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Greenhouse gas emissions in the Netherlands 1990 - 1995. Methodology and data for 1994 and provisional data for 1995

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**A report for the
International Commitments with respect to
Greenhouse Gas Emission Inventories for the Climate Convention and for
the European Union's Greenhouse Gas Monitoring Mechanism**

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N.B. Tables in Appendices (IPCC Standard data Tables and tables on energy use, CO_2, CH_4 and N_2O) are not listed here.

CHEMICAL COMPOUNDS

CFCs	Chlorofluorocarbons
CF_4	Perfluoromethane (tetrafluoromethane)
C_2F_6	Perfluoroethane (hexafluoroethane)
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CTC	Carbon tetrachloride (tetrachloromethane)
FICs	Fluoroiodocarbons
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HNO_3	Nitric Acid
MCF	Methyl Chloroform (1,1,1-Trichloroethane)
NO_x	Nitrogen oxide (NO and NO_2), expressed as NO_2
N_2O	Nitrous oxide
NMVOC	Non-Methane Volatile Organic Compounds
PFCs	Perfluorocarbons
SO_2	Sulphur dioxide
SF_6	Sulphur hexafluoride
VOC	Volatile Organic Compounds (may include or exclude methane)

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)

CONVERSION FACTORS FOR EMISSION FACTORS

From element basis to full molecular mass:

$C \rightarrow CO_2$:	x 44/12 = 3.6666
$C \rightarrow CH_4$:	x 16/12 = 1.3333
$C \rightarrow CO$:	x 28/12 = 2.3333
$N \rightarrow N_2O$:	x 44/28 = 1.5714
$N \rightarrow NO$:	x 30/14 = 2.1428
$N \rightarrow NO_2$:	x 46/14 = 3.2857
$N \rightarrow NH_3$:	x 17/14 = 1.2143
$N \rightarrow HNO_3$:	x 63/14 = 4.5
$S \rightarrow SO_2$:	x 64/32 = 2

From full molecular mass to element basis:

$CO_2 \rightarrow C$:	x 12/44 = 0.2727
$CH_4 \rightarrow C$:	x 12/16 = 0.75
$CO \rightarrow C$:	x 12/28 = 0.4286
$N_2O \rightarrow N$:	x 28/44 = 0.6363
$NO \rightarrow N$:	x 14/30 = 0.4667
$NO_2 \rightarrow N$:	x 14/46 = 0.3043
$NH_3 \rightarrow N$:	x 14/17 = 0.8235
$HNO_3 \rightarrow N$:	x 14/63 = 0.2222
$SO_2 \rightarrow S$:	x 32/64 = 0.5

ABSTRACT

The inventory presented in this report complies with the obligations under the European Union's Greenhouse Gas Monitoring Mechanism and the UN-FCCC for emission reports on all greenhouse gases not covered under the Montreal protocol. This inventory of greenhouse gas emissions in the Netherlands has been prepared according to the IPCC Guidelines on the basis of figures provided by the *Environmental Balance 1996*. A short description is given on how the Guidelines have been applied in the Netherlands. Differences between IPCC sectors and target groups in the Netherlands are addressed and resulting emission differences accounted for. Time series on emissions between 1990 and 1995 are presented for all non-ODP greenhouse gases.

In 1994, carbon dioxide emissions were 2.8% higher than in 1990. In the period 1990-1994 methane emissions decreased by 3%, nitrous oxide emissions increased by 11% and CO_2-equivalent emissions of HFCs, PFCs, and SF6 increased by 17%. The total emissions of non-ODP greenhouse gases increased by 3% from 1990 to 1994, mainly due to increasing emissions of CO_2 and HFCs. In 1994, non-CO_2 gases contributed about 22% to all CO_2-equivalent emissions in that year. CH_4 contributed about 10%, N_2O about 8% and the non-ODP halocarbons about 4%. Provisional data suggest an increase of 3.9% carbon dioxide emissions in 1995 due to increased energy use. The emissions of HFCs were 33% higher in 1995 than in 1994.

SUMMARY

This report, recording the greenhouse gas emissions in the Netehrlands for 1990-1995, has been written at the request of the Netherlands' Ministry of Housing, Spatial Planning and the Environment in comliance with the European Unions Greenhouse Gas Monitoring Mechanism (Council Decision 93/389/EEC). It also complies with the obligations under the United Nations Framework Convention on Climate Change (UN-FCCC).

The European Community and its Member States have adopted the objective of stabilising CO_2 emissions for the whole Community at 1990 levels by 2000. The monitoring mechanism provides a means for the Commission to monitor progress towards this stabilisation target. The mechanism is based om are annual emission inventories provided by the Member States, and national programmes which set out emission trajectories and policy measures to mitigate CO_2 or to increase sinks. The mechanism also requires Member States to report inventories of other greenhouse gases not regulated by the Montreal Protocol. In 1996 Member States should supply their greenhouse gas emissions inventories for 1994 on the basis of final data and for 1995 on the basis of provisional data. This should include IPCC/OECD Standard Data Tables for CO_2, CH_4 and N_2O, as a written document and on diskette, e.g. in Excel format. If the annual total or the allocation to the various subsectors differs from previous submissions, this submission also includes data for the base year 1990 and for 1993. In 1997 a review of the data and calculations submitted by the member states will be carried under the responsibility of the European Commission.

The inventory, based on figures provided in the *Environmental Balance 1996,* is compatible with the UN-FCCC reporting requirements as described by the *IPCC Guidelines*. However, for a number of activities, more detailed information is given. It contains a greenhouse gas emission inventory for the years 1994 and 1995, along with overview tables with sectoral trends for the period 1990-1995; there is also a short description of how the internationally adopted *IPCC Guidelines* have been applied in the Netherlands. The emission levels reported here are compared with emissions from target groups in the Netherlands as defined for environmental policy purposes.

A recalculation of the carbon dioxide emissions for 1993 was necessary because of the different methods and emission factors used in previous inventories. When used in conjunction with the figures provided in the background document to the first *Netherlands' National Communication on Climate Change Policies*, a consistent time series of CO_2 emissions in the Netherlands for 1990-1995 is provided. This method was also used in the *Environmental Balance 1996*. For other gases, the figures also comply with data provided by the *Environmental Balance 1996*, except for a few revisions which are described in the text.

In 1994, temperature-corrected carbon dioxide emissions were 2.8% higher than in 1990. In 1994 the emissions of methane decreased by 3% compared to 1990. Emissions of nitrous oxide increased by 11%. Provisional data for 1995 suggest a significant increase of carbon dioxide emissions by 3.9% in 1995. In 1995, the increase in energy use (+3.4% after temperature correction) was more than the economic growth (+2.1%). Contributing the most to this growth of

CO_2 emissions between 1990 and 1994 are the energy, transportation, and the chemical industry sector. Also non-sectoral energy use (statistical differences) increased in 1995.

Table 8.1 presents the CO_2 equivalent greenhouse gas emissions of the Netherlands from anthropogenic sources for the period 1990-1995. When interpreting this table one should take account into the following observations:

- the contribution of non-CO_2 gases is very uncertain;
- the contribution of ozone precursors and SO_2 is not represented in CO_2-equivalent emissions at all.

Taking these limitations into consideration the following conclusions can be drawn:

- Total CO_2-equivalent emissions of compounds covered under the UN-FCCC increased by 3% from 1990 to 1994, mainly due to increasing emissions of CO_2 and of HFCs;
- CO_2 emissions are showing an increasing trend (+2.8 % in 1994 relative to 1990);
- CH_4 emissions are slowly decreasing (-3% in 1994 relative to 1990);
- N_2O emissions are showing an increasing trend (+11% in 1994 relative to 1990);
- emissions of HFCs, PFCs and SF_6 are increasing (about +17% in 1994 relative to 1990) due to the replacement of CFCs and halons (notably by HFCs) and due to emissions of HFC-23 as a by-product of HCFC-22 production;
- emissions of ozone precursors are all decreasing (-9 to -16% in 1994 relative to 1990);
- SO_2 emissions have been substantially decreased by 28% since 1990;
- non-CO_2 gases contributed about 22% to total CO_2-equivalent emissions in 1994, of which methane contributed about 10% and nitrous oxide about 8%;
- HFCs, PFCs and SF_6 contributed about 4% in 1994.

The Appendices A to C provide the IPCC Standard Tables 7A, 7B and 8A for 1990, 1994 and 1995 (provisional), while Appendix D provides the IPCC Standard Data Tables 1 to 7 for 1994 and 1995. Finally, in Appendices E and F some additional tables are found on energy use and the emissions of CO_2, CH_4 and N_2O.

SAMENVATTING

Dit rapport is geschreven op verzoek van het Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer om te voldoen aan de verplichtingen in het kader van het Bewakingsmechanisme Broeikasgassen, volgens besluit van de Milieuraad van de Europese Unie van 24 juni 1993 (93/389/EEC). Het rapport dient tevens om te voldoen aan de verplichtingen in het kader van het Klimaatverdrag van de VN (UN-FCCC).

De lidstaten van de Europese Unie hebben afgesproken hun gezamenlijke emissie van CO_2 in 2000 te stabiliseren ten opzichte van 1990. Het Bewakingsmechanisme biedt de Commissie de mogelijkheid de vorderingen op weg naar dit doel te volgen op basis van een jaarlijkse inventarisatie van emissies van broeikasgassen die niet onder het Montreal-protocol vallen. Lidstaten dienen daarover te rapporteren, alsmede over (beleids)maatregelen en/of programma's die tot doel hebben de emissies van broeikasgassen te reduceren en de vastlegging van CO_2 te vergroten. Ook wordt aan de lidstaten gevraagd om de emissies van andere broeikasgassen, die niet onder het Montreal-protocol vallen, te rapporteren. Onder het Bewakingsmechanisme dient iedere lidstaat in 1996 zijn emissie-inventarisaties voor 1994 met definitieve data en voor 1995 met voorlopige cijfers te rapporteren, inclusief de IPCC/OECD Standaard Data Tabellen voor CO_2, CH_4 en N_2O (als rapport en op diskette, bijv. in Excel-formaat). Deze tweede rapportage bevat ook cijfers voor 1990 en 1993 voor zover de jaarlijkse totalen of de verdeling over de subsectoren verschilt van eerdere rapportages. Onder de verantwoordelijkheid van de Commissie zal een *review* worden uitgevoerd van de cijfers en de berekeningen die door de lidstaten gerapporteerd zijn.

Deze rapportage is conform de instructies van de UN-FCCC zoals beschreven in de *IPCC Guidelines* en is gebaseerd op cijfers uit de *Milieubalans 1996*. Op een aantal plaatsen in dit rapport wordt echter meer gedetailleerde informatie geleverd. Het rapport bevat een emissie-inventarisatie van broeikasgassen voor 1994 en 1995, tezamen met overzichtstabellen met de sectorale trends voor de periode 1990-1995 en een korte beschrijving hoe de internationaal gebruikte methodiek van de *IPCC Guidelines* toegepast is in Nederland. Hierbij wordt opgemerkt dat de sectorindeling volgens de IPCC op punten afwijkt van de doelgroepindeling ten behoeve van nationaal milieubeleid. Na herschikking van de sectorale emissies zijn er nog enkele kleine verschillen met de IPCC-definities, die in de tekst worden toegelicht.
De methodiek voor berekening van CO_2-emissies voor 1994 en voorlopig voor 1995 is dezelfde als die voor de eerste Nederlandse *National Communication* is toegepast en door de Nederlandse regering goedgekeurd voor gebruik ten behoeve van beleidstoepassingen. Deze rapportage bevat ook een herberekening van de CO_2-emissies voor 1993 op basis van deze methodiek. Samen met de CO_2-cijfers uit het achtergronddocument bij de eerste *Netherlands' National Communication on Climate Change Policies,* september 1994, wordt daarmee een consistente reeks 1990-1995 gecompleteerd. Deze methode is ook gebruikt in de *Milieubalans 1996*. Voor andere gassen zijn de cijfers in overeenstemming met dit rapport, op enkele uitzonderingen na die in de tekst worden toegelicht.

Temperatuur-gecorrigeerde kooldioxyde-emissies in 1994 waren 2,8% hoger dan in 1990. In 1994 waren de emissies van methaan 3% lager dan in 1990. De emissies van lachgas stegen in de laatste vier jaar met 11%. Voorlopige cijfers voor 1995 suggereren een significante groei in de kooldioxyde emissies van 3.9% in 1995. De groei van het energiegebruik in 1995 (na temperatuurcorrectie 3,4%) was beduidend groter dan de economische groei (2,1%). Deze groei van CO_2-emissies trad vooral op bij de energiesector, het verkeer en de chemische industrie alsmede door toename in 1995 van het energiegebruik dat niet aan sectoren valt toe te wijzen (de zogenaamde 'statistische verschillen').

In Tabel 8.1 zijn de Nederlandse emissies van broeikasgassen uit antropogene bronnen in CO_2-equivalenten gepresenteerd voor de periode 1990-1995. Bij de interpretatie van de tabel dient het volgende opgemerkt te worden:

- de bijdrage van niet-CO_2 broeikasgassen is tamelijk onzeker;
- de bijdrage van ozon-veroorzakende stoffen en van SO_2 zijn in het geheel niet opgenomen.

Met inachtneming van de eerder genoemde beperkingen kunnen de volgende conclusies worden getrokken:

- de totale emissies in CO_2-equivalenten van de broeikasgassen die onder het Klimaatverdrag vallen zijn tussen 1990 en 1994 met 3% gestegen, voornamelijk door toename van de emissies van CO_2 en van HFK's;
- de emissies van CO_2 nemen toe, met 2.8 % tussen 1990 en 1994;
- de emissies van methaan (CH_4) nemen af met 3% tussen 1990 en 1994;
- de emissies van lachgas (N_2O) nemen toe met circa 11% tussen 1990 en 1994;
- de emissies van HFK's, PFK's en SF_6 nemen toe vanwege de vervanging van CFK's en halonen. Deze toename bedraagt 17% tussen 1990 en 1994. Dit is met name een gevolg van stijgende HFK-emissies en van de emissie van HFK-23 als bijproduct van de productie van HCFK-22;
- de emissies van ozon-veroorzakende stoffen nemen alle af (van -9% tot -16% tussen 1990 en 1994);
- de emissie van SO_2 is substantieel verminderd, met 28% sinds 1990;
- in 1994 was de bijdrage van niet-CO_2 broeikasgassen ongeveer 22%. Methaan had een aandeel van 10%, lachgas van 8%;
- de bijdrage van emissies van HFK's, PFK's en SF_6 bedroeg in 1994 ca. 4%.

In de Appendices A tot C worden de standaard IPCC-tabellen 7A, 7B en 8A gepresenteerd voor 1990, 1994 en 1995 (voorlopig), terwijl in Appendix D de IPCC *Standard Data Tables* 1 tot 7 worden gepresenteerd voor 1994 en 1995 (voorlopig). Tenslotte zijn in de Appendices E en F nog enkele andere tabellen opgenomen over energiegebruik en de emissies van CO_2, CH_4 en N_2O.

1. INTRODUCTION

The United Nations Framework Convention on Climate Change (UN-FCCC) was ratified by the Netherlands in December 1993. One of the obligations is to provide National Communications on emissions, mitigation measures and projections for 2000 and beyond. In August 1994 the First Netherlands' National Communication on Climate Change Policies was published (VROM, 1994). Since then new measures were formulated to mitigate emissions. In 1997 an update will be published by the Netherlands' government. With the European Union, a greenhouse gas monitoring mechanism was established under Council Decision 93/389/EEC. Member states are required to submit annually their inventories of greenhouse gases emissions. A first report for the EU was published in 1995 (Van Amstel, 1995). This is the second report for the EU monitoring mechanism.

The present report has been written at the request of the Netherlands' Ministry of Housing, Spatial Planning and Environment, to comply with the obligations under the Climate Convention and the European Union. It documents the methodology for Greenhouse Gas Inventories for the Climate Convention and for the European Union and it documents the relevant activity levels, the emission factors and the emissions with a focus on the direct greenhouse gases CO_2, CH_4 and N_2O as well as on HFCs and other zero-ODP halocarbons. Time series of emissions for 1990 to 1995 are given.

In the Netherlands different reports have been published on the national emissions of greenhouse gases. A first report for the European Union Monitoring Mechanism was published in September 1995 and concerned the Netherlands greenhouse gas emissions in 1993 and the provisional data for 1994. In that report however, the method used for calculating CO_2 emissions was different from the methods used earlier: detailed emission factors were applied and higher carbon storage in synthetic products was assumed. As a consequence of these different methods, the presented CO_2 emissions for 1993 and provisional for 1994 in that EU report could not be compared with the CO_2 emissions for 1990, 1991 and 1992 published earlier in the first National Communication.

Since September 1995, the CO_2 emissions and method used in the first National Communications (VROM, 1994) has officially been adopted by the Netherlands' government as the only method to be used for policy purposes concerning greenhouse gas emissions. This method was also used in the *Environmental Balance 1996* (RIVM, 1996a,b) and in the *Environmental Programme 1997-2000* (VROM, 1996c). In the *Annual Emissions Report 1996* (in Dutch: EmissieJaarRapport (EJR'96) (VROM, 1996c) this method was not yet applied. Consequently, this report uses that 'first National Communication' method to calculate CO_2 emissions for 1994 and provisionally for 1995. In addition, this report also presents a recalculation of the carbon dioxide emissions for 1993, thereby providing a consistent time series of CO_2 emissions in the Netherlands for 1990-1995.

For other gases, the figures comply with data provided by the *Environmental Balance 1996* (RIVM, 1996a,b), except for a few revisions which are described in the text.

2. DEFINITIONS

2.1 Greenhouse gases

In this report we present emissions estimates for the Netherlands of the direct greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as of 'new' halocarbons such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), fluoroiodicarbons (FICs) and of sulphur hexafluoride (SF_6). In particular HFCs are considered to be so-called zero-ODP substitutes for CFCs and HCFCs. A temperature correction for fuel use for space heating is only applied to CO_2 emissions.

In addition, many other halocarbons are greenhouse gases, such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride (CTC), methyl chloroform (1,1,1 thrichloroethane or MCF) and hydrochlorofluorocarbons (HCFCs). These compounds also have a Ozone Depleting Potential (ODP). Their emissions are only briefly mentioned here since they are already reported in other Conventions (e.g. Montreal Protocol or on Long-Range Transboundary Air Pollution).

Finally, a number of gases such as nitrogen oxide (NO_x), carbon monoxide (CO) and Non-Methane Volatile Organic Compounds (NMVOC) contribute indirectly to global warming, through the formation of tropospheric ozone, which is also a greenhouse gas. Since it is believed that emissions of sulphur dioxide (SO_2) may have a local cooling effect, this compound is also related to the issue of climate change.

In this report emission estimates of these gases in the Netherlands are reported, with a focus on the direct greenhouse gases CO_2, CH_4 and N_2O, and on the emission of zero-ODP halocarbons. For these compounds also the calculation method is briefly discussed. Due to different rounding procedures, the direct sum of sectoral figures may differ slightly from the reported totals.

2.2 Territory; import/export

The territory of the Netherlands from which emissions are reported is the legal territory, including a twelve miles zone from the coastline. It includes emissions from inland water bodies like the IJsselmeer, the estuaries and the Waddensea. Natural emissions are reported, but not included in the national totals. Emissions from offshore oil and gas production at the Netherlands' part of the continental shelf are included. CO_2 emissions from international aviation and sea transport are reported under bunker emissions, and not included in the national totals. Emissions from all electricity generation in the Netherlands are accounted for, including electricity which is exported. Carbon embedded in imported (tropical) wood is not reported.

2.3 Carbon dioxide

Carbon stored in products like plastics and bitumen is estimated from feedstock use and an estimate of percentage storage. Estimates are made of carbon emissions from plastics (and other fossil origin) in incinerated waste. The increase in carbon stock of the forests in the Netherlands is reported. Emission totals are presented with and without subtraction of change in carbon stock. The energy statistics show a small difference between the total national energy consumption (indigenous production + import - export - stock change) and the bottom-up sum of all sectoral energy use. In calculating national carbon dioxide emissions from energy use, this difference (typically < 2%) is included, in accordance to the IPCC guidelines.

In 1995 the government decided to use the international IPCC methodology for all policy purposes, including national policy aims (letter to Parliament about Climate Policy, LE/E/95rw.20B, 15 September 1995). The government also selected 1990 as base year with a national CO_2 emission level of 172.5 Mton, being the temperature-corrected level as reported in the first National Communication (174.0 Mton) under subtraction of the annual increase of carbon stock in forests. In Chapter 3 more details are presented on the differences with methods used earlier.

2.4 Methane

Starting in 1994, the net methane emissions are calculated according to the methods described in Chapter 4. Methane from combustion is estimated using the energy statistics and emission factors from the *Annual Emissions Report 1996* (EmissieJaarRapport, EJR), with figures provided by the Emission Registration system. Methane emissions from oil and gas are estimated for onshore and offshore sites separately. Methane from agriculture is estimated based on emission factors developed in the methane background document (Van Amstel *et al.*, 1993), and agricultural statistics for animal numbers and manure production from the Netherlands' Central Bureau for Statistics (CBS). Methane emissions from landfills are estimated based on a database on landfills maintained at RIVM and a time dependent first order decay function as described by Oonk *et al.* (1994). Methane emissions from agricultural soils are estimated based on the methane background document and are reported as 'natural emissions', as are methane emissions from wetlands and water.

2.5 Nitrous oxide

Starting in 1994, the net nitrous oxide emissions estimate is based on the methods described in the nitrous oxide background document of Kroeze (1994). For emissions from nitric acid production, the estimate is based on measurements at the individual plants as included in the Emission Registration system.

2.6 Halocarbons

In the Netherlands, policy on compounds regulated by the Montreal Protocol is based on *consumption* data of halocarbons as defined according to the Protocol. The focus on consumption instead of emissions is also reflected in trend data on ozone depleting substances annually published by RIVM, which also refers to consumption (or 'potential emissions') and does not present actual emission estimates for halocarbons (RIVM, 1996a,b). However, in the FCCC/IPCC approach the focus is on estimating actual emissions rather than potential emissions. Therefore, in this report we present for these compounds emission estimates, which have been compiled by Matthijsen (1995).

2.7 Netherlands' economic sectors ('target groups') versus IPCC sectors

In the Netherlands, emissions - both from combustion and non-combustion processes - are grouped by so-called target groups (economic sector). In the *'Environmental Balance 1995'* and *'1996'* (RIVM, 1995a,b and 1996a,b) emissions are presented for the period 1990-1995 per target group as calculated by the RIVM's Environmental Planning and Information System RIM$^+$, with data from the Emission Registration project (VROM, 1994-1996). These target groups do not always directly relate to IPCC source categories. The target groups with a different definition are briefly described in Table 2.1:

Table 2.1 Netherlands' target groups and (sub)sectors included.

Target Group	Subsectors included
Waste:	includes landfills and waste incineration; excluding Waste Water Treatment Plants (WWTP), which is a separate target group.
Construction:	construction of buildings and roads.
Residential:	energy use by residential dwellings and residential activities in households.
Drinking water:	drinking water production and distribution.
Energy:	public power generation, oil and gas exploration, production and transmission; excluding refineries and coke production; including joint ventures between industry and energy sector for co-generation.
Commercial:	commercial and public services; excluding drinking water production and distribution, including auto- and co-generators within the commercial sector.
Industry:	including coke production; excluding the construction sector; excluding energy production and processing; also excluding refineries, including auto- and co-generators within the industry.
Agriculture:	including fuel combustion; including indirect emissions from agricultural soils (including natural background emissions, since in measurements they cannot be distinguished from indirect emissions resulting from agricultural activities), including co-generators within the agriculture.
Refineries:	-
Waste Water Treatment Plants	-
Transport:	all modes of transport, including *all* LTO cycles of aircraft; including off-road vehicles, e.g. used for construction and agriculture
Other:	statistical differences and polluted surface waters
Indirect:	actual emissions from feedstocks

In general, emissions from solvent use and cogeneration of heat and power are accounted for in the target groups where they are applied.

For converting the emissions presented per target group to IPCC reporting sectors we used the conversion scheme listed in Table 2.2. Please note that the emissions from coke ovens are included under 'Industry' (except for CO_2) and that off-road emissions are included under 'Transport'. We also note that aircraft emissions included in 'Transport' have not been corrected for the IPCC definition of domestic air transport (except for CO_2).

Table 2.2 Conversion table used for converting emission data grouped by Netherlands' Target Groups into emissions per IPCC sector.

Target Group	Substance	IPCC Sector
Waste	CH_4:	6A. Landfills
	Other:	6C. Waste incineration
Construction	Combustion NMVOC:	included in 1A5. Other
	Combustion other:	included in 1A4a. Commercial/institutional
	Non-combustion:	included in 3. Solvents and other product use
Residentials	Biofuel combustion:	1A6. Biomass burned for energy
	Combustion NMVOC:	1A5. Other
	Combustion other:	1A4b. Residential
	Non-combustion:	included in 3. Solvents and other product use
Drinking Water Treatment		
	CH_4:	7A. Drinking water treatment
	Combustion NMVOC:	included in 1A5. Other
	Combustion other:	included in 1A4a. Commercial/institutional
Energy	Non-combustion :	
	- CH_4:	1B2. Fugitive fuel emissions
	- NMVOC:	1B2. Fugitive fuel emissions
	Remaining CH_4:	1A1. Electricity and heat production
	Remaining NMVOC:	1A5. Other
	Non-combustion CO_2:	included under 2. Industrial processes
	Other:	1A1a. Electricity and heat production
Commercials	Combustion NMVOC:	included in 1A5. Other
	Combustion other:	included in 1A4a. Commercial/institutional
	Non-combustion:	included in 3. Solvents and other product use
Industry [1]	Non-combustion:	
	- NMVOC:	partly included under 2. Industrial processes; remaining included in 3. Solvents and other product use
	- other:	2. Industrial processes
	Combustion CO_2:	coke oven emissions included under 1A1b. Other transformation;
	Remaining part CO_2:	1A2. Industry
	Combustion NMVOC:	included in 1A5. Other
	Combustion other:	1A2. Industry
Agriculture	Non-combustion:	
	- CH_4	4A. Enteric fermentation and 4B. Manure management
	- N_2O:	4D. Agricultural soils
	Combustion CH_4	remaining part under 1A4c. Agriculture /forestry/ fishing
	Combustion N_2O:	remaining part under 1A4c. Agriculture /forestry/ fishing
	Combustion other:	1A4c. Agriculture/forestry/fishing
Refineries	NMVOC:	include under 1B2. Fugitive fuel emissions
	Other:	1A1b. Other transformation
Waste Water Treatment Plants		
	All:	6B. Waste water treatment
Transport [2]	All:	A3. Transport
Other	CO_2:	1A5c. Statistical differences
	N_2O:	7B. Polluted surface waters
Indirect	CO_2:	1A2f. Actual from feedstocks

1) Emissions from coke ovens are included under 'Industry' (except for CO_2).

