6	0.3	0.2	219.4	213.2
2006	179.2	173.1	20.1	13.7	1.9	0.3	0.2	215.4	209.2
2007	179.3	173.2	20.2	11.9	2.0	0.4	0.2	214.1	208.0
2008	182.2	176.2	20.4	8.2	2.1	0.3	0.2	213.6	207.5
2009	177.6	171.4	20.2	8.0	2.2	0.3	0.2	208.5	202.3
2010	188.6	182.7	20.2	7.9	2.5	0.3	0.2	219.7	213.8
2011	175.8	169.9	19.7	7.8	2.4	0.3	0.1	206.1	200.0
2012	172.8	166.8	19.2	7.6	2.3	0.2	0.2	202.4	196.3
2013	**172.4**	**166.2**	**19.2**	**7.8**	**2.3**	**0.1**	**0.1**	**202.0**	**195.8**

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

	1. Energy	2. Ind. Processes and prod. use	3. Agriculture	4. LULUCF	5. Waste	6. Other	Total (incl. LULUCF)	Total (excl. LULUCF)
Base year	**154.6**	**26.5**	**25.3**	**5.7**	**14.8**	**NA**	**226.8**	**221.1**
1990	154.6	24.8	25.3	5.7	14.8	NA	225.1	219.5
1991	159.7	23.6	25.6	6.4	14.9	NA	230.2	223.8
1992	158.3	24.1	25.7	6.3	14.6	NA	229.1	222.8
1993	163.1	25.1	25.5	6.5	14.3	NA	234.4	228.0
1994	162.4	27.4	24.5	6.5	13.8	NA	234.6	228.1
1995	166.4	26.5	24.6	6.3	13.1	NA	236.9	230.6
1996	174.2	28.1	24.2	6.4	12.7	NA	245.6	239.2
1997	166.9	29.4	24.1	6.3	12.3	NA	239.0	232.7
1998	168.7	30.0	22.9	6.3	11.8	NA	239.7	233.4
1999	162.9	23.6	22.4	6.3	10.8	NA	225.9	219.6
2000	165.1	22.4	21.2	6.2	10.2	NA	225.2	219.0
2001	171.4	18.1	20.8	6.3	9.3	NA	225.9	219.6
2002	171.6	18.6	19.6	6.3	8.5	NA	224.6	218.3
2003	174.9	16.6	19.2	6.5	7.6	NA	224.8	218.3
2004	176.2	17.0	19.0	6.2	7.0	NA	225.4	219.2
2005	171.3	16.8	18.8	6.1	6.3	NA	219.4	213.2
2006	168.1	16.6	18.8	6.2	5.8	NA	215.4	209.2
2007	168.1	15.9	18.5	6.2	5.4	NA	214.1	208.0
2008	172.3	11.5	18.6	6.1	5.1	NA	213.6	207.5
2009	167.7	11.2	18.5	6.3	4.8	NA	208.5	202.3
2010	179.0	11.8	18.5	5.9	4.5	NA	219.7	213.8
2011	165.4	12.3	18.2	6.0	4.2	NA	206.1	200.0
2012	162.7	11.6	18.0	6.2	4.0	NA	202.4	196.3
2013	162.3	11.4	18.3	6.2	3.8	NA	202.0	195.8

ES4 Other information

General uncertainty evaluation

The results of the uncertainty estimation according to the IPCC Tier 1 uncertainty approach are summarized in Annex 2 of this report. The Tier 1 estimation of annual uncertainty in CO_2-eq emissions results in an overall uncertainty of 3%, based on calculated uncertainties of 2% for CO_2 (excluding LULUCF), 18% for CH_4, 43% for N_2O and 40–42% for F-gases.

However, these figures do not include the correlation between source categories (e.g. cattle numbers for enteric fermentation and animal manure production), nor a correction for non-reported sources. Therefore, the actual uncertainty of total annual emissions per gas and of the grand total will be somewhat higher; it is currently estimated by the RIVM at:

CO_2	± 3%	**HFCs**	± 50%
CH_4	± 25%	**PFCs (incl NF_3)**	± 50%
N_2O	± 50%	**SF_6**	± 50%
Total GHGs			± 5%

Annex 2 summarizes the estimates of the trend uncertainties 1990–2013 calculated according to the IPCC Tier 1 approach set out in the 2006 IPCC Guidelines. The result is a trend uncertainty in total CO_2-eq emissions (including LULUCF) for 1990–2013 (1995–2013 for F-gases) of ± 2%. This means that the trend in total CO_2-eq emissions between 1990 and 2013 (excluding LULUCF), which is calculated to be a 10% decrease, will be between a 12% decrease and an 8% 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 ± 13%, respectively. More details of the trend uncertainty assessment can be found in Annex 2.

Completeness of the national inventory

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

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

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

Methodological changes, recalculations and improvements

This NIR (2015) is based on the National System of the Netherlands, in accordance with Article 5.1 of the Kyoto Protocol. In past years, the results of various improvement actions have been implemented in the methodologies and processes of compiling the GHG inventory of the Netherlands. Compared with the NIR 2014 and based on the results of the UNFCCC reviews, some improvements of the inventory (including minor recalculations) have been undertaken in the last year. The main changes in this submission are the adoption of the 2006 IPCC Guidelines (including new GWPs and an updated list of fuels) and a methodology change in the Agricultural sector (manure management). The rationale behind the recalculations is documented in Chapters 3–10.

Table ES.3 shows the results of recalculations in the NIR 2015 compared with the NIR 2014.

Table ES.3 Differences between NIR 2015 and NIR 2014 due to recalculations and the resubmitted data from October 2013 (Tg CO_2 eq; F-gases: Gg CO_2 eq)

Gas	Source	1990	1995	2000	2005	2009	2010	2011	2012
CO_2 [Tg] **Incl. LULUCF**	NIR 2015	**166.1**	178.2	177.1	182.8	177.6	188.6	175.8	172.8
	NIR 2014	**162.2**	173.5	172.2	178.1	173.0	184.6	171.4	168.7
	Difference	*2.4%*	*2.7%*	*2.8%*	*2.6%*	*2.6%*	*2.2%*	*2.6%*	*2.5%*
CO_2 [Tg] **Excl. LULUCF**	NIR 2015	**160.5**	171.9	170.9	176.7	171.4	182.7	169.9	166.8
	NIR 2014	**159.2**	170.7	169.9	175.9	169.9	181.4	168.1	165.3
	Difference	*1.0%*	*0.8%*	*0.7%*	*0.5%*	*1.0%*	*0.8%*	*1.1%*	*1.0%*
CH_4 [Tg]	NIR 2015	**32.9**	30.9	25.5	20.5	20.2	20.2	19.7	19.2
	NIR 2014	**25.7**	24.3	19.9	16.1	16.0	15.9	15.3	14.9
	Difference	*28.1%*	*27.1%*	*28.0%*	*27.5%*	*26.2%*	*26.6%*	*28.8%*	*28.8%*
N_2O [Tg]	NIR 2015	**17.6**	17.7	15.7	13.8	8.0	7.9	7.8	7.6
	NIR 2014	**20.0**	19.9	17.4	15.5	9.5	9.3	9.3	9.1
	Difference	*-11.9%*	*-10.9%*	*-10.1%*	*-10.5%*	*15.4%*	*15.8%*	*-16.1%*	*-15.8%*
PFCs [Gg]	NIR 2015	2662	**2278**	1893	339	300	302	263	173
	NIR 2014	2264	**1938**	1581	265	168	209	183	151
	Difference	*17.5%*	*17.5%*	*19.8%*	*27.9%*	*78.7%*	*44.4%*	*43.7%*	*14.7%*
HFCs [Gg]	NIR 2015	5606	**7577**	4714	1638	2212	2519	2350	2283
	NIR 2014	4432	**6019**	3891	1511	2070	2257	2132	2055
	Difference	*26.5%*	*25.9%*	*21.2%*	*8.4%*	*6.9%*	*11.6%*	*10.2%*	*11.1%*
SF_6 [Gg]	NIR 2015	208	**274**	282	229	163	176	140	187
	NIR 2014	218	**287**	295	240	170	184	147	196
	Difference	*-4.6%*	*-4.6%*	*-4.6%*	*-4.6%*	*-4.6%*	*-4.6%*	*-4.6%*	*-4.6%*
Total [Tg CO_2 eq] **Incl. LULUCF**	NIR 2015	225.1	236.9	225.2	219.4	208.5	219.7	206.1	202.4
	NIR 2014	214.9	226.0	215.4	211.7	201.0	212.6	198.5	195.2
	Difference	*4.8%*	*4.8%*	*4.5%*	*3.6%*	*3.8%*	*3.3%*	*3.8%*	*3.7%*
Total [Tg CO_2 eq] **Excl. LULUCF**	NIR 2015	219.5	230.6	219.0	213.2	202.3	213.8	200.0	196.3
	NIR 2014	211.8	223.2	213.0	209.4	197.8	209.3	195.1	191.7
	Difference	*3.6%*	*3.3%*	*2.8%*	*1.8%*	*2.3%*	*2.2%*	*2.6%*	*2.4%*

Note: Base year values are indicated in bold.

Improving the QA/QC system

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

Emissions trends for indirect GHGs and SO_2

Compared with 1990, CO and NMVOC emissions were reduced in 2013 by 56% and 69%, respectively. For SO_2, the reduction was 83%; for NO_x, the 2012 emissions were 59% lower than the 1990 level. Table ES.4 provides trend data. In contrast to the direct GHGs, precursor emissions from road transport have not been corrected in relation to fuel sales as recorded in national energy statistics (compiled by Statistics Netherlands), but are directly related to transport statistics on vehicle-km – a method that differs to some extent from the IPCC approach. Recalculations (due to changes in methodologies and/or allocation) have been performed only for 1990, 1995, 2000, 2005 and 2010 to 2012 for all sources.

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

	1990	1995	2000	2005	2010	2011	2012	2013
Total NO_X	559	463	384	328	319	293	282	260
Total CO	1,219	885	810	724	728	718	714	668
Total NMVOC	483	339	238	178	171	169	167	157
Total SO_2	198	138	77	69	80	59	49	37

Part 1: Annual inventory report

1 Introduction

1.1 Background information on greenhouse gas inventories and climate change

1.1.1 Background information on climate change

The United Nations Framework Convention on Climate Change (UNFCCC) was ratified for the European part of the Netherlands in 1994 and took effect in March 1994. One of the commitments made by the ratifying Parties to the Convention was to develop, publish and regularly update national emissions inventories of greenhouse gases (GHGs). This National Inventory Report (NIR), together with the Common Reporting Format (CRF) tables, represents the 2013 national emissions inventory of GHGs under the UNFCCC (Part 1 of this report) The Kyoto Protocol reporting (normally Part 2 of this report) is not included in the NIR this year.

Geographical coverage

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

1.1.2 Background information on GHG inventory

As indicated, this NIR documents the 2013 Greenhouse Gas Emission Inventory for the Netherlands under the UNFCCC and under the Kyoto Protocol. The estimates provided in the report are consistent with the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The methodologies applied to the Netherlands' inventory are also consistent with the guidelines under the Kyoto Protocol and the European Union's Greenhouse Gas Monitoring Mechanism.

For detailed assessments of the extent to which changes in emissions are due to the implementation of policy measures, see the *Environmental Balance* (PBL, 2009; in Dutch), the *Sixth Netherlands national communication under the United Nations Framework Convention on Climate Change* (IenM, 2013) and the *Netherlands' report on demonstrable progress* under Article 3.2 of the Kyoto Protocol (VROM, 2006).

The Netherlands also reports emissions under other international agreements, such as the United Nations Economic Commission for Europe (UNECE), the Convention on Long Range Transboundary Air Pollutants (CLRTAP) and the EU's National Emission Ceilings (NEC) Directive. All emission estimates are taken from the Netherlands' Pollutant Release and Transfer Register (PRTR), which is compiled by a

special project in which various organizations co-operate. The GHG inventory and the PRTR share underlying data, which ensures consistency between the inventories and other internationally reported data. Several institutes are involved in the process of compiling the GHG inventory (see also Section 1.3).

The NIR covers the seven direct GHGs included in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (the last three are called the F-gases; NF_3 is included in the figure for PFCs but cannot be reported separately due to the confidentiality of the data). Emissions of the following indirect GHGs are also reported: nitrogen oxides (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCand sulphur oxides (SO_x).

This report provides explanations of the trends in GHG emissions per gas and per sector for the 1990–2013 period and summarizes the methods used and data sources for: (a) Tier 1 assessments of the uncertainty in annual emissions and in emissions trends; (b) key source assessments following the Tier 1 and Tier 2 approaches of the 2006 IPCC Guidelines; (c) quality assurance and quality control (QA/QC) activities.

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

From 2015 onwards, emissions data must be reported according to the 2006 IPCC Guidelines (implemented in accordance with the UNFCCC Reporting Guidelines). Therefore, the methodologies have been aligned with those Guidelines. At the same time, for reasons of efficiency, the monitoring protocols have been replaced by five methodology reports, one for each PRTR Task Force. The present NIR is based on the methodologies described in these methodology reports, which should be considered as part of the National System. The reports are available at the National System website http://english.rvo.nl/nie. The maintenance of five methodology reports is easier than the update of 40 protocols. In addition, the administrative procedure is simplified because the 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 reviewed by the National Inventory Entity and approved by the chairperson of the PRTR Task Force concerned.

In 2007, the UN performed an in-country initial review under the Kyoto Protocol. The review concluded that the Netherlands' National System had been established in accordance with the guidelines and that it met

the requirements. This was confirmed by later reviews, such as the review of the NIR 2014.
Since then, the following two changes to the National System have been implemented:

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

The structure of this report complies with the format required by the UNFCCC (outline and general structure of the national inventory report as described in UNFCCC Decision 24/CP.19). As a result of the inadequate functioning of the reporter software this years submission does not includes supplementary information under Article 7 of the Kyoto Protocol (normally reported inPart 2 of the report).

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

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

Chapter 10 provides details of the extent to which the CRF data files for 1990–2013 have been completed and of improvements made since the last submission.

According to Decision 13/CP.20 of the Conference of the Parties to the UNFCCC, CRF Reporter version 5.0.0 was usedin order to enable Annex I Parties to submit their CRF tables for the year 2015. In the same Decision, the Conference of the Parties reiterated that Annex I Parties in 2015 may submit their CRF tables after 15 April, but no later than the end of the corresponding delay in the CRF Reporter availability. 'Functioning' software means that the data on GHG emissions/removals is reported accurately in terms of both reporting format tables and XML format.

CRF Reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it

therefore does not yet allow submission of all the information required under the Kyoto Protocol.

Bearing in mind the Conference of Parties' invitation to submit as soon as practically possible, and considering that CRF Reporter 5.10 allows sufficiently accurate reporting under the UNFCCC (even if minor inconsistencies may still exist in the reporting tables, as per the Release Note accompanying CRF Reporter 5.10), the present report is the official submission for the year 2015 under the UNFCCC. The present report is not an official submission under the Kyoto Protocol, even though some of the information included may relate to the requirements under the Kyoto Protocol.

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

Part 2 of this report should provide the supplementary information under Article 7 of the Kyoto Protocol, as the UNFCCC software that should be used for reporting of emissions and removals did not function completely. It is exptected that next year's report will contain the supplementary information.

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

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

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

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

1.2.2 Overview of inventory planning, preparation and management

The Dutch PRTR system has been in operation in the Netherlands since 1974. This system encompasses data collection, data processing and the registering and reporting of emissions data for approximately 350 policy-relevant compounds and compound groups that are present in air, water and soil. The emissions data is produced in an annual (project) cycle (RIVM, 2014). This system also serves as the basis for

the national GHG inventory. The overall co-ordination of the PRTR is outsourced by the IenM to the RIVM.

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

1.2.2.1 Responsibility for reporting

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

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

Following the annotated outline, the supplementary information, as required according to Article 2 of the Kyoto Protocol, is usually reported in the NIR Part 2. This information is prepared by RVO.nl using information from various other organizations involved, such as the NEa (Dutch Emissions Authority), the WUR and the IenM.
KP-LULUCF is not reported in this NIR.

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

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

1.2.3.1 Information on the QA/QC plan

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

As part of its National System, the Netherlands has developed and implemented a QA/QC programme. This programme is assessed annually and updated, if necessary. The key elements of the current programme (RVO.nl, 2014) are summarized in this chapter, notably those related to the current NIR.

1.2.3.2 QA/QC procedures for the CRF/NIR 2015

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

Several QC issues relate to the NIR:

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

For the NIR 2015, changes were incorporated in and references were updated to the National System website (http://english.rvo.nl/nie), providing additional information on the methodology reports and relevant background documents.

To facilitate the general QC checks, a checklist was developed and implemented. A number of general QC checks have been introduced as part of the annual work plan of the PRTR and are also mentioned in the methodology reports. The QC checks included in the work plan are aimed at covering issues such as the consistency, completeness and correctness of the CRF data. The general QC for the present inventory was largely performed at the institutes involved as an integrated part of their PRTR work (Wever, 2011). The PRTR Task Forces fill in a standard-format database with emissions data for 1990–2013 (with the exception of LULUCF). After a first check of the data by the RIVM and TNO for completeness, the (corrected) data is made available to the relevant Task Forces for consistency checks and trend analyses (comparability, accuracy). The Task Forces have access to the national emissions database. Several weeks before the dataset was fixed, a trend

verification workshop was organized by the RIVM (December 2014; see Box 1.1). The conclusions of this workshop, including the actions for the Task Forces to resolve the identified clarification issues, is documented at the RIVM. Required changes to the database are then made by the Task Forces.

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

Quality assurance for the current NIR includes the following activities:

- Due to the late availability of the CRF tables, the NIR was delayed, with the result that the usual peer and public reviews did not take place. Next year, a peer and public review are planned again.
- In the preparation of this NIR, the results of former UNFCCC reviews were taken onboard and used to improve the NIR (see Chapter 10.4 for an overview).

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

- The *QA/QC programme* (RVO.nl, 2014) that has been developed and implemented as part of the National System. This programme includes quality objectives for the National System, the QA/QC plan and a schedule for the implementation of the activities. It is updated annually as part of an 'evaluation and improvement cycle' for the inventory and National System and is kept available for review.
- The *adaptation of the PRTR project to the quality system* of the RIVM (ISO 9001:2008 system), completed in 2012;
- The annual *work plan* of the RIVM (RIVM, 2014). The work plan describes the tasks and responsibilities of the parties involved in the PRTR process, such as products to be delivered, scheduling (planning) and emissions estimation (including the methodology reports on GHGs), as well as those of the members of the Task Forces. The annual work plan also describes the general QC activities to be performed by the Task Forces before the annual PRTR database is fixed (see section 1.6.2).
- *Responsibility for the quality of data in annual environmental reports* (AER) and validation of the data. The former lies with the companies themselves, the latter with the competent authorities. It is the responsibility of the institutes involved in the PRTR to judge whether or not to use the validated data of individual companies to be used in the calculation of the national total emissions. (CO_2 emissions, however, are based on energy statistics and standard EFs, and only approved specific EFs from AERs are used.)
- *Agreements/covenants* between the RIVM and other institutes involved in the annual PRTR process. The general agreement is that, by accepting the annual work plan, the institutes involved commit themselves to deliver capacity for the work/products specified in that work plan. The role and responsibility of each

institute have been described (and agreed upon) within the framework of the PRTR work plan.

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

proposals are prioritized in a consensus process and budgets are made available for the selected improvements. The available resources have to be shared between the different items of the inventory (GHG, CLRTAP and water emissions). GHG-related issues are given high priority when they relate to improvements of key source estimates and/or if the reviews ask for specific improvements in methods or activity data. Proposals for improvements that contribute to a decrease in the uncertainty of emissions estimates are given higher priority than others. All planned improvements are documented in the annual work plan.

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

In 2014, a quantitative assessment was made of the possible inconsistencies in CO_2 emissions between data from the ETS, the NIR and national energy statistics. The figures that were analysed related to approximately 40% of the CO_2 emissions in the Netherlands in 2012. The differences could be explained reasonably (e.g. different scope) within the time available for this action (Ligt, 2015). Since this study, the Task Force has used the ETS figures to cross-check and/or improve their emissions estimates (where applicable).

1.2.3.3 Verification activities for the CRF/NIR 2015

Two weeks prior to a trend analysis meeting, a snapshot from the database was made available by the RIVM in a web-based application (Emission Explorer, EmEx) for checking by the institutes and experts involved (PRTR Task Forces). This allowed the Task Forces to check for level errors and consistency in the algorithms/methods used for calculations throughout the time series. The Task Forces performed checks for all gases and sectors. The sector totals were compared with the previous year's dataset. Where significant differences were found, the Task Forces evaluated the emissions data in greater detail. The results of these checks were then brought up for discussion at the trend analysis workshop and subsequently documented. Furthermore, the Task Forces were provided with CRF Reporter software to check the time series of emissions per substance. During the trend analysis, the GHG emissions for all years between 1990 and 2013 were checked in two ways:

(1) The datasets from previous years' submissions were compared with the current submission; emissions from 1990 to 2012 should (with some exceptions) be identical to those reported last year.
(2) The data for 2013 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 2014 (RIVM, 2014). 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 2012 and 2013. In this table, differences of >5% at sector level were used to document trends;
- Based on the PRTR emissions database, a table with a comparison of the complete inventories of 2013 and 2014, to check that no historical data had been accidentally changed;
- A table with a comparison of data from the two sources, to check that no errors had occurred during the transfer of data from the PRTR emissions database to the CRF tables.

The data checks were performed by sector experts and others involved in preparing the emissions database and the inventory. Communications (emails) between the participants in the data checks were centrally collected and analysed. This resulted in a checklist of actions to be taken. This checklist was used as input for the trend verification workshop and was supplemented by the actions agreed in this workshop. Furthermore, in the trend verification workshop, trends of >5% at sector level were explained. Table 1.1 shows the key verification actions for the CRF tables/NIR 2015.

Table 1.1 Key actions for the NIR 2015

Item	Date	Who	Result	Documentation
Automated initial check on internal and external data consistency	During each upload	Data Exchange Module (DEX)	Acceptation or rejection of uploaded sector data	Upload event and result logging in the PRTR database
Input of hanging issues for this inventory	27-11-2014	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten definitieve cijfers 1990-2013 v 21 nov 2014.xls
Comparison sheets to check for accidentally changed historical data	25-11-2014	RIVM-PRTR	List of issues/actions to be finalised before the trend analyses	Verschiltabellen 25-11-2014.zip
Comparison sheets dataset years 2012/2013	01-12-2014	RIVM	Input for trend analyses	Verschiltabellen 01-12-2014.zip
List of required actions (action list)	01-12-2014	RIVM	Input for trend analysis	Actiepunten definitieve cijfers 1990-2013 v 1 dec 2014.xls
Trend analysis	4-12-2014	Task Forces	Updated Action list	Actiepunten definitieve cijfers 1990-2013 v 5 dec 2014.xls
Resolving the issues on the action list	Until 10-12-2014	Task Forces RIVM/NIC/TNO	Final dataset	Actiepunten definitieve cijfers 1990-2013 v 12 dec 2014.xls
Comparison sheets with final data	12-12-2014	RIVM	Input for trend analyses	Verschiltabellen LUCHT 11-12-2014.zip
Comparison of data in CRF tables and EPRTR database	Until September2015	NIC/TNO	First draft CRF sent to the EU	
Writing and checks of NIR	Until October 2015	Task Forces/ NIC/TNO/NIE	Draft texts	S:\ \NI National Inventory Report\NIR 2015\NIR2015-werkversie
Generation of tables for NIR from CRF tables	Until October 2015	NIC/TNO	Final text and tables NIR	NIR 2014 Tables and Figures v5.xlsx

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

As the CRF Reporter software was not fit for purpose in January 2015, the process of preparing the NIR was delayed and the Netherlands was

not able to submit a first draft of the CRF before July 2015. In the months up to October 2015, the CRF filling was improved and the NIR could be compiled on the basis of internal reviews. The subsequent versions and all documentation (emails, data sheets and checklists) are stored electronically on a server at the RIVM.

1.2.3.4 Treatment of confidentiality issues

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

1.3 Inventory preparation; data collection, processing and storage

1.3.1 GHG and KP-LULUCF inventory

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

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

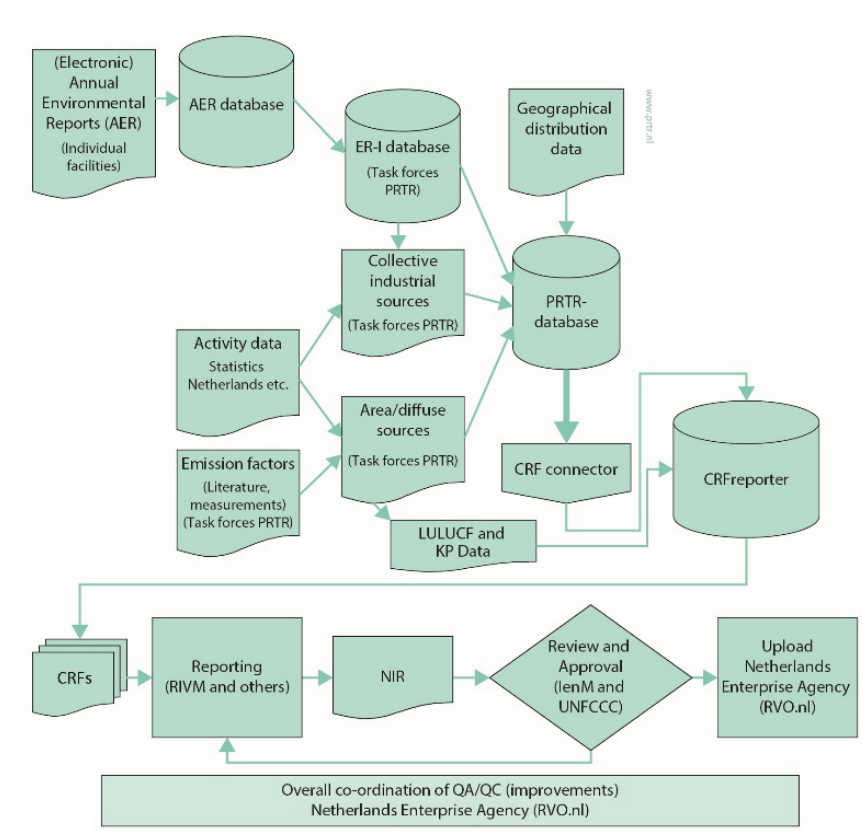


Figure 1.1 Main elements in the GHG inventory process

1.3.2 Data collection

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

Statistical data

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

Data from individual companies

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

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

Additional GHG-related data

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

1.3.3 Data processing and storage

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

The emissions calculations and estimates that are made using the input data are performed by five Task Forces, each dealing with specific sectors or source categories:

- ENINA: Energy, industrial processes and waste (combustion, process emissions, waste handling);
- TGL Agriculture (agriculture, sinks);
- WESP: Consumers and services (non-industrial use of products);
- Transport (including bunker emissions);
- MEWAT: Water (less relevant for GHG emissions).

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

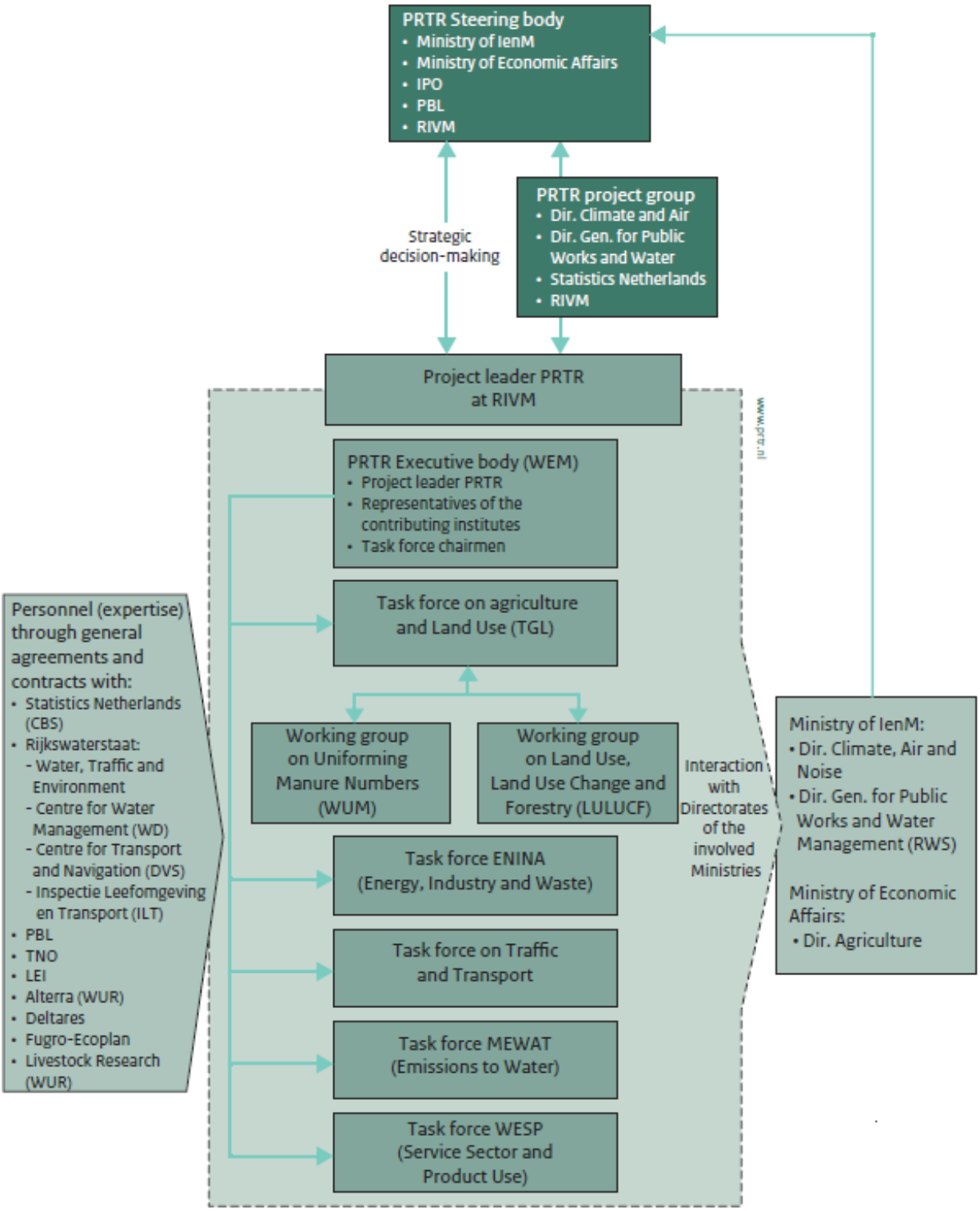


Figure 1.2 Organisational arrangements for PRTR project

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

1.4.1 GHG inventory

Methodologies
Table 1.2 provides an overview of the methods used to estimate GHG emissions. Methodology reports (formerly monitoring protocols), documenting the methodologies, data sources and QA/QC procedures used in the GHG inventory of the Netherlands, as well as other key documents, are listed in Annex 3.
All key documents are electronically available in PDF format at http://english.rvo.nl/nie.

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

Table 1.2 CRF Summary Table 3 with methods and EFs applied

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	CS,NA,T1,T2,T3	CS,D,NA,PS	NA,T1,T1b,T2,T3	CS,D,NA,PS	D,NA,T1,T2	CS,D,NA
A. Fuel combustion	CS,NA,T1,T2	CS,D,NA	NA,T1,T2,T3	CS,D,NA	D,NA,T1,T2	CS,D,NA
1. Energy industries	CS,T2	CS,D	T1,T2	CS,D	D,T1	D
2. Manufacturing industries and construction	NA,T2	CS,D,NA	NA,T1,T2	CS,D,NA	D,NA,T1,T2	D,NA
3. Transport	T1,T2	CS,D	T1,T2,T3	CS,D	T1,T2	CS,D
4. Other sectors	T2	CS,D	T1,T2	CS,D	T1	D
5. Other	T2	D	T2	CS	T2	CS
B. Fugitive emissions from fuels	CS,T1,T2,T3	CS,D,PS	T1,T1b,T2,T3	CS,D,PS	NA	NA
1. Solid fuels	T2	CS	NA	NA	NA	NA
2. Oil and natural gas	CS,T1,T2,T3	CS,D,PS	T1,T1b,T2,T3	CS,D,PS	NA	NA
C. CO_2 transport and storage	NA	NA				
2. Industrial processes	IA,T1,T1a,T1b,T2	CS,D,NA,PS	CS	CS	CS,T2	CS,PS
A. Mineral industry	CS	CS,D,PS				
B. Chemical industry	CS,T1b	CS	CS	CS	T2	PS
C. Metal industry	D,NA,T1a,T2	CS,D,NA	NA	NA	NA	NA
D. Non-energy products from fuels and solvent use	CS,D	CS,D	CS	CS	NA	NA
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	NA,T1	D,NA	CS	CS	CS	CS
H. Other	T1	CS	NA	NA	NA	NA
3. Agriculture			T1,T2	CS,D	CS,T1,T1b,T2	CS,D
A. Enteric fermentation			T1,T2	CS,D		
B. Manure management			T2	CS,D	CS	CS
C. Rice cultivation			NA	NA		
D. Agricultural soils[3]					T1,T1b,T2	CS,D
E. Prescribed burning of savannas			NA	NA	NA	NA
F. Field burning of agricultural residues			NA	NA	NA	NA
G. Liming	T1	D				
H. Urea application	NA	NA				
I. Other carbon-containing fertilizers	NA	NA				
J. Other			NA	NA	NA	NA
4. Land use, land-use change and forestry	CS,T1,T2	CS,D	CS	D	CS,D,T1	CS,D
A. Forest land	NA	NA	NA	NA	NA	NA
B. Cropland	CS,T1	CS,D			D,T1	CS
C. Grassland	T1	D			D,T1	CS
D. Wetlands	NA	NA			NA	NA
E. Settlements	T1	CS,D			NA	NA
F. Other land	T1	D				
G. Harvested wood products						
H. Other						
5. Waste	NA	NA	NA,T2	CS,NA	NA,T1	D,NA
A. Solid waste disposal	NA	NA	T2	CS		
B. Biological treatment of solid waste			NA	NA	NA	NA
C. Incineration and open burning of waste	NA	NA	NA	NA	NA	NA
D. Waste water treatment and discharge			T2	CS	T1	D
E. Other	NA	NA	NA	NA	NA	NA

1.4.2 Data sources

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

- Fossil fuel data: (1) national energy statistics from Statistics Netherlands (Energy Monitor); (2) natural gas and diesel consumption in the agricultural sector (Agricultural Economics Institute, LEI); (3) (residential) bio fuel data: national renewable energy statistics from Statistics Netherlands (Renewable Energy);
- Transport statistics: (1) monthly statistics for traffic and transport; (2) national renewable energy statistics from Statistics Netherlands (Renewable Energy);
- Industrial production statistics: (1) AERs from individual companies; (2) national statistics;
- Consumption of HFCs: annual reports from the accountancy firm PriceWaterhouseCoopers (only HFC data are used, due to inconsistencies for PFCs and SF_6 with emissions reported elsewhere);
- Consumption/emissions of PFCs and SF_6: reported by individual firms;
- Anaesthetic gas: data provided by the three suppliers of this gas in the Netherlands; Linde gas (former HoekLoos), NTG (SOL group) and Air Liquide;
- Spray cans containing N_2O: the Dutch Association of Aerosol Producers (Nederlandse Aerosol Vereniging, NAV);
- Animal numbers: Statistics Netherlands/LEI agricultural database, plus data from the annual agricultural census;
- • Manure production and handling: Statistics Netherlands/LEI national statistics;
- Fertilizer statistics: LEI agricultural statistics;
- Forest and wood statistics: (1) harvest data: FAO harvest statistics;
  (2) stem volume, annual growth and fellings: Dirkse et al. (2003);
  (3) carbon balance: National Forestry Inventory data based on two inventories: HOSP (1988–1992) and MFV (2001–2005);
- Land use and land use change: based on digitized and digital topographical maps of 1990 and 2004 (Kramer et al., 2009);
- Area of organic soils: Vries (2004);
- Soil maps: Groot et al. (2005 a and b);
- Waste production and handling: Working Group on Waste Registration (WAR), Rijkswaterstaat Environment and Statistics Netherlands;
- CH_4 recovery from landfills: Association of Waste Handling Companies (VVAV).

Many recent statistics are available at Statistics Netherlands' statistical website StatLine and in the Statistics Netherlands/PBL environmental data compendium. It should be noted, however, that the units and definitions used for domestic purposes on those websites occasionally differ from those used in this report (for instance: temperature-

corrected CO_2 emissions versus actual emissions in this report; in other cases, emissions are presented with or without the inclusion of organic CO_2 and with or without LULUCF sinks and sources).

1.4.3 KP-LULUCF inventory

Not reported in this NIR

1.5 Brief description of key categories

1.5.1 GHG inventory

The analysis of key sources is performed in accordance with the 2006 IPCC Guidelines. To facilitate the identification of key sources, the contribution of source categories to emissions per gas is classified according to the IPCC potential key source list as presented in Volume 1, Chapter 4, Table 4.1, of the 2006 IPCC Guidelines. A detailed description of the key source analysis is provided in Annex 1 of this report. Per sector, the key sources are also listed in the first section of each of Chapters 3 to 9.

In comparison with the key source analysis for the NIR 2014 submission, three new key sources were identified:

- 1B2 Fugitive emissions from oil and gas operations: natural gas (CH_4);
- 2A4 Other process uses of carbonates (CO_2);
- 2 Other industrial processes (CH_4).

5D Emissions from wastewater handling (N_2O) is no longer a key source. This is due to reduced emissions as a result of the changed methodology and new data on uncertainty.

1.5.2 KP-LULUCF inventory

Not reported in this NIR.

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

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

1.6.1 GHG inventory

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

- Estimates used for reporting uncertainty in GHG emissions in the Netherlands that were discussed at a national workshop in 1999 (Amstel et al., 2000);
- Default uncertainty estimates provided in the 2006 IPCC Guidelines;
- RIVM fact sheets on calculation methodology and data uncertainty (RIVM, 1999);

- Other information on the quality of data (Boonekamp et al., 2001);
- A comparison with uncertainty ranges reported by other European countries, which has led to a number of improvements in (and increased underpinning of) the Netherlands' assumptions for the present Tier 1 assessment (Ramírez-Ramírez et al., 2006).

These data sources were supplemented by expert judgements by RIVM/PBL and Statistics Netherlands emissions experts. The expert judgements were based on independent uncertainty estimates from these experts. Their views were discussed to reach a consensus on the estimates. This was followed by an estimation of the uncertainty in the emissions in 1990 and 2012 according to the IPCC Tier 1 methodology – for both the annual emissions and the emissions trend for the Netherlands. All uncertainty figures should be interpreted as corresponding to a confidence interval of two standard deviations (2σ), or 95%. In cases where asymmetric uncertainty ranges were assumed, the larger percentage was used in the calculation.

The results of the uncertainty calculation according to the IPCC Tier 1 uncertainty approach are summarized in Annex 2 of this report. The Tier 1 calculation of annual uncertainty in CO_2-equivalent emissions results in an overall uncertainty of approximately 2% in 2013, based on calculated uncertainties of 2%, 18%, 43% and 42% 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 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) or a correction for non-reported sources. Therefore, the Tier 2 uncertainty of total annual emissions per gas (and the total of all gases) will be somewhat higher; see Table 1.3 for the currently estimated values.

Table 1.3 Uncertainty of total annual emissions (excl. LULUCF)

CO_2	± 3%	**HFCs**	± 50%
CH_4	± 25%	**PFCs (incl. NF_3)**	± 50%
N_2O	± 50%	**SF_6**	± 50%
Total GHGs			± 5%

Table 1.4 shows the ten sources (excluding LULUCF) contributing most to total annual uncertainty in 2013, ranked according to their calculated contribution to the uncertainty in total national emissions (using the column 'Combined uncertainty as a percentage of total national emissions in 2013' in Table A7.1).

Table 1.4 Ten sources contributing most to total annual uncertainty in 2013

IPCC category	Category	Gas	Combined uncertainty as a percentage of total national emissions in 2013
3Da	Direct N_2O emissions from agricultural soils	N_2O	1.4%
3B1	Emissions from manure management: cattle	CH_4	1.1%
3B3	Emissions from manure management: swine	CH_4	1.1%
1A2	Stationary combustion: manufacturing industries and construction: liquids	CO_2	.0.9%
3Db	Indirect N_2O emissions from managed soils	N_2O	0.8%
1A1b	Stationary combustion: petroleum refining: liquids	CO_2	0.8%
1A4a	Stationary combustion: other sectors: commercial/institutional: gases	CO_2	0.6%
2F	Product uses as substitutes for ODS	HFC	0.6%
1A4b	Stationary combustion: other sectors, residential: gases	CO_2	0.5%
1A	Emissions from combustion (excluding transport): non-CO_2	CH_4	0.5%

Comparing this data with the NIR 2014, 3B3 Emissions from manure management: swine (CH_4) and 1A Emissions from combustion (excluding transport): non-CO_2 (CH_4) have replaced 4D2 Animal production on agricultural soils (N_2O) and Emissions from manure management (N_2O). This is the result of using the new 2013 emissions and uncertainty data. Table A2.1 of Annex 2 summarizes the estimation of the trend uncertainty for 1990–2013 calculated according to the IPCC Tier 1 approach in the 2006 IPCC Guidelines. The result is a trend uncertainty in total CO_2-equivalent emissions (excluding LULUCF) for 1990–2013 (1995–2013 for F-gases) of ± 2%. This means that the trend in total CO_2-equivalent emissions between 1990 and 2013, which is calculated as -12% (decrease), will be between -14% and -10%.

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. Table 1.5 shows the ten sources (excluding LULUCF) contributing most to the calculated trend uncertainty in the national total.

Table 1.5 Ten sources contributing most to trend uncertainty in the national total in 2013

IPCC cat.	Category	Gas	Uncertainty introduced into the trend in total national emissions
5A	Solid waste disposal	CH_4	1.0%
3Db	Indirect N_2O emissions from managed soils	N_2O	0.9%
1A4a	Stationary combustion: other sectors: commercial/institutional: gases	CO_2	0.7%
3Da	Direct N2O emissions from agricultural soils	N_2O	0.6%
1A4b	Stationary combustion: other sectors, residential: gases	CO_2	0.6%
2F	Product uses as substitutes for ODS	HFC	0.5%
3B3	Emissions from manure management: swine	CH_4	0.5%
1A4c	Stationary combustion: other sectors, agriculture/forestry/fisheries: gases	CO_2	0.5%
1A1b	Stationary combustion: petroleum refining: liquids	CO_2	0.4%
1B2	Fugitive emissions venting/flaring: CO_2	CO_2	0.3%

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

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

Even more important is the fact that, although the uncertainty estimates have been based on the documented uncertainties mentioned above, uncertainty estimates are ultimately – and unavoidably – based on the judgement of the expert. On occasion, only limited reference to actual data for the Netherlands is possible in support of these estimates. By focusing on the order of magnitude of the individual uncertainty estimates, it is expected that this dataset provides a reasonable first assessment of the uncertainty of key source categories.
Furthermore, in 2006 a Tier 2 uncertainty assessment was carried out (Ramírez-Ramírez et al., 2006). This study used the same uncertainty assumption used in the Tier 1 study but accounted for correlations and non-Gaussian distributions. Results reveal that the Tier 2 uncertainty in total Netherlands' CO_2-equivalent emissions is of the same order of

magnitude as that in the Tier 1 results, although a slightly higher trend uncertainty is found (see Tables 1.6 and 1.7).

Table 1.6 Effects of Tier 1 assumptions on the uncertainties of 2004 emissions (without LULUCF)

Greenhouse gas	Tier 1 annual uncertainty	Tier 2 annual uncertainty
Carbon dioxide	1.9%	1.5%
Methane	18.0%	15.0%
Nitrous oxide	45.0%	42.0%
F-gases	27.0%	28.0%
Total	4.3%	3.9%

Table 1.7 Effects of Tier 1 assumptions on the uncertainty in the emissions trend for 1990–2004 (without LULUCF)

Greenhouse gas	Emissions trend 1990–2004	Tier 1 trend uncertainty	Tier 2 trend uncertainty
Carbon dioxide	+13.0%	2.7%	2.1%
Methane	-32.0%	11.0%	15.0%
Nitrous oxide	-16.0%	15.0%	28.0%
F-gases	-75.0%	7.0%	9.1%
Total	+1.6%	3.2%	4.5%

The Tier 2 uncertainty for 1990 emissions is slightly higher (approximately 1.5%) than the uncertainty for the 2004 emissions.The resulting distribution for total CO_2-equivalent emissions in the Netherlands turns out to be clearly positively skewed.

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

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

A independent verification of emissions levels and emissions trends using, for example, comparisons with atmospheric concentration measurements is, therefore, encouraged by the IPCC Good Practice Guidance (IPCC, 2001). 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

Not reported in this NIR.

1.7 General assessment of completeness

1.8.1 GHG inventory

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

1.8.2 KP-LULUCF inventory

Not reported in this NIR.

2 Trends in GHG emissions

Chapter 2 summarizes the trends in GHG emissions during the period 1990–2013 by GHG and by sector. Detailed explanations of these trends are provided in Chapters 3–8. In 2013, total direct GHG emissions (excluding emissions from LULUCF) in the Netherlands were estimated at 195.8 Tg CO_2 eq. This is 11.5% lower than the 221.1 Tg CO_2 eq reported in the base year (1990; 1995 for fluorinated gases (F-gases)).

Figure 2.1 shows the trends and relative contributions of the different gases to the aggregated national GHG emissions. In the period 1990–2013, emissions of carbon dioxide (CO_2) increased by 3.5% (excluding LULUCF), while emissions of non-CO_2 GHGs decreased by 49% compared with base year emissions. Of the non-CO_2 GHGs, methane (CH_4), nitrous oxide (N_2O) and F-gases decreased by 42%, 56% and 75%, respectively.

Emissions of LULUCF-related sources increased by about 1% in 2013 compared with 2012. In 2013, total GHG emissions (including LULUCF) decreased by 0.4 Tg CO_2 eq compared with 2012 (202.0 Tg CO_2 eq in 2013).

2.2 Emissions trends by gas

2.2.1 Carbon dioxide

Figure 2.2 shows the contribution of the most important sectors, as defined by the Intergovernmental Panel on Climate Change (IPCC), to the trend in total national CO_2 emissions (excluding LULUCF). In the period 1990–2013, national CO_2 emissions increased by 3.6% (from 160.5 to 166.2 Tg). The Energy sector is by far the largest contributor to CO_2 emissions in the Netherlands (96%), the categories 1A1 Energy industries (38%), 1A4 Other sectors (24%) and 1A3 Transport (22%) being the largest contributors in 2013.

The relatively high level of CO_2 emissions in for instance 2010 is mainly explained by the cold winter, which increased energy use for space heating in the residential sector. The resulting emissions are included in category 1A4 (Other sectors). The relatively low level of CO_2 emissions in 2013 is explained by relatively warm winter.

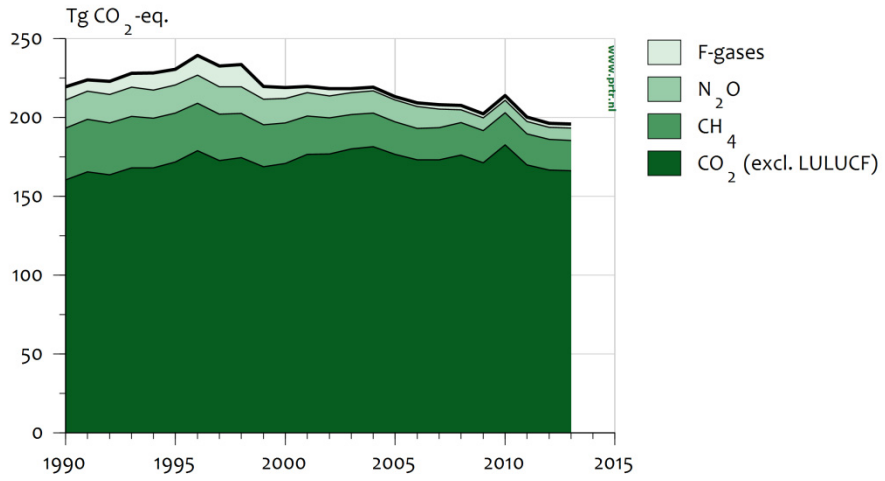


Figure 2.1 Greenhouse gases: trend and emissions levels (excl. LULUCF), 1990–2013

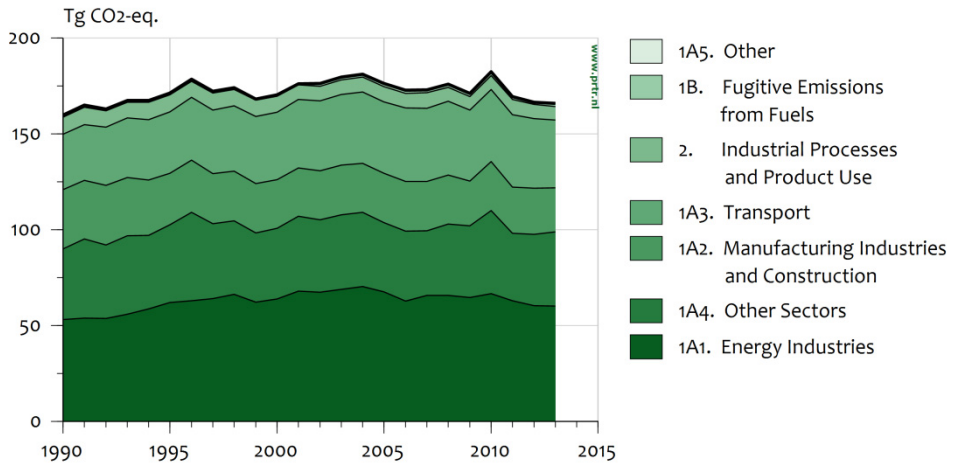


Figure 2.2 CO_2: trend and emissions levels of sectors (excl. LULUCF), 1990–2013

2.2.2 *Methane*

Figure 2.3 shows the contribution of the principal sectors to the trend in total CH_4 emissions. National CH_4 emissions decreased by 42%, from 32.9 Tg in 1990 to 19.2 Tg CO_2 eq in 2013. The Agriculture and Waste sectors (65% and 19%, respectively) were the largest contributors in 2013.

Compared with 2012, national CH_4 emissions decreased by about 0.1% in 2013 (0.01 Tg CO_2 eq). CH_4 emissions decreased in the category 5A

(Solid waste disposal on land) but were balanced by an increase in emissions from Agriculture.

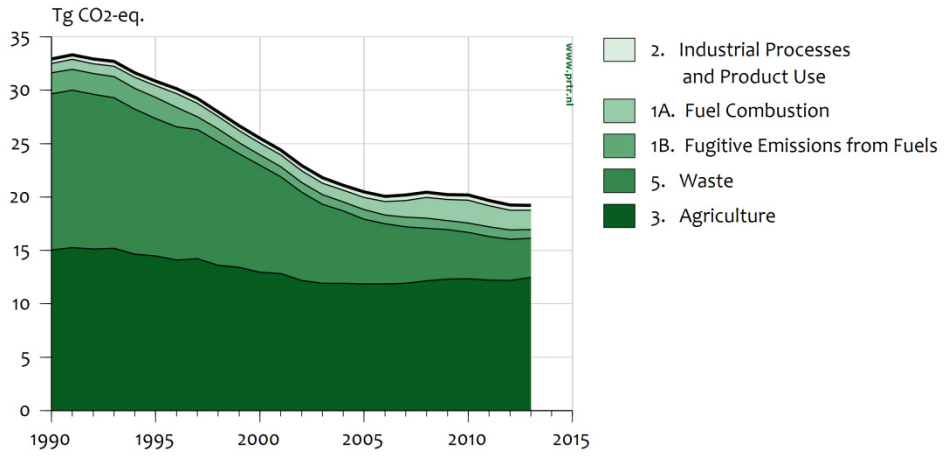


Figure 2.3 CH_4: trend and emissions levels of sectors, 1990–2013

2.2.3 *Nitrous oxide*

Figure 2.4 shows the contribution of the principal sectors to the trend in national total N_2O emissions. The total national inventory of N_2O emissions decreased by about 55%, from 17.6 Gg CO_2 eq in 1990 to 7.9 Tg CO_2 eq in 2013. The Industrial processes sector contributed the most to this decrease in N_2O emissions (emissions decreased by more than 81% compared with the base year).

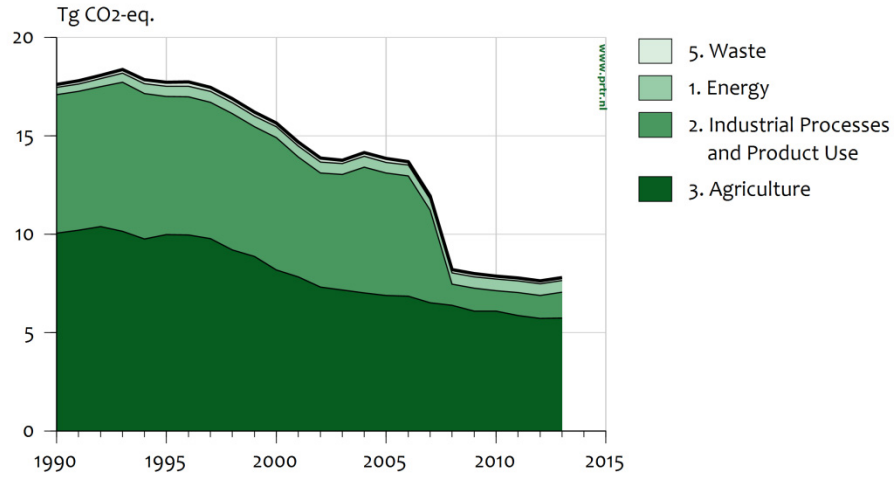


Figure 2.4 N_2O: trend and emissions levels of sectors, 1990–2013

Compared with 2012, total N_2O emissions increased by 2.3% in 2013, mainly due to a rise in emissions in the chemical industry.

2.2.4 *Fluorinated gases*

Figure 2.5 shows the trend in F-gas emissions included in the national GHG inventory. Total emissions of F-gases decreased by 75% from 10.1 Tg CO_2 eq in 1995 (base year for F-gases) to 2.6 Tg CO_2 eq in 2013. Emissions of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) decreased by approximately 70% and 95%, respectively, during the same period, while sulphur hexafluoride (SF_6) emissions decreased by 52%. It should be noted that due to national circumstances the emissions of NF_3 can not be reported separately and are included in the PFC emissions.

Emissions between 2012 and 2013 decreased by 0.4% and 27%, respectively, for HFCs and PFCs. SF_6 emissions decreased by 29% in the same period. The aggregated emissions of F-gases decreased by 3.5%.

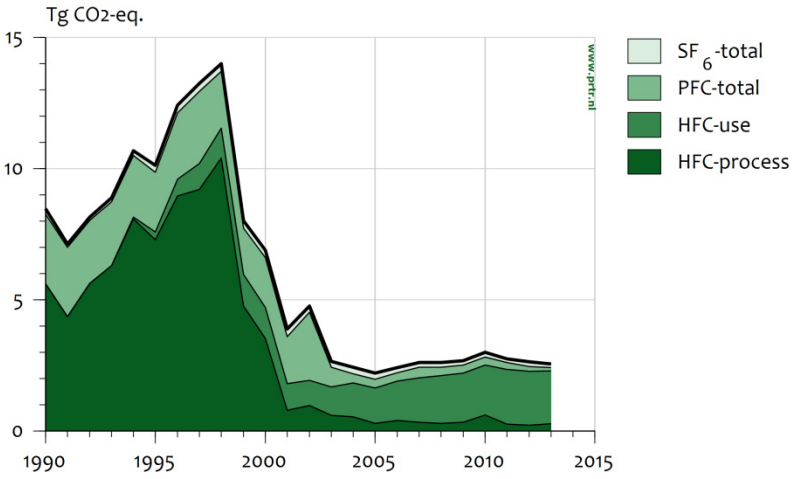


Figure 2.5 Fluorinated gases: trend and emissions levels of individual F-gases, 1990–2013

2.2.5 *Uncertainty in emissions specified by greenhouse gas*

The uncertainty in the trend of CO_2 equivalent emissions of the six GHGs together is estimated to be approximately 2%, based on the IPCC Tier 1 Trend Uncertainty Assessment; see Section 1.7. For each individual gas, the trend uncertainty in total emissions of CO_2, CH_4, N_2O and the sum of the F-gases is estimated to be ± 2%, ± 6%, ± 7% and ± 11%, respectively. For all GHGs taken together, the uncertainty estimate in annual emissions is ± 3% and for CO_2 ± 2%. The uncertainty estimates in annual emissions of CH_4 and N_2O are ± 25% and ± 50%, respectively, and for HFCs, PFCs and SF_6, ± 50% (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.
The IPCC Energy sector is by far the largest contributor to total GHG emissions in the national inventory (contributing 70% in the base year and 83% in 2013; the relative share of the other sectors decreased correspondingly). The emissions level of the Energy sector increased by approximately 5% in the period 1990–2013, and total GHG emissions from the Waste, Industrial processes and Agriculture sectors decreased by 74%, 54% and 28%, respectively, in 2013 compared with the base year.

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

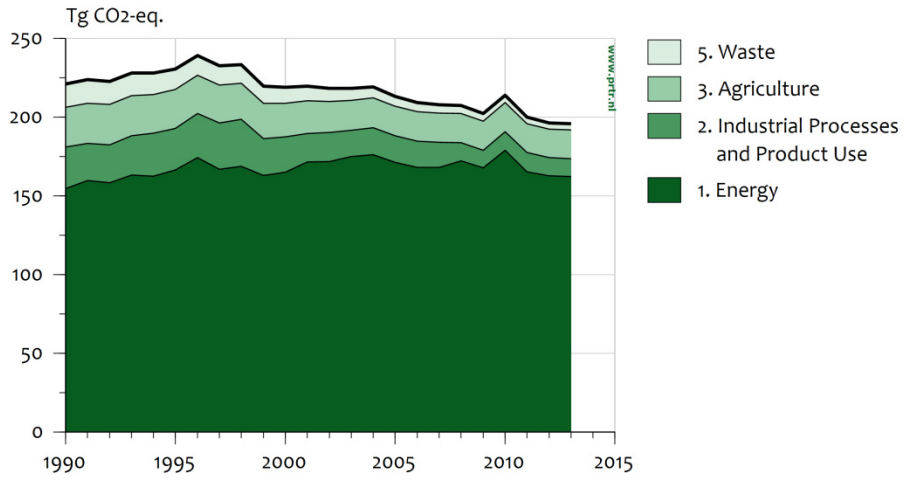


Figure 2.6 Aggregated GHGs: trend and emissions levels of sectors (excl. LULUCF), 1990–2013

CO_2 emissions from LULUCF increased in the period 1990–2013 from 5.7 to 6.2 Tg CO_2 eq.

2.3.1 Uncertainty in emissions by sector

The uncertainty estimates in annual CO_2-equivalent emissions of IPCC sectors Energy (1), Industrial processes (2), Agriculture (3) and Waste (4) are about ± 2%, ± 10%, ± 24% and ± 21%, respectively; for the LULUCF sector (4) the uncertainty is estimated at ± 100%. The uncertainty in the trend of CO_2-equivalent emissions per sector is calculated for sector 1 (Energy) at ± 2% in the 5% increase, for sector 2 (Industrial processes) at ± 7% in the 57% decrease, for sector 3 (Agriculture) at ± 8% in the 28% decrease and for sector 5 (Waste) at ± 1% in the 74% decrease.

2.4 Emissions trends for indirect greenhouse gases and SO2

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 2013 reduced by 50% and 69%, respectively. For SO_2, the reduction was 85%; and for NO_x, 2013 emissions were 60% 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 CO from industrial sources have not been verified. Therefore, the emissions data for the years 1991–1994 and 1996–1998. are of poor quality. The same holds for the emissions of other compounds in these years.

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

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

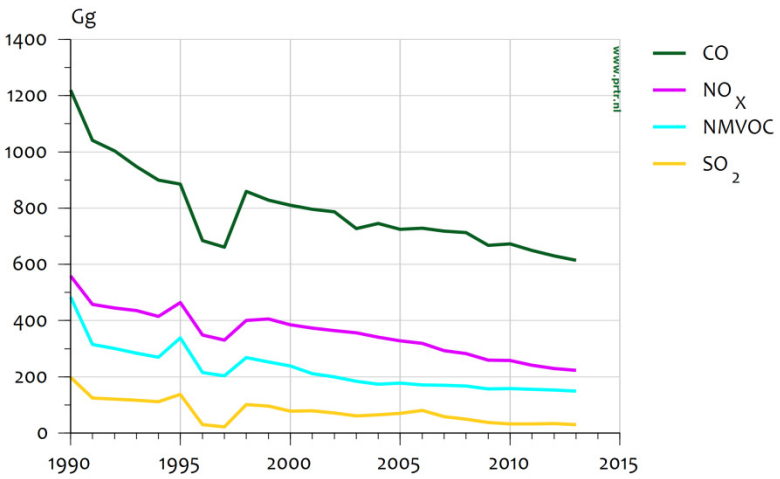


Figure 2.7 Emissions levels and trends of CO, NO_x, NMVOC and SO_2 (Gg)

3 Energy (CRF sector 1)

Major changes in the Energy sector compared with the National Inventory Report 2014

Emissions:	Compared with 2012, GHG emissions in the energy sector decreased by 0.2%.
Key sources:	Fugitive emissions from oil and gas operations: natural gas (1B2) is now a key source
Methodologies:	New emission factors for fuel combustion
Activity data:	Fuel use by fisheries and the military was updated due to a revision of the energy statistics

3.1 Overview of sector

Energy supply and energy demand

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

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

Emissions from fuel combustion are consistent with national energy statistics. However, the time series of the energy statistics is not fully consistent at the detailed sector and detailed fuel-type levels for the years 1991–1994. This inconsistency was caused by revisions in the economic classification scheme implemented in 1993, a change from the 'special trade' to 'general trade' system to define the domestic use of oil products, some error corrections and the elimination of statistical differences. These changes were incorporated into the datasets for 1990, 1995 and subsequent years, leaving the existing inconsistency within the 1991–1994 dataset. For the base year 1990, Statistics Netherlands has reassessed the original statistics and made them compatible with the 'new' 1993 classification system, and the ECN (Energy Research Centre of the Netherlands) was commissioned to recalculate the statistics of 1991–1994 at a higher level of detail (for both fuels and sectors). This is visible in Figure 3.1, where fuel use in these years is shown only as a total value and not specified allocated to individual fuels .

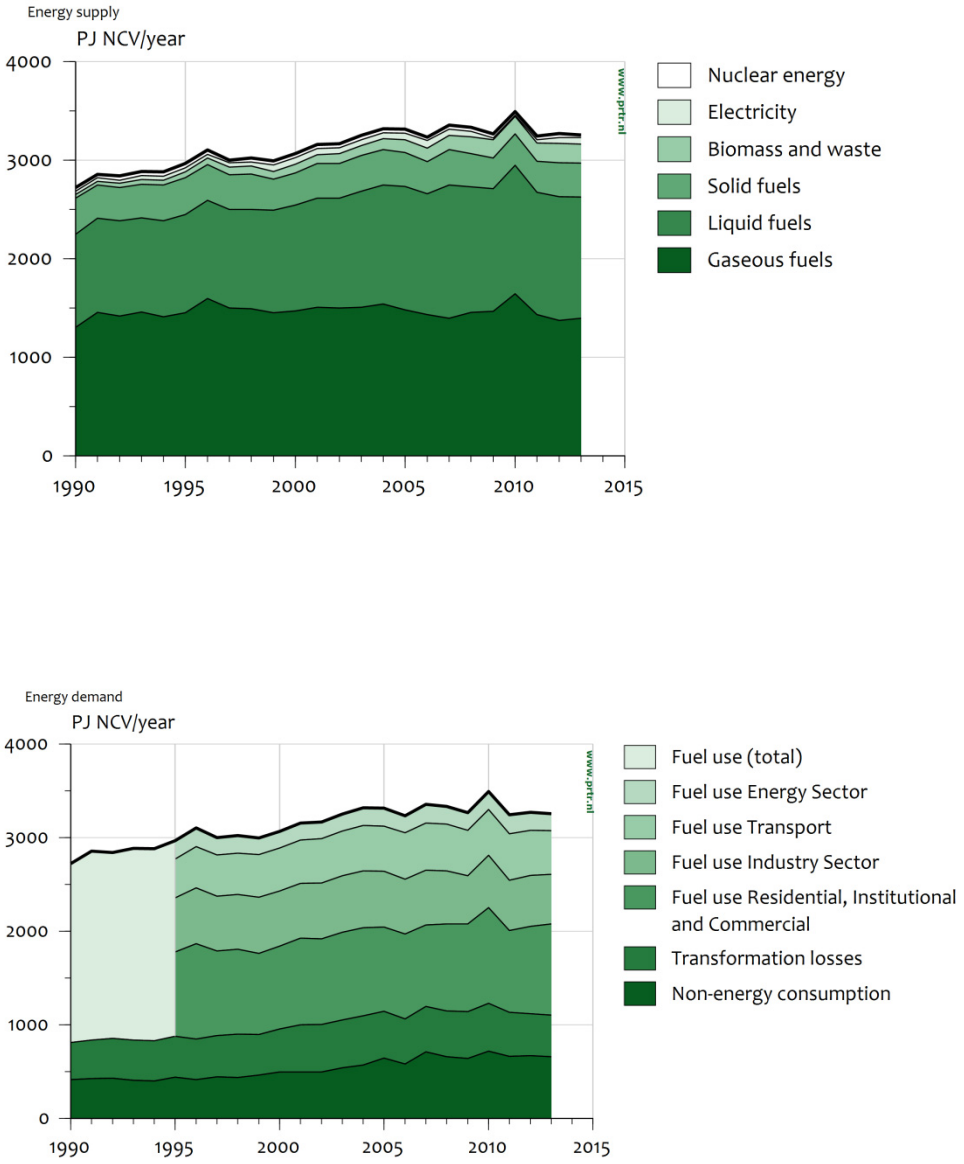


Figure 3.1 Overview of energy supply and energy demand in the Netherlands (For the years 1990–1994, only the total fuel use is shown. See Section 3.1.1 for an explanation. 'Electricity' refers to imported electricity only.)

Trends in fossil fuel use and fuel mix

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

Although the combustion of fossil waste (reported under Other fuels) has increased fourfold since 1990, its share in total fossil fuel use is still

only 1% at the present time. In the 1990–2013 period, total fossil fuel combustion increased by 14%, due to a 7% increase in gas consumption, while liquid fuel use increased by 30%. At the same time, the combustion of solid fuels decreased by 7%.

Total fossil fuel consumption for combustion decreased by about 0.2% between 2012 and 2013, mainly due to a 2.1% decrease in liquid fuel consumption, a 0.6% decrease in gas consumption and a 1.7% increase in solid fuel consumption. The increase in solid fuel consumption and decrease in gaseous fuel consumption were mainly caused by the relatively low prices of coal in the public electricity sector and the increased import of electricity.

The year 2010 had a cold winter compared with the other years. This caused an increase in the use of gaseous fuel for space heating in 2010 compared with other years.

3.1.1 GHG emissions from the Energy sector

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

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

The energy sector includes:

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

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

Overview of shares and trends in emissions

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

Key sources

Table 3.1 presents the key categories in the Energy sector specified by both level and trend (see also Annex 1). The key categories 1A1, 1A2, 1A3 and 1A4 are based on aggregated emissions by fuel type and category, which is in line with the IPCC Guidelines (see Volume 1, Table 4.1 in IPCC, 2006). Since CO_2 emissions have the largest share in the

total of national GHG emissions, it is not surprising that a large number of CO_2 sources are identified as key categories. The total CH_4 emissions from stationary combustion sources taken together are also identified as a key category.

Compared with the previous submission, Fugitive emissions from oil and gas operations: natural gas (1B2) is now a key source.

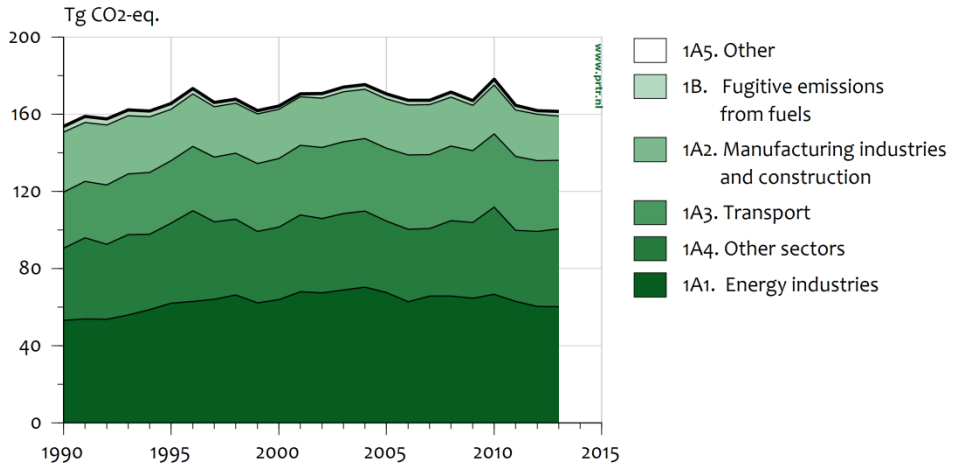


Figure 3.2 Sector 1 Energy: trend and emissions levels of source categories, 1990–2013

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

			Emissions in Tg CO_2 eq			**Tg CO_2 eq**	**Contribution to total in 2013 (%)**		
Sector/category	**Gas**	**Key**	**Base year**	**2012**	**2013**	**Change 2012–2013**	**By sector**	**Of total gases**	**Of total CO_2 eq**
1 Energy	CO_2		151.4	159.3	159.1	-0.3	98.0	95.6	81.2
	CH_4		2.8	2.7	2.6	0.0	1.6	0.5	1.3
	N_2O		0.4	0.6	0.6	0.0	0.4	0.0	0.3
	All		154.6	162.7	162.3	-0.4	100.0		82.9
1A Fuel combustion	CO_2		150.2	158.3	157.4	-0.9	97.0	94.7	80.4
	CH_4		0.9	1.9	1.8	0.0	1.1	0.4	0.9
	N_2O		0.4	0.6	0.6	0.0	0.4	0.0	0.3
	All		151.5	160.7	159.8	-0.9	98.5		81.6
1A Emissions from stationary combustion	CH_4	L,T	0.7	1.8	1.8	0.0	1.1	0.4	0.9
1A1 Energy industries	CO_2		53.1	60.4	60.3	-0.2	37.1	36.3	30.8
1A1a Public electricity and heat production	CO_2		39.9	48.1	48.3	0.2	29.7	29.0	24.7

			Emissions in Tg CO_2 eq			Tg CO_2 eq	Contribution to total in 2013 (%)		
Sector/category	**Gas**	**Key**	**Base year**	**2012**	**2013**	**Change 2012–2013**	**By sector**	**Of total gases**	**Of total CO_2 eq**
1A1a liquids	CO_2	L,T	0.2	1.0	1.0	0.0	0.6	0.6	0.5
1A1a solids	CO_2	L,T1	25.8	25.9	26.3	0.4	16.2	15.8	13.4
1A1a gas	CO_2	L1,T1	13.3	18.6	18.1	-0.4	11.2	10.9	9.3
1A1a other fuels: waste incineration	CO_2	L1,T	0.6	2.6	2.8	0.2	1.7	1.7	1.4
1A1b petroleum refining	CO_2		11.1	9.8	9.3	-0.5	5.7	5.6	4.7
1A1b liquids	CO_2	L,T	10.0	6.4	5.9	-0.5	3.6	3.5	3.0
1A1b gases	CO_2	L1,T1	1.0	3.3	3.4	0.1	2.1	2.0	1.7
1A1c manufacture of solid fuels and other energy industries	CO_2		2.2	2.6	2.7	0.2	1.7	1.6	1.4
1A1c gases	CO_2	L,T	1.5	2.1	2.1	0.1	1.3	1.3	1.1
1A2 Manufacturing industries and construction	CO_2		31.0.	24.0	22.9	-1.1	14.1	13.8	11.7
1A2 liquids	CO_2	L,T	7.6.	7.3	6.8	-0.5	4.2	4.1	3.5
1A2 solids	CO_2	L,T1	4.4	3.5	3.0	-0.5	1.9	1.8	1.6
1A2 gases	CO_2	L,T1	19.0	13.2	13.1	-0.1	8.1	7.9	6.7
1A2a iron and steel	CO_2		3.4	3.8	3.5	-0.3	2.2	2.1	1.8
1A2b non-ferrous metals	CO_2		0.2	0.2	0.2	0.0	0.1	0.1	0.1
1A2c chemicals	CO_2		17.4	12.6	12.2	-0.4	7.5	7.3	6.2
1A2d pulp. paper and print	CO_2		1.7	1.1	1.0	-0.1	0.6	0.6	0.5
1A2e food processing. beverages and tobacco	CO_2		4.1	3.4	3.3	-0.1	2.0	2.0	1.7
1A2f non-metallic minerals	CO_2		2.3	1.2	1.1	-0.1	0.7	0.7	0.6
1A2g other	CO_2		1.9.	1.7	1.7	-0.1	1.0	1.0	0.9
1A3 Transport	CO_2		28.8.	36.4	35.3	-1.1	21.7	21.2	18.0
	N_2O		0.1	0.2	0.3	0.0	0.2	0.0	0.1
	All		29.1.	36.7	35.6	-1.1	21.9		18.2
1A3a civil aviation	CO_2		0.08	0.0	0.0	0.0	0.0	0.0	0.0
1A3b road	CO_2		25.3	32.6	31.4	-1.1	19.4	18.9	16.0

			Emissions in Tg CO_2 eq			Tg CO_2 eq	Contribution to total in 2013 (%)		
Sector/category	**Gas**	**Key**	**Base year**	**2012**	**2013**	**Change 2012–2013**	**By sector**	**Of total gases**	**Of total CO_2 eq**
1A3b petrol	CO_2	L,T1	10.8	12.4	12.0	-0.5	7.4	7.2	6.1
1A3b diesel oil	CO_2	L,T	11.8	19.4	18.8	-0.6	11.6	11.3	9.6
1A3b LPG	CO_2	L1,T1	2.7	0.7	0.6	0.0	0.4	0.4	0.3
1A3b road	N_2O	T2	0.1	0.2	0.2	0.0	0.1	0.0	0.1
1A3c railways	CO_2		0.1	0.1	0.1	0.0	0.1	0.0	0.0
1A3d navigation	CO_2	L1,T1	0.7	1.1	1.1	0.1	0.7	0.7	0.6
1A4 Other sectors	CO_2		36.8.	37.2	38.7	1.5	23.8	23.3	19.8
	CH_4		0.5	1.6	1.6	0.0	1.0	0.3	0.8
	All		37.4.	38.8	40.3	1.5	24.8		20.6
1A4 liquids (excl. from 1A4c)	CO_2	T	3.0	0.6	0.7	0.1	0.4	0.4	0.4
1A4a commercial/institutional	CO_2		8.4	11.4	11.9	0.5	7.3	7.1	6.1
1A4a gas	CO_2	L,T	7.6	11.1	11.5	0.4	7.1	6.9	5.9
1A4b residential gas	CO_2	L,T1	19.5	17.9	19.0	1.1	11.7	11.4	9.7
	CH_4		0.4	0.4	0.5	0.0	0.3	0.1	0.2
1A4b gases	CO_2		18.7	17.7	18.7	1.1	11.5	11.3	9.6
1A4c agriculture/forestry/fisheries	CO_2		9.0	7.8	7.8	0.0	4.8	4.7	4.0
1A4c liquids	CO_2	L,T	0.0	0.6	0.6	0.0	0.4	0.3	0.3
1A4c gases	CO_2	L,T	7.3	7.2	7.1	-0.1	4.4	4.3	3.6
1A5 Other	CO_2		0.4	0.2	0.2	0.0	0.1	0.1	0.1
1B Fugitive emissions from fuels	CO_2		1.2	1.1	1.7	0.6	1.0	1.0	0.9
	CH_4		2.0	0.9	0.8	0.0	0.5	0.2	0.4
	All		3.1	1.9	2.5	0.6	1.5		1.3
1B1b coke production	CO_2		0.4	0.3	0.6	0.3	0.4	38.1	0.3
1B2 Venting/flaring	CO_2	T	0.8	0.1	0.1	0.0	0.0	3.8	0.0
	CH_4	T	1.5	0.4	0.3	0.0	0.2	0.1	0.2
Total national emissions	CO_2		160.5	166.8	166.2	-0.5		100	84.9
	CH_4		823.4	481.0	480.7	-0.3		100	245.5

			Emissions in Tg CO_2 eq			Tg CO_2 eq	Contribution to total in 2013 (%)		
Sector/category	**Gas**	**Key**	**Base year**	**2012**	**2013**	**Change 2012–2013**	**By sector**	**Of total gases**	**Of total CO_2 eq**
	N_2O		5.247.6	2.273.4	2.323.9	50.5		100	1186.8
National total GHG emissions (excl. CO_2 LULUCF)	All		221.1	196.3	195.8	-0.5			100.0

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

3.2 Fuel combustion (1A)

3.2.1 Comparison of the sectoral approach with the Reference Approach

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

Energy supply balance

The energy supply balance for the Netherlands in 1990 and 2013 is shown in Table 3.2 at a relatively high aggregation level. The Netherlands produces large amounts of natural gas, both onshore (Groningen gas) and offshore; a large share of the gas produced is exported. Natural gas represents a very large share of the national energy supply.

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

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

Year	Role	Indicator name	Solid fuels	Crude oil and petroleum	Gas
1990	Supply	Primary production	0	171	2,301
		Total imports	491	5,367	85
		Stock change	-22	2	0
		Total exports	-101	-4,076	-1,081
		Bunkers	0	-500	0
	Consump-tion	Gross inland consumption	-368	-964	-1305
		whereof: Final non-energy consumption	-11	-328	-101

Year	Role	Indicator name	Solid fuels	Crude oil and petroleum	Gas
2013	Supply	Primary production	0	65	2,587
		Total imports	1,063	7,949	810
		Stock change	-38	1	6
		Total exports	-683	-6,108	-2,007
		Bunkers	0	-677	0
	Consump-tion	Gross inland consumption	-342	-1,231	-1,396
		whereof: Final non-energy consumption	-7	-610	-82

Comparison of CO_2 emissions

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

National energy statistics are provided by Statistics Netherlands. National default, partly country-specific, CO_2 emission factors are taken from Zijlema, 2015 (see Annex 2.1, Table A2.1). Carbon storage fractions are the average of annual carbon storage fractions calculated per fossil fuel type for 1995–2002 from reported CO_2 emissions in the sectoral approach and are kept constant over time.

Table 3.3 presents the results of the RA calculation for 1990–2013, compared with the official national total emissions reported as fuel combustion (source category 1A). The annual difference calculated from the direct comparison varies between 2% and 5%. The reasons for the differences in results between these two methods are explained below.

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

	1990	1995	2000	2005	2010	2011	2012	2013
RA								
Liquid fuels [1)]	45.7	46.9	54.1	55.7	55.0	54.6	54.6	52.6
Solid fuels [1)]	34.0	34.7	30.5	32.2	29.7	29.3	32.2	32.2
Gaseous fuels	71.9	79.9	81.0	81.8	90.9	79.0	75.7	77.1
Others	0.6	0.8	1.6	2.1	2.5	2.6	2.6	2.8
Total RA	152.2	162.3	167.2	171.7	178.1	165.5	165.1	164.8
NA								
Liquid fuels	50.0	52.7	54.7	56.3	54.4	53.9	52.5	50.4
Solid fuels	31.0	32.4	28.8	30.2	28.3	27.4	29.9	30.0
Gaseous fuels	68.6	76.0	76.7	78.5	88.1	76.5	73.2	74.2

	1990	1995	2000	2005	2010	2011	2012	2013
Others	0.6	0.8	1.6	2.1	2.5	2.6	2.6	2.8
Total NA	150.2	161.9	161.8	167.1	173.3	160.4	158.3	157.4
Difference (%)								
Liquid fuels	-8.7%	-11.0%	-1.0%	-1.1%	1.0%	1.4%	4.0%	4.4%
Solid fuels	9.8%	7.2%	6.1%	6.6%	5.0%	6.9%	7.4%	7.6%
Gaseous fuels	4.8%	5.2%	5.5%	4.2%	3.2%	3.3%	3.4%	3.9%
Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	1.3%	0.3%	3.4%	2.8%	2.7%	3.2%	4.3%	4.7%

Causes of differences between the two approaches
There are three main reasons for differences between the two approaches (see Table 3.4):

1. The fossil fuel-related emissions reported as Process emissions (sector 2) and fugitive emissions (category 1B) are not included in the Sectoral Approach total of category 1A. The most significant of these are gas used as feedstock in Ammonia production (2B1) and Losses from coke/coal inputs in blast furnaces (2C1).
2. The country-specific carbon storage factors used in the RA are multi-annual averages, so the RA calculation for a specific year will deviate somewhat from the factors that could be calculated from the specific mix of feedstock/non-energy uses of different fuels.
3. The use of plant-specific carbon emission factors in the NA vs. national default emission factors in the RA.

Correction of inherent differences
The correction terms for the RA/NA total are selected CRF sector 2 components listed in Table 3.4 and selected fugitive CO_2 emissions included in CRF sector 1B.

If the NA is corrected by including category 1B and sector 2 emissions that should be added to the 1A total before the comparison is made (see Table 3.4), then a much smaller difference remains between the approaches. The remaining difference is generally below ± 2%. The remaining difference is due to the use of one multi-annual average carbon storage factor per fuel type in all years and plant-specific EFs in some.

Table 3.4 Corrections of RA and NA for a proper comparison (Tg)

	1990	1995	2000	2005	2010	2012	2013
Difference RA–NA	2.0	0.4	5.4	4.7	4.8	6.8	7.4
Reference Approach:	152.2	162.3	167.2	171.7	178.1	165.1	164.8
National Approach:	150.2	161.9	161.8	167.1	173.3	158.3	157.4
CO_2 **fossil in cat. 1B**	0.8	0.8	0.6	1.6	2.0	1.1	1.7
1B1b Solid fuel transf.	0.4	0.5	0.4	0.6	1.0	0.3	0.6
1B2c Flaring	0.4	0.3	0.2	0.1	0.1	0.1	0.1
1B2a–iv Oil refining	NA	NA	NA	0.9	1.0	0.7	1.0

	1990	1995	2000	2005	2010	2012	2013
CO_2 fossil in Sector 2:	6.3	6.5	5.8	5.2	4.8	5.1	5.0
2B1 Ammonia production	0.1	0.3	0.1	0.1	NO	NO	NO
2B7 Soda ash production	0.2	0.3	0.3	0.3	0.2	0.2	0.2
2C1 Iron and steel production	6.3	6.5	5.8	5.2	4.8	5.1	5.0
2D1 Lubricant use	0.1	0.3	0.1	0.1	NO	NO	NO
2H2 Food and beverages industry	0.2	0.3	0.3	0.3	0.2	0.2	0.2
NA+1B+Ind. proc.	157.4	169.2	168.2	173.9	180.1	164.4	164.1
RA	152.2	162.3	167.2	171.7	178.1	165.1	164.8
New difference (abs)	-5.2	-6.9	-1.0	-2.2	-2.0	0.7	0.7
New difference (%)	-3.4%	-4.2%	-0.6%	-1.3%	-1.1%	0.4%	0.4%

Feedstock component in the CO_2 RA
Feedstock/non-energy uses of fuels in the energy statistics are also part of the IPCC Reference Approach for the calculation of CO_2 emissions from fossil fuel use. The fraction of carbon not oxidized during the use of these fuels in product manufacture or for other purposes is subtracted from the total carbon contained in total apparent fuel consumption in each fuel type. The fractions stored/oxidized are calculated as three average values: for gas and for liquid and solid fossil fuels:

- 77.7 ± 2% for liquid fuels;
- 57.5 ± 13% for solid fuels;
- 38.8 ± 4% for natural gas.

These are calculated for all processes for which emissions are calculated in the NA, either by assuming a fraction oxidized, for example ammonia, or by accounting for by-product gases (excluding emissions from blast furnaces and coke ovens). In Table A.4.4 of the NIR 2005, the calculation of annual oxidation fractions for 1995–2002 is presented along with the average values derived from them. The table shows, indeed, that the factors are subject to significant interannual variation, particularly the factor for solid fuels.

The use of one average storage/oxidation factor per fuel type for all years, despite the fact that, in the derivation of the annual oxidation, differences of up to a few per cent can be observed, is one reason for the differences between the RA and the corrected NA.

In the Netherlands, about 10–25% of all carbon in the apparent consumption of fossil fuels is stored in manufactured products.

Other country-specific data used in the RA
Apart from different storage/oxidation fractions of the non-energy use of fuels, as presented in the previous paragraph, other country-specific information used in the RA is found in:

- ***Carbon contents (CO_2 emission factors) used***
  For the fuels used in the RA, the factors used are listed in the Netherlands' list of fuels (Zijlema, 2015). These are the national defaults. For 'other bituminous coal' and 'BKB and patent fuel',

the values of bituminous coal and coal bitumen, respectively, are used.

- ***Fuel consumption in international marine and aviation bunkers***
  Some changes are made annually in the national energy statistics on total apparent consumption, mainly for diesel, jet kerosene and residual fuel oil, due to the reallocation for the emissions inventory of part of the bunker fuels to domestic consumption (e.g. fisheries and inland navigation). This explains the difference between the original bunker statistics in the national energy statistics (and as reported to international agencies such as the IEA) and the bunker fuel data used in the RA calculation.

3.2.2 International bunker fuels

The Rotterdam area has four large refineries, producing large quantities of heavy fuel oils. A large proportion of these heavy fuel oils is sold as international bunkers. In addition, most marine fuel oil produced in Russia is transported to Rotterdam, where it is sold on the market. Combined, this makes Rotterdam the world's largest supplier of marine bunker fuel. The quantities of this bunker fuel are shown in Figure 3.3. The Dutch refineries also produce considerable amounts of aviation fuel, which is delivered to airlines at airports. In addition, Schiphol Airport is Western Europe's largest supplier of aviation bunker fuels (jet fuel). Given the small size of the country, almost all of the aviation fuel is used by non-Dutch operators. Figure 3.3 shows the time series of the fuel quantities exported as marine and aviation bunker fuels.

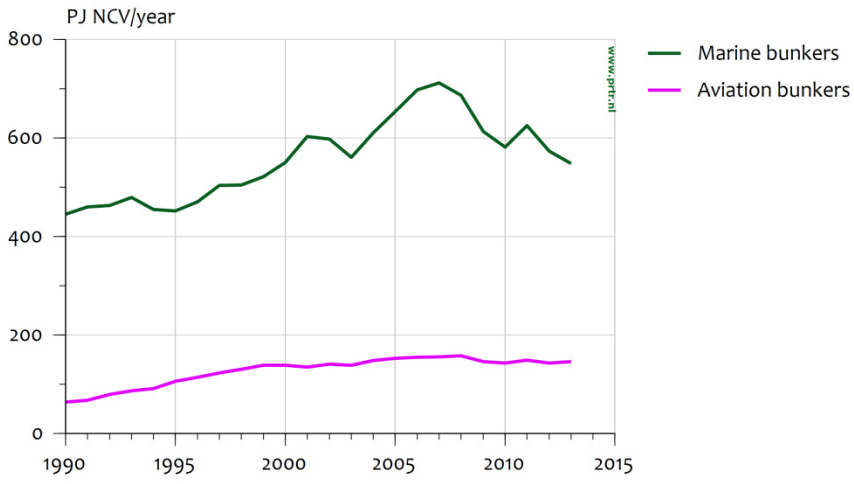


Figure 3.3 Marine and aviation bunker fuel exports (PJ NCV/year)

3.2.3 Feed stocks and non-energy use of fuels

Table 3.2 shows that a large share of the gross national consumption of petroleum products was used in non-energy applications. These fuels were mainly used as feedstock (naphta) in the petro-chemical industry and in products in many applications (bitumen, lubricants, etc.). Also, a fraction of the gross national consumption of natural gas (mainly in ammonia production) and coal (mainly in iron and steel production) was used in non-energy applications and hence not directly oxidized. In

many cases, these products are finally oxidized in waste incinerators or during use (e.g. lubricants in two-stroke engines). In the RA, these product flows are excluded from the calculation of CO_2 emissions.

3.2.4 Energy industries (1A1)

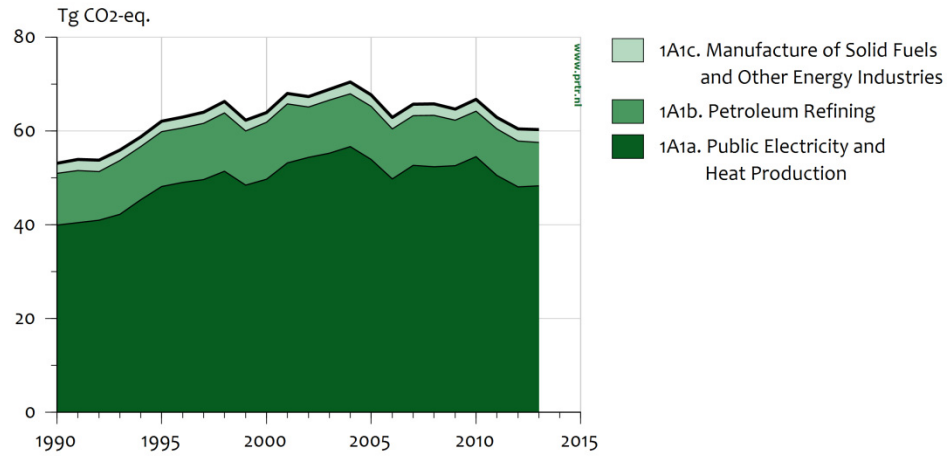


Figure 3.4 1A1 Energy industries: trend and emissions levels by source sub-category, 1990–2013

3.2.4.1 Category description

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

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

Within this category, natural gas and coal combustion in public electricity and heat production, and oil combustion in petroleum refining are the biggest sources. Other key sources are liquid fuels and other fuels (waste) in public electricity and heat production, and natural gas combustion in petroleum refining and in the manufacture of solid fuels and other energy industries. CH_4 and N_2O emissions from 1A1 contribute relatively little to the total national inventory of GHG emissions. CH_4 from stationary combustion is a key source, on account of an increase of the CH_4 emission factor due to the proliferation of small combined heat and power (CHP) plants. N_2O emissions from Energy industries are not a key source (see Table 3.1).

Public electricity and heat production (1A1a)

The Dutch electricity sector has a few notable features: it has a large share of coal-fired power stations and a large proportion of gas-fired cogeneration plants, many of the latter being operated as joint ventures with industries. In comparison with some other countries in the EU, nuclear energy and renewable energy provide very little of the total

primary energy supply in the Netherlands. The two main renewable energy sources are biomass and wind. The public electricity and heat production source category also includes all emissions from large-scale waste incineration, since all incineration facilities produce heat and/or electricity and the waste incinerated in these installations is therefore regarded as a fuel. In addition, a large proportion of the blast furnace gas and a significant part of the coke oven gas produced by the single iron and steel plant in the Netherlands is combusted in the public electricity sector (see Figure 3.5).

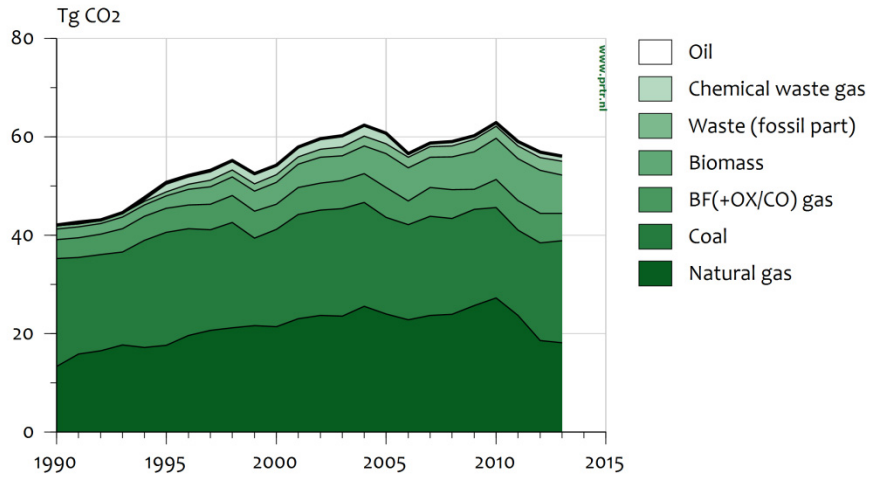


Figure 3.5 Trend in sources of CO_2 from fuel use in power plants (The abbreviation BF(+OX/CO) refers to blast furnace gas, oxygen furnace gas and coke oven gas.)

1A1a (public electricity and heat production) is the largest source category within the 1A1 Energy industries category (see Figure 3.4 and Table 3.1). Between 1990 and 2013, total CO_2 emissions from public electricity and heat production increased. The increasing trend in electric power production corresponds to a substantial increase in CO_2 emissions from fossil fuel combustion by power plants, which is partly compensated for by a shift from coal to natural gas and the increased efficiency of power plants.

CO_2 emissions from the waste incineration of fossil carbon increased due to the increasing amounts of municipal waste that are combusted instead of being deposited in landfills, which is the result of environmental policy aimed at reducing waste disposal in landfills as well as the import of waste (see Chapter 7). The increase in the CO_2 emission factor for other fuels since 2004 is due to the increase in the share of plastics (which have a high carbon content) in combustible waste (see Table 7.3 on the composition of incinerated waste). The decrease in the implied emission factor (IEF) for CO_2 from biomass is due to the increase in the share of pure biomass (co-combusted with coal-firing), as opposed to the organic carbon in waste combustion with

energy recovery, which traditionally contributes the most to biomass combustion. For the former type, a lower EF is applied than for the latter.

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

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

A significant drop is seen in the emissions from 1A1a (electricity and heat production) in 1999 (-6% compared with 1998), which is explained by the higher share of imported electricity in domestic electricity consumption in that year, which was double that in 1998 (10% in 1998 versus 20% in 1999), and by a significant shift from coal to chemical waste gas and natural gas in 1999. The net import of electricity decreased again in 2001, and this was compensated for by an increased production of electricity from gas and coal combustion in the public electricity sector. In 2004, CO_2 emissions increased by 3% as a direct result of the start-up in 2004 of a 790 MWe gas-fired cogeneration plant and a 2% decrease in coal combustion. CO_2 emissions decreased in 2006 as a result of increased import of electricity, while they increased again in 2010 as a result of the increased export of electricity.

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. Since 2010, emissions have decreased due to a decrease in electricity production. Instead, more electricity is imported from other countries.

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

1A1b (petroleum refining) is the second largest emission source in the category 1A1 (Energy industries). The combustion emissions from this category should be viewed in relation to the fugitive emissions reported under category 1B2. Between 1990 and 2013, total CO_2 emissions from the refineries (including fugitive CO_2 emissions from hydrogen production reported in 1B2a-iv Refining) fluctuated between 10 and 12 Tg CO_2.

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

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

The use of plant-specific EFs for refinery gas from 2002 onwards also caused a change in the IEF for CO_2 emissions from total liquid fuel, compared with the years prior to 2002. The EF for refinery gas is adjusted to obtain exact correspondence between the total CO_2 emissions calculated and the total CO_2 emissions officially reported by the refineries. Disregarding this non-energy/feedstock use of fuel for hydrogen production in the years prior to 2002, the energy and carbon balance between the oil products produced does not match the total crude oil input and fuel used for combustion. The conclusion to be drawn is that not all residual refinery gases and other residual fuels are accounted for in national energy statistics. The carbon difference is always a positive figure. It is therefore assumed, for the years up to 2002, that part of the residual refinery gases and other residual fuels were combusted (or incinerated by flaring) but not monitored/reported by the industry and are thus unaccounted for. The CO_2 emissions from this varying fuel consumption have been included in the fuel type 'liquids', which represents approximately 10% (5–20%) of the total fuel consumption accounted for in the statistics. For 1998–2001, the unspecified CO_2 process emissions from the hydrogen plant were also included.

The interannual variation in the IEFs for CO_2, CH_4 and N_2O emissions from liquid fuels is explained both 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, and by the variable addition of 'unaccounted for' liquids, which is used only to estimate otherwise missing CO_2 emissions (but not used for CH_4 and N_2O). From 2002 onwards, however, the 'unaccounted for' amount has been reduced substantially due to the subtraction of fuel used for the non-combustion process of producing hydrogen (with CO_2 as a by-product), the emissions of which are now reported under 1B2.

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

Manufacture of solid fuels and other energy industries (1A1c)
Source category 1A1c comprises:

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

The proportion of 1A1c (manufacture of solid fuels (coke) and other energy industries; fuel production) in total GHG emissions within the category 1A1 (Energy industries) was approximately 3% in 1990 and 3% in 2012. This category comprises mostly CO_2 emissions from the combustion of natural gas. The combustion emissions from oil and gas production refer to 'own use' for energy purposes by the gas and oil production industry (including transmission), which is the difference between the amounts of fuel produced and sold, after subtraction of the amounts of associated gas that are flared, vented or lost by leakage. Production and sales data are based on national energy statistics; amounts flared and vented are based on reports from the sector. CO_2 emissions from this source category increased, mainly due to the operation of less productive sites for oil and gas production, compared with those operated in the past. This fact explains the steady increase over time shown by this category with respect to gas consumption. The interannual variability in the EFs for CO_2 and CH_4 emissions from gas combustion is mainly due to differences in gas composition and the variable losses in the compressor stations of the gas transmission network, which are reported in the AERs of the gas transport company.

3.2.4.2 Methodological issues

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

For CO_2, IPCC default EFs are used (see Annex 2, Table A2.1), with the exception of CO_2 for natural gas, coal, cokes, waste, waste gases, gas/diesel oil, petrol, LPG, liquid biomass and gaseous biomass, for which country-specific EFs are used. When available, company-specific or sector-specific EFs are used, particularly for derived gases such as refinery gas, chemical waste gas, blast furnace gas, coke oven gas, oxy gas and phosphor gas. If companies report different EFs for derived gases, it is possible to deviate from the standard EF when estimating emissions generated by these companies.

The CH_4 emission factors are taken from Scheffer and Jonker (1997), except for the use of natural gas in gas engines (see ENINA, 2015for more details on the CH4 EF of gas engines). For N_2O, IPCC default EFs are used.

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

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

- Refinery gas: Since 2002, company-specific EFs have been derived for all companies and are used in the emissions inventory. For the years prior to this, EFs from the Netherlands' list of fuels (Zijlema, 2015) 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. In 2012, this selection of companies consisted of ten companies (more than in previous years). If any of these companies was missing, then a company-specific EF for the missing company was used (derived in 1995). For the period 1990–1994, a country-specific EF based on an average EF for four companies has been used.
- Blast furnace gas: Since 2007, company-specific EFs have been derived for most companies. Since blast furnace gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all blast furnace gas has the same content and the derived EF is used for all companies using blast furnace gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2015) are used.
- Coke oven gas: Since 2007, company-specific EFs have been derived for most companies. Since coke oven gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all coke oven gas has the same content and the derived EF is used for all companies that use coke oven gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2015) are used.
- Phosphor gas: Since 2006, company-specific EFs have been derived for the single company and are used in the emissions inventory. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2015) are used.
- Coal: Since 2006, company-specific EFs have been derived for most companies and for the remaining companies the default EFs is used. For previous years, EFs from the Netherlands list of fuels (Zijlema, 2015) are used.

- Coke oven/gas coke: Since 2006, a company-specific EF has been derived for one company. For the other companies, a country-specific EF is used. For the years prior to this, a country-specific EF is used for all companies.

In 2013, approximately 92% of CO_2 emissions were calculated using country-specific or company-specific EFs. The remaining 8% of CO_2 emissions were calculated using default IPCC EFs. The latter mentioned emission originate mostly from solid biomass, petroleum cokes and part of the chemical waste gas.

An overview of the EFs used for the most important fuels (up to 95% of the fuel use) in the category Energy industries (1A1) is provided in Table 3.5. Since some emissions data in this sector originates from individual companies, some of the values (in Table 3.5) are IEFs. For reasons of confidentiality, detailed data on fuel consumption and emission factors per CRF category and fuel is not presented in the NIR, but is available to the reviewers upon request.

Table 3.5 Overview of EFs used in 2013 in the category Energy industries (1A1)

Fuel	Amount of fuel used in 2013 (TJ NCV)	(Implied) emission factors (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	414,225	57.2	0.17	7.4
Other bituminous coal	220,667	94.1	1.50	0.44
Refinery gas	85,721	64.9	0.10	3.6
Waste, biomass	40,461	124.8	5.5	
Waste, fossil	33,373	83.7	4.4	
Blast furnace gas	23,005	238.0	0.10	0.35
Other	21,921	NA	NA	NA

Explanation for the source-specific EFs:

- The standard CH_4 EF for natural gas is 5.7 g/GJ. Only in category 1A1c 'other energy industries' is 'wet' natural gas (directly extracted from the wells) used for combustion. For this unprocessed gas, a higher EF is used, which explains the higher EF for this category. Also, the CO_2 and N_2O EFs for natural gas deviate from the standard EFs (56.5 kg CO_2/GJ and 0.1 g N_2O/GJ), because this category includes emissions from the combustion of crude gas 'wet' natural gas.
- The CO_2 emissions from coal are counted as emissions occurring in the public electricity sector. The emissions are based on emissions data from the ETS and the implied EF is different from the country-specific EF.
- The CO_2 emissions from refinery gas are counted as emissions occurring in refineries and in the Energy sector. The emissions are partly based on emissions data from the ETS.
- The EF for N_2O emissions from waste combustion (fossil and biomass) is either with or without an SNCR (9.43 g/GJ and 1.89 g/GJ, respectively), depending on the amount of waste incinerated in incinerators. The EF for CH_4 from waste

incineration has been changed to 0 g/GJ as a result of a study on emissions from waste incineration (DHV, 2010, and NL Agency, 2011b). The emissions are reported in the CRF file with the code 'NO' (as the CRF cannot handle 0 (zero) values). The EF of CO_2 is dependent on the carbon content of the waste, which is determined annually (Rijkswaterstaat, 2013b).
- The CO_2 emissions from blast furnace gas are based on emissions data from the ETS, and the implied EF is different from the country-specific emission factor.

More details on EFs, methodologies, data sources and country-specific source allocation issues are provided in the *Methodology report on the calculation of emissions to air from the sectors Energy, Industry and Waste* (ENINA, 2015). In accordance with the IPCC Guidelines, only fossil fuel-related CO_2 emissions are included in the total national inventory, thus excluding CO_2 from organic carbon sources from the combustion of biomass. The CO_2 from biomass resulting from waste incineration is reported as a memo item.

3.2.4.3 Uncertainty and time series consistency

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

The two exceptions are solids in power generation and liquids in refineries, which have a larger estimated uncertainty (1% and 5%, respectively) on account of the proportion of blast furnace gas in total solid consumption and the 'unaccounted for' liquids calculated for refineries (Olivier et al., 2009). A higher uncertainty in the liquids in refineries applies to the years prior to 2002, for which CO_2 emissions data is not available at the required aggregation level.

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

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

2002); consequently, when the default EF is applied to other years, the uncertainty is larger, approximately 1%.

Analysis of the default CO_2 EFs for coke oven gas and blast furnace gas reveals uncertainties of approximately 10% and 15%, respectively (data reported by the steel plant). Since the share of BF/OX gas in total solid fuel emissions from power generation is approximately 15–20%, the overall uncertainty in the CO_2 EF for solids in power generation is estimated to be approximately 3%. The CO_2 EFs for chemical waste gas and – to a lesser extent – BF/OX gas are more uncertain than those for other fuels used by utilities. So, for liquid fuels in these sectors, a higher uncertainty of 20–25% is assumed in view of the quite variable composition of the derived gasses used in both sectors.

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

3.2.4.4 Category-specific QA/QC and verification

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

CO_2 emissions reported by companies (both in their AERs and within the ETS) are validated by the competent authority and then compared. Furthermore, in 2014, a quantitative assessment was made of the possible inconsistencies in CO_2 emissions between data from the ETS, the NIR 2014 and national energy statistics. The figures that were analysed related to about 45% of the CO_2 emissions in the Netherlands in 2013. The differences could reasonably be explained (e.g. different scope) and are reported for earlier years in Ligt (2014).

More details on the validation of energy data are to be found in ENINA (2015).

3.2.4.5 Category-specific recalculations

CO_2 emissions have been recalculated for the complete time series, because of an update in 2014 of the CO_2 EFs for chemical waste gas, refinery gas and petroleum coke.

N_2O emissions have been recalculated for the complete time series, becasue of an update of the N_2O EF from coal and lignite (default value

from the 2006 IPCC Guidelines, instead of the default value from the 1996 IPCC Guidelines).

Emissions have been recalculated for the sector 1A1c for 2009 (CO_2) and 2010 (N_2O). The emissions have been corrected in the oil and gas exploration sector on the basis of improved data from the competent authority of the oil and gas operators.

3.2.4.6 Category-specific planned improvements
No planned improvements.

3.2.5 Manufacturing industries and construction (1A2)

3.2.5.1 Source category description
This source category consists of six sub-categories:

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

Within these categories, liquid fuel and natural gas combustion by the chemical industry, solid fuel combustion by the iron and steel industry and natural gas combustion by the food processing and other industries are the dominating emissions sources. Natural gas in the pulp and paper industries and liquid fuels (mainly for off-road machinery) in the other industries are also large emission sources. The shares of CH_4 and N_2O emissions from industrial combustion are relatively small and these are not key sources.

Natural gas is mostly used in the chemical, food and drinks and related industries; solid fuels (i.e. coal and coke-derived fuels, such as blast furnace/oxygen furnace gas) are mostly used in the iron and steel industry (1A2a); liquid fuels are mostly used in the chemicals industry (1A2c) and in other industries (1A2f) (see Table 3.6).

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

	Amount of fuel used (PJ NCV)					
Fuel type/Category	**1990**	**1995**	**2000**	**2005**	**2010**	**2013**
Gaseous fuels						
Iron and steel	11.7	13.0	13.7	12.5	12.0	11.7
Non-ferrous metals	3.8	4.3	4.2	4.0	3.6	2.7
Chemicals	170.7	138.9	119.5	103.3	96.3	97.8
Pulp, paper and print	30.2	24.4	27.4	29.7	21.0	17.9
Food processing, beverages and tobacco	63.7	68.3	73.7	67.1	59.0	56.7
Non-metallic minerals	26.1	23.8	26.5	23.5	22.6	16.8
Other	28.6	35.1	36.5	32.8	29.7	28.1
Liquid fuels						

	Amount of fuel used (PJ NCV)					
Fuel type/Category	**1990**	**1995**	**2000**	**2005**	**2010**	**2013**
Iron and steel	0.3	0.3	0.2	0.2	0.2	0.2
Non-ferrous metals	0.0	0.0	0.3	0.0	NO	0.1
Chemicals	116.6	82.1	81.7	92.7	112.9	98.9
Pulp, paper and print	0.3	0.1	0.1	0.0	0.0	0.0
Food processing, beverages and tobacco	3.1	1.6	0.7	0.7	0.2	0.1
Non-metallic minerals	6.2	4.7	2.2	1.0	1.0	0.5
Other	22.4	23.6	26.0	23.9	21.5	20.6
Solid fuels						
Iron and steel	29.8	35.0	25.2	29.0	27.8	25.8
Non-ferrous metals	0.0	NO	NO	NO	NO	NO
Chemicals	12.8	0.2	2.1	1.7	1.2	NO
Pulp, paper and print	0.1	NO	NO	NO	NO	NO
Food processing, beverages and tobacco	2.4	1.3	1.1	0.6	1.0	0.8
Non-metallic minerals	3.3	2.1	2.3	1.5	1.5	1.2
Other	0.4	0.1	0.1	0.1	0.2	0.2

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

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

In the period 1990–2013, CO_2 emissions from combustion in 1A2 (Manufacturing industries and construction) decreased (see Figure 3.6). The chemical industry contributed the most to the decrease in emissions in this source category.

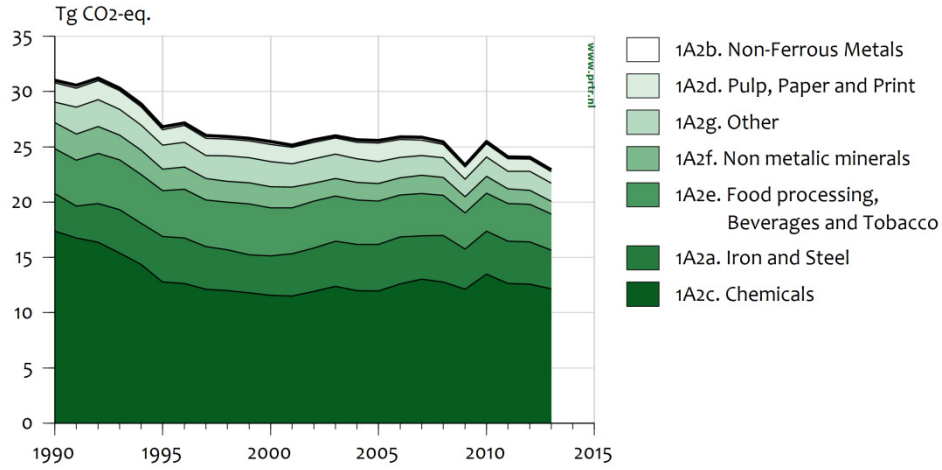


Figure 3.6 1A2 Manufacturing industries and construction: trend and emissions levels of source categories, 1990–2013

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

Iron and steel (1A2a)

This category refers mainly to the integrated steel plant Tata Steel, which produces approximately 7,000 ktons of crude steel (in addition to approximately 100 ktons of electric steel production and iron foundries). The category also includes emissions from electric arc furnaces at another (small) plant.

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

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

When all CO_2 emissions from the sector are combined – including the net process emissions reported under category 2C1 – total emissions closely follow the interannual variation in crude steel production (see Figures 3.7 and 3.8). Total CO_2 emissions from the iron and steel sector

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

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

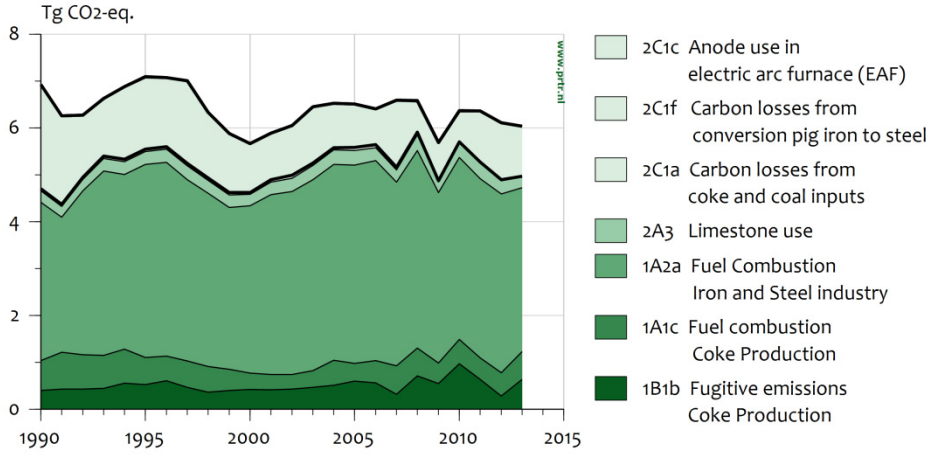


Figure 3.7. Emissions levels (Gg-eq) from the iron and steel industry

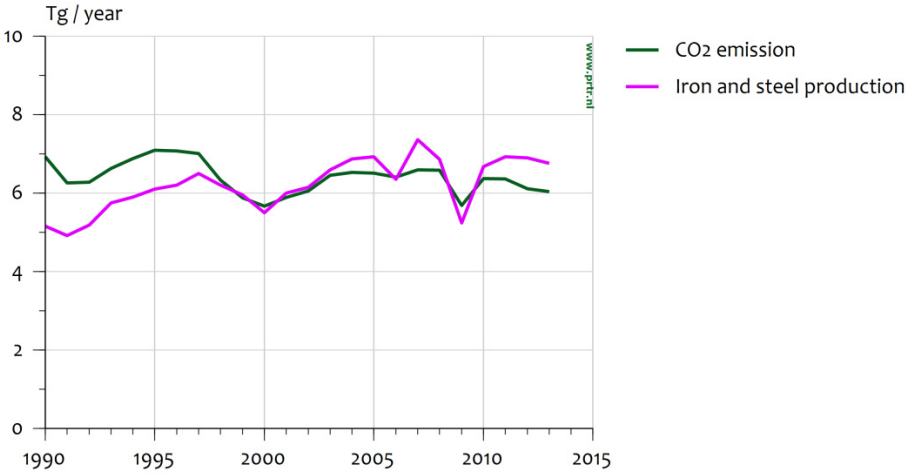


Figure 3.8. CO_2 emissions (Gg) from the iron and steel industry compared with the iron and steel production (ktonnes)

Non-ferrous metals (1A2b)
This category consists mainly of two aluminium smelters. CO_2 emissions from anode consumption in the aluminium industry are included in 2C (Metal production). This small source category contributes only about 0.2 Tg CO_2 to the total national GHG inventory, predominantly from the combustion of natural gas. Energy production in the aluminium industry is largely based on electricity, the emissions of which are included in 1A1a (public electricity and heat production).

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

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

The steadily decreasing CO_2 emissions from the combustion of natural gas can be largely explained by the decreasing numbers of cogeneration facilities in this industrial sector. CO_2 emissions from liquid fuel combustion stem predominantly from the combustion of chemical waste gas. The marked decrease in liquid fuel consumption since 1995 is not due to a decrease in chemical production or data errors, but mainly to a shift in the ownership of a large cogeneration plant – one using chemical waste gas – to a joint venture, thus reallocating it to energy industries. This also explains the 88% decrease in solid fuel combustion in 1994 and the 28% decrease in liquid fuel combustion in 1995. In these years, the then-existing coal-fired and oil-fired cogeneration plants shifted to joint ventures and thus moved to the Energy industry.

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

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

solid fuels to some 149.5 kg/GJ. For more details, see Appendix 2 of the NIR 2005.

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

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

Food processing, beverages and tobacco (1A2e)
CO_2 emissions from this category decreased in the period 1990–2013. This is due to the reallocation (since 2003) of joint ventures at cogeneration plants, whose emissions were formerly allocated to 1A2e but are now reported under public electricity and heat production (1A1a).

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

Non-metallic minerals (1A2f)
CO_2 emissions from this category decreased in the period 1990–2013 as a result of the decreasing consumption of natural gas in this category.

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

Other (1A2g)
This category includes all other industry branches, including production of textiles, wood and wood products and electronic equipment. Most of the CO_2 emissions from this source category stemmed from gas and biomass combustion.

3.2.5.2 Methodological issues

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

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

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

For N_2O, IPCC default EFs were used.

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

- Refinery gas: Since 2002, company-specific EFs have been derived for all companies and are used in the emissions inventory. For the years prior to this, EFs from the Netherlands' list of fuels (Zijlema, 2015) 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. In 2012, this selection of companies consisted of ten companies (more than in previous years). If any of these companies was missing, then a company-specific EF for the missing company was used (derived in 1995). For the period 1990–1994, a country-specific EF based on an average EF for four companies has been used.
- Blast furnace gas: Since 2007, company-specific EFs have been derived for most companies. Since blast furnace gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all blast furnace gas has the same content and the derived EF is used for all companies using blast furnace gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2015) are used.
- Coke oven gas: Since 2007, company-specific EFs have been derived for most companies. Since coke oven gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all coke oven gas has the same content and the derived EF is used for all companies that use coke oven gas. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2015) are used.

- Phosphor gas: Since 2006, company-specific EFs have been derived for one company and are used in the emissions inventory. For previous years, EFs from the Netherlands' list of fuels (Zijlema, 2015) are used.
- Coal: Since 2006, company-specific EFs have been derived for most companies and for the remaining companies the default EFs is used. For previous years, EFs from the Netherlands list of fuels (Zijlema, 2015) are used.
- Coke oven/gas coke: Since 2006, a company-specific EF has been derived for one company. For the other companies, a country-specific EF is used. For the years prior to this, a country-specific EF is used for all companies.

For 2013, approximately 90% emissions were calculated using country-specific or company-specific EFs. The remaining 10% of CO_2 emissions were calculated with default IPCC EFs. These remaining emissions mainly are the result of the combustion of chemical waste gas (partly), solid biomass and some other oil, residual fuel oil and lignite.

More details of methodologies, data sources and country-specific source allocation issues are provided in ENINA (2015).

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 3.7. Since some emissions data in this sector originates from individual companies, the values in Table 3.7 partly represent implied emission factors. For reasons of confidentiality, detailed data on fuel consumption and EFs per CRF category and fuel are not presented in the NIR, but are available to reviewers upon request.

Table 3.7 Overview of emission factors used (in 2013) in the category Manufacturing industries and construction (1A2)

Fuel	Amount of fuel used in 2012 (TJ NCV)	Implied emission factors (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	231,746	56.5	0.10	6.8
Waste gas	95,078	66.9	0.10	3.6
Gas/Diesel oil	18,296	74.3	2.97	1.4
Coke oven gas	13,746	42.6	0.10	2.8
Blast furnace gas	11,761	238.0	0.10	0.3
Solid biomass	9,971	109.6	4.00	32.6
Other	11,800	NA	NA	NA

Explanations for the IEFs:

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

- The CH_4 emissions from solid biomass are calculated with an EF of 30 g/GJ for the industrial sector and an EF of 300 g/GJ for the building construction sector.

More details on EF methodologies, data sources and country-specific source allocation issues are provided in ENINA (2015).

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

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

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

Details of the method for this source category can be found in ENINA (2015).

3.2.5.3 Uncertainty and time series consistency

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

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

3.2.5.4 Category-specific QA/QC and verification

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

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

More details on the validation of the energy data can be found in ENINA (2015).

3.2.5.5 Category-specific recalculations

CO_2 emissions have been recalculated for the complete time series, because of an update of the CO_2 EFs for chemical waste gas, refinery gas and petroleum coke.

N_2O emissions have been recalculated for the complete time series, because of an update of the N_2O EF for coal and lignite (default value from the 2006 IPCC Guidelines, instead of the default value from the 1996 IPCC Guidelines).

3.2.5.6 Category-specific planned improvements

No planned improvements.

3.2.6 Transport (1A3)

3.2.6.1 Category description

The source category Transport (1A3) includes emissions from civil aviation, road transport, railways, waterborne navigation and non-road mobile machinery, as shown in Table 3.8. Civil aviation (1A3a) includes only emissions from domestic aviation, i.e. aviation with departure and arrival in the Netherlands. Similarly, waterborne navigation (1A3d) includes only emissions from domestic waterborne navigation. Emissions from fuels delivered to international aviation and navigation companies (aviation and marine bunkers) are reported separately in the inventory (see Section 3.2.2). Emissions from military aviation and shipping are included in 1A5 (other; see Section 3.2.8). Energy consumption for pipeline transport is not recorded separately in national energy statistics but is included in 1A1c for gas compressor stations and in 1A4a for pipelines for oil and other products.

Table 3.8 Overview of Transport (1A3)

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

In previous inventories, emissions from non-road mobile machinery (NRMM) were reported under different source categories. Emissions from agricultural machinery were included in 1A4c (agriculture, forestry and fisheries), while emissions from other machinery, such as road and building construction equipment, were reported under category 1A2f. Since emissions from NRMM in the Netherlands in all economic sectors – agriculture, forestry, industry (including construction and maintenance), residential – and sectors, such as airport ground support equipment, agricultural tractors, chainsaws, forklifts and snowmobiles are calculated using the same modelling approach, reporting emissions from all NRMM under under 1A3e ii

In the next submission we will make the NRMM reporting in full accordance with the 2006 Guidelines and agreed CRF format and use the disagregeated categories 1A2 and 1A4.

Overview of shares and trends in emissions
Transport was responsible for 18% of total GHG emissions in the Netherlands in 2013. Greenhouse gas emissions from transport increased by 22% between 1990 and 2013, with total emissions in 2013 amounting to 35.7 Tg CO_2 eq. This increase in emissions was mainly due to an increase in diesel fuel consumption and corresponding CO_2 emissions from road transport.

Total fuel consumption and resulting GHG emissions from transport are summarized in Figure 3.9. Road transport accounts for 88–90% of total fuel consumption and GHG emissions over the time series. CO_2 is by far the most important GHG within the transport sector, accounting for 99% of total GHG emissions (in CO_2 eq.) from transport throughout the entire 1990–2013 period.