2) Off-road emissions are included under 'Transport'. Also, aircraft have not been corrected for the IPCC definition of domestic air transport (except for CO_2).

3. CARBON DIOXIDE

3.1 Introduction

The most important anthropogenic source of carbon dioxide is the combustion of fossil fuels. In the Netherlands the fossil fuel production and use is recorded by the Central Bureau of Statistics (CBS) and is published in the Netherlands' Energy Statistics *'Netherlands Energy Housekeeping' (NEH)* (CBS, annual publication) The NEH shows total energy consumption (from indigenous production, import, export, and stock change) as well as total energy demand (bottom-up total of demand per sector). For calculations of national carbon dioxide emissions, the total energy consumption is used. This is done by first calculating emissions from energy demand sectors (Sections 3.2.1. and 3.2.2), and then adding emissions from the statistical difference between supply (total national consumption) and demand (Section 3.2.5). Other anthropogenic sources of carbon dioxide are industrial processes with lime addition (cement, steel, ceramics, glass, flue gas desulphurization; section 3.2.3) and waste incineration (section 3.2.4). In the Netherlands these are small sources and account for less than 2% of the total carbon dioxide emissions.

3.2 Emissions

In September 1995, the Netherlands' government decided to report national greenhouse gas emissions for all policy purposes according to the international IPCC methodology, as was also applied in the first National Communication (VROM, 1994b). This document also reports carbon dioxide emissions according to this methodology and is in accordance with the *Environmental Programme 1997-2000* (VROM, 1996*), Second Memorandum on Climate Change* (VROM, 1996) and *Environmental Balance 1996* (MB'96, RIVM, 1996a,b). However, sectors according to IPCC format (see Section 2.7) differ from Netherlands' target groups used for environmental policy purposes. While the national total carbon dioxide emissions in both reports are the same, small differences between emissions per IPCC sector (this report) and per target group (MB'96) exist. The emissions reported here also differ from published figures in the *Annual Environmental Report 1996* (in Dutch: EmissieJaarRapport [EJR]) (VROM, 1996), in which a far more detailed bottom-up inventory of actual carbon dioxide emissions was used.

Last years' report to the EU monitoring mechanism (Van Amstel, 1995) also used an modified methodology to calculate carbon dioxide emissions: detailed emissions factors were used and an increased storage of carbon in synthetic products was assumed. Therefore CO_2 figures for 1993 and 1994 from that first Netherlands' EU report can *not* be compared with the 'official' figures for 1990, 1991 and 1992 as published in the first National Communication. For this reason, a complete, consistent set of carbon dioxide emissions 1990-1995 is presented here, calculated according to the officially adopted 'first National Communication methodology'. This series includes a recalculation of the values for 1993 and 1994 as earlier presented in the EU report submitted last year.

Total Netherlands' carbon dioxide emissions are listed for 1990-1995 in Table 3.1.a. Carbon dioxide emissions have constantly increased since the economic crisis in 1982-1983. In the Netherlands, carbon stock in growing forests is part of greenhouse gas mitigation efforts. Therefore national policy strategies are related to emission levels that take into account the carbon sink in forests. This level ('net emissions') is presented as well. Detailed tables are provided in Appendix E. In the following sections the different sources of carbon dioxide emissions will be subsequently discussed.

Table 3.1.a Carbon dioxide emissions [Mton] in the Netherlands per IPCC sector, 1990-1995. Data for 1995 are preliminary.

IPCC sector	1990	1991	1992	1993	1994	1995
1. All energy combustion and fugitive	**164.8**	**171.2**	**169.3**	**173.1**	**172.2**	**180.4**
A. Fuel combustion total	164.8	171.2	169.3	173.1	172.2	180.4
Energy and transformation	51.5	52.9	53.2	54.6	57.6	59.7
Industry: combustion	33.5	32.4	34.4	34.2	31.9	33.5
Industry: actual from feedstocks	14.8	15.6	14.9	12.7	14.3	14.0
Transport	26.8	26.9	28.0	28.5	29.0	30.1
Commercial/Institutional	10.6	12.3	11.5	12.3	10.9	11.3
Residential	19.2	21.7	19.5	20.6	19.6	20.7
Agriculture/Forestry	7.5	8.4	8.5	8.7	8.7	9.0
Statistical differences	1.1	1.0	-0.4	1.6	0.6	2.5
(temperature correction)	(6.4)	(0.4)	(4.5)	(1.2)	(3.8)	(2.5)
2. Industrial processes	**1.9**	**1.8**	**1.8**	**1.9**	**2.0**	**2.1**
A. Iron and steel	0.7	0.7	0.7	0.8	0.8	0.8
B. Non-metallic mineral products	1.0	0.9	1.0	1.0	1.0	1.0
F. Other	0.2	0.2	0.1	0.1	0.2	0.3
5. Land-use change and forestry	**(-1.5)**	**(-1.6)**	**(-1.6)**	**(-1.6)**	**(-1.7)**	**(-1.7)**
A. Temperate forests biomass change	(-1.5	(-1.6)	(-1.6)	(-1.6)	(-1.7)	(-1.7)
6. Waste	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**
C. Waste incineration	0.9	0.9	0.9	0.9	0.9	0.9
Total CO_2 emissions (= 1+2+6)	**167.6**	**174.1**	**172.1**	**175.9**	**175.1**	**183.4**
Total CO_2 emissions (= 1+2+6), temp.corrected	174.0	174.5	176.6	177.1	178.9	185.9
Net CO_2 emissions (= 1+2+5+6), temp.corrected	172.5	173.0	175.1	175.5	177.2	184.2

(Source: RIVM 1996a)

Sectors and target groups

Although total carbon dioxide emissions reported here are equal to those reported in the *Environmental Balance 1996,* there are differences due to the different definitions of IPCC sectors and Netherlands' target groups. Key differences are:

- Coke ovens, with 1.4 Mton CO_2 emissions (1994), are part of the energy sector. In *Environmental Balance 1996* however, coke ovens are part of the target group 'Industry'.
- Also the refineries are part of the energy sector (1994: 13.2 Mton CO_2), but for the Netherlands' environmental policy they are a target group of their own. Therefore, in the *Environmental Balance 1996* the carbon dioxide emissions of the target group 'Energy sector' is about 14.6 Mton smaller than reported here for the energy sector.

- In the *Environmental Balance 1996*, carbon dioxide emissions for traffic were calculated from fuel consumption figures that were based on estimates of total vehicle-km (passengers) and ton-km (freight). Also, *all* Landing and Take-Off (LTO) cycles at airports were included. In this report however, carbon dioxide emissions for traffic are calculated - according to *the IPCC Guidelines* - from total fuel for mobile sources sold within the Netherlands. Therefore figures for 1994 reported here are about 40 PJ (3.0 Mton carbon dioxide) smaller than in the *Environmental Balance 1996.*
- In the *Environmental Balance 1996*, total carbon dioxide emissions were calculated according to the *IPCC-Guidelines.* With this boundery condition, the too high fuel consumption within the traffic sector was chosen to be compensated for in the service sector. Therefore, carbon dioxide emissions reported here are about 3 Mton higher than in the *Environmental Balance 1996* (data for 1994).

To illustrate these differences, emission totals according to Netherlands' target group definitions and the *Environmental Balance 1996* are listed below (Table 3.1.b).

Table 3.1.b Carbon dioxide emissions [Mton] in the Netherlands per target group, 1990-1995, temperature corrected. Data for 1995 are preliminary figures.

Target group	1990	1991	1992	1993	1994	1995
Energy sector	38.2	38.7	39.4	40.0	42.9	44.9
Refineries	12.0	12.8	12.5	13.1	13.2	13.4
Industry	52.0	51.3	53.0	50.3	49.9	51.1
Transport	29.5	30.2	30.8	31.7	32.2	33.1
Commercial/Institutional* +Construction+WWTP	8.9	8.6	8.9	8.7	8.0	8.3
Residential	22.3	21.9	21.6	21.2	21.4	21.9
Agriculture/Forestry	8.6	8.5	9.4	9.0	9.3	9.3
Waste management	1.4	1.4	1.4	1.4	1.4	1.4
Statistical differences	1.1	1.0	-0.4	1.6	0.6	2.5
Total carbon dioxide emissions	**174.0**	**174.5**	**176.6**	**177.1**	**178.9**	**185.9**

(Source: RIVM (1996a,b) [RIM+])

* The allocation to the service sector and to agriculture has been slightly changed (without changing the total) after completion of RIVM (1996a,b).

3.2.1 Energy: combustion and transformation [1A]

All carbon dioxide emissions from energy use are top-down calculated on basis of the Netherlands' Energy Statistics. These include all combustion emissions and process emissions from the use of energy carriers. Aggregated emission factors for coal, oil and gas are used (Table 3.2).

Table 3.2 Aggregated emission factors for carbon dioxide.

Energy carrier	Emission factor [kg/GJ]
coal	94
oil	73
natural gas	56

(Source: CBS).

According to the Netherlands' Energy Statistics, energy demand is divided in four categories: 1) energy transformation in combined heat and power (CHP) installations, 2) all other energy transformation, 3) final use for energetic purposes (mainly combustion for generation of heat), 4) final use as chemical feedstock. Energy use from the first three categories is assumed to result entirely in carbon dioxide emissions, using the aggregated factors of Table 3.2. The increase of coal consumption in 1994 and 1995 is mainly due to new coal-fired power plants. Oil consumption grew rapidly because of increased road traffic and volume developments in industry and refineries. Natural gas consumption was relatively constant in the industrial sector but increased in the energy sector, mainly due to new CHP plants which are installed as joint-ventures with the industry. Detailed energy statistics are shown in Appendix *E*.

Table 3.3 Non-feedstock energy demand by sectors in the Netherlands, corrected for temperature effects, excluding statistical differences, 1990-1995. Data for 1995 are preliminary.

Energy carrier	unit	1990	1991	1992	1993	1994	1995
coal	[PJ]	356	328	325	327	335	367
oil	[PJ]	654	656	691	709	721	745
gas	[PJ]	1322	1362	1396	1384	1374	1385
other	[PJ]	95	95	106	110	113	116
TOTAL	**[PJ]**	**2427**	**2441**	**2518**	**2530**	**2543**	**2603**

(Source: CBS).

Temperature correction

In the Netherlands, a significant part of the energy consumption is used for space heating. Despite the moderate sea climate, the energy consumption in cold winters is substantially higher than in mild winters, leading to a disturbance of the CO_2 trend of up to 5%. For policy purposes however it is desired to separate these climatic disturbances from fluctuations in CO_2 emissions due tot other causes like economic developments, efficiency improvements and policy measures. Therefore, the Netherlands' CO_2 emissions are corrected for outside temperature variations, using a method outlined below (Zonneveld, 1995).

Nearly 100% of space heating in the Netherlands is based on natural gas. Therefore it is assumed that only gas consumption for space heating is sensitive to the outside temperature. For each economic sector, the fraction of gas consumption applied for space heating is estimated: this is the sectoral ***application factor***, listed in Table 3.4. Furthermore, it is assumed that indoor space heating takes place when outdoor temperatures are below 18° C.

The annual need for space heating is expressed in the number of degree days. This number is defined as $\Sigma_i (18-T_i)$, where T_i is the average temperature at any day *i* below 18°C. A thirty-year moving average is calculated for this indicator, which serves as the reference value ('normal value') for year *t*. The ratio of the 'normal' and actual value of the degree days number expresses the ***correction factor*** for space heating gas consumption in year *t* (Table 3.5). Thus, the corrected natural gas consumption $E_{s,\ corr}(t)$ is calculated by multiplication of the sectoral consumption $E_s(t)$ with the sectoral application factor A_s, and the correction factor C(t):

$$E_{s,corr}(t) = E_s(t) . A_s . C(t).$$

In Table 3.5 the temperature correction per sector is presented. As can be seen, almost 50% of the total correction takes place in the residential sector. Other important sectors are commercial and public services, and agriculture (greenhouse horticulture). For all years the correction has a positive sign, indicating that all winters in the period 1990-1995 were milder than in the previous thirty years. The tendency towards milder winters is also reflected in the thirty-year moving average of degree days: it has decreased about 100 degree days since the early eighties (Appendix E). This effect is responsible for a smaller correction of natural gas consumption of about 20 PJ, which is equivalent to about 1 Mton CO_2.

Table 3.4 Fraction of natural gas consumption for space heating, per sector.

Sector	Application factor
Residential dwellings	0.85
Commercial and public services	0.80
Agriculture	0.80
Industry	0.16
Energy sector	0.05

(Source: CBS)

Table 3.5 Temperature correction of carbon dioxide emissions per sector in Mton, 1990-1995. Data for 1995 are preliminary figures.

Sector	1990	1991	1992	1993	1994	1995
Residential dwellings	3.1	0.2	2.1	0.6	1.8	1.2
Commercial and public services	1.2	0.1	0.9	0.2	0.8	0.6
Agriculture	1.2	0.1	0.9	0.2	0.7	0.4
Industry	0.6	0.0	0.4	0.1	0.3	0.2
Energy sector	0.1	0.0	0.1	0.0	0.1	0.1
Total CO_2 correction	**6.4**	**0.4**	**4.5**	**1.2**	**3.8**	**2.5**

Statistical differences [Other, 1A5a]

The total national energy consumption is equal to the bottom-up total of all energy use by sectors (total energy demand) plus the so-called statistical differences, which is defined as energy consumption not registered within any sector. The fuel used through statistical differences is assumed to be entirely incinerated into carbon dioxide because there is no reason to assume any storage. The statistical difference between supply and demand is usually smaller than 2%. Per energy carrier however, the difference between supply and demand may vary in both sign and size, as shown in Table 3.6.

Table 3.6 Carbon dioxide emissions from statistical differences, 1990-1995.

Energy carrier	Unit	1990	1991	1992	1993	1994	1995
coal	[PJ]	7	0	-4	9	-9	15
oil	[PJ]	16	25	15	26	26	28
gas	[PJ]	-13	-14	-20	-20	-8	-17
total fossil fuel	[PJ]	10	11	-9	15	8	26
CO_2 from stat. differences	**[Mton]**	**1.1**	**1.0**	**-0.4**	**1.6**	**0.6**	**2.5**

(Source: CBS)

Energy use for feedstocks [Industry, 1A2]

Feedstock use of energy carriers, the fourth category of energy use, only partially results in CO_2 emissions. A fraction of the energy carrier is stored in products like plastics or asphalt. These fractions are listed in Table 3.7. The non-stored fraction of the carbon in the energy carrier or product is oxidised, resulting in carbon dioxide emissions, either during the use of the energy carrier in the industrial process (e.g. fertiliser production), or during use of the product (e.g. solvents, lubricants), or in both (e.g. monomers). These emissions are categorised as industrial process emissions.

Using this table and the feedstock use of fossil energy carriers according to the National Energy Statistics, the actual emissions are estimated (Table 3.8). These emissions mainly stem from the fertiliser industry and the organic chemistry, a sector extremely sensitive for conjunctural developments. In 1992 and 1993 the production volume dropped, but the sector recovered in 1994 and 1995. In 1994, feedstocks from coal were significantly larger than in other years, leading to about 1.3 Mton of extra feedstock emissions. In 1995, however, coal feedstocks were back to 'normal' levels. This was partly compensated by the increase of feedstock emissions in the organic chemistry. Appendix E gives more detailed information on the use of energy carriers and products that lead to actual CO_2 emissions.

Table 3.7 Emission factors for carbon dioxide from feedstock use of energy carriers.

Energy carrier/product	Emission factor CO_2 [kg /GJ]	Fraction stored [%]	Emitted during production [%]	Emitted during use [%]
coal and coke (steel industry)	*94*	0	0	100
coal (other)	*94*	100	0	0
natural gas (fertiliser)	*56*	0	100	0
natural gas (other)	*56*	55	20	25
solvents	*73*	0	0	100
monomers	*73*	55	20	25
lubricants	*73*	0	0	100
bitumen	*73*	100	0	0
petroleum cokes	*73*	0	0	100

(Source: Van Amstel *et al.*, 1994)

Table 3.8 Actual carbon dioxide emissions from feedstock use of fossil energy in Mton, 1990-1995. Data for 1995 are preliminary.

Energy carrier	1990	1991	1992	1993	1994	1995
coal	0.4	0.4	0.4	0.3	1.7	0.4
oil products	10.0	10.5	9.7	7.7	7.7	8.6
natural gas	4.4	4.9	4.9	4.7	4.9	5.1
CO_2 from feedstocks	**14.8**	**15.6**	**14.9**	**12.7**	**14.3**	**14.0**

(Source: CBS; Van Amstel *et al.*, 1994)

3.2.2 Industrial non-energy process emissions [2]

When using lime in high-temperature industrial processes, the carbonate is thermally destroyed and carbon dioxide is formed, including long-cycle carbon. Mineral carbon dioxide emissions from limestone were estimated to be 1.9 Mton in 1990 (Van Amstel *et al.*, 1994). This was calculated from a total use of 2.45 mln ton of lime and an emission factor of 0.8 ton CO_2 per ton pure lime. For 1994 and 1995 the consumption growth of lime is estimated to be mainly due to increased flue gas desulphurization at coal-fired power stations. For 1994 and 1995, total emissions from lime are estimated to be 2.0 and 2.1 Mton carbon dioxide respectively (Table 3.9). The CO_2 emissions from cement production in the Netherlands are based on clinker production data, since this process is responsible for the process emission of CO_2 and about half of the clinker used for cement production in the Netherlands is imported.

Table 3.9 Carbon dioxide emissions [Mton] from lime use. Data for 1995 are preliminary figures.

Process	1990	1991	1992	1993	1994	1995
2A. Iron and steel production	0.7	0.7	0.7	0.8	0.8	0.8
2E.1 Clinker production (cement)	0.8	0.7	0.7	0.7	0.7	0.7
2E.3 Glass manufacture	0.2	0.2	0.3	0.3	0.3	0.3
2F. Flue gas desulphurization	0.2	0.2	0.1	0.1	0.2	0.3
Total CO_2	**1.9**	**1.8**	**1.8**	**1.9**	**2.0**	**2.1**

3.2.3 Waste incineration [6C]

The total amount of carbon dioxide emissions from the incineration of synthetics, i.e. materials containing long cycle (fossil) carbon, is estimated at 0.9 Mton yearly. This estimate is based on an analysis of waste streams in the Neteherlands and the amount of fossil carbon in these waste streams for 1990 (De Jager and Blok, 1993). In this report it was assumed that 4313 kton of waste was incinerated with 888 kton of carbon content. Only 27% of this carbon (= 240 kton) was of fossil origin, resulting in 880 kton (0.9 Mton) 'fossil' carbon dioxide emissions. This figure can be expected to be relatively stable. The amount of incinerated waste is increasing, but mainly due to more materials with short-cycle carbon. This is the result of the policy to prohibit landfill destination of waste that can be burned. Therefore the figure of 0.9 Mton CO_2 is used until new data become available.

3.3 Sink: forestry and other [5A2, 5A5]

The carbon sink in biomass mainly refers to the net growth of forests and other trees in the Netherlands. On an average, Netherlands' trees are getting older and heavier. Besides this maturing of the forests, the total forest area is increasing because of forest extension. These relatively young plantations show the largest annual volume increment per acre. However, besides growth of forests there are also fellings which reduce part of the volume increment of biomass. For calculating the carbon sink in Netherlands' biomass, the following data were used:

Table 3.10 Data for calculating carbon sink through increment of woody mass (all data for 1994).

Total 'forest' area in the Netherlands including all trees:	439.000 ha
Average volume increment per year (trunks only)	7.9 m^3/ha, slowly decreasing
Average fellings per year (trunks only)	4.45 m^3/ha , decreasing
Specific mass of dry matter and carbon content in dry matter	0.5 ton/m^3, 50% C (mass)

(Source: Foundation Forest and Wood, 1995; LNV)

When these data are applied and fellings are subtracted, a volume increment of 1.51 million m^3 is calculated from tree trunks only. However, the volume of a tree is supposed to be 20% more due to roots, branches and tree tops. After this correction, a net volume gain of 1.81 million m^3 in 1994 was calculated, containing 0.45 Mton of carbon, the equivalent of 1.7 Mton of carbon dioxide. In earlier reports the carbon sink was estimated at about 0.12 Mton CO_2 (VROM, 1994). This was based on the sink of the extra area and tree types planted in the Netherlands (forest extension only). Since 1990, a slow reduction in growthrate (because forests are maturing) is slightly overcompensated by the planting of fast growing species like poplar and douglas. Fellings are reduced in recent years. For 1994 and 1995, the carbon sink in forests was therefore estimated to be equivalent to 1.7 Mton CO_2 (Table 3.11).

Table 3.11 Carbon dioxide sink from change of biomass stock, 1990-1995. Data for 1995 are preliminary figures.

	unit	1990	1991	1992	1993	1994	1995
Specific volume increment	[m^3/ha]	8.12	7.97	7.82	7.85	7.88	7.90
Specific fellings	[m^3/ha]	5.12	4.63	4.63	4.52	4.45	4.40
Net volume increment	[10^6 m^3]	1.58	1.76	1.68	1.75	1.81	1.84
Carbon dioxide	[Mton]	**-1.5**	**-1.6**	**-1.6**	**-1.6**	**-1.7**	**-1.7**

3.4 Bunkers

Air and marine bunkers also contribute to the emission of anthropogenic carbon dioxide. International emissions from Netherlands' bunkers are relatively large when compared with national carbon dioxide emissions (e.g. 24% in 1994). This is partly due to the fact that Rotterdam is the worlds' largest marine bunker location. Also, because of relatively low kerosene prices, Amsterdam airport is Europe's largest air bunker location. As can be seen from Table 3.12, air bunkers have increased over 50% since 1990. The following emission factors have been applied: 77 kg/GJ for marine bunkers and 73 kg/GJ for air bunkers.

Table 3.12 Bunkers and international carbon dioxide emissions, 1990-1995. Data for 1995 are preliminary figures.

Category	Unit	1990	1991	1992	1993	1994	1995
Marine bunkers	[PJ]	466	476	478	495	474	487
Air bunkers	[PJ]	61	68	81	89	92	97
Total bunkers	[PJ]	527	544	559	584	566	584
Marine bunkers CO_2	[Mton]	35.9	36.7	36.8	38.1	36.5	37.5
Air bunkers CO_2	[Mton]	4.5	5.0	5.9	6.5	6.7	7.1
Total bunkers CO_2	[Mton]	**40.4**	**41.7**	**42.7**	**44.6**	**43.2**	**44.6**

(source: CBS)

4. METHANE

4.1 Introduction

The method for estimating methane emissions has been based on Van Amstel *et al.* (1993). The methodology is in general according to IPCC (IPCC, 1994). If differences with the IPCC methodology occur they are explicitly addressed. The largest sources of methane emissions in the Netherlands are waste in landfills (374 Gg), agriculture (ruminants 382 Gg and animal waste 101 Gg), and the production and transmission of oil and gas (169 Gg). A minor source is fuel combustion (31 Gg). These sources are described below [IPCC source categories between brackets]. Emissions from agricultural waste burning and from the combustion of wood and wood waste for energy purposes by the industry are currently not accounted for.

4.2 Emissions

In Table 4.1 the CH_4 emissions are summarised per source category for the period 1990-1995, as used in RIVM (1996a,b). Methods for the estimation of methane emissions are described in a background document (Van Amstel *et al.*, 1993) and summarised by Van Amstel *et al.* (1994). Some assumptions are different from earlier estimates and new information on emission factors have been used in some cases:

- Methane emissions from oil and gas production have been completely revised by using separate emission factors for onshore and offshore production, which differ substantially due to different flaring and venting practices. These data comply with data used in the sectoral analysis made in RIVM (1996a,b); however, the summary table for methane in that report erroneously shows other figures. Also, for the 1995 estimate revised preliminary production data are use.
- Methane emissions from transport are estimated as a percentage of total VOC per process per fuel type.
- Also for the agricultural sector new statistical information about manure production has become available. Previous calculations underestimated manure production by beef cattle. On average, annual agricultural emissions are now 5% higher than earlier estimates. Therefore a revision was made for all years, including 1990 (see Table 4.4, updated 1990 figure: 102.5 mln kg).
- In the residential sector, methane emissions from space heating by biofuel (about 4 kton) have been included from 1994. For maintaining a consistent time series, the figures for previous years have been revised to include this source. This was not yet done in RIVM (1996a,b).
- For drinking water production, data for 1994-1995 were corrected after completion of RIVM (1996a,b).

The development of total methane emissions in 1994 relative to 1993, which is almost zero (increase of 0.7%), is mainly the result of four effects which compensate each other:

1. a strong increase of 9.9 kton (+32%) in 1994 of methane emissions from offshore production of natural gas, which contributed in 1993 about 40% to the total emission of the energy sector;
2. a decrease of 9.9 kton (-12%) in 1994 due to transport and distribution, because of the relatively warm winter (causing 8% less gas consumption) as well as a decrease of 4% in the emission factor for gas distribution;
3. a decrease of 11.1 kton (about 3%) of methane emitted by ruminants, due to less numbers of animals, in particular of dairy cattle (e.g. 7.1 kton from females and young females >1 year) and beef cattle (e.g. 1.8 kton by steers);
4. a decrease of 4.2 kton (about 4%) of manure emissions due to less manure production, in particular by fattening pigs (1.7 kton), poultry (laying hens) (1 kton), and beef cattle in stables (1 kton).

Other factors which influenced the development of total methane emissions are discontinuities in sectoral time series (commercial and drinking-water production sectors (-6 and +2 kton, respectively).

Table 4.1 Methane emissions per source category in the Netherlands, 1990-1995 [in mln kg].

Sector	1990	1991	1992	1993	1994	1995*
1 A. Energy: fuel combustion total	33.1	33.7	33.1	32.9	30.7	30.7
1A1. Electricity and other transformation	*0.3*	*0.4*	*0.4*	*0.4*	*0.5*	*0.4*
1A2. Industry (only energy)	*2.7*	*2.9*	*2.9*	*2.6*	*2.5*	*2.4*
1A3. Transport	*7.2*	*6.5*	*6.4*	*6.1*	*6.2*	*5.9*
*1A4. Residentials, Comm./Instit., Agric. ****	*19.2*	*20.1*	*19.6*	*20.0*	*17.6*	*18.1*
1A5. Other	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1A6. Biomass burned for energy	*3.7*	*3.7*	*3.8*	*3.8*	*3.9*	*3.9*
1 B. Energy: fugitive fuel emissions **	178.5	186.7	162.9	157.8	169.2	170.1
2. Industrial processes	5.8	6.2	6.1	5.6	5.3	5.0
3. Solvents and other product use	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	505.0	517.0	505.0	497.0	482.3	475.4
5. Land use change and forestry	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	379.4	378.0	376.0	375.0	379.1	379.5
7. Other (production of drinking water) ****	2.0	2.0	2.0	2.0	2.0	2.0
TOTAL	**1103.8**	**1123.6**	**1085.1**	**1070.3**	**1068.6**	**1062.7**

(Source: RIVM (1996a,b) [RIM+], with exceptions as specified below)

* Data for 1995 are preliminary figures.