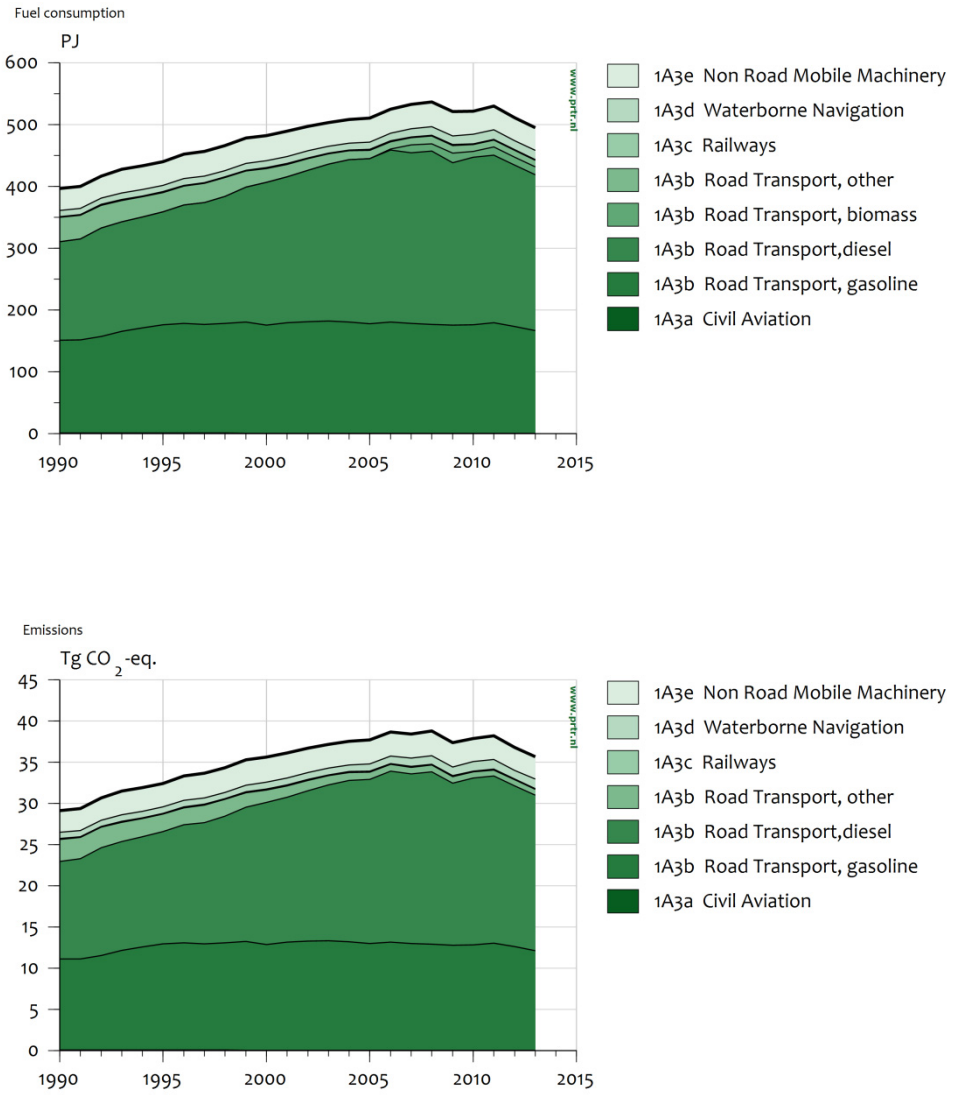


Figure 3.9 1A3 Transport: fuel consumption and emissions levels of source categories, 1990–2013

Figure 3.9 shows that the GHG emissions from transport steadily increased between 1990 and 2006, on average by 1.8% per year. This increase is more or less in line with the increase in road transport volumes. Between 2006 and 2008, emissions stabilized due to an increase in the use of biofuels in road transport. CO_2 emissions from biofuels are reported separately in the inventory and are not part of the national emissions totals. In 2009, GHG emissions from transport decreased by almost 4%, primarily due to the economic crisis and the resulting decrease in freight transport volumes. In 2010 and 2011, emissions increased slightly due to a decrease in the use of biofuels in 2010 and an increase in road transport volumes in 2011. But emissions have decreased again in both 2012 (3.7%) and 2013 (3.0%). This decrease can mainly be attributed to a decrease in fuel sales to road

transport, caused by further improvement of the fuel efficiency of the Dutch passenger car fleet and an increase in cross-border fuelling due to 2014 increase in excise duties for road transport fuels in the Netherlands.

Civil aviation (1A3a)
The share of civil aviation in total GHG emissions in the Netherlands was less than 0.1% in both 1990 and 2013. Given the small size of the country, there is hardly any domestic aviation in the Netherlands. The use of jet kerosene for civil aviation decreased from 1 PJ in 1990 to 0.5 PJ in 2013, whereas the use of aviation gasoline (AVGAS) decreased from 0.16 PJ in 1990 to 0.06 PJ in 2013. Greenhouse gas emissions from civil aviation decreased accordingly.

Road transport (1A3b)
The share of Road transport (1A3b) in national GHG emissions increased from 11.6% in 1990 to 16.2% in 2013. Between 1990 and 2013, GHG emissions from road transport increased from 25.6 to 31.7 Tg CO_2 equivalents, resulting for the most part from an increase in diesel fuel consumption (i.e. fuel sold), as shown in Figure 3.9. Between 1990 and 2008, diesel fuel consumption increased by 121 PJ (76%). This increase was, in turn, caused by the large growth in (road) 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 10% to 252 PJ in 2013. This decrease can be attributed to three factors: the improved fuel efficiency of the (diesel) passenger car fleet, the stabilization of road transport volumes and an increase in cross-border fuelling. The fuel efficiency of the passenger car fleet in the Netherlands has improved rapidly in recent years resulting from stringent EU CO_2 emissions standards and fiscal incentives for purchasers of fuel-efficient cars. As more fuel-efficient cars have entered the car fleet, average fuel-efficiency has improved steadily in recent years as well. Also, road transport volumes have been more or less stable since 2008, mainly due to the economic crisis. Finally, an increase in excise duties for diesel fuel in the Netherlands in 2014 has led to an increase in cross-border fuelling, especially for freight transport (Ministry of Finance, 2014).

Petrol consumption increased from 150 to 175 PJ between 1990 and 1995 and subsequently fluctuated between 175 and 180 PJ until 2011. In 2012 and 2013, petrol sales to road transport decreased by 3.3% and 3.9%, respectively. This decrease can be attributed to a combination of improved fuel efficiency, stabilization of road transport volumes and an increase in cross-border fuelling.

LPG fuel consumption for road transport has decreased steadily throughout the time series: from 40 PJ in 1990 to 10 PJ in 2013, mainly due the decreasing number of LPG-powered passenger cars in the car fleet. As a result, the share of LPG in total energy use by road transport decreased significantly between 1990 and 2013, as shown in Figure 3.10. The use of natural gas in road transport has increased greatly in recent years, but is still very small. In 2005, natural gas use in road transport was estimated to be 30 TJ, whereas in 2013 it was estimated

to be 1096 TJ, according to Statistics Netherlands. Within the transport sector, natural gas is mainly used for public transport buses, although the number of CNG-powered passenger cars and light-duty trucks has also increased in recent years.

The share of CH_4 in total GHG emissions from road transport (in CO_2 eq.) is very small (0.2% in 2013). CH_4 emissions from road transport decreased by 67% between 1990 and 2013 (from 7.4 Gg to 2.4 Gg). In 2013, CH_4 emissions from road transport decreased by approximately 4% (0.1 Gg) compared to 2012. The continuing decrease in CH_4 emissions from road transport is due to a reduction in total VOC emissions, resulting from the implementation and subsequent tightening of EU emissions legislation for new road vehicles. Total combustion and evaporative VOC emissions from road transport decreased by approximately 84% between 1990 and 2013, primarily due to the penetration of catalyst-equipped and canister-equipped vehicles in the passenger car fleet. Since CH_4 emissions are estimated as a proportion of total VOC emissions, the decrease in VOC emissions throughout the time series also results in a decrease in CH_4 emissions.

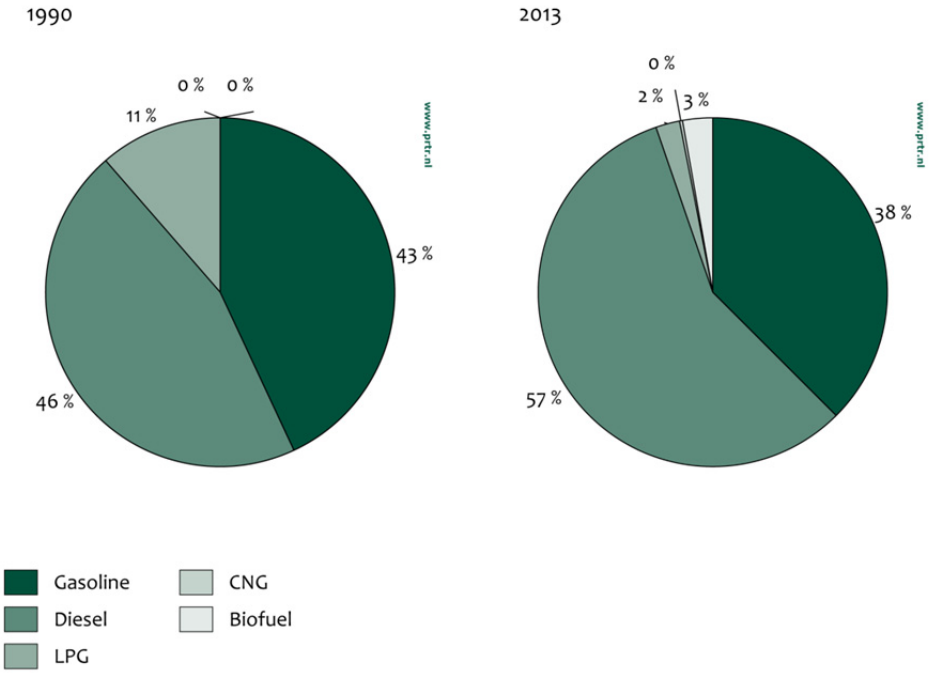


Figure 3.10 Shares of fuel types in total fuel sales to Road transport in 1990 and 2013.

The share of N_2O in total GHG emissions from road transport (in CO_2 eq) is also very small (0.7% in 2013). N_2O emissions from road transport increased from 0.3 Gg in 1990 to 0.8 Gg N_2O in 1997, but have since stabilized at approximately 0.7 Gg. The increase in N_2O emissions up to 1997 resulted from the increasing number of petrol cars equipped with a three-way catalyst (TWC) in the passenger car fleet, as these emit more N_2O than petrol cars without a TWC. The subsequent stabilization of N_2O emissions between 1997 and 2013, despite a further increase in transport volumes, can be explained by a combination of developments:

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

In 2013 N_2O emissions from road transport remained constant at 0.7 Gg, with the decrease in emissions from petrol-powered passenger cars being offset by the increase in emissions from heavy-duty trucks.

Railways (1A3c)
Railways (1A3c) are a minor source of GHG emissions, accounting for approximately 0.3% of total GHG emissions from transport in the Netherlands. Diesel fuel consumption by railways has shown a decreasing trend in recent years due to the increasing electrification of rail transport. In 2013, diesel fuel consumption by railways amounted to 1.1 PJ. Passenger transport by diesel trains accounts for approximately 0.4 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.

Waterborne navigation (1A3d)
Waterborne navigation is also a small source of GHG emissions in the Netherlands. Waterborne navigation for the most part is internationally orientated, i.e. either departs or arrives abroad. Emissions from international navigation are not part of the national emissions totals; therefore, the share of (domestic) waterborne navigation in total GHG emissions from transport is small and varies between 2% and 3% 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 15 PJ in 2013. This increase can partially be attributed to an increase in fuel consumption for offshore operations, which increased from 2 PJ in 2001 to 5.4 PJ in 2013, according to the National Energy Balance.

In line with the increase in fuel consumption, GHG emissions from domestic waterborne navigation increased throughout the time series: from 0.7 Tg CO_2 equivalents in 1990 to 1.1 Tg in 2013. In 2013, GHG emissions increased by 6% compared with 2012, an increase that can mainly be attributed to a 16% increase in fuel consumption for offshore operations.

Non-road mobile machinery (1A2g.vii and 1A4c.ii, in this submission reported under 1A3e)
Non-road mobile machinery (NRMM) includes a variety of machinery that is used in different economic sectors in the Netherlands, including industry, construction and agriculture. NRMM is also used for residential purposes. Combined, NRMM is responsible for 8–9% of GHG emissions by transport in the Netherlands.

GHG emissions from NRMM increased from 2.6 Gg in 1990 to 3.1 Gg in 2001 but have since decreased and amounted to 2.7 Gg in 2013. The reduction of energy use and resulting GHG emissions in recent years was mainly due to the economic recession and the resulting decrease in economic activity in the construction sector.

Key sources
CO_2 emissions from petrol, diesel and LPG use in road transport are assessed separately in the key source analysis. CO_2 emissions from all three fuel types are key sources in the Tier 1 level and trend assessment. CO_2 emissions from petrol and diesel use in road transport are also key sources in the Tier 2 level assessment and diesel and LPG are key sources in the Tier 2 trend assessment. N_2O emissions from road transport are a key source in the Tier 2 trend assessment. CH_4 emissions from road transport are not a key source in the inventory.

CO_2 emissions from domestic waterborne navigation are a key source in both the Tier 1 and the Tier 2 level and trend assessment. CO_2 emissions from civil aviation and railways are not a key source. The same holds for the (combined) N_2O and CH_4 emissions from waterborne navigation, railways and civil aviation.

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

Civil aviation (1A3a)
GHG emissions resulting from the use of aviation gasoline (AVGAS) and kerosene for domestic civil aviation in the Netherlands are estimated using a Tier 1 methodology. Fuel consumption for domestic aviation as reported in the inventory is derived from the Energy Balance. The heating values and CO_2 EFs for AVGAS and kerosene are derived from Zijlema (2015). IPCC default EFs are used to calculate emissions of CH_4 and N_2O. The EFs are shown in Table 3.9. Since civil aviation is a minor source of GHG emissions in the Netherlands and is not a key source in the inventory, the use of a Tier 1 methodology to estimate emissions is deemed sufficient.

Table 3.9 Emission factors for Civil aviation, Railways and Waterborne navigation

Source Category		Fuel type	MJ/kg	g CO_2/MJ	mg N_2O/MJ	mg CH_4/MJ
1A3a	Civil aviation	AVGAS	44.0	72.0	2.0	0.5
1A3a	Civil aviation	Jet kerosene	43.5	71.5	2.0	0.5
1A3c	Railways	Diesel	42.7	74.3	0.56	4.26
1A3d	Waterborne navigation	Diesel	42.7	74.3	2.0	7.0
1A3d	Waterborne navigation	Petrol	44.0	72.0	0.86	47.23

Emissions of precursor gases (NO_x, CO, NMVOC and SO_2), reported in the NIR under domestic aviation, are the uncorrected emissions values from the Netherlands PRTR and refer to aircraft emissions during landing and take-off (LTO) cycles at Schiphol Airport. The great majority of aircraft activities (>90%) in the Netherlands are related to Schiphol Airport; therefore emissions from other airports are ignored. 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)

An IPCC Tier 2 methodology is used for calculating CO_2 emissions from road transport, using national data on fuel sales for road transport from Statistics Netherlands and country-specific EFs, as reported in Klein et al. (2015) and in Zijlema (2015). The country-specific CO_2 EFs for road transport fuels are derived from the analysis of 50 fuel samples taken in 2004 in the Netherlands (Olivier, 2004). The country-specific EFs are slightly higher than the IPCC default EFs, as proposed in the 2006 IPCC Guidelines, but are within the uncertainty range.

Table 3.10 Heating values and CO_2 EFs for road transport

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

*) Source: Zijlema, 2015

**) MJ/Nm^3 ae

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

- Vehicle type, i.e. passenger cars, light-duty trucks, heavy-duty trucks and buses;
- Fuel type, e.g. petrol, diesel, LPG and natural gas;

- Emission control technology, as a function of the different EU standards for air pollutant emissions;
- Operating conditions, using different EFs for urban driving, rural driving and highway driving.

N_2O is primarily emitted by petrol and LPG vehicles equipped with TWCs. Most emissions result from the cold start, when the catalyst is not yet warmed up. The EFs used for N_2O are derived from a study by TNO (Kuiper and Hensema, 2012) and are partially country-specific and partially derived from the EEA Emission Inventory Guidebook (EEA, 2013). For older vehicle types, country-specific EFs are derived from national emissions measurement programmes (Gense and Vermeulen, 2002; Riemersma et al., 2003). For recent generations of road vehicles, no country-specific EFs are available, so default EFs are used from the Guidebook.

CH_4 emissions from road transport are derived from total VOC emissions using VOC species profiles. VOC EFs for different vehicle types are for the most part derived from the VERSIT+ EF model by the TNO. The VERSIT+ model and resulting EFs are described in more detail in Klein et al. (2015). The mass fraction of CH_4 in total VOC emissions is dependent on the fuel type, vehicle type and – for petrol vehicles – whether or not the vehicle is equipped with a TWC. Petrol-fuelled vehicles equipped with a catalyst emit more CH_4 per unit of VOC than vehicles without a catalyst. In absolute terms, however, passenger cars with a catalyst emit far less CH_4 than passenger cars without a catalyst because total VOC emissions are far lower. The VOC species profiles used to derive CH_4 emissions from total VOC emissions are derived from Broeke and Hulskotte (2009).

Figure 3.11 shows the IEFs for petrol, diesel and LPG. The underlying EFs per vehicle type are reported in detail in Klein et al. (2015). The CH_4 EFs have been decreasing steadily for all fuel types due to the EU emissions legislation. The N_2O EFs for petrol and LPG increased between 1990 and 1995 due to the increasing number of catalyst-equipped cars in the car fleet, but have since decreased steadily. The IEF for diesel has increased in recent years, mainly due to the increasing number of heavy-duty trucks and buses equipped with an SCR catalyst, as described in Section 3.2.6.1.

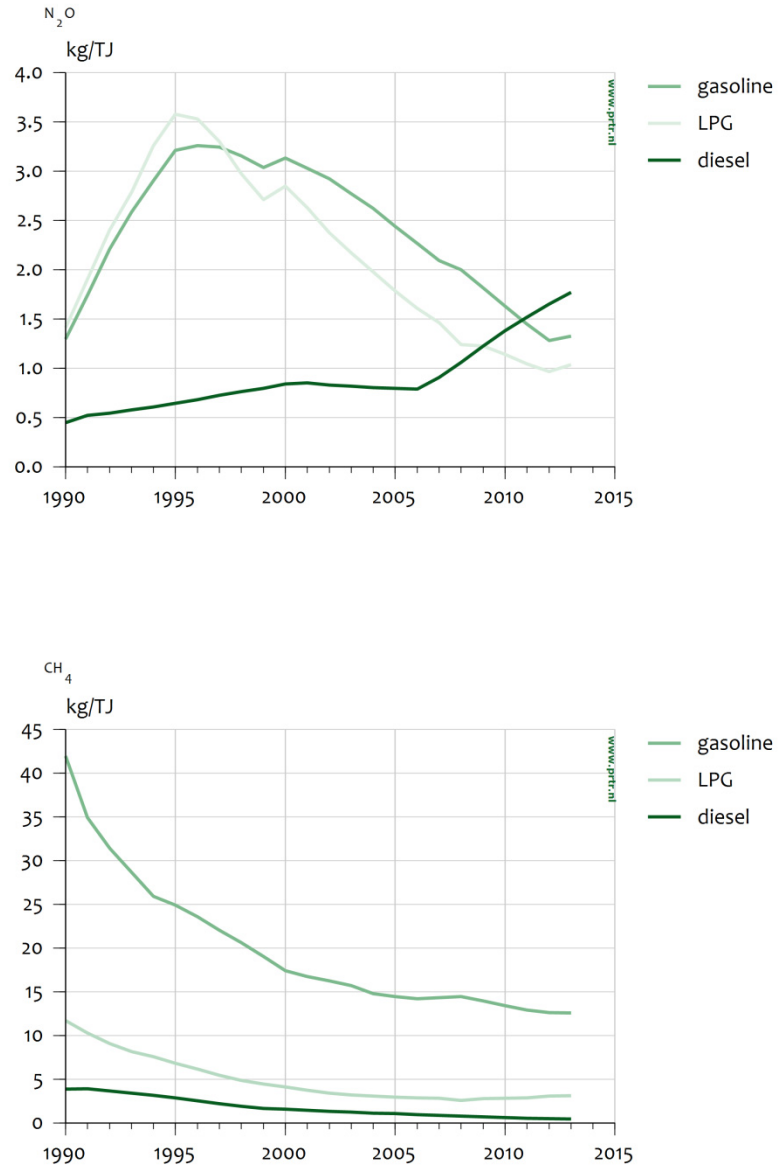


Figure 3.11: IEFs per fuel type for CH_4 and N_2O emissions by road transport

According to the 2006 IPCC Guidelines, GHG emissions from road transport should be attributed to the country where the fuel is sold. Total fuel consumption by road transport should therefore reflect the amount of fuel sold within the country's territory. To make sure CH_4 and N_2O emissions from road transport are consistent with fuel sales data, the bottom-up approach described above is used to calculate fleet-average CH_4 and N_2O EFs. These EFs are consequently combined with the fuel sales data from the Energy Balance to calculate total CH_4 and N_2O emissions from road transport.

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

Emissions resulting from the use of biofuels in road transport are reported separately in the CRF tables. The emissions calculation for biofuels is comparable to that for fossil fuels and is based on sales data for biodiesel and ethanol, as derived from the Energy Balance (CBS). Emissions of CH_4 and N_2O from biodiesel and ethanol are calculated using the same EFs as used for fossil diesel and petrol, respectively.

Railways (1A3c)
CO_2 emissions from railways are calculated using an IPCC Tier 2 methodology, based on fuel sales data and country-specific CO_2 EFs (Zijlema, 2015). Due to a lack of country-specific CH_4 and N_2O EFs for railways, CH_4 and N_2O emissions are estimated using a Tier 1 methodology, employing default EFs derived from the 2013 EEA Emission Inventory Guidebook (EEA, 2013). The Guidebook provides EFs for N_2O (24 g/tonne fuel) and CH_4 (182 g/tonne fuel). The resulting EFs per MJ for railways are shown in Table 3.7. Emissions from railways are not a key source in the inventory, so the use of Tier 1 and Tier 2 methodologies is deemed sufficient.

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

Waterborne navigation (1A3d)
A Tier 2 methodology is used to calculate CO_2 emissions from domestic waterborne navigation, using country-specific CO_2 EFs as shown in Table 3.7. Diesel fuel consumption for domestic inland navigation is derived from the Energy Balance. Petrol 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 petrol consumption by recreational craft, fuel consumption is estimated annually using a bottom-up approach derived from Waterdienst (2005). Petrol sales data for road transport, as derived from the Energy Balance, is corrected accordingly.

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

from petrol use in NRMM, as provided by the Emission Inventory Guidebook.

Non-road mobile machinery (1A2g.vii and 1A4c.ii in this submission reported under 1A3e)
Fuel consumption by NRMM in different sectors is not reported separately in the Energy Balance. Therefore, fuel consumption and resulting emissions from NRMM are calculated using a modelling approach. The EMMA model (Hulskotte and Verbeek, 2009) uses sales data and survival rates for different types of machinery to estimate the active fleet annually. Combined with assumptions on the average use (annual operating hours) and the fuel consumption per hour of operation for the different types of machinery, total fuel consumption of NRMM is estimated. The methodology of the EMMA model is similar to the methodology used in the EPA NON-ROAD USA model by the US Environmental Protection Agency (EPA). The methodology for estimating fuel consumption from NRMM is described in detail in Klein et al. (2015).

CO_2 emissions from NRMM are estimated using a Tier 2 methodology. Country-specific heating values and CO_2 EFs are derived from the Netherlands' list of fuels (Zijlema, 2015). CH_4 and N_2O emissions from NRMM are estimated using a Tier 1 methodology, using default EFs derived from the EEA Emission Inventory Guidebook 2013 (EEA, 2013).

3.2.6.3 Uncertainties and time series consistency

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

The uncertainty in annual CH_4 emissions from road transport is estimated to be ± 50%. The uncertainty in total VOC emissions from road transport is estimated to be ± 30%. The uncertainty concerning the share of CH_4 in VOC emissions is estimated by Broeke and Hulskotte (2009) to be ± 40% for petrol and ± 25% for diesel. Combined with the uncertainties in fuel sales and the share of both fuel types in total CH_4 emissions from road transport, the uncertainty of total CH_4 emissions from road transport is estimated to be ± 50%.
The uncertainty in annual N_2O emissions from road transport is estimated to be ± 70%. Recent measurements of N_2O are scarce;

therefore, the current N_2O EFs are rather uncertain (estimated at ± 50%).

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

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

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

The uncertainty in the activity data for NRMM is estimated to be equal to the uncertainty for road transport, i.e. ± 2% for petrol and diesel and ± 5% for LPG. These uncertainty estimates were derived from national statistics and apply to total sales of petrol, diesel and LPG for road transport and NRMM. The split between road transport and NRMM is based on the EMMA model and is rather uncertain, although road transport will be by far the dominant source. The uncertainty in CO_2 EFs for NRMM is also equal to the uncertainty in CO_2 EFs for road transport. Uncertainty estimates for CH_4 EFs (-40%/+ 250%) and N_2O (-50%/+300%) are derived from the 2006 IPCC Guidelines.

3.2.6.4 Category-specific QA/QC and verification

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

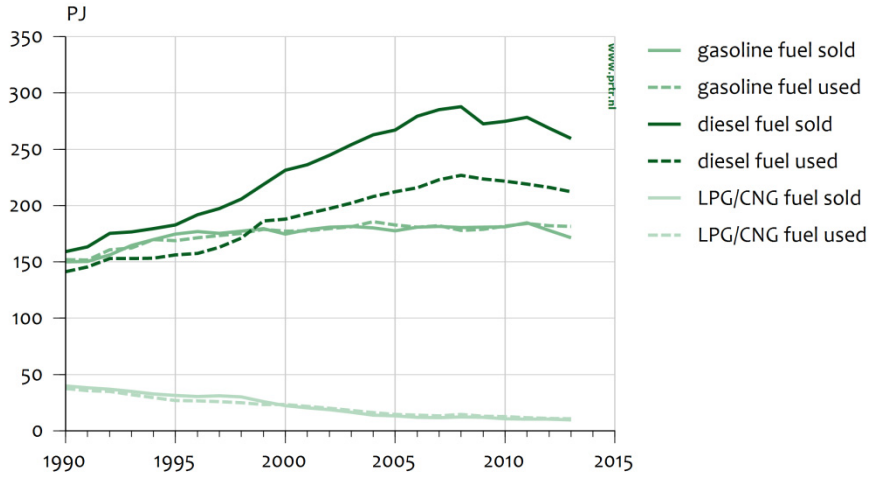


Figure 3.12: Fuel sold and fuel used for road transport in the Netherlands

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

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

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

For railways, the correspondence between diesel consumpation 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 consumption in recent years in the time series. Consequently, the decline in diesel consumption for railways, as derived from the Energy Balance, is deemed plausible.

In 2013, CE Delft conducted a sample check on the GHG emissions from transport as reported in the NIR 2013. They concluded that the reporting of underlying figures and assumptions was generally satisfactory. CE Delft (2014) was able to reproduce the reported emissions of N_2O and CO_2 from road transport using the NIR and the underlying protocols and method report (Klein et al., 2015). It did, however, recommend the improvement of consistency in reporting between the NIR and the methodology report, as well as the re-evaluation of the reported Tiers for estimating the emissions from the different source categories. In accordance with these recommendations, the descriptions in the underlying protocols were updated to ensure consistency and the Tiers for civil aviation and inland navigation were adjusted.

3.2.6.5 Category-specific recalculations

This year's submission contains several improvements in the methodologies used for calculating GHG emissions from transport in the Netherlands.

Activity data for domestic civil aviation

In this year's submission the use of jet kerosene for domestic civil aviation is derived from the revised Energy Balance from Statistics Netherlands. In previous inventories, the use of jet kerosene for domestic civil aviation was based on the estimated fuel consumption for the year 2000 given by an internal study by the Civil Aviation Authority (Pulles, 2000). Due to a lack of data, this estimate was subsequently applied to the entire time series. Statistics Netherlands had recorded the amount of jet kerosene delivered for aviation in the Netherlands, but this figure included fuel deliveries for military aviation as well as for civil aviation. Because the split between military and civil aviation could not be established, the figures from Statistics Netherlands were not used in the inventory. Since 2011, however, Statistics Netherlands has reported domestic fuel deliveries to military aviation separately from deliveries to (domestic) civil aviation. Therefore, in the 2013 inventory the use of aviation gasoline was derived from the Energy Balance.

As was reported in the NIR 2013, Statistics Netherlands figures for jet kerosene were not applied because the figure for jet kerosene supplied for military aviation as reported by Statistics Netherlands was lower than that for fuel purchases as reported by the Ministry of Defence. A comparison between the two data sources has shown that this difference can be explained by two factors. First, foreign purchases are included in the figures from the Ministry, whereas the figures from Statistics Netherlands include only fuel deliveries within the Netherlands. Second, the figures from the Ministry include only fuel purchases by the Dutch

military, whereas the figures from Statistics Netherlands include all fuel supplies for military purposes within the Netherlands. Because the differences between the two data sources have been sufficiently explained, it was decided that for this year's inventory the jet kerosene figures for both civil and military aviation would be derived from national statistics.

The study by the Civil Aviation Authority estimated the use of jet kerosene for domestic civil aviation at 230 TJ in 2000. In previous inventories, as stated, this figure was applied to the entire time series. The new figures from Statistics Netherlands show that the supply of jet kerosene for domestic civil aviation is higher than previously estimated, but has been decreasing throughout the time series. In 1990, the use of jet kerosene was 1 PJ, but this decreased to approximately 0.5 PJ in 2013. This decrease can be explained by the fact that the daily domestic flights from Amsterdam's Schiphol Airport to several smaller airports, such as Groningen, Enschede, Maastricht and Eindhoven, in earlier years of the time series have since been stopped.

Activity data for domestic waterborne navigation
The amount of diesel fuel used for domestic inland navigation has been derived from the revised Energy Balance in this year's submission. In previous years, fuel use for domestic navigation was not reported separately from fuel use for international navigation; therefore, the Energy Balance could not be used for waterborne navigation. Instead, a bottom-up approach was used to estimate fuel consumption for domestic waterborne navigation. Using the Dutch Emission Monitor Shipping (EMS), it was possible to distinguish between national and international navigation based on kilometres travelled by different types of ship (Hulskotte & Bolt, 2012). The EMS was used to derive total fuel consumption for domestic waterborne navigation. Since the revision of the Energy Balance in 2014, Statistics Netherlands has reported the amount of fuel supplied for domestic and for international inland navigation separately. The EMS-based estimation of fuel used for domestic navigation is therefore no longer required.

The revised Energy Balance also includes fuel supplies for 'work at sea'. This is the fuel used by ships that supply oil platforms or are involved in activities at sea such as the construction of Maasvlakte 2, the western expansion of the Rotterdam port area in the North Sea. Since these vessels remain in Dutch territory, the resulting GHG emissions are included in the national emissions totals. In previous inventories, these emissions were not included, since the EMS estimates only energy use for freight transport in inland navigation.

Furthermore, in previous inventories, fuel consumption by recreational craft was not included in waterborne navigation because the EMS estimated only fuel consumption for freight transport. Instead, fuel consumption for recreational craft was included in the fuel sales data for road transport. In the current inventory this has been corrected by estimating fuel consumption for recreational craft using a bottom-up approach (as described above) and adding this to the consumption for waterborne navigation, while also correcting fuel sales data for road transport accordingly. Since the CO_2 EF for diesel oil is the same for

both purposes, this mainly leads to a different allocation of emissions; emissions totals are not substantially affected (N_2O and CH_4 EFs for waterborne navigation do differ from those for road transport, so emissions totals are not identical, but the contribution of these two substances to total GHG emissions by transport is minimal).

Figure 3.13 shows both the old and new time series for energy use in domestic waterborne navigation. It also shows the new time series excluding energy use by recreational craft and work at sea, which makes for a better comparison with the previous time series. As can be seen, the latter is more in less in line with the previous time series, although the jump in energy use in 1999 is not visible in the new time series. This jump resulted from a reported increase in freight transport volumes that were used for EMS modelling.

Energy use for work at sea increased from approximately 1 PJ in 1990 to 5 PJ in 2013. This resulted in an additional CO_2 emissions of approximately 200 kt in 1990 and 300 kt in 2011 and 2012 compared to last year's inventory.

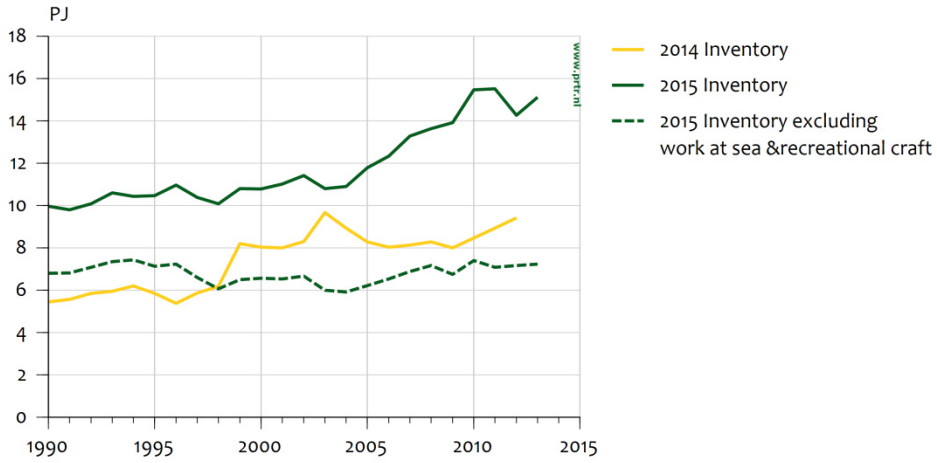


Figure 3.13: Energy use for domestic waterborne navigation

CO_2 emissions from urea-based catalysts

In this year's inventory, CO_2 emissions from catalytic converters using urea have been included as a separate emission source. This emission source was not addressed in the 1996 IPCC Guidelines, which were used for previous inventories, but is included in the 2006 Guidelines, which are used for this inventory and will be used for forthcoming inventories. To estimate the CO_2 emissions from urea-based catalysts, TNO carried out a study commissioned by the Dutch PRTR to estimate road type specific CO_2 EFs from the use of urea additives. Since 2005, Selective Catalytic Reduction (SCR) technology has been applied in diesel-fuelled heavy-duty vehicles for reduction of NO_x emissions. The use of a urea additive (AdBlue) was estimated, as a percentage of diesel consumption,

at 6% for Euro V engines and 3% for Euro VI engines. Urea additive CO_2 emissions are calculated to be ≤ 0.6% of diesel fuel CO_2 emissions for Euro V engines and ≤ 0.3% for Euro VI engines. The methodology used is described in more detail in Stelwagen & Ligterink (2014). Resulting CO_2 emissions are estimated at 0.1 kt in 2005, increasing to 21 kt in 2013. The emissions from urea-based catalysts are reported in CRF category 2D3.

3.2.6.6 Category-specific planned improvements

In 2015, the Netherlands plans to further investigate the heating value and carbon content of the motor fuels used in road transport, in order to improve the CO_2 EFs for these fuels.

3.2.7 Other sectors (1A4)

3.2.7.1 Source category description

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

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

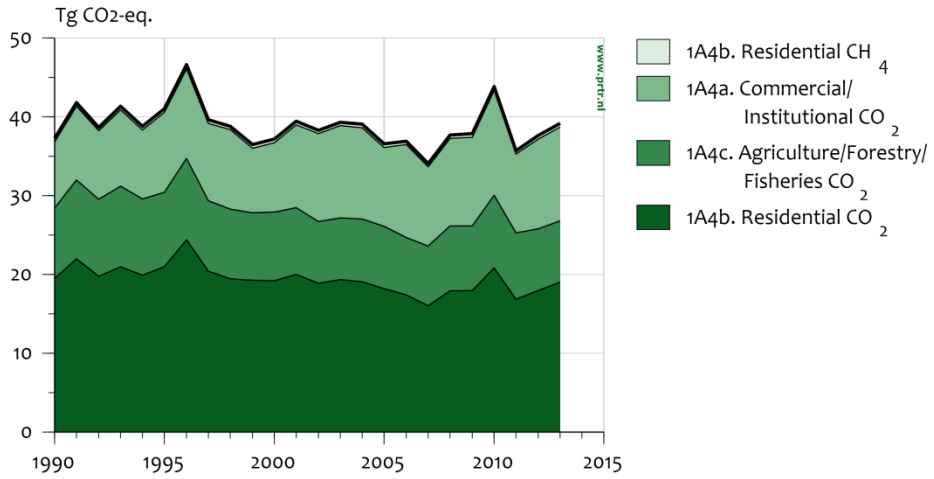


Figure 3.14 1A4 (other sectors): trend and emissions levels of source categories, 1990–2013

Commercial and institutional services (1A4a)
CO_2 emissions in the commercial and institutional services (1A4a) category have increased since 1990. The emissions trends should not be considered to be robust. The consumption of natural gas and the (small) use of liquid and solid fuels in this category show a very large interannual variation due to the relatively large inaccuracy of fuel consumption data in energy statistics. This large inaccuracy is the result of the calculation scheme used in national energy statistics, which allocates to this category all fossil fuel use remaining after subtraction of the amounts allocated to the previous source categories (1A1, 1A2, 1A3) and sub-categories (1A4b and 1A4c). Thus, all the uncertainties in the other allocations accumulate in this remaining category, which causes large interannual changes in the underlying mix of solid and liquid fuels. This explains the relatively large interannual variation that can be observed in the IEFs of CO_2, CH_4 and N_2O for solid and liquid fuels.

For 1991–1994 in particular, the mix assumed for liquid and solid fuels was different from the adjacent years 1990 and 1995 due to the revision of the energy statistics at a high aggregation level (discussed in Section 3.1.1). The biomass combustion reported in this sector refers mainly to the combustion of biogas recovered by WWTPs, which shows a steadily increasing trend, and biomass consumption by industrial companies (e.g. landfill gas used as fuel), which is reported in this sector.

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

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

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

Agriculture, forestry and fisheries (1A4c)
Most of the energy in this source category is used for space heating and water heating; although some energy is used for cooling. The major fuel used in the category is natural gas. Almost no solid fuels are used in this category.

Total CO_2 emissions in the agriculture, forestry and fisheries category have decreased since 1990, mainly due to a decrease in gas consumption for stationary combustion as a result of various energy

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

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

CO_2 emissions from fisheries have shown a decreasing trend in recent years. This has been caused by a decrease in the number of ships in the Netherlands: since 1990 the number of fishing vessels in the Netherlands has decreased, as has the engine power of these ships. Because of the smaller fleet, energy use and related emissions have decreased significantly throughout the time series.

CO_2 emissions from agricultural machinery have fluctuated in recent years.

3.2.7.2 Methodological issues

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

The activity data for the residential category (1A4b) and from stationary combustion in agriculture (1A4c–i) is compiled using data from separate surveys for these categories. However, due to the late availability of the statistics on agricultural fuel use, preliminary data is often used for the most recent year in national energy statistics. Also, trends in agricultural fuel consumption are estimated using indicators that take no account of varying heating demand due to changes in heating degree days. The fuel consumption data used in 1A4a (commercial and institutional services) is determined by subtracting the energy consumption allocated to the other source categories (1A1, 1A2, 1A3) and other sub-categories (1A4b, 1A4c and 1A5) from the total energy consumption, which means that the resulting activity data is the least accurate of all three categories.

For CO_2, IPCC default EFs are used (see Annex 5), with the exception of CO_2 for natural gas, gas/diesel oil, LPG and gaseous biomass, for which country-specific EFs are used. In the Netherlands' list of fuels (Zijlema,

2015), it is indicated whether the EFs are country-specific or IPCC default values. For CH_4, country-specific EFs are used, with the exception of CH_4 for solid biomass and charcoal and CH_4 for diesel use in the fisheries sector. For the use of natural gas in gas engines, a different EF is used (see ENINA, 2015). The CH_4 country-specific EF for residential gas combustion includes start-up losses, a factor mostly neglected by other countries. For N_2O, IPCC default EFs are used.

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

Fuel consumption by off-road agricultural machinery is derived from the EMMA model (Hulskotte & Verbeek, 2009). This model is based on sales data for different types of mobile machinery and assumptions made about average use (hours per year) and fuel consumption (kilograms per hour) for different machine types. It is assumed that only diesel fuel is used by mobile machinery. The use of petrol (gasoline) and LPG is small and not separately recorded in national energy statistics. Instead, it is included in total petrol and LPG use in the transport sector.

In 2013, 95% of the CO_2 emissions in this catagory were calculated using country-specific EFs (mainly natural gas). The remaining 5% of CO_2 emissions were calculated with default IPCC EFs. These mainly consist of solid biomass and r kerosene, residual fuel oil, charcoal and lignite.

An overview of the EFs used for the most important fuels (up to 95% of the fuel use) in the other sectors (1A4) is provided in Table 3.11. 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 the reviewers upon request.

Table 3.11 Overview of EFs used (in 2013) in Other sectors (1A4)

Fuel	Amount of fuel used in 2013 (TJ NCV)	Emission factors (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	661,586	56.5	0,10	87.67
Other	24,238	NA	NA	NA

The standard CH_4 EF for natural gas is 5.7 g/GJ. Only for gas engines is a higher EF used, which explains the higher EF for this sector.

More details on EFs, methodologies, data sources and country-specific source allocation issues are provided in the methodology report (ENINA 2015) (see http://english.rvo.nl/nie).

3.2.7.3 Uncertainties and time series consistency

It should be noted that the energy consumption data for the category 1A4 (other sectors) as a whole is much more accurate than the data for the sub-categories of 1A4. In particular, energy consumption in the

services and agriculture categories (particularly in the latest year) is less closely monitored than it is in the residential sector. Trends in emissions and activity data for these categories should be treated with some caution when drawing conclusions. The uncertainty in total CO_2 emissions from this source category is approximately 7%, with an uncertainty concerning the composite parts of approximately 5% for the residential category, 10% for the 'agriculture' category and 10% for the services category (see Section 1.6 and Annex 2 for more details).

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

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

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

The deviating IEFs in the 1991–1994 period of CH_4 for liquids and gas and of N_2O for liquids are due to the higher aggregation level used in the revised energy statistics.

3.2.7.4 Category-specific QA/QC and verification

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

level, for which explanations were sought and included in the NIR. More details on the validation of the energy data can be found in ENINA (2015).

3.2.7.5 Category-specific recalculations

N_2O emissions have been recalculated for the complete time series, becasue of an update of the N_2O EF from coal and lignite (default value from the 2006 IPCC Guidelines, instead of the default value from the 1996 IPCC Guidelines).

The CO_2, CH_4 and N_2O emissions from the source categories 1A4ai and 1A4ci have been recalculated for the year 2012, due to updated activity data. Part of natural gas consumption (and emissions) that was previously allocated to source category 1A4ci is now allocated to source category 1A4ai.

The CO_2, CH_4 and N_2O emissions from source category 1A4bi have been recalculated for the years 2010, 2011 and 2013, due to an update of the activity data on charcoal use for barbecuing.

The CO_2, CH_4 and N_2O emissions from source category 1A4bi have been recalculated for the complete time series as a result of updated activity data on residential wood consumption.

Activity data on fisheries has been derived from the revised Energy Balance in this year's inventory. In previous inventories, the consumption of diesel oil and heavy fuel oil by fisheries was estimated using statistics on the number of days at sea ('hp days') of four types of Dutch fishing vessel. This information was compiled by the LEI, and the estimates included specific fuel consumption per vessel (per day and per unit of power (hp) based on a study by the TNO (Hulskotte, 2004). Although the Energy Balance also included fuel supplied for fisheries, these figures were not previously used because the trend was deemed implausible. The revision of the Energy Balance in 2014 has led to an adjustment of the time series for fisheries. The resulting time series shows good agreement with the previously used bottom-up calculation of energy use, as can be seen in Figure 3.15.

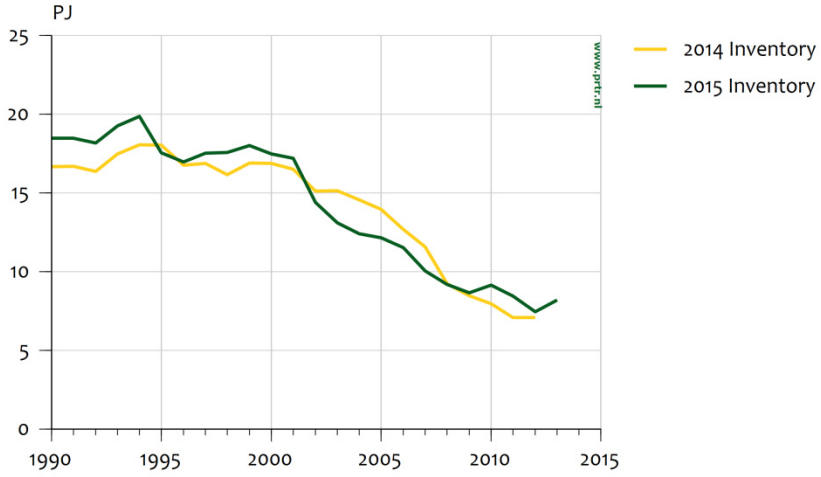


Figure 3.15. Activity data (energy use) for fisheries

3.2.7.6 Category-specific planned improvements,
There are no source-specific recalculations envisaged.

3.2.8 Other (1A5)

3.2.8.1 Source category description
Category 1A5 (Other) includes emissions from military vessels and aircraft (in 1A5b). CO_2 emissions from this source category are approximately 0.2 Tg, with some interannual variation caused by different levels of operation, including fuel use for multilateral operations, which are included here. Emissions of CH_4 and N_2O are negligible.

The EFs used are presented in Table 3.12.

Table 3.12 Emission factors used for military marine and aviation activities

Category		**CO_2**	**CH_4**	**N_2O**
Military ships	Emission factor (g/GJ)	75,250	2.64	1.87
Military aviation	Emission factor (g/GJ)	72,900	10.00	5.80
Total	Emissions in 2013(Gg)	233.84	0.02	0.01

Source: Hulskotte, 2004a

3.2.8.2 Methodological issues
A country-specific top-down (Tier 2) method is used for calculating the emissions from fuel combustion from 1A5 (Other). The emissions in this sector are calculated using fuel consumption data from the Ministry of Defence that includes consumption for both domestic military shipping and aviation activities as well as so-called multilateral operations. Fuel consumption by military aviation is derived from the Energy Balance. The fuel used for aviation consists of a mixture of jet kerosene, F65 and SFC. The sector-specific EFs that are used are those reported by the Ministry of Defence. The methodology and data sources for the calculation of these emissions can be found on the website http://english.rvo.nl/nie.

3.2.8.3 Uncertainties and time series consistency
The uncertainty in CO_2 emissions from fuel combustion in category 1A5 (Other) is estimated to be approximately 10%. The uncertainty for CH_4 and N_2O emissions is estimated to be about 100%. The accuracy of fuel consumption data is tentatively estimated at 10%. For EFs, the uncertainties are estimated at 3% for CO_2 and 100% for CH_4 and N_2O.

A consistent methodology is used throughout the time series. The time series consistency of the activity data is good due to the continuity in the data provided.

3.2.8.4 Category-specific QA/QC and verification
This source category is covered by the general QA/QC procedures discussed in Chapter 1.

3.2.8.5 Category-specific recalculations
In this year's submission the use of jet kerosene for military aviation is derived from the revised Energy Balance. In previous inventories, the use of jet kerosene for military aviation was obtained from the Ministry

of Defence, whose figures included both domestic military aviation and so-called multilateral operations. Statistics Netherlands did report the amount of jet kerosene delivered for domestic aviation in the Netherlands, but this figures included fuel for both civil aviation and military aviation. Because the split between military and civil aviation could not be established until recently, the figures from Statistics Netherlands were not previously used in the inventory. Since 2011, Statistics Netherlands has reported domestic fuel deliveries to military aviation separately from deliveries to (domestic) civil aviation.

As was reported in the NIR 2013, Statistics Netherlands figures for jet kerosene were not applied because the figure for jet kerosene supplied for military aviation as reported by Statistics Netherlands was lower than that for fuel purchases as reported by the Ministry of Defence. A comparison between the two data sources has shown that this difference can be explained by two factors. First, foreign purchases are included in the figures from the Ministry, whereas the figures from Statistics Netherlands include only fuel deliveries within the Netherlands. Second, the figures from the Ministry include only fuel purchases by the Dutch military, whereas the figures from Statistics Netherlands include all fuel supplies for military purposes within the Netherlands. Because the differences between the two data sources have been sufficiently explained, it was decided that for this year's inventory the jet kerosene figures for both civil and military aviation would be derived from national statistics.

Figure 3.16 shows both the old and the new time series for kerosene consumption by military aviation. As explained above, figures in the new time series are lower than those in the previous time series, the difference varying between 1 and 2 PJ. In general, however, the trend in both time series shows good agreement.

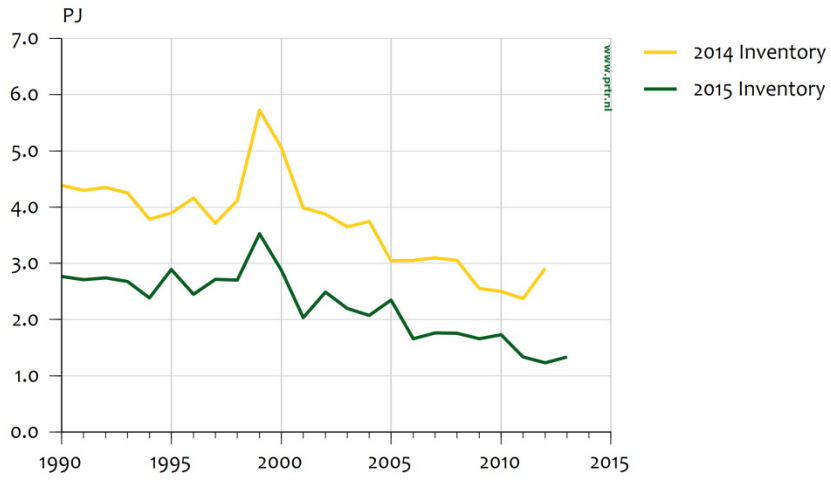


Figure 3.16 Time series for kerosene consumption by military aviation

3.2.8.6 Category-specific planned improvements
There are no source-specific recalculations envisaged.

3.3 Fugitive emissions from fuels (1B)

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

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

The contribution of emissions from source category 1B to the total national GHG emissions inventory was 1.5% in 1990 and 1.3% in 2013. Table 3.1 shows that total GHG emissions in 1B decreased from 3.1 Tg CO_2 eq to 2.5 Tg CO_2 eq between 1990 and 2013.

3.3.1 Solid fuels (1B1)

3.3.1.1 Source category description
Fugitive emissions from this category refer mainly to CO_2 from 1B1b (coke manufacture; see Table 3.1). 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. The fugitive emissions of CO_2 and CH_4 from both coke production sites are included here. There are no fugitive emissions from coal mining and handling activities (1B1a) in the Netherlands; these activities ceased with the closing of the last coal mine in the early 1970s. There is no methane recovery at abandoned coal mines. Since the pumping of mine water stopped, the mines have been flooded with water; therefore, no emissions are accounted for.

With respect to fugitive emissions from charcoal production, until 2009 the Netherlands had one large production location that served most of the Netherlands and also occupied a large share of the market for neighbouring countries. Production at this location ceased in 2010.

CO_2 emissions in 1B1 remained quite stable between 1990 and 2009. After a peak in 2010, emissions decreased to 0.7 Tg CO_2 eq in 2013.

3.3.1.2 Methodological issues
CO_2 emissions related to transformation losses (1B1) from coke ovens are only a small part of the total emissions from the iron and steel industry in the Netherlands. Emissions totals for the iron and steel industry and the CRF category that they are reported in can be found in Section 3.2.5. The figures for emissions from transformation losses are based on national energy statistics of coal inputs and of coke and coke oven gas produced and a carbon balance of the losses. The completeness of the accounting for coke oven gas produced, in energy statistics, is not an issue, since any non-captured gas is by definition included in the net carbon loss calculation used for the process emissions. As a result of the 2011 in-country review, a mass balance for the year 2009 has been made available. For reasons of confidentiality, the mass balance for the iron and steel industry is included in NIRs but can be made available for review purposes.

Detailed information on activity data and EFs can be found in the Methodology Report on Air Emissions Calculation (IPCC and Air Actual) for the Energy, Industry and Waste Sectors.

3.3.1.3 Uncertainty and time series consistency

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

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

3.3.1.4 Source-specific QA/QC and verification

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

3.3.1.5 Source-specific recalculations

This year there have been no source-specific recalculations in comparison with the previous submission.

3.3.1.6 Source-specific planned improvements

No source-specific improvements are planned.

3.3.2 Oil and natural gas (1B2)

3.3.2.1 Source category description

There is very little oil production in the Netherlands. The fugitive emissions from category 1B2 comprise:

- Non-fuel combustion emissions from flaring and venting (CO_2, CH_4);
- Emissions from oil and gas production (CO_2, CH_4);
- Emissions from oil and gas transport (compressor stations) (CO_2, CH_4);
- 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).

Fugitive CO_2 emissions from refineries are included in the combustion emissions reported in category 1A1b. Combustion emissions from exploration and production are reported under 1A1c.

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

Gas production and gas transmission vary according to demand – in cold winters, more gas is produced. The gas distribution network is still gradually expanding as new estates are being built, mostly using PVC

and PE, which are also used to replace cast iron pipelines (see table 3.44 in NIR 2005). 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 5%; in 1990 it was 10%.

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

CO_2 emissions from hydrogen plants remained fairly stable between 2002 and 2013. Emissions from oil and gas transport and gas distribution networks also remained fairly stable between 1990 and 2013.

3.3.2.2 Methodological issues

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

The IPCC Tier 3 method for CH_4 emissions from Gas distribution due to leakages (1B2b) is based on two country-specific EFs: 610 m^3 (437 Gg) methane per km of pipeline for grey cast iron, and 120 m^3 (86 Gg) per km of pipeline for other materials. The EFs are based on seven measurements at one pressure level of leakage per hour for grey cast iron and on 18 measurements at three pressure levels for other materials (PVC, steel, nodular cast iron and PE) and subsequently aggregated to factors for the material mix in 2004. From 2004 onwards, the gas distribution sector annually recorded the number of leaks found per material, and any possible trends in the EFs have been derived from this data. Total emissions of both CO_2 and methane (CH_4) due to the transport of natural gas are taken from the V,G&M (safety, health and environment) annual reports submitted by the NV Nederlandse Gasunie. These emissions are not split into process and combustion emissions, but because the CO_2 emissions are primarily combustion emissions, they are reported under IPCC category 1A1c. As from the resubmission of November 2011, the Netherlands has accounted for the (relatively very small) fugitive emissions from gas transmission using the total transmission pipeline length and the IPCC default CO_2 EF. From this this submission onwards, the amount of fugitive CO_2 emissions from gas transportation is calculated using the Tier 1 method with the new default IPCC EF of 8.8E-7 Gg per 106 m^3 of marketable gas, taken from the IPCC Guidelines 2006, chapter 4, table 4.2.4. This figure is added to CRF category 1B2b4 for the whole time series.

Fugitive emissions of methane from refineries in category 1B2a4 are based on a 4% share in total VOC emissions reported in the AERs of the refineries (Spakman et al., 2003) and for the most recent years have been directly reported in those AERs. These show significant annual fluctuations in CH_4 emissions, as the allocation of the emissions to either combustion or process has not been uniform over the years. For more information, see ENINA (2015). As the AERs account only for emissions, activity data for this category is taken from national energy statistics as a proxy and is reported in the CRF tables. The data in the statistics can be adjusted retrospectively (changes in definitions/allocation) and these will show up in the latest version of the CRF tables.

3.3.2.3 Uncertainty and time series consistency

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

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

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

A consistent methodology is used to calculate emissions throughout the time series.

3.3.2.4 Source-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1. Until 2013, the emissions reported in the e-AERs of the oil and gas operators were not included in the validation of the ENINA Task Force to assist the local competent authorities by checking the most relevant emissions and use the e-AER system to advise the operator and competent authority. This procedure originated from the fact that the competent authority of the oil and gas operators was different from that of other industrial operators. The competent authority for the oil and gas operators is the SodM (Staatstoezicht op de Mijnen) department of the Ministry of Economic Affairs. In 2014, arrangements were made with SodM to include the oil and gas operators in this validation procedure of ENINA.

3.3.2.5 Source-specific recalculations

Fugitive emissions of CO_2 from gas transmission have been recalculated for the whole time series as a result of the implementation of the new

IPCC Tier1 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.

3.3.2.6 Source-specific planned improvements

Emissions from Gas distribution and gas transmission will be evaluated and improved. For the gas distribution sector, new sets of leakage measurements will become available and for gas transmission new emissions data will become available as a result of the implementation of the LDAR (Leak Detection and Repair) programme of Gasunie.

4 Industrial processes and product use (CRF sector 2)

Major changes in the Industrial processes and product use sector compared with the National Inventory Report 2014

Emissions:	The total GHG emissions of the sector decreased from 11.8 Tg CO_2 eq in 2012 to 11.6 Tg CO_2 eq in 2013.
Key sources:	There have been no changes in key sources in this sector.
Methodologies:	Until the 2015 submission, CO_2 emissions from glass production were based on country-specific EFs and gross glass production. From the 2015 submission, emissions are based on the verified EU ETS Emission Reports of the glass production companies (for the years available). As a result of the implementation of the 2006 guidelines, the following additional changes have been made in this sector: • The former CRF sector 3 Solvent and other product use has been incorporated in this CRF sector. • CO_2 emissions from the ceramic industry (2A4a), i.e. process emissions from clay, have been included. • All CO_2 from non-energy use in 2B1 Ammonia production are reported in that category. • NF_3 is included in the figure for PFCs from Semiconductor manufacture (2E1).

4.1 Overview of sector

Emissions of GHGs in this sector include the following:

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

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

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

GHG emissions from fuel combustion in industrial activities and product use are included in the Energy sector. Fugitive emissions of GHGs in the Energy sector (not relating to fuel combustion) are included in IPCC category 1B (Fugitive emissions). The main categories (2A–G) in the CRF sector 2 (Industrial processes and product use) are discussed in the following sections.

A description of the methodologies applied for estimating emissions of CO_2, CH_4, N_2O and F-gases from industrial processes and product use in the Netherlands
can be found in ENINA (2015).

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

Nitric acid production is a Tier 1 trend key source of N_2O emissions, due to the reduction achieved in this category, and caprolactam production is a level key source of N_2O.

Key sources of CO_2 emissions are ammonia production, iron and steel production and the manufacture of other chemical products.

PFC from aluminium production and HFC-22 manufacture are Tier 1 trend key sources of F-gases and the consumption of halocarbons and SF_6 is a Tier 1 level and trend key source of HFC.

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

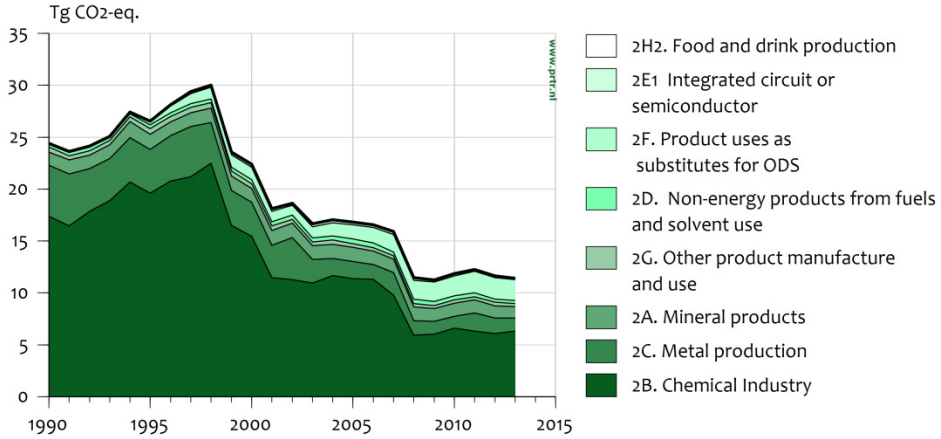


Figure 4.1 Sector 2 Industrial processes and product use: trend and emissions levels of source categories, 1990–2013

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

Sector/category	Gas	Emissions base-year		2012		2013		Absolute 2013 - 2012	Contribution to total in 2013(%)		
		Gg	Tg CO2-eq	Gg	Tg CO2-eq	Gg	Tg CO2-eq		by sector	of total gas	of total CO2-eq
2 Total Industrial Processes	CO_2		8.9		7.3		7.1	-0.3		4%	3.6%
	CH_4	17.5	0.4	19.0	0.5	18.1	0.5	0.0		2.4%	0.2%
	N_2O	23.6	7.0	3.9	1.2	4.4	1.3	0.0		17%	0.7%
	HFC		7.6		2.3		2.3	0.0		100%	1.2%
	PFC		2.3		0.2		0.1	0.0		100%	0.1%
	SF_6		0.3		0.2		0.1	0.0		100%	0.1%
	All		26.5		11.6		11.4	-0.2			5.8%
2A. Mineral industry	CO_2		1.2		1.2		1.1	-0.1	9%	0.6%	0.6%
2B. Chemical industry	CO_2		4.6		4.3		4.4	0.1	39%	2.7%	2.3%
	CH_4	15.5	0.4	17.4	0.4	16.3	0.4	0.0	4%	2.1%	0.2%
	N_2O	22.9	6.8	3.6	1.1	4.1	1.2	0.0	11%	16%	0.6%
	HFC		7.3		0.2		0.3	0.0	2%	12%	0.1%
	PFC		0.0		0.0		0.0	0.0	0%	12%	0.0%
	All		17.4		6.1		6.3	0.2			3.2%
2B1 Ammonia production	CO_2		3.7		3.6		3.8	0.1	33%	2%	1.9%
2B2 Nitric acid production	N_2O	20.4	6.1	0.9	0.3	0.9	0.3	0.0	2%	4%	0.1%
2B4 Caprolactam production	N_2O	2.5	0.7	2.8	0.8	3.2	0.9	0.0	8%	12%	0.5%
2B8 Petrochemical and carbon black production	CO_2		0.8		0.7		0.7	-0.1	6%	0%	0.3%
	CH_4	15.5	0.4	17.4	0.4	16.3	0.4	0.0	4%	2.1%	0.2%
2B9 Fluorochemical production	HFC		7.3		0.2		0.3	0.1	2%	12.1%	0.1%
	PFC	NO			0.0		0.0	0.0	0%	11.7%	0.0%
2.B.10	CO_2	NA		NA		NA		0.0	NA	NA	NA
2C. Metal Production	CO_2		2.7		1.5		1.3	-0.2	11%	0.8%	0.6%
	PFC		2.2		0.0		0.0	0.0	0%	9%	0.0%
	All		4.2		1.5		1.3	-0.2			0.6%
2C1 Iron and steel production	CO2		2.3		1.2		1.1	-0.2	9%	0.7%	0.6%
2C3 PFC emissions from aluminium production	PFC		2.2	0.0	0.0	0.0	0.0	0.0	0.1%	9%	0.0%
2D. Non-energy products from fuels and solvent use	CO_2		0.3		0.3		0.3	0.0	2.7%	0.2%	0.2%
	CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%	0%	0.0%
	All		0.3		0.3		0.3	0.0			0.2%
2D1. Lubricant use	CO_2		0.2		0.2		0.2	0.0	1.4%	0.1%	0.1%
2D2. Paraffin wax use	CO_2		0.1		0.2		0.2	0.0	1.3%	0.1%	0.1%
2E1 Integrated circuit or semiconductor	PFC		0.0		0.1		0.1	0.0	1%	80%	0.1%
2F. Product uses as substitutes for ODS	HFC		0.3		2.1		2.0	0.0	18%	88%	1.0%
2G. Other	CO_2		0.0	0.0	0.0	0.0	0.0	0.0	0%	0.0%	0.0%
	CH_4	2.0	0.1	1.7	0.0	1.7	0.0	0.0	0%	0%	0.0%
	N_2O	0.8	0.22	0.3	0.09	0.3	0.10	0.0	0.8%	1.2%	0.05%
2G2. SF6 and PFCs from other product use	SF_6		0.3	0.0	0.0	0.0	0.0	0.0	0%	0%	0.0%
	All		0.48		0.3		0.3	0.0			0.1%
2G3. N2O from product uses	N_2O	0.7	0.22	0.3	0.08	0.3	0.09	0.0	0.8%	1.1%	0.04%
2.H.2	CO_2		0.02		0.03		0.03	0.0	0%	21.7%	0.01%
Total National emissions	CO_2		160.5		166.8		166.2	0.0			
	CH_4	1.3	32.9		19.2		19.2	0.0			
	N_2O	0.1	17.6		7.6		7.8	0.0			
	HFCs		7.6		2.3		2.3	0.0			
	PFCs		2.3		0.2		0.1	0.0			
	SF_6		0.3		0.2		0.1	-0.1			
National Total GHG emissions (excl. CO2 LUCF)	*All*		221.1		196.3		195.8	-0.5			

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

In 2013, Industrial processes and product use contributed 5.9% of the total national GHG emissions (without LULUCF) in comparison with 12.1% in the base year. The sector is a major source of N_2O emissions in the Netherlands, accounting for 16.9% of total national N_2O emissions.

Category 2B (Chemical industry) contributes most to the emissions from this sector with 6.3 Tg CO_2 eq in 2013.

4.2 Mineral products (2A)

4.2.1 Category description

4.2.1.1 General description of the source categories

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

- Cement clinker production (2A1);
- Glass production (2A3);
- Other process uses of carbonates (2A4);
  - Ceramics (2A4a): Ceramics include bricks and roof tiles, vitrified clay pipes and refractory products. Process-related CO_2 emissions from ceramics result from the calcination of carbonates in the clay.
  - Other uses of soda ash (2A4b);
  - Other (2A4d).

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

CO_2 emissions from other process uses of carbonates (2A4d) originate from:

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

4.2.1.2 Key sources

No key sources are identified in this source category.

4.2.1.3 Overview of shares and trends in emissions

Total CO_2 emissions in category 2A decreased from 1.25 Tg in 1990 to 1.08 Tg in 2013 (see Table 4.1). Total CO_2 emissions in category 2A decreased from 1.18 Tg in 2012 to 1.08 Tg in 2013.

4.2.2 Methodological issues

For all the source categories, country-specific methodologies are used to estimate emissions of CO_2 in compliance with the 2006 IPCC Guidelines, volume 3. More detailed descriptions of the methods and EFs used are found in ENINA (2015), as indicated in Section 4.1.

2A1 (Cement clinker production):

Because of changes in raw material composition over time, it is not possible to reliably estimate CO_2 process emissions on the basis of clinker production activity data and a default EF. For that reason, the only cement producer in the Netherlands company has chosen to base the calculation of CO_2 emissions on the carbonate content of the process input. From 2002 onwards, the methodology for carbon measurements and for calculating emissions can be described as follows:

The first carbonate input in the kiln is the raw material. The CO_2 emissions from this input are calculated on a monthly basis by multiplying the amount of raw material by a derived process EF. From every batch in a month, a sample is taken just before the raw material is fed into the kiln. The process EF and composition of the batch are determined in a laboratory. The EF is determined by measuring the weight loss of the sample (excluding the amount of organic carbon). The monthly EF is set as the average of all sample EFs determined that month. The second carbonate input in the kiln is sewage sludge. The ¶ emissions from this source are also calculated monthly by multiplying the amount of sewage sludge by the monthly derived process EF. Besides the CO2 emissions resulting from calcination of the carbonate input in the kiln, the company considers the CO_2 emissions from burning off the small amount of organic carbon in the raw material as process emissions.

As a result, the total yearly process emissions of the company are the sum of all monthly CO_2 emissions from the following sources:

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

This methodology is also included in a monitoring plan applied to emissions trading. This plan has been approved by the Dutch Emissions authority (NEa), the government organization responsible for the emissions trading scheme (ETS) in the Netherlands. This organization is also responsible for the verification of the data reported by this company. The verified CO_2 emissions are also reported in its AER.

For the years prior to 2002, only total CO_2 emissions from the AER are available, so that it is not possible to allocate the total CO_2 emissions to fuel use and the above mentioned subsources. Therefore, for that period, CO_2 process emissions have been calculated by multiplying the average IEF of 2002 and 2003 by the clinker production. Clinker production figures are obtained from the AERs.

CO_2 process emissions from the AERs are related to clinker production figures to give the annual CO_2 IEF for clinker production. Table 4.2 shows the trend in the CO_2 IEFs for clinker production during the period 2002–2013 (IPCC Default = 0.52 t/t clinker).

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

Gas	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2	0.54	0.54	0.54	0.52	0.51	0.48	0.48	0.52	0.50	0.52	0.51	0.50

2A3 (Glass production):

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

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

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

2A4a (ceramics):

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

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

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

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

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

Mc = Mclay x cc

Where:

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

cc = the default carbonate content of clay (0.1) from the 2006 Guidelines.

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

2A4d (other):
CO_2 emissions from this source category are based on consumption figures for limestone use for flue gas desulphurization (FGD) in coal-fired power plants and in iron and steel production and for apparent dolomite consumption (mostly in road construction). Activity data on plaster production for use in desulphurizing installations at power plants is based on the AERs of the coal-fired power plants. To calculate CO_2 emissions from the use of limestone in iron and steel production, the amount of limestone reported in the AERs of Tata Steel is used. The AERs are also used for emissions data. The consumption of dolomite is based on statistical information obtained from Statistics Netherlands, which can be found on the website www.cbs.nl.
From 2000 onwards, data reported in the AERs of Tata Steel has been used to calculate CO_2 emissions from limestone use in iron and steel production. For the period 1990–2000, CO_2 emissions were calculated by multiplying the average IEF (107.9 kg CO_2 per ton of crude steel produced) over the 2000–2003 period by the crude steel production.
CO_2 from limestone use = limestone use x $f_{(limestone)}$ x $EF_{limestone}$, where f is the fractional purity.
CO_2 emissions from the use of limestone and dolomite and from the use of other substances in the glass production sector are included in 2A3, Glass production.
The emissions are calculated using the standard IPCC EF of 415 kg CO_2 per ton of soda ash (Na2CO3) (2006 IPCC Guidelines, volume 3, chapter 2, table 2.1; for limestone use: EF = 0.440 t/t (IPCC default); for dolomite use: EF = 0.477 t/t (IPCC default)).

4.2.3 Uncertainties and time series consistency

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

Uncertainty estimates used in the Tier 1 analysis are based on the judgement of experts, since no detailed information is available that might enable the uncertainties of the emissions reported by the facilities (cement clinker production, limestone and dolomite use, and soda ash production) to be assessed. The uncertainty in CO_2 emissions from cement clinker production is estimated to be approximately 10%; for limestone and dolomite use, the uncertainty is estimated to be 25% and for other sources 50%, on account of the relatively high uncertainty in the activity data.

Soda ash use, limestone and dolomite use, and glass production are assumed to be relatively uncertain (respectively 25%, 25% and 50%). The uncertainties of the IPCC default EFs used for some processes are not assessed. As these are minor sources of CO_2, however, this absence of data was not given any further consideration.

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

4.2.4 Category-specific QA/QC and verification

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

4.2.5 Category-specific recalculations

As mentioned in Section 4.2.2, the methodology to estimate CO_2 emissions from glass production has been changed. The results of the recalculation and changes can be found in Table 4.3.

Table 4.3 Effects of change in methodology applied to Glass production (2A3) 1990–2012 (Gg CO_2 eq)

Year	NIR 2015: CO_2 emission	NIR 2014: CO_2 emission	Difference
1990	142	142	0
1991	140	153	12
1992	138	157	19
1993	136	170	34
1994	134	183	49
1995	132	196	64
1996	129	225	96
1997	127	256	129
1998	125	268	143
1999	123	280	157
2000	121	275	155
2001	119	278	159
2002	116	255	138
2003	114	246	132
2004	112	260	148
2005	110	264	154
2006	107	271	165
2007	108	270	161
2008	104	269	165
2009	96	228	131
2010	98	232	134
2011	104	248	144
2012	97	231	134

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

4.3 Chemical industry (2B)

4.3.1 Category description

General description of the source categories

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

- Ammonia production (2B1): CO_2 emissions: in the Netherlands, natural gas is used as feedstock for ammonia production. CO_2 is a by-product of the chemical separation of hydrogen from natural gas. During the process of ammonia (NH_3) production, hydrogen and nitrogen are combined and react together.
- Nitric acid production (2B2): N_2O emissions: The production of nitric acid (HNO_3) generates nitrous oxide (N_2O), which is a by-product of the high-temperature catalytic oxidation of ammonia. Until 2010, three companies, each with two HNO_3 production plants, were responsible for the N_2O emissions from nitric acid production in the Netherlands. Two plants of one company were closed in 2010 and one of these has been moved to one of the other companies. Since then, two companies, one with three and one with two HNO_3 production plants, are responsible for the N_2O emissions from nitric acid production in the Netherlands.
- Caprolactam, glyoxal and glyoxylic acid production (2B4): caprolactam production (2B4a): N_2O emissions.
- Silicon carbide production (2B5): CH_4 emissions: Petrol cokes are used during the production of silicon carbide; the volatile compounds in the petrol cokes form CH_4.
- Titanium dioxide production (2B6): CO_2 emissions arise from oxidation of coke as reductant.
- Soda ash production (2B7): CO_2 emissions are related to the non-energy use of coke.
- Petrochemical and carbon black production (2B8):
  - ethylene oxide production (2B8d): CO2 emissions result from the production of ethylene oxide.
- 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 (2B9a2): 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 CO2 is emitted.

- Use of petcoke as feedstock and use of lubricants: These are both very small CO2 sources.
- Carbon electrode production: Carbon electrodes are produced from petroleum coke and coke, used as feedstock, In this process CO2 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 CO2 is a by-product.

Adapic acid (2B3), glyoxal (2B4b), glyoxylic acid (2B4c) and calcium carbide (included in 2B5) are not produced in the Netherlands. CO_2 emissions resulting from the use of fossil fuels as feedstocks for the production of silicon carbide, carbon black, ethylene and methanol are included in the Energy sector (1A2c; see Section 3.2.7 for details).

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

Key sources

Ammonia production and other chemical product manufacture are identified as key sources of CO_2 emissions, while caprolactam production is identified as a key source of N_2O emissions. Since 2008, nitric acid production has not been a Tier 2 level key source of N_2O emissions; due to emissions reductions in 2007 and 2008, it has been devalued to a trend key source (see Table 4.1). The production of HCFC-22 (HFC-23 emissions) is a trend key source; see Table 4.1.

Overview of shares and trends in emissions

Figure 4.2 shows the trend in CO_2-equivalent emissions from 2B (Chemical industry) in the period 1990–2013. Table 4.1 gives an overview of proportions of emissions from the main categories.

Emissions from this category contributed 7.8% of total national GHG emissions (without LULUCF) in the base year and 3.2% in 2013.

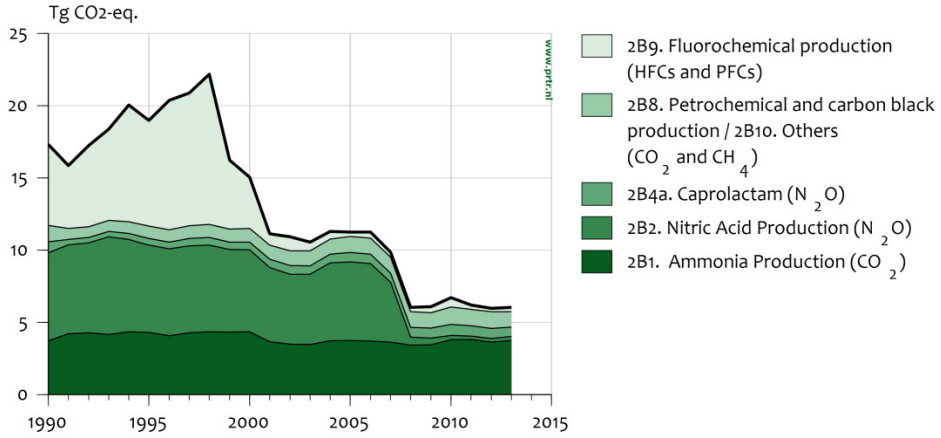


Figure 4.2 2B Chemical industry: trend and emissions levels of source categories, 1990–2013

From 1990 to 2001, total GHG emissions from 2B (Chemical industry) decreased by 5.9 Tg CO_2 eq, mainly due to a reduction in HFC-23 emissions from HCFC-22 production. From 2001 to 2008, total GHG emissions from 2B (Chemical industry) decreased by 5.6 Tg CO_2 eq, mainly due to a reduction in N_2O emissions from the production of nitric acid. During the period 2009–2013, total GHG emissions from 2B remained at almost the same level as in 2008.

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

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

Year	B2 Nitric acid production	B4a caprolactam Production	Total
1990	6,085	737	6,821
1991	6,169	655	6,823
1992	6,228	646	6,874
1993	6,765	595	7,360
1994	6,407	781	7,188
1995	6,035	774	6,809
1996	6,020	790	6,810
1997	6,020	730	6,750
1998	5,990	771	6,760
1999	5,731	689	6,419
2000	5,670	900	6,569
2001	5,134	830	5,964
2002	4,837	862	5,699
2003	4,864	917	5,781
2004	5,400	887	6,287
2005	5,440	678	6,118
2006	5,380	637	6,017
2007	4,138	478	4,616
2008	536	462	999
2009	473	580	1,053
2010	290	655	944
2011	234	837	1,070
2012	254	823	1,076
2013	274	949	1,223

Nitric acid production (2B2)

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

Technical measures implemented at all nitric acid plants in the third quarter of 2007 resulted in an emissions reduction of 23% compared with 2006. In 2008, the full effect of the measures was reflected in the low emissions (a reduction of 90% compared with 2006). The further reduction in 2009 was primarily caused by the economic crisis. Because of the closure of one of the plants and an improved catalytic effect in another, emissions decreased again in 2010. The reduction in 2011 was caused by an improved catalytic effect in two of the plants. In 2012 and 2013, N_2O emissions from the nitric acid plants remained almost at the same level as in 2011.

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

Table 4.5 Overview with detailed information per nitric acid plant

Plant:	**1**	**2**	**3**	**4**	**5**	**6**
Type of production technology	Mono pressure (3.5 bar)	Dual pressure (4/10 bar)	Mono pressure (3.5 bar)	Dual pressure (4/10 bar)	Dual pressure (4–6/10–12 bar)	Dual pressure (4–6/10–12 bar)
Abatement technology implemented	Catalyst, which breaks down N_2O, in existing NH_3 reactors, just below the platinum catalyst system	EnviNOx[1] process variant 1 system from UHDE (tertiary technique)	Idem 1	Idem 2	Catalyst (pellets) technology which breaks down N_2O in the first stage of nitric acid production when ammonia is burned	Idem 5
Time of installation	Oct. 2007	Dec. 2007	Oct. 2007	Dec. 2007	Nov. 2007	May 2007
N_2O emissions in tonnes 2006: 2007: 2008: 2009: 2010: 2011: 2012: 2013:	 1,269 1,190 415 387 0 0 0 0	 1,273 1,026 0.05 3.4 1.4 12.3 26 116	 770 631 143 107 139 67 105 65	 4,015 3,275 2.26 40 44 40 35 54	 4,527 4,448 318 310 352 250 196 211	 5,888 3,311 921 741 436 415 489 471
Abatement efficiency 2007–2008[2]	80.40%	99.94%	69.68%	99.997%	92.84%	84.80%

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

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

From 2008 onwards, N_2O emissions from HNO_3 production in the Netherlands were included in the European Emission Trading Scheme (EU-ETS). For this purpose, the companies developed monitoring plans that were approved by the NEa, the government organization responsible for EU-ETS in the Netherlands. In 2014, the companies' emissions reports (2013 emissions) were independently verified and submitted to the NEa, where they were checked against those reported in the CRF tables (2013). No differences were found between the emissions figures in the CRF tables and those in the in the emissions reports under EU-ETS.

Caprolactam production (2B4a)
For the period 1990–2002, calculations are based on the production indices for the 1990–2002 period and an average IEF (see also Section 4.3.2).

The emissions fluctuations during the period 2003–2010 were mainly caused by the uncertainty of the measurements within the plant. During that period, annual emissions were based on only a few emissions measurements per point per year. In 2011, data from a long-term measurement campaign came available. The results showed increased emissions compared to the former estimates basedon a few emissions measurements per point. Based on the 2011 measurements and the production indices, the 2014 submission was to have included a report on the feasibility of improving the whole emissions time series. Because the investigation was still in progress, this proposal was postponed. Due to a lack of information, however, it is not possible to update the emissions time series at this moment. By the time of the next submission, it will have become clear whether or not it is possible to update the series.

Fluorochemical production (2B9)
Total HFC emissions in category 2B were 5.8 Tg in 1995 and 0.18 Tg CO_2 eq in 2013, HFC-23 emissions from HCFC-22 production (2B9) being the major source of HFC emissions. HFC emissions from Handling activities (2E3) were responsible for 31% of total HFC emissions from this category in 2012.

Table 4.6 shows the trend in HFC emissions from the categories HCFC-22 production and HFCs from handling activities for the period 1990–2013. Emissions of HFC-23 increased by approximately 35% in the period 1995–1998, due to increased production of HCFC-22. In the period 1998–2000, however, emissions of HFC-23 decreased by 69% following the installation of a thermal converter (TC) at the plant.

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

Due to the economic crisis, the production level of HCFC-22 was much lower in the last quarter of 2008 and in 2009, resulting in lower HFC-23 emissions in both 2008 and 2009. Primarily as a result of the economic recovery, the production level of HCFC-22 was much higher in 2010,

resulting in higher HFC-23 emissions in 2010, compared with 2009. Due to the increasing removal efficiency of the Thermal Converter after 2010, HFC-23 emissions declined in both 2011 and 2012. Because of a decreasing removal efficiency, HFC-23 emissions increased in 2013.

The significant emissions fluctuations in category 2E3 (Handling activities) during the period 1992–2013 can be explained by the large fluctuations in handling activities, which depend on the demand from customers.

Table 4.6 Trends in HFC-23 by-product emissions from the production of HCFC-22 and HFC emissions from handling activities (2B9a1 and 2B9a2) (Gg CO_2 eq)

Year	2B9a1: HFC-23	2B9a2: HFCs	Total
1990	5,606	NO	5,606
1991	4,366	NO	4,366
1992	5,594	27	5,621
1993	6,257	54	6,312
1994	7,941	137	8,078
1995	7,285	13	7,298
1996	8,712	248	8,960
1997	8,486	718	9,204
1998	9,855	544	10,399
1999	4,352	418	4,769
2000	3,062	472	3,534
2001	569	222	791
2002	866	110	976
2003	525	78	603
2004	448	97	546
2005	248	55	303
2006	355	55	410
2007	307	36	343
2008	268	25	293
2009	195	222	417
2010	494	155	650
2011	211	89	299
2012	159	80	238
2013	238	54	292

CH_4 emissions (2B8g)

CH_4 emissions in these categories (2B4 and 2B5) are non-key sources and did not change much over time (level approximately 300 Gg CO_2 eq for all years).

4.3.2 Methodological issues

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

Country-specific methodologies are used for the CO_2 process emissions from the chemical industry. More detailed descriptions of the methods

used and EFs can be found in ENINA (2015), 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. Because not enough information on the amount of CO_2 recovered for downstream use is available, it is assumed that the amount of CO_2 recovered is zero.
  Data on the use of natural gas is obtained from Statistics Netherlands. Because there are only two ammonia producers in the Netherlands, the consumption of natural gas and the country-specific EF are confidential information.
- 2B2 (Nitric acid production): An IPCC Tier 2 method is used to estimate N_2O emissions. Until 2002, N_2O emissions from nitric acid production were based on IPCC default EFs. N_2O emissions measurements made in 1998 and 1999 resulted in a new EF of 7.4 kg N_2O/ton nitric acid for total nitric acid production. The results of these measurements are confidential and can be viewed at the company's premises.
  Plant-specific EFs for the period 1990–1998 are not available. Because no measurements were taken but the operational conditions did not change during the period 1990–1998, the EFs obtained from the 1998/1999 measurements have been used to recalculate the emissions for the period 1990–1998. Activity data are also confidential.
  The emissions figures are based on data reported by the nitric acid manufacturing industry and are included in the emissions reports under EU-ETS and the national Pollutant Release and Transfer Register (PRTR).
  2B4a (caprolactam production): After 2002, more accurate measurements were performed to estimate N_2O emissions from caprolactam production. From the 2003 and 2004 measurements and the production indices (production data is confidential business information) of 2003 and 2004, an average IEF has been derived. For the period 1990–2002, calculations are based on the production indices for the 1990–2002 period and the average IEF. From 2003 onwards, figures for N_2O emissions from caprolactam production are based on emissions data reported by the company (based on measurements). Plant-specific N_2O EFs and activity data are confidential. This year, a production index series for the period 1990–2013 was received from the company.
- 2B5 (Carbide production): The activity data (petcoke) is confidential, so the IPCC default EF was used to calculate CH_4 emissions.
- 2B6 (Titanium dioxide production): Activity data is confidential. Only emissions are reported by the company.
- 2B7 (Soda ash production): Before the closure in 2010 of the only soda ash producer, CO_2 emissions were calculated on the basis of the non-energy use of coke and the IPCC default EF (0.415 t/t), assuming the 100% oxidation of carbon. The environmental report was used for data on the non-energy use of coke. To avoid double counting, the plant-specific data on the non-energy use of coke is subtracted from the non-energy use of

coke and earmarked as feedstock in national energy statistics. The Netherlands has included the notation code NO in the CRF tables (from 2010 onwards) as soda ash production stopped.

- 2B8 (Petrochemicals and carbon black production):

  2B8a: methanol
  2b8b: ethylene
  2B8e: acrylonitrile
  2B8f: carbon black
  2B8g: other: styrene
  The process emissions from these sources are calculated by multiplying the specific EF by the annual production.
  2B8d: ethylene oxide production
  CO_2 emissions are estimated on the basis of capacity data by using a default capacity utilization rate of 86% (based on Neelis et al., 2005) and applying a default EF of 0.45 t/t ethylene oxide. As there is no real activity data available at this moment in the Prodcom database from EUROSTAT, the Netherlands can not verify this assumption on thee activity data for ethylene production.

- 2B9a1: production of HCFC-22: This source category is identified as a trend key source of HFC-23 emissions. In order to comply with the 2006 IPCC Guidelines, volume 3, an IPCC Tier 2 method is used to estimate the emissions from this source category. HFC-23 emissions are calculated using both data on the mass flow of HFC-23 produced in the process and the amount of HFC-23 processed in the TC.
  The activity data used to estimate emissions of HFC-23 from 2B9a1 is based on confidential information provided by the manufacturer (production figures of HCFC-22 and amount of HFC-23 in untreated flow/year).
  The IEF used to estimate emissions of HFC-23 from 2B9a is based on the following the removal efficiency of the TC (kg HFC-23 processed in TC/kg HFC-23 in untreated flow/year, which is confidential).
- 2B9a2: Handling activities (HFCs): Tier 1 country-specific methodologies are used to estimate emissions of HFCs from handling activity. The estimations are based on emissions data reported by the manufacturing and sales companies. Activity data used to estimate HFC emissions is confidential. The EFs used are plant-specific and confidential, and they are based on 1999 measurement data.
- 2B10: Other: The aggregated CO_2 emissions included in this source category are identified as a key source. Because no IPCC methodologies exist for these processes, country-specific methods and EFs are used. These refer to:
  - The production of industrial gases: With natural gas as input (chemical feedstock), industrial gases, e.g. H2 and CO, are produced. The oxidation fraction of 20% (80% storage) is derived from Huurman (2005). From the two producers in the Netherlands, the total amount of carbon stored in the industrial gases produced and the total carbon content of the natural gas used as feedstock are derived from the AERs.

These data result in a storage factor of 80%
The storage factor is determined by dividing the total amount of carbon stored in the industrial gases produced by the carbon content of the natural gas used as feedstock.

- Use of petcokes and lubricants form the basis for the CO_2 emissions.
- Production of carbon electrodes: CO_2 emissions are estimated on the basis of fuel use (mainly petcoke and coke). A small oxidation fraction (5%) is assumed, based on data reported in the AERs.
- Production of activated carbon: CO_2 emissions are estimated on the basis of the production data for Norit and by applying an EF of 1 t/t Norit. The EF is derived from the carbon losses from peat use reported in the AERs. As peat consumption is not included in national energy statistics, the production data since 1990 has been estimated on the basis of an extrapolation of the production level of 33 Tg reported in 2002. This is considered to be justified because this source contributes relatively little to the national inventory of GHGs.

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

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

4.3.3 Uncertainty and time series consistency

Uncertainty

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

The uncertainty in annual CO_2 emissions from ammonia production is estimated to be approximately 10%. For all the other sources in this category the uncertainty is estimated to be about 71%. The uncertainty in the activity data and the EF for CO_2 is estimated at 2% and 10% for ammonia production and at 50% for all the other sources in this category.

The uncertainty in the annual emissions of N_2O from caprolactam production is estimated to be approximately 30%.
Since N_2O emissions from HNO_3 production in the Netherlands are included in the EU-ETS, all companies have continuous measuring of their N_2O emissions. This has resulted in a lower annual emissions uncertainty, of approximately 8%.

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

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

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

The confidential information is checked and verified as follows:
- As mentioned in ENINA (2015), the confidential information (the HFC 23 load in the untreated flow, and the removal efficiency of the TC) can be viewed at the company's premises.
- During the annual verification of the AER, the competent authorities check the reliability of the information at the company.
- The industrial expert of the Dutch emission inventory team checks the information at the company.

4.3.5 Category-specific recalculations
As a result of the implementation of the 2006 IPCC Guidelines, all CO_2 emissions from non-energy use are reported in this category from this submission onwards. This has resulted in higher emissions levels. Compared with the last submission, the emissions level for 1990 is 0.6 Mton higher, and for 2012 1.0 Mton higher.

4.3.6 Category-specific planned improvements
Efforts will be made to recalculate the N_2O emissions from caprolactam production over the total time series on the basis of plant-specific, long-term measurements and production indices.

4.4 Metal production (2C)

4.4.1 Category description
General description of the source categories
The national inventory of the Netherlands includes emissions of GHGs related to two source categories belonging to 2C (Metal production):
- Iron and steel production (2C1): CO_2 emissions: the Netherlands has one integrated iron and steel plant (Tata Steel, previously Corus and/or Hoogovens). During the production of iron and steel, coke and coal are used as reducing agents in the blast and oxygen furnaces, resulting in the by-products blast furnace gas and oxygen furnace gas. A small percentage of these gases is emitted (lost) and the rest is used as fuel for energy purposes. Only the carbon losses are reported in category 2C1.
  In addition, CO_2 is produced during the conversion of pig iron to steel. These emissions are also reported in this category.
  The process emission from anode use during steel production in the electric arc furnace is also included in this category.
  As mentioned in Section 3.2.5 (1A2a), the emissions calculation for this sector is based on a mass balance, which is not included in the NIR for reasons of confidentiality but can be made available for the UNFCCC review.

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

There are some small Ferroalloy production (2C2) companies in the Netherlands, but they do not have GHG process emissions. Their combustion emissions are included in 1A2.

The following source categories do not occur in the Netherlands:
- magnesium production (2C4);
- lead production (2C5);
- zinc production via the electro-thermic distillation or the pyrometallurgical process (2C6);
- other metal production (2C7).

Key sources

Iron and steel production (carbon inputs) is identified as a key source of CO_2 emissions, aluminium production as a trend key source for PFC emissions (see Table 4.1).

Overview of shares and trends in emissions

Table 4.1 provides an overview of emissions, by proportion, from the main categories. Total CO_2 emissions from 2C1 (Iron and steel production) decreased by 1.5 Tg during the period 1990–2013. In 2013, CO_2 emissions decreased by 0.2 Tg compared with 2012.

Table 4.7 shows the trend in CF_4 and C_2F_6 emissions for aluminium production during the period 1990–2013. Zalco, the largest company, was responsible for approximately two-thirds of total national production. Emissions decreased by 2.2 Tg CO_2 eq between 1995 and 2013. In 1998, the smaller company, Aldel, switched from side feed to point feed; this switch was made by Zalco in 2002/2003, thereby explaining the decreased emissions from this year onwards. The higher level of emissions in 2002 was caused by specific process-related problems during the switching process at Zalco.
From 2004 onwards, the level of the PFC emissions depended mainly on the number of anode effects.

Because of the closure of Zalco, PFC emissions decreased after 2011 to 0.01 Tg CO_2 eq in 2013.

Table 4.7 Emissions for CF_4 and C_2F_6 from Aluminium production (2C3) (Gg CO_2 eq)

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

4.4.2 Methodological issues

The methodologies used to estimate the GHG emissions for all source categories of metal production comply with the 2006 IPCC Guidelines. More detailed descriptions of the methods and EFs used can be found in ENINA (2015).

Iron and steel production (2C1)

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

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

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

The same plant-specific EF (0.21485 tons CO^2 per GJ) is used for blast furnace gas and oxygen furnace gas (see Annex 5).

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

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

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

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

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

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

Estimations of the PFC emissions from primary aluminium production reported by these two facilities are based on the IPCC Tier 2 method for the complete period 1990–2013. Emission factors are plant-specific and confidential and are based on measured data.

4.4.3 Uncertainty and time series consistency

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

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

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

4.4.5 Category-specific recalculations
No recalculations have been made.

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

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

4.5.1 Category description
General description of the source categories
The national inventory of the Netherlands includes emissions of GHGs related to two sources in this source category:

- Lubricant use (2D1);
- Paraffin wax use (2D2).

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.

Key sources

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

Overview of shares and trends in emissions

The small CO_2 and CH_4 emissions remained fairly constant between 1990 and 2013.

4.5.2 Methodological issues
The methodologies used to estimate the GHG emissions in 2D1 and 2D2 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 fuels in the production of lubricants, an ODU factor of 50% and for the production of waxes an ODU factor of 100% have been used.

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

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

The uncertainty in CO_2 EF is estimated to be approximately 50% in the ODU factor for lubricants. The uncertainty in the activity data (such as

domestic consumption of these fuel types) is generally very large, since it is based on production, import and export figures.

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

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

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

4.5.5 Category-specific recalculations
No recalculations have been made.

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

4.6 Electronics industry (2E)

4.6.1 Category description

General description of the source categories
PFCs (incl. NF3) and SF_6 are released via the use of these compounds in Semiconductor manufacture (2E1). The SF_6 emissions are included in 2G2. PFC and SF_6 emissions from TFT flat panel display (2E2), Photovoltaics (2E3) and Heat transfer fluid (2E4) manufacturing do not occur in the Netherlands. No Other sources (2E5) are identified in the inventory.

Key sources

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

Overview of shares and trends in emissions

The contribution of F-gas emissions from category 2E to the total national inventory of F-gas emissions was 0.5% in the base year 1995 and 4% in 2013. The latter figure corresponds to 0.1 Tg CO_2 eq and accounts for 0.1% of the national total GHG emissions in 2013.

Due to a increasing production level in the semiconductor manufacturing industry, PFC emissions increased from 47 Gg CO_2 eq in the base year to 282 Gg CO_2 eq in 2007. The decrease after 2007 was mainly achieved thanks to an intensive PFC (incl. NF_3) reduction scheme (see Table 4.8).

Table 4.8 Emissions trend from the use of PFCs (incl. NF_3) in Electronics industry (2E1) (Gg CO_2 eq)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
PFCs	24	47	251	227	248	282	228	161	194	128	142	101

4.6.2 Methodological issues

To comply with the 2006 IPCC Guidelines, volume 3, an IPCC Tier 2 method is used to estimate emissions from semiconductor manufacturing.

Activity data on the use of PFCs in semiconductor manufacturing was obtained from the only manufactory company (confidential information). Emission factors are confidential information. Detailed information on the activity data and EFs can be found in ENINA (2015).

4.6.3 Uncertainty and time series consistency

Uncertainty

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

Time series consistency

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

4.6.4 Category-specific QA/QC and verification

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

4.6.5 Category-specific recalculations

There were no recalculations in this sector.

4.6.6 Category-specific planned improvements

No source-specific improvements are planned.

4.7 Product use as substitutes for ODS (2F)

4.7.1 Category description

General description of the source categories

The national inventory comprises the following sources within this category:

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

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

Key sources

Emissions from Product use as substitutes for ODS (2F) are identified as a key source of HFCs.

Overview of shares and trends in emissions

The contribution of F-gas emissions from category 2F to the total national inventory of F-gas emissions was 3% in the base year 1995 and 79% in 2013. The latter figure corresponds to 2.0 Tg CO_2 eq and accounts for 1% of the national total GHG emissions in 2013.

Due to increased HFC consumption as a substitute for (H)CFC use, the level of HFC emissions increased by a factor of 7 in 2013 compared with 1995.

Table 4.9 Emissions trends specified per compound from the use of HFCs as substitutes for ODS (Gg CO_2 eq)

Year	HFC-134a	HFC-143a	HFC-125	HFC-32	HFC-23	Other HFCs	HFC Total
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	19	NO	NO	NO	NO	62	81
1995	52	9	10	1	NO	208	280
1996	89	32	33	3	NO	480	638
1997	124	56	54	5	NO	744	984
1998	154	76	67	6	NO	844	1147
1999	177	93	82	6	NO	845	1203
2000	228	137	119	8	NO	688	1180
2001	283	182	162	9	NO	385	1021
2002	336	226	200	10	NO	181	953
2003	389	274	243	11	NO	167	1083
2004	437	321	283	11	NO	236	1289
2005	483	365	321	12	NO	164	1345
2006	523	407	359	14	NO	196	1499
2007	561	455	397	14	NO	267	1694
2008	595	504	429	15	NO	284	1827
2009	619	550	450	14	NO	252	1885
2010	625	574	467	15	1	229	1910
2011	639	590	481	16	1	363	2090
2012	654	609	495	16	2	283	2059
2013	669	607	510	17	2	211	2015

4.7.2 Methodological issues

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

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

- Consumption data of HFCs (stationary refrigeration, aerosols and foam-blowing agents) was obtained from the annual report by PriceWaterhouseCoopers (PWC, 2014).
- For mobile air-conditioning, the number of cars (by year of construction) and the number of scrapped cars (by year of construction) were obtained from Statistics Netherlands. The amounts of recycled and destroyed refrigerants were obtained from ARN, a waste-processing organization.

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

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

More detailed descriptions of the methods used can be found in ENINA (2015), as indicated in Section 4.1.

4.7.3 Uncertainty and time series consistency

Uncertainty

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

Time series consistency

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

4.7.7 Category-specific QA/QC and verification

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

4.7.5 Category-specific recalculations

No recalculations have been made.

4.7.6 Category-specific planned improvements

No source-specific improvements are planned for this category.

4.8 Other product manufacture and use (2G)

4.8.1 Category description

General description of the source categories

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

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

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

Key sources

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

Overview of shares and trends in emissions

Table 4.10 shows the trend in emissions from the use of SF_6 during the period 1990–2013.

Table 4.10 Emissions from the use of SF_6, 1990–2013 (Gg CO_2 eq)

	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
SF_6	208	274	282	229	190	179	175	163	176	140	187	132

After 2000, the decrease in SF_6 emissions was mainly caused by:

- the closure of the only manufacturer of high-voltage installations at the end of 2002;
- an intensive PFC-reduction scheme in the Semiconductor manufacture sector (2E1);
- the use of leak detection equipment in 2G1 Electrical equipment.

N_2O emissions from 2G3 decreased by 61% during the period 1990–2013. N_2O emissions from anaesthesia fell by 89% between 1990 and 2013 due to better dosing in hospitals and other medical institutions. Domestic sales of cream in aerosol cans have increased sharply since 1990. For this reason, emissions of N_2O from food aerosol cans increased by 129% during the period 1990–2013.

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

4.8.2 Methodological issues

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

the Netherlands, and the emissions from testing were abtained from the single test laboratory wich uses the gas.

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

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

Furthermore, based on the new emissions data from 2006 and existing emissions data from 1999, SF^6 emissions from electrical equipment have been recalculated by interpolation for the period 2000-2005 to achieve a consistent time series.

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

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

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

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

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

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

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

The major hospital supplier of N_2O for anaesthetic use reports the consumption data for anaesthetic gas in the Netherlands annually. The

Dutch Association of Aerosol Producers (NAV) reports data on the annual sales of N_2O-containing spray cans.

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

The methodologies used to estimate the GHG emissions of 2G4 are:
- Fireworks and candles: Country-specific methods and EFs are used to estimate emissions of CO_2, CH_4 and N_2O.
- Degassing of drinking water: A country-specific methodology and EF are used to estimate CH_4 emissions, this being the main source of CH_4 emissions in this category.

The activity data used in 2G4 derives from the following sources:
- Fireworks: data on annual sales from teh trade organization;
- Candles: average annual use of 3.3 kg per person (www.bolsius.com);
- Production of drinking water: volume and fuel use from Statistics Netherlands.

The EFs used in 2G4 are based on the following:
- Fireworks: CO2: 43 kg/t; CH4: 0.78 kg/t; N2O: 1.96 kg/t (Brouwer et al., 1995);
- Candles: CO2: 2.3 kg/t (EPA, 2001);
- Production of drinking water: 2.47 tons CH4/106 m3 (Brouwer et al., 1995).

4.8.3 Uncertainty and time series consistency

Uncertainty

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

The uncertainty in SF_6 emissions from 2G1 and 2G2 is estimated to be 50%. For the activity data and the EFs for the SF_6 sources, the uncertainty is estimated to be approximately 50% and 25%, respectively.

Because, for 2007 and 2008, the country-specific method for the source category Electrical equipment is equivalent to the IPCC Tier 3b method and, from 2009 onwards, to the IPCC Tier 3a method, the uncertainty in SF_6 emissions from 2G1 has changed. The uncertainty in SF_6 emissions from 2G1 is estimated to be 34%. For the activity data and the EFs for 2G1 and 2G2, the uncertainty is estimated to be approximately 30% and 15%, respectively.

For N_2O emissions (2G3), the uncertainty is estimated to be approximately 50%, based on the judgement of experts. Uncertainty in the activity data on N_2O use is estimated to be 50% and that of the EF to be less than 1% (the assumption is that all gas is released).

The uncertainty in CO_2 emissions from 2G4 is estimated to be approximately 50% (5% in activity data and 50% in EF). 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.

The uncertainty in CH_4 emissions is estimated to be 50% (10% in activity data and 50% in EF). The uncertainty in N_2O emissions is estimated at 70% (50% in activity data and 50% in EF). All figures are based on the judgements of experts, since no specific monitoring data or literature are available for the current situation in the Netherlands.

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
No recalculations have been made.

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

4.9 Other (2H)

4.9.1 Category description

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

Key sources

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

Overview of shares and trends in emissions

Emissions vary around 0.05 Tg and are rounded to either 0.1 or 0.0 Tg (see Table 4.1).

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

4.9.3 Uncertainty and time series consistency

Uncertainty

The Tier 1 uncertainty analysis outlined in Annex 2, shown in Tables A2.1 and A2.2, provides estimates of the uncertainties by IPCC source category. The uncertainty in the emissions of this category is estimated to be 5%.

Time series consistency

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

4.9.4 Category-specific QA/QC and verification

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

4.9.5 Category-specific recalculations

No recalculations have been made.

4.9.6 Category-specific planned improvements

No source-specific improvements are planned.

5 Agriculture (CRF sector 3)

Major changes in the Agriculture sector compared with the National Inventory Report 2014

Emissions: Methane (CH_4) emissions from Agriculture increased by 2.4% from 2012 to 2013, while nitrous oxide (N_2O) emissions remained almost unchanged, translating into a 1.7% overall increase in total CO_2 eq emissions produced by this sector.

Some increases in animal numbers occurred from 2012 to 2013, leading to increased CH_4 and N_2O emissions. However, for N_2O the increase is countered by lower emissions from inorganic N-fertilizers and crop residues (due to lower activity in grassland renewal).

Key sources: No changes compared with the NIR 2014.

Methodologies: In accordance with the 2006 IPCC Guidelines, the Y_m used in the calculation of CH_4 from enteric fermentation has increased from 0.06 to 0.065. For white veal calves a country- and year-specific value has been derived, increasing from 0.3 to 1.9% over the 1990–2013 period. This reflects the changes in this sector, where a diet previously consisting of artificial milk only is nowadays supplemented by roughages enhancing rumen development.
Within the methodology for CH_4 from manure management, the volatile solids content of the manure is now based on calculations instead of manure analysis results. As this relates directly to excretion, it improves emission estimates in the key categories cattle, swine and poultry, which are supported by data on concentration measurements in animal houses. In the remaining animal categories, a Tier 1 approach is adopted.

For N_2O from manure management, EFs have been updated to the values of the 2006 Guidelines. Although the EF for liquid manure doubled, the decrease in EFs for solid manure and especially poultry manure result in a decrease in total emissions.

Several definition changes in the Guidelines see new sources being taken up in the inventory, including an extension of histosols to include organic soils, pasture renewal within crop residues and the application of compost. On the other hand, N-fixing crops have been removed as a source, as indicated by the Guidelines. The category Indirect N_2O emissions following atmospheric deposition of ammonia and nitric oxide has been split into the contributions from Manure management (3B) and Agricultural soils (3D). The new sources have also been added to the calculations of indirect emissions following atmospheric deposition and leaching and run-off, where applicable.

Finally, CO_2 emissions from liming are now attributed to Agriculture, but methods have remained the same as for the previous reporting under the LULUCF sector.

5.1 Overview of the sector

Emissions of GHGs from agriculture include all anthropogenic emissions from the agricultural sector, with the exception of emissions from fuel combustion and carbon dioxide (CO_2) emissions through land use in agriculture. These emissions are included in 1A3eii (see Section 3.2.6) and 1A4c Agriculture/forestry/fisheries (Section 3.2.7) and in 4 Land use, land use change and forestry (LULUCF; Sections 6).

In the Netherlands, there four source categories in the agricultural sector:

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

The other 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. Open fires/burning in the field is prohibited by law and therefore negligible in practice. In the production of other carbon-containing fertilizers, CO_2 is bound from the atmosphere. After application, this CO_2 is released again, and therefore no net emission takes place. Urea application (3H) is included in the sub-category 3Da1 inorganic N fertilizers.

Manure management (3B) includes all emissions from confined animal waste management systems (AWMS). CH_4 emissions from animal manure produced on pasture land during grazing are included in category 3B; N_2O emissions from this source are, however, included within category 3Da3 urine and dung from grazing animals. These differing approaches are in accordance with the 2006 IPCC Guidelines.

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

The methodologies, activity data and EFs applied in estimating N_2O and CH_4 emissions from agriculture in the Netherlands are described in more detail in Vonk et al. (2015).

Overview of shares and trends in emissions

Table 5.1 shows the contribution of the agricultural source categories to the total national GHG inventory. This table also presents the key sources identified in the agricultural sector, by trend or level, or both.

Table 5.1 Contribution of main categories and key sources in sector 3 Agriculture

Sector/ category	Gas	Key	Emissions base year	2012	2013	Absolute 2013–2012	Contribution to total in 2013 (%)		
			Tg CO_2 eq	Tg CO_2 eq	Tg CO_2 eq	Tg CO_2 eq	by sector	of total gas	of total CO_2 eq
3 Agriculture	CO_2		0.2	0.1	0.1	0.00	0.4	0	0.0
	CH_4		15.0	12.2	12.5	0.29	68.2	65	6.4
	N_2O		10.0	5.7	5.7	0.02	31.4	74	2.9
	All		25.3	18.0	18.3	0.31			9.3
3A Enteric fermentation	CH_4		9.2	7.9	8.1	0.27	44.5	42	4.2
3A1 Cattle	CH_4	L,T	8.2	7.0	7.2	0.27	39.6	38	3.7
3A3 Swine	CH_4		0.5	0.5	0.5	0.00	2.5	2	0.2
3A4 Other livestock	CH_4	NK	0.5	0.5	0.5	0.00	2.5	2	0.2
3B Manure management	CH_4		5.8	4.3	4.3	0.02	23.7	23	2.2
	N_2O		0.9	0.6	0.6	-0.01	3.5	8	0.3
	All		6.7	5.0	5.0	0.01	27.2		2.5
3B1 Cattle	CH_4	L,T2	1.8	2.0	2.1	0.09	11.7	11	1.1
3B3 Swine	CH_4	L,T2	3.5	2.2	2.1	-0.07	11.4	11	1.1
3B4 Poultry	CH_4	T2	0.5	0.1	0.1	0.00	0.4	0	0.0
3B4 Other livestock	CH_4	NK	0.0	0.0	0.0	0.00	0.2	0	0.0
3B1–4 Direct emissions	N_2O	L	0.5	0.4	0.4	0.01	2.3	5	0.2
3B5 Indirect emissions	N_2O		0.4	0.2	0.2	-0.02	1.2	3	0.1
3D Agricultural soils	N_2O		9.1	5.1	5.1	0.03	27.9	65	2.6
3Da1 inorganic N-fertilizers	N_2O	L,T	2.5	1.3	1.3	-0.04	7.1	17	0.7
3Da2 organic N-fertilizers	N_2O	L,T	0.8	1.2	1.2	0.04	6.8	16	0.6
3Da3 urine and dung from grazing animals	N_2O	L,T	3.0	1.0	1.1	0.05	5.8	13	0.5
3Da4 crop residues	N_2O		0.3	0.2	0.1	-0.03	0.8	2	0.1
3Da6 cultivation of organic soils	N_2O		0.8	0.8	0.8	0.00	4.3	10	0.4
3Db indirect N_2O emissions from managed soils	N_2O	L,T	1.6	0.6	0.6	0.01	3.2	8	0.3
National total GHG emissions (excl. CO_2 LULUCF)	CO_2		160.8	166.9	166.4	-0.53		100	
	CH_4		32.9	19.3	19.2	-0.02		100	
	N_2O		17.6	7.7	7.8	0.08		100	
	All		195.1	196.5	195.9	-0.56			100

CO_2-equivalent emissions from sector 3 Agriculture were responsible for 9.3% of total national emissions (without LULUCF) in 2013, compared with 13.0% in 1990. In 2013, emissions of CH_4 and N_2O from agricultural sources accounted for 65% and 74% of the national total CH_4 and N_2O emissions, respectively. Category 3A Enteric fermentation is the main source of CH_4 emissions and categories 3Da1 inorganic N-fertilizers and 3Da2 organic N-fertilizers are the largest sources of N_2O emissions in this sector.

Total GHG emissions from agriculture decreased by approximately 28% between 1990 and 2013, from 25.3 Tg CO_2 eq in 1990 to 18.3 Tg CO_2 eq in 2013 (see Figure 5.1). This decrease was largely the result of reduced numbers of livestock, decreased application of animal manure and decreased use of inorganic N-fertilizers.

Methane (CH_4) emissions from agriculture increased by almost 0.3 Tg CO_2 eq from 2012 to 2013 as a result of increased cattle numbers. Nitrous oxide (N_2O) emissions remained stable at 5.7 Tg CO_2 eq, since at the same time inorganic N-fertilizer consumption decreased. Overall, this translated into a 1.7% increase in total CO_2 eq produced by this sector from 2012 to 2013.

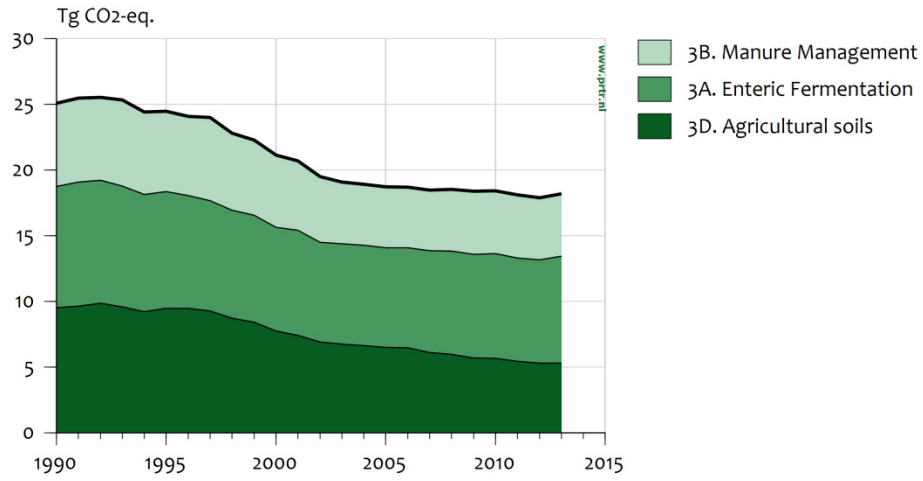


Figure 5.1 Category 3 Agriculture: trend and emissions levels of source categories, 1990–2013

Overview of trends in activity data

Livestock numbers form the primary activity data used in emissions calculations for agriculture, and are taken from the annual agricultural survey performed by Statistics Netherlands. Data can be found on the website www.cbs.nl and in background documents (e.g. Bruggen et al., 2015). Table 5.2 presents an overview.

The number of privately owned horses was estimated by the Product Boards for Livestock, Meat and Eggs to be approximately 300,000 in 2005 (PVE, 2005). As information on activity data for privately owned horses is scarce, this estimate is used for the whole time series. Because the Netherlands chooses not to report emissions in CRF sector 6 Other, the estimate is added to the animal numbers from the agricultural census. It is subsequently used in calculations and reported as part of agriculture.

Table 5.2 Numbers of animals in 1990–2013 (x 1,000) (www.cbs.nl)

Animal type	1990	1995	2000	2005	2010	2011	2012	2013
Cattle	4,926	4,654	4,069	3,797	3,975	3,885	3,879	3,999
- mature dairy cattle	1,878	1,708	1,504	1,433	1,479	1,470	1,484	1,553
- mature non-dairy cattle	120	146	163	151	115	105	99	84
- young cattle	2,929	2,800	2,402	2,213	2,381	2,311	2,297	2,363
Sheep	1,702	1,674	1,305	1,361	1,130	1,088	1,043	1,034
Goats	61	76	179	292	353	380	397	413
Horses	370	400	417	433	441	436	431	429
Mules and asses	NO	NO	NO	NO	1	1	1	1
Swine	13.9	14.4	13.1	11.3	12.3	12.4	12.2	12.2
Poultry	94.9	91.6	106.5	95.2	103.4	98.9	97.0	99.4
Other animals	1,340	951	981	1,058	1,261	1,278	1,358	1,342

Three categories of cattle are recognized (option B in the CRF):

- Mature dairy cattle: adult cows for milk production;
- Mature non-dairy cattle: adult cows for meat production;
- Young cattle: mixture of age categories for breeding and meat production, including adult male cattle.

Between 1990 and 2013, (dairy) cattle, pig and sheep numbers decreased by 17%, 12% and 39%, respectively. Poultry and horse numbers increased by 5% and 16%, respectively, over the same period, while goat numbers increased by a factor close to six. Within the other animals category, the numbers of rabbits and fur-bearing animals are reported to have remained constant over the 1990–2013 period. However, the proportion between the two species has changed considerably, the number of rabbits kept more than halving and the number of fur-bearing animals almost doubling between 1990 and 2013.

For mature dairy cattle, the decrease in numbers was associated with an increase in milk production per cow between 1990 and 2013. The increased milk production per cow is the result of both genetic changes (due to breeding programmes for milk yield) and an increase in feed intake. Total milk production in the Netherlands is determined mainly by EU policy on milk quotas, which have remained virtually unchanged. In order to comply with milk quotas, numbers of mature dairy cattle, therefore, had to decrease to counteract the effect of increased milk production per cow. In the last few years, an increase in Dutch milk quotas has led to a stabilization in the number of mature dairy cattle. Between 1990 and 2013, the numbers of young (dairy) cattle followed

the same trend as the numbers of adult female cattle – namely, a decrease.

The Netherlands' manure and fertilizer policy also influences livestock numbers. Pig and poultry numbers, in particular, decreased when the government purchased some pig and poultry production rights (ceilings for total phosphate production by animals) and lowered the maximum application limits for manure and inorganic N-fertilizer. The decreasing trend of the past has, however, levelled off in the last couple of years.

The increased numbers of swine in 1997 was a direct result of the outbreak of classical swine fever in that year (see NIR 2009). In areas where this disease was present, the transport of pigs, sows and piglets to the slaughterhouse was disallowed, so the animals had to remain on the pig farms for a relatively long period (accumulation of pigs).

An increase in the number of poultry was observed between 1990 and 2002. In 2003, however, poultry numbers decreased by almost 30% as a direct result of the avian flu outbreak. In the following years, the population recovered, reaching a level of 4% below the 2002 number in 2013.

The increase in the number of goats can be explained as an effect of the milk quotas for cattle. As a result of the milk quotas for cattle and the market development of goat milk products, dairy farmers are tending to change their management in favour goats.

Compared with 2012, animal numbers remained fairly stable in 2013. Fewer mature non-dairy cattle were kept (-15%), but as this is only a small sub-category it is easily offset by the 4.6% increase in mature dairy cattle. Young stock categories generally follow these developments, i.e. an increase in dairy and a decrease in meat cattle. Overall, cattle numbers increased by 3%, while no structural trends can be seen in the other animal categories.

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. pigs, horses, mules and asses) produce CH_4, but per unit of feed intake ruminants generate considerably more.

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

system of the host ruminant. With a variation in feed characteristics, there is a variation in the extent of rumen fermentation and the amount of hydrogen produced and converted into methane.

Of the animal categories included in the CRF, buffalo, camels and llamas do not occur in the Netherlands. Enteric fermentation from poultry is not reported due to the negligible amount of CH_4 production in this animal category. The IPCC Guidelines do not provide a default EF; nor do other parties estimate enteric CH_4 emissions from poultry.

5.2.2 Overview of shares and trends in emissions

In 2013, enteric fermentation accounted for 42% of the total GHG emissions from the Agriculture sector in the Netherlands (see Table 5.1). Cattle accounted for the majority (89%) of CH_4 emissions from enteric fermentation that year. Swine contributed 5.5% and the remaining animal categories (sheep, goats, horses and mules, and donkeys) accounted for the remaining 5.5%.

Trends in CH_4 emission from enteric fermentation are explained by changes in animal numbers, changes in EF or both. CH_4 emissions from enteric fermentation decreased from 9.2 Tg CO_2 eq to 8.1 Tg (-12%) between 1990 and 2013, which is almost entirely explained by a decrease in CH_4 emissions from cattle. Although EFs for enteric fermentation in cattle increased during this period, the reduction in cattle numbers has more than compensated for the effect.

5.2.3 Activity data and EFs

Detailed information on activity data sources and EFs can be found in chapter 2 of the methodology report (Vonk et al., 2015). Table 5.2 (in Section 5.1) presents an overview of animal numbers. A full time series for all animal (sub-)categories is available through the website www.cbs.nl and in Bruggen et al., 2015.

All relevant documents concerning methodology, EFs and activity data are published on the website http://english.rvo.nl/nie.

Cattle

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

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

The energy value of the feed depends on its composition and hence the feed composition also determines estimated feed intake. The intake of fresh grass, grass silage (and hay), maize silage, wet by-products and standard and protein-rich concentrates is estimated from national statistics, which can be found at www.cbs.nl.

Mature dairy cattle
CH_4 emissions from enteric fermentation by mature dairy cattle is calculated by a Tier 3 approach using an updated version of the model of Mills et al. (2001), which was published by Bannink et al. (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 young cattle. The model calculates the gross energy (GE) intake, CH_4 EF (in kg CH_4/cow/year) and the methane conversion factor (Y_m; % of GE intake converted into CH_4) on the basis of data on the share of feed components (grass silage, maize silage, wet by-products and concentrates), their chemical nutrient composition (soluble carbohydrates, starch, neutral detergent fiber, crude protein, ammonia, crude fat, organic acids and ash) and the intrinsic degradation characteristics of starch, neutral detergent fiber and crude protein in the rumen.

Data on the share of feed components in the diet can be found at www.cbs.nl. Data on the chemical nutrient composition of individual roughages is provided by Blgg (a leading laboratory in the Dutch agricultural and horticultural sector with roughage sampling, analytical and advisory activities that is able to deliver data that can be taken as representative of average Dutch farming conditions; www.blgg.com). Because of differences in diet (especially the amounts of maize), calculations are split for the north-west (NW) and south-east (SE) parts of the country. Data used between 1990 and 2012 are published in an annex to Bruggen et al. (2015).

Young cattle and mature non-dairy cattle
The EFs for methane emissions from enteric fermentation in mature non-dairy and young 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. Data on the amounts of feed components, expressed as dry matter (DM) intake, can be found at www.cbs.nl. The equation for calculating the EF (in kg CH_4/animal/year) is:

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

Where:

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

And:

GE intake =	Dry matter intake (kg DM/animal/day) × 18.45 MJ/kg DM (IPCC, 2006);

Y_m = Country- and year-specific value for white veal calves (Gerrits et al., 2014) and 0.065 for the other categories of young cattle and mature non-dairy cattle (IPCC, 2006).

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

An overview of the GE intake and EFs calculated for cattle is presented in Bruggen et al. (2015).

Trends in cattle EFs
Table 5.3 shows the EFs of the different cattle categories that are reported, including the subdivision into the NW and SE regions for mature dairy cattle. The EF for young cattle is an average of several sub-categories (Bruggen et al., 2015).

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

	1990	1995	2000	2005	2010	2011	2012	2013
Mature dairy cattle (average)	110.3	114.3	119.9	124.9	128.1	128.3	127.7	128.1
Of which NW region	110.9	115.3	121.6	126.3	129.9	130.0	129.6	130.5
Of which SE region	109.9	113.5	118.4	123.6	126.8	127.1	126.3	126.5
Mature non-dairy cattle	70.3	71.3	72.1	76.7	78.1	79.1	79.1	78.6
Young cattle	38.3	38.6	35.4	34.4	35.0	34.8	35.3	35.4

For both mature dairy cattle and mature non-dairy cattle, EFs increased primarily as a result of an increase in total feed intake during the period 1990–2013. For mature dairy cattle, a change in the feed nutrient composition partly counteracted this effect (see Section 5.2.4). For young cattle, the decrease of EF between 1990 and 2013 can be explained by a decrease in the average total feed intake due to a shift towards meat calves in the population of young cattle (see www.cbs.nl or Annex 1 in Bruggen et al., 2015).

Comparison of cattle EFs with IPCC defaults
Table 5.4 shows that the mature dairy cattle EF follows the increasing trend in milk production. The EF used in the Netherlands is slightly lower than the default IPCC EF of 117 kg CH_4 per cow per year (at a milk production rate of 6,000 kg/cow/year). An explanation of the difference can be found in the data on feed intake, dietary composition and the nutrient composition of dietary components as input to an alternative country-specific Tier 3 approach that predicts the methane EF for mature dairy cattle (Bannink, 2010).

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

	1990	1995	2000	2005	2010	2011	2012	2013
Milk production	6,003	6,596	7,416	7,568	8,075	8,063	8,006	7,990
EF for methane	110.3	114.3	119.9	124.9	128.1	128.3	127.7	128.1

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) can be seen.

The higher EF for mature non-dairy cattle (compared with the IPCC default value of 57 kg per animal) can be explained by the higher total feed intake per mature non-dairy cow. The relatively large share of meat calves for white and rose veal production explains the relatively low EF for young cattle, compared with the IPCC default value (see www.cbs.nl or Annex 1 in Bruggen et al., 2015).

Other livestock
For swine, sheep, goats, horses and mules, and donkeys, IPCC default EFs are used (1.5, 8, 5, 10 and 18 kg CH_4/animal, respectively). Changes in emissions from these animal categories are therefore explained entirely by changes in animal numbers. To a great extent, this is also the case for cattle, but the total decrease in CH_4 emissions is lower due to a gradual increase in calculated EFs.

For more information on methods and the calculation used, see Sections 5.2.4 and 5.2.5.