** Data are in compliance with data used in sectoral analysis made in RIVM (1996a,b), but they differ (in particular for 1990) from the figures in the summary table for CH4 published in that report. Data for 1995 are based on production data which were revised after completion of VROM (1996a,b). Not corrected for possible partial conversion in the soil by bacteria before the methane is emitted to the air.

*** Data for 1990-1993 for the residential sector were revised after completion of RIVM (1996a,b).

**** Data for 1994-1995 were revised after completion of RIVM (1996a,b).

Methane from fuel combustion [1A]

Emissions factors for methane from fuel combustion are not estimated separately, but derived from the emission factors of total VOC, based on the assumed fraction in the compound group profile of total VOC. Emission factors for VOC were determined partly by direct measurements, as in the case of large point sources, and partly based on literature (*Bakkum et al.*, 1987, for stationary sources, and Veldt and Van der Most, 1993, for mobile sources). The VOC profiles used are also based on these references. In Table 4.2 the methane fractions in the total VOC profile are shown for specific fuel type/source combinations, used to derive the methane emission factor from the emission factor of total VOC for the various VOC sources. We note, that emissions from the combustion of wood and wood waste for energy purposes are for the residential sector only; industrial emissions from biofuel use are not yet accounted for.

Table 4.2 Emission factors for methane: CH_4 as fraction in total VOC profile.

Sector	Basic fuel type	Fuel type	Fraction of total VOC
Stationary sources	Solid fuel	coal and coal products	0.50
		wood	0.25
	Liquid fuel	all oil products	0.20
	Gaseous fuel	natural gas	0.60
		LPG	0.35
		other gases	0.35
Mobile sources	Liquid fuel	oil products	0.20
		gasoline (w/o catalyst)	0.05
		gasoline (with catalyst)	0.12
		diesel (LDV)	0.04
		diesel (HDV)	0.04
		LPG	0.03
		moped	0.05
		unknown type	0.05
		jet engine	0.10

(Source: Van der Auweraert [TNO-MEP], pers. comm., 1996)

Methane emissions from oil and gas [1B2]

Tables 4.3 shows the emission factors used in the emission calculation, which are aggregated values, including venting and flaring practices, both as percentage of the gas or oil volume handled and as g/GJ. For the conversion, one standard cubic metre of natural gas is assumed to contain 0.58 kg CH_4 and one standard m^3 of oil is equivalent to 0.89 ton oil; one ton oil being 41.87 GJ. Table 4.2 shows the emissions in the Netherlands in the period 1980-1995, estimated according to the IPCC method (IPCC, 1995) and using specific Netherlands' emission factors. The emission estimates are based on the emission factors presented in Table 4.3 and on the amounts of oil and gas produced, transported and distributed as presented in Table 4.4. The emissions from gas distribution are not corrected for possible partial conversion in the soil before the methane is emitted into the atmosphere, which may occur when specific bacteria are present.

Table 4.3 Emission factors for methane from oil and gas production and transmission in the Netherlands 1990-1995. Data for 1995 are preliminary figures.

Year	Natural gas					Oil		
	Production Onshore	Offshore	Weighted Total	Transport	Distribution	Production Onshore	Offshore	Weighted Total
	Emission factors in % of volume**							
1990	0.041	0.70	0.20	0.015	0.60	5.00	2.95	3.59
1991	0.034	0.69	0.18	0.014	0.58	4.00	2.70	3.10
1992	0.017	0.66	0.15	0.014	0.56	2.50	2.30	2.38
1993	0.009	0.63	0.14	0.013	0.54	1.30	1.95	1.67
1994	0.009	0.62	0.19	0.013	0.52	1.25	1.88	1.69
1995*	0.009	0.62	0.19	0.012	0.50	1.25	1.88	1.67
	Emission factors in g/GJ							
1990	7.6	127.7	37.2	2.8	110.5	134.2	79.2	96.4
1991	6.3	126.4	33.6	2.6	106.9	107.3	72.5	83.3
1992	3.2	121.7	27.9	2.5	103.2	67.1	61.7	63.9
1993	1.6	115.3	25.8	2.4	99.5	34.9	52.3	44.8
1994	1.6	114.4	35.5	2.3	95.8	33.5	50.5	45.3
1995*	1.6	114.4	35.3	2.2	92.1	33.5	50.5	44.8

Note: Emission factors are in compliance with data used in sectoral analysis made in RIVM (1996a,b), which differ from the data used to compile the summary table for CH_4 published in that report.

* Data for 1995 are preliminary figures.

** Equivalent %, for gas production including emissions due to flaring.

For more information see Table F.1.

Table 4.4.a Activity data for oil and gas production and transmission in the Netherlands 1990-1995.

Year	Natural gas [10^9 m^3]					Oil [10^6 m^3]		
	Production Onshore	Offshore	Total	Transport	Distribution	Production Onshore	Offshore	Total
1990	54.6	17.9	72.4	72.4	20.7	1.2	2.75	3.99
1991	63.7	18.7	82.4	82.4	24.0	1.1	2.53	3.67
1992	65.7	17.3	83.0	83.8	23.1	1.3	1.92	3.21
1993	66.2	17.9	84.0	84.0	24.8	1.3	1.71	3.01
1994	54.9	23.6	78.4	78.4	22.7	1.2	2.81	4.02
1995*	56.2	24.0	80.2	79.3	23.9	1.0	2.02	3.05

* Data for 1995 are preliminary figures, based on production data which were revised after completion of VROM (1996a,b).

For a time series 1980-1995 see Table F.2.

Recently, methane emissions from oil and gas operations are estimated separately for onshore and for offshore activities (Oonk and Vosbeek, 1995). For 1994, the emission factor for offshore oil and gas production is 52 and 115 g/GJ, respectively. At onshore sites less methane is emitted because in most cases flaring is practised. The emission factors for onshore oil and gas production are 34 and 2 g/GJ, respectively. The large difference between onshore and offshore factors can be explained by the fact that in offshore activities gas venting thus of methane, is predominant, because flaring is considered to be too dangerous. Table 4.3 also clearly shows, that leaks in the gas distribution system are responsible for an emission factor which is similar to the factor for offshore gas production.

Table 4.4.b. Methane emissions [mln kg] from oil and gas production and transmission in the Netherlands 1990-1995. Data for 1995 are preliminary figures, based on production data which were revised after completion of RIVM (1996a,b).

Year	Natural gas						Oil			Total
	Production			Transport	Distribution	Total	Production		Total	
	Onshore	Offshore	Total		*	Gas	Onshore	Offshore	Oil	Oil + gas
1990	13.1	72.2	85.2	6.3	72.6	164.2	6.2	8.1	14.3	178.5
1991	12.7	74.8	87.5	6.7	81.1	175.3	4.6	6.8	11.4	186.7
1992	6.6	66.6	73.2	6.6	75.4	155.2	3.2	4.4	7.6	162.9
1993	3.3	65.2	68.5	6.4	77.9	152.8	1.7	3.3	5.0	157.8
1994	2.7	85.3	88.0	5.7	68.7	162.4	1.5	5.3	6.8	169.2
1995	2.8	86.9	89.7	5.5	69.7	165.0	1.3	3.8	5.1	170.1

* Not corrected for possible partial conversion in the soil by bacteria before the methane is emitted to the air.
For a time series 1980-1995 see Table F.3.

Methane emissions from enteric fermentation of ruminants [4A]
Enteric fermentation produces methane that escapes the ruminants e.g. through belching. In the recommended IPCC methodology for cattle, emission factors are based on the weight of the animals and the energy intake for maintenance and milk/meat production. Calculated emission factors are given in Table 4.5. Information on the calculation procedure can be found in Van Amstel *et al.* (1993). Recommended emission factors for the other animal types are adopted from IPCC. Numbers of animals are based on the official Netherlands agricultural statistics. In Table 4.5 the emission calculation for methane from enteric fermentation and manure is summarised for the period 1980-1995.

Methane emissions from animal waste [4A]
Methane from animal manure escapes during anaerobic storage and resulting fermentation. These circumstances exist in manure collected in tanks or silos outside or under the stables. Also during the meadow period part of the manure produced is collected in these same storage's since part of the dairy cattle is kept inside, while the fresh grass is cut and directly fed. It is estimated that 30% of the manure from the meadow period of dairy cattle is collected in the stables, because animals are kept inside. Emission factors are calculated according to the IPCC method from the volatile solids fraction and the emission potential of different manure types. The methane fraction that is emitted from the potential is assumed lower than the IPCC defaults (dairy cattle 5%, others 10%). The resulting emission factors are:

- 0.698 kg/m^3 for dairy cattle manure that is collected in covered silos near the stable;
- 2.534 kg/m^3 for beef cattle/calves manure that is collected in silos near the stable;

- 3 kg/m^3 for manure from pigs, sheep and goats; from pigs it is collected under the stables, under relatively warm circumstances;
- 4.11 kg/m^3 for poultry manure.

The manure production data are based on a recent research of LEI-DLO, IKC-Landbouw, RIVM and CBS (Van den Hoek *et al.*, 1997). For cattle it is assumed that 30% of the manure produced in the meadow period still ends up in the storage silos. This is because part of the herd is kept inside in the summer period. Previous calculations underestimated manure production by beef cattle.

Table 4.5. Methane emissions from enteric fermentation of ruminants in the Netherlands 1990-1995. Data for 1995 are preliminary figures.

Animal type/ subtype	Em. factor (kg/head/yr)	Emission (mln kg) 1990	1991	1992	1993	1994	1995
Dairy cattle							
- young <1 yr	49.25	39.7	40.4	38.1	36.3	36.2	36.5
- young female >1yr	62.80	55.2	57.0	56.1	52.5	50.4	50.7
- female	102.13	191.8	189.2	181.3	178.4	173.4	174.4
- male >1yr	93.22	4.0	4.4	4.5	3.8	3.8	3.9
Beef cattle							
- calves	17.65	10.6	11.0	11.3	11.6	12.2	11.8
- steers	87.01	52.1	58.6	56.2	54.3	52.5	47.07
- female >1yr	102.13	12.2	14.2	14.9	16.0	14.9	14.91
Sheep	8.00	13.6	15.1	15.6	15.3	14.1	13.39
Goats	8.00	0.5	0.6	0.5	0.5	0.5	0.608
Pigs	1.50	20.9	19.8	21.2	22.4	21.6	21.6
Horses	18.00	1.3	1.4	1.6	1.7	1.8	1.8
TOTAL		**401.9**	**411.7**	**401.3**	**392.8**	**381.7**	**376.7**

Table 4.6 Methane emissions from animal waste in the Netherlands 1990-1995. Data for 1995 are preliminary figures.

Animal type	Emission factor (kg/m^3)	Emission (mln kg) 1990	1991	1992	1993	1994	1995
Dairy cattle	0.698	25.5	25.4	24.5	23.8	23.1	23.3
Beef cattle	2.534	11.9	13.6	13.4	13.2	12.1	11.2
Sheep & goats	2.979	0.8	0.8	0.8	0.8	0.8	0.7
Fattening calves	2.534	5.3	5.5	5.7	5.8	6.1	5.9
Pigs	3.009	49.2	49.3	49.2	51.0	49.3	48.6
Poultry	4.11	10.3	10.4	10.6	10.2	9.2	8.9
TOTAL		**103.0**	**105.1**	**104.3**	**104.8**	**100.6**	**98.7**

Source: Van der Hoek *et al.*, 1997.

In Table 4.6 the emission calculation for methane from animal waste is summarised for the period 1990-1995. In this table the earlier reported methane emissions from manure are now updated (see Table 4.6, 1990: 103 mln kg). On average, annual emissions are 5% higher than earlier estimates.

Methane emissions from landfills [6A]
Methane emissions are calculated according to a time dependent method originally developed by Hoeks (1983) and described in a methane background document (Van Amstel *et al.*, 1993). Recent research suggests that the formation factor needs refinement in the near future (Oonk *et al.*, 1994). The method is based on an equation for specific gas production:

$$A = 0.8\ k\ P\ e^{-kt}$$

where:

- A = production (in m^3 waste gas or ton per year)
- 0.8 = the fraction of the waste that actually degrades
- k = degradation rate constant of 0.1 per year (half degraded in 7 years)
- P = concentration of degradable organic carbon (in kg/ton waste)
- t = time after landfilling (in years)

The current production potential of waste gas from waste dumped in the past is accounted for by integrating the production potential over time. Other assumptions are that waste contains 17% or 170 kg/ton degradable carbon in 1990 to 1995. The average methane content of waste gas is set at 50%. Specific weight of methane gas is 0.58 kg CH_4/m^3. The conversion factor for carbon to methane is 16/12. The methane oxidation in the soil cover is assumed to be 20%. Actual recovery of methane was 43 mln kg in 1990. A fast growth of recovery occurred to 65 mln kg per year in 1994 and in 1995 (RIVM, 1996a,b).

The amount of waste landfilled has been substantially reduced in recent years, but the methane generated is mostly from earlier disposed material. The amounts landfilled are 13900 mln kg in 1990, 11300 mln kg in 1993, 9100 mln kg in 1994 and 8500 mln kg in 1995. The related emissions were 376.4 mln kg in 1990, 372 mln kg in 1993, 374 mln kg in 1994 and 374.4 mln kg in 1995. The aggregated time dependent emission factor is 33 kg/ton in 1993, 41 kg/ton in 1994 and 44 kg/ton in 1995.

The same method was applied to individual landfills, based on a database at RIVM (Coops *et al.* 1995), and using a formation factor of 0.58 a total emission in 1994 was calculated of 246 mln kg. However, recalculation in 1996 using more specific information on waste composition of individual landfills resulted in an emission estimate of 374 mln kg for 1994 (RIVM, 1996a,b). In Table 4.7 the data used for the calculations is summarised for the period 1980-1995.

Table 4.7. Methane emissions from landfills in the Netherlands 1980-1995.

Year	Total waste landfilled [mln kg]	Total Degradable Organic Carbon [mln kg DOC]	Total methane produced [mln kg]	Recovered methane [mln kg]	Methane emission [mln kg]
1980	10600	1900	260	0	260.0
1981*	*11080*	*1980*	*276*	*4*	272.6
1982*	*11560*	*2060*	*292*	*7*	285.2
1983*	*12040*	*2140*	*309*	*11*	297.8
1984*	*12520*	*2220*	*325*	*14*	310.4
1985	13000	2300	341	18	323.0
1986*	*13180*	*2320*	*357*	*22*	334.8
1987*	*13360*	*2340*	*373*	*26*	346.5
1988*	*13540*	*2360*	*390*	*32*	358.2
1989*	*13720*	*2380*	*410*	*40*	370.0
1990	13900	2400	420	43	376.4
1991	11900	*2190*	421	46	375.0
1992	11400	*1980*	423	50	373.0
1993	11300	*1770*	425	53	372.0
1994	9100	*1560*	439	65	374.0
1995**	8500	1350	439	65	374.4

Data for 1980, 1985 and 1990 are from Van Amstel, 1993

* Interpolated data (printed in italic).

** Data for 1995 are preliminary figures.

Methane from wetlands, including agricultural soils [nature]

Methane is formed in wetlands and shallow waters in anaerobic circumstances. Measurements results indicate that brackish and salt mud flats produce hardly any methane at all (Bartlett and Harris, 1993). In Van Amstel *et al.* (1994) an estimate was made of methane from wetlands, including organic soils. According to Netherlands' definitions, this methane is not considered to be an anthropogenic emission source. In the Netherlands since 1950 many peat soils are drained for agriculture. The average water table of these soils since the fifties is lowered about 30 cm (Van Amstel *et al.*, 1989). In Table 4.8 the emission calculation is presented, which has been based on statistics of land-use and watertable classes (Bakker *et al.*, 1989) and emission factors from Bartlett and Harris (1993). In 1950 about 2000 km^2 of wet organic soils were not drained. In 1990-1995 373 km^2 of soils with a high-water table survived. The area of drained organic soils in 1990-1995 is estimated at 1500 km^2. Inland water considered is the IJsselmeer (1657 km^2) and other water more than 6 m wide (1498 km^2). The estuaries and Waddensea are salt or brackish and these are assumed not to emit methane in any significant quantities. Wet natural areas are about 600 km^2 (Bakker *et al.*, 1989).

The resulting methane emissions from agricultural soils are estimated to be about 50 mln kg; emissions from other soils, including wetlands, are estimated to be about 75 mln kg in 1994. As mentioned above, methane emissions from agricultural soils, other soils and wetlands are not considered to be anthropogenic and are thus not included in the national total.

Table 4.8 Methane emissions from wetlands (including agricultural soils) in the Netherlands in 1950 and 1990-1995.

Wetland/soil type	Area [km^2] in	period	Emission factor [mg CH_4/m^2/day]			Emission factor [ton/km^2/year] ***		
	1950	1990-1995	low	high	medium	low	high	medium
Wet organic soils *	2000	373	80	200	180	20.4	51.0	45.9
Drained organic soils **	0	1500	10	200	110	2.6	51.0	28.1
Inland water >6 m wide	3155	3155	20	50	45	5.1	12.8	11.5
Water <6 m wide	600	600	80	200	180	20.4	51.0	45.9
TOTAL	**5755**	**5628**						

* Water table class 0 and 1.

** Water table class >1.

*** Growing season of 255 days.

Table 4.8 Methane emissions from wetlands (including agricultural soils) in the Netherlands in 1950 and 1990-1995 (Continued).

Wetland/soil type	Emission 1950 [mln kg CH_4]			Emission 1990-1995 [mln kg CH_4]		
	low	high	medium	low	high	medium
Wet organic soils *	40.8	102.0	91.8	7.6	19.0	17
Drained organic soils **	0.0	0.0	0.0	3.8	76.5	42
Inland water >6 m wide	16.1	40.2	36.2	16.1	40.2	36
Water <6 m wide	12.2	30.6	27.5	12.2	30.6	28
TOTAL	**69.1**	**172.8**	**155.5**	**39.8**	**166.3**	**123**

* Water table class 0 and 1.

** Water table class >1.

5. NITROUS OXIDE

5.1 Introduction

Emissions of nitrous oxide are surrounded with large uncertainties. Therefore, with increasing knowledge on the sources, revision of emission estimates for specific sectors may be expected. In the Netherlands the largest sources are: agricultural soils (27 Gg), industrial processes (18 Gg), road transport (7 Gg) and polluted surface water (4 Gg). As mentioned in previous reports, in addition to the standard reporting categories of IPCC in the Netherlands two other sources of nitrous oxide are identified, which are of anthropogenic origin and are not negligible: waste water (sewage) treatment plants and polluted surface water. These sources are described below [IPCC source category between brackets]. Emissions from agricultural waste burning and from the combustion of wood and wood waste for energy purposes by the industry are currently not accounted for.

5.2 Emissions

In Table 5.1 the N_2O emissions are summarised per IPCC category for the period 1990-1995, as used in RIVM (1996a,b). Methods for compiling a national emission inventory for nitrous oxide are described in Kroeze (1994). The most important revisions of sectoral emission estimates are:

- Emissions from polluted surface water are now reported under 'Other' [7], instead of under 'Nature', since these emissions are indirectly caused by (predominantly) human activities.
- For agriculture, the 1994 figure is 0.2 Gg N_2O higher than reported in RIVM (1996a,b), due to a revision of manure export data after completion of those reports.
- For waste incineration, the figures for 1990-1995 are different from RIVM (1996a,b) due to corrections of underlying calculations after completion of these reports (updated activity data). Also, in Van Amstel *et al.* (1995) an erroneous emission factor was applied, which resulted in too high N_2O emissions.
- For electric power generation and refineries, the figures for 1990-1993 are different from RIVM (1996a,b) due to a correction of erroneous emission factors, which resulted in too high N_2O emissions. These erroneous data were also applied in Van Amstel *et al.* (1995).
- Some earlier estimates, as described by Van Amstel *et al.* (1994) are now downscaled. The emission from sewage treatment plants is now estimated to amount about 0.5 million kg/yr instead of 4.0 million kg/yr as reported earlier for 1990. Also, the estimate of nitrous oxide from polluted inland and coastal waters is now 3.8 million kg/yr instead of earlier estimates of 10.9 million kg for 1990. These reduced estimates result from measurement information as recently published in scientific literature and summarised by Kroeze (1994).
- Recently, information from emission measurements by the nitric acid producers has become available. This information has been used to calculate the N_2O emissions in 1993 and 1994.

Table 5.1 Nitrous oxide emissions per source category in the Netherlands 1990-1995 [in mln kg N_2O].

Sector	1990	1991	1992	1993	1994	1995*
1A. Fuel combustion total	5.8	6.3	7.0	7.5	7.9	8.4
1A1. Electricity and other transformation	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*
1A2. Industry (only energy)	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
1A3. Transport	*4.9*	*5.4*	*6.1*	*6.6*	*7.2*	*7.7*
*1A4. Residentials, Comm./Instit., Agric. ***	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*
1A5. Other	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1A6. Biomass burned for energy	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
1B. Fugitive fuel emissions	0.0	0.0	0.0	0.0	0.0	0.0
2. Industrial processes	18.6	19.6	19.1	19.0	18.0	18.1
3. Solvents and other product use*****	0.5	0.5	0.5	0.5	0.5	0.5
4. Agriculture	22.2	22.9	26.1	26.2	26.6	26.9
5. Land use change and forestry	NE	NE	NE	NE	NE	NE
6. Waste ****	0.6	0.6	0.6	0.6	0.6	0.6
7. Other (specified) ***	3.8	3.8	3.8	3.8	3.8	3.8
TOTAL	**51.2**	**53.4**	**56.7**	**57.2**	**57.4**	**58.3**

Source: RIVM (1996a,b) [RIM+], with exceptions as specified below.
* Data for 1995 are preliminary figures
** Data for agriculture have been corrected for emissions from polluted surface water [7]. In addition, the '94 figure is 0.2 higher than RIVM (1996a,b) due to revised manure export data.
*** Polluted surface water. In RIVM (1996a,b) these figures are included in agriculture.
**** Data for waste incineration were revised after completion of RIVM (1996a,b) (updated activity levels).
***** Anaesthesia use.

The development of total nitrous oxide emissions in 1994 relative to 1993, which is on balance almost constant, is mainly the result of three effects:

- a decrease of 1.0 kton N_2O emissions (-5%) in the industry sector, due to a decrease in nitric acid production as well as revision of emission factors for 1993 and 1994 for nitric acid production, based on information from recent emission measurements by nitric acid producers;
- an increase of 0.6 kton N_2O emissions (+9%) in the transport sector, mainly due to increased penetration of catalyst equipped gasoline cars;
- an increase of 0.4 kton of nitrous oxide emissions (+2%) from agriculture, in particular resulting from manure spreading (+0.9 kton N_2O), due to direct incorporation of animal manure prescribed by legislation aiming at reducing ammonia emissions, leading to a strong increase of direct incorporation in recent years: 60, 80 and 100% for 1993, 1994 and 1995, respectively. Compared to surface spreading this leads to higher emission factors for N_2O. This effect was partially compensated by reduced emissions from other activities of the agricultural sector, e.g. -0.3 kton N_2O emissions due to decreased application (-5%) of synthetic fertilisers.

Nitrous oxide emission from stationary fuel combustion [1A]

The emission factors used are 1.4 g N_2O/GJ for coal, 0.6 g N_2O/GJ for oil and 0.1 g N_2O/GJ for natural gas. In Kroeze (1994) it was shown, that the use of about 1.6 PJ coal in fluidized bed combustion (FBC) systems in 1990, with a relatively high emission factor of 42 g N_2O/GJ, results in 10% higher total emissions from coal combustion. In view of the relative large uncertainty related to the emission factors of N_2O in fuel combustion in general, it was decided not to include a subdivision of fuel use for this technology. On the other hand, measurement data of conventional coal fired power plants in the Netherlands indicate that the emission factor for N_2O in these systems may be negligible. This refinement was also not incorporated in the emission estimates, thereby possibly overestimating the N_2O emissions from the energy sector. The resulting calculation is presented in Table 5.2. We note, that emissions from the combustion of wood and wood waste for energy purposes are for the residential sector only; industrial emissions of biofuels are not yet accounted for.

Table 5.2 Nitrous oxide emissions from stationary combustion in the Netherlands 1990-1995.

IPCC sector *****	Emission factor [g N_2O/GJ]	Activity data [PJ] 1990	1993	1994	1995 *	Emission of N_2O [mln kg N_2O] 1990	1993	1994	1995 *
Electricity production									
Coal	1.4	250	221	252	268	0.35	0.31	0.35	0.38
Oil	0.6	1	4	12	12	0.00	0.00	0.01	0.01
Gas ****	0.1	279	362	352	361	0.03	0.04	0.04	0.04
Subtotal (rounded)						**0.4**	**0.3**	**0.4**	**0.4**
Transformation **									
Coal	1.4	13	14	15	16	0.02	0.02	0.02	0.02
Oil	0.6	151	162	163	166	0.09	0.10	0.10	0.10
Gas	0.1	18	23	23	22	0.00	0.00	0.00	0.00
Subtotal (rounded)						**0.1**	**0.1**	**0.1**	**0.1**
Industry ***									
Coal	1.4	34	38	20	35	0.05	0.05	0.03	0.05
Oil	0.6	83	100	99	111	0.05	0.06	0.06	0.07
Gas ****	0.1	362	349	342	330	0.04	0.03	0.03	0.03
Subtotal (rounded)						**0.1**	**0.1**	**0.1**	**0.1**

* Data for 1995 are preliminary figures.
** Refineries and coke ovens.
*** Excluding coke ovens; coal use excludes coke, coke oven gas and blast furnace gas.
**** Gas includes coke oven and blast furnace gas.
***** The IPCC sectors Residential, Commercial/Institutional, and Agriculture/Forestry/Fishing each result in totals of 0.0 (rounded).

Nitrous oxide emission from transport [1A3]

For road transport emission factors are expressed in g N_2O/km. Emission factors are increasing with increasing penetration and ageing of three-way catalytic converters in passenger cars. Specific information per type of transport is presented in Table 5.2, including activity data, emission factors and resulting emissions. For calculating activity data for LPG passenger cars in 1994 and 1995 a new method has been used, resulting in lower figures than the old method. Figures for 1993 and earlier years have not yet been revised, so there is a discontinuity in the time series for this sector from 1993 to 1994, but this does not show in the sectoral total N_2O emissions due to the minor contribution of emissions from LPG use to total transport emissions. Furthermore, air traffic emissions refer to all so-called LTO emissions near airports, both for domestic and international flights, and are negligible (about 0.04 mln kg N_2O). Therefore, no attempt was made to estimate and replace by specific emissions of all domestic flights.