5.2.4 Methodological issues

A detailed description of the method, data sources and EFs is to be found in chapter 2 of the methodology report (Vonk et al., 2015), as indicated in Section 5.2.3. In 2009, a recalculation was carried out with regard to feed intake and the resulting cattle EFs for the whole time series (CBS, 2009; Bannink, 2011). During th establishment of the split of the calculation for mature dairy cattle between the NW and SE parts of the country, some small deviations from basic data on the chemical composition of feed components were corrected (Bruggen et al., 2014).

The other livestock categories (sheep, goats, horses, mules and asses, and swine) have a share in total CH_4 emissions from enteric fermentation of less than 10%. According to the IPCC Guidelines, no Tier 2 method is needed if the share of a source category is less than 25% of the total emissions from a key source category. EFs used for the source categories swine, sheep, goats, horses, and mules and asses are the IPCC default Tier 1 EFs (IPCC, 2006). As these factors 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 male animals is inlcuded in that of female animals.

As mentioned in Section 5.2.1, enteric fermentation emissions from poultry are not estimated due to the negligible amounts and the lack of data on CH_4 EFs for this animal category.

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

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

5.2.5 *Uncertainty and time series consistency*

Uncertainty

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

Time series consistency

A consistent methodology is used throughout the time series; see Section 5.2.4. Emissions are calculated from animal population data and EFs. The animal population data is collected in an annual census and published by Statistics Netherlands. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected via an annual survey and published by Statistics Netherlands.

The compilers of the activity data strive to use consistent methods. The time series consistency of this data is, therefore, very good due to the consistency of the methods and the continuity in the data provided.

In order to comply with requirements set by the Farm Accountancy Data Network (FADN) of the EU, however, a new definition for farms has been used since 2010. Previously, the criterion for inclusion in the agricultural census was three Dutch size units (NGE). This was changed to 3,000 Output (SO). The influence of this change on the measured population has been minimized by setting the new criterion to a value that matches 3 NGE. As a result, the official statistics did not have to be recalculated and, therefore, the inventory for the years prior to 2010 also remained unchanged.

5.2.6 *Source-specific QA/QC and verification*

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

5.2.7 *Source-specific recalculations*

When the 2006 IPCC Guidelines were implemented, the effect of changes to the default Y_m values was evaluated. The increase of the general cattle Y_m from 0.06 to 0.065 was deemed appropriate, but the continued application of the Y_m for feedlot cattle to white veal calves was not. Therefore, a country- and year-specific Y_m is now calculated on the basis of the proportions of milk products and other feed components and

associated Y_m values of 0.003 and 0.055, respectively. Milk products bypass the rumen, and the Y_m for other feed components is lower than the default 0.065 because the rumen is not fully developed in white veal calves. Also, instead of the IPCC default energy content of 18.45 MJ/kg DM, a value of 21 MJ/kg DM is assumed for the milk products in the rations fed (Gerrits et al., 2014).

5.2.8 Source-specific planned improvements

No improvements are planned for this category.

5.3 Manure management (3B)

5.3.1 Source category description

Of the animal categories in the CRF, buffalo, camels and llamas do not occur in the Netherlands.

Both CH_4 and N_2O are emitted during the handling and storage of manure from cattle, swine, poultry, sheep, goats, horses, mules and asses, and other animals (rabbits and fur-bearing animals). These emissions are related to the quantity and composition of the manure, and to manure management system types and the conditions therein. For instance, aerobic conditions in a manure management system will generally increase N_2O emissions and decrease CH_4 emissions compared with an anaerobic situation. Furthermore, longer storage times and higher temperatures will increase CH_4 emissions.

Three animal manure management systems are recognized for use in emission estimates for both CH_4 and N_2O: liquid and solid manure management systems and manure produced on pasture land while grazing. In accordance with IPCC Guidelines, N_2O emissions from manure produced on pasture land during grazing are not taken into account in source category 3B Manure management, but are included in source category 3D Agricultural soils (see Section 5.4).

5.3.2 Overview of shares and trends in emissions

In 2013, CH_4 from manure management accounted for 23% of the total GHG emissions from the Agriculture sector (Table 5.1 and Figure 5.2). In the Netherlands, CH_4 emissions from manure management are particularly related to cattle and swine manure management, which in 2013 contributed 12% and 11%, respectively, to total GHG emissions in the Agriculture sector. Poultry is a minor key source of CH_4 emissions from manure management based on trend.

N_2O emissions from manure management contribute 8% to total GHG emissions from the Agriculture sector.

CH_4 from manure management

Between 1990 and 2013, emissions of CH_4 from manure management decreased by 26%. Emissions from cattle increased by 17%, while swine and poultry emissions decreased by 40% and 80%, respectively, during this period. With cattle increasingly being kept indoors, a larger proportion of manure excretion takes place in animal housing, at far higher EFs. In poultry, the decrease is mostly associated with changing husbandry, from battery cage systems with liquid manure to ground

housing or the aviary system with solid manure. For pigs, lower animal numbers are the main driver of the decrease.

The decrease in animal numbers and volatile solids (VS) excretions for swine (Bruggen et al., 2015) results in a decreasing trend in CH_4 emissions from swine during the time series. The decrease is somewhat softened, however, by an increase in the methane conversion factor (MCF) (Hoek and Van Schijndel, 2006). The MCF has increased with the fraction of manure stored under higher temperatures, i.e. in animal housing. For young and mature dairy and non-dairy cattle, emissions have decreased as a result of lower animal numbers and only a small increase in EF. For poultry, the large decrease in CH_4 emissions between 1990 and 2013 can be explained only by the shift towards a solid manure management system, with a lower associated EF.

N_2O from manure management

Emissions of N_2O from manure management decreased by 33% between 1990 and 2013, from 0.9 to 0.6 Tg CO_2 eq (Table 5.1). Decreasing animal numbers and lower N excretions per animal are the main cause of this trend. From 2007 on, emissions are rising , which is explained by stabilizing or slightly increasing animal numbers and N excretions.

N_2O emissions from manure management remained stable from 2012 to 2013, with somewhat higher animal numbers compensated for by a slight decrease in indirect emissions due to lower ammonia emissions, which resulted from an increase in the implementation of low-emission housing systems.

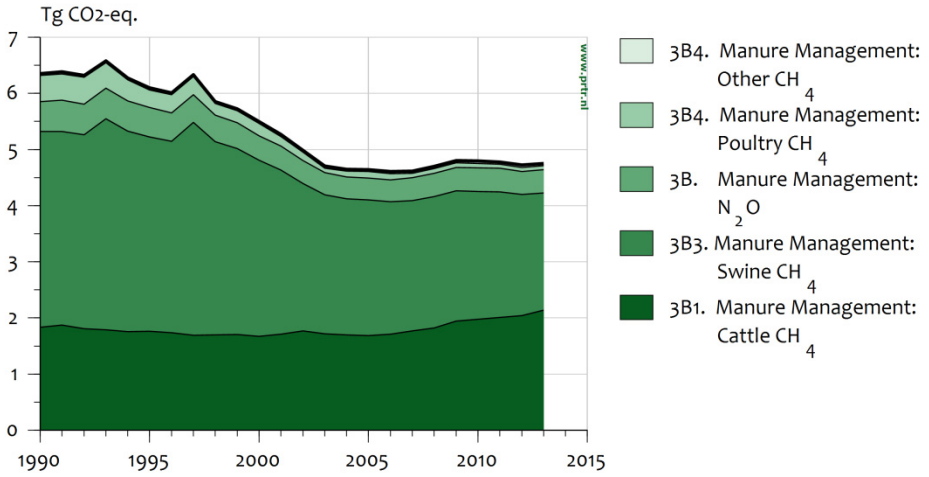


Figure 5.2 Category 3B Manure management: trend and emissions levels of source categories, 1990–2013

5.3.3 *Activity data and (implied) EFs*

Detailed information on data sources (for activity data and EFs) can be found in chapters 3 (CH_4) and 6 (N_2O) of the methodology report (Vonk et al., 2015). Table 5.2 (in Section 5.1) presents an overview of animal numbers. A full set of years and animal (sub-)categories can be found on the website www.cbs.nl and in Bruggen et al., 2015. In the latter, further data used for the calculation and resulting CH_4 EFs can be found.

All relevant documents concerning methodology, EFs and activity data are published on the website http://english.rvo.nl/nie.

CH_4 EFs (EF) for manure management

A country-specific Tier 2 approach is used to calculate CH_4 EFs for manure management annually, based on data on manure characteristics and manure management system conditions. The EFs are calculated for both manure management systems (i.e. liquid and solid manure) within the key animal categories cattle, swine and poultry and where applicable, for the manure produced on pasture land during grazing. These calculations are based on country-specific data on:

- Manure characteristics: volatile solids excretion (VS, in kg) and maximum CH_4 producing potential (B0, in m^3 CH_4/kg VS);
- Manure management system conditions (storage temperature and period) for liquid manure systems, which determine the MCF.

In formula: EF = VS * B0 * MCF * 0.67

Where:
0.67 = specific weight of methane, kg per m^3

Typically in the Netherlands, animal manure is stored in cellars under the slatted floors of animal housing. When these are full, it is pumped into outside storage facilities. Given this practice, country-specific MCF values were calculated, as demonstrated in Hoek and Van Schijndel (2006). For solid manure systems and manure produced on pasture land while grazing, IPCC default values are used. The IPCC Guidelines recommend an MCF value of 0.02 for stored solid cattle and swine manure, MCF = 0.015 for stored solid poultry manure, and a value of 0.01 for manure produced on pasture land during grazing.

For the sake of comparison, Table 5.5 shows the IEFs for manure management per animal category. These are expressed as kg CH_4 per animal per year and are calculated by dividing total emissions by animal numbers in a given category. For sheep, goats, horses, and mules and asses Tier 1 default EFs apply.

Table 5.5 CH_4 implied emission factor (kg/animal/year) for manure management of key categories and other animals specified by animal category, 1990–2013

Animal type	1990	1995	2000	2005	2010	2011	2012	2013
Cattle								
- mature dairy cattle	26.43	27.54	31.86	35.35	40.25	40.83	41.30	41.48

Animal type	1990	1995	2000	2005	2010	2011	2012	2013
- mature non-dairy cattle	8.43	8.55	8.52	8.91	9.14	8.92	9.01	9.10
- young cattle	7.75	7.90	7.34	6.92	7.80	8.39	8.52	8.61
Swine[1]	10.03	9.62	9.57	8.55	7.42	7.21	7.05	6.83
Swine excl. piglets	16.00	15.73	15.66	14.33	12.76	12.56	12.23	12.03
- fattening pigs	13.33	12.96	12.78	11.53	10.27	10.02	9.77	9.52
- breeding swine	27.03	27.51	28.04	26.70	24.70	24.79	24.45	24.21
Poultry	0.20	0.14	0.08	0.05	0.03	0.03	0.03	0.03
Other animals	0.33	0.37	0.44	0.48	0.54	0.54	0.54	0.54

[1] The IEF is calculated on the basis of total swine numbers, including piglets. Manure production by piglets is accounted for in manure production by adult breeding swine.

Trends in IEF

Mature dairy cattle

The IEF for the manure management of mature dairy cattle increased between 1990 and 2013 because increased milk production during that period (Table 5.4) was accompanied by an increase in VS production per cow. Both developments resulted from a higher feed intake. A third development was a shift in the proportion of the two main dairy manure management systems (liquid manure in the animal house and manure production on pasture land). The share of liquid animal house manure increased between 1990 and 2013, while the amount of manure produced on pasture land during grazing decreased (Bruggen et al., 2015). This was a consequence of the increase in the average time dairy cattle were kept indoors, due to the efficiency gained by keeping the animals indoors for 365 days per year, whereby production of both grassland and animals themselves can be maximized. With animal housing manure showing an 8.5-fold higher EF for CH_4 emissions, the new practice of keeping herds in animal housing throughout the year increased methane emissions per head (Bruggen, et al, 2015; Hoek and Van Schijndel, 2006).

Poultry

For poultry, the substantial decrease in the CH_4 IEF of manure management between 1990 and 2013 mainly explains the decrease in CH_4 emissions. This decrease can be explained by a shift in the proportion of the two poultry manure management systems (solid and liquid manure) in this period. The proportion of the solid manure system increased between 1990 and 2013 from approximately 40% to more than 99% as the liquid manure system was almost completely replaced by the solid manure system. The CH_4 EF for the solid system is about 25–35 times lower than that for the liquid manure system (Bruggen et al., 2015). Overall, this leads to a substantially decreased IEF which, even in combination with a 5% increase in animal numbers, fully explains the decrease in CH_4 emissions (Hoek and Van Schijndel, 2006).

Swine
Between 1990 and 2013, the IEF of swine manure management (based on total swine numbers, including piglets) decreased in line with lower VS excretions per animal. Temporary increases occurred in 1993 and 1997 as a result of the storage of manure under higher temperatures (increased storage capacity below animal housing).

Remaining animal categories
Sheep, goats, horses, and mules and asses produce only solid manure, which has a low EF; therefore, resulting IEFs are also small. These represent the IPCC Tier 1 defaults. Other animals comprises rabbits and fur-bearing animals, which produce solid and liquid manure, respectively. The resulting IEF for this category is therefore largely dependent on the ratio between the two species in a given year. As rabbit numbers decreased and fur-bearing animal numbers increased over the time period, the CH_4 IEF increased, since a larger proportion of the manure consisted of liquid manure, which has a higher EF.

Comparison with IPCC default EF for methane
The EFs per animal category used by the Netherlands are not the same as the IPCC default values because of the different assumptions regarding the share of each animal manure management system underlying the IPCC defaults.

The Netherlands' MCF values for the liquid manure system are equal to with the IPCC default MCF values for cattle, but higher for swine, following the research of Zeeman (1994). For solid manure systems and for manure production on pasture land, the Netherlands uses the IPCC default MCF values.

Although the method applied by the Netherlands for CH_4 calculations differs slightly from the IPCC method, it is in accordance with the IPCC Guidelines. Since the CH_4 emissions from manure management of cattle, swine and poultry are key sources (see Table 5.1), the present country-specific Tier 2 methodology fully complies with the IPCC Guidelines.

N_2O IEF for manure management
Emissions of N_2O from manure management are calculated within the National Emission Model for Agriculture (NEMA), in which EFs are the 2006 IPCC default values for liquid and solid manure management systems of 0.002 and 0.005, respectively. Exceptions are poultry manure, where the default value is 0.001, and goats, which are considered deep bedding, with an EF of 0.01.

Table 5.6 N_2O IEFs for manure management and total N excretion per management system, 1990–2013 (mln. kg/year and kg N_2O/kg manure)

	1990	1995	2000	2005	2010	2011	2012	2013
Total N excretion	514.5	516.1	432.5	393.5	423.3	423.2	410.6	419.6
- liquid system	412.4	411.8	337.7	305.1	326.8	329.4	321.2	327.2
- solid system	102.1	104.3	94.8	88.4	96.5	93.8	89.5	92.4
N_2O emissions manure management	1.78	1.77	1.45	1.32	1.41	1.41	1.38	1.41
N_2O IEF manure management	0.0035	0.0034	0.0034	0.0034	0.0033	0.0033	0.0034	0.0034

Table 5.6 shows that the N_2O emissions from manure management decreased between 1990 and 2013 which is a consequence of the decrease in total N-excretion.

5.3.4 Methodological issues

Methane emissions from animal manure

A Tier 2 approach is followed for CH_4 emissions calculations. The amounts of volatile solids (in kg) produced are calculated annually for several sub-categories within the key categories cattle, swine and poultry and for each manure management system. The total amount of VS produced is calculated by multiplying VS production (in kg per head per year) by animal numbers. Detailed descriptions of the methods can be found in the methodology report (Vonk et al., 2015). More specified data on manure management is based on statistical information on manure management systems that can be found at www.cbs.nl. This data is also documented in Hoek and Van Schijndel (2006) and in Bruggen et al. (2015).

Nitrous oxide emissions from animal manure

For the relevant manure management systems and animal categories, the total N content of the manure produced – also called N excretion – (in kg N) is calculated by multiplying N excretion (kg/year/head) by animal numbers. Activity data is 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 fully complies with the 2006 IPCC Guidelines. N_2O emissions from manure produced on pasture land 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).

5.3.5 Uncertainty and time series consistency

Uncertainty

The Tier 1 uncertainty analysis detailed in Annex 2 provides estimates of uncertainty according to IPCC source categories. The uncertainty in the annual CH_4 and N_2O emissions from manure management is estimated to be approximately 100%. The uncertainty in the amount of animal manure (10%) is based on a 5% uncertainty in animal numbers and a 5–10% uncertainty in manure production per animal. The resulting uncertainty of 7–11% is rounded off to 10%. The uncertainty in the CH_4 EFs for manure management, based on the judgement of experts, is estimated to be 100% (Olivier et al., 2009).

Time series consistency

A consistent methodology is used throughout the time series. The time series consistency of the activity data is very good due to the continuity in the data provided.

In order to comply with requirements set by the FADN, however, a new definition for farms has been used since 2010. Previously, the criterion for inclusion in the agricultural census was three Dutch size units (NGE). This was changed to 3,000 standard output (SO). The influence of this change on the measured population has been minimized by setting the

new criterion to a value that matches 3 NGE. As a result, the official statistics did not have to be recalculated and, therefore, the inventory for the years prior to 2010 also remained unchanged.

5.3.6 Source-specific QA/QC

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

5.3.7 Source-specific recalculations

Previously, CH_4 emissions from manure management were calculated using an analysis of VS in manure. However, as some time passes between excretion and analysis, part of the VS may already have degraded. Furthermore, since the analyses were not conducted within a monitoring programme but on request, it could be that the samples were not representative. A method of calculating VS excretion was therefore developed for the key categories cattle, swine and poulty (Zom and Groenestein, 2015). For the other livestock categories, a Tier 1 approach is adopted.

Table 5.7 Change in CH_4 emissions from manure management (Gg CO_2 eq)

	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**
Cattle	-63	-152	-39	-61	-87	-128	-103
Swine	2,116	1,846	1,606	1,129	993	1,324	1,256
Poultry	137	86	57	36	21	21	21
Other animals	-3	-6	-6	-5	-2	7	8
TOTAL	2,187	1,773	1,618	1,099	925	1,224	1,182

For N_2O emissions from manure management, the Tier 1 EFs of the 1996 Guidelines were replaced by the Tier 1 EFs of the 2006 Guidelines. As a result, emissions decreased from 606 Gg CO_2 eq in 1990 to 557 Gg CO_2 eq in 2012.

5.3.8 Source-specific planned improvements

A possible technical measure to prevent methane emissions caused by manure management is manure treatment in an anaerobic digester. In 2008, 0.6% of the total liquid manure in animal housing was treated in an anaerobic digester (www.cbs.nl). The Netherlands is examining future needs and possibilities in this area to include anaerobic treatment in the methodology and to extend calculations. Results of initial research (Hoeksma et al., 2012) make it clear that further investigation is needed.

5.4 Agricultural soils (3D)

5.4.1 Source category description

In the Netherlands, this category consists of the N_2O source categories specified in Table 5.1:

- Direct soil emissions from the application of inorganic N-fertilizers (3D1);
- Direct soil emissions from the application of organic N-fertilizers, i.e. animal manure, sewage sludge and compost to soils (3D2);

- Animal production – animal manure produced on pasture land during grazing (3D3);
- Crop residues (3D4);
- Cultivation of histosols (3D5);
- Indirect emissions from N leaching and run-off and from N deposition (3Db).

5.4.2 Overview of shares and trends in emissions

In 2013, agricultural soils were responsible for 28% of total GHG emissions in the Agriculture sector. Direct N_2O emissions from inorganic and organic fertilizers, emissions from animal production on pasture land and cultivation of organic soils accounted for 7%, 7%, 6% and 4%, respectively, of total GHG emissions in the Agriculture sector. Indirect N_2O emissions form agricultural soils accounted for 3% in 2013.

Total N_2O emissions from agricultural soils decreased by 44% between 1990 and 2013 (see Figure 6.3). Direct emissions from inorganic N-fertilizers decreased by 48%, while emissions from organic N-fertilizers increased by 50%. Emissions from animal manure produced on pasture land and indirect emissions both decreased by 63%.

This decrease was caused by a relatively high decrease in N input into soil (from manure and inorganic N-fertilizer application and animal production on pasture land), partly counteracted by the increased IEF in this period, which resulted from a shift from the practice of surface spreading manure on the soil to the incorporation of manure into the soil as a result of the ammonia policy.

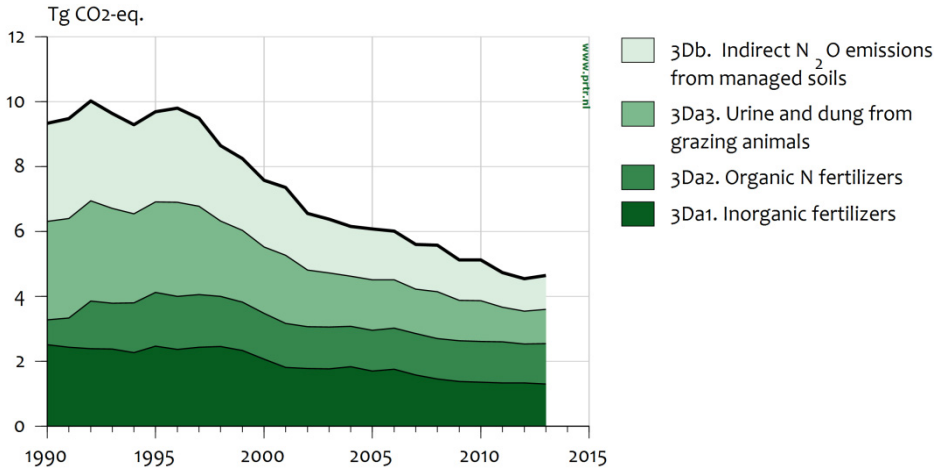


Figure 5.3 Category 3D Agricultural soils: trend and emissions levels of source categories, 1990–2013

5.4.3 Key sources

Direct N_2O soil emissions from both inorganic and organic N-fertilizers, animal production on agricultural soils, and indirect N_2O soil emissions are level and/or trend key sources (see Table 5.1).

5.4.4 Activity data and (implied) EFs

Detailed information on data sources (for activity and EFs) can be found in chapter 10 of the methodology report (Vonk et al., 2015).

More details and specific data (on activity and EFs), including data sources, are included in background documents. All relevant documents concerning methodology, EFs and activity data are published on the website http://english.rvo.nl/nie.

Calculations of N_2O emissions from agricultural soils are based on a variety of activity data, including manure production (calculated as described in Section 5.3.3) and statistics on inorganic N-fertilizer application, crop area and the agricultural use of sewage sludge. For an overview of data sources, see the methodology report (Vonk et al., 2015) or the background document (Hoek et al., 2007). The activity data and factors for crops can also be found in Bruggen et al., 2015.

Nitrogen flows

In Figure 5.4 a schematic representation of N flows and the resulting emissions from agriculture is shown. Gross amounts are used throughout, i.e. emissions of various N substances from a given source are calculated using the same basic nitrogen amount. For instance, with N excretion in animal housing, losses in the form of ammonia, nitric oxide, nitrogen gas and laughing gas are all relative to the amount of N excreted. Only at the end of the calculation is the combined loss subtracted in order to yield the remaining N available for application.

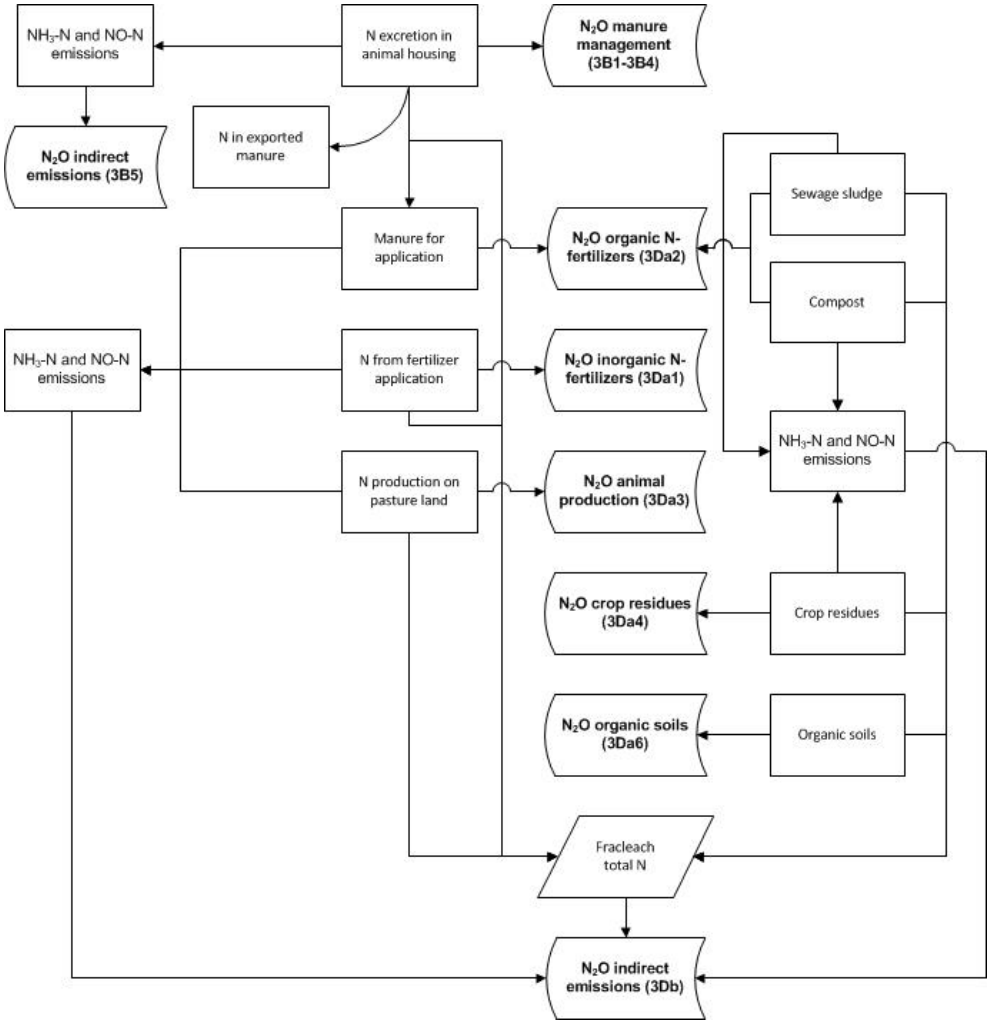


Figure 5.4 Schematic representation of N flows in agriculture and the allocation of emissions to source categories

Table 5.8 shows the resulting N flows from N excretion in animal housing and on pasture land, as well as inorganic N-fertilizer and manure application in the Netherlands. Between 70% and 80% of the N excreted in animal housing is eventually applied to soils. A growing proportion of the manure N (from 1% in 1990 to 10% in 2013) is exported; while approximately 10–15% is emitted as ammonia or nitric oxide during storage. Other N losses, in various forms, account for the remaining difference.

Of the manure N applied to the soil between 1990 and 2013, the part emitted as ammonia (NH_3) decreased from 44% to 13%, due to a change in the method of animal manure application to agricultural soils. Before 1991, manure was applied to the soil by surface spreading on both grassland and arable land. In accordance with the Netherlands' policy to reduce ammonia emissions, this practice changed in 1991, shifting to manure incorporation into the soil (e.g. shallow injection or ploughing-in), resulting in lower NH_3 emissions. Ultimately, between 1990 and 2013, the part of the N in animal manure and inorganic

fertilizer emitted as NH_3 (in the animal housing and during storage, grazing and application to the field) decreased from approximately 25% to 14%. In combination with lower inorganic N-fertilizer application (-48%) and nitrogen excretion by animals (-31%), this resulted in a reduction of 66% in the amount of N deposited atmospherically over the 1990–2013 period.

The total nitrogen supply to soil, which is used for calculating leaching and run-off, equals that resulting from manure production in animal housing and on pasture land, plus inorganic N-fertilizer, sewage sludge and compost application, minus the net export of manure. In accordance with the 2006 IPCC Guidelines, no correction is made for the N being emitted, since, after atmospheric deposition, this will also be subject to leaching and run-off. Total N supply to the soil decreased by 40% between 1990 and 2013. This can be explained by the Netherlands' manure and fertilizer policy, which is 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 swine and poultry manure production rights and maximum application limits for manure and inorganic N-fertilizer. Since the leaching fraction has also decreased over time, the amount of nitrogen leached or run off has been reduced by 48% since 1990.

Table 5.8 Nitrogen flows in relationship to source categories for N_2O (mln. kg N/year)

	1990	1995	2000	2005	2010	2011	2012	2013	Change 1990–2013
3B Manure management									
Nitrogen excretion in animal housing	514.5	516.1	432.5	393.5	423.3	423.2	410.6	419.6	-18%
of which in solid form	102.1	104.3	94.8	88.4	96.5	93.8	89.5	92.4	-9%
of which in liquid form	412.4	411.8	337.7	305.1	326.8	329.4	321.2	327.2	-21%
NH_3-N emissions from animal housing	82.8	81.1	64.2	54.4	54.4	50.8	48.1	44.8	-46%
NO-N emissions from animal housing	1.1	1.1	0.9	0.8	0.9	0.9	0.9	0.9	-21%
N_2O-N emissions from animal housing	1.1	1.1	0.9	0.8	0.9	0.9	0.9	0.9	-21%
Other N losses from animal housing[1]	9.7	9.7	8.0	8.6	11.0	13.7	13.9	16.3	68%
Nitrogen in exported manure	6.8	25.8	20.6	29.0	38.5	37.6	40.8	40.0	486%
Nitrogen in processed manure	7.7	4.9	6.1	7.4	21.8	21.2	23.4	23.6	208%
Available manure for application (N excretion in animal housing – total N losses in animal housing – exported/processed manure)	405.3	392.4	331.8	292.5	295.7	298.0	282.6	293.1	-28%
Atmospheric deposition of NH_3-N/NO-N	83.9	82.2	65.1	55.3	55.3	51.7	49.0	45.7	-46%
N_2O-N emissions atmospheric deposition	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.5	-46%

	1990	1995	2000	2005	2010	2011	2012	2013	Change 1990–2013
3D Agricultural soils									
3Da1/2 Direct soil emissions									
Available manure for application	405.3	392.4	331.8	292.5	295.7	298.0	282.6	293.1	-28%
(N excretion in animal housing - total N losses in animal housing - exported/incinerated manure)									
NH_3-N emissions from manure application	180.2	66.1	53.5	45.8	37.1	37.7	35.0	36.8	-80%
NO-N emissions from manure application	4.9	4.7	4.0	3.5	3.5	3.6	3.4	3.5	-28%
N_2O-N emissions from manure application	1.6	3.5	3.0	2.6	2.7	2.7	2.5	2.6	62%
Nitrogen from inorganic N-fertilizer application[2]	412.4	405.8	339.5	280.0	222.1	219.2	218.8	213.0	-48%
NH_3-N emissions from inorganic N-fertilizer application	12.0	12.0	10.5	11.4	8.9	9.3	12.0	12.0	0%
NO-N emissions from inorganic N-fertilizer application	4.9	4.9	4.1	3.4	2.7	2.6	2.6	2.6	-48%
N_2O-N emissions from inorganic N-fertilizer application	5.4	5.3	4.4	3.6	2.9	2.9	2.8	2.8	-48%
Nitrogen in crop residues left in field	36.4	34.9	34.1	32.1	25.5	25.8	25.2	25.7	-29%
NH_3-N emissions from crop residues	3.4	3.3	2.6	1.9	2.0	1.8	1.7	1.9	-46%
N_2O-N emissions from crop residues	0.7	0.7	0.7	0.5	0.4	0.4	0.4	0.3	-56%
Nitrogen mineralization in organic soils	89.8	88.0	86.2	84.7	83.6	83.4	83.2	83.0	-8%
N_2O-N emissions from organic soils	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	-8%
Nitrogen in sewage sludge on agricultural land	5.0	1.5	1.5	1.2	0.9	0.8	0.8	0.8	-84%
NH_3-N emissions from sewage sludge	1.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-95%
NO-N emissions from sewage sludge	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-84%
N_2O-N emissions from sewage sludge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-64%
Nitrogen in compost	2.0	7.4	8.0	7.7	7.4	7.3	7.3	7.3	265%
NH_3-N emissions from compost	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	265%
NO-N emissions from compost	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	265%
N_2O-N emissions from	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	265%

	1990	1995	2000	2005	2010	2011	2012	2013	Change 1990–2013
compost									
3Da3 Animal production on agricultural soils									
Nitrogen excretion on pasture land	195.9	179.9	132.5	101.2	81.3	68.9	65.0	68.0	-65%
NH_3-N emissions excretion on pasture land	15.2	13.7	4.5	3.0	1.8	1.3	1.2	1.2	-92%
NO-N emissions excretion on pasture land	2.4	2.2	1.6	1.2	1.0	0.8	0.8	0.8	-65%
N_2O-N emissions excretion on pasture land	6.5	5.9	4.4	3.3	2.7	2.3	2.1	2.2	-65%
3Db Indirect emissions									
Atmospheric deposition of NH_3-N/NO-N	220.9	104.2	78.9	68.9	55.7	56.0	55.6	57.6	-74%
N_2O-N emissions atmospheric deposition	2.2	1.0	0.8	0.7	0.6	0.6	0.6	0.6	-74%
Total nitrogen supply to soil (Available manure for application + N excretion on pasture land + N from fertilizer + crop residues + organic soils + sewage sludge + compost)	1,146.7	1,109.9	933.7	799.4	716.5	703.5	682.9	690.9	-40%
Nitrogen lost through leaching and run-off	174.2	157.2	123.2	105.0	93.7	92.1	89.5	90.1	-48%
N_2O-N emissions from leaching and run-off	1.3	1.2	0.9	0.8	0.7	0.7	0.7	0.7	-48%

[1] Includes N_2-N losses from animal housing, N in the rinsing liquid of air scrubbers and N produced in the free-range for poultry.

[2] Including N in the rinsing liquid of air scrubbers.

Emission factors

For inorganic N-fertilizer application, the EF for direct N_2O emissions from agricultural soils is based on a weighted mean of different inorganic N-fertilizer types applied on both mineral and organic soils. The EFs for the application of animal manure or manure produced on pasture land during grazing are also based on weighted means of those two soil types. As arable farming hardly ever occurs on organic soils, the EF for crop residues is based on mineral soils only. An overview of the EFs used is presented in Table 5.9, with default IPCC EFs included for comparison.

Table 5.9 EFs for direct N_2O emissions from soils (kg N_2O-N per kg N supplied)

Source	Default IPCC	EF used	Reference
Inorganic N-fertilizer	0.01	0.013	4
Animal manure application	0.01		
Surface spreading		0.004	4
Incorporation into soil		0.009	4

Sewage sludge	0.01		
Surface spreading		0.004	4
Incorporation into soil		0.009	4
Compost	0.01	0.004	
Crop residues	0.01	0.01	2
Cultivation of organic soils (histosols)		0.02	2,3
Animal manure during grazing (cattle/pigs/poultry)	0.02	0.033	4
Animal manure during grazing (sheep/other animals)	0.01	0.033	4

References 1 = Kroeze, 1994; 2 = Hoek et al., 2007; 3 = Kuikman et al., 2005; 4 = Velthof et al., 2010; Velthof and Mosquera, 2011; Schijndel en Van der Sluis, 2011.

Implied EF

Table 5.10 shows the IEFs for direct N_2O emissions from agricultural soils for the application of animal manure. A 117% increase in IEF occurred in the period 1990–2013, which was caused by an ammonia policy-driven shift from the surface spreading of manure to the incorporation of manure into the soil. Combined with a 28% decrease in N manure input to soil (see Table 5.8), this explains the 62% increase in N_2O from manure application.

The decrease in indirect N_2O emissions is fully explained by the decrease in N from atmospheric deposition due to lower NH_3 and NO emissions, and less leaching and run-off because of lower total N to soil. The decrease in N_2O emissions from animal manure produced on pasture land is also entirely reflected in the decrease in N input to soil in this category. The decrease in direct N_2O emissions can be explained by the decrease in the direct N input to soil by manure and inorganic fertilizer application, softened by an increase in IEF because of the incorporation into soil.

Table 5.10 N_2O IEFs from animal manure applied to agricultural soils (kg N/kg N-input)

	1990	1995	2000	2005	2010	2011	2012	2013
IEF	0.004	0.009	0.009	0.009	0.009	0.009	0.009	0.009

5.4.5 *Methodological issues*

Direct and indirect N_2O emissions from agricultural soils, as well as N_2O emissions from animal production on pasture land, are estimated using country-specific activity data on N input to soil and NH_3 volatilization during grazing, manure management (animal housing and storage) and manure application. Most of this data is estimated at a Tier 2 or Tier 3 level. The present methodologies fully comply with the 2006 IPCC Guidelines.

For a description of the methodologies and data sources used, see the methodology report (Vonk et al., 2015) available on http://english.rvo.nl/nie. A full description of the methodologies is provided in Hoek et al. (2007), with more details in Kroeze (1994).

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, i.e. 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. Furthermore, the animal manure is more concentrated (i.e. hot spots) than with surface spreading and hence the process conditions for nitrification and denitrification are generally less good.

Since 2010, calculations have been made on gross instead of net N flows in order to make them more transparent. At the same time, EFs have been updated on the basis of laboratory and field experiments, quantifying the effect of a manure application technique on N_2O emission (Velthof et al., 2010; Velthof and Mosquera, 2011; Schijndel and Van der Sluis, 2011).

Animal production on agricultural soils
An IPCC Tier 1b/2 methodology is used to estimate direct N_2O emissions from animal production on agricultural soils. The method calculates the total N excreted during grazing, multiplied by a country-specific EF to yield the emissions figure; see Section 5.3.4.

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 emissions (estimated at a Tier 3 level) are multiplied by the IPCC default N_2O EF.

Indirect N_2O emissions resulting from leaching and run-off are estimated using country-specific data on total N input to soil and leaching fraction (estimated at a Tier 3 level). The difference in '$frac_{leach}$' is justified due to specific characteristics of the Netherlands' agricultural soils, with relatively high water tables. A model (STONE) was adopted to assess this fraction, as described in Velthof and Mosquera (2011), with IPCC default values used for the N_2O EF.

In the Netherlands, no experimental data is available to evaluate the value of the EFs for indirect emissions.

5.4.6 Uncertainty and time series consistency

Uncertainty
The Tier 1 uncertainty analysis, outlined in Annex 2, provides estimates of uncertainty by IPCC source category. The uncertainty in direct N_2O emissions from agricultural soils is estimated to be approximately 60%. The uncertainty in indirect N_2O emissions from N used in agriculture is estimated to be more than a factor of 2 (Olivier et al., 2009).

Time series consistency
Consistent methodologies are used throughout the time series. The time series consistency of the activity data is very good due to the continuity in the data provided.

In order to comply with requirements set by the FADN, however, a new definition for farms has been used since 2010. Previously, the criterion for inclusion in the agricultural census was three Dutch size units (NGE). This was changed to 3,000 standard output (SO). The influence of this change on the measured population has been minimized by setting the new criterion to a value that matches 3 NGE. As a result, the official statistics did not have to be recalculated and, therefore, the inventory for the years prior to 2010 also remained unchanged.

5.4.7 Source-specific QA/QC

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

5.4.8 Source-specific recalculations

Compost
The use of compost (from both organic waste and green refuse) has been added to the inventory.

Crop residues
In accordance with the 2006 IPCC Guidelines, the definition of crop residues was extended to include grassland renewal.

Organic soils
Following the new definition of organic soils within the 2006 Guidelines, a second area and EF was added to the existing calculation for histosols.

Indirect emissions
N_2O emissions following atmospheric deposition were split towards the shares attributed to manure management and agricultural soils.

5.4.9 Source-specific planned improvements

None.

5.5 Liming (3G)

5.5.1 Source category description

The source category 3G (Liming) includes only the emissions of CO_2 from the treatment of agricultural land with limestone (calcium carbonate) and dolomite (calcium-magnesium carbonate). Limestone and dolomite are used in the Agriculture sector to maintain a pH range suitable for crop and grass production.

5.5.2 Activity data and (implied) EFs

The activity data is derived from agricultural statistics on total lime fertilizers (period 1990–2013). The data available on the application of limestone and dolomite does not address its use on grassland and cropland separately.

5.5.3 Overview of shares and trends in emissions

Table 5.11 CO_2 emissions from the use of limestone and dolomite in agriculture (Gg CO_2)

	1990	1995	2000	2005	2010	2011	2012	2013
3G Liming	183	98	98	75	60	73	69	69

5.5.4 *Activity data and EFs*

Information on liming was derived from national statistics, updated annually, on fertilizer use. The yearly amounts of limestone and dolomite used are converted into carbon dioxide emissions in line with the calculations in the 2006 IPCC Guidelines.

5.5.5 *Methodological issues*

The reporting is considered to be at the Tier 2 level (see Vonk et al., 2015, chapter 12). Limestone (lime marl) and dolomite (carbonic magnesium lime) 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). More detailed descriptions of the methods used and the EFs can be found in the above-mentioned methodology report on the website http://english.rvo.nl/nie, as indicated in Section 5.1.

5.5.6 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 analysis explained in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The uncertainty in the CO_2 emissions from Liming of soils is calculated to be 25%. The uncertainty in the activity data is estimated to be 25% and the uncertainty in the EFs is 1%. When considered over a longer time span, all carbon applied through liming is emitted.

Time series consistency

The methodology used to calculate CO_2 emissions from limestone and dolomite application for the period 1990–2013 is consistent over time. These fertilizers make up 40% to 60% of the calcium-containing fertilizers used in agriculture. The remaining percentage consists mainly (30%–55% of the total) of sugar beet factory lime. The CO_2 emissions related to the latter fertilizer are balanced by the CO_2 sink in sugar production and are therefore not accounted for. The total use of fertilizer containing calcium carbonate in the Netherlands decreased from 265 million kg in 1990 to 133 million kg in 2012 (on the basis of CaO). Over that period, the amounts of limestone used remained fairly stable and the amounts of dolomite gradually decreased to about one third of the amount applied in 1990. The CO_2 emissions related to limestone and dolomite are shown in Table 5.11. For the years 2012 and earlier, observed values are available (except for 2009). Due to the lack of fertilizer statistics for 2013, the 2013 emissions have been set as equal to those of the previous year.

5.5.7 *Source-specific QA/QC and verification*

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

5.5.8 *Source-specific recalculations*

2012 emissions have been recalculated because the lime fertilizer data for 2012 has become available.

5.5.9 Source-specific planned improvements

A recalculation of emissions in 2013 will be carried out when the lime fertilizer data becomes available.

6 Land use, land use change and forestry (CRF sector 5)

Major changes in the LULUCF sector compared with the National Inventory Report 2014

Emissions:	Emissions from LULUCF in 2013 are about 1% higher than those in 2012.
Methodologies:	An important change is the implementation of the 2006 IPCC Guidelines, in which Tier 1 default values for carbon fractions in biomass were differentiated for coniferous tree species, broadleaved tree species and other vegetation. Carbon stock changes from peaty soils are now included explicitly and reported under organic soils. As a result, net emissions from organic soils and consequently total emissions are significantly higher in the current submission than in previous submissions. The 2006 IPCC Guidelines and corresponding CRF tables also introduced the category Harvested wood products (4G); emissions from these products are now reported for the first time. At the same time, emissions from the application of limestone and dolomite are no longer reported under LULUCF, but (as a separate category) under Agriculture (3G). Additionally, carbon stock differences between the three National Forest Inventories have been used to assess carbon stock changes in forest land between 1990 and 2003. Now the calculation method for this period is equivalent to the calculation method use for the subsequent period, 2003–2013.

6.1 Overview of sector

Overview and trends in the 2013 results

This chapter describes the 2013 GHG inventory for the Land use, land use change and forestry (LULUCF) sector. It covers both the sources and sinks of CO_2 GHGs from land use, land use change and forestry. The emission of nitrous oxide (N_2O) from land use is included in the Agriculture sector (3D) and the emission of methane (CH_4) from wetlands is not estimated due to the lack of data.
The structure of this section and of the main submission for the NIR and CRF tables is based on the reporting guidelines set out in Decision 24/CP.19 and follows the categories of the CRF tables, as agreed at the 39th session of the Subsidiary Body for Scientific and Technological Advice to the United Nations Framework Convention on Climate Change (UNFCCC).

Land use in the Netherlands is dominated by agriculture (50.7%), settlements (14.6%) and forestry (9.6%, including trees outside forests); 5.3% comprises dunes, nature reserves, wildlife areas, heather and reed swamp. The remaining area (19.7%) in the Netherlands is open water.

The soils in the Netherlands are dominated by mineral soils – mainly sandy soils and clay soils (of fluvial or marine origin). Organic soils, used mainly as meadowland or hayfields, cover about 12% of the land area (including peaty soils).

The Netherlands has an intensive agricultural system with high inputs of nutrients and organic matter. The majority of agricultural land is used as grassland (55%), for arable farming (25%) or to grow fodder maize (12%), and the remaining land is fallow or used for horticulture, fruit trees, etc. About 80% of grassland is permanent grassland (5% of which is high nature value grassland); the remaining 20% is temporary grassland, on which grass and fodder maize are cultivated in rotation.

Since 1990, the agricultural land area has decreased by about 5%, mainly because of conversion to settlements/infrastructure and natural land.

The LULUCF sector in the Netherlands is estimated to be a net source of CO_2, amounting in 2013 to 6.14 Tg CO_2 equivalent. (The recalculated value for 2012 is: 6.09 Tg CO_2.) The fact that the LULUCF sector is a net source is due to the large amount of carbon emitted from drained peat soils, which exceeds the sequestration of carbon in forest land. The LULUCF sector is responsible for 3.0% of total GHG emissions in the Netherlands (see Table 6.2).

Methodology and coverage

The methodology of the Netherlands for assessing emissions from LULUCF is based on the 2006 IPCC Guidelines (IPCC, 2006) and follows a carbon stock change approach based on inventory data subdivided into appropriate pools and land use types and a wall-to-wall approach for the estimation of area per category of land use. The information on activities and land use categories covers the entire territorial (land and water) surface area of the Netherlands.

This sector comprises seven categories: Forest Land (4A); Cropland (4B); Grassland (4C); Wetlands (4D) (including open water); Settlements (4E); Other Land (4F); and Harvested wood products (HWP) (4G). Emissions from land use-related activities such as liming formerly reported here are to be found under Agriculture (3G); see Section 5.5. The changes in land use ('remaining' or 'converted') are presented in a 6 x 6 matrix, which is fully in accordance with the approach described in the 2006 IPCC Guidelines.

To better match available national maps and databases on land use, the category Grassland is the aggregation of 'grasslands' and 'nature' (see Definitions below). The sub-category 'nature' includes heathland, peat land and moorland. All categories are relevant in the Netherlands.

The carbon cycle of managed forests and the wood production system is considered in the calculations of the relevant CO_2 emissions.

An overview of the reporting for this sector is provided in Table 6.1.

Table 6.1 Pools for which emissions are reported in the National System per land use (conversion) category for the 2015 submission.

From → To↓	FL	CL	GL	WL	Sett	OL
FL	BG-BL+DW-FF	BG-BL+MS	BG-BL+MS	BG+MS	BG+MS	BG+MS
CL	BG-BL-DW-Litt+MS		BG-BL+MS	BG+MS	BG+MS	BG+MS
GL	BG-BL-DW-Litt	BG-BL+MS	-WF	BG+MS	BG+MS	BG+MS
WL	-BL-DW-Litt+Soils	-BL+Soils	-BL+Soils	+Soils	+Soils	+Soils
Sett	-BL-DW-Litt+Soils	-BL+Soils	-BL+Soils	+Soils	+Soils	+Soils
OL	-BL-DW-Litt+Soils	-BL+Soils	-BL+Soils	+Soils	+Soils	+Soils

Carbon stock changes included are: BG: biomass gain; BL: biomass loss; DW: dead wood; FF: forest fires; WF: wildfires; Litt: litter; MS: mineral soils; OS: organic soils. Land use types are: FL: forest land; CL: cropland; GL: grassland; WL: wetland; Sett: settlement; OL: other land.

Carbon stock changes in mineral soils

The Netherlands has developed a Tier 2 approach to carbon stock changes in mineral soils and organic soils. For mineral soils, the approach is based on the overlay of the Dutch soil map on the land use maps, combined with the quantification of soil carbon stocks for each land use/soil type combination. For organic soils, the procedure is based on an overlay of a map with water level regimes and the soil map, indicating the areas with peat and peaty soils, combined with assumptions typically valid for agricultural peat and peaty soils in the Netherlands. Detailed information is provided in Arets et al. (2015).

For the Netherlands, the basis for quantifying the carbon emissions from land use changes on mineral soils is the LSK national sample survey of soil map units (Finke et al., 2001), covering about 1,400 locations and at five different depths. The carbon stock in the upper 30 cm was measured by de Groot et al. (2005) and the data was classified into 11 soil types and land use (at the time of sampling, Lesschen et al., 2012).

Samples were taken only on forest land, cropland and grassland. For conversions of land use involving other land uses, estimates were made using the 2006 IPCC Guidelines. The assumptions were:

- For conversion to settlements: 50% 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 wetlands converted to or from forest, no change in carbon stock is assumed.
- For other land, a carbon stock of zero is conservatively assumed.

The 2006 IPCC Guidelines prescribe a transition period of 20 years, during which the carbon stock changes take place. Such a 20-year transition period for carbon stock changes in mineral soils means that land-use changes in 1970 will still have a small effect on reported carbon stock changes in mineral soils in 1990. Here we implemented a transition period starting with 1990, as we do not have sufficient information on land-use changes before 1990. This means that we have ignored removals and emissions from land-use changes that took place before 1990.

Carbon stock changes in organic soils
Previously, only peat soils (soils that have a peat layer of at least 40 cm within the first 120 cm) were included in this category but, in accordance with the new definition in the 2006 IPCC Guidelines, peaty soils (in Dutch: 'moerige gronden'), which have a peat layer of 5–40 cm within the first 80 cm, are now also included. Based on the available data, two approaches to the calculation of EFs have been developed.

For CO_2 emissions from cultivated organic soils, the methodology described in Kuikman et al. (2005) is used. This method is based on subsidence as a consequence of the oxidation of organic matter. The estimated total annual emissions from cultivated soils are then converted to an annual EF per ha peat soil to report emissions from peat soils for the land use (change) categories Grassland, Cropland and Settlements.

For peaty soils, another approach was used, based on a large dataset of soil profile descriptions over time (de Vries et al., in press). From this dataset the average loss rate of peat was derived from the change in thickness of the peat layer over time. Detailed information on calculations for peat and peaty soils is provided in Arets et al. (2015).

Emissions and removals from drainage, 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 N_2O emissions from disturbance associated with land use conversions
Until 2012, nitrous oxide (N_2O) emissions from soils by disturbance associated with land use changes had to be calculated only for conversions to cropland. From the 2013 NIR onwards, emissions are included for all land use changes, using a Tier 2 methodology (see Arets et al., 2015). 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 used (Arets et al., 2015). For all other aggregated soil types, we used the default C:N ratio of 15 (2006 IPCC Guidelines, p. 11.16). For

aggregated soil types where the change of land use led to a net carbon gain, N_2O emissions were set at zero.

Controlled biomass burning
Controlled biomass burning is reported as included elsewhere (IE) and not occurring (NO). The area and emissions of the occasional burning carried out as part 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 of this year and the recalculation for years reported earlier
The category Harvested wood products has been added as well as the organic content estimation for the remaining soils at regions with former organic soils. All data has been recalculated for the period 1990–2012.

This year, the following changes led to recalculations:

- In the past, the Tier 1 default values for carbon fractions in biomass were the same for all species groups (0.5). In the 2006 IPCC Guidelines these Tier 1 default values were further differentiated between conifers (0.51) and broadleaved species (0.48). Because the share of conifers and broadleaved species is not the same, and also changes over time, the carbon stock changes in biomass for land use changes involving forest land for the period 1990–2012 show small differences from the previous submission.
- Carbon stock differences between twoNational Forest Inventories were used to assess carbon stock changes in forest land between 1990 and 2003. Now the calculation method for this period is equal to the calculation method in the subsequent period, 2003–2012.
- The biomass increment function used to assess carbon stock gains in living biomass in land converted to forest land was updated for the period 2003–2012 on the basis of new information from the 6th National Forest Inventory (NBI6), leading to recalculations for the period 2003–2012.
- Previously, the estimated total annual emissions from cultivated peat soils (4.246 Mt CO_2) were reported under Grassland remaining grassland. From the NIR 2015, this total emission is converted to an annual EF of 19.03 tonnes CO_2 per ha peat soil and emissions are now allocated and reported under land use (change) categories involving grassland, cropland and settlements. Emissions from organic soils were therefore recalculated for the period 1990–2012.
- As a result of the implementation of the 2006 IPCC Guidelines, the changes to the carbon stock of peaty soils are now included and reported under Organic soils. As a result, for the period 1990–2012, net emissions from organic soils, and consequently total emissions, are significantly higher in the current submission than in previous submissions.
- As a result of the implementation of the 2006 IPCC Guidelines and new CRF tables, the category Harvested wood products (4G) has been added.

- Emissions resulting from the application of limestone and dolomite are no longer reported under LULUCF, but (in a new category) under Agriculture (3G).

Contribution of the sector to GHG emissions and removals
Table 6.2 shows the sources and sinks in the LULUCF sector in 1990 and 2013. For 1990 and 2013, the total net emissions are estimated to be approximately 5.67 Tg CO_2 and 6.14 Tg CO_2, respectively. The major source in 2013 is included in 4C (Grassland), namely CO_2 emissions from the decrease in carbon stored in peat lands, which totals to 4.2 Tg CO_2 (see Arets et al., 2015) due to agricultural and water management. The major sink is the storage of carbon in forests: -2.67 Tg CO_2, which includes emissions from Forest land remaining forest land (4A1) and Land converted to forest land (4A2). Sector 4 (LULUCF) accounted for about 3% of total national CO_2 emissions in 2013.

Table 6.2 Contribution of main categories and key sources in sector 4 LULUCF

Sector/category	Gas	Key	Emission base year (1990)	2012	2013	Absolute 2013–2012	Contribution to total in 2013 (%)		
			Tg CO_2 eq	Tg CO_2 eq	Tg CO_2 eq	Tg CO_2 eq	by sector	of total gas	of total CO_2 eq
4 LULUCF	CO_2		5.67	6.09	6.14	0.06	100%	3.6%	3.0%
4A Forest land	CO_2	L,T	-1.89	-2.37	-2.67	-0.31	-44%	-1.5%	-1.3%
4A1 Forest land remaining forest land	CO_2		-1.95	-2.06	-2.37	-0.30	-39%	-1.4%	-1.2%
4A2 Land converted to forest land	CO_2		0.06	-0.31	-0.31	0.00	-5%	-0.2%	-0.2%
4B Cropland	CO_2	L,T	1.63	2.41	2.54	0.13	41%	1.5%	1.3%
4B1 Cropland remaining cropland	CO_2		1.47	0.88	0.85	-0.03	14%	0.5%	0.4%
4B2 Land converted to cropland	CO_2		0.17	1.53	1.68	0.16	27%	1.0%	0.8%
4C Grassland	CO_2	L,T	5.45	4.27	4.41	0.14	72%	2.6%	2.2%
4C1 Grassland remaining grassland	CO_2		5.19	4.12	4.07	-0.05	66%	2.4%	2.0%
4C2 Land converted to grassland	CO_2		0.26	0.15	0.34	0.20	6%	0.2%	0.2%
4D Wetlands	CO_2		0.09	0.06	0.06	0.01	1%	0.0%	0.0%
4D1 Wetlands remaining wetlands	CO_2		NE	NE	NE				
4D2 Land converted to wetlands	CO_2		0.09	0.06	0.06	0.01	1%	0.0%	0.0%
4E Settlements	CO_2	L,T	0.89	1.51	1.58	0.08	26%	0.9%	0.8%

4E1 Settlements remaining settlements	CO_2		0.38	0.37	0.38	0.01	6%	0.2%	0.2%
4E2 Land converted to settlements	CO_2		0.51	1.13	1.20	0.07	20%	0.7%	0.6%
4F Other land	CO_2		0.03	0.11	0.12	0.01	2%	0.1%	0.1%
4F1 Other land remaining other land	CO_2		0.00	0.00	0.00	0.00	0%	0.0%	0.0%
4F2 Land converted to other land	CO_2		0.03	0.11	0.12	0.01	2%	0.1%	0.1%
4G Harvested wood products	CO_2		-0.53	0.11	0,11	-0.01	2%	0.1%	0.1%
Total national emissions (incl. CO_2 LULUCF)	CO_2		166.1	172.84	172.37	-0.47		100%	85%
	All		225.2	202.44	202.04	-0.40			100%

The methodologies applied in estimating CO_2 emissions and removals of the LULUCF sector in the Netherlands are described in a methodological background document (Arets et al., 2015).

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. (2015).

Definitions
Forest land (4A)
The Netherlands has chosen to define the land use category Forest Land as all land with woody vegetation, now or expected in the near future (e.g. clear-cut areas to be replanted, young afforestation areas). It is further defined as follows:

- Patches of land exceeding 0.5 ha with a minimum width of 30 m.
- Land with tree crown cover of at least 20%; and
- Land with a tree height of at least 5 m or, if this is not the case yet, these thresholds are likely to be achieved at the particular site.

This definition conforms to UNs Food and Agricultural Organization (FAO) reporting and was chosen within the ranges set by the Kyoto Protocol.

Cropland (4B)
The Netherlands has chosen to define cropland as arable land or nurseries (including tree nurseries). Intensive grasslands are not included in this category and are reported under Grassland. On some agricultural land, rotation between cropland and grassland is frequent, but data on where exactly this occurs is as yet lacking. Currently, the situation recorded on the topographical map is used as the guideline, with land under agricultural crops and classified as arable land at the time of recording reported under Cropland and land with grass vegetation at the time of recording classified as Grassland.

Grassland (4C)
The Netherlands currently reports under Grassland any type of terrain that is predominantly covered by grass vegetation. Grassland also includes vegetation that falls below the threshold used in the Forest land category (see above) and is not expected, without human intervention, to exceed that threshold. Grassland is subdivided into:

- 'Grasslands', i.e. all areas predominantly covered by grass vegetation (whether natural, recreational or cultivated);
- 'Nature', i.e. all natural areas excluding grasslands. 'Nature' mainly consists of heathland, peat land and moorland. Many such areas have the occasional tree as part of the typical vegetation structure.

No explicit spatial distinction is made between agricultural intensively and extensively managed grasslands and natural grasslands. Nevertheless, for managed grasslands the emissions from organic soils are reported.

Apart from pure grasslands, all orchards (with standard fruit trees, dwarf varieties or shrubs) are included in the Grassland category. They do not conform to the Forest definition, and while agro-forestry systems are mentioned in the definition of Cropland, in the Netherlands the main undergrowth of orchards is grass. Therefore, orchards are reported under Grassland, but, as with other types of Grassland no change in above-ground biomass is reported, as the carbon stored in these trees is not reported.

Wetlands (4D)
The Netherlands is characterized by many wet areas, but many of these areas are covered by grassy vegetation and are included under Grassland. Some wetland is covered by rough vegetation (wild grasses or shrubby plants); these areas are reported in the sub-category of Grassland 'nature', while forested wetlands like willow coppices are included in Forest land.

Consequently, in the Netherlands, only reed marshes and open water bodies are included in the Wetlands land use category. Open water bodies include:

- Natural open water areas in rivers;
- Man-made open water areas in channels, ditches and artificial lakes;
- Bare areas that are under water only part of the time, as a result of tidal influences ('emerging surfaces');

- Very wet areas without vegetation;
- 'Wet' infrastructure for boats, i.e. harbours and docks as well as navigable waterways.

Settlements (4E)
In the Netherlands, the main classes of the category Settlements are (1) built-up areas and (2) urban areas and transport infrastructure. Built-up areas are areas that include any constructed item, independent of the type of construction material, that 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 labour. It therefore includes detached houses, rows of houses, apartment blocks, office buildings, shops and warehouses, as well as filling stations and greenhouses.

The sub-category urban areas and transport infrastructure includes all roads, whether paved or not, with the exception of forest roads, which are included under Forest land. It also includes train tracks, (paved) open spaces in urban areas, car parks and graveyards. Though some of the latter classes are covered by grass, the distinction cannot be made from a study of maps. Because even grass graveyards are not managed as grassland, their inclusion in the land use category Settlements conforms better to the rationale of the land use classification.

Other land (4F)
In general, Other land does not have a substantial amount of carbon. The Netherlands uses this land use category to report areas 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) and uncultivated land alongside rivers. It does not include bare areas that emerge from shrinking and expanding water surfaces, which are included in Wetlands.

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

One consistent approach is used over all land use categories. The Netherlands has a full and spatially explicit land use mapping system that permits geographical stratification at 25 m x 25 m (0.0625 ha) pixel resolution (Kramer et al. 2009; Wyngaert et al. 2012). This corresponds with the wall-to-wall approach used for reporting under the IPCC (approach 3 in Chapter 3 of IPCC, 2006).

Harmonized and validated digital topographical maps dated 1st January 1990, 2004, 2009 and 2013 were used for wall-to-wall map overlays (Kramer et al., 2009; Wyngaert et al., 2012, Arets et al., 2015), resulting in three national scale land use and land use change matrices for the period 1990–2004 (Table 6.3), 2004–2009 (Table 6.4) and 2009–2013 (Table 6.5). The data on the activities and land use categories covers the entire territorial (land and water) surface area of the Netherlands. The sum of all land use categories is constant over time.

The detailed land use maps that best represent land use on 1st January 1990, 2004, 2009 and 2013 were originally developed to support

temporal and spatial development in land use and policy in the field of nature conservation (MNP, 2008; Kramer et al. 2007, 2015). For more details see Arets et al. (2015).

Table 6.3 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the period 1990–2004 (ha)

	BN 1990						
BN 2004	**Forest land**	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	***Total***
Forest land	350,751	14,560	22,540	1,217	2,530	651	*392,248*
Cropland	1,605	739,190	196,595	596	1,623	8	*939,617*
Grassland	17,902	176,797	1,190,740	9,092	10,987	2,547	*1,408,064*
Wetlands	1,822	6,821	18,641	776,007	1,390	2,583	*807,265*
Settlements	10,019	81,783	78,259	2,836	392,805	630	*566,332*
Other land	809	201	907	2,791	122	33,144	*37,974*
Total	*382,907*	*1,019,353*	*1,507,682*	*792,539*	*409,457*	*39,563*	*4,151,500*

Note: For comparison with CRF tables, map dates are 1st January of 1990 and 2004, i.e. the areas for 2004 correspond to the areas reported in CRF tables for the 2003 inventory year.

Table 6.4 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the period 2004–2009 (ha)

	BN 2004						
BN 2009	**Forest land**	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	***Total***
Forest land	377,584	2,304	8,827	466	6,155	238	*395,573*
Cropland	487	813,282	106,547	177	4,367	2	*924,863*
Grassland	6,417	108,480	1,243,329	9,633	23,123	506	*1,391,488*
Wetlands	829	1,794	10,610	794,785	3,033	890	*811,941*
Settlements	6,694	13,729	37,705	1,441	529,417	137	*589,123*
Other land	238	27	1,047	762	237	36,200	*38,512*
Total	*392,248*	*939,617*	*1,408,064*	*807,265*	*566,332*	*37,974*	*4,151,500*

Table 6.5 Projected land use and land use change matrix for the six UNFCCC land use categories for the period 2009–2013 using the land use data available on 1-1-2013 (ha)

	BN 2009						
2013	**Forest land**	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other land**	***Total***
Forest land	380,255	2,791	9,672	763	3,346	494	*397,320*
Cropland	1,535	793,892	145,410	304	3,198	1	*944,340*
Grassland	7,778	116,002	1,194,126	6,180	20,653	970	*1,345,709*
Wetlands	863	1,410	10,849	801,539	4,477	1,825	*820,962*
Settlements	4,907	10,740	30,915	1,311	557,312	328	*605,512*
Other land	235	28	516	1,846	135	34,897	*37,657*
Total	*395,572*	*924,863*	*1,391,488*	*811,941*	*589,121*	*38,515*	*4,151,500*

Annual land use changes that can be assessed from the matrix 2009–2013 (Table 6.5) will be used to extrapolate annual land use changes in the coming years until new land use statistics become available.

Table 6.6 Overview of the categories in LULUCF. Each category includes: land remaining in this category and land converted to this category.

Category	Description	Issues
4A	Forest land	Living biomass, harvest, thinning, dead wood, litter, Emissions from Forest Fires, Fertilizer use in forests (nitrous oxide emissions)
4B	Cropland	Living biomass, Emissions from: Disturbance associated with land-use conversions to cropland
4C	Grassland	Living biomass, Soil (drainage and subsidence of peatland) Emissions from wildfires
4D	Wetland	Reed marshes and open waterbodies only (including rivers, channels, ditches and artificial lakes) Included in grassland when covered with grassy vegetation and included in forest land when covered with willow coppice.
4E	Settlement	Including a national category built-up areas and a national category urban areas (including paved open areas in urban environment, car parks, graveyards) and transport infrastructure (including roads and rail tracks)
4F	Other land	All land not included in 4A-4E, mainly: bare sands (including beaches, dunes, sandy roads) and uncultivated land alongside the rivers.
4G	Other (related) activities	Harvested wood products

6.4 Forest land (4A)

6.4.1 Description

This category includes emissions and sinks of CO_2 relating to forest land. All forests in the Netherlands are classified as temperate, 30% of them being 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[7]). In the Netherlands, with its very high population density and strong pressure on land, all forests are managed. Consequently, no sub-division between managed and unmanaged forest land is applied. Where such sub-divisions are asked for in the CRF tables, the code 'NO' is used in unmanaged forests.

The category includes two sub-categories: Forest land remaining forest land (4A1) and Land converted to forest land (4A2). The first sub-category includes estimates of emissions resulting from changes in the carbon stock in different carbon pools in the forest. The second sub-category includes estimates of emissions resulting from changes in land use from mainly agricultural areas to forest land since 1990 during a 20-year transition period.

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

Also included in this section (under 'forest land converted to other land use categories') are emissions related to the conversion of forest land to other land use categories (deforestation).

6.4.2 *Methodological issues*

Removals and emissions of CO_2 from forestry activity and changes in woody biomass stock are estimated using a country-specific Tier 2 methodology. The approach chosen follows the 2006 IPCC Guidelines (IPCC, 2006), which suggest a stock difference approach. The basic assumption is that the net flux can be derived from converting the change in growing stock volumes in the forest into carbon. Detailed descriptions of the methods used and EFs can be found in the methodological background report for the LULUCF sector (Arets et al., 2015). The Netherlands' National System follows the carbon cycle of a managed forest and wood products system. Changes in the carbon stock are calculated for above-ground biomass, below-ground biomass and dead wood and litter in forests.

National Forest Inventories

Data on forests was taken from three National Forest Inventories (NFIs), carried out in 1988–1992 (HOSP data, Schoonderwoerd and Daamen 1999), 2000–2005 (MFV data, Daamen and Dirkse, 2005) and 2012–2013 (NBI6, Schelhaas et al., 2014). As these most accurately describe the state of Dutch forests and represent the state of the forest at three moments in time – 1990 (HOSP), 2003 (MFV) and 2012 (NBI6) – 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. Estimates of changes between 2013 and 2020 were based on projections using the EFISCEN model (see Arets et al., 2015).

Using plot-level data from the HOSP, MFV and NBI6, changes in carbon stocks in living biomass in forests were calculated. In addition, changes in activity were assessed using several databases containing tree biomass information and 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. (2015).

6.4.2.1 Forest land remaining forest land

A net change in carbon stocks in Forest land remaining forest land is calculated as the difference in carbon contained in forest land 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 are assessed for the periods 1990–2003 and 2003–2012. The annual changes during these periods are determined using linear interpolation.

Living biomass

For each plot that is measured during the forest inventories, information is recorded on the presence of the dominant tree species, the standing stock (stem volumes) and the forest area it represents. On the basis this

information, the following calculations are made (for more details see Arets et al., 2015):

1. From the growing stock information and biomass expansion functions (BCEF) for each plot in the NFIs, total tree biomass per hectare is calculated. Tree biomass is calculated on the basis of the growing stock information from the three inventories. For all plots in the NFIs, biomass is calculated using the dominant tree species' specific BCEFs.
2. Average growing stocks (m^3 ha^{-1}), average BCEFs (tonnes biomass m^{-3}) and average root-to-shoot ratios, weighted for the representative area of each of the NFI plots in each of the inventories, are calculated (Arets et al., 2015).
3. Based on the distribution of total biomass per hectare over coniferous and broadleaved plots (determined on the basis of the dominant tree species), the relative share of coniferous and broadleaved forests 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, average BCEF and root-to-shoot ratios, the average above-ground and below-ground biomasses (tonnes d.m. ha-1) are estimated for each year (Table 6.7).
6. Using the relative share of coniferous and broadleaved forests and the differentiated Tier 1 carbon fractions for conifers and broadleaved species, above- and below-ground biomass is converted to carbon. (Losses from wood harvesting are already included in the differences in carbon stocks between the three forest inventories, HOSP, MFV and NBI6.)

Table 6.7 Annual values for growing stock, above-ground (AGB) and below-ground (BGB) biomass, and BCEF based on temporal interpolation between the inventories and/or model projections

Year	Growing stock (m^3 ha^{-1})	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

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})
2003	195	0.736	143	26
2004	197	0.739	145	26
2005	199	0.742	148	27
2006	201	0.744	150	27
2007	203	0.747	152	27
2008	206	0.750	154	28
2009	208	0.753	156	28
2010	210	0.756	159	29
2011	212	0.758	161	29
2012	214	0.761	163	29
2013	217	0.764	165	30

Dead wood
Data on dead wood volume was available from the three forest inventories. The calculation of carbon stock changes in dead organic matter in forests follows the approach for the calculation of carbon emissions from living biomass (see above) and is done for both lying and standing dead wood.

Litter
Analysis of carbon stock changes based on collected data has shown that there is probably a build-up of litter in Dutch forest land. Data from around 1990, however, is extremely unreliable; therefore, this sink is not reported.

Effects of wood harvests on biomass gains and losses
The effects of harvesting wood on carbon in the remaining forest biomass are already implicitly included in the carbon stock differences between the NFIs. The gross gains in biomass between the inventories were thus higher than calculated from the NFIs' stock differences. Therefore, the carbon in the wood harvested in a given year is added to the carbon stock changes in the living biomass. At the same time, this same amount of carbon is reported under carbon stock losses from living biomass, resulting in a net change as determined from the carbon stock differences between the forest inventories. As a consequence, the net stock change is gradual, but the gains and losses are more erratic.

For each year, first the amount of timber recovered from deforestation is estimated by multiplying the area deforested 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 the total harvest deriving from forest management is later used in the calculations relating to harvested wood products (see 6.10). All harvests are calculated as thinnings.

Emissions from forest fires
In the Netherlands, no recent statistics are available on the occurrence and intensity of wildfires in forests (forest fires). The area of forest

burned annually 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 burned (37.77 ha) from the period 1980–1992 is used for all years from 1990 onwards (Arets et al., 2015).

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). Mass of fuel for forest fires is based on the average annual carbon stock in living biomass, litter and dead wood (see Table 6.8). These values change yearly, depending on forest growth and harvesting.

With the available data it is not possible to distinguish between forest fires in forest land remaining forest land and and those in land converted to forest land. Therefore, total emissions from all forest fires are reported in CRF Table 4(V) under 'wildfires in forests remaining forests'.

Emissions from fertilizer use and drainage in forests
N_2O emissions can result from the use of fertilizer in forests or from the drainage of forest land. Neither management practice is much applied in forestry in the Netherlands. It is therefore assumed that N_2O emissions from fertilizer use and drainage are irrelevant in forest land.

6.4.2.2 Land converted to rorest 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 2006 IPCC Guidelines and its updates in the Good Practice Guidance on Land Use, Land Use Change and Forestry (IPCC, 2003). The basic assumption is that the net flux can be derived by converting the change in growing stock volume in the forest into carbon and that young plots (< 20 years) in the national forest inventory are representative for newly reforested/afforested plots.

Living biomass
The increase in living biomass in land converted to forest land is estimated from the NFIs, using the following set of assumptions:

1. At time of regeneration, growth is close to zero.
2. Between regeneration and 20 years of age, the specific growth curve is unknown and is approximated by a linear relationship.
3. The exact height of this linear curve is best approximated by a linear regression on the mean growth rates per age as derived from the NFI. One mean value for each age is taken to avoid confounding effects of the age distribution of the NFI plots (some of which are not afforested but regenerating after a clear cut).
4. The EF is calculated for each annual set of afforested plots separately. Thus, the specific age of the reforested/afforested plots is taken into account and a general mean value is reached only at a constant rate of afforestation for more than 20 years (with varying rates of afforestation, the IEF will vary as well).
5. Between 1990 and 2000, rates are based on the HOSP inventory. From 2000 to 2013, these rates are based on the MFV inventory

and from 2013 onwards the relationship is based on data from the NBI6 (Arets et al., 2015).

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

Litter and dead organic matter
As the extent of the carbon sink formed by the accumulation of dead wood and litter in newly afforested plots (see Arets et al., 2012) is not known, this sink is not reported.

6.4.2.3 Forest land converted to other land use categories

Living biomass
Total emissions from trees after deforestation are calculated by multiplying the total area deforested by the average carbon stock in living biomass, above as well as below ground, as estimated by the calculations for Forest land remaining forest land. Thus it is assumed that, with deforestation, all carbon stored in above- and below-ground biomass is lost to the atmosphere. National averages are used (see Table 6.8), as there is no record of the spatial occurrence of specific forest types.

The IEF for carbon stock change from changes in living biomass, i.e. the average carbon stock in living biomass, follows the calculations from the NFI data. The calculated EFs show a progression over time. The systematic increase in average standing carbon stock reflects the fact that the annual increment exceeds the annual harvest in the Netherlands.

Table 6.8 Emission factors for deforestation (Mg C ha^{-1})

Year	EF biomass	EF dead wood	EF litter
1990	65.6	0.41	28.66
1991	67.0	0.49	29.22
1992	68.3	0.57	29.78
1993	69.6	0.64	30.34
1994	70.9	0.72	30.90
1995	72.3	0.80	31.46
1996	73.6	0.87	32.02
1997	75.0	0.95	32.59
1998	76.4	1.03	33.15
1999	77.7	1.10	33.71
2000	79.1	1.18	34.27
2001	80.5	1.26	34.83
2002	81.8	1.33	35.39
2003	83.2	1.41	35.95
2004	84.5	1.45	35.95
2005	85.7	1.50	35.95
2006	86.9	1.55	35.95
2007	88.2	1.59	35.95
2008	89.5	1.64	35.95

2009	90.7	1.69	35.95
2010	92.0	1.73	35.95
2011	93.3	1.78	35.95
2012	94.6	1.82	35.95
2013	95.8	1.87	35.95

Dead wood
Total emissions from dead wood 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 the carbon stored in dead wood is lost to the atmosphere. National averages are used as there is no record of the spatial occurrence of specific forest types.

Litter
Total emissions from litter 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 the carbon stored in above- and below-ground biomass is lost to the atmosphere. National averages are used, as there is no record of the spatial occurrence of specific forest types.

The average carbon stock in the litter layer has been estimated at national level (Wyngaert et al., 2012). Data for litter layer thickness and carbon in litter are available from five datasets. In addition, selected forest stands on poor and rich sands were intensively sampled with the explicit purpose of providing conversion factors or functions. None of the available datasets could be used exclusively. Therefore, a stepwise approach was used to estimate the national litter carbon stock in a consistent way. A step-by-step approach was developed to accord mean litter stock values with any of the plots sampled in the NFIs (HOSP, MFV and NBI6).

6.4.3 Uncertainty and time series consistency

Forest land remaining forest land (4A1)

Uncertainty

The Tier 1 analysis described in Annex 2, shown in Table A2.1, provides estimates of uncertainty by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates of forest statistics, land use and land use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in CO_2 emissions from 4A1 (Forest land remaining forest land) is calculated at 67%. See Olivier et al. (2009) for details.

The uncertainty in the IEF for the increase in living biomass is calculated at 13%. The uncertainty in the IEF for the decrease in living biomass is calculated at 30%. The uncertainty in the net carbon flux from dead wood is calculated at 30%.

Time series consistency
The updated time series for category 4A1 shows removals averaging about 1,880 Gg CO_2 $year^{-1}$ with a range from 1,640 Gg CO_2 $year^{-1}$ to 2,370 Gg CO_2 $year^{-1}$ in years 1990–2013. The data in category 4A1 shows the net result of the sequestration in live trees, dead wood and litter and emissions from harvesting. The figures for live trees change only slightly over time, with no clear direction. Emissions from harvesting are more erratic, as the extent of harvesting depends on many external factors. Overall harvest levels show a decreasing trend, probably as a result of fewer building activities. The figures for afforestation show a steadily decreasing net source from 1990 to quasi neutral in 1995, with the net sink further increasing up to 2009, then stabilizing when the first 20-year transition period has ended. In 2012, the sequestration level reached 554 Gg CO_2 $year^{-1}$.

Land converted to forest land (4A2)
Uncertainty
The Tier 1 analysis outlined in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates for forest statistics, land use and land use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in the CO_2 emissions from 4A2 (Land converted to forest land) is calculated at 63%. See Olivier et al. (2009) for details.

Uncertainty in IEF of 4A2 (Land converted to forest land)
For the increase in living biomass, the same data and calculations were used as for 4A1 (Forest land remaining forest land) and, therefore, the same uncertainty figures are used in the Tier 1 calculation spreadsheet.

Time series consistency
The updated time series for category 4A2 shows a steadily decreasing net source from 1990, when forests are extremely young and biomass losses from cropland and grassland dominate the values, to quasi neutral in 1995, with the net sink increasing up to 2009, then stabilizing when the 20-year transition period has ended (Figure 6.2). In 2013, the sequestration level reached about 310 Gg CO_2 $year^{-1}$.

Forest land converted to other land use categories (4A3)
Uncertainty
The Tier 1 analysis explained in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates for forest statistics, land use and land use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in the CO_2 emissions from Forest land converted to other land use categories is calculated at 50%. See Olivier et al. (2009) for details.

Time series consistency
The updated time series for Forest land converted to other land use categories shows it to be a steadily increasing net source from 763 Gg

CO_2 year^{-1} in 1990 to 1,538 Gg CO_2 year^{-1} in 2012. Each new land use map and resulting land use change matrix results in a step increase in the annual area of deforested land. The EF gradually increases over time.

6.4.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures discussed in Chapter 1. Additional forest land-specific QA/QC includes:

- During the three NFIs, specific QA/QC measures were implemented to prevent errors in measurement and reporting (see Arets et al., 2015).
- Previously, changes in forest area and mean carbon stocks in Dutch forests were verified by data from the FAO's Forest Resources Assessment (FRA).

6.4.5 Category-specific recalculations

This year, the following changes led to recalculations in the category Forest land.

- In the past, the Tier 1 default values for carbon fractions in biomass were the same for all species groups (0.5). In the 2006 IPCC Guidelines these Tier 1 default values were further differentiated between conifers (0.51) and broadleaved species (0.48). Because the share of conifers and broadleaved species is not the same, and also changes over time, the carbon stock changes in biomass for land use changes involving forest land for the period 1990–2012 show small differences from the previous submission.
- Carbon stock differences between the three National Forest Inventories were used to assess carbon stock changes in forest land between 1990 and 2003. Now the calculation method for this period is equivalent to the calculation method in the subsequent period, 2003–2012.
- The biomass increment function used to assess carbon stock gains in living biomass in land converted to forest land was updated for the period 2003–2012 on the basis of new information from the 6th National Forest Inventory (NBI6), leading to recalculations for the period 2003–2012.
- Changes in the allocations of emissions from peat soils and including emissions from peaty soils for changes from Cropland, Grassland or Settlements to Forest land led to recalculations in the emissions from organic soils for the period 1990–2012 (see Section 6.1).

6.4.6 Category-specific planned improvements

For this land use category, no improvements are planned in the immediate future.

6.5 Cropland (4.B)

6.5.1 Description

In annual cropland no net accumulation of biomass carbon stocks will occur over time (IPCC, 2006). Because cropland in the Netherlands mainly consists of annual cropland, carbon stock changes in living biomass are not estimated for Cropland remaining cropland. Similarly,

no carbon stock changes in mineral soils are expected. Therefore for Cropland remaining cropland, no net carbon stock changes in mineral soils are calculated. Emissions from the lowering of the water table in organic cropland soils, however, are explicitly calculated for areas of cropland remaining cropland (see Arets et al., 2015).

6.5.2 *Methodological issues*

For soil emissions, a 20-year transition period is included, starting from 1990, while carbon stock changes in biomass are instantaneous on conversion. In the CRF tables, 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 are calculated using a Tier 1 approach. These values are also used for determining emissions from Cropland converted to other land use categories (4A2, 4C2–4F2). Net carbon stock changes in both mineral and organic soils in land use changes involving cropland are calculated using the methodology provided in Arets et al. (2015).

6.5.3 *Uncertainty and time series consistency*

Uncertainty and time series consistency for Cropland

Uncertainty

The Tier 1 analysis explained in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the LULUCF sector. The analysis combines uncertainty estimates for forest statistics, land use and land use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals. The uncertainty in the CO_2 emissions from 4B2 (Land converted to cropland) is calculated at 56%; see Olivier et al. (2009) for details (rounded off to 50% in the Tier 1 calculation spreadsheet, since it is the order of magnitude that is important).

The activity data relates to area change, calculated by comparing the three topographical maps. The uncertainty of one topographical map is estimated to be 5% (expert judgement).

Time series consistency

The yearly emissions of CO_2 due to the conversion of land to cropland show an increase from 169 Gg CO_2 in 1990 to 1,690 Gg CO_2 in 2012.

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*

Changes in the allocation of emissions from peat soils and including emissions from peaty soils led to recalculations in the emissions from organic soils for the period 1990–2012 (see Section 6.1)

6.5.6 *Category-specific planned improvements*

For this land use category, no improvements are planned in the immediate future.

6.6 Grassland (4C)

6.6.1 *Description*

The annual production of biomass in grassland can be large, but due to rapid turnover, changes of standing biomass will be limited in permanent grasslands (IPCC, 2006). For carbon stock changes in living biomass in Grassland remaining grassland (4C1), the Netherlands applies the Tier 1 method assuming there is no change in carbon stocks (IPCC, 2006). Similarly, no carbon stock changes in mineral soils are expected and therefore these are not calculated for 4C1. Emissions from the lowering of the water table in organic soils in grassland, however, are explicitly calculated for areas of Grassland remaining grassland (see Arets et al., 2015).

6.6.2 *Methodological issues*

For soil emissions, a 20-year transition period is included, starting from 1990, while carbon stock changes in biomass are instantaneous on conversion. In the CRF table, 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 4C2 Land converted to grassland are calculated using a Tier 1 approach. These values are also used to determine emissions from Grassland converted to other land use categories (4A2, 4B2, 4D2–4F2). Net carbon stock changes in both mineral and organic soils from land use changes involving grassland are calculated using the methodology provided in Arets et al. (2015).

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 as described in the 2006 IPCC Guidelines.

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. This includes all land use categories. Most wildfires in the Netherlands, however, are associated with heath and grassland. All 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.

6.6.3 *Uncertainty and time series consistency*

Uncertainty

The Tier 1 analysis given in Annex 2, shown in Table A2.1, provides estimates of uncertainties by IPCC source category. The uncertainty for

the CO_2 emissions in categories 4C1 (Grassland remaining grassland) and 4C2 (Land converted to grassland) is calculated to be 56%; see Olivier et al. (2009) for details.

The uncertainty for the oxidation of organic soils in category 4C1 (Grassland remaining grassland) is calculated at 55% (50% used in the Tier 1 calculation spreadsheet).

For the uncertainty of 4C2 (Land converted to grassland), reference is made to the description of 4B2 (Land converted to cropland) (Section 6.6.2). The calculation for Land converted to grassland is based on the same assumptions as those made for Land converted to cropland and is, therefore, identical. The uncertainty is estimated to be 56% (50% used in the Tier 1 calculation spreadsheet).

Time series consistency
Annual emissions of CO_2 due to the conversion of land to grassland show an increase from 287 Gg CO_2 in 1990 to 385 Gg CO_2 in 2013.

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
Changes in the allocation of emissions from peat soils and including emissions from peaty soils led to recalculations in the emissions from organic soils for the period 1990–2012 (see Section 6.1).

6.6.6 Category-specific planned improvements
For this land use category, no improvements are planned in the immediate future.

6.7 Wetlands (4D)

6.7.1 Description
The land use category Wetlands mainly includes open water. Therefore, for 4D1 (Wetland remaining wetland), no changes in carbon stocks in living biomass or soil are estimated. For land use changes from Forest land, cropland and grassland to wetlands (4D2), the losses in carbon stocks in living biomass are included. For all land use conversions to wetlands (4D2) net carbon stock changes in soils are included.

6.7.2 Methodological issues
Living biomass
Carbon stocks in living biomass and dead organic matter on flooded land and open water are considered to be zero. For conversion from other land uses to wetlands, the Netherlands applies a stock difference method that assumes that all the carbon in biomass and organic matter that existed before conversion is emitted.

Emissions of CH_4 from wetlands are not estimated, due to a lack of data.

6.7.3 Uncertainty and time series consistency

Uncertainty

For information on uncertainty estimates, the reader is referred to section 6.6.3, which discusses the uncertainty of soil carbon and changes in land use.

Time series consistency

The time series shows an increase in CO_2 levels from 78.6 Gg CO_2 in 1990 to 232 Gg CO_2 in 2012.

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

For this land use category no category specific recalculations have been made.

6.7.6 Category-specific planned improvements

For this land use category, no improvements are planned in the immediate future.

6.8 Settlements (4E)

6.8.1 Description

As Settlements (4E) includes areas with grass and trees, biomass gains and losses are expected to be in balance. Since no data is available on carbon stocks in biomass and dead organic matter in Settlements, the Netherlands applies the Tier 1 method, assuming no change in carbon stocks in biomass, in 4E1 Settlements remaining settlements. Similarly, it is assumed that no carbon stock changes occur in soils under Settlements remaining settlements. For conversion from other land uses to settlements, the Netherlands applies a stock difference method assuming that all the carbon in living biomass and organic matter that existed before conversion is emitted at once.

6.8.2 Methodological issues

The methodology used to calculate 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 Settlements. Land use conversions from Wetlands or other land to settlements will result in no changes in carbon stocks in living biomass.

6.8.3 Uncertainty and time series consistency

Uncertainty

Uncertainty estimates are provided in Section 6.6.3, which discusses the uncertainty of soil carbon and changes in land use.

Time series consistency

The time series shows a consistent increase from 509 Gg CO_2 in 1990 to 1,205 Gg CO_2 in 2012.

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
Changes in the allocation of emissions from peat soils and including emissions from peaty soils led to recalculations in the emissions from organic soils for the period 1990–2012 (see Section 6.1).

6.8.6 Category-specific planned improvements
For this land use category, no improvements are planned in the immediate future.

6.9 Other land (4F)

6.9.1 Description
This source category includes only CO_2 emissions from 4F1 (Other land remaining other land) and 4F2 (Land converted to other land). In general, Other land does not have a substantial amount of carbon, as the Netherlands uses this land use category to report bare soil surfaces that are not included in any other category.

6.9.2 Methodological issues
Methodology to calculate carbon stock changes in biomass for Forest Land converted to Settlements is provided in Chapter 6.4. Chapters 6.5 (Cropland) and 6.6 (Grassland) provide the methodology to calculate carbon stock changes in biomass for conversions from Cropland and Grassland to Settlement. Land-use conversions from Wetlands or Other Land to Settlements will result in no changes in carbon stocks in living biomass.

6.9.3 Uncertainty and time series consistency
Uncertainty
For information on uncertainty estimates, the reader is referred to Section 6.6.3, which discusses the uncertainty of soil carbon and changes in land use.

Time series consistency
The time series shows a consistent, slow increase from 26 Gg CO_2 in 1990 to
117 Gg CO_2 in 2012.

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
For this land use category no category specific recalculations have been done.

6.9.6 Category-specific planned improvements
For this land use category, no improvements are planned in the immediate future.

6.10 Harvested wood products (4G)

6.10.1 Description

The Netherlands calculates emissions sources and carbon sinks in the category Harvested wood products (HWP) on the basis of the change of the pool, as suggested in the 2013 IPCC Kyoto Protocol Guidance (IPCC, 2014). For greater transparency, and following footnote 12 in the CRF table 4.G s1, the HWP changes reported to both the Convention and to the Kyoto Protocol are calculated using the same methodology. Under the Convention, HWP is reported in the CRF tables under 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 Guidance (IPCC, 2014). As required by the guidelines, carbon from harvests allocated to deforestation is reported using instantaneous oxidation (Tier 1) as the method for calculations. The remainder of harvests 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 calculations for the HWP pools follow the Tier 2 approach outlined in the 2013 IPCC Guidance (i.e. applying equations 2.8.1–2.8.6 in that guidance).

Four categories of HWP are taken into account: sawn wood, wood-based panels, other industrial round wood, and paper and paperboard.

The distribution of material inflow in the different HWP pools is based on the data reported to FAO-stat as imports, production and exports of the different wood product categories, including those of wood pulp as a whole.

6.10.3 Uncertainty and time series consistency

Uncertainty

For HWP, no Tier 1 uncertainty analysis is available at the moment. Instead, for LULUCF a Tier 2/3 'Monte Carlo' approach is being developed and implemented. The results of this analysis will be reported in future inventories.

Time series consistency

The annual changes in carbon stocks in HWP are erratic by nature on account of highly variable input of wood production, imports and exports over a longer time period. The net CO_2 emissions and removals in the period 1990–2013 ranges between -532 Gg CO_2 (removals) and 239 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

This is the first time the Netherlands has reported on this new category.

6.10.6 Category-specific planned improvements

For this land use category, no improvements are planned in the immediate future.

7 Waste (CRF sector 5)

Major changes in the Waste sector compared with the National Inventory Report 2014	
Emissions:	In 2013, total GHG emissions in this sector decreased further.
Key sources:	No changes in key sources in this category.
Methodologies:	No methodology changes.

7.1 Overview of sector

The national inventory of the Netherlands comprises four source categories in the Waste sector:

- Solid waste disposal on land (5A): CH_4 (methane) emissions;
- Composting and digesting of organic waste (5B): CH_4 and N_2O emissions;
- Treatment of waste, including communal waste incineration plants (5C): CO_2 and N_2O emissions (included in 1A1a);
- Wastewater treatment and discharge (5D): CH_4 and N_2O emissions.

Carbon dioxide emissions from the anaerobic decay of waste in landfill sites are not included, since these are considered to be part of the carbon cycle and are not a net source. The Netherlands does not report emissions from waste incineration facilities in the Waste sector because these facilities also produce electricity and/or heat used for energy purposes; these emissions are therefore included in category 1A1a (to comply with IPCC reporting guidelines).

Methodological issues concerning this source category are briefly discussed in Section 7.4. The methodology is described in detail in the methodology report (ENINA, 2015) available on the website http://english.rvo.nl/nie.

The Waste sector accounted for 2% of total national emissions (without LULUCF) in 2013, compared with 7% in 1990, emissions of CH_4 and N_2O accounting for 96% and 4% of CO_2-equivalent emissions from the sector, respectively. Emissions of CH_4 from waste – almost all (89%) originates from landfills (5A1 Managed waste disposal on land) – accounted for 18% of total national CH_4 emissions in 2013. N_2O emissions from the Waste sector stem from domestic and commercial wastewater. Fossil fuel-related emissions from waste incineration, mainly CO_2, are included in the fuel combustion emissions from the Energy sector (1A1a), since all large-scale incinerators also produce electricity and/or heat for energy purposes.

Emissions from the Waste sector decreased by 74% between 1990 and 2013 (see Figure 7.1), mainly due to a 76% reduction in CH_4 from

landfills (5A1). Between 2012 and 2013, CH_4 emissions from landfills decreased by approximately 5%. 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 5% in 1990 to 15% in 2013).

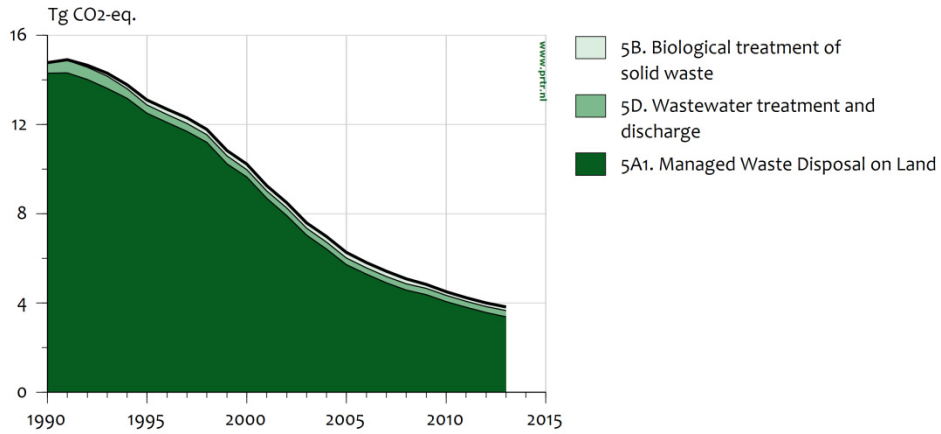


Figure 7.1 Sector 5 Waste: trend and emissions levels of source categories, 1990–2013

Table 7.1 shows the contribution of the emissions from the Waste sector to total GHG emissions in the Netherlands and also presents the key sources in this sector by level, trend or both. The list of all (key and non-key) sources in the Netherlands is shown in Annex 1. Total GHG emissions from the Waste sector decreased from 14.8 Tg CO_2 eq in 1990 to 3.8 Tg CO_2 eq in 2013.

Table 7.1 Contribution of main categories and key sources in sector 5 Waste

Sector/ category	**Gas**	**Key**	**Emissions base year**		**Emissions 2012**		**Emissions 2013**		**Change 2013–2012**	**Contribution to total in 2013 (%)**		
			Gg	Tg CO_2 eq	Gg	Tg CO_2 eq	Gg	Tg CO_2 eq	Gg	By sec-tor	Of total gas	Of total CO_2 eq
5 Waste	CH_4		584.7	14.6	154.0	3.9	146.6	3.7	-0.2	96	19	2
	N_2O		0.5	0.2	0.5	0.2	0.6	0.2	0.0	4	2	0.1
	All			14.8		4.0		3.8	-0.2	100		2
5A Solid waste disposal on land	CH_4		572.0	14.3	142.8	3.6	135.3	3.4	-0.2	89	18	2

Sector/ category	Gas	Key	Emissions base year		Emissions 2012		Emissions 2013		Change 2013–2012	Contribution to total in 2013 (%)		
5A1 Managed waste disposal on land	CH_4	L.T	572.0	14.3	142.8	3.6	135.3	3.4	-0.2	89	18	2
5B Biological treatment of solid waste	CH_4		0.5	0.0	3.1	0.1	3.1	0.1	0.0	2	0	0
	N_2O		0.0	0.0	0.3	0.1	0.3	0.1	0.0	2	1	0.0
5D Wastewater treatment and discharge	N_2O		0.5	0.1	0.2	0.1	0.2	0.1	0.0	2	1	0.0
	CH_4		12.2	0.3	8.1	0.2	8.2	0.2	0.0	5	1.1	0.1
	All			0.5		0.3		0.3	0.0	7		0.1
National total GHG emissions (excl. CO_2 LULUCF)	CH_4		1,317.7	32.9	770.0	19.3	769.1	19.2	0.0		100	
	N_2O		59.1	17.6	25.9	7.7	26.2	7.8	0.1		100	
	All			221.5		198.9		195.5	-2.9			100

CH_4 emissions from landfills constitute the largest proportion of GHG emissions in this sector. Categories 5A1 (Solid waste disposal sites (SWDS)) and 5B (Composting and digesting of organic waste) are key sources of CH_4 emissions by both level and trend.

7.2 Solid waste disposal on land (5A)

7.2.1 Category description

In 2013 there were 22 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 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% in 1990 and 2% in 2013 – a decrease of 76%. This decrease is partly due to the increase in recovered CH_4 – from about 5% in 1990 to 15% in 2013 – but also to the decrease in methane produced at solid waste disposal sites and the decrease of the relative amount of methane in landfill gas from 60% to 50%.

In 2013, solid waste disposal on land accounted for 89% of total emissions from the Waste sector and 2% of total national CO_2-equivalent emissions (see Table 7.1).

The policy that has been implemented in the Netherlands is directly aimed at reducing the amount of waste sent to landfill sites. This policy requires enhanced prevention of waste production and increased recycling of waste, followed by incineration. As early as the 1990s, the government introduced bans on the landfilling of certain categories of waste; for example, the organic fraction of household waste. Another means of reducing landfilling was raising landfill taxes in line with the higher costs of incinerating waste. Depending on the available incineration capacity , the government can grant exemption from these 'obligations'. As a result of this policy, the amount of waste sent to landfills decreased from more than 14 million tons in 1990 to 3 million tons in 2012, 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 ENINA (2015) on the website http://english.rvo.nl/nie.

Data on the amount of waste disposed of at landfill sites derives mainly from the annual survey performed by the Working Group on Waste Registration at all the landfill sites in the Netherlands. This data can be found on the website http://english.rvo.nl/nie and is documented in Rijkswaterstaat (2014). This document also contains the amount of CH_4 recovered from landfill sites yearly. The IEFs correspond with the IPCC default values.

In order to calculate CH_4 emissions from all the landfill sites in the Netherlands, it was assumed that all waste was disposed of at one landfill site; an action that started in 1945. As stated above, however, characteristics of individual sites vary substantially. CH_4 emissions from this 'national landfill' were then calculated using a first-order decomposition model (first-order decay function) with an annual input of the total amounts deposited and the characteristics of the landfilled waste and the amount of landfill gas extracted. This is equivalent to the IPCC Tier 2 methodology. Since landfills are a key source of CH_4 emissions, the present methodology is in line with the 2006 IPCC Guidelines (IPCC, 2006).

The parameters used in the landfill emissions model are as follows:

- Total amount of landfilled waste;
- Fraction of degradable organic carbon (DOC) (see Table 7.2 for a detailed time series);
- CH_4 generation (decomposition) rate constant (k): 0.094 up to and including 1989, decreasing to 0.0693 in 1995; decreasing

from 2000 to 2004 to 0.05 (IPCC parameter) and remaining constant thereafter; this corresponds to a half-life of 14.0 years (see Table 7.2 for a detailed time series);
- CH_4 oxidation factor: 10%;
- Fraction of DOC actually dissimilated (DOCF): 0.58 until 2000 (see also Oonk et al., 1994); from 2000 to 2004, decreasing to 0.5 (IPCC parameter) and remaining constant thereafter;
- CH_4 conversion factor (IPCC parameter): 1.0;
- The fraction of methane in landfill gas recovered has been determined yearly since 2002 on the basis of the composition of landfill gas at all sites with CH_4 recovery. For the years up until 2001, the fraction of methane in landfill gas has been set at 60%.

Trend information on IPCC Tier 2 method parameters that change over time is provided in Table 7.2. The change in DOC values was due to factors such as the prohibition on depositing combustible waste in landfills, whereas the change in k-values (CH_4 generation rate constant) was caused by a sharp increase in the recycling of vegetable, fruit and garden waste in the early 1990s. Moreover, since 2008 there has been a decrease in the amount of combustible waste deposited in landfills, due to overcapacity at incineration plants. The integration time for the emissions calculation is defined as the period from 1945 to the year for which the calculation is made.

Table 7.2 Parameters used in the IPCC Tier 2 method that change over time (additional information on solid waste handling)

Parameter	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2013**
Waste generation rate (kg/cap/day)	1.52	1.50	1.69	1.75	1.66	1.61	1.54
Fraction MSW disposed to SWDS	0.38	0.29	0.09	0.01	0.00	0.01	0.01
Fraction DOC in MSW	0.13	0.13	0.11	0.06	0.03	0.03	0.03
CH_4 generation rate constant (k)	0.09	0.07	0.07	0.05	0.05	0.05	0.05
Number of SWDS recovering CH_4	45	50	55	50	53	53	53
Fraction CH_4 in landfill gas	0.6	0.6	0.6	0.53	0.51	0.50	0.49

7.2.3 Uncertainty and time series consistency

Uncertainty

The Tier 1 uncertainty analysis shown in Tables A2.1 and A2.2 of Annex 2 provides estimates of uncertainties by IPCC source category and gas. The uncertainty in CH_4 emissions from solid waste disposal sites is estimated to be approximately 24% in annual emissions. The uncertainty in the activity data and the EF are estimated to be less than 0.4% 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. Since 2002, the fraction of CH_4 in landfill gas has been determined yearly on the basis of the composition of the landfill gas (at CH_4 recovering sites). It is expected that this will reflect the average fraction of CH_4 in the landfill gas better than the default used in previous inventories and it slightly reduces uncertainties in the emissions estimations of the post-2001 period. This 'new' CH_4 fraction is used to estimate only the amount of methane in the recovered biogas and not the generation of methane within the landfill site.

7.2.4 Source-specific QA/QC and verification
The source categories are covered by the general QA/QC procedures discussed in Chapter 1, and the specific QA/QC described in the document on QA/QC of outside agencies (Wever, 2011).

7.2.5 Source-specific recalculations
Compared with the previous submission, no recalculations took place for this submission.

7.2.6 Source-specific planned improvements
In 2015, potential improvements for this category (in coherence with the categories Solid waste disposal on land and Other waste handling) were investigated. These potential improvements were selected based on uncertainty and amount of emissions. Due to the prioritizing of all possible improvements in the Dutch inventory, however, none of the waste improvements was selected to be carried out.

7.3 Biological treatment of organic waste (5B)

7.3.1 Category description
This source category, which consists of the CH_4 and N_2O emissions from the composting and digesting of separately collected organic waste from households and green waste from gardens and companies, is not considered to be a key source. Emissions from the small-scale composting of garden waste and food waste by households are not estimated, as these are assumed to be negligible.

The amount of composted and digested organic waste increased from nearly 0 million tons in 1990 to 3.6 million tons in 2013. In 2013, this treatment accounted for less than 1% of the emissions in the Waste sector (see Table 7.1).

7.3.2 Methodological issues
Activity data and EFs
Detailed information on activity data and EFs can be found in ENINA (2015) on the website http://english.rvo.nl/nie. The activity data for the amount of organic waste composted at industrial composting facilities derives mainly from the annual survey performed by the Working Group on Waste Registration at all industrial composting sites in the Netherlands. Data can be found on the website http://english.rvo.nl/nie

and in a background document (Rijkswaterstaat, 2014). This document also contains the amount of compost produced on a yearly basis.

7.3.3 Uncertainty and time series consistency

Uncertainty

The emissions from this source category are calculated using an average EF that has been obtained from the literature. The uncertainty in annual CH_4 and N_2O emissions is estimated at 29% and 24%, respectively, with an uncertainty in the activity data of less than 0.5% and in the EFs of 29% and 24%. For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time series consistency

The time series consistency of the activity data is very good, due to the continuity in the data provided.

7.3.4 Source-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1, and the specific QA/QC described in the document for QA/QC of outside agencies (Wever et al., 2011).

In general, the QA/QC procedures within the waste sector are:

- Checking activity data against other sources within the monitoring of waste;
- Checking trends in the resulting emissions;
- Checking EFs every four to five years against EFs in other European countries.

7.3.5 Source-specific recalculations

Compared with the previous submission, no recalculations took place for this submission.

7.3.6 Source-specific planned improvements

In 2015, potential improvements for this category (in coherence with the categories Solid waste disposal on land and Other waste handling) were investigated. These potential improvements were selected based on uncertainty and amount of emissions. Due to the prioritizing of all possible improvements in the Dutch inventory, however, none of the waste improvements was selected to be carried out.

7.4 Waste incineration (5C)

7.4.1 Category description

Emissions from the source category Waste incineration are included in category 1A1 (Energy industries) as part of the source 1A1a (public electricity and heat production), since all waste incineration facilities in the Netherlands also produce electricity and/or heat used for energy purposes. According to the 2006 IPCC Guidelines, these activities should be included in category 1A1a (public electricity and heat production: other fuels, see Section 3.2.4).

7.4.2 *Methodological issues*

Activity data and EFs

The activity data for the amount of waste incinerated derives mainly from the annual survey performed by the Working Group on Waste Registration at all 14 waste incinerators in the Netherlands. Data can be found on the website http://english.rvo.nl/nie and in a background document (Rijkswaterstaat, 2013a).

A more detailed description of the method and the EFs used can be found in the methodology report (ENINA, 2015) on the website http://english.rvo.nl/nie, as indicated in Section 8.1 and in a background document (Rijkswaterstaat, 2013b).

Total CO_2 emissions – i.e. the sum of organic and fossil carbon – from waste incineration are reported for each facility in AERs and included in the inventory dataset for individual companies . Fossil-based and organic CO_2 and N_2O emissions from waste incineration are calculated from the total amount of waste incinerated. The composition of the waste is determined for each waste stream (e.g. business waste). An assumption is made for each of the six types of waste composition with respect to the specific carbon and fossil carbon fractions, which subsequently yield the CO_2 emissions. For some waste streams, the composition is updated on a yearly basis, based on analyses of the sorting of household residual waste.

Table 7.3 shows the total amounts of waste incinerated, the fractions of the different waste components used for calculating the amounts of fossil and organic carbon in the waste (from their fossil and organic carbon fraction) and the corresponding amounts of fossil and organic carbon in the total waste incinerated.

The method is described in detail in Rijkswaterstaat (2013b) and in the methodology report (ENINA, 2015). Based on measurement data (Spoelstra, 1993), an EF of 20 g/ton waste is applied to N_2O from incineration with SCR. For incineration with SNCR, an EF of 100 g/ton is applied. The percentage of SCR increased from 6% in 1990 to 36% in 2013.

In 2013, a new waste stream was introduced with its own calculation for the composition. This is imported waste. The reason for this change was the substantially increased amount of imported waste that was being processed in waste incinerators in the Netherlands. In 2013, 21% of incinerated waste was imported from other countries. This change is also described in detail in Rijkswaterstaat (2013b).

A survey of EFs for CH_4 used in other countries and an analysis of emissions from waste incinerators in the Netherlands made it clear that the CH_4 concentration in the flue gases from waste incinerators is below the background CH_4 concentration in ambient air. The Netherlands therefore uses an EF of 0 g/GJ and reports no methane. When it is unable to record such a value, the code 'NO' is used. More information can be found in Rijkswaterstaat (2013b).

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

Table 7.3 Composition of incinerated waste

	1990	1995	2000	2005	2010	2012	2013
Total waste incinerated (Gg)	2,780	2,913	4,896	5,503	6,459	7,480	7.549
- of which household waste (Gg)	2,310	2,083	3,115	4,413	3,727	3,222	2,602
- of which							
paper/cardboard (weight %)	26%	33%	32%	25%	21%	20%	19%
wood (weight %)	1%	2%	2%	3%	4%	3%	3%
other organic matter (weight %)	51%	37%	35%	35%	33%	38%	38%
plastics (weight %)	8%	11%	13%	19%	18%	14%	14%
other combustible (weight %)	3%	5%	5%	6%	10%	10%	10%
non-combustible (weight %)	11%	13%	13%	13%	14%	15%	16%
Total waste incinerated (TJ)	22,746	27,903	51,904	55,058	63,818	71,209	73,833
Energy content (MJ/kg)	8.2	9.6	10.6	10.0	9.9	9.5	9.8
Fraction organic (energy %)	58.2%	55.2%	50.4%	47.8%	53.1%	55.6%	54.8%
Amount of fossil carbon (Gg)	164	221	433	561	675	708	762
Amount of organic carbon (Gg)	544	561	938	909	1,172	1,363	1,377

7.4.3 Uncertainty and time series consistency

Uncertainty

The Tier 1 uncertainty analysis is shown in Tables A2.1 and A2.2, in Annex 2, and provides estimates of uncertainties by IPCC source category and gas. The uncertainty in annual CO_2 emissions 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 organic carbon in the waste (from their fossil and organic carbon fraction) and the corresponding amounts of fossil and organic carbon in the total waste incinerated. The uncertainty in the amounts of incinerated fossil waste and the uncertainty in the corresponding EF are estimated to be 3.2% and 5.7%, respectively.

The uncertainty in annual N_2O emissions from waste incineration is estimated at 73%. 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 73%, respectively.

For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time series consistency

The time series are based on consistent methodologies for this source category. The time series consistency of the activity data is considered to be very good, due to the continuity of the data provided by the Working Group on Waste Registration.

7.4.4 Source-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, which are discussed in Chapter 1, and the specific QA/QC described in the document for QA/QC of outside agencies 2011 (Wever et al., 2011).

7.4.5 Source-specific recalculations

There are no source-specific recalculations for this category.

7.4.6 Source-specific planned improvements

In 2015, potential improvements for this category (in coherence with the categories Solid waste disposal on land and Other waste handling) were investigated. These potential improvements were selected based on uncertainty and amount of emissions. Due to the prioritizing of all possible improvements in the Dutch inventory, however, none of the waste improvements was selected to be carried out.

7.5 Wastewater handling (5D)

7.5.1 Category description

This source category covers emissions from wastewater handling and includes emissions from industrial wastewater, domestic or urban wastewater and septic tanks. In 2013, only 0.6% of the Dutch population was not connected to a closed sewer system, and these households were obliged to treat wastewater in a small scale on-site treatment system(a septic tank or a more advanced system).

In 2013, urban wastewater (the mixture of domestic and commercial wastewater, including urban run-off) was treated aerobically in 341 public wastewater treatment plants (WWTP). The treatment of the resulting wastewater sludges is accomplished mainly by anaerobic digesters. During the wastewater treatment, the biological breakdown of degradable organic compounds (DOC) and nitrogen compounds can result in CH_4 and N_2O emissions. Incidental venting of biogas also leads to CH_4 emissions. Moreover, as 0.6% of the resident population is still connected to a septic tank, CH_4 emissions from septic tanks are also calculated, but these are 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 53 operational anaerobic industrial WWTPs (IWWTPs).

N_2O emissions from the wastewater sector (see Table 7.4) contributed about 0.9% of total N_2O emissions in 2013 and 0.035% in total CO_2-equivalent emissions. N_2O emissions from wastewater handling and effluents decreased by 54% during the period 1990–2013. This decrease is mainly the result of lower untreated discharges, resulting in lower effluent loads (see Table 7.5) and a subsequent decrease in (indirect) N_2O emissions from domestic and industrial effluents.

The contribution of wastewater handling to the national total of CH_4 emissions in 2013 was 1.1%. Since 1994, CH_4 emissions from public WWTPs have decreased due to the introduction in 1990 of a new sludge stabilization system in one of the largest WWTPs. As the operation of the

plant took a few years to optimize, venting emissions were higher in the introductory period (1991–1994) than under subsequent normal operating conditions. CH_4 emissions from wastewater handling decreased by 33% during the period 1990–2013. The amount of wastewater and sludge being treated does not change much over time. Therefore, the interannual changes in methane emissions can be explained by varying fractions of methane being vented incidentally instead of flared or used for energy purposes. It should be noted that non-CO_2 emissions from the combustion of biogas at wastewater treatment facilities are allocated to category 1A4 (Fuel combustion – other sectors) because this combustion is partly used for heat or power generation at the treatment plants.

Table 7.4 shows the trend in GHG emissions from the different types of wastewater handling.

Table 7.4 Wastewater handling emissions of CH_4 and N_2O (Gg/year)

	1990	**1995**	**2000**	**2005**	**2010**	**2012**	**2013**
CH_4 industrial wastewater	0.29	0.37	0.39	0.41	0.38	0.39	0.38
CH_4 domestic wastewater	8.00	6.70	6.73	6.80	7.24	7.02	7.14
CH_4 septic tanks	3.93	2.84	1.99	1.29	0.68	0.68	0.66
Net CH_4 emissions	12.22	9.91	9.10	8.49	8.30	8.10	8.18
CH_4 recovered and/or flared	33.0	39.5	40.6	41.2	39.0	41.3	44.9
N_2O domestic WWTP	0.076	0.076	0.076	0.077	0.079	0.081	0.079
N_2O effluents	0.42	0.33	0.27	0.22	0.16	0.15	0.15
Total N_2O emissions	0.50	0.40	0.34	0.29	0.24	0.23	0.23

7.5.2 Methodological issues

Activity data and EFs

Most of the activity data on wastewater treatment is collected by Statistics Netherlands (StatLine, 2014) in yearly questionnaires that cover all public WWTPs as well as all anaerobic IWWTPs; see also www.statline.nl for detailed statistics on wastewater treatment. Table 7.5 shows the development in the main activity data with respect to domestic wastewater treatment as well as industrial wastewater treatment and septic tanks.

Due to varying weather conditions, the volumes of treated wastewater and of the total load of DOC of domestic wastewater can fluctuate from year to year, depending on the amount of run-off rainwater that enters the sewer systems. In the method developed for calculating methane emissions, the DOC (or TOW) is based on an organic load expressed in terms of chemical oxygen demand (COD). the calculation of the COD of produced sewage sludge it is made use of the average content of 1.4 kg COD per kg organic dry solids.
From Table 7.5 it can be concluded that the DOC of treated wastewater and sludge does not significantly change over time. Therefore, interannual changes in CH_4 emissions can be explained by varying fractions of CH_4 being vented instead of flared or used for energy purposes. The source Septic tanks has steadily decreased since 1990.

This can be explained by the increased number of households connected to the sewer system in the Netherlands (and therefore no longer using septic tanks; see Table 7.5).

A full description of the methodology is provided in the methodology report (ENINA, 2015) on the website http://english.rvo.nl/nie.

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

Table 7.5 Activity data of domestic and industrial wastewater handling

	Unit	1990	1995	2000	2005	2010	2011	2012	2013[6)]
Treated volume WWTP	Mm3/yr	1,711	1,908	2,034	1,841	1,934	1,917	1,989	1,879
TOW urban WWTP [1)]	Gg / year	933	921	921	943	953	965	972	972
Sludge DOC Urban WWTP [1)]	Gg/ year	365	420	431	467	476	486	491	491
Biogas produced [2)]	mio m3/yr	74.0	85.2	87.9	91.1	98.5	99.4	102.5	109.9
Biogas flared	1,000 m3/yr	8,961	6,465	6,150	7,536	7,360	6,449	6,938	5,877
Biogas vented	1,000 m3/yr	2,524	170	284	400	1,066	379	218	82
TOW IWWTP [1)]	Gg/ year	181	233	244	254	240	238	245	235
Resident population [3)]	1,000	14,952	15,459	15,926	16,320	16,615	16,693	16,755	16,804
inhabitants with septic tank	% of pop.	4.0	2.8	1.9	1.2	0.62	0.62	0.62	0.60
Actual PE load WWTP [4)]	1,000	23,798	23,807	23,854	24,271	24,745	25,070	25,182	24,657
Nitrogen in effluents [5)]	Gg/yr	53.8	41.5	33.8	27.7	20.5	19.4	19.3	19.3

1) Expressed in terms of chemical oxygen demand (COD).
2) Sum of measured biogas, total for energy conversion, flaring, venting and external deliveries.
3) Average population over a year.
4) PE = Population Equivalents, representing the total load of biodegradable substances in domestic and industrial wastewater
5) Sum of domestic and industrial discharges of N in wastewater to surface water.
6) Preliminary data.

CH_4 emissions from domestic wastewater treatment (5D1)
In 2013, 99.4% of the population was connected to closed sewer systems, which were in turn connected to 341 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. Wastewater treatment process steps, e.g. from the influent cellars, from anaerobic zones and from anaerobic pockets in zones with poor aeration.
2. Anaerobic sludge digestion in treatment plants. In addition to the methane that is recovered and used for energy processes, uncontrolled CH_4 emissions can arise from sludge (post-)thickeners, sludge silos and the digesters.
3. Incidental venting of biogas produced in anaerobic sludge digesters.

Wastewater treatment process steps
Methane emissions from the wastewater treatment process are calculated using the standard EF from the 2006 IPCC Guidelines and country-specific data for the TOW and sludge produced.

The EF is calculated as:

$$EF = B_o \times MCF_{stp} = 0.00875 \text{ kg } CH_4/\text{kg COD}$$

Where: B_o = methane formation capacity = 0.25 kg CH_4/kg COD converted (IPCC, 2006);
MCF_{stp} = methane correction factor for advanced aerobic treatment plants = 3.5% (Doorn et al., 1997, as referred to in 2006 IPCC Guidelines).

The emissions are calculated with the formula (IPCC, 2006):

$$CH_4 = EF \times (TOW\text{-}S) = 0.00875 \times (TOW\text{-}S)$$

Where: TOW = total organics in wastewater influent, kg COD per year;
S = total organics in sludge produced, kg COD per year.

Country-specific activity data on the influent COD, as well as the amounts of sludge produced in all public WWTPs, are derived from the yearly survey conducted by Statistics Netherlands among the Water Boards. Data is available for the years 1990 until the present for every treatment plant.

The COD of sludge is calculated using the conversion factor of 1.4 kg COD per kg organic solids. Organic solids are calculated as total dry solids minus the inorganic fraction, measured as ash content. Table 7.5 gives the time series of the values of influent COD and sludge COD.

Anaerobic sludge digestion
Emissions of CH_4 from sludge digesters and related process steps (e.g. post-thickening) are calculated using a country-specific method based on an EF per m^3 biogas produced in the sludge digesters. The emissions are calculated per WWTP with sludge digestion facilities.

In 2013, 81 WWTPs were equipped with sludge digesters. A calculation using the DOC value of the sludge production per plant minus the sludge removal per plant is not feasible because in many of these plants, sludges from other WWTPs are also digested. So the real DOC of the digested sludges is higher than the DOC produced at the own plant. This factor probably would lead to an underestimation of the emissions. However, it is often not known exactly how much sludge from other WWTPs is digested, so the CH_4 emissions are directly related to the biogas production, as a proxy for the DOC converted. This pragmatic method has been developed by the Dutch public wastewater sector itself and is used in the yearly reporting for e-PRTR.

The EF that is used is based on a value for methane recovery (MR) of 94% from the sludge digester process installations, including post-thickeners. This MR value is reported in the IPCC background document to the Good Practice Guidance (Hobson, 2001). This value means that, on top of the recovered methane, 6% of the total is emitted from the sludge digester process line, including post-thickeners and sludge buffer tanks.

The EF is calculated as:

$$EF = (1\text{-}MR) \times F_{CH4} = 0.0264 \text{ kg } CH_4/m^3 \text{ biogas recovered}$$

Where: MR = fraction of methane recovered from the digesters = 0.94 (-) (IPCC/Hobson, 2001);
F_{CH4} = methane content of biogas = 440 g CH_4/m^3 biogas (Baltussen et al., 2015).

The emissions are calculated per plant using the formula:

$$CH_4 \text{ (kg)} = EF \times V_{biogas} = 0.0264 \times V_{biogas}$$

Where: V_{biogas} = Measured volume of recovered biogas in m^3/yr.

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

Incidental venting of biogas
Incidental venting of biogas at public WWTPs is recorded by the plant operators and subsequently reported to Statistics Netherlands. In 2013, the amount of CH_4 emitted by the venting of biogas was 0.04 Gg CH_4, equalling 0.5% of total CH_4 emissions from the category Domestic wastewater. During the last decade, this value varied between 1% and 9%, which means that venting of biogas in 2013 was very low.

Recovered biogas is for largely used for energy generation purposes, but a small amount is also flared, vented or delivered to third parties. Table 7.5 provides the data on recovery of CH_4 (total) and CH_4 combusted via flaring.

CH_4 emissions from industrial wastewater treatment (5D2)
In the calculation of methane emissions from anaerobic industrial wastewater treatment, the Netherlands uses the default IPCC parameters for the EF and country-specific activity data for the TOW as well as a country-specific fraction for losses of methane by leakage. Recovered biogas is generally used as fuel in energy processes. The emissions from biogas combustion are included in the Energy sector.

For anaerobic IWWTPs, the CH_4 EF is calculated as:

$$EF = B_o \times MCF = 0.2 \text{ kg } CH_4/\text{kg COD}$$

Where: B_o = maximum CH_4-producing capacity = 0.25 kg CH_4/kg COD (IPCC, 2006);
MCF = methane correction factor (fraction) = 0.8 for anaerobic reactors (IPCC, 2006).

In the Netherlands no information is available on the actual load of COD that is processed in the IWWTPs. The COD is thus determined by using statistics on the design capacity of the IWWTPs and an assumed average loading rate of 80% of the design capacity (Oonk, 2004).

The design capacity is expressed in terms of a standardized value for quantifying organic pollution in industrial wastewater: Pollution Equivalents (PE). One PE equals an amount of 40 kg COD per year. Data on the design capacity is available from Statistics Netherlands (CBS, 2014). TOW can thus be calculated as:

$$TOW = PE \times 40 \text{ kg COD/yr} \times 0.8 = PE \times 32$$

Where: PE = total design capacity of IWWTP (-);
0.8 = average loading rate (fraction of design capacity) (Oonk, 2004).

There is no correction for excess sludge removal because anaerobic reactors produce very little or no excess sludge. So the method includes emissions from the simultaneous digestion of excess sludge in the anaerobic reactors. The total methane emission is calculated by assuming a methane recovery of 99% from the anaerobic reactors and thus a loss or leakage of 1%.

Total methane emissions are calculated as follows:

$$CH_4 \text{ emissions} = EF \times TOW \times (1\text{-}MR_{ind}) = 0.2 \times 32 \times PE \times 0.01 = 0.64 \times PE$$

Where: MR_{ind} = fraction of methane recovered from the treatment process = 0.99 (Oonk, 2004)

Table 7.5 provides the time series of total TOW for IWWTPs, based on the design capacity (source: CBS, 2014). In 2013, 65% of the anaerobic capacity was installed within the food and beverage industry. Other branches with anaerobic wastewater treatment are the waste processing facilities (15%), chemical industry (16%) and paper and cardboard industry (4%).

CH_4 emissions from industrial sludge treatment (5D2)
Data from the survey among IWWTPs conducted by Statistics Netherlands shows that only 2 out of a total of 160 IWWTPs are equipped with anaerobic sludge digestion reactors. This data is not published on www.cbs.statline.nl for reasons of confidentiality. Forthcoming CH_4 emissions are not estimated (NE) because it is not known what sludge treatment capacity these plants have and how much sludge is digested.