Table 5.3 Nitrous oxide emissions from combustion of transport in the Netherlands 1990-1995.

Transport mode/type	Activity data				Emission factor				Emission			
	1990	1993	1994	1995 *	1990	1993	1994	1995 *	1990	1993	1994	1995 *
ROAD TRANSPORT	**[mln v-km]**				**[g N_2O/v-km]**				**[mln kg N_2O]**			
Passenger cars												
- gasoline	50582	56224	58145	61264	0.024	0.049	0.057	0.062	1.2	2.8	3.3	3.8
- diesel	15213	15495	16144	17298	0.031	0.031	0.031	0.031	0.5	0.5	0.5	0.5
- LPG **	14193	12427	13083	11416	0.04	0.04	0.04	0.040	0.6	0.5	0.5	0.5
Freight transport												
- Low duty gasoline	1698	1707	1619	1493	0.015	0.017	0.016	0.031	0.0	0.0	0.0	0.0
- Low duty diesel	5551	7980	8407	8824	0.031	0.031	0.031	0.031	0.2	0.2	0.3	0.3
- Low duty LPG	440	458	430	389	0.04	0.04	0.04	0.040	0.0	0.0	0.0	0.0
- Heavy duty trucks (diesel	3713	3945	3707	3898	0.2	0.2	0.2	0.2	0.7	0.8	0.7	0.8
- Heavy duty trailers (diesel)	2304	2741	2772	3017	0.2	0.2	0.2	0.2	0.5	0.5	0.6	0.6
Other road transport												
- Special vehicles gasoline	48	23	18	16	0.015	0.02	0.015	0.2	0.0	0.0	0.0	0.0
- Special vehicles diesel	307	270	253	267	0.174	0.166	0.2	0.2	0.1	0.0	0.1	0.1
- Buses	630	627	615	647	0.199	0.193	0.2	0.2	0.1	0.1	0.1	0.1
- Motorcycles	945	1206	1324	1408	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0
- Mopeds	1708	1280	1340	1210	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0
TOTAL ROAD	97332	104383	107857	1111481					**3.9**	**5.6**	**6.1**	**6.7**
NON-ROAD TRANSPORT	**[mln kg fuel]**				**[kg/mln kg fuel]**							
Water/rail/air/off-road	1527	1510	1537	1759	690	650	650	650	1.0	1.0	1.0	1.1
TOTAL TRANSPORT									**4.9**	**6.6**	**7.1**	**7.9**

* Data for 1995 are preliminary figures

** The estimation procedure for vehicle km of LPG vehicles has been changed since 1994; figures for previous years are not yet revised accordingly

Nitrous oxide emission from industrial processes [2]

In the Netherlands nitric acid is produced by a number of companies. Recently, information from emission measurements by the nitric acid producers has become available. This information has been used to calculate the N_2O emissions in recent years. The total annual nitric acid production combined with the reported emission figures corresponds with aggregated emission factors of 27.5, 24.9 and 24.7 g N_2O per mln kg HNO_3-N in 1990, 1993 and 1994, respectively. In addition, in caprolactam production an emission has been measured of 1.6 mln kg N_2O. The total from these processes in 1990, 1994 and 1995 is 18.6, 18.0 and 18.1 mln kg.

The emission calculation, when not prohibited by industrial confidentiality of production data, is included in Table 5.4.

Nitrous oxide emission from product use [3]
In the commercial sector the use of anaesthesia in hospitals resulted in non-combustion emissions of an estimated 500 ton in 1994.

Table 5.4. Nitrous oxide emissions from industrial processes and waste treatment in the Netherlands 1990-1995.

Source category	Emission factor	Activity data				Emission [mln kg N_2O]			
		1990	1993	1994	1995*	1990	1993	1994	1995*
Industrial processes	[g N_2O/ kg N]	[mln kg N]							
- Nitric acid production	27.5 -> 24.7	618	698	664	668	17.0	17.4	16.4	16.5
- Caprolactam production**	NA	M	M	M		1.6	1.6	1.6	1.6
TOTAL PROCESS						**18.6**	**19.0**	**18.0**	**18.1**
Waste treatment	[g N_2O/tonne]	[mln kg]							
- Waste incineration	20	3735	3880	4410	4370	0.1	0.1	0.1	0.1
	[2%]	[mln kg N removed]							
- Waste water treatment	0.02	25.7	27	27	27	0.5	0.5	0.5	0.5
TOTAL WASTE						**0.6**	**0.6**	**0.6**	**0.6**
Other sources	[1.57%]	[mln kg N-load]							
- Polluted inland and coastal surface water	0.0157	240	240	240	240	3.8	3.8	3.8	3.8
TOTAL OTHER						**3.8**	**3.8**	**3.8**	**3.8**

* Data for 1995 are preliminary figures .
** Emission data from individual plants as included in VROM (1996a)
NA = Not Available
M = measured

Nitrous oxide emission from agriculture [4B, 4D]
Emission of nitrous oxide from agriculture stems from synthetic fertiliser use and animal manure application on agricultural soils, from storage of manure from livestock in stables, as well as from nitrogen fixation by legumes. Since 1991, environmental legislation prescribes direct incorporation of animal manure, leading to 100% direct incorporation as of 1995. Compared to surface spreading this leads to higher emission factors for N_2O. This largely explains the growth in agricultural N_2O emissions in the previous five years. In addition, biogenic N_2O production may occur due to addition of nitrogen to soils, both agricultural and non-agricultural, through atmospheric deposition of volatilized N containing compounds like ammonia (Kroeze, 1994). Anthropogenic background emissions from agricultural soils are estimated to be about 3 mln kg per year. This refers to emissions related to past lowering of the groundwater tables and past

application of fertilisers and manure (Kroeze, 1994). We note that the total figure for 1994 of 26.6 mln kg N_2O is slightly different than the figure reported in RIVM (1996a,b) (26.4) due to revision of figures for manure export, after completion of the latter reports. More information on the calculation method, setting aside the allocation to sectors, can be found in Van Amstel *et al.* (1993) and Kroeze (1994). In Table 5.5 the emission calculation for 1990-1995 is summarised.

Nitrous oxide emission from waste treatment and polluted surface water [6B, 7]

In waste incineration, an emission factor of 20 g N_2O/ton waste has been assumed. This is equivalent to 12.7 g N_2O-N/ton, a factor derived from a Netherlands' incinerator reported by Spoelstra (1993) and referred to in Kroeze (1994). The volume of waste incinerated has been revised according to data used in RIVM (1996a,b), and is now about 10% higher than reported in Van Amstel (1995). This has not affected the base year value of 0.3 mln kg. We note that in RIVM (1996a,b) and VROM (1996), for 1994 and 1995 accidentally no N_2O emissions have been reported. This has been improved in this report, resulting in 0.4 mln kg N_2O for 1994 and 0.3 mln kg for 1995 from waste incineration. For waste water treatment, an emission is assumed of 2% of the total nitrogen removed from the waste water. For polluted inland and coastal surface water, an emission source currently not included in the IPCC guidelines, an emission of 1.57% of the N-load to surface water has been assumed. This latter source is now reported as 'Other anthropogenic source' instead of including under 'Nature'. The emission calculation on these sources is presented in Table 5.4.

Table 5.5. Nitrous oxide emissions from agricultural soils in the Netherlands 1990-1995.

SOURCE / N flow	Emission factor	1990	1991	1992	1993	1994	1995*
ANTHROPOGENIC BACKGROUND							
agricultural soils**		**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
CHEMICAL FERTILISER							
total N consumption		412.0	400.0	392.0	390.0	372.0	372.0
NH_3-N emission		8.2	8.0	7.8	7.8	7.4	7.4
net N application		403.8	392.0	384.2	382.2	364.6	364.6
mineral soils 90%	0.010	363.4	352.8	345.7	344.0	328.1	328.1
organic soils 10%	0.020	40.4	39.2	38.4	38.2	36.5	36.5
subtotal N_2O-N emission		**4.4**	**4.3**	**4.2**	**4.2**	**4.0**	**4.0**
MANURE							
total N excretion		657.0	679.0	664.0	682.0	648.0	643.0
excretion in meadow		164.3	169.8	166.0	170.5	162.0	160.8
NH_3-N emission grazing		13.1	13.6	13.3	13.6	13.0	12.9
share N in urine		0.6	0.6	0.6	0.6	0.6	0.6
urine-N in meadow	0.020	90.7	93.7	91.6	94.1	89.4	88.7
faeces-N in meadow	0.010	60.4	62.5	61.1	62.7	59.6	59.2
subtotal N_2O-N emission		**2.4**	**2.5**	**2.4**	**2.5**	**2.4**	**2.4**
STABLE + STORAGE							
excretion in stable		492.8	509.3	498.0	511.5	486.0	482.3
NH3 emission stable		83.7	86.0	85.2	88.4	85.3	84.3
NH3 emission storage		5.2	5.5	5.8	6.2	5.9	3.9
net N content manure		419.5	433.9	423.1	433.6	410.9	409.6
biologically treated storage	0.020	0.0	1.0	1.0	1.0	2.0	2.0
anaerobic storage	0.001	419.5	432.9	422.1	432.6	408.9	407.6
subtotal N_2O-N emission		**0.4**	**0.5**	**0.4**	**0.5**	**0.4**	**0.4**
MANURE SPREADING							
manure-export abroad		6.4	6.8	11.2	15.0	18.0	23.0
field application		413.1	426.1	410.9	417.6	390.9	384.6
NH3 emission application		104.9	104.4	57.8	64.5	45.3	32.4
check: NH3-N emission		86.4	86.0	47.6	53.1	37.3	26.7
net N content applied manure		326.8	340.1	363.3	364.5	353.5	357.9
surface application mineral soil 87%	0.010	284.3	265.1	93.9	94.3	13.5	0.0
surface application organic soil 13%	0.020	42.5	44.2	47.2	47.4	46.0	0.0
share incorporation (fraction)		0.0	0.1	0.6	0.6	0.8	1.0
incorporation all soils	0.020	0.0	30.8	222.1	222.8	294.1	357.9
subtotal N2O-N emission		**3.7**	**4.2**	**6.3**	**6.3**	**6.9**	**7.2**
LEGUMES							
total N-fixation	0.010	15.0	14.0	14.0	14.0	14.0	14.0
subtotal N2O-N emission		**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
TOTAL GENERAL as N_2O-N		**14.1**	**14.6**	**16.6**	**16.7**	**16.9**	**17.1**
TOTAL GENERAL as N_2O	**1.571**	**22.2**	**22.9**	**26.0**	**26.2**	**26.6**	**26.9**

Source: Van der Hoek *et al.*, 1997.

* Data for 1995 are preliminary figures.

** Resulting from past lowering of the groundwater tables and past application of fertilisers and manure (Kroeze, 1994).

6. HALOCARBONS (HFCs, PFCs, FICs, SF_6 and Ozone Depleting Substances)

6.1 Introduction

From the perspective of the UN-FCCC, halocarbons can be divided into two groups:

- ozone depleting substances already regulated by the Montreal Protocol and its subsequent amendments of London and Copenhagen, and thus not covered by the Framework Convention on Climate Change (FCCC): CFCs, halons, CTC, MCF, methyl bromide and HCFCs;
- other 'non-ODP' halocarbons, which have a zero Ozone Depleting Potential (ODP), and which are therefore not regulated by the Montreal Protocol: HFCs, PFCs, FICs and SF_6.

In this chapter we discuss both groups, since the phase-out of the primary use and the use of recycled ODP substances (i.e. compounds regulated by the Montreal Protocol) will still influence the substitution by non-ODP halocarbons and will contribute - though not part of the compounds covered by the FCCC - to greenhouse gas emissions of halocarbons.

In the Netherlands the emissions of compounds regulated by the Montreal Protocol are based on *consumption* data of halocarbons as defined according to the Protocol. This implies for example that emissions due to leakage from imported appliances which contain halocarbons, such as refrigerators, are not accounted for as Netherlands' consumption and, thus, also not as Netherlands' emissions. Annually, the Netherlands' CFC Commission published a survey on the use of several halocarbons in the Netherlands (CFC Commission, 1995). Since January 1995 the CFC Commission has finished its work because the phase-out of production and use of new CFC had been completed by that date. However, the use in 1995 of hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), carbon tetrachloride (also known as tetrachloroethane or CTC), methyl chloroform (also known as 1,1,1 trichloroethane or MCF) and methyl bromide have now been reported by Netherlands' companies through a survey compiled by an independent accountant (KPMG, 1996), which had been commissioned by the Netherlands' Government. In addition, Matthijsen has estimated the use and emissions of HFCs, PFCs and SF_6 based on information from several sources (Matthijsen, 1995). In this chapter we will make a clear distinction between 'non-ODP halocarbons', which have a zero ODP but which are greenhouse gases, and ozone depleting substances, which are regulated by the Montreal Protocol. Regarding PFCs, we will discuss the emissions of carbon tetrafluoride (CF_4) - also known as CFC-14 or perfluoromethane - and carbon hexafluoride (C_2F_6) - also known as perfluoroethane - which are mainly emitted as by-product of aluminium production.

Table 6.1 gives an overview of the halocarbon consumption data for 1986 and for the period 1989-1995, which has been based on the surveys mentioned above. The emission of PFCs by the aluminium industry and of SF_6 was not reported in the surveys of the CFC Commission and of KPMG, but have been calculated or estimated separately (see Section 6.3). At present, it is assumed that currently no fluoroiodocarbons (FICs) are used in the Netherlands. Based on references, own estimates and consultation of CBS and TNO, Matthijsen has estimated total consumption in 1993 and 1994 and allocated it to different applications and to the target groups ('economic sectors') 'Industry' and 'Commercials' (Matthijsen, 1995). In Table 6.2 per compound the split of consumption over these target groups is summarised for 1993 and 1994 as well as an estimate for 1990. We stress that for 1995 no estimate was made for emissions related to the production and handling of HFCs and HFCs, whereas in the 1993 and 1994 data most estimated emissions of HFCs stem from these activities.

Table 6.1 The use of halocarbons in the Netherlands 1986-1995.

Compound	Consumption [ton] 1986	1989	1990	1991	1992	1993	1994	1995*	
HFC-23			0				0	PM	c)
HFC-32			0				0	PM	c)
HFC-125			0				0	50	
HFC-134a			0				274	454	f)
HFC-143a			0				0	34	
HFC-152a			0				0	PM	c)
HFC-227ea			0				0	PM	c)
Total HFCs	**0**	**0**	**0**	**0**	**0**	**0**	**274**	**561**	
CF_4 emission from aluminium	346	363	310	305	272	278	300	300	
C_2F_6 emission from aluminium	35	36	31	30	27	28	30	30	
PFC use h)	21	22	22	22	22	23	23	23	d)
Total PFCs	**402**	**421**	**363**	**357**	**321**	**329**	**353**	**353**	
SF_6	**55**	**57**	**58**	**59**	**60**	**60**	**61**	**61**	i)
TOTAL HFCs, PFCs, SF_6	**457**	**478**	**421**	**416**	**381**	**389**	**688**	**975**	
CFC-11	7952	5815	5317	5116	3836	1145	606	0	e)
CFC-12	4843	2586	1043	687	670	449	383	0	e)
CFC-13	7	0	3	4	3	2	1	0	e)
CFC-113	1335	1403	1197	983	963	491	101	0	e)
CFC-114	91	71	99	127	85	0	0	0	e)
CFC-115	96	104	105	114	85	64	34	0	e)
Halon 1211	292	NE	212	157	70	22	0	0	e)
Halon 1301	171	NE	170	132	90	61	12	0	e)
Total CFCs and halons	**14787**	**9979**	**8146**	**7320**	**5802**	**2234**	**1137**	**0**	e)
Carbon tetrachloride	NE	689	777	794	547	300	100	PM	a) b) j)
Trichloroethane	NE	5915	5540	4751	3803	2813	1915	1181	
Methyl bromide	NE	NE	NE	89	42	34	35	23	
Total CTC, MCF, MBr	**0**	**6604**	**6317**	**5634**	**4392**	**3147**	**2050**	**1204**	
HCFC-22	NE	1616	2120	2669	3342	3025	2973	2548	
HCFC-123						PM	PM	PM	b)
HCFC-124								17	
HCFC-141b	NE	0	0	25	287	1080	1392	1612	
HCFC-142a						1	1	1	g)
HCFC-142b	NE	829	1023	934	1031	824	751	609	
Total HCFCs	**0**	**2445**	**3143**	**3628**	**4660**	**4930**	**5117**	**4787**	
TOTAL ODP COMPOUNDS	**14787**	**19028**	**17606**	**16582**	**14854**	**10311**	**8304**	**5991**	

Source: CFC Commission (1995); KPMG (1996); for exceptions see notes.
* Data for 1995 are preliminary figures.
Notes: see next page.

Notes:
a) Essential use approved by EC.
b) Amount is confidential but small.
c) Amount is confidential: total reported use of all compounds (HFC-23, 32, 152a and 227ea) in 1995 is 23.
d) Amount is confidential: total reported use of all PFCs in 1995 is 23 ton.
For these so-called pre-Montreal applications, we assume for previous years an annual consumption trend following industrial production (1% per year).
e) Exclusive of use of recycled materials, which was for CFCs 248 ton in 1995.
f) Value for 1994 taken from Matthijsen and Kroeze (1996).
g) Values taken from Matthijsen (1995).
h) Thus excluding PFCs emitted during primary aluminium production.
i) Values taken from Matthijsen and Kroeze (1996).
j) The figures of CTC for 1993 and 1994 were 548 and 669 according to CFC Commission (1995), but these numbers were not corrected for destruction and use as feedstock, the amount of which is confidential. Therefore we use here the figures estimated by Matthijsen (1995).

Table 6.2 The use of halocarbons in the Netherlands per source category 1990-1994.

Target Group	Year	CFC					Halon		CTC	MCF	MBr	HCFC			HFC
		11	12	13	113	115	1211	1301				22	141b	142b	134a
Industry	1990	5164	527	3	980	54	77	59	777	5540	0	1551	0	1023	
	1993	1112	227	2	402	33	8	21	300 a)	2813	5	2213	1080	824	
	1994	565	194	1	75	18	0	4	100 a)	1915	5	2175	1392	751	
Commercials	1990	153	516	0	217	51	135	111	0	0	0	569	0	0	
	1993	33	222	0	89	31	14	40	0	0	29	812	0	0	
	1994	41	189	0	26	16	0	8	0	0	30	798	0	0	
TOTAL	1990	5317	1043	3	1197	105	212	170	777	5540	100 b)	2120	0	1023	NE
	1993	1145	449	2	491	64	22	61	300 a)	2813	34	3025	1080	824	NE
	1994	606	383	1	101	34	0	12	100 a)	1915	35	2973	1392	751	274

Source: 1990: totals from CFC Commission (1995); sectoral totals derived from sectoral consumption ratio of 1993
1993 and 1994: Matthijsen (1995), except HFCs which are taken from Matthijsen and Kroeze (1996).

Notes:
a) Number differs from figures reported by the CFC Commission (1995) because the CFC Commission did not correct for destruction and use as feedstock for reasons of confidentiality.
b) Own estimate based on figure for 1991.

6.2 Consumption and emission of halocarbons

The use of *recycled* CFCs is still permitted. Actual emissions are therefore expected to continue for some time. Matthijsen (1996) and Matthijsen and Kroeze (1996) have estimated the actual emissions of halocarbons - for both non-ODP and ODP compounds - in 1990, 1993 and 1994. The emission calculation conforms, by and large, with the methods applied by AFEAS in there annual emission reports (AFEAS, 1996, and references therein), but were adapted in some cases by Kroeze (Kroeze, 1995). For 1995, the actual emissions were not calculated in this way, but were estimated based on the ratio of consumption figures in 1994 and 1995 (as reported in Table 6.1) and the calculated emissions for 1994. The results of these calculations

Table 6.3. Calculated and estimated actual emission of halocarbons in the Netherlands 1990-1995 (according to AFEAS method as adapted by Kroeze).

Compound	GWP g) [100 year]	Emission [ton] 1990	1993	1994	1995*	Emission [mln kg CO_2-eq.] 1990	1993	1994	1995*
HFC-23	11700	410	423	536	649 i) d)	4797	4949	6271	7593 d)
HFC-32	650	0	0	1	PM c) d)	0	0	1	0 d)
HFC-125	2800	20	7	20	50 c)	56	20	56	140
HFC-134a	1300	30	12	31	454 c)	39	16	40	590
HFC-143a	3800	4	3	6	34 c)	15	11	23	129
HFC-152a	140	25	29	24	PM c) d)	4	4	3	0 d)
HFC-227ea	2900	0			PM c) d)	0	0	0	0 d)
Total HFCs		**912**	**474**	**618**	**1210**	**4911**	**5000**	**6394**	**8453**
CF_4 emission from aluminium	6500	310	278	300	300	2010	1807	1950	1950
C_2F_6 emission from aluminium	9200	31	28	30	30	290	258	276	276
PFC use h)	7200 f)	22	23	23	23 c)	157	162	164	166
Total PFCs		**363**	**329**	**353**	**353**	**2457**	**2227**	**2390**	**2392**
SF_6	23900	58	58	61	61	1380	1434	1458	1458
TOTAL HFCs, PFCs, SF_6		**921**	**863**	**1032**	**1624**	**8803**	**8661**	**10234**	**12302**
CFC-11	3800 D	NE	918	725	532 a)	NE	3488	2755	2022
CFC-12	8100 D	NE	553	437	321 a)	NE	4479	3540	2600
CFC-13	11700 D	NE	28	18	8 a)	NE	328	211	94
CFC-113	4800 D	NE	505	138	0 a)	NE	2424	662	0
CFC-114	9300 D	NE	12	1	0 a)	NE	112	9	0
CFC-115	9300 D	NE	105	53	1 a)	NE	977	493	9
Halon-1211	NE D	NE	22	0	0 a)	NE	0	0	0
Halon-1301	5400 D	NE	61	12	0 a)	NE	329	65	0
Total CFCs and halons		NE	**2204**	**1384**	**862**	**35600**	**12137**	**7735**	**4725**
Carbon tetrachloride (CTC)	1400 D	NE	169	56	0 a)	NE	237	78	0
Trichloroethane (MCF)	100 D	NE	2657	1835	1013 a)	NE	266	184	101
Methyl bromide	NE	NE	34	35	36 a)	NE	0	0	0
Total CTC, MCF, MBr		NE	**2860**	**1926**	**1049**	**1130**	**502**	**262**	**101**
HCFC-22	1500 D	NE	1916	1878	1610 b)	NE	2874	2817	2414
HCFC-123	90 D	NE	7	PM	PM e)	NE	1	0	0
HCFC-124	470 D	NE	229	306		NE	108	144	0
HCFC-141b	600 D	NE	64	83	96 b)	NE	38	50	58
HCFC-142a	NE D	NE	1	1	1 a)	NE	0	0	0
HCFC-142b	1800 D	NE	124	108	88 b)	NE	223	194	158
Total HCFCs		NE	**2341**	**2376**	**1794**	**2300**	**3244**	**3205**	**2630**
TOTAL ODP COMPOUNDS		NE	**7405**	**5686**	**3705**	**39030**	**15883**	**11202**	**7456**

Source: Matthijsen (1995) for 1993 and 1994; consumption data for 1995 from KPMG (1996); SF_6 from Matthijsen and Kroeze (1996); emissions from aluminium production and of HFC-23 in 1995: this report. Emissions in 1990 were estimated by multiplying the emission in 1993 by the consumption ratio of 1990 over 1993, except for HFCs which were taken from Matthijsen and Kroeze (1996).

* Data for 1995 are preliminary figures. Notes:

a) 1995: extrapolation; excluding emissions due to used of recycled material.

b) 1995: emission of 1994 times the growth ratio between '94 and '95.

c) 1995: assumed that use = emission, for PFC use also for previous years.

d) Amount is confidential: total use of HFC-23, 32, 152a and 227ea is 23 ton (excluding emissions as by-product from HCFC-22 production).

e) Amount is confidential but small.

f) Information on individual PFCs is not available; an average GWP value of 7200 has been assumed (KPMG, 1996).

g) From IPCC (1996), except for CFC-13, 114 and 115, which are taken from IPCC (1995). [NE = Not estimated The GWP for CFCs, halons, CTC and MCF includes only direct effects (marked with D), since the indirect effect is very uncertain For Halon-1301, CTC and MCF the total GWP, including indirect effects, may well be negative (IPCC, 1996).

h) Thus excluding PFCs emitted during primary aluminium production .

i) Value for 1995 is own estimate based on increase in previous years (emissions as by-product of HCFC-22 production).

are presented in Table 6.3, grouped in non-ODP compounds and in ODP compounds regulated by the Montreal Protocol. Also included in this table are the emissions expressed in CO_2 equivalents using the Global Warming Potential (GWP) values for a time horizon of 100 years according to the latest estimates of the IPCC (1996), except for CFC-13, 114, and 115, where we used the direct GWP values of IPCC (1995). We stress, that the GWPs of CFCs, halons, CTC, MCF and HFCs include only the direct effects, so the calculated CO_2-eq. emissions for these compounds should be regarded as qualitatively different when comparing with the emissions of other compounds. In particular for halon-1301, CTC and MCF, the total GWP - including indirect effects - may well be negative.

In 1994, the CO_2-eq. emissions from non-ODP halocarbons stem for about 60% from HFC-23 and about 20% from aluminium production, whereas emissions of SF_6 contributed about 15%. The emissions from aluminium production, however, are very uncertain (see Section 6.3). When comparing the emissions of 1994 and 1995, note that for 1995 no emissions are estimated for HFC-23, 32, 152a and 227ea. In particular the emissions of HFC-23 as by-product of the production of HCFC-22 can be substantial, as the figures for 1993 and 1994 indicate. If one would take into account the direct effects of CFCs, CTC and MCF, their additional contribution to CO_2-eq. emissions would be about 100% in 1994, mainly from CFC-11, 12 and HCFC-22.

6.3 CF_4 and C_2F_6 emissions from aluminium production

CF_4 and C_2F_6 are produced simultaneously during the process of primary aluminium smelting. They are accidental by-products of the Hall-Heroult electrolysis process, introduced about 100 years ago. Emissions of CF_4 and C_2F_6 result from the so-called 'anode effect', which occurs when the aluminium oxide is depleted of alumina. Then a gas film forms on the surface of the anode and creates a barrier to the flow of electrical current, causing a sudden, sharp increase in voltage. The electrical arcing occurring as a result of this occasional high voltage at the anode is called the 'anode effect', after which CF_4, C_2F_6 as well as CO are formed. Measurements have confirmed that these PFCs are not emitted at detectable levels when the smelting pot is functioning normally.