CH_4 emissions from septic tanks (5D3)
Emissions of methane from septic tanks are calculated using IPCC default values for Bo and MCF and IPCC value of TOW of 60 g BOD per connected person per day (IPCC, 2006, table 6.4).

The EF is calculated as:

$$EF_{st} = B_o \times MCF_{st} = 0.3 \text{ kg } CH_4/\text{kg BOD}$$

Where: B_o = maximum CH_4-producing capacity = 0.6 kg CH_4/kg BOD (IPCC, 2006);
MCF_{st} = methane correction factor for septic tanks = 0.5 (IPCC, 2006).

The TOW is calculated as BOD, using the following formula (IPCC, 2006):

$$TOW = P_{st} \times BOD \times 0.001 \times 365$$

Where: P_{st} = average population connected to septic tanks in inventory year, number
BOD = country-specific per capita BOD in inventory year = 60 g/person/day (IPCC, 2006)
0.001 = conversion from grams BOD to kg BOD
365 = number of days per year

The resulting calculation for CH_4 emissions from septic tanks is:

$$CH_4 \text{ emissions} = 6.57 \text{ kg } CH_4 \times P_{st}$$

Table 7.5 shows the time series of the numbers of capita connected to septic tanks (P_{st}). These are calculated using mean population statistics per inventory year and the fraction of the population connected to septic tanks per inventory year. The % of population connected to septic tanks decreased from 4% in 1990 to 0.6% in 2013. This data derives from surveys and estimates by various organizations in the Netherlands, such as Rioned (Rioned, 2009) and the National Water Authorities.

N_2O emissions from centralized wastewater treatment (5D1)
N_2O emissions from domestic wastewater handling are determined on the basis of the IPCC default EF and country-specific activity data for the number of capita connected, including the extra fraction of industrial and commercial wastewater.

$$N_2O_{PLANTS} = PE \times EF_{PLANT}$$

Where: PE = actual load in inventory year, expressed in Population Equivalents (persons).

EF_{PLANT} = EF, 3.2 g N_2O/person/year (IPCC, 2006)

The number of population equivalents is in fact a proxy for the total number of persons connected to the public WWTPs, including the industrial, commercial and urban run-off fraction of the incoming wastewater. One PE equals the average amount of wastewater – and degradable pollutants contained in it – from one person per day. The PE is implemented as the national standard in Dutch wastewater management and is determined at all public WWTPs on the basis of measurements of daily COD and Nitrogen-kjeldahl loads in the influent. The PE is calculated as:

$$PE = (COD + 4.57 \times N_{kjeldahl})/150$$

Where: COD = daily load of COD in influent of WWTP, gram COD/day;
$N_{kjeldahl}$ = daily load of $N_{kjeldahl}$-N in influent of WWTP, gram $N_{kjeldahl}$-N/day;
150 = gram of oxygen needed to convert degradable pollutants of one person per day.

Table 7.5 provides a times series of the PE. In 2013, the total PE equalled 24.7 mln.

Wastewater treated at public WWTPs is a mixture of household wastewater, run-off rainwater and wastewater from industries and services, so forthcoming N_2O emissions are reported under category 5D1 (Domestic and commercial wastewater).

Indirect N_2O emission from surface water as a result of discharge of domestic and industrial effluents (5D1 and 5D2)
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' Pollutant Release and Transfer Register (PRTR, 2014). This data in turn derives from several sources, including statistical surveys, environmental reporting and models.

The emissions are calculated as:

$$N_2O_{effluents} = EF \times N_{effluents}$$

Where: EF = 0.005 kg N_2O-N/kg N discharged (IPCC, 2006);
$N_{effluents}$= total load of N in domestic, industrial and commercial effluents (kg).

Table 7.5 provides a times series of the total N discharges.

N_2O emissions from industrial wastewater treatment (5D2)
Because of their insignificance in comparison with public wastewater treatment, no N_2O emissions are estimated separately for industrial wastewater treatment. The first reason is that most industries discharge their wastewater into the sewer system/WWTPs (emissions included in 5D1). The second reason is that the nitrogen content in most IWWTP is lower than in public WWTP and related conversions of nitrogen also are small.

7.5.3 Uncertainty and time series consistency

Uncertainty
The Tier 1 uncertainty analysis shown in Tables A2.1 and A2.2, in Annex 2, provides estimates of uncertainties by IPCC source category and gas. The uncertainty in annual CH_4 and N_2O emissions from wastewater handling is estimated to be 38% and 102%, respectively.

The uncertainty in activity data is based on the judgements of experts and is estimated to be > 20%. The yearly loads of $DOC_{influent}$, $N_{influent}$ and $N_{effluent}$ are calculated on the basis of wastewater sampling and analysis, as well as flow measurements at 341 WWTPs; all these measurements can be a source of uncertainty.

The uncertainty in the EFs for CH_4 and N_2O is estimated to be 32% and 100%, respectively.

A recent international study (GWRC, 2011), in which the Dutch public wastewater sector also participated, showed that N_2O EFs, in particular, are highly variable among WWTPs as well as at the same WWTP during different seasons or even at different times of day. In fact, the same study concludes that the use of a generic EF (such as the IPCC default) to estimate N_2O emissions from an individual WWTP is inadequate; but at the same time the study provides no alternative method, except the recommendation that GHG emissions from an individual WWTP can be determined only on the basis of continuous measurements over the whole operational range of the WWTP (GWRC, 2011). The results of this study, therefore, provide no starting point from which to improve the method for estimating CH_4 and N_2O emissions and the related uncertainty.

Time series consistency
The same methodology has been used to estimate emissions for all years, thereby providing good time series consistency. The time series consistency of the activity data is very good due to the continuity in the data provided by Statistics Netherlands.

7.5.4 *Source-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, as discussed in chapter 1. Moreover, statistical data is covered by the specific QA/QC procedures of Statistics Netherlands.

For annual CH_4 and N_2O emissions from domestic and commercial wastewater handling, the results of a recent study neither confirm nor reject the use of current methods (see also Section 7.5.3). The Dutch wastewater sector will continue research to determine more precisely the factors and circumstances that lead to the formation of CH_4 and N_2O in public WWTP.

In the case of N_2O emissions from WWTP and indirect N_2O emissions from discharges of effluents, the methods used in neighbouring countries are not yet known, since this is the first year in which the 2006 IPCC Guidelines have been implemented in the methods. In the next submission, it will be possible to make a comparison with the methods adopted by other Western European countries.

In the latest review it was recommended that future NIRs should include an estimate of the biogas recovery at anaerobic IWWTP. This will not be possible, at least not at the short term. Statistics Netherlands has data on total biogas recovery from biomass fermentation plants, including anaerobic WWTP, but in the statistics no distinction is made in the type of substrate or type of installation. It will require a substantial effort to elaborate this and, as resources are under pressure, priority will not be given to this issue.

7.5.5 *Source-specific recalculations*

N_2O emissions have been recalculated for the complete time series, as a result of an update to the N_2O EFs for:

- Indirect emissions from effluents;
- Emissions from advanced wastewater treatment (default value from the 2006 IPCC Guidelines, instead of the default value from the 1996 IPCC Guidelines).

7.5.6 *Source-specific planned improvements*

There are no source-specific planned improvements.

8 Other (CRF sector 6)

The Netherlands allocates all GHG emissions to sectors 1 to 5. Therefore, no sources of GHG emissions are included in sector 6.

9 Indirect CO_2 and NO_2 emissions

9.1 Description of sources

Methane, carbon monoxide (CO) and NMVOC emissions are eventualy oxidized to CO_2 in the atmosphere. In this chapter the CO_2 emissions resulting from NMVOC emissions of solvent and other product use (indirect CO_2 emissions) are described. The indirect CO_2 emissions from NMVOC amounted to 1.0 Tg in 1990 and decreased to the level of 0.3 Tg thanks to NMVOC emission reduction policies in the Netherlands.

9.2 Methodological issues

Indirect CO_2 emissions are calculated as follows:

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

Where: C = default IPCC carbon content (C) of 0.6.

NMVOC emissions data is 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 the indirect CO_2 emissions.

9.4 Category-specific QA/QC and verification

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

9.5 Category-specific recalculations

No recalculations have been made.

9.6 Category-specific planned improvements

No source-specific improvements are planned for this category.

10 Recalculations and improvements

Major recalculations and improvements compared with the National Inventory Report 2014

For this NIR we used methods conforming with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). As the methods for specific (sub-)categories and the global warming potential (GWP) of non-CO_2 GHGs prescribed in the 2006 Guidelines differ from those in the 1996 Guidelines the emissions values presented in this NIR are not direct comparable to those reported in the NIR 2014.

For the NIR 2015, the data for the most recent year (2013) was entered in the corresponding Common Reporting Format (CRF) tables

During the compilation of this NIR, some errors in previous submissions were detected and corrected. These have resulted in minor changes in emissions values over the entire 1990–2012 period.

Furthermore, some recalculations were performed as a result of new or improved activity data and/or improved EFs.

For more details on the effects of and justification for the recalculations, see Chapters 3–8.

10.1 Explanation of and justification for the recalculations

10.1.1 GHG inventory

For this submission (NIR 2015), the Netherlands used the new CRF Reporter software v5.10.1.

The present CRF tables are based on updated methodologies and data according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). Furthermore, we included the remarks made in the UNFCCC review in 2014 in the national improvement programmes. The adapted and improved methodologies are now described in so-called methodology reports, which are under preparation and which will include all relevant information from the former monitoring protocols.

This chapter summarizes the relevant changes in emissions figures compared with the NIR 2014.

As explained before, due to the implementation of the 2006 Guidelines, there were several types of change to emissions values from 1990 to 2012:

- Methodological changes: e.g. changed default EFs;
- Source allocation changes: e.g. new sub-categories and allocation of certain emissions to different sub-categories;
- Error correction/data improvements: e.g. due to the revised GWP for non-CO_2 GHGs.

As a result of the implementation of the 2006 Guidelines, we now include CO_2 emissions from the ceramic industry (process emissions from clay) and report all CO_2 from non-energy use in the fertilizer industry in that category. Carbon storage in fertilizer is ignored. Furthermore, recalculations in the LULUCF sector were required and performed.

Some of the 2012 data has also changed as a result of the publication of final activity data and minor error corrections.

Methodological changes
The improvements in QA/QC activities (process of assessing and documenting methodological changes) implemented in past years are still in place. This process (using a brief checklist for timely discussion on likely changes with involved experts and users of information) improves peer review and the timely documentation of the background to and justification for changes made. The methodological changes initiated last year as a result of QA/QC activities (which are now included in the inventory) are:

- Improved model calculation for residential wood combustion;
- Improved time series, emissions for the glass industry, data now being based on ETS-reported emissions, with extrapolation of these figures to the historic years;
- Improved country-specific calculation of excretion of organic matter in manure;
- Improved activity (fuel) data for fisheries, shipping, aviation and military activities;
- Improved (country-specific) methodology for the calculation of emissions from enteric fermentation in calves;
- Inclusion of CO_2 emissions from urea-based catalysts.
- Use of revised GWPs for non-CO_2 GHGs prescribed in the 2006 Guidelines

Source allocation
As a result of the implementation of the 2006 Guidelines, all allocations were checked and where nescesarry adapted (for details, see Chapter 3–8).

Error correction/data improvements
In general, the 2012 figures have been updated where improved statistical data has become available since the 2014 submission. Furthermore, as a result of internal QA/QC procedures, minor errors (in activity data and emissions figures) have been detected and corrected.

10.1.2 KP-LULUCF inventory

Not reported in this NIR.

10.2 Implications for emissions levels in GHG inventory

10.2.1 GHG inventory

This chapter outlines and summarizes the implications of the changes described in section 10.1 for the emissions levels reported in the GHG inventory. All the individual changes are not quantified seperately in this NIR. For this submission we indicate only the resulting changes in the

emissions for the base year and for 2012 in Table 10.1. The main differences are due to the different GWPs used in the 2014 and the 2015 submissions.

Table 10.1 Summary of the changes in emissions resulting from the implementation of the 2006 Guidelines and methodological chanes for the years 1990 and 2012 (Gg CO_2 eq, excluding LULUCF)

	1990	1995	2012
Submission 2014	211,850	223,161	191,669
Submission 2015	**219,477**	**230,590**	**195,807**
Difference	7,627	7,429	4,183

10.2.2 KP-LULUCF inventory

Not reported in this NIR.

10.3 Implications for emissions trends, including time series consistency

10.3.1 GHG inventory

In general, the recalculations and implementation of the 2006 Guidelines further improved both the accuracy and the time series consistency of the estimated emissions.

10.3.2 KP-LULUCF inventory

Not reported in this NIR.

10.4 Recalculations, response to the review process and planned improvements

10.4.1 GHG inventory

10.4.1.1 Response to the review process

Public and peer review

Drafts of the NIR are usually subject to an annual process of general public review and peer review. Due to the malfunction of the CRF Reporter software, no such reviews have taken place in 2015.

Peer reviews in past years have focused on the following sectors and categories: Energy (excluding transport) (CE Delft, 2014), Industrial process emissions (Royal HaskoningDHV, 2013), LULUCF (Somogyi, 2012), Waste (Oonk, 2011), Transport (Hanschke, 2010), Combustion and process emissions in industry (Neelis et al., 2009) and Agriculture (Monteny, 2008). In general, the conclusion of these peer reviews has been that the Dutch NIR adequately describes the way that the Netherlands calculates the emissions of GHGs. The major recommendations have referred to the readability and transparency of the NIR, and there have been suggestions for textual improvement.

UNFCCC review

In December 2014, the *Report on the individual review of the annual submission of the Netherlands submitted in 2014* was published. Table 10.2 elaborates the actions undertaken (in the preparation of this NIR) to address the recommendations of the expert review team (ERT).

Table 10.2 Improvements made in response to the latest UNFCCC review of 2014

ARR 2014 Paragraph *	Category	ERT recommendations	Netherlands' response	Reference (Section of NIR)
14	Inventory management	Include additional information regarding its quality management system in future NIRs	Implemented	
19	Energy, QA/QC	Improve QC procedures to ensure that all the information provided in the CRF tables and the NIR is consistent	As a result of the CRF Reporter problems this will remain an area for further improvement in the next submission	
20	Energy, QA/QC	Provide a clearer indication of the origin of the EFs used in the NIR	The origin of EFs is indicated in the (new) Netherlands' list of fuels	Chapter 3
21	Energy, QA/QC	Provide information on the verification process performed using EU ETS data	This is described in the NIR and in the methodology report	3.2.4.4
22	Energy, QA/QC	Correct the notation key in the fuel consumption row from 'IE' to 'NO'	This is corrected in the CRF tables	
27	Energy, liquid fuels – CO_2	Provide a more transparent description, including additional information on the AD and EF used, to justify the low value of the IEF in stationary combustion liquid fuels	This is mainly caused by the large amount of chemical waste gas used in this sector	
29	Oil and natural gas: gaseous fuels – CO_2	Report on the progress made to derive a revised time series	Implemented	NIR 3.3.2
32	IP	Change the notation keys "NA', 'NE' and 'NO' to 'C' in the reporting of the AD and IEFs	Implemented (see Note)	
33	IP	Ensure consistency in the reporting of the notation codes	Implemented (see Note)	
34	IP	Improve the consistency of the information reported in the NIR and the CRF tables	Implemented (see Note)	

ARR 2014 Paragraph *	Category	ERT recommendations	Netherlands' response	Reference (Section of NIR)
35	IP	Change the notation code 'NA' to 'C'	Implemented (see Note)	
36	IP – SF_6	In co-operation with relevant stakeholders, obtain sufficient data to ensure a consistent time series, focusing on the period 1990–1999	Description included	4.8.2
39	Agriculture	Include information on the key parameters (weight, milk production, feed intake, diet composition) in the NIR and in CRF table 4.A	These parameters are not used within the Dutch methodology, and therefore not estimated (NE) either	
40	Agriculture	Correct the notation code to 'NO'	Improved CRF tables	
41	Agriculture	Continue and enhance efforts to improve the 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	CH_4 from Manure management recalculated for this submission, improving consistency with N_2O calculations	
42	Agriculture, soils – N_2O	Improve the transparency of the reporting of the use of country-specific parameters	More detailed information published in the methodology report (Vonk et al., 2015)	
Table 3	LULUCF	Obtain the data and report the estimates for all categories currently reported as 'NE' for which methodologies and EFs are available in the IPCC Good Practice Guidance for LULUCF	Emissions of the LULUCF sector recalculated and CRF tables and NIR section revised	Chapter 6
45	LULUCF	Estimate emissions for the carbon pools reported as 'NE' and for which methods and EFs are available in the	Emissions of the LULUCF sector recalculated and CRF tables and NIR chapter revised	Chapter 6

ARR 2014 Paragraph *	Category	ERT recommendations	Netherlands' response	Reference (Section of NIR)
		IPCC Good Practice Guidance for LULUCF		
51	Waste	Enhance QC procedures to prevent inconsistencies and typographical errors	Implemented (see Note)	
52	Waste	Include important AD such as the amount and composition of disposed waste in the NIR	Not yet implemented	
54	Waste	Ensure consistency of the information on the EFs used for the calculations and reported in the NIR (or in the monitoring protocol)	Implemented (see Note)	
55	Waste	Provide an estimate of the recovered methane in anaerobic industrial wastewater treatment plants	Statistics Netherlands has data on total biogas recovery from biomass fermentation plants, including anaerobic WWTP, but in the statistics no distinction is made in the type of substrate or type of installation. It will require a substantial effort to elaborate this and as resources are under pressure no priority will be given to this issue	7.5.4
56	Waste	Ensure complete AD time series for composting	Not yet implemented	
67	Kyoto protocol units	Include in the annual submission missing information required to be reported	Not applicable to this submission	

NOTE: The Netherlands would like to stress that the 2015 problems with the new CRF Reporter software affected the QA/QC of the (non-emission) entries in the CRF tables. There might still be some inconsistencies between the notation keys in the CRF and the description in the NIR. Available time after completion of the CRF tables was too short to check all entries to full extend. In general, the representations provided in the NIR should be used in the reviewing process.

10.4.1.2 Completeness of sources

The Netherlands' GHG emission inventory includes all sources identified by the revised Intergovernmental Panel on Climate Change (IPCC)

Guidelines (IPCC, 2006), with the exception of the following, very minor, sources:

- CO_2 from asphalt roofing (2A5), due to missing activity data;
- CO_2 from road paving (2A6), due to missing activity data;
- CH_4 from enteric fermentation of poultry (4A9), due to missing EFs;
- N_2O from industrial wastewater (6B1), due to negligible amounts;
- Part of CH_4 from industrial wastewater (6B1b sludge), due to negligible amounts;
- Precursor emissions (i.e. carbon monoxide (CO), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2)) from memo item 'International bunkers' (international transport).

For more detailed information on this issue, see Annex 6.

10.4.1.3 Completeness of CRF tables

For the years 1991–1994, energy data is less detailed for all industrial source categories than in both the preceding and following years, but it adequately covers all sectors and source categories. All emissions are specified by fuel type (solid, liquid and gaseous fossil fuels). Coal-derived gases (coke oven gas, blast furnace gas, etc.) are included in 'solid fuels' and refinery gases and residual chemical gases (as well as LPG, except for Transport) are included in 'liquid fuels'. The fuel category 'other fuels' is used to report emissions from fossil waste in waste incineration (included in 1A1a).

Since the Industrial processes source categories in the Netherlands often relate to only a few companies, it is generally not possible to report detailed and disaggregated data. Activity data is confidential and not reported when a source category comprises three (or fewer) companies.

10.4.1.4 Planned improvements

The Netherlands' National System was established by the end of 2005, in line with the requirements of the Kyoto Protocol and the EU Monitoring Mechanism, as a result of the implementation of a monitoring improvement programme (see Section 1.6). In 2007, the system was reviewed during the initial review. The review team concluded that the Netherlands' National System had been established in accordance with the guidelines for National Systems under article 5, section 1 of the Kyoto Protocol (decision 19/CMP.1) and that it met the requirements for the implementation of the general functions of a National System, as well the specific functions of inventory planning, inventory preparation and inventory management.

Monitoring improvement

The National System includes an annual evaluation and improvement process. The evaluation is based on experience in previous years and results of UN reviews, peer reviews and audits. Where needed, improvements are included in the annual update of the QA/QC programme (RVO.nl, 2014).

QA/QC programme
The QA/QC programme for this year (RVO.nl, 2014) continues the assessment of improvement options in the longer term based on the consequences of the 2006 IPCC Guidelines on reporting from 2015 onwards. Improvement actions for new methodologies and changes of EF will be performed in 2015.

The ERT recommended to further centralize the archiving of intermediate calculations by Task Forces. Since 2011, the RIVM database has held storage space where Task Forces can store the data required for their emissions calculations.

Finally, the improvement of uncertainty estimates will be continued in 2015.

10.4.2 KP-LULUCF inventory

No major improvements are foreseen.

Annex 1 Key categories

A1.1 Introduction

As explained in the IPCC Good Practice Guidance (IPCC, 2001), 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 7.1 in chapter 7 of the Good Practice Guidance. As suggested in the guidance, carbon dioxide (CO_2) emissions from stationary combustion (1A1, 1A2 and 1A4) are aggregated by fuel type. CO_2, methane (CH_4) and nitrous oxide (N_2O) emissions from Mobile combustion: road vehicles (1A3) are assessed separately. CH_4 and N_2O emissions from aircraft and ships are relatively small (about 1–2 Gg CO_2 equivalent). Other mobile sources are not assessed separately by gas. Fugitive emissions from oil and gas operations (1B) are important sources of GHG emissions in the Netherlands. The most important gas/source combinations in this category are separately assessed. Emissions in other IPCC sectors are disaggregated, as suggested by the IPCC.

The IPCC Tier 1 method consists of ranking the list of source category/gas combinations according to their contribution to national total annual emissions and to the national total trend. The categories at the top of the tables in this annex are the largest key sources, of which the total adds up to 95% of the national total (excluding LULUCF): 34 sources for annual level assessment (emissions in 2013) and 34 sources for the trend assessment out of a total of 73 sources. The two lists can be combined to obtain an overview of sources that meet one or both of these criteria.

The IPCC Tier 2 method for the identification of key sources requires the incorporation of the uncertainty in each of these sources before ordering the list of shares. This has been carried out using the uncertainty estimates presented in Annex 2 (for details of the Tier 1 uncertainty analysis see Olivier et al., 2009). Here, a total contribution of up to 90% to the overall uncertainty has been used to avoid the inclusion of too many small sources. The results of the Tier 1 and Tier 2 level and trend assessments are summarized in Table A1.1 and show a total of 45 key sources (excluding LULUCF). As expected, the Tier 2 level and trend assessments increase the importance of highly uncertain sources. It can be concluded that in using the results of a Tier 2 key source assessment, eight sources are added to the list of 45 Tier 1 level and trend key sources (excluding LULUCF):

- 1A3 Mobile combustion: road vehicles: N_2O (Tier 2 trend);
- 1B2 Fugitive emisssions from oil and gas operations: natural gas CH_4 (Tier 2 level);

- 2B8 Petrochemical and carbon black production: CO_2 (Tier 2 level);
- 2 Other industrial: CH_4 (Tier 2 level);
- 3A8 Enteric fermentation: swine: CH_4 (Tier 2 level);
- 3B Manure management N_2O (Tier 2 level);
- 3B4 Manure management: poultry: CH_4 (Tier 2 trend);
- 3G Liming: CO_2 (Tier 2 trend).

The share of these sources in the national annual total becomes larger when taking their uncertainty (50%–100%) into account (Table A1.4). When we include the most important Land use, land use change and forestry (LULUCF) emission sinks and sources in the Tier 1 and Tier 2 key source calculations, this results in four additional key sources, giving an overall total of 49 key sources; see also Table A1.2. In this report, the key source assessment is based on emissions figures from theCRF for the year 2013 submitted to the European Union (EU) in October 2015.

Please note that the key source analysis for the base year (1990 for direct GHGs and 1995 for F-gases) is included in the CRF Reporter and not in this annex.

Table A1.1 Key source list identified by the Tier 1 level and trend assessments for 2013 emissions (excluding LULUCF sources)

IPCC	Source category	Gas	Key source?	Tier 1 level recent year without LULUCF	Tier 1 trend without LULUCF	Tier 2 level recent year without LULUCF	Tier 2 trend without LULUCF
	ENERGY SECTOR						
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	Key(L1,T)	1	1	0	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	Key(L,T)	1	1	1	1
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	Key(L1,T1	1	1	0	0
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste incineration	CO2	Key(L1,T)	1	1	0	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	Key(L,T)	1	1	1	1
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	Key(L1,T1	1	1	0	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	Non key	0	0	0	0
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	Key(L,T)	1	1	1	1
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	Key(L,)	1	0	1	0
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	Key(L,T)	1	1	1	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	Key(L,T1)	1	1	1	0
1A3b	Mobile combustion: road vehicles: gasoline	CO2	Key(L,T1)	1	1	1	0
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	Key(L,T)	1	1	1	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	Key(L1,T)	1	1	0	1
1A3	Mobile combustion: domestic navigation	CO2	Key(L,T)	1	1	1	1
1A3	Mobile combustion: domestic aviation	CO2	Non key	0	0	0	0
1A3	Mobile combustion: other (railways)	CO2	Non key	0	0	0	0
1A3	Mobile combustion: other (non-road)	CH4	Non key	0	0	0	0
1A3	Mobile combustion: other (non-road)	N2O	Non key	0	0	0	0
1A3	Mobile combustion: road vehicles	CH4	Non key	0	0	0	0
1A3	Mobile combustion: road vehicles	N2O	Key(,T2)	0	0	0	1
1A4	Stationary combustion : Other Sectors, solids	CO2	Non key	0	0	0	0
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	Key(L,T)	1	1	1	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	Key(L,T)	1	1	1	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	Key(L,T1)	1	1	1	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	Key(L,T)	1	1	1	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	Key(L1,T)	1	1	0	1

1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	Key(L1,T)	1	1	0	1
1A5	Military use of fuels (1A5 Other)	CO2	Non key	0	0	0	0
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	Key(L,T)	1	1	1	1
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	Non key	0	0	0	0
1B1b	CO2 from coke production	CO2	Non key	0	0	0	0
1B2	Fugitive emissions venting/flaring: CO2	CO2	Key(L,T)	1	1	1	1
1B2	Fugitive emissions venting/flaring	CH4	Key(,T)	0	1	0	1
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	Key(L2,)	0	0	1	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	Non key	0	0	0	0
	INDUSTRIAL PROCESSES AND PRODUCT USE						
2A1	Cement production	CO2	Non key	0	0	0	0
2A3	Glass production	CO2	Non key	0	0	0	0
2A4	Other process uses of carbonates	CO2	Key(L,)	1	0	1	0
2B1	Ammonia production	CO2	Key(L,T1)	1	1	1	0
2B2	Nitric acid production	N2O	Key(,T)	0	1	0	1
2B5	Caprolactam production	N2O	Key(L,T2)	1	0	1	1
2B8	Petrochemical and carbon black production	CO2	Key(L2,)	0	0	1	0
2C1	Iron and steel production (carbon inputs)	CO2	Key(L1,T1)	1	1	0	0
2C3	CO2 from aluminium production	CO2	Non key	0	0	0	0
2C3	PFC from aluminium production	PFC	Key(,T)	0	1	0	1
2G	SF6 emissions from SF6 use	SF6	Non key	0	0	0	0
2F	Product uses as substitutes for ODS	HFC	Key(L,T)	1	1	1	1
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	Key(,T)	0	1	0	1
2B1	HFC by-product emissions from HFC manufacture	HFC	Non key	0	0	0	0
2E	Electronic Industry	PFC	Non key	0	0	0	0
2	Other industrial: direct CO2	CO2	Non key	0	0	0	0
2	Other industrial: CH4	CH4	Key(L2,)	0	0	1	0
2	Other industrial: N2O	N2O	Non key	0	0	0	0
2D	Indirect CO2 from solvents/product use	CO2	Non key	0	0	0	0
	AGRICULTURE						
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	Key(L,T1)	1	1	1	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	Non key	0	0	0	0
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	Key(L,T1)	1	1	1	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	Key(L2,)	0	0	1	0
3A	CH4 emissions from enteric fermentation: other	CH4	Non key	0	0	0	0
3B	Emissions from manure management	N2O	Key(L2,)	0	0	1	0
3B1	Emissions from manure management : cattle	CH4	Key(L,T)	1	1	1	1
3B3	Emissions from manure management : swine	CH4	Key(L,T)	1	1	1	1
3B4	Emissions from manure management : poultry	CH4	Key(,T2)	0	0	0	1
3B	Emissions from manure management : other	CH4	Non key	0	0	0	0
3Da	Direct N2O emissions from agricultural soils	N2O	Key(L,T)	1	1	1	1
3Db	Indirect N2O Emissions from managed soils	N2O	Key(L,T)	1	1	1	1
3G	Liming	CO2	Key(,T2)	0	0	0	1
	WASTE						
5A	Solid waste disposal	CH4	Key(L,T)	1	1	1	1
5D	Wastewater treatment and discharge	CH4	Non key	0	0	0	0
5B	Emissions from wastewater handling	N2O	Non key	0	0	0	0
	OTHER						
	OTHER CH4	CH4	Non key	0	0	0	0
	OTHER N2O	N2O	Non key	0	0	0	0
	1) = 6D Other waste						
	2) = 4D animal production - waste dropped on soils + 3D Solvents						
			SUM	33	34	31	29

Table A1.2 Key source list identified by the Tier 1 level and trend assessments.
Level assessment for 2012 emissions (including LULUCF sources)

IPCC	Source category	Gas	Key source?	Tier 1 level recent year with LULUCF	Tier 1 trend with LULUCF	Tier 2 level recent year with LULUCF	Tier 2 trend with LULUCF
	ENERGY SECTOR						
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	Key(L1,T)	1	1	0	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	Key(L,T)	1	1	1	1
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	Key(L1,T1)	1	1	0	0
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste incineration	CO2	Key(L1,T)	1	1	0	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	Key(L,T)	1	1	1	1
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	Key(L1,T1)	1	1	0	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	Non key	0	0	0	0
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	Key(L,T)	1	1	1	1
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	Key(L,)	1	0	1	0
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	Key(L,T)	1	1	1	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	Key(L,T1)	1	1	1	0
1A3b	Mobile combustion: road vehicles: gasoline	CO2	Key(L,T1)	1	1	1	0
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	Key(L,T)	1	1	1	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	Key(L1,T)	1	1	0	1
1A3	Mobile combustion: domestic navigation	CO2	Key(L,T)	1	1	1	1
1A3	Mobile combustion: domestic aviation	CO2	Non key	0	0	0	0
1A3	Mobile combustion: other (railways)	CO2	Non key	0	0	0	0
1A3	Mobile combustion: other (non-road)	CH4	Non key	0	0	0	0
1A3	Mobile combustion: other (non-road)	N2O	Non key	0	0	0	0
1A3	Mobile combustion: road vehicles	CH4	Non key	0	0	0	0
1A3	Mobile combustion: road vehicles	N2O	Key(,T2)	0	0	0	1
1A4	Stationary combustion : Other Sectors, solids	CO2	Non key	0	0	0	0
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	Key(L,T)	1	1	1	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	Key(L,T)	1	1	1	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	Key(L,T1)	1	1	1	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	Key(L,T)	1	1	1	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	Key(L1,T)	1	1	0	1
1A5	Military use of fuels (1A5 Other)	CO2	Non key	0	0	0	0
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	Key(L,T)	1	1	1	1
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	Non key	0	0	0	0
1B1b	CO2 from coke production	CO2	Non key	0	0	0	0
1B2	Fugitive emissions venting/flaring: CO2	CO2	Key(L,T)	1	1	1	1
1B2	Fugitive emissions venting/flaring	CH4	Key(,T)	0	1	0	1
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	Key(L2,)	0	0	1	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	Non key	0	0	0	0
	INDUSTRIAL PROCESSES AND PRODUCT USE						
2A1	Cement production	CO2	Non key	0	0	0	0
2A3	Glass production	CO2	Non key	0	0	0	0
2A4	Other process uses of carbonates	CO2	Key(L,)	1	0	1	0
2B1	Ammonia production	CO2	Key(L,T1)	1	1	1	0
2B2	Nitric acid production	N2O	Key(,T)	0	1	0	1
2B5	Caprolactam production	N2O	Key(L,T2)	1	1	1	1
2B8	Petrochemical and carbon black production	CO2	Key(L2,)	0	0	1	0
2C1	Iron and steel production (carbon inputs)	CO2	Key(L1,T1)	1	1	0	0
2C3	CO2 from aluminium production	CO2	Non key	0	0	0	0
2C3	PFC from aluminium production	PFC	Key(,T)	0	1	0	1
2G	SF6 emissions from SF6 use	SF6	Non key	0	0	0	0
2F	Product uses as substitutes for ODS	HFC	Key(L,T)	1	1	1	1
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	Key(,T)	0	1	0	1
2B1	HFC by-product emissions from HFC manufacture	HFC	Non key	0	0	0	0
2E	Electronic Industry	PFC	Non key	0	0	0	0
2	Other industrial: direct CO2	CO2	Non key	0	0	0	0
2	Other industrial: CH4	CH4	Key(L2,)	0	0	1	0
2	Other industrial: N2O	N2O	Non key	0	0	0	0
2D	Indirect CO2 from solvents/product use	CO2	Non key	0	0	0	0
	AGRICULTURE						

	AGRICULTURE						
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	Key(L,T1)	1	1	1	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	Non key	0	0	0	0
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	Key(L,T1)	1	1	1	1
3A8	CH4 emissions from enteric fermentation: swine	CH4	Key(L2,)	0	0	1	0
3A	CH4 emissions from enteric fermentation: other	CH4	Non key	0	0	0	0
3B	Emissions from manure management	N2O	Key(L2,)	0	0	1	0
3B1	Emissions from manure management : cattle	CH4	Key(L,T)	1	1	1	1
3B3	Emissions from manure management : swine	CH4	Key(L,T)	1	1	1	1
3B4	Emissions from manure management : poultry	CH4	Key(,T2)	0	1	0	1
3B	Emissions from manure management : other	CH4	Non key	0	0	0	0
3Da	Direct N2O emissions from agricultural soils	N2O	Key(L,T)	1	1	1	1
3Db	Indirect N2O Emissions from managed soils	N2O	Key(L,T)	1	1	1	1
3G	Liming	CO2	Key(,T2)	0	0	0	1
	LAND USE, LAND-USE CHANGE AND FORESTRY						
4A	4A. Forest Land	CO2	Non key	0	0	0	0
4B	4B. Cropland	N2O	Non key	0	0	0	0
4B	4B. Cropland	CO2	Non key	0	0	0	0
4C	4C. Grassland	CO2	Key(,T2)	0	0	0	1
4C	4C. Grassland	N2O	Non key	0	0	0	0
4G	4G. Harvested wood products	CO2	Non key	0	0	0	0
4E	4E. Settlements	CO2	Key(,T)	0	1	0	1
4F	4F. Other Land	CO2	Non key	0	0	0	0
4H	4H. Other	CO2	Non key	0	0	0	0
	WASTE						
5A	Solid waste disposal	CH4	Key(L,T)	1	1	1	1
5D	Wastewater treatment and discharge	CH4	Non key	0	0	0	0
5B	Emissions from wastewater handling	N2O	Non key	0	0	0	0
	OTHER						
	OTHER CH4	CH4	Non key	0	0	0	0
	OTHER N2O	N2O	Non key	0	0	0	0
	1) = 6D Other waste						
	2) = 4D animal production - waste dropped on soils + 3D Solvents						
			SUM	33	37	31	32

A1.2 Changes in key sources compared with previous submission

Due to the use of emissions data for 2013 and new uncertainty data on the treatment and disposal of waste, the following changes in key sources have taken place in comparison with the previous NIR:

- 1B2 Fugitive emissions from oil and gas operations: natural gas: CH_4: now key (Tier 2, Level)
- 2A4 Other process uses of carbonates: CO_2: now key (Tier 1, Level);
- 2 Other industrial: CH_4: now key (Tier 2, Level).

A1.3 Tier 1 key source and uncertainty assessment

In Tables A1.3a and A1.3b, the source ranking is done according to the contribution to the 2013 annual emissions total and in Tables A1.4a and A1.4b to the base-year-to-2013 trend. This results in 33 level key sources and 34 trend key sources. Inclusion of LULUCF sources in the analysis adds two Tier 1 level and trend key sources (see Table A1.2).

Table A1.3a Source ranking using IPCC Tier 1 level assessment 2013 excluding LULUCF (Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq last year	Share	Cum. Share	Key ?
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	26310	13%	13%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	18752	10%	23%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18736	10%	33%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	18147	9%	42%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	13094	7%	49%	1
1A3b	Mobile combustion: road vehicles: gasoline	CO2	11966	6%	55%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	11545	6%	61%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	7098	4%	64%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	6763	3%	68%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	5878	3%	71%	1
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	4975	3%	73%	1
3Da	Direct N2O emissions from agricultural soils	N2O	4518	2%	75%	1
2B1	Ammonia production	CO2	3760	2%	77%	1
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	3398	2%	79%	1
5A	Solid waste disposal	CH4	3383	2%	81%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	3040	2%	82%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste incineration	CO2	2795	1%	84%	1
1A3	Mobile combustion: other (non-road)	CO2	2622	1%	85%	1
3B1	Emissions from manure management : cattle	CH4	2138	1%	86%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	2128	1%	87%	1
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2090	1%	88%	1
3B3	Emissions from manure management : swine	CH4	2086	1%	89%	1
2F	Product uses as substitutes for ODS	HFC	2015	1%	91%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	1767	1%	91%	1
1A3	Mobile combustion: domestic navigation	CO2	1119	1%	92%	1
2C1	Iron and steel production (carbon inputs)	CO2	1083	1%	93%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	1060	1%	93%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	1027	1%	94%	1
2B5	Caprolactam production	N2O	949	0%	94%	1
3Db	Indirect N2O Emissions from managed soils	N2O	800	0%	95%	1
2A4	Other process uses of carbonates	CO2	719	0%	95%	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	700	0%	95%	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	699	0%	96%	1
2B8	Petrochemical and carbon black production	CO2	650	0%	96%	1
1B1b	CO2 from coke production	CO2	633	0%	96%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	594	0%	97%	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	579	0%	97%	0
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	485	0%	97%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	458	0%	97%	0
2	Other industrial: CH4	CH4	452	0%	98%	0
3A	CH4 emissions from enteric fermentation: other	CH4	452	0%	98%	0
3B	Emissions from manure management	N2O	419	0%	98%	0
2	Other industrial: direct CO2	CO2	399	0%	98%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	339	0%	98%	0
1B2	Fugitive emissions venting/flaring	CH4	311	0%	99%	0
2A1	Cement production	CO2	274	0%	99%	0
2B2	Nitric acid production	N2O	274	0%	99%	0
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	238	0%	99%	0
1A5	Military use of fuels (1A5 Other)	CO2	234	0%	99%	0
1A3	Mobile combustion: road vehicles	N2O	209	0%	99%	0
5D	Wastewater treatment and discharge	CH4	205	0%	99%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	164	0%	99%	0
2G	SF6 emissions from SF6 use	SF6	132	0%	99%	0
2C3	CO2 from aluminium production	CO2	125	0%	99%	0
2E	Electronic Industry	PFC	116	0%	100%	0
2	Other industrial: N2O	N2O	96	0%	100%	0
2A3	Glass production	CO2	84	0%	100%	0
	OTHER N2O	N2O	83	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	83	0%	100%	0
	OTHER CH4	CH4	77	0%	100%	0
3G	Liming	CO2	70	0%	100%	0
5B	Emissions from wastewater handling	N2O	69	0%	100%	0
3B4	Emissions from manure management : poultry	CH4	67	0%	100%	0

3B4	Emissions from manure management : poultry	CH4	67	0%	100%	0
1A3	Mobile combustion: road vehicles	CH4	60	0%	100%	0
1A3	Mobile combustion: other (non-road)	N2O	43	0%	100%	0
3B	Emissions from manure management : other	CH4	41	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	40	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	40	0%	100%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	23	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	11	0%	100%	0
2C3	PFC from aluminium production	PFC	11	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	7	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0%	100%	0
			195807			34

Table A1.3b Source ranking using IPCC Tier 1 level assessment 2013 including LULUCF (amounts in Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq last year abs	Share	Cum. Share	Key ?
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	26310	13%	13%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	18752	9%	22%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18736	9%	31%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	18147	9%	40%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	13094	6%	46%	1
1A3b	Mobile combustion: road vehicles: gasoline	CO2	11966	6%	52%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	11545	6%	57%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	7098	3%	61%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	6763	3%	64%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	5878	3%	67%	1
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	4975	2%	69%	1
3Da	Direct N2O emissions from agricultural soils	N2O	4518	2%	71%	1
4C	4C. Grassland	CO2	4408	2%	73%	1
2B1	Ammonia production	CO2	3760	2%	75%	1
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	3398	2%	77%	1
5A	Solid waste disposal	CH4	3383	2%	78%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	3040	1%	80%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste incineration	CO2	2795	1%	81%	1
4A	4A. Forest Land	CO2	-2675	1%	83%	1
1A3	Mobile combustion: other (non-road)	CO2	2622	1%	84%	1
4B	4B. Cropland	CO2	2536	1%	85%	1
3B1	Emissions from manure management : cattle	CH4	2138	1%	86%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	2128	1%	87%	1
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2090	1%	88%	1
3B3	Emissions from manure management : swine	CH4	2086	1%	89%	1
2F	Product uses as substitutes for ODS	HFC	2015	1%	90%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	1767	1%	91%	1
4E	4E. Settlements	CO2	1585	1%	92%	1
1A3	Mobile combustion: domestic navigation	CO2	1119	1%	92%	1
2C1	Iron and steel production (carbon inputs)	CO2	1083	1%	93%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	1060	1%	93%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	1027	0%	94%	1
2B5	Caprolactam production	N2O	949	0%	94%	1
3Db	Indirect N2O Emissions from managed soils	N2O	800	0%	95%	1
2A4	Other process uses of carbonates	CO2	719	0%	95%	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	700	0%	95%	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	699	0%	96%	1
2B8	Petrochemical and carbon black production	CO2	650	0%	96%	1
1B1b	CO2 from coke production	CO2	633	0%	96%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	594	0%	97%	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	579	0%	97%	0
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	485	0%	97%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	458	0%	97%	0
2	Other industrial: CH4	CH4	452	0%	98%	0

2	Other industrial: CH4	CH4	452	0%	98%	0
3A	CH4 emissions from enteric fermentation: other	CH4	452	0%	98%	0
3B	Emissions from manure management	N2O	419	0%	98%	0
2	Other industrial: direct CO2	CO2	399	0%	98%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	339	0%	98%	0
1B2	Fugitive emissions venting/flaring	CH4	311	0%	98%	0
2A1	Cement production	CO2	274	0%	99%	0
2B2	Nitric acid production	N2O	274	0%	99%	0
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	238	0%	99%	0
1A5	Military use of fuels (1A5 Other)	CO2	234	0%	99%	0
1A3	Mobile combustion: road vehicles	N2O	209	0%	99%	0
5D	Wastewater treatment and discharge	CH4	205	0%	99%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	164	0%	99%	0
2G	SF6 emissions from SF6 use	SF6	132	0%	99%	0
2C3	CO2 from aluminium production	CO2	125	0%	99%	0
4F	4F. Other Land	CO2	117	0%	99%	0
2E	Electronic Industry	PFC	116	0%	99%	0
4G	4G. Harvested wood products	CO2	106	0%	99%	0
2	Other industrial: N2O	N2O	96	0%	100%	0
2A3	Glass production	CO2	84	0%	100%	0
	OTHER N2O	N2O	83	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	83	0%	100%	0
	OTHER CH4	CH4	77	0%	100%	0
3G	Liming	CO2	70	0%	100%	0
5B	Emissions from wastewater handling	N2O	69	0%	100%	0
4B	4B. Cropland	N2O	68	0%	100%	0
3B4	Emissions from manure management : poultry	CH4	67	0%	100%	0
4D	4.D Wetlands	CO2	66	0%	100%	0
1A3	Mobile combustion: road vehicles	CH4	60	0%	100%	0
1A3	Mobile combustion: other (non-road)	N2O	43	0%	100%	0
3B	Emissions from manure management : other	CH4	41	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	40	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	40	0%	100%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	23	0%	100%	0
4H	4H. Other	CO2	21	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	11	0%	100%	0
2C3	PFC from aluminium production	PFC	11	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	7	0%	100%	0
4C	4C. Grassland	N2O	5	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0%	100%	0
			202044			38

Table A1.4a Source ranking using IPCC Tier 1 trend assessment 2013 excluding LULUCF (Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq base year	CO2-eq last year	level assessment last year	trend assessment	% Contr. to trend	Cumu-lative	Key ?
5A	Solid waste disposal	CH4	14299	3383	2%	5%	11%	11%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	11818	18752	10%	5%	10%	21%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	13348	18147	9%	4%	8%	29%	1
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	7285	238	0%	4%	8%	36%	1
2B2	Nitric acid production	N2O	6085	274	0%	3%	6%	43%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	7632	11545	6%	3%	6%	48%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	19020	13094	7%	2%	5%	53%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	25776	26310	13%	2%	4%	57%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	10008	5878	3%	2%	4%	61%	1
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	1042	3398	2%	1%	3%	64%	1
1A3b	Mobile combustion: road vehicles: gasoline	CO2	10806	11966	6%	1%	3%	67%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels:	CO2	601	2795	1%	1%	3%	69%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18696	18736	10%	1%	3%	72%	1
3Da	Direct N2O emissions from agricultural soils	N2O	7479	4518	2%	1%	3%	75%	1
2C3	PFC from aluminium production	PFC	2230	11	0%	1%	2%	77%	1

2C3	PFC from aluminium production	PFC	2230	11	0%	1%	2%	77%	1
2F	Product uses as substitutes for ODS	HFC	280	2015	1%	1%	2%	79%	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	2653	700	0%	1%	2%	81%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	683	1767	1%	1%	1%	83%	1
1B2	Fugitive emissions venting/flaring	CH4	1495	311	0%	1%	1%	84%	1
3Db	Indirect N2O Emissions from managed soils	N2O	2039	800	0%	1%	1%	85%	1
3B3	Emissions from manure management : swine	CH4	3489	2086	1%	1%	1%	86%	1
2C1	Iron and steel production (carbon inputs)	CO2	2266	1083	1%	1%	1%	87%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	4401	3040	2%	0%	1%	88%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liqu	CO2	1621	579	0%	0%	1%	89%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	207	1027	1%	0%	1%	90%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	1526	2128	1%	0%	1%	91%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gase	CO2	7330	7098	4%	0%	1%	92%	1
3B1	Emissions from manure management : cattle	CH4	1834	2138	1%	0%	1%	93%	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	1356	699	0%	0%	1%	93%	1
1A3	Mobile combustion: domestic navigation	CO2	739	1119	1%	0%	1%	94%	1
2B1	Ammonia production	CO2	3730	3760	2%	0%	1%	94%	1
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2802	2090	1%	0%	0%	95%	1
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	5179	4975	3%	0%	0%	95%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	775	1060	1%	0%	0%	96%	1
3B4	Emissions from manure management : poultry	CH4	464	67	0%	0%	0%	96%	0
1A3	Mobile combustion: other (non-road)	CO2	2622	2622	1%	0%	0%	97%	0
2B5	Caprolactam production	N2O	737	949	0%	0%	0%	97%	0
1B1b	CO2 from coke production	CO2	403	633	0%	0%	0%	97%	0
2C3	CO2 from aluminium production	CO2	408	125	0%	0%	0%	98%	0
1A5	Military use of fuels (1A5 Other)	CO2	447	234	0%	0%	0%	98%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	189	23	0%	0%	0%	98%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	224	339	0%	0%	0%	98%	0
1A3	Mobile combustion: road vehicles	N2O	96	209	0%	0%	0%	98%	0
2G	SF6 emissions from SF6 use	SF6	274	132	0%	0%	0%	98%	0
2A4	Other process uses of carbonates	CO2	690	719	0%	0%	0%	99%	0
1A3	Mobile combustion: road vehicles	CH4	185	60	0%	0%	0%	99%	0
2	Other industrial: N2O	N2O	225	96	0%	0%	0%	99%	0
2A1	Cement production	CO2	416	274	0%	0%	0%	99%	0
3G	Liming	CO2	183	70	0%	0%	0%	99%	0
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	445	485	0%	0%	0%	99%	0
	OTHER N2O	N2O	7	83	0%	0%	0%	99%	0
2E	Electronic Industry	PFC	47	116	0%	0%	0%	99%	0
5D	Wastewater treatment and discharge	CH4	306	205	0%	0%	0%	99%	0
2	Other industrial: CH4	CH4	437	452	0%	0%	0%	99%	0
	OTHER CH4	CH4	14	77	0%	0%	0%	100%	0
5B	Emissions from wastewater handling	N2O	149	69	0%	0%	0%	100%	0
3B	Emissions from manure management	N2O	530	419	0%	0%	0%	100%	0
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	7586	6763	3%	0%	0%	100%	0
2A3	Glass production	CO2	142	84	0%	0%	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	83	40	0%	0%	0%	100%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& sol	CO2	634	594	0%	0%	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	13	40	0%	0%	0%	100%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	210	164	0%	0%	0%	100%	0
2B8	Petrochemical and carbon black production	CO2	759	650	0%	0%	0%	100%	0
3B	Emissions from manure management : other	CH4	34	41	0%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	N2O	40	43	0%	0%	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	20	11	0%	0%	0%	100%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	522	458	0%	0%	0%	100%	0
3A	CH4 emissions from enteric fermentation: other	CH4	514	452	0%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	5	7	0%	0%	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	91	83	0%	0%	0%	100%	0
2	Other industrial: direct CO2	CO2	450	399	0%	0%	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0	0%	0%	0%	100%	0
			221130	195807					34

Table A1.4b Source ranking using IPCC Tier 1 trend assessment 2013, including LULUCF (Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq base year abs	CO2-eq last year abs	level assessment last year	trend assessment	% Contr. to trend	Cumu-lative	Key ?
5A	Solid waste disposal	CH4	14299	3383	2%	5%	11%	11%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	11818	18752	9%	4%	9%	20%	1
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	7285	238	0%	3%	7%	28%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	13348	18147	9%	3%	7%	35%	1
2B2	Nitric acid production	N2O	6085	274	0%	3%	6%	41%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	7632	11545	6%	3%	5%	46%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	19020	13094	6%	2%	5%	51%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	25776	26310	13%	2%	4%	55%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	10008	5878	3%	2%	4%	58%	1
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	1042	3398	2%	1%	3%	61%	1
1A3b	Mobile combustion: road vehicles: gasoline	CO2	10806	11966	6%	1%	3%	64%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste incineration	CO2	601	2795	1%	1%	3%	66%	1
3Da	Direct N2O emissions from agricultural soils	N2O	7479	4518	2%	1%	3%	69%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18696	18736	9%	1%	2%	71%	1
2C3	PFC from aluminium production	PFC	2230	11	0%	1%	2%	73%	1
2F	Product uses as substitutes for ODS	HFC	280	2015	1%	1%	2%	76%	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	2653	700	0%	1%	2%	77%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	683	1767	1%	1%	1%	79%	1
4B	4B. Cropland	CO2	1635	2536	1%	1%	1%	80%	1
3B3	Emissions from manure management : swine	CH4	3489	2086	1%	1%	1%	81%	1
1B2	Fugitive emissions venting/flaring	CH4	1495	311	0%	1%	1%	82%	1
3Db	Indirect N2O Emissions from managed soils	N2O	2039	800	0%	1%	1%	84%	1
4A	4A. Forest Land	CO2	-1890	-2675	1%	1%	1%	85%	1
2C1	Iron and steel production (carbon inputs)	CO2	2266	1083	1%	1%	1%	86%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	4401	3040	1%	0%	1%	87%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	1621	579	0%	0%	1%	88%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	207	1027	0%	0%	1%	89%	1
4E	4E. Settlements	CO2	888	1585	1%	0%	1%	90%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	1526	2128	1%	0%	1%	91%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	7330	7098	3%	0%	1%	91%	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	1356	699	0%	0%	1%	92%	1
3B1	Emissions from manure management : cattle	CH4	1834	2138	1%	0%	1%	92%	1
4C	4C. Grassland	CO2	5452	4408	2%	0%	1%	93%	1
1A3	Mobile combustion: domestic navigation	CO2	739	1119	1%	0%	1%	94%	1
2B1	Ammonia production	CO2	3730	3760	2%	0%	0%	94%	1
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2802	2090	1%	0%	0%	95%	1
4G	4G. Harvested wood products	CO2	-533	106	0%	0%	0%	95%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	775	1060	1%	0%	0%	95%	1
3B4	Emissions from manure management : poultry	CH4	464	67	0%	0%	0%	96%	1
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	5179	4975	2%	0%	0%	96%	0
2B5	Caprolactam production	N2O	737	949	0%	0%	0%	97%	0
1A3	Mobile combustion: other (non-road)	CO2	2622	2622	1%	0%	0%	97%	0
1B1b	CO2 from coke production	CO2	403	633	0%	0%	0%	97%	0
2C3	CO2 from aluminium production	CO2	408	125	0%	0%	0%	97%	0
1A5	Military use of fuels (1A5 Other)	CO2	447	234	0%	0%	0%	98%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	189	23	0%	0%	0%	98%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	224	339	0%	0%	0%	98%	0
1A3	Mobile combustion: road vehicles	N2O	96	209	0%	0%	0%	98%	0
2G	SF6 emissions from SF6 use	SF6	274	132	0%	0%	0%	98%	0
2	Other industrial: N2O	N2O	225	96	0%	0%	0%	98%	0
1A3	Mobile combustion: road vehicles	CH4	185	60	0%	0%	0%	98%	0
2A4	Other process uses of carbonates	CO2	690	719	0%	0%	0%	99%	0
2A1	Cement production	CO2	416	274	0%	0%	0%	99%	0
3G	Liming	CO2	183	70	0%	0%	0%	99%	0
4F	4F. Other Land	CO2	26	117	0%	0%	0%	99%	0
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	445	485	0%	0%	0%	99%	0
	OTHER N2O	N2O	7	83	0%	0%	0%	99%	0
2E	Electronic Industry	PFC	47	116	0%	0%	0%	99%	0
5D	Wastewater treatment and discharge	CH4	306	205	0%	0%	0%	99%	0
4B	4B. Cropland	N2O	3	68	0%	0%	0%	99%	0
5B	Emissions from wastewater handling	N2O	149	69	0%	0%	0%	99%	0
	OTHER CH4	CH4	14	77	0%	0%	0%	100%	0
2	Other industrial: CH4	CH4	437	452	0%	0%	0%	100%	0
3B	Emissions from manure management	N2O	530	419	0%	0%	0%	100%	0
2A3	Glass production	CO2	142	84	0%	0%	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	83	40	0%	0%	0%	100%	0
2B8	Petrochemical and carbon black production	CO2	759	650	0%	0%	0%	100%	0

2B8	Petrochemical and carbon black production	CO2	759	650	0%	0%	0%	100%	0
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	7586	6763	3%	0%	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	13	40	0%	0%	0%	100%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	634	594	0%	0%	0%	100%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	210	164	0%	0%	0%	100%	0
4H	4H. Other	CO2	2	21	0%	0%	0%	100%	0
4D	4.D Wetlands	CO2	88	66	0%	0%	0%	100%	0
3B	Emissions from manure management : other	CH4	34	41	0%	0%	0%	100%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	522	458	0%	0%	0%	100%	0
3A	CH4 emissions from enteric fermentation: other	CH4	514	452	0%	0%	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	20	11	0%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	N2O	40	43	0%	0%	0%	100%	0
4C	4C. Grassland	N2O	0	5	0%	0%	0%	100%	0
2	Other industrial: direct CO2	CO2	450	399	0%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	5	7	0%	0%	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	91	83	0%	0%	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0	0%	0%	0%	100%	0
			226801	202044		46%			39

A1.4 Tier 2 key source assessment

Using the uncertainty estimate for each key source as a weighting factor (see Annex 2), the key source assessment was performed again. This is called the Tier 2 key source assessment. The results of this assessment are presented in Tables A1.5a and A1.5b for the contribution to the 2013 annual emissions total and in Tables A1.6a and A1.6b for the contribution to the trend. Comparison with the Tier 1 assessment presented in Tables A1.3a and A1.4a shows fewer level and trend key sources (31 and 29, respectively, instead of 33 and 34).
The inclusion of LULUCF sources in the analysis adds four CO_2 sources: 4A Forest land, 4B Cropland, 4C Grassland and 4E Settlements.