There are two major types of primary aluminium manufacturing technologies, using either Prebaked or Søderberg anode types. Prebaked aluminium pots use multiple anodes, which are formed and baked prior to use (so-called 'green anodes'), while the Søderberg pots use a single, continuous anode that is shaped and baked in place. The prebaked technology is considered to be the modern type. In recent years new designs for the ovens and the introduction of computerised process control have greatly reduced the number and duration of the anode effects. As a consequence, it can be expected that CF_4 and C_2F_6 emissions will have been reduced considerably.

Estimating emissions of CF_4 and C_2F_6

In Søderberg pots about 1 to 2 kg CF_4 is emitted per ton of primary aluminium produced. In prebaked pots about 0.05 to 1.75 kg CF_4 per metric ton of primary aluminium is emitted, with a weighted global average of 1.4 kg/ton (IPCC, 1996b). Country-specific estimates can be based on production data from actual primary aluminium smelters and surveys of the frequency and duration of the anode effect. However, in the absence of statistical information on the anode effect, for prebaked anodes a global default emission factor of 1.2 kg CF_4/ton may be used, which is a globally weighted average of default values compiled by IPCC (1996b), with an uncertainty range of 0.05-1.75. For C_2F_6, the recently developed IPCC Guidelines recommend to use an emission factor equal to 1/10 of the factor used for CF_4.

In the Netherlands the aluminium industry uses prebaked anodes. Since it is assumed that emissions are decreasing because of technology change, we have assumed that the emission factor for CF_4 is equal to the weighted default of 1.2 kg CF_4/ton (globally weighted average of old and modern prebaked technology), whereas for 1980 we have assumed a somewhat higher factor of 1.4 kg CF_4/ton. A much better emission estimate can be made when more information becomes available on the definition of the default types 'old' and 'modern' prebaked as identified by the IPCC and of the actual process technology used in the Netherlands. The aluminum production in the Netherlands is reported by the National Bureau of Statistics (CBS). In Table 6.4 the production and estimated emissions of CF_4 and C_2F_6 are presented for the years 1980-1995. We stress that, given the uncertainty range for the emission factors, this estimate could also be either 10% or 150% of the calculated values.

Table 6.4 Emissions of CF_4 and C_2F_6 from primary aluminium production in the Netherlands 1980-1995.

Year	Primary aluminium production	Emission factor		Emission	
		CF_4	C_2F_6	CF_4	C_2F_6
	[mln kg]	[kg/ton]	[kg/ton]	[ton]	[ton]
1980	258	1.4	0.14	361	36
1981	262	1.4	0.14	367	37
1982	251	1.4	0.14	351	35
1983	235	1.4	0.14	329	33
1984	249	1.4	0.14	349	35
1985	251	1.3	0.13	326	33
1986	266	1.3	0.13	346	35
1987	276	1.3	0.13	359	36
1988	278	1.3	0.13	361	36
1989	279	1.3	0.13	363	36
1990	258	1.2	0.12	310	31
1991	254	1.2	0.12	305	30
1992	227	1.2	0.12	272	27
1993	232	1.2	0.12	278	28
1994	250	1.2	0.12	300	30
1995*	250	1.2	0.12	300	30

* Data for 1995 are preliminary figures.

6.4 Other halocarbons: FICs and SF_6

For other gases with high GWPs, only the use and emission of SF_6 in the Netherlands has been estimated by Matthijsen and Kroeze (1996). It has been assumed that in 1987 this compound was used for the following applications (Annema, 1989):

- as insulation gas or for fire suppression in switch gears and circuit breakers: 49-54 ton
- other applications, e.g. for etching, as tracer, etc.: 1-5 ton

For 1986, we assumed total use to be 55 ton, with a growth in consumption corresponding to growth in industrial production (about 1% annually). In addition, to estimate emissions we assumed that the consumption is in a quasi-stationary state, i.e. that the annual consumption rate is equal to annual emission rate to the atmosphere. The resulting figures have been included in the Tables 6.1 and 6.3.

7. OTHER INDIRECT GREENHOUSE GASES AND SO_2

7.1 Introduction

Indirect greenhouse gases, such as nitrogen oxide (NO_x), carbon monoxide (CO) and Non-Methane Volatile Organic Compounds (NMVOC), react in the atmosphere to form tropospheric ozone and other substances. The indirect greenhouse effect from this ozone formation has been assessed but uncertainty in lifetimes and the many reactions involved prevents a Global Warming Potential to be calculated (IPCC, 1996). In the first IPCC assessment some GWP-100 values for the indirect effect were given, but in the second assessment these were questioned. In addition, it is believed that sulphur dioxide (SO_2) has a cooling effect, i.e. a negative GWP, but as this effect appears to be of a local instead of a global nature its size is hard to estimate. So, for the emissions of these compounds no equivalent CO_2 emissions will be calculated.

7.2 Emissions of NO_x, CO, NMVOC and SO_2

In the Netherlands, nitrogen oxides and carbon monoxide are predominantly emitted by the transportation sector, whereas sulphur dioxide is mostly emitted by refineries, industries and mobile combustion. Non-methane hydrocarbons are emitted from transport, both during combustion and by evaporation from the reservoir, e.g. when loading but also during the diurnal cycle of the ambient temperature, and by the industry. Also, NMVOC is emitted in fossil fuel production and solvent use. In the '*Environmental Balance 1995*' and '*1996*' (RIVM, 1995a,b and 1996a,b) emissions are given for the period 1990-1995 per target group as calculated by the RIVM's Environmental Information System RIM+, with data from the Emission Registration project (VROM, 1994-1996). More information on the definition of the Netherlands' target groups can be found in Section 2.6. We recall that the emissions from agricultural waste burning and from the combustion of wood and wood waste for energy purposes by the industry are currently not accounted for.

In Tables 7.1 to 7.4 the emissions are presented per IPCC sector for the years 1990-1995 as used in RIVM (1996), however converted from target groups into the standard IPCC sectors. The emissions of NMVOC are recorded in the RIM+ system according to the 'KWS-2000' definition only. This definition differs somewhat from the NMVOC definition used in the Annual Emission Reports published by the Ministry of the Environment: CTC, methyl chloroform and CFC-11 emissions are not included and emissions of other CFCs are only partially (0.346) included in the 'NMVOC-KWS-2000' definition. The main difference will be found in the target group 'Industry', where the use of CFCs, CTC and MCF is about 2 mln kg according to Matthijsen (1995) (about 2.5% of total NMVOC). Furthermore, the figures for transport include for air traffic all so-called LTO emissions near airports, both for domestic and international flights (about 2 mln kg NO_x, 5 mln kg CO, 1 mln kg NMVOC and 0.2 mln kg SO_2). No attempt was made to estimate specific emissions of all domestic flights (including cruise emissions).

To compose the IPCC Summary Reports, which are presented in the Appendices A and B, additional information was used to distribute the sectoral emissions over the appropriate IPCC source categories.

Table 7.1 Nitrogen oxide emissions per source category in the Netherlands 1990-1995 [in mln kg].

Sector	1990	1991	1992	1993	1994	1995*
1A. Fuel combustion total	556.6	558.7	548.7	525.3	509.7	505.5
1A1. Electricity and other transform.	*99.9*	*97.7*	*94.9*	*88.1*	*76.1*	*77.5*
1A2. Industry (only energy)	*63.2*	*63.9*	*61.3*	*56.5*	*53.1*	*53.7*
1A3. Transport	*350.9*	*352.9*	*349.8*	*337.0*	*341.0*	*333.8*
1A4. Residentials, Comm./Instit., Agric.	*40.5*	*42.1*	*40.6*	*41.5*	*37.3*	*38.3*
1A5. Other	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1A6. Biomass burned for energy	*2.1*	*2.1*	*2.1*	*2.2*	*2.2*	*2.2*
1B. Fugitive fuel emissions	NA	NA	NA	NA	NA	NA
2. Industrial processes	12.7	12.2	11.7	11.2	10.7	10.5
3. Solvents and other product use	IE	IE	IE	IE	IE	IE
4. Agriculture	NA	NA	NA	NA	NA	NA
5. Land use change and forestry	NE	NE	NE	NE	NE	NE
6. Waste	4.6	4.5	5.2	6.1	3.6	1.9
7. Other (specified)	NA	NA	NA	NA	NA	NA
TOTAL	**573.9**	**575.4**	**565.6**	**542.6**	**524.0**	**517.9**

Source: RIVM (1996a,b) [RIM+].
* Data for 1995 are preliminary figures.

Table 7.2 Carbon monoxide emissions per source category in the Netherlands 1990-1995 [in mln kg].

Sector	1990	1991	1992	1993	1994	1995*
1A. Fuel combustion total	940.1	877.9	836.7	805.9	787.0	760.1
1A1. Electricity and other transform.	*17.1*	*17.2*	*16.1*	*13.9*	*21.2*	*21.1*
1A2. Industry (only energy)	*131.4*	*131.4*	*105.9*	*132.2*	*114.4*	*119.6*
1A3. Transport	*706.4*	*633.5*	*619.6*	*565.9*	*551.1*	*518.0*
1A4. Residentials, Comm./Instit., Agric.	*0.5*	*10.0*	*8.1*	*5.9*	*11.2*	*12.3*
1A5. Other	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1A6. Biomass burned for energy	*84.7*	*85.8*	*87.0*	*88.0*	*89.1*	*89.1*
1B. Fugitive fuel emissions	NA	NA	NA	NA	NA	NA
2. Industrial processes	116.1	112.3	108.6	104.8	101.0	108.0
3. Solvents and other product use **	2.0	2.0	2.0	2.0	2.0	2.0
4. Agriculture	NA	NA	NA	NA	NA	NA
5. Land use change and forestry	NE	NE	NE	NE	NE	NE
6. Waste	2.2	2.1	2.0	2.1	4.4	3.1
7. Other (specified)	NA	NA	NA	NA	NA	NA
TOTAL	**1060.4**	**994.3**	**949.2**	**914.8**	**894.4**	**873.2**

Source: RIVM (1996a,b) [RIM+].
* Data for 1995 are preliminary figures.
** Tabacco smoking. Data for 1990-1993 for the residential sector were corrected after completion of RIVM (1996a,b).

Table 7.3 NMVOC emissions per source category in the Netherlands 1990-1995 [in mln kg], (according to 'KWS-2000' definition).

Sector	1990	1991	1992	1993	1994	1995*
1A. Fuel combustion total	207.5	184.9	178.2	181.3	172.9	157.9
1A1. Electricity and other transform.	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
1A2. Industry (only energy)	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
1A3. Transport	*196.9*	*176.2*	*170.9*	*160.1*	*158.0*	*148.1*
1A4. Residentials, Comm./Instit., Agric.	*1.2*	*1.5*	*1.2*	*2.0*	*2.3*	*2.3*
1A5. Other	*3.5*	*1.3*	*0.0*	*13.1*	*6.4*	*1.3*
1A6. Biomass burned for energy	*5.9*	*6.0*	*6.1*	*6.1*	*6.2*	*6.2*
1B. Fugitive fuel emissions	35.1	34.2	33.3	32.4	31.5	33.0
2. Industrial processes	101.5	95.7	89.8	87.0	78.1	78.1
3. Solvents and other product use	100.1	98.6	97.1	95.6	94.1	94.1
4. Agriculture	NA	NA	NA	NA	NA	NA
5. Land use change and forestry	NE	NE	NE	NE	NE	NE
6. Waste	0.1	0.1	0.1	0.1	1.0	1.0
7. Other (specified)	NA	NA	NA	NA	NA	NA
TOTAL	**444.3**	**413.5**	**398.5**	**396.4**	**377.6**	**364.1**

Source: RIVM (1996a,b) [RIM+].
* Data for 1995 are preliminary figures.

Table 7.4 Sulphur dioxide emissions per source category in the Netherlands 1990-1995 [in mln kg].

Sector	1990	1991	1992	1993	1994	1995*
1A. Fuel combustion total	174.5	167.1	142.0	139.9	127.4	129.0
1A1. Electricity and other transform.	*118.0*	*111.9*	*92.5*	*89.4*	*75.5*	*78.1*
1A2. Industry (only energy)	*25.0*	*22.3*	*16.8*	*17.5*	*16.2*	*16.3*
1A3. Transport	*26.5*	*27.3*	*27.9*	*27.9*	*31.0*	*30.3*
1A4. Residentials, Comm./Instit., Agric.	*4.8*	*5.4*	*4.6*	*4.9*	*4.5*	*4.1*
1A5. Other	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1A6. Biomass burned for energy	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*
1B. Fugitive fuel emissions	NA	NA	NA	NA	NA	NA
2. Industrial processes	25.0	22.8	20.6	18.4	16.2	16.9
3. Solvents and other product use	IE	IE	IE	IE	IE	IE
4. Agriculture	NA	NA	NA	NA	NA	NA
5. Land use change and forestry	NE	NE	NE	NE	NE	NE
6. Waste	3.0	3.0	4.3	2.3	2.3	0.9
7. Other (specified)	NA	NA	NA	NA	NA	NA
TOTAL	**202.5**	**192.9**	**166.9**	**160.6**	**145.9**	**146.8**

Source: RIVM (1996a,b) [RIM+].*
Data for 1995 are preliminary figures.

8. TOTAL GREENHOUSE GAS EMISSIONS

8.1 Global Warming Potentials according to the IPCC

To represent the total emissions of greenhouse gases from anthropogenic sources in the Netherlands, we selected the GWP values for a time horizon of 100 years from the most recent IPCC assessment (IPCC, 1996), if reported. For CFC-13, 114 and 115 we used the values reported by IPCC (1995), whereas for halon-1211, methyl bromide, and for HCFC-142a no GWPs are available.

The use of Global Warming Potentials, though very useful for comparing the impact to the enhanced greenhouse effect for different compounds, has its limitations. Any GWP value - except for CO_2 of course - has a limited precision; typical uncertainties are of the order of 35%. In addition, the contribution of the indirect effect to the GWP of CFCs, CTC, MCF and HCFCs, which will result in lower net GWPs, is often even more uncertain. This is in particular true for halon-1301, CTC and MCF (IPCC, 1996). For NO_x, CO and NMVOC, which contribute as precursors of the tropospheric ozone - which is also a greenhouse gas - indirectly to the enhanced greenhouse effect, no GWPs exist. This also holds for SO_2, which is now recognised to have a local cooling effect. So these emissions can not represented on a CO_2 equivalent basis.

8.2 Netherlands' CO_2 equivalent emissions in the period 1990-1995

Nevertheless, in Table 8.1 the CO_2 equivalent greenhouse gas emissions of the Netherlands from anthropogenic sources are presented for the period 1990-1995. When interpreting this table one should take account of the following observations:

- the contribution of non-CO_2 gases is quite uncertain;
- the contribution of ozone precursors and SO_2 is not represented in CO_2-eq. emissions;

and regarding halocarbons:

- the emissions of halocarbons are based on consumption statistics according to the Montreal Protocol definition, which does not take into account import and export of halocarbon containing appliances;
- the indirect effect of CFCs, CTC and MCF, which tends to decrease the GWP, is not included;
- the emissions of HCFCs in 1993-1994 and in 1995 are based on different assumptions and can not be compared well (see Chapter 6).

The contribution per compound to the CO_2-equivalent emissions in 1994 is presented in the Figures 8.1 and 8.2. Taking these limitations into consideration, we can derive the following conclusions from Table 8.1 and Figure 8.1:

- CO_2-eq. emissions of compounds covered under the UN-FCCC are increasing from 1990 to 1994 by 3%, mainly due to increasing emissions of CO_2 and of HFCs;
- CO_2 emissions show an increasing trend (+2.8 % in 1994 relative to 1990);
- CH_4 emissions are slowly decreasing (-3% in 1994 relative to 1990);
- N_2O emissions show an increasing trend (+11% in 1994 relative to 1990);
- non-CO_2 gases contributed in 1994 about 22% to total CO_2 equivalent emissions in 1994, of which CH_4 contributed about 10%, N_2O about 8% and non-ODP halocarbons HFCs, PFCs and SF_6 contributed in 1994 about 4%;
- emissions of HFCs, PFCs and SF_6 are increasing (about +17% in 1994 relative to 1990) due to the replacement of CFCs and halons, notably by HFCs, and due to emissions of HFC-23 as by-product of HCFC-22 production;
- emissions of the ozone precursors NO_x, CO and NMVOC are all decreasing (-9 to -16% in 1994 relative to 1990);
- SO_2 emissions have been substantially decreased by 28% since 1990.

Table 8.1 Contribution of different compounds to anthropogenic greenhouse gas emissions in the Netherlands in 1990-1995 (in mln kg CO_2-eq.) (halocarbons according to the Montreal Protocol and direct effects only).

Compound	GWP [100 yr]	CO_2-eq. emission [mld kg CO_2] 1990**	1991	1992	1993	1994	1995*	Index [1990=100] '90	'91	'92	'93	'94	'95*
A. Gases covered under the FCCC													
CO_2	1	174.0	174.4	176.6	177.1	178.9	185.9	100	100	101	102	103	107
CH_4	21	23.2	23.6	22.8	22.5	22.4	22.3	100	102	98	97	97	96
N_2O	310	15.9	16.6	17.7	17.9	17.8	18.1	100	104	111	112	111	113
Subtotal excluding halocarbons		**213.1**	**214.6**	**217.1**	**217.4**	**219.1**	**226.3**	**100**	**101**	**102**	**102**	**103**	**106**
HFCs a)	NA	*4.9*			5.0	6.4	8.5	*100*			102	130	172
PFCs	NA	*2.4*			2.2	2.3	2.4	*100*			91	97	97
FICs	NA	*0.0*			0.0	0.0	0.0	*0*			0	0	0
SF_6	23900	*1.4*			1.4	1.5	1.5	*100*			104	106	106
Subtotal 'non-ODP' halocarbons		***8.7***			**8.6**	**10.2**	**12.3**	***100***			**99**	**117**	**141**
TOTAL CO_2-EQUIVALENT		***221.8***			**226.0**	**229.2**	**238.6**	***100***			**102**	**103**	**108**
B. Ozone depleting substances:													
CFCs	NA	*34.7*			11.8	7.7	4.7	*100*			34	22	14
halons	NA	*0.9*			0.3	0.1	0.0	*100*			36	7	0
CTC, MCF, MBr	NA	*1.1*			0.5	0.3	0.1	*100*			44	23	9
HCFCs	NA	*2.3*			3.2	3.2	2.6	*100*			142	140	115
Total 'ODP' halocarbons		***39.1***			**15.9**	**11.2**	**7.5**	***100***			**41**	**29**	**19**
C. Ozone precursors:		**Emission [mln kg]**											
NO_x b)	NA	574.0	575.2	565.5	542.7	524.0	517.9	100	100	99	95	91	90
CO	NA	1060.4	963.6	949.2	914.8	894.4	873.2	100	91	90	86	84	82
NMVOC c)	NA	444.2	413.5	398.5	396.4	377.6	364.1	100	93	90	89	85	82
D. Other gases affecting climate:													
SO_2	NA	202.5	192.9	166.8	160.9	145.8	146.8	100	95	82	79	72	72

* Data for 1995 are preliminary figures.

** Emissions in 1990 of halocarbons were estimated by multiplying the emission in 1993 by the consumption ratio of 1990 over 1993. Notes: see next page.

Notes: see next page.

Notes:

a) HFC in 1990 and 1995 include an estimate for HFC-23 as by-product emission based on extrapolation of 1993 and 1994 data Data for 1995 can not be compared well with 1993 and 1994 data, as they are estimated differently by different sources.

b) as NO_2.

c) NMVOC emissions reported here are emissions of NMVOC according to the so-called 'KWS-2000' definition total NMVOC minus CTC, MCF and CFC-11; and other CFCs, which are only partially (0.346) included.

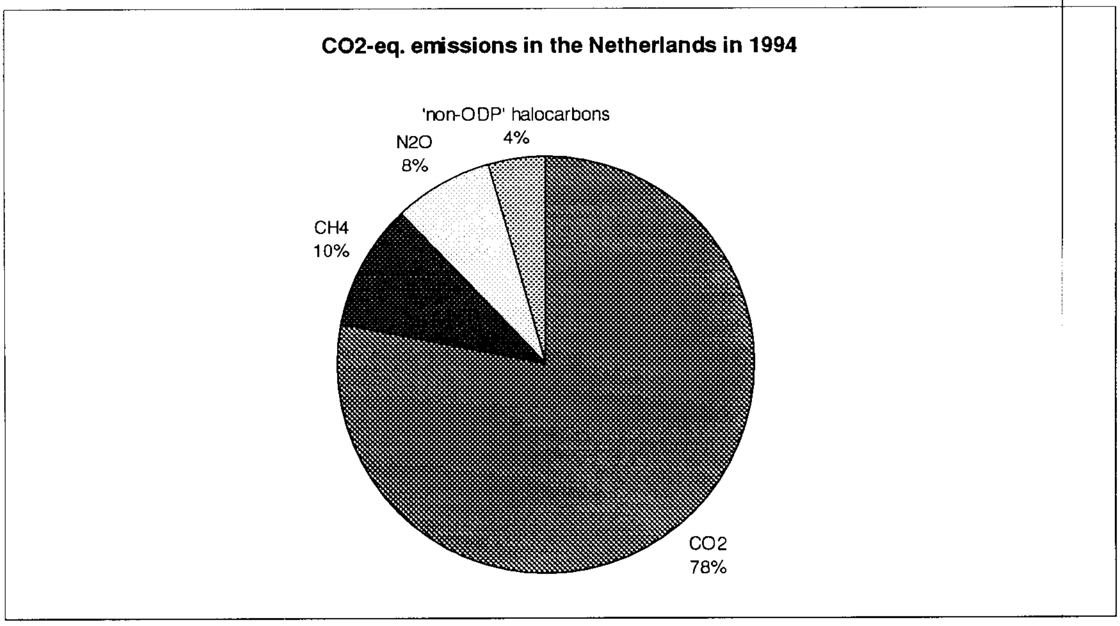

Fig. 8.1 Greenhouse gas emissions in the Netherlands per compound in 1994 (direct effects only) (temperature corrected).

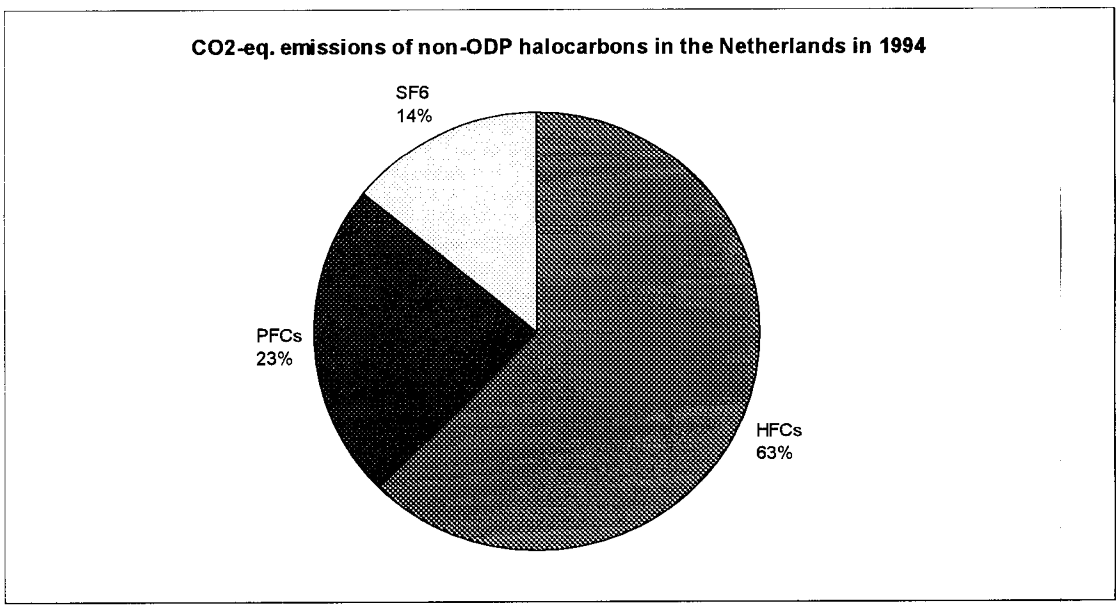

Fig. 8.2 Calculated emissions of halocarbons for the Netherlands in 1994 (direct effects only).

8.3. Contribution of source categories to CO_2 equivalent emissions

In Figure 8.3 the development of the share of the Netherlands' target groups in CO_2 equivalent emissions is presented for the period 1990-1995. This figure clears shows the large contribution of the target groups Industry and Energy in all years. In the period 1990-1994 total CO_2-eq. emissions of compounds covered under the UN-FCCC have been increasing by about 3% (also 3% when excluding halocarbons). In these years, energy and transport emissions have increased by 11%, mainly due to increasing CO_2 emissions, whereas the emissions from the industry remained about at the same level in this period although there was a sharp increase of emissions of non-ODP halocarbons, in particular of HFCs. The increasing trend of these sectors continues in 1995 (preliminary figures). As a result of both large initial shares and highest growth rates, the shares of the Energy and Transport sectors in the national total have been increasing over the last years to 20 and 15% in 1994, respectively, while the shares of the Industry and Agricultural sectors remained almost constant at 29 and 12%, respectively.

More information on the causes of these trends and comparisons with emissions and trends in our neighbour countries can be found in the annual *Environmental Balance 1996* (RIVM, 1996a,b).

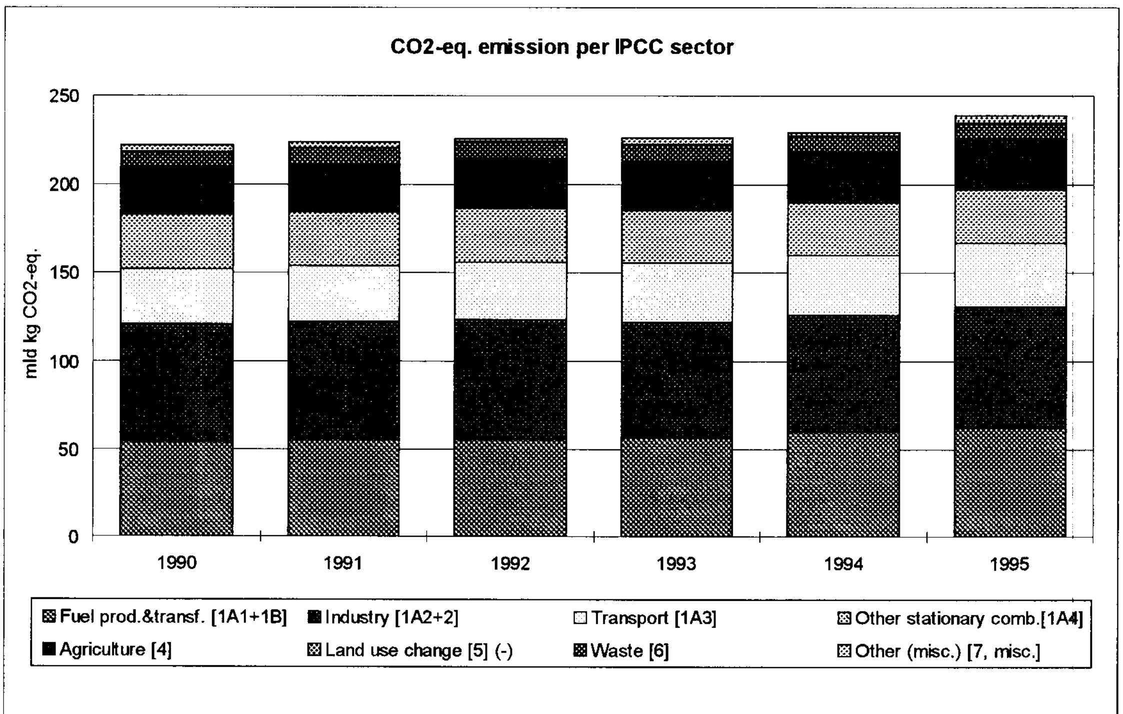

Fig. 8.3 Greenhouse gas emissions in the Netherlands per source category 1990-1995 (direct effects only, temperature corrected).

Note:

Industry includes estimates for non-ODP halocarbons cf. AFEAS/Kroeze and Montreal Protocol;

(-) Not visible (small);

Other: construction, drinking water, indirect/other, waste water treatment.

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APPENDIX A.

Summary Report for 1990, 1994 and 1995 [IPCC Table 7A]

IPCC TABLE 7A: SHORT SUMMART REPORT OF GREENHOUSE GASES IN THE NETHERLANDS (1995: PRELIMINARY DATA) (Gg a-1)
Including temperature correction for CO2.

Short Summary Report for National Greenhouse Gas Inventories (Gg a-1 full molecular weight)

Year: 1990

Source categories	CO2 Emissions**	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2
Total Net National Emissions and Removals	*173950*	(-1500)*	1103.8	51.2	573.9	1071.8	444.3	202.5
1. All energy (combustion and fugitive)	*171200*		211.7	5.5	556.6	951.6	242.6	174.5
1A. Fuel combustion total	*171200*		33.2	5.5	556.6	951.6	207.5	174.5
1B. Fugitive fuel emissions	*NA*		178.5	NA	NA	NA	35.1	NE
2. Industrial processes	*1850*		5.8	18.6	12.7	116.1	101.5	25.0
3. Solvents and other product use	*NE*		NE	0.5	IE	2.0	100.1	NA
4. Agriculture	*0*		504.9	22.2	NA	NA	NA	NA
5. Land-use change and forestry *		(-1500)*	NE	NE	NE	NE	NE	NE
6. Waste	*900*		379.4	0.6	4.6	2.2	0.1	3.0
7. Other sources (specified)	*IE*		2.0	3.8	NA	NA	NA	NA
International bunkers ***	40400							
Nature ****	..		125.0	1.5	16.3	26.7	3.7	..
Halocarbon emission total (Gg):	0.888							
HFCs	0.489							
PFCs	0.341							
FICs	0							
SF6	0.058							

Year: 1994

Source categories	CO2 Emissions**	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2
Total Net National Emissions and Removals	178900	(-1700)*	1068.6	57.7	524	894.4	377.6	145.9
1. All energy (combustion and fugitive)	176000		199.9	7.9	509.74	787	204.4	127.4
1A. Fuel combustion total	176000		30.7	7.9	509.74	787	172.9	127.4
1B. Fugitive fuel emissions	NA		169.2	NA	NA	NA	31.5	NE
2. Industrial processes	2000		5.3	18	10.66	101	78.1	16.2
3. Solvents and other product use	NE		NE	0.5	IE	2	94.1	NA
4. Agriculture	0		482.3	26.6	NA	NA	NA	NA
5. Land-use change and forestry *		(-1700)*	NE	NE	NE	NE	NE	NE
6. Waste	900		379.1	0.9	3.6	4.4	1	2.3
7. Other sources (specified)	IE		2	3.8	NA	NA	NA	NA
International bunkers ***	43200							
Nature ****	..		125	1.5	16.3	26.7	3.7	..
Halocarbon emission total (Gg):	1.032							
HFCs	0.618							
PFCs	0.353							
FICs	0							
SF6	0.061							

Year: 1995

Source categories	CO2 Emissions**	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2
Total Net National Emissions and Removals	*185900*	(-1700)*	1062.7	58.5	517.9	873.2	364.1	146.8
1. All energy (combustion and fugitive)	*182900*		200.8	8.4	505.5	760.1	190.9	129.0
1A. Fuel combustion total	*182900*		30.7	8.4	505.5	760.1	157.9	129.0
1B. Fugitive fuel emissions	*NA*		170.1	NA	NA	NA	33.0	NE
2. Industrial processes	*2100*		5.0	18.1	10.5	108.0	78.1	16.9
3. Solvents and other product use	*NE*		NE	0.5	IE	2.0	94.1	NA
4. Agriculture	*0*		475.4	26.9	NA	NA	NA	NA
5. Land-use change and forestry *		(-1700)*	NE	NE	NE	NE	NE	NE
6. Waste	*900*		379.5	0.8	1.9	3.1	1.0	0.9
7. Other sources (specified)	*IE*		2.0	3.8	NA	NA	NA	NA
International bunkers ***	44600							
Nature ****	..		125.0	1.5	16.3	26.7	3.7	..
Halocarbon emission total (Gg):	1.624							
HFCs	1.21							
PFCs	0.353							
FICs	0							
SF6	0.061							

Notes:
- * CO2 removal between brackets.
- ** Including temperature correction for CO2.
- *** Not included in net national total.
- **** Not included in national total. Methane emissions include 50 Gg natural background emissions from agricultural soils

APPENDIX B.

Detailed Summary Report for 1990, 1994 and 1995 [IPCC Table 7B]

IPCC Table 7B. GREENHOUSE GASES IN THE NETHERLANDS IN 1990 (Gg a-1 full molecular weight).
Including temperature correction for CO2.

Greenhouse gas emissions (Gg = 10^9 g)	CO2 not corrected	CO2 *temp.corrected*	CH4	N2O	NOx	CO	NMVOC	SO2
Total net national emissions	167550	*173950*	1103.8	51.2	573.9	1071.8	444.3	202.5
1. All Energy (combustion and fugitive)	164800	*171200*	211.7	5.5	556.6	951.6	242.6	174.5
1A. Fuel combustion total ****	164800	*171200*	33.2	5.5	556.6	951.6	207.5	174.5
1A1a. Electricity and heat production	38100	*38300*	IE	0.4	81.1	12.2	IE	48.1
1A1c. Other transformation **	13300	*13300*	0.3	0.1	18.8	4.9	IE	69.9
1'A2. Industry (only energy) **	33400	*34100*	2.7	0.1	63.2	131.4	IE	25.0
1A2f. Actual from feedstocks	14800	*14800*	NE	NE	NE	NE	NE	NE
1A3. Transport ***	26800	*26800*	7.2	4.9	350.9	706.4	196.9	26.5
1A4a. Commercial/institutional	10600	*11800*	7.6	0.0	11.5	3.0	IE	3.4
1A4b. Residential	19200	*22300*	11.6	0.0	18.9	6.0	IE	0.9
1A4c. Agriculture/forestry/fishing	7500	*8700*	0.1	NE	10.1	2.9	1.2	0.5
1A5. Other	0	*0*	NA	NA	NA	NA	3.5	NA
1A5c. Statistical differences	1100	*1100*	NE	NE	NE	NE	NE	NE
1A6. Biomass burned for energy	(1600)*	*(1600)**	3.7	0.0	2.1	84.7	5.9	0.2
1B. Fugitive fuel emissions	NA	*NA*	178.5	NA	NA	NA	35.1	NE
1B1. Coal mining	NA	*NA*	NA	NA	NA	NA	NA	NA
1B2a. Crude oil	NE	*NE*	14.3	NA	NA	NA	14.3	NE
1B2b. Natural gas	NE	*NE*	164.2	NA	NA	NA	20.8	NE
2. Industrial processes (ISIC)	1850	*1850*	5.8	18.6	12.7	116.1	101.5	25.0
2.A. Iron and steel	700	*700*	IE	NA	IE	IE	IE	IE
2.B. Non-ferrous metals	IE	*IE*	IE	NA	IE	IE	IE	IE
2.C. Chemicals (inorganic)	IE	*IE*	IE	18.6	IE	IE	IE	IE
2.D. Chemicals (organic)	IE	*IE*	IE	IE	IE	IE	IE	IE
2.E. Non-metallic mineral products	1000	*1000*	IE	NE	IE	IE	IE	IE
2.F. Other	150	*150*	5.8	NE	12.7	116.1	101.5	25.0
3. Solvents and other product use *****	NE	*NE*	NE	0.5	IE	2.0	100.1	NA
4. Agriculture	0	*0*	504.9	22.2	NA	NA	NA	NA
4A. Enteric fermentation	0	*0*	401.9	NA	NA	NA	NA	NA
4B. Manure management	0	*0*	103.0	IE	NA	NA	NA	NA
4C. Rice cultivation	NA	*NA*	NA	NA	NO	NO	NO	NO
4D. Agricultural soils	0	*0*	0.0	22.2	NA	NA	NA	NA
4E. Savanna burning	NA	*NA*	NA	NA	NA	NA	NA	NA
4F. Agricultural waste burning	0	*0*	NE	NE	NE	NE	NE	NE
5. Land use change and forestry	(-1500)*	*(-1500)**	NE	NE	NE	NE	NE	NE
5A. Forest clearing	NE	*NE*	NE	NE	NE	NE	NE	NE
5A2. Plantation establishment	(-15]00)*	*(-1500)**	NE	NE	NE	NE	NE	NE
5B. Conversion of grass to cult. land	NE	*NE*	NE	NE	NE	NE	NE	NE
5C. Abandonment of managed lands	NE	*NE*	NE	NE	NE	NE	NE	NE
5D. Other	NE	*NE*	NE	NE	NE	NE	NE	NE
6. Waste	900	*900*	379.4	0.6	4.6	2.2	0.1	3.0
6A. Landfills (solid waste disposal)	NE	*NE*	376.4	NE	NA	NA	0.1	NA
6B. Wastewater treatment (sewage)	NE	*NE*	3.0	0.5	IE	IE	IE	IE
6C. Waste incineration	900	*900*	0.0	0.1	4.6	2.2	0.0	3.0
6D. Other waste	NE	*NE*	NE	NE	NE	NE	NE	NE
7. Other (specified)	IE	*IE*	2.0	3.8	NA	NA	NA	NA
7A. Drinking-water treatment	IE	*IE*	2.0	NE	NA	NA	NA	NA
7B. Polluted surface water	NA	*NA*	NE	3.8	NA	NA	NA	NA
NATURE *	..	..	125.0	1.5	16.3	26.7	3.7	..

Notes:
a. NMVOC = Non-Methane Volatile Organic Compounds (as defined acc. 'KWS-2000')
b. ISIC = International Standard Industrial Classification
c. CO2 from biomass burning is not included in the energy category total. If net CO2 emissions result from unsustainable bioenergy use, this will appear in the land-use change categories
d. NE = not estimated, small
e. NA = not applicable
f. IE = included elsewhere, NO = not occuring

* Not included in national total. Methane emissions include 50 Gg natural background emissions from agricultural soils.
** For CO2, coke oven emissions are included under 'Other transferation'; for non-CO2 gases, the emissions of coke ovens are included under 'Industry'.
*** NMVOC emissions from combustion in transport include 48 Gg from evaporation (about 24% of total).
**** Emissions from cogeneration (CHP) are included in the sectors in which it is applied.
***** N2O emissions from anaesthesia use and CO emissions from tabacco smoking.

Other greenhouse gas emissions (Gg = 10^9 g)

Halocarbons (	Consumption	Emission
HFCs	0.000	0.489
HFC-23	0.000	0.410
HFC-32	0.000	0.000
HFC-125	0.000	0.020
HFC-134a	0.000	0.030
HFC-143a	0.000	0.004
HFC-152a	0.000	0.025
HFC-227ea	0.000	0.000
PFCs	0.000	0.341
CF4		0.310
C2F6		0.031
Other PFC us	0.000	0.000
FICs	0.000	0.000
SF6	0.058	0.058
International bunkers (Gg):		40400
CO2 from marine bunkers		35900
CO2 from aviation bunkers		4500

Uncertainty:
CO2: 2%; CH4: 25%; N2O: 50%
CO, NOx, NMVOC: 50%; SO2: 25%
HFCs: 50%, PFCs:100%, FICs: NA, SF6: 50%

IPCC Table 7B. SUMMARY REPORT OF GREENHOUSE GASES IN THE NETHERLANDS IN 1994 (Gg a-1 full molecular weight).
Including temperature correction for CO2.

Greenhouse gas emissions (Gg)	CO2 no temp. corr.	CO2 *temp. corrected*	CH4	N2O	NOx	CO	NMVOC	SO2
Total net national emissions	**175200**	***178900***	**1068.6**	**57.7**	**524.0**	**894.4**	**377.6**	**145.9**
1. All Energy (combustion and fugitive)	**172300**	***176000***	**199.9**	**7.9**	**509.7**	**787.0**	**204.4**	**127.4**
1A. Fuel combustion total ****	**172300**	***176000***	**30.7**	**7.9**	**509.7**	**787.0**	**172.9**	**127.4**
1A1a. Electricity and heat productio	42800	*42900*	IE	0.4	59.4	18.9	IE	16.6
1A1c. Other transformation **	14600	*14600*	0.5	0.1	16.7	2.3	IE	58.9
1'A2. Industry (only energy) **	31900	*32200*	2.5	0.1	53.1	114.4	IE	16.2
1A2f. Actual from feedstocks	14300	*14300*	NE	NE	NE	NE	NE	NE
1A3. Transport ***	29000	*29000*	6.2	7.2	341.0	551.1	158.0	31.0
1A4a. Commercial/Institutional	10900	*11700*	1.0	0.0	7.1	3.3	IE	3.4
1A4b. Residential	19600	*21400*	13.1	0.1	20.0	6.3	IE	0.9
1A4c. Agriculture/forestry/fishing	8600	*9300*	3.5	NE	10.2	1.6	2.3	0.4
1A5. Other		*0*	NA	NA	NA	NA	6.4	NA
1A5c. Statistical differences	600	*600*	NE	NE	NE	NE	NE	NE
1A6. Biomass burned for energy	(1600)*	*(1600)**	3.9	0.0	2.2	89.1	6.2	0.2
1B. Fugitive fuel emissions	**NA**	***NA***	169.2	NA	NA	NA	**31.5**	**NE**
1B1. Coal mining	NA	*NA*	NA	NA	NA	NA	NA	NA
1B2a. Crude oil	NE	*NE*	6.8	NA	NA	NA	11.4	NE
1B2b. Natural gas	NE	*NE*	162.4	NA	NA	NA	20.1	NE
2. Industrial processes (ISIC)	**2000**	***2000***	**5.3**	**18.0**	**10.7**	**101.0**	**78.1**	**16.2**
2.A. Iron and steel	800	*800*	IE	NA	IE	IE	IE	IE
2.B. Non-ferrous metals	IE	*IE*	IE	NA	IE	IE	IE	IE
2.C. Chemicals (inorganic)	IE	*IE*	IE	18.0	IE	IE	IE	IE
2.D. Chemicals (organic)	IE	*IE*	IE	IE	IE	IE	IE	IE
2.E. Non-metallic mineral products	1000	*1000*	IE	NE	IE	IE	IE	IE
2.F. Other	200	*200*	5.3	NE	10.7	101.0	78.1	16.2
3. Solvents and other product use *****	**NE**	***NE***	**NE**	**0.5**	IE	**2.0**	**94.1**	**NA**
4. Agriculture	**0**	***0***	**482.3**	**26.6**	**NA**	**NA**	**NA**	**NA**
4A. Enteric fermentation	0	*0*	381.7	NA	NA	NA	NA	NA
4B. Manure management	0	*0*	100.6	IE	NA	NA	NA	NA
4C. Rice cultivation	NA	*NA*	NA	NA	NO	NO	NO	NO
4D. Agricultural soils	0	*0*	0.0	26.6	NA	NA	NA	NA
4E. Savanna burning	NA	*NA*	NA	NA	NA	NA	NA	NA
4F. Agricultural waste burning	0	*0*	NE	NE	NE	NE	NE	NE
5. Land use change and forestry	**(-1700)***	***(-1700)****	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5A. Forest clearing	NE	*NE*	NE	NE	NE	NE	NE	NE
5A2. Plantation establishment	(-1700)*	*(-1700)**	NE	NE	NE	NE	NE	NE
5B. Conversion of grass to cult. lanc	NE	*NE*	NE	NE	NE	NE	NE	NE
5C. Abandonment of managed land	NE	*NE*	NE	NE	NE	NE	NE	NE
5D. Other	NE	*NE*	NE	NE	NE	NE	NE	NE
6. Waste	**900**	***900***	**379.1**	**0.9**	**3.6**	**4.4**	**1.0**	**2.3**
6A. Landfills (solid waste disposal)	NE	*NE*	374.0	NE	NA	NA	1.0	NA
6B. Wastewater treatment (sewage)	NE	*NE*	5.1	0.5	0.2	0.1	NE	0.7
6C. Waste incineration	900	*900*	0.0	0.4	3.4	4.3	0.0	1.6
6D. Other waste	NE	*NE*	NE	NE	NE	NE	NE	NE
7. Other (specified)	**IE**	***IE***	**2.0**	**3.8**	**NA**	**NA**	**NA**	**NA**
7A. Drinking-water treatment	IE	*IE*	2.0	NE	NA	NA	NA	NA
7B. Polluted surface water	NA	*NA*	NE	3.8	NA	NA	NA	NA
NATURE *	..	..	**125.0**	**1.5**	**16.3**	**26.7**	**3.7**	..

Notes:
a. NMVOC = Non-Methane Volatile Organic Compounds (as defined acc. 'KWS-2000')
b. ISIC = International Standard Industrial Classification
c. CO2 from biomass burning is not included in the energy category total. If net CO2 emissions result from unsustainable bioenergy use, this will appear in the land-use change categories
d. NE = not estimated, small
e. NA = not applicable
f. IE = included elsewhere, NO = not occuring

* Not included in national total. Methane emissions include 50 Gg natural background emissions from agricultural soils.
** For CO2, coke oven emissions are included under 'Other transferation'; for non-CO2 gases, the emissions of coke ovens are included under 'Industry'.
*** NMVOC emissions from combustion in transport include 45 Gg from evaporation (about 28% of total).
**** Emissions from cogeneration (CHP) are included in the sectors in which it is applied.
***** N2O emissions from anaesthesia use and CO emissions from tabacco smoking.

Other greenhouse gas emissions (Gg = 10^9 g)

Halocarbons (Gg)	Consumption	Emission
HFCs	**0.274**	**0.618**
HFC-23		0.536
HFC-32		0.001
HFC-125		0.020
HFC-134a	0.274	0.031
HFC-143a		0.006
HFC-152a		0.024
HFC-227ea		0.000
PFCs	**0.023**	**0.353**
CF4		0.300
C2F6		0.030
Other PFC use	0.023	0.023
FICs	**0.000**	**0.000**
SF6	**0.061**	**0.061**
International bunkers (Gg):		43200
CO2 from marine bunkers		36500
CO2 from aviation bunkers		6700

Uncertainty:
CO2: 2%; CH4: 25%; N2O: 50%
CO, NOx, NMVOC: 50%; SO2: 25%
HFCs: 50%, PFCs:100%, FICs: NA, SF6: 50%

IPCC Table 7B. SUMMARY REPORT OF GREENHOUSE GASES IN THE NETHERLANDS IN 1995 (PRELIMINARY DATA)

Including temperature correction for CO2.

Greenhouse gas emissions (Gg)	CO2	CO2	CH4	N2O	NOx	CO	NMVOC	SO2
	no temp. corr.	*temp. corrected*						
Total net national emissions	**183400.0**	***185900.0***	**1062.7**	**58.5**	**517.9**	**873.2**	**364.1**	**146.8**
1. All Energy (combustion and fugitive)	**180400.0**	***182900.0***	**200.8**	**8.4**	**505.5**	**760.1**	**190.9**	**129.0**
1A. Fuel combustion total ****	**180400.0**	***182900.0***	30.7	8.4	505.5	760.1	157.9	129.0
1A1a. Electricity and heat production	44800	*44900*	IE	0.4	60.6	18.8	IE	17.5
1A1c. Other transformation **	14700	*14700*	0.4	0.1	16.9	2.3	IE	60.6
1'A2. Industry (only energy) **	33400	*33600*	2.4	0.1	53.7	119.6	IE	16.3
1A2f. Actual from feedstocks	14000	*14000*	NE	NE	NE	NE	NE	NE
1A3. Transport ***	30100	*30100*	5.9	7.7	333.8	518.0	148.1	30.3
1A4a. Commercial/Institutional	11300	*11900*	1.0	0.0	7.2	3.2	IE	3.0
1A4b. Residential	20700	*21900*	13.6	0.1	20.6	7.5	IE	0.7
1A4c. Agriculture/forestry/fishing	8900	*9300*	3.5	NE	10.5	1.6	2.3	0.4
1A5. Other			NA	NA	NA	NA	1.3	NA
1A5c. Statistical differences	2500	*2500*	NE	NE	NE	NE	NE	NE
1A6. Biomass burned for energy	(1600)*	*(1600)**	3.9	0.0	2.2	89.1	6.2	0.2
1B. Fugitive fuel emissions	NA	*NA*	170.1	NA	NA	NA	33.0	NE
1B1. Coal mining	NA	*NA*	NA	NA	NA	NA	NA	NA
1B2a. Crude oil	NE	*NE*	5.1	NA	NA	NA	12.6	NE
1B2b. Natural gas	NE	*NE*	165.0	NA	NA	NA	20.4	NE
2. Industrial processes (ISIC)	**2100**	***2100***	**5.0**	**18.1**	**10.5**	**108.0**	**78.1**	**16.9**
2.A. Iron and steel	800	*800*	IE					
2.B. Non-ferrous metals	NE		IE					
2.C. Chemicals (inorganic)	NE	*NE*	IE	18.1	IE	IE	IE	IE
2.D. Chemicals (organic)	NE		IE					
2.E. Non-metallic mineral products	1000	*1000*	IE	NE	IE	IE	IE	IE
2.F. Other	300	*300*	5.0	NE	10.5	108.0	78.1	16.9
3. Solvents and other product use *****	NE	*NE*	NE	**0.5**	IE	**2.0**	**94.1**	NA
4. Agriculture	0	*0*	***475.4***	***26.9***	NA	NA	NA	NA
4A. Enteric fermentation	0	*0*	376.7	NA	NA	NA	NA	NA
4B. Manure management	0	*0*	98.7	IE	NA	NA	NA	NA
4C. Rice cultivation	NA	*NA*	NA	NA	NO	NO	NO	NO
4D. Agricultural soils	0	*0*	0.0	26.9	NA	NA	NA	NA
4E. Savanna burning	NA	*NA*	NA	NA	NA	NA	NA	NA
4F. Agricultural waste burning	0	*0*	NE	NE	NE	NE	NE	NE
5. Land use change and forestry	(-1700)*	*(-1700)**	NE	NE	NE	NE	NE	NE
5A. Forest clearing	NE	*NE*	NE	NE	NE	NE	NE	NE
5A2. Plantation establishment	(-1700)*	*(-1700)**	NE	NE	NE	NE	NE	NE
5B. Conversion of grass to cult. land	NE	*NE*	NE	NE	NE	NE	NE	NE
5C. Abandonment of managed lands	NE	*NE*	NE	NE	NE	NE	NE	NE
5D. Other	NE	*NE*	NE	NE	NE	NE	NE	NE
6. Waste	**900**	***900***	**379.5**	**0.8**	**1.9**	**3.1**	**1.0**	**0.9**
6A. Landfills (solid waste disposal)	NE	*NE*	374.4	NE	NA	NA	0.8	NA
6B. Wastewater treatment (sewage)	NE	*NE*	5.1	0.5	0.2	0.1	NE	0.6
6C. Waste incineration	900	*900*	0.0	0.3	1.7	3.0	0.2	0.3
6D. Other waste	NE	*NE*	NE	NE	NE	NE	NE	NE
7. Other (specified)	IE	*IE*	**2.0**	**3.8**	**NA**	**NA**	**NA**	**NA**
7A. Drinking-water treatment	IE	*IE*	2.0	NE	NA	NA	NA	NA
7B. Polluted surface water	NA	*NA*	NE	3.8	NA	NA	NA	NA
NATURE *	..	..	125.0	1.5	16.3	26.7	3.7	..

Notes:
a. NMVOC = Non-Methane Volatile Organic Compounds (as defined acc. 'KWS-2000')
b. ISIC = International Standard Industrial Classification
c. CO2 from biomass burning is not included in the energy category total. If net CO2 emissions result from unsustainable bioenergy use, this will appear in the land-use change categories
d. NE = not estimated, small
e. NA = not applicable
f. IE = included elsewhere, NO = not occuring

* Not included in national total. Methane emissions include 50 Gg natural background emissions from agricultural soils.
** For CO2, coke oven emissions are included under 'Other transferation'; for non-CO2 gases, the emissions of coke ovens are included under 'Industry'.
*** NMVOC emissions from combustion in transport include 45 Gg from evaporation (about 30% of total).
**** Emissions from cogeneration (CHP) are included in the sectors in which it is applied.
***** N2O emissions from anaesthesia use and CO emissions from tabacco smoking.

Other greenhouse gas emissions (Gg = 10^9 g)

Halocarbons (Gg)	Consumption	Emission	
HFCs	0.274	1.210	
HFC-23		0.649	a)
HFC-32			a)
HFC-125		0.050	
HFC-134a	0.274	0.454	
HFC-143a		0.034	
HFC-152a		0.023	a)
HFC-227ea			a)
PFCs	0.023	0.353	
CF4		0.300	
C2F6		0.030	
Other PFC use	0.023	0.023	
FICs	0.000	0.000	
SF6	0.061	0.061	

International bunkers (Gg):	44600
CO2 from marine bunkers	37500
CO2 from aviation bunkers	7100

Uncertainty:
CO2: 2%; CH4: 25%; N2O: 50%
CO, NOx, NMVOC: 50%; SO2: 25%
HFCs: 50%, PFCs:100%, FICs: NA, SF6: 50%

a) Amount is confidential: total use of HFC-23, 32, 152a and 227ea is 23 ton (excluding emissions as by-product from HCFC-22 production).