Table A1.5a Source ranking using IPCC Tier 2 level assessment 2013 excluding LULUCF (Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq last year	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U	Key ?
3Da	Direct N2O emissions from agricultural soils	N2O	4518	2%	61%	1%	10%	10%	1
3B1	Emissions from manure management : cattle	CH4	2138	1%	100%	1%	8%	18%	1
3B3	Emissions from manure management : swine	CH4	2086	1%	100%	1%	8%	25%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	6763	3%	25%	1%	6%	32%	1
3Db	Indirect N2O Emissions from managed soils	N2O	800	0%	206%	1%	6%	38%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	5878	3%	25%	1%	5%	43%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	11545	6%	10%	1%	4%	47%	1
2F	Product uses as substitutes for ODS	HFC	2015	1%	54%	1%	4%	51%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18736	10%	5%	0%	3%	55%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	1767	1%	50%	0%	3%	58%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	26310	13%	3%	0%	3%	61%	1
5A	Solid waste disposal	CH4	3383	2%	24%	0%	3%	64%	1
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	4975	3%	16%	0%	3%	67%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gase	CO2	7098	4%	10%	0%	3%	69%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	18752	10%	3%	0%	2%	71%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	1060	1%	50%	0%	2%	73%	1
2B8	Petrochemical and carbon black production	CO2	650	0%	71%	0%	2%	75%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	2128	1%	21%	0%	2%	76%	1
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2090	1%	21%	0%	2%	78%	1
3B	Emissions from manure management	N2O	419	0%	100%	0%	2%	79%	1
1A3	Mobile combustion: other (non-road)	CO2	2622	1%	15%	0%	1%	81%	1
2B1	Ammonia production	CO2	3760	2%	10%	0%	1%	82%	1
2A4	Other process uses of carbonates	CO2	719	0%	50%	0%	1%	83%	1

2A4	Other process uses of carbonates	CO2	719	0%	50%	0%	1%	83%	1
1A3b	Mobile combustion: road vehicles: gasoline	CO2	11966	6%	3%	0%	1%	85%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	3040	2%	10%	0%	1%	86%	1
2B5	Caprolactam production	N2O	949	0%	30%	0%	1%	87%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	13094	7%	2%	0%	1%	88%	1
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	485	0%	50%	0%	1%	89%	1
2	Other industrial: CH4	CH4	452	0%	51%	0%	1%	90%	1
3A8	CH4 emissions from enteric fermentation: swine	CH4	458	0%	50%	0%	1%	90%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	1027	1%	20%	0%	1%	91%	0
2	Other industrial: direct CO2	CO2	399	0%	50%	0%	1%	92%	0
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels:	CO2	2795	1%	7%	0%	1%	93%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	339	0%	50%	0%	1%	93%	0
1A3	Mobile combustion: road vehicles	N2O	209	0%	70%	0%	1%	94%	0
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	699	0%	20%	0%	1%	94%	0
3A	CH4 emissions from enteric fermentation: other	CH4	452	0%	30%	0%	0%	95%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& sol	CO2	594	0%	20%	0%	0%	95%	0
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	18147	9%	1%	0%	0%	95%	0
1B1b	CO2 from coke production	CO2	633	0%	15%	0%	0%	96%	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liqu	CO2	579	0%	15%	0%	0%	96%	0
1B2	Fugitive emissions venting/flaring	CH4	311	0%	25%	0%	0%	96%	0
5D	Wastewater treatment and discharge	CH4	205	0%	38%	0%	0%	97%	0
3G	Liming	CO2	70	0%	100%	0%	0%	97%	0
5B	Emissions from wastewater handling	N2O	69	0%	1.019804	0%	0%	97%	0
2	Other industrial: N2O	N2O	96	0%	71%	0%	0%	97%	0
3B4	Emissions from manure management : poultry	CH4	67	0%	100%	0%	0%	98%	0
2C1	Iron and steel production (carbon inputs)	CO2	1083	1%	6%	0%	0%	98%	0
1A3	Mobile combustion: domestic navigation	CO2	1119	1%	5%	0%	0%	98%	0
1A5	Military use of fuels (1A5 Other)	CO2	234	0%	20%	0%	0%	98%	0
2G	SF6 emissions from SF6 use	SF6	132	0%	34%	0%	0%	99%	0
3B	Emissions from manure management : other	CH4	41	0%	100%	0%	0%	99%	0
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	700	0%	5%	0%	0%	99%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	164	0%	21%	0%	0%	99%	0
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	238	0%	14%	0%	0%	99%	0
2A1	Cement production	CO2	274	0%	11%	0%	0%	99%	0
1A3	Mobile combustion: road vehicles	CH4	60	0%	50%	0%	0%	99%	0
1A3	Mobile combustion: other (non-road)	N2O	43	0%	70%	0%	0%	99%	0
2E	Electronic Industry	PFC	116	0%	25%	0%	0%	99%	0
2A3	Glass production	CO2	84	0%	25%	0%	0%	100%	0
2B2	Nitric acid production	N2O	274	0%	8%	0%	0%	100%	0
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	3398	2%	1%	0%	0%	100%	0
	OTHER N2O	N2O	83	0%	17%	0%	0%	100%	0
	OTHER CH4	CH4	77	0%	17%	0%	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	40	0%	30%	0%	0%	100%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	23	0%	51%	0%	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	40	0%	22%	0%	0%	100%	0
2C3	CO2 from aluminium production	CO2	125	0%	5%	0%	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	11	0%	54%	0%	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	83	0%	5%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	7	0%	50%	0%	0%	100%	0
2C3	PFC from aluminium production	PFC	11	0%	20%	0%	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0%	27%	0%	0%	100%	0
			195807			14%			30

Table A1.5b Source ranking using IPCC Tier 2 level assessment 2013 including LULUCF (Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq last year abs	Share	Uncertainty estimate	Level * Uncertainty	Share L*U	Cum. Share L*U	Key ?
3Da	Direct N2O emissions from agricultural soils	N2O	4518	2%	61%	1.3%	8%	8%	1
4C	4C. Grassland	CO2	4408	2%	56%	1.2%	7%	15%	1
3B1	Emissions from manure management : cattle	CH4	2138	1%	100%	1.0%	6%	21%	1
3B3	Emissions from manure management : swine	CH4	2086	1%	100%	1.0%	6%	28%	1
4A	4A. Forest Land	CO2	-2675	1%	67%	0.9%	5%	33%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	6763	3%	25%	0.8%	5%	38%	1
3Db	Indirect N2O Emissions from managed soils	N2O	800	0%	206%	0.8%	5%	43%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	5878	3%	25%	0.7%	4%	47%	1
4B	4B. Cropland	CO2	2536	1%	56%	0.7%	4%	51%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	11545	6%	10%	0.6%	3%	54%	1
2F	Product uses as substitutes for ODS	HFC	2015	1%	54%	0.5%	3%	58%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18736	9%	5%	0.5%	3%	60%	1
4E	4E. Settlements	CO2	1585	1%	56%	0.4%	3%	63%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	1767	1%	50%	0.4%	3%	65%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	26310	13%	3%	0.4%	2%	68%	1
5A	Solid waste disposal	CH4	3383	2%	24%	0.4%	2%	70%	1
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	4975	2%	16%	0.4%	2%	73%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	7098	3%	10%	0.3%	2%	75%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	18752	9%	3%	0.3%	2%	76%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	1060	1%	50%	0.3%	2%	78%	1
2B8	Petrochemical and carbon black production	CO2	650	0%	71%	0.2%	1%	79%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	2128	1%	21%	0.2%	1%	80%	1
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2090	1%	21%	0.2%	1%	82%	1
3B	Emissions from manure management	N2O	419	0%	100%	0.2%	1%	83%	1
1A3	Mobile combustion: other (non-road)	CO2	2622	1%	15%	0.2%	1%	84%	1
2B1	Ammonia production	CO2	3760	2%	10%	0.2%	1%	85%	1
2A4	Other process uses of carbonates	CO2	719	0%	50%	0.2%	1%	86%	1
1A3b	Mobile combustion: road vehicles: gasoline	CO2	11966	6%	3%	0.2%	1%	87%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	3040	1%	10%	0.1%	1%	88%	1
2B5	Caprolactam production	N2O	949	0%	30%	0.1%	1%	89%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	13094	6%	2%	0.1%	1%	90%	1
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	485	0%	50%	0.1%	1%	90%	1
2	Other industrial: CH4	CH4	452	0%	51%	0.1%	1%	91%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	458	0%	50%	0.1%	1%	92%	0
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	1027	0%	20%	0.1%	1%	92%	0
2	Other industrial: direct CO2	CO2	399	0%	50%	0.1%	1%	93%	0
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste	CO2	2795	1%	7%	0.1%	1%	93%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	339	0%	50%	0.1%	0%	94%	0
1A3	Mobile combustion: road vehicles	N2O	209	0%	70%	0.1%	0%	94%	0
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	699	0%	20%	0.1%	0%	95%	0
3A	CH4 emissions from enteric fermentation: other	CH4	452	0%	30%	0.1%	0%	95%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	594	0%	20%	0.1%	0%	95%	0
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	18147	9%	1%	0.0%	0%	96%	0
1B1b	CO2 from coke production	CO2	633	0%	15%	0.0%	0%	96%	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	579	0%	15%	0.0%	0%	96%	0
1B2	Fugitive emissions venting/flaring	CH4	311	0%	25%	0.0%	0%	97%	0
5D	Wastewater treatment and discharge	CH4	205	0%	38%	0.0%	0%	97%	0
3G	Liming	CO2	70	0%	100%	0.0%	0%	97%	0
5B	Emissions from wastewater handling	N2O	69	0%	102%	0.0%	0%	97%	0
2	Other industrial: N2O	N2O	96	0%	71%	0.0%	0%	97%	0
3B4	Emissions from manure management : poultry	CH4	67	0%	100%	0.0%	0%	98%	0
4F	4F. Other Land	CO2	117	0%	56%	0.0%	0%	98%	0
2C1	Iron and steel production (carbon inputs)	CO2	1083	1%	6%	0.0%	0%	98%	0
1A3	Mobile combustion: domestic navigation	CO2	1119	1%	5%	0.0%	0%	98%	0
4G	4G. Harvested wood products	CO2	106	0%	56%	0.0%	0%	98%	0
1A5	Military use of fuels (1A5 Other)	CO2	234	0%	20%	0.0%	0%	98%	0
2G	SF6 emissions from SF6 use	SF6	132	0%	34%	0.0%	0%	99%	0
4B	4B. Cropland	N2O	68	0%	63%	0.0%	0%	99%	0
3B	Emissions from manure management : other	CH4	41	0%	100%	0.0%	0%	99%	0
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	700	0%	5%	0.0%	0%	99%	0
4D	4.D Wetlands	CO2	66	0%	56%	0.0%	0%	99%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	164	0%	21%	0.0%	0%	99%	0
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	238	0%	14%	0.0%	0%	99%	0

2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	238	0%	14%	0.0%	0%	99%	0
2A1	Cement production	CO2	274	0%	11%	0.0%	0%	99%	0
1A3	Mobile combustion: road vehicles	CH4	60	0%	50%	0.0%	0%	99%	0
1A3	Mobile combustion: other (non-road)	N2O	43	0%	70%	0.0%	0%	99%	0
2E	Electronic Industry	PFC	116	0%	25%	0.0%	0%	100%	0
2A3	Glass production	CO2	84	0%	25%	0.0%	0%	100%	0
2B2	Nitric acid production	N2O	274	0%	8%	0.0%	0%	100%	0
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	3398	2%	1%	0.0%	0%	100%	0
	OTHER N2O	N2O	83	0%	17%	0.0%	0%	100%	0
	OTHER CH4	CH4	77	0%	17%	0.0%	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	40	0%	30%	0.0%	0%	100%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	23	0%	51%	0.0%	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	40	0%	22%	0.0%	0%	100%	0
2C3	CO2 from aluminium production	CO2	125	0%	5%	0.0%	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	11	0%	54%	0.0%	0%	100%	0
4H	4H. Other	CO2	21	0%	25%	0.0%	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	83	0%	5%	0.0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	7	0%	50%	0.0%	0%	100%	0
4C	4C. Grassland	N2O	5	0%	56%	0.0%	0%	100%	0
2C3	PFC from aluminium production	PFC	11	0%	20%	0.0%	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0%	27%	0.0%	0%	100%	0
			202044	100%		16.5%			32

With respect to Tier 2 level key sources, and perhaps surprisingly, the Energy industries, with the highest share (30%) in the national total, are not number one when uncertainty estimates are included. As Table A1.5a shows, three large but quite uncertain sources (N_2O and CH_4) are now among the top five level key sources:

- 3Da (and 3Db) N_2O emissions from agricultural soils (managed soils);
- 3B3 CH_4 emissions from manure management cattle (swine).

The uncertainty in these emissions is estimated at 60% to 100%, an order of magnitude higher than the 4% uncertainty for CO_2 from the Energy industries.

Table A1.6a Source ranking using IPCC Tier 2 trend assessment excluding LULUCF (in Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq base year	CO2-eq last year	level assessment last year	trend assessment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative	Key ?
5A	Solid waste disposal	CH4	14299	3383	2%	5%	24%	1%	15%	15%	1
3Db	Indirect N2O Emissions from managed soils	N2O	2039	800	0%	1%	206%	1%	14%	28%	1
3Da	Direct N2O emissions from agricultural soils	N2O	7479	4518	2%	1%	61%	1%	8%	36%	1
3B3	Emissions from manure management : swine	CH4	3489	2086	1%	1%	100%	1%	7%	43%	1
2F	Product uses as substitutes for ODS	HFC	280	2015	1%	1%	54%	1%	6%	49%	1
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	7285	238	0%	4%	14%	1%	6%	55%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	10008	5878	3%	2%	25%	0%	5%	60%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	683	1767	1%	1%	50%	0%	4%	64%	1
3B1	Emissions from manure management : cattle	CH4	1834	2138	1%	0%	100%	0%	3%	67%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	7632	11545	6%	3%	10%	0%	3%	70%	1
2B2	Nitric acid production	N2O	6085	274	0%	3%	8%	0%	3%	73%	1
2C3	PFC from aluminium production	PFC	2230	11	0%	1%	20%	0%	3%	75%	1
3B4	Emissions from manure management : poultry	CH4	464	67	0%	0%	100%	0%	2%	78%	1
1B2	Fugitive emissions venting/flaring	CH4	1495	311	0%	1%	25%	0%	2%	79%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	11818	18752	10%	5%	3%	0%	2%	81%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	775	1060	1%	0%	50%	0%	1%	82%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	207	1027	1%	0%	20%	0%	1%	83%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	1526	2128	1%	0%	21%	0%	1%	84%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: waste incineration	CO2	601	2795	1%	1%	7%	0%	1%	85%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	1621	579	0%	0%	15%	0%	1%	86%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	25776	26310	13%	2%	3%	0%	1%	87%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18696	18736	10%	1%	5%	0%	1%	87%	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	1356	699	0%	0%	20%	0%	1%	88%	1
3G	Liming	CO2	183	70	0%	0%	100%	0%	1%	89%	1
2B5	Caprolactam production	N2O	737	949	0%	0%	30%	0%	1%	89%	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	2653	700	0%	1%	5%	0%	1%	90%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	4401	3040	2%	0%	10%	0%	1%	90%	1

1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	4401	3040	2%	0%	10%	0%	1%	90%	1
1A3	Mobile combustion: road vehicles	N2O	96	209	0%	0%	70%	0%	1%	91%	0
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2802	2090	1%	0%	21%	0%	1%	92%	0
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	19020	13094	7%	2%	2%	0%	0%	92%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	189	23	0%	0%	51%	0%	0%	93%	0
2	Other industrial: N2O	N2O	225	96	0%	0%	71%	0%	0%	93%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	224	339	0%	0%	50%	0%	0%	93%	0
1A3b	Mobile combustion: road vehicles: gasoline	CO2	10806	11966	6%	1%	3%	0%	0%	94%	0
5B	Emissions from wastewater handling	N2O	149	69	0%	0%	102%	0%	0%	94%	0
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	5179	4975	3%	0%	16%	0%	0%	95%	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	7330	7098	4%	0%	10%	0%	0%	95%	0
2A4	Other process uses of carbonates	CO2	690	719	0%	0%	50%	0%	0%	95%	0
2C1	Iron and steel production (carbon inputs)	CO2	2266	1083	1%	1%	6%	0%	0%	96%	0
1A3	Mobile combustion: road vehicles	CH4	185	60	0%	0%	50%	0%	0%	96%	0
3B	Emissions from manure management	N2O	530	419	0%	0%	100%	0%	0%	96%	0
2B1	Ammonia production	CO2	3730	3760	2%	0%	10%	0%	0%	97%	0
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	445	485	0%	0%	50%	0%	0%	97%	0
1A3	Mobile combustion: other (non-road)	CO2	2622	2622	1%	0%	15%	0%	0%	97%	0
1B1b	CO2 from coke production	CO2	403	633	0%	0%	15%	0%	0%	98%	0
2G	SF6 emissions from SF6 use	SF6	274	132	0%	0%	34%	0%	0%	98%	0
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	13348	18147	9%	4%	1%	0%	0%	98%	0
2	Other industrial: CH4	CH4	437	452	0%	0%	51%	0%	0%	98%	0
1A5	Military use of fuels (1A5 Other)	CO2	447	234	0%	0%	20%	0%	0%	99%	0
1A3	Mobile combustion: domestic navigation	CO2	739	1119	1%	0%	5%	0%	0%	99%	0
5D	Wastewater treatment and discharge	CH4	306	205	0%	0%	38%	0%	0%	99%	0
2E	Electronic Industry	PFC	47	116	0%	0%	25%	0%	0%	99%	0
2B8	Petrochemical and carbon black production	CO2	759	650	0%	0%	71%	0%	0%	99%	0
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	1042	3398	2%	1%	1%	0%	0%	99%	0
	OTHER N2O	N2O	7	83	0%	0%	17%	0%	0%	99%	0
2C3	CO2 from aluminium production	CO2	408	125	0%	0%	5%	0%	0%	99%	0
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	7586	6763	3%	0%	25%	0%	0%	99%	0
3B	Emissions from manure management : other	CH4	34	41	0%	0%	100%	0%	0%	100%	0
	OTHER CH4	CH4	14	77	0%	0%	17%	0%	0%	100%	0
2A3	Glass production	CO2	142	84	0%	0%	25%	0%	0%	100%	0
2A1	Cement production	CO2	416	274	0%	0%	11%	0%	0%	100%	0
1A3	Mobile combustion: domestic aviation	CO2	83	40	0%	0%	30%	0%	0%	100%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	634	594	0%	0%	20%	0%	0%	100%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	13	40	0%	0%	22%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	N2O	40	43	0%	0%	70%	0%	0%	100%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	210	164	0%	0%	21%	0%	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	20	11	0%	0%	54%	0%	0%	100%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	522	458	0%	0%	50%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	5	7	0%	0%	50%	0%	0%	100%	0
3A	CH4 emissions from enteric fermentation: other	CH4	514	452	0%	0%	30%	0%	0%	100%	0
2	Other industrial: direct CO2	CO2	450	399	0%	0%	50%	0%	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	91	83	0%	0%	5%	0%	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0	0%	0%	27%	0%	0%	100%	0
			221130	195807				9%			27

Table A1.6b Source ranking using IPCC Tier 2 trend assessment including LULUCF (Gg CO_2 eq)

IPCC	Category	Gas	CO2-eq base year abs	CO2-eq last year abs	level assessment last year	trend assessment	Uncertainty estimate	Trend * uncertainty	% Contr. to trend	Cumulative	Key ?
5A	Solid waste disposal	CH4	14299	3383	2%	5%	24%	1%	13%	13%	1
3Db	Indirect N2O Emissions from managed soils	N2O	2039	800	0%	1%	206%	1%	12%	25%	1
3Da	Direct N2O emissions from agricultural soils	N2O	7479	4518	2%	1%	61%	1%	7%	32%	1
3B3	Emissions from manure management : swine	CH4	3489	2086	1%	1%	100%	1%	6%	38%	1
2F	Product uses as substitutes for ODS	HFC	280	2015	1%	1%	54%	1%	5%	43%	1
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	7285	238	0%	3%	14%	0%	5%	48%	1
1A1b	Stationary combustion : Petroleum Refining: liquids	CO2	10008	5878	3%	2%	25%	0%	4%	53%	1
4A	4A. Forest Land	CO2	-1890	-2675	1%	1%	67%	0%	4%	56%	1
4B	4B. Cropland	CO2	1635	2536	1%	1%	56%	0%	3%	60%	1
1A	Emissions from combustion (excluding Transport): non-CO2	CH4	683	1767	1%	1%	50%	0%	3%	63%	1
3B1	Emissions from manure management : cattle	CH4	1834	2138	1%	0%	100%	0%	3%	66%	1
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO2	7632	11545	6%	3%	10%	0%	3%	69%	1
4E	4E. Settlements	CO2	888	1585	1%	0%	56%	0%	2%	71%	1
2B2	Nitric acid production	N2O	6085	274	0%	3%	8%	0%	2%	73%	1
2C3	PFC from aluminium production	PFC	2230	11	0%	1%	20%	0%	2%	76%	1
3B4	Emissions from manure management : poultry	CH4	464	67	0%	0%	100%	0%	2%	78%	1
4C	4C. Grassland	CO2	5452	4408	2%	0%	56%	0%	1%	79%	1
1B2	Fugitive emissions venting/flaring	CH4	1495	311	0%	1%	25%	0%	1%	81%	1
1A3b	Mobile combustion: road vehicles: diesel oil	CO2	11818	18752	9%	4%	3%	0%	1%	82%	1
4G	4G. Harvested wood products	CO2	-533	106	0%	0%	56%	0%	1%	83%	1
1B2	Fugitive emissions venting/flaring: CO2	CO2	775	1060	1%	0%	50%	0%	1%	84%	1
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO2	207	1027	0%	0%	20%	0%	1%	85%	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO2	1526	2128	1%	0%	21%	0%	1%	86%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: was	CO2	601	2795	1%	1%	7%	0%	1%	87%	1

1A1a	Stationary combustion : Public Electricity and Heat Production: other fuels: wa	CO2	601	2795	1%	1%	7%	0%	1%	87%	1
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO2	1621	579	0%	0%	15%	0%	1%	87%	1
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO2	1356	699	0%	0%	20%	0%	1%	88%	1
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO2	25776	26310	13%	2%	3%	0%	1%	89%	1
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO2	18696	18736	9%	1%	5%	0%	1%	89%	1
3G	Liming	CO2	183	70	0%	0%	100%	0%	1%	90%	1
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO2	4401	3040	1%	0%	10%	0%	1%	90%	1
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO2	2653	700	0%	1%	5%	0%	1%	91%	1
2B5	Caprolactam production	N2O	737	949	0%	0%	30%	0%	0%	91%	0
3A1	CH4 emissions from enteric fermentation: young cattle	CH4	2802	2090	1%	0%	21%	0%	0%	92%	0
1A3	Mobile combustion: road vehicles	N2O	96	209	0%	0%	70%	0%	0%	92%	0
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO2	19020	13094	6%	2%	2%	0%	0%	93%	0
2	Other industrial: N2O	N2O	225	96	0%	0%	71%	0%	0%	93%	0
1A4	Stationary combustion : Other Sectors, solids	CO2	189	23	0%	0%	51%	0%	0%	93%	0
1A	Emissions from combustion (excluding Transport): non-CO2	N2O	224	339	0%	0%	50%	0%	0%	94%	0
5B	Emissions from wastewater handling	N2O	149	69	0%	0%	102%	0%	0%	94%	0
1A3b	Mobile combustion: road vehicles: gasoline	CO2	10806	11966	6%	1%	3%	0%	0%	95%	0
3B	Emissions from manure management	N2O	530	419	0%	0%	100%	0%	0%	95%	0
2C1	Iron and steel production (carbon inputs)	CO2	2266	1083	1%	1%	6%	0%	0%	95%	0
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO2	7330	7098	3%	0%	10%	0%	0%	96%	0
3A1	CH4 emissions from enteric fermentation: mature dairy cattle	CH4	5179	4975	2%	0%	16%	0%	0%	96%	0
1A3	Mobile combustion: road vehicles	CH4	185	60	0%	0%	50%	0%	0%	96%	0
4F	4F. Other Land	CO2	26	117	0%	0%	56%	0%	0%	100%	0
2A4	Other process uses of carbonates	CO2	690	719	0%	0%	50%	0%	0%	96%	0
1B2	Fugitive emissions from oil and gas operations: Natural gas	CH4	445	485	0%	0%	50%	0%	0%	97%	0
2B1	Ammonia production	CO2	3730	3760	2%	0%	10%	0%	0%	97%	0
1A3	Mobile combustion: other (non-road)	CO2	2622	2622	1%	0%	15%	0%	0%	97%	0
1B1b	CO2 from coke production	CO2	403	633	0%	0%	15%	0%	0%	97%	0
4B	4B. Cropland	N2O	3	68	0%	0%	63%	0%	0%	98%	0
2G	SF6 emissions from SF6 use	SF6	274	132	0%	0%	34%	0%	0%	98%	0
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO2	13348	18147	9%	3%	1%	0%	0%	98%	0
1A5	Military use of fuels (1A5 Other)	CO2	447	234	0%	0%	20%	0%	0%	98%	0
2	Other industrial: CH4	CH4	437	452	0%	0%	51%	0%	0%	98%	0
5D	Wastewater treatment and discharge	CH4	306	205	0%	0%	38%	0%	0%	98%	0
1A3	Mobile combustion: domestic navigation	CO2	739	1119	1%	0%	5%	0%	0%	99%	0
2B8	Petrochemical and carbon black production	CO2	759	650	0%	0%	71%	0%	0%	99%	0
2E	Electronic Industry	PFC	47	116	0%	0%	25%	0%	0%	99%	0
1A1b	Stationary combustion : Petroleum Refining: gases	CO2	1042	3398	2%	1%	1%	0%	0%	99%	0
	OTHER N2O	N2O	7	83	0%	0%	17%	0%	0%	99%	0
2C3	CO2 from aluminium production	CO2	408	125	0%	0%	5%	0%	0%	99%	0
3B	Emissions from manure management : other	CH4	34	41	0%	0%	100%	0%	0%	99%	0
2A3	Glass production	CO2	142	84	0%	0%	25%	0%	0%	99%	0
2A1	Cement production	CO2	416	274	0%	0%	11%	0%	0%	99%	0
	OTHER CH4	CH4	14	77	0%	0%	17%	0%	0%	99%	0
1A3	Mobile combustion: domestic aviation	CO2	83	40	0%	0%	30%	0%	0%	99%	0
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO2	7586	6763	3%	0%	25%	0%	0%	99%	0
4D	4.D Wetlands	CO2	88	66	0%	0%	56%	0%	0%	99%	0
2B1	HFC by-product emissions from HFC manufacture	HFC	13	40	0%	0%	22%	0%	0%	99%	0
1A1c	Stationary combustion Manuf, of Solid Fuels and Other En. Ind: liquids& solids	CO2	634	594	0%	0%	20%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	N2O	40	43	0%	0%	70%	0%	0%	100%	0
3A1	CH4 emissions from enteric fermentation: other mature cattle	CH4	210	164	0%	0%	21%	0%	0%	100%	0
4H	4H. Other	CO2	2	21	0%	0%	25%	0%	0%	100%	0
3A8	CH4 emissions from enteric fermentation: swine	CH4	522	458	0%	0%	50%	0%	0%	100%	0
1B2	Fugitive emissions from oil and gas operations: Oil	CH4	20	11	0%	0%	54%	0%	0%	100%	0
4C	4C. Grassland	N2O	0	5	0%	0%	56%	0%	0%	100%	0
3A	CH4 emissions from enteric fermentation: other	CH4	514	452	0%	0%	30%	0%	0%	100%	0
2	Other industrial: direct CO2	CO2	450	399	0%	0%	50%	0%	0%	100%	0
1A3	Mobile combustion: other (non-road)	CH4	5	7	0%	0%	50%	0%	0%	100%	0
1A3	Mobile combustion: other (railways)	CO2	91	83	0%	0%	5%	0%	0%	100%	0
2D	Indirect CO2 from solvents/product use	CO2	0	0	0%	0%	27%	0%	0%	100%	0
			226801	202044				10%			31

Annex 2 Assessment of uncertainty

2.1 Description of methodology used for estimating uncertainty

As described in Section 1.7, a Tier 1 uncertainty assessment was made to estimate the uncertainty in total national GHG emissions and in emissions trends. Tier 1 here means that non-Gaussian uncertainty distributions and correlations between sources have been ignored. The uncertainty estimates for the activity data and EFs listed in Table A2.2 were also used for a Tier 1 trend uncertainty assessment, as shown in Table A2.1. Uncertainties for the activity data and EFs are derived from a mixture of empirical data and expert judgement and are presented here as half the 95% confidence interval. The reason for halving the 95% confidence interval is that the value then corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus x%'.

Since 2012, all data on uncertainty for each source has been included in the PRTR database. At the start of the NIR compilation, the Task Forces are asked to submit new uncertainty information, which is included in the annual key source assessment of the NIR.

We note that a Tier 2 uncertainty assessment and a comparison with a Tier 1 uncertainty estimate based on similar data showed that, in the Dutch circumstances, the errors made in the simplified Tier 1 approach to estimating uncertainties are quite small (Olsthoorn and Pielaat, 2003; Ramírez-Ramírez et al., 2006). This conclusion holds for both annual uncertainties and the trend uncertainty (see Section 1.7 for more details).

Table A2.1 Tier 1 trend uncertainty estimates

	Uncertainty in emissions level	Uncertainty in emissions trend
CO_2	± 2%	± 2% of 4% increase
CH_4	± 16%	± 5% of 42% decrease
N_2O	± 43%	± 8% of 55% decrease
F-gases	± 42%	± 13% of 71% decrease

Details of this calculation can be found in Table A2.2 and in Olivier et al. (2009). It should be stressed that most uncertainty estimates are ultimately based on collective expert judgement and are therefore themselves rather uncertain (usually in the order of 50%). Nevertheless, these estimates help to identify the most important uncertain sources. For this purpose, a reasonable order-of-magnitude estimate of the uncertainty in activity data and in EFs is usually sufficient. Uncertainty estimates are a means of identifying and prioritizing inventory improvement activities, rather than an objective in themselves.

Part of the uncertainty is due to an inherent lack of knowledge concerning the sources. Another part, however, can be attributed to elements of the inventory whose uncertainty could be reduced over time by dedicated research initiated by either the NIE or other researchers. When this type of uncertainty is in sources that are expected to be significant for emission reduction policies, the effectiveness of these policies could greatly reduced if the unreduced emissions turn out to be much lower than originally estimated.

The results of this uncertainty assessment of potential key sources can also be used to refine the Tier 1 key source assessment discussed above.

Table A2.2 Tier 1 level and trend uncertainty assessment 1990–2013 (for F-gases with base year 1995) with the categories of the IPCC potential key source list (without adjustment for correlation sources)

IPCC	Category	Gas	CO_2 eq base year abs	CO_2 eq last year abs	AD unc	EF unc	Uncertainty estimate	Combined uncertainty as % of total national emissions	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
1A	Emissions from combustion (excluding transport): non-CO_2	CH_4	683	1,767	3.0%	50.0%	50%	0.4%	0.5%	1%	0.3%	0.0%	0.3%
1A	Emissions from combustion (excluding transport): non-CO_2	N_2O	224	339	3.0%	50.0%	50%	0.1%	0.1%	0%	0.0%	0.0%	0.0%
1A1a	Stationary combustion: public electricity and heat production: gases	CO_2	13,348	18,147	0.5%	0.3%	1%	0.1%	2.8%	8%	0.0%	0.1%	0.1%
1A1a	Stationary combustion: public electricity and heat production: other fuels: waste incineration	CO_2	601	2,795	3.2%	5.7%	7%	0.1%	1.0%	1%	0.1%	0.1%	0.1%
1A1a	Stationary combustion: public electricity and heat production: solids	CO_2	25,776	26,310	1.0%	3.0%	3%	0.4%	1.5%	12%	0.0%	0.2%	0.2%
1A1a	Stationary combustion: pPublic electricity and heat production: liquids	CO_2	207	1,027	0.5%	20.0%	20%	0.1%	0.4%	0%	0.1%	0.0%	0.1%
1A1b	Stationary combustion: petroleum refining: gases	CO_2	1,042	3,398	0.5%	0.3%	1%	0.0%	1.1%	1%	0.0%	0.0%	0.0%
1A1b	Stationary combustion: petroleum refining: liquids	CO_2	10,008	5,878	5.0%	25.0%	25%	0.7%	-1.3%	3%	-0.3%	0.2%	0.4%
1A1c	Stationary combustion: manuf. of solid fuels and other en. ind.: gases	CO_2	1,526	2,128	20.0%	5.0%	21%	0.2%	0.3%	1%	0.0%	0.3%	0.3%

1A1c	Stationary combustion: manuf. of solid fuels and other en. ind.: liquids & solids	CO_2	634	594	20.0%	2.0%	20%	0.1%	0.0%	0%	0.0%	0.1%	0.1%
1A2	Stationary combustion: manufacturing industries and construction: gases	CO_2	19,020	13,094	2.0%	0.3%	2%	0.1%	-1.7%	6%	0.0%	0.2%	0.2%
1A2	Stationary combustion: manufacturing industries and construction: liquids	CO_2	7,586	6,763	1.0%	25.0%	25%	0.8%	0.0%	3%	0.0%	0.0%	0.0%
1A2	Stationary combustion: manufacturing industries and construction: solids	CO_2	4,401	3,040	2.0%	10.0%	10%	0.2%	-0.4%	1%	0.0%	0.0%	0.1%
1A3	Mobile combustion: domestic aviation	CO_2	83	40	30.0%	4.0%	30%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3	Mobile combustion: domestic navigation	CO_2	739	1,119	5.0%	2.0%	5%	0.0%	0.2%	0%	0.0%	0.0%	0.0%
1A3	Mobile combustion: other (non-road)	CO_2	2,622	2,622	15.0%	2.0%	15%	0.2%	0.1%	1%	0.0%	0.2%	0.2%
1A3	Mobile combustion: other (non-road)	N_2O	40	43	2.0%	70.0%	70%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3	Mobile combustion: other (non-road)	CH_4	5	7	2.0%	50.0%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3	Mobile combustion: other (railways)	CO_2	91	83	5.0%	2.0%	5%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3	Mobile combustion: road vehicles	N_2O	96	209	2.0%	70.0%	70%	0.1%	0.1%	0%	0.0%	0.0%	0.0%
1A3	Mobile combustion: road vehicles	CH_4	185	60	2.0%	50.0%	50%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1A3b	Mobile combustion: road vehicles: diesel oil	CO_2	11,818	18,752	2.0%	2.0%	3%	0.3%	3.6%	8%	0.1%	0.2%	0.2%
1A3b	Mobile combustion: road vehicles: gasoline	CO_2	10,806	11,966	2.0%	2.0%	3%	0.2%	1.0%	5%	0.0%	0.1%	0.2%
1A3b	Mobile combustion: road vehicles: LPG (including LNG)	CO_2	2,653	700	5.0%	2.0%	5%	0.0%	-0.7%	0%	0.0%	0.0%	0.0%

1A4	Stationary combustion: other sectors: liquids excl. From 1A4c	CO_2	1,356	699	20.0%	2.0%	20%	0.1%	-0.2%	0%	0.0%	0.1%	0.1%
1A4	Stationary combustion: other sectors: solids	CO_2	189	23	50.0%	10.0%	51%	0.0%	-0.1%	0%	0.0%	0.0%	0.0%
1A4a	Stationary combustion: other sectors:: commercial/institutional: gases	CO_2	7,632	11,545	10.0%	0.3%	10%	0.6%	2.1%	5%	0.0%	0.7%	0.7%
1A4b	Stationary combustion: other sectors: residential: gases	CO_2	18,696	18,736	5.0%	0.3%	5%	0.5%	0.9%	8%	0.0%	0.6%	0.6%
1A4c	Stationary combustion: other sectors: agriculture/forestry/fisheries: gases	CO_2	7,330	7,098	10.0%	0.3%	10%	0.4%	0.3%	3%	0.0%	0.4%	0.4%
1A4c	Stationary combustion: other sectors: agriculture/forestry/fisheries: liquids	CO_2	1,621	579	15.0%	2.0%	15%	0.0%	-0.4%	0%	0.0%	0.1%	0.1%
1A5	Military use of fuels (1A5 Other)	CO_2	447	234	20.0%	2.0%	20%	0.0%	-0.1%	0%	0.0%	0.0%	0.0%
1B1b	CO2 from coke production	CO_2	403	633	2.0%	15.0%	15%	0.0%	0.1%	0%	0.0%	0.0%	0.0%
1B2	Fugitive emissions from oil and gas operations: natural gas	CH_4	445	485	2.0%	50.0%	50%	0.1%	0.0%	0%	0.0%	0.0%	0.0%
1B2	Fugitive emissions from oil and gas operations: oil	CH_4	20	11	20.0%	50.0%	54%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
1B2	Fugitive emissions venting/flaring	CH_4	1,495	311	2.0%	25.0%	25%	0.0%	-0.4%	0%	-0.1%	0.0%	0.1%
1B2	Fugitive emissions venting/flaring: CO_2	CO_2	775	1,060	50.0%	2.0%	50%	0.3%	0.2%	0%	0.0%	0.3%	0.3%
2A1	Cement production	CO_2	416	274	5.0%	10.0%	11%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2A3	Glass production	CO_2	142	84	25.0%	5.0%	25%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2A4	Other process uses of carbonates	CO_2	690	719	50.0%	5.0%	50%	0.2%	0.0%	0%	0.0%	0.2%	0.2%

2B1	Ammonia production	CO_2	3,730	3,760	2.0%	10.0%	10%	0.2%	0.2%	2%	0.0%	0.0%	0.1%
2B1	HFC by-product emissions from HFC manufacture	HFC	13	40	10.0%	20.0%	22%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2B1	HFC-23 emissions from HCFC-22 manufacture	HFC	7,285	238	10.0%	10.0%	14%	0.0%	-2.8%	0%	-0.3%	0.0%	0.3%
2B2	Nitric acid production	N_2O	6,085	274	5.0%	6.0%	8%	0.0%	-2.3%	0%	-0.1%	0.0%	0.1%
2B5	Caprolactam production	N_2O	737	949	20.0%	23.0%	30%	0.1%	0.1%	0%	0.0%	0.1%	0.1%
2B8	Petrochemical and carbon black production	CO_2	759	650	50.0%	50.0%	71%	0.2%	0.0%	0%	0.0%	0.2%	0.2%
2C1	Iron and steel production (carbon inputs)	CO_2	2,266	1,083	3.0%	5.0%	6%	0.0%	-0.4%	0%	0.0%	0.0%	0.0%
2C3	CO_2 from aluminium production	CO_2	408	125	2.0%	5.0%	5%	0.0%	-0.1%	0%	0.0%	0.0%	0.0%
2C3	PFC from aluminium production	PFC	2,230	11	2.0%	20.0%	20%	0.0%	-0.9%	0%	-0.2%	0.0%	0.2%
2D	Indirect CO_2 from solvents/product use	CO_2	0	0	25.0%	10.0%	27%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2E	Electronic Industry	PFC	47	116	5.0%	25.0%	25%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2F	Product uses as substitutes for ODS	HFC	280	2,015	20.0%	50.0%	54%	0.5%	0.8%	1%	0.4%	0.3%	0.5%
2G	SF_6 emissions from SF_6 use	SF_6	274	132	30.0%	15.0%	34%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
2O	Other industrial: CH_4	CH_4	437	452	10.0%	50.0%	51%	0.1%	0.0%	0%	0.0%	0.0%	0.0%
2O	Other industrial: direct CO_2	CO_2	450	399	5.0%	50.0%	50%	0.1%	0.0%	0%	0.0%	0.0%	0.0%
2O	Other industrial: N_2O	N_2O	225	96	50.0%	50.0%	71%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
3A	CH_4 emissions from enteric fermentation: other	CH_4	514	452	5.0%	30.0%	30%	0.1%	0.0%	0%	0.0%	0.0%	0.0%
3A1	CH_4 emissions from enteric fermentation: mature dairy cattle	CH_4	5,179	4,975	5.0%	15.0%	16%	0.4%	0.2%	2%	0.0%	0.2%	0.2%
3A1	CH_4 emissions from enteric fermentation: other mature cattle	CH_4	210	164	5.0%	20.0%	21%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
3A1	CH_4 emissions from enteric fermentation: young cattle	CH_4	2,802	2,090	5.0%	20.0%	21%	0.2%	-0.2%	1%	0.0%	0.1%	0.1%

3A8	CH_4 emissions from enteric fermentation: swine	CH_4	522	458	5.0%	50.0%	50%	0.1%	0.0%	0%	0.0%	0.0%	0.0%
3B	Emissions from manure management	N_2O	530	419	10.0%	100.0%	100%	0.2%	0.0%	0%	0.0%	0.0%	0.0%
3B	Emissions from manure management: other	CH_4	34	41	10.0%	100.0%	100%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
3B1	Emissions from manure management: cattle	CH_4	1,834	2,138	10.0%	100.0%	100%	1.1%	0.2%	1%	0.2%	0.1%	0.3%
3B3	Emissions from manure management: swine	CH_4	3,489	2,086	10.0%	100.0%	100%	1.0%	-0.5%	1%	-0.5%	0.1%	0.5%
3B4	Emissions from manure management: poultry	CH_4	464	67	10.0%	100.0%	100%	0.0%	-0.2%	0%	-0.2%	0.0%	0.2%
3Da	Direct N_2O emissions from agricultural soils	N_2O	7,479	4,518	10.0%	60.0%	61%	1.4%	-0.9%	2%	-0.6%	0.3%	0.6%
3Db	Indirect N_2O emissions from managed soils	N_2O	2,039	800	50.0%	200.0%	206%	0.8%	-0.4%	0%	-0.9%	0.2%	0.9%
3G	Liming	CO_2	183	70	10.0%	100.0%	100%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4A	Forest land	CO_2	-1,890	-2,675	25.0%	61.8%	67%	-0.9%	-0.4%	-1%	-0.3%	-0.4%	0.5%
4B	Cropland	CO_2	1,635	2,536	25.0%	50.0%	56%	0.7%	0.5%	1%	0.2%	0.4%	0.5%
4B	Cropland	N_2O	3	68	25.0%	57.9%	63%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4C	Grassland	CO_2	5,452	4,408	25.0%	50.0%	56%	1.2%	-0.2%	2%	-0.1%	0.7%	0.7%
4C	Grassland	N_2O	0.238	5	25.0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4D	Wetlands	CO_2	88	66	25.0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4E	Settlements	CO_2	888	1,585	25.0%	50.0%	56%	0.4%	0.4%	1%	0.2%	0.2%	0.3%
4F	Other Land	CO_2	26	117	25.0%	50.0%	56%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
4G	Harvested wood products	CO_2	-533	106	25.0%	50.0%	56%	0.0%	0.3%	0%	0.1%	0.0%	0.1%
4H	Other	CO_2	2	21	25.0%	1.0%	25%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
5A	Solid waste disposal	CH_4	14,299	3,383	0.4%	24.0%	24%	0.4%	-4.1%	1%	-1.0%	0.0%	1.0%
5B	Emissions from wastewater handling	N_2O	149	69	20.0%	100.0%	102%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
5D	Wastewater treatment and discharge	CH_4	306	205	20.0%	32.0%	38%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
	OTHER CH_4	CH_4	14	77	0.1%	17.0%	17%	0.0%	0.0%	0%	0.0%	0.0%	0.0%
	OTHER N_2O	N_2O	7	83	0.1%	17.0%	17%	0.0%	0.0%	0%	0.0%	0.0%	0.0%

Table A2.3 Emissions (Gg) and uncertainty estimates for the sub-categories of Sector 5 LULUCF, as used in the Tier 1 uncertainty analysis

IPCC	Category	Gas	CO_2 eq base year	CO_2 eq latest year	AD unc	EF unc	Uncertainty estimate
4A	Forest Land	CO_2	-1,890	-2,675	25.0%	61.8%	67%
4B	Cropland	N_2O	3.051	68	25.0%	57.9%	63%
4B	Cropland	CO_2	1,635	2,536	25.0%	50.0%	56%
4C	Grassland	CO_2	5,452	4,408	25.0%	50.0%	56%
4C	Grassland	N_2O	0	5	25.0%	50.0%	56%
4D	Wetlands	CO_2	88	66	25.0%	50.0%	56%
4G	Harvested wood products	CO_2	-533	106	25.0%	50.0%	56%
4E	Settlements	CO_2	888	1,585	25.0%	50.0%	56%
4F	Other Land	CO_2	26	117	25.0%	50.0%	56%
4H	Other	CO_2	2	21	25.0%	1.0%	25%

Annex 3 Detailed methodological descriptions of individual source or sink categories

A detailed description of methodologies per source/sink category, including a list of country-specific EFs, can be found in the relevant methodology reports on the website http://english.rvo.nl/nie.

Annex 4 CO_2 The national energy balance for the most recent inventory year

The national energy balance for 2013 of the Netherlands (as used for this submission) can be found on line at:
http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=70846NED&D1=0-37&D2=15,19&D3=0&D4=17-18&VW=T

Annex 5 The Netherlands' fuels and standard CO_2 EFs, version 2015

Name (Dutch)	Name (English)	Unit	Calorific value (MJ/unit)				CO_2 EF (kg/GJ)			
			2013	2014	2015	Ref [1)]	2013	2014	2015	Ref [1)]
	A. Liquid fossil – primary fuels									
Ruwe aardolie	Crude oil	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC
Orimulsion	Orimulsion	kg	27.5	27.5	27.5	IPCC	77.0	77.0	77.0	IPCC
Aardgascondensaat	Natural gas liquids	kg	44.0	44.0	44.0	CS	64.2	64.2	64.2	IPCC
Fossiele additieven	Fossil fuel additives	kg	44.0	44.0	44.0	CS	73.3	73.3	73.3	IPCC
	Liquid fossil – secondary fuels/products									
Motorbenzine	Gasoline	kg	44.0	44.0	44.0	CS	72.0	72.0	72.0	CS
Vliegtuigbenzine	Aviation gasoline	kg	44.0	44.0	44.0	CS	72.0	72.0	72.0	CS
Kerosine luchtvaart	Jet kerosene	kg	43.5	43.5	43.5	CS	71.5	71.5	71.5	IPCC
Petroleum	Other kerosene	kg	43.1	43.1	43.1	CS	71.9	71.9	71.9	IPCC
Leisteenolie	Shale oil	kg	38.1	38.1	38.1	IPCC	73.3	73.3	73.3	IPCC
Gas-/dieselolie	Gas/Diesel oil	kg	42.7	42.7	42.7	CS	74.3	74.3	74.3	CS
Zware stookolie	Residual fuel oil	kg	41.0	41.0	41.0	CS	77.4	77.4	77.4	IPCC
LPG	Liquefied petroleum gas (LPG)	kg	45.2	45.2	45.2	CS	66.7	66.7	66.7	CS
Ethaan	Ethane	kg	45.2	45.2	45.2	CS	61.6	61.6	61.6	IPCC
Nafta's	Naphta	kg	44.0	44.0	44.0	CS	73.3	73.3	73.3	IPCC
Bitumen	Bitumen	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
Smeeroliën	Lubricants	kg	41.4	41.4	41.4	CS	73.3	73.3	73.3	IPCC
Petroleumcokes	Petroleum coke	kg	35.2	35.2	35.2	CS	97.5	97.5	97.5	IPCC
Raffinaderij grondstoffen	Refinery feedstocks	kg	43.0	43.0	43.0	IPCC	73.3	73.3	73.3	IPCC
Raffinaderijgas	Refinery gas	kg	45.2	45.2	45.2	CS	67.0	67.0	67.0	CS

Name (Dutch)	Name (English)	Unit	Calorific value (MJ/unit)				CO_2 EF (kg/GJ)			
			2013	2014	2015	Ref [1)]	2013	2014	2015	Ref [1)]
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 ovens)	kg	28.6	28.6	28.6	CS	95.4	95.4	95.4	CS
Cokeskolen	Coking coal (used in blast furnaces)	kg	28.6	28.6	28.6	CS	89.8	89.8	89.8	CS
Overige bitumineuze steenkool [2)]	Other bituminous coal [2)]	kg	25.0	25.0 [2)]	25.0 [2)]	CS	94.7	94.7	94.7	CS
Sub-bitumineuze kool	Sub-bituminous coal	kg	18.9	18.9	18.9	IPCC	96.1	96.1	96.1	IPCC
Bruinkool	Lignite	kg	20.0	20.0	20.0	CS	101.0	101.0	101.0	IPCC
Bitumineuze Leisteen	Oil shale	kg	8.9	8.9	8.9	IPCC	107.0	107.0	107.0	IPCC
Turf	Peat	kg	9.76	9.76	9.76	IPCC	106.0	106.0	106.0	IPCC
	Solid fossil – secondary fuels									
Steenkool- and bruinkoolbriketten	BKB & Patent fuel	kg	20.7	20.7	20.7	IPCC	97.5	97.5	97.5	IPCC
Cokesoven/gascokes	Coke oven/Gas coke	kg	28.5	28.5	28.5	CS	106.8	106.8	106.8	CS
Cokesovengas	Coke oven gas	MJ	1.0	1.0	1.0	CS	42.8	42.8	42.8	CS
Hoogovengas	Blast furnace gas	MJ	1.0	1.0	1.0	CS	247.4	247.4	247.4	CS
Oxystaalovengas	Oxy gas	MJ	1.0	1.0	1.0	CS	191.9	191.9	191.9	CS

Name (Dutch)	Name (English)	Unit	Calorific value (MJ/unit)				CO_2 EF (kg/GJ)			
			2013	2014	2015	Ref [1)]	2013	2014	2015	Ref [1)]
Fosforovengas	Fosfor gas	Nm3	11.0	11.0	11.0	CS	143.9	143.9	143.9	CS
Steenkool bitumen	Coal tar	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
	C. Gaseous fossil fuels									
Aardgas [3)]	Natural gas (dry) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.4[3)]	56.5[3)]	CS
Compressed natural gas (CNG) [3)]	Compressed natural gas (CNG) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.4[3)]	56.5[3)]	CS
Liquified natural gas (LNG) [3)]	Liquified natural gas (LNG) [3)]	Nm3 ae	31.65	31.65	31.65	CS	56.5[3)]	56.4[3)]	56.5[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									
Biomassa vast	Solid biomass	kg	15.1	15.1	15.1	CS	109.6	109.6	109.6	IPCC
Houtskool	Charcoal	kg	30.0	30.0	30.0	CS	112.0	112.0	112.0	IPCC
Biobenzine	Biogasoline	kg	27.0	27.0	27.0	CS	72.0	72.0	72.0	CS
Biodiesel	Biodiesels	kg	37.0	37.0	37.0	CS	74.3	74.3	74.3	CS
Overige vloeibare biobrandstoffen	Other liquid biofuels	kg	36.0	36.0	36.0	CS	79.6	79.6	79.6	IPCC
Biomassa gasvormig	Gas biomass	Nm3	21.8	21.8	21.8	CS	90.8	90.8	90.8	CS
RWZI biogas	Wastewater biogas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
Stortgas	Landfill gas	Nm3	19.5	19.5	19.5	CS	100.7	100.7	100.7	CS
Industrieel fermentatiegas	Industrial organic waste gas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
	D. Other fuels									
Afval [2)]	Waste [2)]	Kg	9.8	9.8[2)]	9.8[2)]	CS	106.2	106.2[2)]	106.2[2)]	CS

Notes on the fuel list

The Netherlands Enterprise Agency (RVO.nl) has been publishing a list of fuels and standard CO_2 EFs for the Netherlands annually since 2004.

This list was completely revised in 2015 in comparison with the 2014 list (Vreuls and Zijlema, 2014), in order that all international reports compiled in or after 2015 (the first reporting year of the second Kyoto budget period) should comply with the 2006 IPCC Guidelines. The list contains not only calorific values and EFs taken from the 2006 IPCC Guidelines but also a number of country-specific values.

The validity of values is governed by the following:

- 2006 IPCC default EFs are valid from 1990.
- The country-specific calorific values and EFs may be divided into the following three groups:
  - Most country-specific calorific values and EFs 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 EFs for some fuels (natural gas, other bituminous coal and waste) are updated annually.

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 organizations involved was Statistics Netherlands, to ensure consistency with the Dutch Energy Balance.

With effect from 2015, the lists of calorific values and of EFs will both contain columns for three successive years. In the present version of the fuel list (relating to April 2015), the years in question are 2013, 2014 and 2015. The values in these columns are used for the following purposes:

1. **2013**: these values are used in 2015 for calculations concerning the calendar year 2013, which are required for international reports concerning GHG emissions pursuant to the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the European Regulation on the monitoring and reporting of GHG emissions (MMR, 525/2013/EU). The National Inventory Report for 2015 (NIR 2015) gives full details of GHG emissions in the Netherlands up to and including 2013. The fuel list forms an integral part of the NIR 2015.
2. **2014**: these values are used in 2015 for reports on energy consumption and CO_2 emissiond for the calendar year 2014 in the electronic Annual Environmental Report (e-AER), 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. **2015**: these values will be used in 2016 in emissions reports for the calendar year 2015 by companies participating in the EU

Emission Trading Scheme (ETS), which are allowed to report the EF and calorific value of 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 2015.

Annex 6 Assessment of completeness and (potential) sources and sinks

The Netherlands' emissions inventory focuses on completeness, and accuracy in the most relevant sources. This means that for all 'NE' sources, it was investigated what information was available and whether it could be assumed that a source was really (very) small/negligible. For those sources that turned out not to be small, methods for estimating the emissions were developed during the improvement programme. As a result of this process, it was decided to keep only a very few sources as 'NE', where data for estimating emissions was not available and the source was very small. Of course, (developments in) data on NE sources that indicate any (major) increase in emissions and (new) data sources for estimating emissions are checked/re-assessed on a regular basis.

The Netherlands GHG emissions inventory includes all sources identified by the Revised IPCC Guidelines (IPCC, 2006 – with the exception of the following (very) minor sources:

- CO_2 from asphalt roofing (2A5) and CO_2 from road paving (2A6), both due to missing activity data; information on the use of bitumen is available only in a division into two groups: the chemical industry and all others. There is no information on the amount of asphalt roofing production and no information on road paving with asphalt. The statistical information on the sales (value) of asphalt roofing and asphalt for road paving was ended by 2002.
  As a follow-up to the 2008 review, information was collected from the branch organization for roofing, indicating that the number of producers of asphalt roofing declined from about fifteen in 1990 to fewer than five in 2008 and that the import of asphalt roofing increased during that period.
  Information has also been sourced on asphalt production (for road paving), as reported in the progress of the voluntary agreements for energy efficiency. A first estimate indicates that the annual CO_2 emissions could be approximately 0.5 kton.
  On the basis of the above, it was assumed that emissions related to these two categories are very low/undetectable and that the effort expended in generating activity data would, therefore, not be cost-effective. So not only the missing activity data, but also the very limited amount of emissions were the rationale behind the decision not to estimate these emissions.
- CH_4 from Enteric fermentation: poultry (4A9), due to missing EFs; for this source category, no IPCC default EF is available.
- N_2O from Industrial wastewater (6B1), due to negligible amounts. As presented in the NIR 2008, on page 194, the annual source for activity data is the yearly questionnaires covering all urban WWTPs and all anaerobic IWWTPs. There are no N_2O emissions from this anaerobic pre-treatment.

In 2000, the Netherlands investigated sources of non-CO_2 emissions not previously estimated. One of these sources was wastewater handling

(DHV, 2000). As a result of this study, emissions were estimated (Oonk, 2004) and the methods are presented in the methodology report ENINA.

We are not able to estimate N_2O emissions from aerobic IWWTPs, as there is no information available on these installations. In the priority assessment for the allocation of budgets for improvements in emissions estimates, we did not consider this to be a source for which it could be argued that a new data collection process or new statistics was a priority. This decision was based on the following arguments:

- The majority of small and medium-size enterprises are linked to municipal WWTPs (for which emissions estimates are made) and do not have their own wastewater treatment systems.
- Anaerobic pre-treatment reduces the N load to the aerobic final treatment.
- Aerobic (post-)treatment for several of the industrial companies is carried out in the municipal WWTPs.
- Industrial wastewater consists primarily of process water and, although we have no specific information on the N content of the influent, it is assumed that it is low. In addition, there are indications that the number of IWWTPs will be reduced in the near future and this will further minimize this source.
- Part of CH_4 from industrial wastewater (6B1b sludge), due to negligible amounts. For industrial wastewater treatment the situation is follows:
    - The major part of Dutch industry emits into the sewer system, which is connected to municipal WWTPs. These emissions are included in the category: Domestic and commercial wastewater.
    - In case of anaerobic wastewater treatment, emissions from sludge handling are included in emissions from anaerobic industrial wastewater handling.
    - Among the aerobic wastewater handling systems used in industry, only two plants operate a separate anaerobic sludge digester and CH_4 emissions from these two plants are not estimated. In the other IWWTP, the sludge undergoes stabilization in the aerobic wastewater reactors. The industrial sludge produced is therefore already very stable in terms of digestible matter and CH_4 emissions are considered to be very low and do not justify setting up a yearly monitoring and estimation system.

Precursor emissions (i.e. CO, NO_x, NMVOC and SO_2) from Memo item international bunkers (international transport) have not been included.

Annex 7 Chemical compounds, GWPs, units and conversion factors

A7.1 Chemical compounds

CF_4	Perfluoromethane (tetrafluoromethane)
C_2F_6	Perfluoroethane (hexafluoroethane)
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HNO_3	Nitric acid
NH_3	Ammonia
NO_x	Nitrogen oxide (NO and NO_2), expressed as NO_2
N_2O	Nitrous oxide
NMVOC	Non-methane volatile organic compounds
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
VOC	Volatile organic compounds (may include or exclude methane)

A7.2 GWPs of selected GHGs

Table A7.1 lists the 100-year GWPs of selected GHGs. Gases indicated in italics are not emitted in the Netherlands.

Table A7.1 100-year GWPs of selected GHGs

Gas	100-year GWP [1)]
CO_2	1
CH_4 [2)]	25
N_2O	298
HFCs [3)]:	
HFC-23	14,800
HFC-32	675
HFC-125	3,500
HFC-134a	1,413
HFC-143a	4,470
HFC-152a	124
HFC-227ea	*3,220*
HFC-236fa	*9,810*
HFC-245ca	*693*
PFCs [3)]:	
CF_4	7,390
C_2F_6	12,200
C_3F_8	*8,830*
C_4F_{10}	*8,860*
C_6F_{14}	*9,300*
SF_6	22,800

Source: IPCC (2014)

1) GWPs calculated with a 100-year time horizon in compliance with the UNFCCC Guidelines for reporting (UNFCCC, 2006).

2) The GWP of methane includes the direct effects and the indirect effects due to the production of tropospheric ozone and stratospheric water vapour; the indirect effect due to the production of CO_2 is not included.

3) The GWP-100 of emissions reported as 'HFC-unspecified' and 'PFC-unspecified' differ per reported year. They are in the order of magnitude of 3,000 and 8,400, respectively.

A7.3 Units

MJ	Mega Joule (10^6 Joule)
GJ	Giga Joule (10^9 Joule)
TJ	Tera Joule (10^{12} Joule)
PJ	Peta Joule (10^{15} Joule)
Mg	Mega gramme (10^6 gramme)
Gg	Giga gramme (10^9 gramme)
Tg	Tera gramme (10^{12} gramme)
Pg	Peta gramme (10^{15} gramme)
ton	metric ton (= 1,000 kilogramme = 1 Mg)
kton	kiloton (= 1,000 metric ton = 1 Gg)
Mton	Megaton (= 1,000,000 metric ton = 1 Tg)
ha	hectare (= 10^4 m^2)
kha	kilo hectare (= 1,000 hectare = 10^7 m^2 = 10 km^2)
mln	million (= 10^6)

A7.4 Conversion factors for emissions

From element basis to full molecular mass:		From full molecular mass to element basis	
$C \rightarrow CO_2$:	x 44/12 = 3.67	$CO_2 \rightarrow C$:	x 12/44 = 0.27
$C \rightarrow CH_4$:	x 16/12 = 1.33	$CH_4 \rightarrow C$:	x 12/16 = 0.75
$C \rightarrow CO$:	x 28/12 = 2.33	$CO \rightarrow C$:	x 12/28 = 0.43
$N \rightarrow N_2O$:	x 44/28 = 1.57	$N_2O \rightarrow N$:	x 28/44 = 0.64
$N \rightarrow NO$:	x 30/14 = 2.14	$NO \rightarrow N$:	x 14/30 = 0.47
$N \rightarrow NO_2$:	x 46/14 = 3.29	$NO_2 \rightarrow N$:	x 14/46 = 0.30
$N \rightarrow NH_3$:	x 17/14 = 1.21	$NH_3 \rightarrow N$:	x 14/17 = 0.82
$N \rightarrow HNO_3$:	x 63/14 = 4.50	$HNO_3 \rightarrow N$:	x 14/63 = 0.22
$S \rightarrow SO_2$:	x 64/32 = 2.00	$SO_2 \rightarrow S$:	x 32/64 = 0.50

Annex 8 List of abbreviations

AD	activity data
ARD	afforestation, reforestation and deforestation
AER	Annual Environmental Report
BF	blast furnace gas
BOD	biological oxygen demand
C	Confidential (notation code in CRF)
CO	coke oven gas
CS	country-specific (notation code in CRF)
CBS	Statistics Netherlands
CHP	combined heat and power
CLRTAP	Convention on Long-Range Transboundary Air Pollution (ECE)
COD	chemical oxygen demand
CRF	Common Reporting Format (of emissions data files, annexed to an NIR)
DM	dry matter
DOC	degradable organic carbon
DOCF	degradable organic carbon fraction
EC-LNV	National Reference Centre for Agriculture
ECE	Economic Commission for Europe (UN)
ECN	Energy Research Centre of the Netherlands
EEA	European Environment Agency
EF	emission factor
ENINA	Task Group Energy, Industry and Waste Handling
EPA	US Environmental Protection Agency
ER	Emission Registration (system)
ER-I	Emission Registration – Individual firms
ERT	Expert Review Team
ERU	Emission Reduction Unit
ETS	Emission Trading System
EU	European Union
EZ	Ministry of Economic Affairs
FADN	Farm Accountancy Data Network
FAO	Food and Agricultural Organization (UN)
F-gases	group of fluorinated compounds comprising HFCs, PFCs and SF_6
FGD	flue gas desulphurization
GE	gross energy
GHG	greenhouse gas
GWP	global warming potential
HDD	heating degree day
HOSP	Timber Production Statistics and Forecast (in Dutch: 'Hout Oogst Statistiek en Prognose oogstbaar hout')

IE	included elsewhere (notation code in CRF)
IEA	International Energy Agency
IEF	implied emission factor
IenM	Ministry of Infrastructure and Environment (formerly VROM)
IWWTP	industrial wastewater treatment plant
IPCC	Intergovernmental Panel on Climate Change
KP-LULUCF	Land use, land use change and forestry according the Kyoto Protocol definitions
LEI	Agricultural Economics Institute
LPG	liquefied petroleum gas
LULUCF	Land use, land use change and forestry
MCF	methane conversion factor
MEP	TNO Environment, Energy and Process Innovation
MFV	Measuring Network Functions (in Dutch: 'Meetnet Functievervulling')
MR	methane recovery
MSW	municipal solid waste
MW	mega watt
NA	not available/not applicable (notation code in CRF); National Approach (vs. Reference or Sectoral Approach)
NACE	Statistical Classification of Economic Activities from the European Union: Nomenclature générale des Activités économiques dans les Communautés Européennes
NAV	Dutch Association of Aerosol Producers
ND	no data
NEa	Dutch Emissions Authority
NE	not estimated (notation code in CRF)
NEa	Netherlands Emission authority (Dutch Emission Authority)
NEC	National Emission Ceilings
NEMA	National Emission Model for Agriculture
NFI	National Forest Inventory
NGE	Nederlandse grootte-eenheid
NIE	National Inventory Entity
NIR	National Inventory Report (annual GHG inventory report to UNFCCC)
NOGEPA	Netherlands Oil and Gas Exploration and Production Association
NOP-MLK	National Research Programme on Global Air Pollution and Climate Change
NS	Dutch Railways
ODS	ozone depleting substances
ODU	oxidation during use (of direct non-energy use of fuels or of petrochemical products)
OECD	Organization for Economic Co-operation and Development
OM	organic matter

OX	oxygen furnace gas
PBL	Netherlands Environmental Assessment Agency (formerly MNP)
PE	Pollution Equivalent
PRTR	Pollutant Release and Transfer Register
QA	quality assurance
QC	quality control
RA	Reference Approach (vs. Sectoral or National Approach)
RIVM	National Institute for Public Health and the Environment
ROB	Reduction Programme on Other Greenhouse Gases
RVO.nl	Netherlands Enterprise Agency
SA	Sectoral Approach (vs. National or Reference Approach)
SCR	selective catalytic reduction
SGHP	Shell Gasification and Hydrogen Production
SNCR	selective non-catalytic reduction
SO	standard output
SWDS	solid waste disposal site
TNO	Netherlands Organisation for Applied Scientific Research
TOW	total organics in wastewater
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	volatile organic compound
VS	volatile solids
WBCSD	World Business Council for Sustainable Development
WEM	Working Group Emission Monitoring
WUR	Wageningen University and Research Centre (or: Wageningen UR)
WWTP	wastewater treatment plant

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Total greenhouse gas (GHG) emissions from the Netherlands in 2013 decreased by approximately 0.2%, compared with 2012 emissions. This decrease was mainly the result of decreased fuel combustion in the transport sector and in the petrochemical industry.

In 2013, total direct GHG emissions (excluding emissions from Land use, land use change and forestry (LULUCF)) in the Netherlands amounted to 195.8 Tg CO2 eq. This is approximately 12% below the emissions in the base year (221.1 Tg CO2 eq).

This report documents the Netherlands' 2015 annual submission of its GHG emissions inventory in accordance with the guidelines provided by the United Nations Framework Convention on Climate Change (UNFCCC) and the European Union's Greenhouse Gas Monitoring Mechanism. Implementation of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) meant the presentation of the emissions data changed in comparison with previous submissions.

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

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