APPENDIX C.

Overview Table with Estimates, Quality and Documentation for 1990, 1994 and 1995 [IPCC Table 8A]

IPCC TABLE 8A: OVERVIEW TABLE OF GREENHOUSE GASES IN THE NETHERLANDS 1990 (Gg a-1 full molecular weight):
Overview table of estimates, quality and documentation.
Including temperature correction for CO2.

Greenhouse gas emissions (Gg a-1)	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		Documentation
Source categories	*Estimate*	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	
Total net national emissions	*173950*	H	**1103.8**	**M**	**51.2**	**L**	**573.9**	**M**	**1071.8**	**M**	**444.3**	**M**	**202.5**	**H**	**H**
1. All energy (combustion and fugitive)	*171200*	H	**211.7**	**M**	**5.5**	**L**	**556.6**	**M**	**951.6**	**M**	**242.6**	**M**	**174.5**	**H**	**H**
1A. Fuel combustion total	*171200*	H	33.2	M	5.5	L	556.6	M	951.6	M	207.5	M	174.5	H	H
1A1. Energy & Transform. Industries **	*51600*	H	0.3	M	0.5	L	99.9	M	17.1	M	IE		118.0	H	H
1'A2. Industry (only energy) **	*34100*	H	2.7	M	0.1	L	63.2	M	131.4	M	IE		25.0	H	H
1A2f. Actual from feedstocks	*14800*	M	NE	M	NE		NE		NE		NE		NE		H
1A3. Transport	*26800*	H	7.2	M	4.9	M	350.9	M	706.4	M	196.9	M	26.5	H	H
1A4. Small combustion	*42800*	H	19.3	M	0.0	L	40.5	M	11.9	M	1.2	M	4.8	H	H
1A5. Other ***	*1100*	H	0.0	M	NA		NA		NA		3.5	M	NA		H
1A6. Biomass burned for energy	*(1600)**	L	3.7	L	0.0	L	2.1	L	84.7	L	5.9	L	0.2	L	H
1B. Fugitive fuel emissions	*NA*		178.5	M	NA		NA		NA		35.1	M	NE		H
1B1. Solid fuels	*NA*		NA		NA		NA		NA		NA		NA		H
1B2. Oil and natural gas	*NE*		178.5	M	NA		NA		NA		35.1	M	NE		H
2. Industrial processes	*1850*	H	**5.8**		**18.6**	**L**	**12.7**	**M**	**116.1**		**101.5**	**M**	**25.0**	**H**	**H**
3. Solvents and other product use	*NE*		**NE**		**0.5**		**IE**		**2.0**		**100.1**	**M**	**NA**		**H**
4. Agriculture	*0*		**504.9**	**M**	**22.2**	**L**	**NA**		**NA**		**NA**		**NA**		**H**
4A. Enteric fermentation	*0*		401.9	M	NA		NA		NA		NA		NA		H
4B. Animal wastes	*0*		103.0	L	IE		NA		NA		NA		NA		H
4C. Rice cultivation	*NA*		NA		NA		NO		NO		NO		NO		H
4D. Agricultural soils	*0*		0.0	L	22.2	L	NA		NA		NA		NA		H
4E. Savanna burning	*NA*		NA		NA		NA		NA		NA		NA		H
4F. Agricultural waste burning	*0*		NE		NE		NE		NE		NE		NE		H
5. Land-use change and forestry	*(-1500)**	M	**NE**	**M**	**NE**	**L**	**NE**	**M**	**NE**	**M**	**NE**		**NE**		**H**
6. Waste	*900*	M	**379.4**	**M**	**0.6**	**L**	**4.6**	**M**	**2.2**	**M**	**0.1**	**M**	**3.0**	**M**	**H**
6A. Landfills (solid waste disposal)	*NE*		376.4	M	NE		NA		NA		0.1	M	NA		H
6B. Wastewater (sewage) treatment	*NE*		3.0	M	0.5	L	IE	M	IE	M	IE		IE	M	H
6C. Waste incineration	*900*	M	0.0	M	0.1	L	4.6	M	2.2	M	0.0	M	3.0	M	H
7. Other sources (specified)	*IE*		**2.0**	**M**	**3.8**	**L**	**NA**		**NA**		**NA**		**NA**		**H**
A. Drinking-water treatment	*IE*		2.0	M	NE		NA		NA		NA		NA		H
B. Polluted surface waters	*NA*		NE		3.8	L	NA		NA		NA		NA		H
International bunkers	**40400**	H													
Nature *	..		**125.0**	**L**	**1.5**	**L**	**16.3**	**L**	**26.7**	**L**	**3.7**	**L**	..		

Halocarbon emission total (Gg):	**0.888**	L
HFCs	0.489	M
PFCs	0.341	L
FICs	0	M
SF6	0.058	M

Uncertainty:
CO, NOx, NMVOC: 50%; SO2: 25%
HFCs: 50%, PFCs:100%, FICs: NA, SF6: 50%

Notes:
a. NMVOC = Non-Methane Volatile Organic Compounds
b. ISIC = International Standard Industrial Classification
c. CO2 from biomass burning is not included in the energy category total. If net CO2 emissions result from unsustainable bioenergy use, this will appear in the land-use change categories
d. NE = not estimated, small
e. NA = not applicable.
f. IE = included elsewhere, NO = not occuring

Q = Quality of data: H=high confidence in estimate, M=medium, L=low.
Disaggregation : CO2: Subsectoral split; Other gases: sectoral split.

* Not included in national total.
** For CO2, coke oven emissions are included under 'Energy and Transformation Industries'; for non-CO2 gases, the emissions of coke ovens are included under 'Industry'.
*** For CO2, including statisitical differences.

IPCC TABLE 8A: OVERVIEW TABLE OF GREENHOUSE GASES IN THE NETHERLANDS 1994 (Gg a-1 full molecular weight):
Overview table of estimates, quality and documentation.
Including temperature correction for CO2.

Greenhouse gas emissions (Gg a-1)	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		Documentation
Source categories	*Estimate*	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	
Total net national emissions	***178900***	**H**	**1068.6**	**M**	**57.7**	**L**	**524.0**	**M**	**894.4**	**M**	**377.6**	**M**	**145.9**	**H**	H
1. All energy (combustion and fugitive)	***176000***	**H**	**199.9**	**M**	**7.9**	**L**	**509.7**	**M**	**787.0**	**M**	**204.4**	**M**	**127.4**	**H**	H
1A. Fuel combustion total	*176000*	H	30.7	M	7.9	L	509.7	M	787.0	M	172.9	M	127.4	H	H
1A1. Energy & Transform. Industries **	*57500*	H	0.5	M	0.5	L	76.1	M	21.2	M	IE		75.5	H	H
1'A2. Industry (only energy) **	*32200*	H	2.5	M	0.1	L	53.1	M	114.4	M	IE		16.2	H	H
1A2f. Actual from feedstocks	*14300*	M	NE	M	NE		NE		NE		NE		NE		H
1A3. Transport	*29000*	H	6.2	M	7.2	M	341.0	M	551.1	M	158.0	M	31.0	H	H
1A4. Small combustion	*42400*	H	17.6	M	0.1	L	37.3	M	11.2	M	2.3	M	4.7	H	H
1A5. Other ***	*600*	H	0.0	M	NA		NA		NA		6.4	M	NA		H
1A6. Biomass burned for energy	*(1600)**	L	3.9	L	0.0	L	2.2	L	89.1	L	6.2	L	0.2	L	H
1B. Fugitive fuel emissions	*NA*		169.2	M	NA		NA		NA		31.5	M	NE		H
1B1. Solid fuels	*NA*		NA		NA		NA		NA		NA		NA		H
1B2. Oil and natural gas	*NE*		169.2	M	NA		NA		NA		31.5	M	NE		H
2. Industrial processes	***2000***	**H**	**5.3**		**18.0**	**L**	**10.7**	**M**	**101.0**		**78.1**	**M**	**16.2**	**H**	H
3. Solvents and other product use	***NE***		**NE**		**0.5**		**IE**		**2.0**		**94.1**	**M**	**NA**		H
4. Agriculture	***0***		**482.3**	**M**	**26.6**	**L**	**NA**		**NA**		**NA**		**NA**		H
4A. Enteric fermentation	*0*		381.7	M	NA		NA		NA		NA		NA		H
4B. Animal wastes	*0*		100.6	L	IE		NA		NA		NA		NA		H
4C. Rice cultivation	*NA*		NA		NA		NO		NO		NO		NO		H
4D. Agricultural soils	*0*		0.0	L	26.6	L	NA		NA		NA		NA		H
4E. Savanna burning	*NA*		NA		NA		NA		NA		NA		NA		H
4F. Agricultural waste burning	*0*		NE		NE		NE		NE		NE		NE		H
5. Land-use change and forestry	***(-1700)****	**M**	**NE**	**M**	**NE**	**L**	**NE**	**M**	**NE**	**M**	**NE**		**NE**		H
6. Waste	***900***	**M**	**379.1**	**M**	**0.9**	**L**	**3.6**	**M**	**4.4**	**M**	**1.0**	**M**	**2.3**	**M**	H
6A. Landfills (solid waste disposal)	*NE*		374.0	M	NE		NA		NA		1.0	M	NA		H
6B. Wastewater (sewage) treatment	*NE*		5.1	M	0.5	L	0.2	M	0.1	M	NE		0.7	M	H
6C. Waste incineration	*900*	M	0.0	M	0.4	L	3.4	M	4.3	M	0.0	M	1.6	M	H
7. Other sources (specified)	***IE***		**2.0**	**M**	**3.8**	**L**	**NA**		**NA**		**NA**		**NA**		H
A. Drinking-water treatment	*IE*		2.0	M	NE		NA		NA		NA		NA		H
B. Polluted surface waters	*NA*		NE		3.8	L	NA		NA		NA		NA		H
International bunkers	**43200**	H													
Nature *	..		**125.0**	**L**	**1.5**	**L**	**16.3**	**L**	**26.7**	**L**	**3.7**	**L**	..		

Halocarbon emission total (Gg):	1.032	L
HFCs	0.618	M
PFCs	0.353	L
FICs	0	M
SF6	0.061	M

0
0
0

Notes:
a. NMVOC = Non-Methane Volatile Organic Compounds
b. ISIC = International Standard Industrial Classification
c. CO2 from biomass burning is not included in the energy category total. If net CO2 emissions result from unsustainable bioenergy use, this will appear in the land-use change categories
d. NE = not estimated, small
e. NA = not applicable.
f. IE = included elsewhere, NO = not occuring

Q = Quality of data: H=high confidence in estimate, M=medium, L=low.
Disaggregation : CO2: Subsectoral split; Other gases: sectoral split.

* Not included in national total.
** For CO2, coke oven emissions are included under 'Energy and Transformation Industries'; for non-CO2 gases, the emissions of coke ovens are included under 'Industry'.
*** For CO2, including statisitical differences.

IPCC TABLE 8A: OVERVIEW TABLE OF GREENHOUSE GASES IN THE NETHERLANDS 1995 (PRELIMINARY DATA) (Gg a-1 full molecular weight):
Overview table of estimates, quality and documentation.
Including temperature correction for CO2.

Greenhouse gas emissions (Gg a-1)	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		Documentation
Source categories	*Estimate*	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	Estimate	Q.	
Total net national emissions	***185900***	**H**	**1062.7**	**M**	**58.5**	**L**	**517.9**	**M**	**873.2**	**M**	**364.1**	**M**	**146.8**	**H**	**H**
1. All energy (combustion and fugitive)	***182900***	**H**	**200.8**	**M**	**8.4**	**L**	**505.5**	**M**	**760.1**	**M**	**190.9**	**M**	**129.0**	**H**	**H**
1A. Fuel combustion total	*182900*	H	30.7	M	8.4	L	505.5	M	760.1	M	157.9	M	129.0	H	H
1A1. Energy & Transform. Industries **	*59600*	H	0.4	M	0.5	L	77.5	M	21.1	M	IE		78.1	H	H
1'A2. Industry (only energy) **	*33600*	H	2.4	M	0.1	L	53.7	M	119.6	M	IE		16.3	H	H
1A2f. Actual from feedstocks	*14000*	M	NE	M	NE		NE		NE		NE		NE		H
1A3. Transport	*30100*	H	5.9	M	7.7	M	333.8	M	518.0	M	148.1	M	30.3	H	H
1A4. Small combustion	*43100*	H	18.1	M	0.1	L	38.3	M	12.3	M	2.3	M	4.1	H	H
1A5. Other ***	*2500*	H	0.0	M	NA		NA		NA		1.3	M	NA		H
1A6. Biomass burned for energy	*(1600)**	L	3.9	L	0.0	L	2.2	L	89.1	L	6.2	L	0.2	L	H
1B. Fugitive fuel emissions	*NA*		170.1	M	NA		NA		NA		33.00106	M	NE		H
1B1. Solid fuels	*NA*		NA		NA		NA		NA		NA		NA		H
1B2. Oil and natural gas	*NE*		170.1	M	NA		NA		NA		33.00106	M	NE		H
2. Industrial processes	***2100***	**H**	**5.0**		**18.1**	**L**	**10.5**	**M**	**108.0**		**78.1**	**M**	**16.9**	**H**	**H**
3. Solvents and other product use	***NE***		**NE**		**0.5**		**IE**		**2.0**		**94.1**	**M**	**NA**		**H**
4. Agriculture	***0***		**475.4**	**M**	**26.9**	**L**	**NA**		**NA**		**NA**		**NA**		**H**
4A. Enteric fermentation	*0*		376.7	M	NA		NA		NA		NA		NA		H
4B. Animal wastes	*0*		98.7	L	IE		NA		NA		NA		NA		H
4C. Rice cultivation	*NA*		NA		NA		NO		NO		NO		NO		H
4D. Agricultural soils	*0*		0.0	L	26.9	L	NA		NA		NA		NA		H
4E. Savanna burning	*NA*		NA		NA		NA		NA		NA		NA		H
4F. Agricultural waste burning	*0*		NE		NE		NE		NE		NE		NE		H
5. Land-use change and forestry	***(-1700)****	**M**	**NE**	**M**	**NE**	**L**	**NE**	**M**	**NE**	**M**	**NE**		**NE**		**H**
6. Waste	***900***	**M**	**379.5**	**M**	**0.8**	**L**	**1.9**	**M**	**3.1**	**M**	**1.0**	**M**	**0.9**	**M**	**H**
6A. Landfills (solid waste disposal)	*NE*		374.4	M	NE		NA		NA		0.8	M	NA		H
6B. Wastewater (sewage) treatment	*NE*		5.1	M	0.5	L	0.2	M	0.1	M	NE		0.6	M	H
6C. Waste incineration	*900*	M	0.0	M	0.3	L	1.7	M	3.0	M	0.2	M	0.3	M	H
7. Other sources (specified)	***IE***		**2.0**	**M**	**3.8**	**L**	**NA**		**NA**		**NA**		**NA**		**H**
A. Drinking-water treatment	*IE*		2.0	M	NE		NA		NA		NA		NA		H
B. Polluted surface waters	*NA*		NE		3.8	L	NA		NA		NA		NA		H
International bunkers	**44600**	H													
Nature *	..		**125.0**	**L**	**1.5**	**L**	**16.3**	**L**	**26.7**	**L**	**3.7**	**L**	..		

Halocarbon emission total (Gg):	**1.624**	L
HFCs	1.21	M
PFCs	0.353	L
FICs	0	M
SF6	0.061	M

0
0
0

Notes:
a. NMVOC = Non-Methane Volatile Organic Compounds
b. ISIC = International Standard Industrial Classification
c. CO2 from biomass burning is not included in the energy category total. If net CO2 emissions result from unsustainable bioenergy use, this will appear in the land-use change categories
d. NE = not estimated, small
e. NA = not applicable.
f. IE = included elsewhere, NO = not occuring

Q = Quality of data: H=high confidence in estimate, M=medium, L=low.
Disaggregation : CO2: Subsectoral split; Other gases: sectoral split.

* Not included in national total.
** For CO2, coke oven emissions are included under 'Energy and Transformation Industries'; for non-CO2 gases, the emissions of coke ovens are included under 'Industry'.
*** For CO2, including statisitical differences.

APPENDIX D.

Detailed Tables for 1994 and 1995 [IPCC Standard Data Tables 1-"7"]

IPCC Standard Data Table 1. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Energy: 1A Fuel combustion activities
Year: 1994

Source category	Activity data (PJ)	*(PJ)* *temp. corr.*	Emission estimate (Gg) CO2	*CO2* *temp. corr.*	CH4	N2O	Aggregate emission factors* (ton/TJ**) CO2	CH4	N2O
1A. FUEL COMBUSTION TOTAL	**2744**	***2811***	**172200**	***176100***	**30.7**	**7.9**		**11200**	**2900**
coal* **	**350**	***350***	**32400**	***32400***		**0.4**	**92.6**		
oil* **	**992**	***992***	**62100**	***62100***		**7.4**	**62.6**		
gas* **	**1402**	***1469***	**77700**	***81500***		**0.1**	**55.4**		
biomass fuel	***NA***	***NA***			***3.9***	***0.0***		**NA**	**NA**
1.A.1 ENERGY	**795**	***797***	**57600**	***57800***	**0.5**	**0.5**		**600**	
1.A.1.a Electricity and heat production									
coal	252	*252*	23688	*23688*	IE	0.4	94		1400
oil	12	*12*	876	*876*	IE	0.0	73		600
gas	330	*332*	18480	*18592*	IE	0.0	56		100
1.A.1.b Refineries									
coal	0	*0*	0	*0*	IE	0.0	94		1400
oil	163	*163*	11899	*11899*	IE	0.1	73		600
gas	23	*23*	1288	*1288*	IE	0.0	56		100
1.A.1.c Cokeovens									
coal	15	*15*	1410	*1410*	0.5	0.0	94		1400
oil	0	*0*	0	*0*	0.0	0.0	73		600
gas	0	*0*	0	*0*	0.0	0.0	56		100
1.A.2 INDUSTRY	**490**	***495***	**46100**	***46400***	**2.5**	**0.1**	-	**5100**	**200**
coal, non-feedstock	**67**	***67***				0.0			**400**
oil, non-feedstock	**99**	***99***				0.1			**600**
gas, non-feedstock	**324**	***329***				0.0			**100**
1.A.2.a Industry: Iron and steel									
coal	62	*62*	5832	*5832*			94		
oil	0	*0*	0	*0*			73		
gas	13	*13*	728	*728*			56		
1.A.2.b: Industry: Non-ferrous metals									
coal	0	*0*	0	*0*			94		
oil	4	*4*	267	*267*			73		
gas	26	*27*	1436	*1512*			56		
1.A.2.c: Industry: Chemicals									
coal	0	*0*	0	*0*			94		
oil	92	*92*	6713	*6713*			73		
gas	108	*110*	6033	*6160*			56		
1.A.2.d: Industry: Pulp, paper and print									
coal	0	*0*	0	*0*			94		
oil	0	*0*	0	*0*			73		
gas	29	*29*	1624	*1624*			56		
1.A.2.e: Industry: Food, Beverages & Tobacco									
coal	1	*1*	94	*94*			94		
oil	2	*2*	146	*146*			73		
gas	72	*73*	4032	*4088*			56		
1.A.2.f Industry: Other									
coal	5	*5*	466	*466*			94		
oil	2	*2*	115	*115*			73		
gas	76	*77*	4256	*4312*			56		
1.A.2.g Industry: actual from feedstocks									
coal	24	*24*	1650	*1650*			69		
oil	246	*246*	7740	*7740*			31		
gas	103	*103*	4940	*4940*			48		
1.A.3 TRANSPORT	**397**	***397***	**29000**	***29000***	**6.2**	**7.2**		**15600**	
coal	0	*0*	0	*0*		0.0	94		1400
oil	397	*397*	28981	*28981*		7.2	73		**18100**
gas	0	*0*	0	*0*		0.0	56		100
1.A.4 SMALL COMBUSTION	**680**	***740***	**38900**	***42300***	**17.6**	**0.1**		**25900**	
1.A.4.a Commercial/Institutional					1.0				
coal	1	*1*	94	*94*		0.0	94		1400
oil	37	*37*	2701	*2701*		0.0	73		600
gas	143	*157*	8008	*8792*		0.0	56		100
1.A.4.b Residential					13.1				
coal	0	*0*	0	*0*		0.0	94		1400
oil	8	*8*	584	*584*		0.0	73		600
gas	339	*371*	18984	*20776*		0.0	56		100
1.A.4.c Agriculture/ forestry					3.5				
coal	0	*0*	0	*0*		0.0	94		1400
oil	3	*3*	219	*219*		0.0	73		600
gas	149	*163*	8344	*9128*		0.0	56		100
1.A.5. OTHER: Statistical differences			**600**	***600***					
coal	-9	*-9*	-846	*-846*			94		NA
oil	26	*26*	1898	*1898*			73		NA
gas	-8	*-8*	-448	*-448*			56		NA
1.A.6. Biomass burned for energy			**(1600)***	***(1600)****	3.9	0.0			

* Emission factors printed in bold are calculated (i.e. aggregated) values; others are basic factors used to estimate the emissions.
** ton/TJ = kg/GJ
*** Including feedstock and statistical differences, thereby reducing the aggregated emission factors of CH4 and N2O.
All values larger than 100 are rounded to 100.

IPCC Standard Data Table 1. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Energy: 1A Fuel combustion activities
Year: 1995

Source category	Activity data (PJ)	(PJ) *temp. corr.*	Emission estimate (Gg) CO2	CO2 *temp. corr.*	CH4	N2O	Aggregate emission factors* (ton/TJ**) CO2	CH4	N2O
1A. FUEL COMBUSTION TOTAL	2866	2910	180700	183100	30.7	8.5		10700	3000
coal* **	393	393	37600	37600		0.4	95.7		
oil* **	1040	1040	64000	64000		7.9	61.5		
gas* **	1433	1477	79100	81700		0.1	55.2		
biomass fuel					3.9	0.0		NA	NA
1.A.1 ENERGY	821	822	59800	59800	0.4	0.5		500	
1.A.1.a Electricity and heat production									
coal	268	268	25192	25192	IE	0.4	94		1400
oil	10	10	730	730	IE	0.0	73		600
gas	339	340	18984	19040	IE	0.0	56		100
1.A.1.b Refineries									
coal	0	0	0	0	IE	0.0	94		1400
oil	166	166	12118	12118	IE	0.1	73		600
gas	22	22	1232	1232	IE	0.0	56		100
1.A.1.c Cokeovens									
coal	16	16	1504	1504	0.4	0.0	94		1400
oil	0	0	0	0	0.0	0.0	73		600
gas	0	0	0	0	0.0	0.0	56		100
1.A.2 INDUSTRY	504	508	47600	47800	2.4	0.1		4800	300
coal, non-feedstock	82	82				0.0			600
oil, non-feedstock	111	111				0.1			600
gas, non-feedstock	311	315				0.0			100
1.A.2.a Industry: Iron and steel					NE	NE			
coal	79	79	7426	7426			94		
oil	0	0	0	0			73		
gas	13	13	728	728			56		
1.A.2.b: Industry: Non-ferrous metals					NE	NE			
coal	0	0	0	0			94		
oil	6	6	438	438			73		
gas	25	25	1400	1400			56		
1.A.2.c: Industry: Chemicals					NE	NE			
coal	0	0	0	0			94		
oil	101	101	7373	7373			73		
gas	104	106	5824	5936			56		
1.A.2.d: Industry: Pulp, paper and print					NE	NE			
coal	0	0	0	0			94		
oil	0	0	0	0			73		
gas	29	29	1624	1624			56		
1.A.2.e: Industry: Food, Beverages & Tobacco					NE	NE			
coal	0	0	0	0			94		
oil	2	2	146	146			73		
gas	69	70	3864	3920			56		
1.A.2.f Industry: Other					NE	NE			
coal	3	3	282	282			94		
oil	2	2	146	146			73		
gas	71	73	3976	4088			56		
1.A.2.g Industry: actual from feedstocks					NA	NA			
coal	11	11	1650	1650			150		
oil	266	266	7740	7740			29		
gas	109	109	4940	4940			45		
1.A.3 TRANSPORT	413	413	30100	30100	5.9	7.7		14300	
coal	0	0	0	0		0.0	94		1400
oil	413	413	30149	30149		7.7	73		18600
gas	0	0	0	0		0.0	56		100
1.A.4 SMALL COMBUSTION	713	753	40700	42900	18.1	0.1		25400	
1.A.4.a Commercial/Institutional					1.0				
coal	1	1	94	94		0.0	94		1400
oil	33	33	2409	2409		0.0	73		600
gas	156	164	8736	9184		0.0	56		100
1.A.4.b Residential					13.6				
coal	0	0	0	0		0.0	94		1400
oil	6	6	438	438		0.0	73		600
gas	361	383	20216	21448		0.0	56		100
1.A.4.c Agriculture/ forestry					3.5				
coal	0	0	0	0		0.0	94		1400
oil	3	3	219	219		0.0	73		600
gas	153	163	8568	9128		0.0	56		100
1.A.5. OTHER: Statistical differences			2500	2500					
coal	15	15	1410	1410			94		NA
oil	28	28	2044	2044			73		NA
gas	-17	-17	-952	-952			56		NA
1.A.6. Biomass burned for energy			(1600)*	(1600)*	3.9	0.0			

* Emission factors printed in bold are calculated (i.e. aggregated) values; others are basic factors used to estimate the emissions.
** ton/TJ = kg/GJ
*** Including feedstock and statistical differences, thereby reducing the aggregated emission factors of CH4 and N2O.
All values larger than 100 are rounded to 100.

GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

IPCC Standard Data Table 1.
Energy: 1B2 Fugitive Emissions from Fuels (Oil and Gas)

Source and Sink Category	Activity data		Emissions estimated			Aggregate emission Factors		
year 1990			CH4	CO2	NMVOC	CH4	CO2	NMVOC
	[unit]	#	[Gg]	[Gg]	[Gg]	[Gg / unit]	[Gg / unit]	[Gg / unit]
1.B TOTAL fugative emission oil and gas			**178.5**	**0.0**	**35.1**			
1B2 a Oil								
i Exploration *			I.E.	N.A.	I.E.			
ii Production of crude oil			I.E.	N.A.	I.E.			
iii Transport of Crude oil			I.E.	N.A.	I.E.			
iv Refining/Storage	Mton crude	51.7	I.E.	N.A.	14.3		N.A.	0.277
v Distribution of Oil Products			I.E.	N.A.	I.E.			
vi Other			N.E.	N.A.	N.E.			
1B2 b Natural Gas								
i Production/Processing			I.E.	N.A.	I.E.			
ii Transmission/Distribution **	PJ	655	78.9	N.A.	7.7	0.120	N.A.	0.012
ii Other leakage			N.E.	N.A.	N.E.			
1B2 c Venting and Flaring ***								
i Oil			I.E.	N.A.	I.E.			
ii Natural Gas			I.E.	N.A.	I.E.			
iii Combined	10^6 m3	190	99.6	I.E	13.1	0.524	I.E	0.069

Source and Sink Category	Activity data		Emissions estimated			Aggregate emission Factors		
year 1994			CH4	CO2	NMVOC	CH4	CO2	NMVOC
	[unit]	#	[Gg]	[Gg]	[Gg]	[Gg / unit]	[Gg / unit]	[Gg / unit]
1.B TOTAL fugative emission oil and gas			**169.2**	**0.0**	**31.5**			
1B2 a Oil								
i Exploration *			I.E.	N.A.	I.E.			
ii Production of crude oil			I.E.	N.A.	I.E.			
iii Transport of Crude oil			I.E.	N.A.	I.E.			
iv Refining/Storage	Mton crude	58.8	I.E.	N.A.	11.4		N.A.	0.194
v Distribution of Oil Products			I.E.	N.A.	I.E.			
vi Other			N.E.	N.A.	N.E.			
1B2 b Natural Gas								
i Production/Processing			I.E.	N.A.	I.E.			
ii Transmission/Distribution **	PJ	717	74.4	N.A.	7.2	0.104	N.A.	0.010
ii Other leakage			N.E.	N.A.	N.E.			
1B2 c Venting and Flaring ***								
i Oil			I.E.	N.A.	I.E.			
ii Natural Gas			I.E.	N.A.	I.E.			
iii Combined	10^6 m3	214	94.8	I.E	12.9	0.443	I.E	0.060

Source and Sink Category	Activity data		Emissions estimated			Aggregate emission Factors		
year 1995****			CH4	CO2	NMVOC	CH4	CO2	NMVOC
	[unit]	#	[Gg]	[Gg]	[Gg]	[Gg / unit]	[Gg / unit]	[Gg / unit]
1.B TOTAL fugative emission oil and gas			**170.1**	**0.0**	**33.0**			
1B2 a Oil								
i Exploration *			I.E.	N.A.	I.E.			
ii Production of crude oil			I.E.	N.A.	I.E.			
iii Transport of Crude oil			I.E.	N.A.	I.E.			
iv Refining/Storage	Mton crude	60.3	I.E.	N.A.	12.6		N.A.	0.209
v Distribution of Oil Products			I.E.	N.A.	I.E.			
vi Other			N.E.	N.A.	N.E.			
1B2 b Natural Gas								
i Production/Processing			I.E.	N.A.	I.E.			
ii Transmission/Distribution **	PJ	756	75.2	N.A.	7.1	0.099	N.A.	0.009
ii Other leakage			N.E.	N.A.	N.E.			
1B2 c Venting and Flaring ***								
i Oil			I.E.	N.A.	I.E.			
ii Natural Gas			I.E.	N.A.	I.E.			
iii Combined	10^6 m3	221	94.9	I.E	13.3	0.429	I.E	0.060

* Includes ALL drilling for exploration and exploitation, both for oil and gas

** Calculations are based on detailed information with destinction between transmission and transport. Figures presented here are therefore aggregated data. Activitydata concern distribution of gas

*** Calculation are based on detailed information on amounts of gas vented and flared, with destinction between on-shore and off-shore activities. Figures presented here are therefore aggregated data.

**** Data for 1995 are preliminary.

IPCC Standard Data Table 2. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Industrial processes [2]

Year: 1990

Source category	Activity data (kiloton)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton product) CO2	CH4	N2O
2.A. Iron and steel	5180	700	IE	NA	0.139		
2.B. Non-ferrous metals			IE	NA			
2.C. Chemicals (inorganic)			IE				
Nitric acid	618			17.0			27.5
Other *	NE			1.6			NA
2.D. Chemicals (organic)			IE	IE			
Adipic acid	0			0.0			NA
Other							
2.E. Non-metallic mineral products			IE	NE			
2E1. Cement production: clinker pr.	973	800			0.800		
2E2. Glass manufacture	1194	250			0.200		
2E3. Other							
2.F. Other			5.8	NE		NA	
2F1. Flue gas desulphurization **	226.6	150			0.662		
2F2. Other							
Total		**1900**	**5.8**	**18.6**			

Year: 1994

Source category	Activity data (kiloton)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton product) CO2	CH4	N2O
2.A. Iron and steel	5949	800	IE	NA	0.139		
2.B. Non-ferrous metals			IE	NA			
2.C. Chemicals (inorganic)			IE				
Nitric acid	664			16.4			24.7
Other *	NE			1.6			NA
2.D. Chemicals (organic)			IE	IE			
Adipic acid	0			0.0			NA
Other							
2.E. Non-metallic mineral products			IE	NE			
2E1. Cement production: clinker pr.	858	700			0.800		
2E2. Glass manufacture	1404	300			0.200		
2E3. Other							
2.F. Other			5.8	NE		NA	
2F1. Flue gas desulphurization **	286	200			0.662		
2F2. Other							
Total		**2000**	**5.8**	**18.0**			

Year: 1995

Source category	Activity data (kiloton)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton product) CO2	CH4	N2O
2.A. Iron and steel	5949	800	IE	NA	0.139		
2.B. Non-ferrous metals			IE	NA			
2.C. Chemicals (inorganic)			IE				
Nitric acid	668			16.5			24.7
Other *	NE			1.6			NA
2.D. Chemicals (organic)			IE	IE			
Adipic acid	0			0.0			NA
Other							
2.E. Non-metallic mineral products			IE	NE			
2E1. Cement production: clinker pr.	858	700			0.800		
2E2. Glass manufacture	1404	300			0.200		
2E3. Other							
2.F. Other			5.8	NE		NA	
2F1. Flue gas desulphurization **	300	200			0.662		
2F2. Other							
Total		**2000**	**5.8**	**18.1**			

* Caprolactam production
** Gypsum production
NE = not estimated, small or confidential
NA = not applicable
IE = included elsewhere, NO = not occuring

IPCC Standard Data Table 3. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Solvents and other product use [3]
Year: 1994

Source category	Activity data (kiloton)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton product) CO2	CH4	N2O
3. Solvents and other product use							
3.D.Other *	0.5	NA	NE	0.5	NA	NA	1000
	NA	**NA**	**NE**	**0.5**	**NA**	**NA**	**NA**

* N2O emissions from anaesthesia use.

Year: 1995

Source category	Activity data (kiloton)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton product) CO2	CH4	N2O
3. Solvents and other product use							
3.D.Other *	0.5	NA	NE	0.5	NA	NA	1000
	NA	**NA**	**NE**	**0.5**	**NA**	**NA**	**NA**

* N2O emissions from anaesthesia use.

IPCC Standard Data Table 4. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Agriculture: 4A and 4B Enteric fermentation and manure management
Year: 1990, 1994, 1995

Source category	Activity data 1990	1994	1995*	Emission estimate (Gg) 1990	1994	1995*	Aggregate emission factors 1990-1995
4. Agriculture							
4A. Enteric fermentation				**401.9**	**381.7**	**376.7**	
4B. Animal wastes				**103.0**	**100.6**	**98.7**	
4.A Enteric fermentation	**(1000 heads) 1990**	**1994**	**1995***	**1990**	**1994**	**1995***	**(kg CH4/head per year) 1990-1995**
1.a. Dairy cattle	3606	3277	3298	290.7	263.9	265.5	
- young <1 yr	*806*	*735*	740	*39.7*	*36.2*	*36.4*	*49.25*
- young female >1yr	*879*	*803*	808	*55.2*	*50.4*	*50.7*	*62.80*
- female	*1878*	*1698*	1708	*191.8*	*173.4*	*174.4*	*102.13*
- male >1yr	*43*	*41*	42	*4.0*	*3.8*	*3.9*	*93.22*
1.b. Non-dairy cattle	1319	1439	1356	74.9	79.6	73.8	
- calves	*601*	*690*	669	*10.6*	*12.2*	*11.8*	*17.65*
- steers	*599*	*603*	541	*52.1*	*52.5*	*47.1*	*87.01*
- female >1yr	*119*	*146*	146	*12.2*	*14.9*	*14.9*	*102.13*
3. Sheep	1700	1766	1674	13.6	14.1	13.4	8.00
4. Goats	63	64	76	0.5	0.5	0.6	8.00
6. Horses	72	97	100	1.3	1.8	1.8	18.00
8. Swine	13933	14565	14397	20.9	21.8	21.6	1.50
TOTAL	**20693**	**21208**	**20901**	**401.9**	**381.7**	**376.7**	
4.B Manure management **	**(million m^3) 1990**	**1994**	**1995***	**1990**	**1994**	**1995***	**(kg/m3) 1990-1995**
1.a. Dairy cattle	36.5	33.1	33.3	25.5	23.1	23.3	0.698
1.b. Non-dairy cattle	4.7	4.8	4.4	11.9	12.1	11.2	2.534
1.b.2 Fattening calves	2.1	2.4	2.3	5.3	6.1	5.9	2.534
3/4. Sheep and goats	0.3	0.3	0.3	0.8	0.8	0.7	2.979
8. Swine	16.4	16.4	16.1	49.2	49.3	48.6	3.009
9. Poultry	2.5	2.2	2.2	10.3	9.2	8.9	4.110
TOTAL	**62.4**	**59.2**	**58.7**	**103.0**	**100.6**	**98.7**	

* Data for 1995 are preliminary figures.

** Manure production in stables, thus excluding manure excreted in meadows which is dealt with under Agricultural soils [4D].

IPCC Standard Data Table 4. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Agriculture: 4D Agricultural soils
Year: 1990, 1993-1995

Source category	SOURCE / N flow	**Activity data (kiloton)**				**Emission estimate (Gg) N2O******				**Aggregate emission factors**	
		1990	**1993**	**1994**	**1995***	**1990**	**1993**	**1994**	**1995***	**(as % of N applied) 1990-1995**	**(kg N2O/ton N applied) 1990-1995**
4D	**Agricultural soils *****					**22.2**	**26.2**	**26.6**	**26.9**		
4D.1	**ANTHROPOGENIC BACKGROUND agricultural soils ****	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**		
4D.2	**CHEMICAL FERTILIZER USE**										
	total N consumption	412.0	390.0	372.0	372.0						
	NH3-N emission	8.2	7.8	7.4	7.4						
	nett N application	403.8	382.2	364.6	364.6						
	mineral soils 90%	363.4	344.0	328.1	328.1	5.7	5.4	5.2	5.2	1	15.7
	organic soils 10%	40.4	38.2	36.5	36.5	1.3	1.2	1.1	1.1	2	31.4
	subtotal N2O emission					**7.0**	**6.6**	**6.3**	**6.3**		
4D.3	**MANURE**										
	total N excretion	657.0	682.0	648.0	643.0						
	part in meadow (fraction)	0.3	0.3	0.3	0.3						
	excretion in meadow	164.3	170.5	162.0	160.8						
	NH3-N emission grazing	13.1	13.6	13.0	12.9						
	share N in urine	0.6	0.6	0.6	0.6						
	urine-N in meadow	90.7	94.1	89.4	88.7	2.8	3.0	2.8	2.8	2	31.4
	faeces-N in meadow	60.4	62.7	59.6	59.2	0.9	1.0	0.9	0.9	1	15.7
	subtotal N2O emission					**3.8**	**3.9**	**3.7**	**3.7**		
4D.4	**STABLE + STORAGE**										
	excretion in stable	492.8	511.5	486.0	482.3						
	NH3 emission stable	83.7	88.4	85.3	84.3						
	NH3 emission storage	5.2	6.2	5.9	3.9						
	nett N content manure	419.5	433.6	410.9	409.6						
	biologically treated storage	0.0	1.0	2.0	2.0	0.0	0.0	0.1	0.1	2	31.4
	anaerobic storage	419.5	432.6	408.9	407.6	0.7	0.7	0.6	0.6	0.1	1.6
	subtotal N2O emission					**0.7**	**0.7**	**0.7**	**0.7**		
4D.5	**MANURE SPREADING**										
	manure-export abroad	6.4	15.0	18.0	23.0						
	field application	413.1	417.6	390.9	384.6						
	NH3 emission application	104.9	64.5	45.3	32.4						
	check: NH3-N emission	86.4	53.1	37.3	26.7						
	nett N content applied manure	326.8	364.5	353.5	357.9						
	surf.appl.mineral soil 87%	284.3	94.3	13.5	0.0	4.5	1.5	0.2	0.0	1	15.7
	surf.appl.organic soil 13%	42.5	47.4	46.0	0.0	1.3	1.5	1.4	0.0	2	31.4
	share incorporation (fraction)	0.0	0.6	0.8	1.0						
	incorporation all soils	0.0	222.8	294.1	357.9	0.0	7.0	9.2	11.2	2	31.4
	subtotal N2O emission					**5.8**	**10.0**	**10.9**	**11.2**		
4D.6	**LEGUMES**										
	total N-fixation	15.0	14.0	14.0	14.0	0.2	0.2	0.2	0.2	1	15.7
	subtotal N2O emission					**0.2**	**0.2**	**0.2**	**0.2**		

* Data for 1995 are preliminary figures.
** Resulting from past lowering of the groundwater tables and past application of fertilizers and manure (Kroeze, 1994).
*** Including present enhanced background emissions due to historical anthropogenic activities (see note 2).
**** No estimate was made for CO2 and CH4.

IPCC Standard Data Table 5. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Land use change & forestry: 5A Changes in forest and other woody biomass stocks

Sheet 1: Annual Growth Increment 1990

Source and sink Categories	A Area [ha]	volume increment trunks only	 total tree [m3/ha]	volume increment [1000 m3]	carbon content [kg C /m3]	B Carbon uptake [Gg C]	C aggregate uptake factor [t C/ha]
Temperate Forests:	**342,000**	**8.12**	**9.74**	**3,332**	**250**	**0.833**	**2.44**
expoited forests	*266,000*						
non-exploited forests	*71,000*						
other forests	*10,000*						
Boreal Forests							
Other ecosystem types							
Non-forrest Trees:	**98,000**	**8.12**	**9.74**	**955**	**250**	**0.239**	**2.44**
trees in line	*66,000*						
solitaires	*2,000*						
urban parks	*p.m.*						
fruit trees	*23,000*						
nurseries	*7,000*						
Total	**440,000**			**4,287**		**1.072**	**2.44**

Sheet 2: Annual Harvest 1990

Source and Sink categories	A Area [ha]	fellings trunks only	 total tree [m3/ha]	biomass removed total tree [1000 m3]	carbon content [kg C /m3]	B carbon emission [Gg]	C aggregate emission factor [t C/ ha]
Temperate forests	342,000	5.12	6.1	2,101	250	0.525	1.54
Non-forrests trees	98,000	5.12	6.1	602	250	0.151	1.54
Total	**440,000**			**2,703**		**0.676**	**1.54**

Sheet 3: CO2 Emissions/Removals 1990

Source and Sink Categories	Emissions/Uptake Carbon [Gg]	Emissions/Removal CO2 [Gg]
Total annual growth increment	1.072	3.93
Total annual fellings (incl. Harvest)	0.676	2.48
Net emissions (+) or removals (-)	**-0.396**	**-1.45**

IPCC Standard Data Table 5. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Land use change & forestry: 5A Changes in forest and other woody biomass stocks

Year: 1994

Sheet 1: Annual Growth Increment 1994

Source and sink Categories	A Area [ha]	volume increment trunks only	 total tree [m3/ha]	volume increment [1000 m3]	carbon content [kg C /m3]	B Carbon uptake [Gg C]	C aggregate uptake factor [t C/ha]
Temperate Forests:	**341,000**	**7.88**	**9.46**	**3,224**	**250**	**0.806**	**2.36**
expoited forests	*266,000*						
non-exploited forests	*71,000*						
other forests	*10,000*						
Boreal Forests							
Other ecosystem types							
Non-forrest Trees:	**98,000**	**7.88**	**9.46**	**927**	**250**	**0.232**	**2.36**
trees in line	*66,000*						
solitaires	*2,000*						
urban parks	*p.m.*						
fruit trees	*23,000*						
nurseries	*7,000*						
Total	**439,000**			**4,151**		**1.038**	**2.36**

Sheet 2: Annual Harvest 1994

Source and Sink categories	A Area [ha]	fellings trunks only	 total tree [m3/ha]	biomass removed total tree [1000 m3]	carbon content [kg C /m3]	B carbon emission [Gg]	C aggregate emission factor [t C/ ha]
Temperate forests	341,000	4.45	5.34	1,821	250	0.455	1.34
Non-forrests trees	98,000	4.45	5.34	523	250	0.131	1.34
Total	**439,000**			**2,344**		**0.586**	**1.34**

Sheet 3: CO2 Emissions/Removals 1994

Source and Sink Categories	Emissions/Uptake Carbon [Gg]	Emissions/Removal CO2 [Gg]
Total annual growth increment	1.038	3.81
Total annual fellings (incl. Harvest)	0.586	2.15
Net emissions (+) or removals (-)	**-0.452**	**-1.66**

IPCC Standard Data Table 5. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Land use change & forestry: 5A Changes in forest and other woody biomass stocks

Sheet 1: Annual Growth Increment 1995

Source and sink Categories	A Area [ha]	volume increment trunks only	 total tree [m3/ha]	volume increment [1000 m3]	carbon content [kg C /m3]	B Carbon uptake [Gg C]	C aggregate uptake factor [t C/ha]
Temperate Forests:	**340,000**	**7.90**	**9.48**	**3,223**	**250**	**0.806**	**2.37**
expoited forests	*266,000*						
non-exploited forests	*71,000*						
other forests	*10,000*						
Boreal Forests							
Other ecosystem types							
Non-forrest Trees:	**98,000**	**7.90**	**9.48**	**929**	**250**	**0.232**	**2.37**
trees in line	*66,000*						
solitaires	*2,000*						
urban parks	*p.m.*						
fruit trees	*23,000*						
nurseries	*7,000*						
Total	**438,000**			**4,152**		**1.038**	**2.37**

Sheet 2: Annual Harvest 1995

Source and Sink categories	A Area [ha]	fellings trunks only	 total tree [m3/ha]	biomass removed total tree [1000 m3]	carbon content [kg C /m3]	B carbon emission [Gg]	C aggregate emission factor [t C/ ha]
Temperate forests	340,000	4.40	5.3	1,795	250	0.449	1.32
Non-forrests trees	98,000	4.40	5.3	517	250	0.129	1.32
Total	438,000			2,313		0.578	1.32

Sheet 3: CO2 Emissions/Removals 1995

Source and Sink Categories	Emissions/Uptake Carbon [Gg]	Emissions/Removal CO2 [Gg]
Total annual growth increment	1.038	3.81
Total annual fellings (incl. Harvest)	0.578	2.12
Net emissions (+) or removals (-)	**-0.460**	**-1.69**

IPCC Standard Data Table 6. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Waste: 6A,C and D Solid waste disposal on land, waste incineration and other waste

Year: 1990

Source category/	Activity dat (Gg)		Emission estimate (Gg)			Aggregate emission factor (kg/ton)			CH4 recovered
disposal method	Landfilled	DOC landfilled	CO2	CH4	N2O	CO2	CH4	N2O	(Gg)
6. Waste			900	376.4					
6A1 Landfills (solid waste disposal)	13900	2400	NE	376.4	NE	NA	156.8	NE	43
6A2 Open dumps	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Waste treated	CO2	CH4	N2O	CO2	CH4	N2O	
6C. Waste incineration		3735	900	0.0	0.1	241	0	0.020	NA
6D. Other waste		NE	NE	NE	NE				

Year: 1993

Source category/	Activity dat (Gg)		Emission estimate (Gg)			Aggregate emission factor (kg/ton)			CH4 recovered
disposal method	Landfilled	DOC landfilled	CO2	CH4	N2O	CO2	CH4	N2O	(Gg)
6. Waste			900	372.0					
6A1 Landfills (solid waste disposal)	11300	1770	NE	372	NE	NA	210.2	NE	53
6A2 Open dumps	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Waste treated	CO2	CH4	N2O	CO2	CH4	N2O	
6C. Waste incineration		3880	900	0.0	0.1	232	0	0.020	NA
6D. Other waste		NE	NE	NE	NE				

Year: 1994

Source category/	Activity dat (Gg)		Emission estimate (Gg)			Aggregate emission factor (kg/ton)			CH4 recovered
disposal method	Landfilled	DOC landfilled	CO2	CH4	N2O	CO2	CH4	N2O	(Gg)
6. Waste			900	374.0					
6A1 Landfills (solid waste disposal)	9100	1560	NE	374.0	NE	NA	239.7	NE	65
6A2 Open dumps	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Waste treated	CO2	CH4	N2O	CO2	CH4	N2O	
6C. Waste incineration		4410	900	0.0	0.1	204	0	0.020	NA
6D. Other waste		NE	NE	NE	NE				

Year: 1995*

Source category/	Activity dat (Gg)		Emission estimate (Gg)			Aggregate emission factor (kg/ton)			CH4 recovered
disposal method	Landfilled	DOC landfilled	CO2	CH4	N2O	CO2	CH4	N2O	(Gg)
6. Waste			900	374.4					
6A1 Landfills (solid waste disposal)	8500	1350	NE	374.4	NE	NA	277.3	NE	65
6A2 Open dumps	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Waste treated	CO2	CH4	N2O	CO2	CH4	N2O	
6C. Waste incineration		4370	900	0.0	0.1	206	0	0.020	NA
6D. Other waste		NE	NE	NE	NE				

* Data for 1995 are preliminary figures.

IPCC Standard Data Table 6. GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Waste: 6B Waste water treatment
Year: 1994

Source category	Activity data (Gg N removed)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton) CO2	CH4	N2O
6. Waste				**0.5**			
6B. Wastewater treatment (sewage)	25.7	NE	NA	0.5			20

Year: 1995*

Source category	Activity data (Gg N removed)	Emission estimate (Gg) CO2	CH4	N2O	Aggregate emission factors (kg/ton) CO2	CH4	N2O
6. Waste				**0.5**			
6B. Wastewater treatment (sewage)	27	NE	NA	0.5			20

* Data for 1995 are preliminary figures.

IPCC Standard Data Table "7". GREENHOUSE GASES IN THE NETHERLANDS (Gg a-1 full molecular weight).

Other: 7A and B Drinking water treatment and polluted surface water

Year: 1994

Source category	Activity data (kiloton)	Emission estimate (Gg)			Aggregate emission factors (kg/ton product)		
		CO2	CH4	N2O	CO2	CH4	N2O
7. Other (specified)			**2.0**	**3.8**			
7A. Drinking-water treatment	NA	IE	2.0	NE		NA	
7B. Polluted surface water	NA	NA	NE	3.8			NA

Year: 1995*

Source category	Activity data (kiloton)	Emission estimate (Gg)			Aggregate emission factors (kg/ton product)		
		CO2	CH4	N2O	CO2	CH4	N2O
7. Other (specified)			**2.0**	**3.8**			
7A. Drinking-water treatment	NA	IE	2.0	NE		NA	
7B. Polluted surface water	NA	NA	NE	3.8			NA

* Data for 1995 are preliminary figures.

APPENDIX E.

Other tables on energy use and CO_2 emissions.

Table E.1 Energy consumption per sector, temperature corrected, 1990-1995.

Target group	Fuel [PJ]	1990	1991	1992	1993	1994	1995
A. Combustion and Transformation							
Energy: cokeovens	coal	13	14	14	14	15	16
	oil	0	0	0	0	0	0
	gas	0	0	0	0	0	0
Energy: refineries	coal	0	0	0	0	0	0
	oil	151	160	156	162	163	166
	gas	18	21	20	23	23	22
Energy: other	coal	250	227	225	221	252	268
	oil	1	3	1	4	12	12
	gas	262	307	324	341	332	340
Industry	coal	92	85	85	90	67	82
	oil	83	73	102	100	99	111
	gas	345	340	343	328	330	314
Transport	coal	0	0	0	0	0	0
	oil	367	369	384	390	397	413
	gas	0	0	0	0	0	0
Residential	coal	1	1	1	0	0	0
	oil	10	10	9	10	8	6
	gas	385	376	373	366	371	382
Agriculture /forestry	coal	0	0	0	0	0	0
	oil	4	3	3	3	3	3
	gas	150	148	164	157	163	162
Public / services	coal	1	1	1	1	1	1
	oil	38	38	37	40	39	35
	gas	160	169	171	170	156	165
B. Feedstocks	coal	11	10	11	11	24	11
	oil	305	315	292	243	246	266
	gas	95	102	101	97	103	109
C. Statistical differences	coal	7	0	-4	9	-9	15
	oil	16	25	15	26	25	28
	gas	-13	-14	-20	-20	-8	-17
TOTAL Consumption	**coal**	**374**	**338**	**332**	**347**	**350**	**393**
	oil	**975**	**996**	**998**	**978**	**992**	**1039**
	gas	**1404**	**1450**	**1477**	**1461**	**1469**	**1477**

Table E.2 Annual number of heating degree days, the moving average and the correction factor for gas consumption for space heating, 1980 - 1995, including correction for natural gas consumption and CO_2 emissions.

Year	Heating degree days	30 years average of degree days	Correction factor	Correction natural gas [PJ]	Correction CO_2 emission [Mton]
1980	3301	3235	0.980	- 13	- 0.7
1981	3234	3238	0.998	- 1	- 0.1
1982	3005	3244	1.080	46	2.6
1983	2999	3232	1.078	45	2.5
1984	3177	3229	1.016	9	0.5
1985	3487	3226	0.925	- 50	- 2.8
1986	3333	3228	0.969	- 18	- 1.0
1987	3372	3219	0.955	- 26	- 1.5
1988	2823	3231	1.144	82	4.6
1989	2729	3219	1.179	103	5.8
1990	2677	3211	1.199	114	6.4
1991	3163	3198	1.011	7	0.4
1992	2829	3203	1.132	80	4.5
1993	3076	3177	1.033	21	1.2
1994	2835	3156	1.113	67	3.8
1995	2917	3140	1.076	44	2.5

Source: EnergieNed.

Table E.3 Carbon dioxide emissions [Mton] from feedstock use, 1990-1995

Year	energy carrier	feedstocks [PJ]	carbon dioxide emissions [Mton] stored	emission during productio	emission during use	TOTAL emission
1990	coal and coke steel industry	5	0.00	0.00	0.44	0.44
	coal (other)	7	0.61	0.00	0.00	0.00
	natural gas (fertilizer)	66	0.00	3.68	0.00	3.68
	natural gas (other)	30	0.91	0.33	0.41	0.75
	solvents	4	0.00	0.00	0.30	0.30
	monomers	270	10.83	3.94	4.92	8.86
	lubricants	5	0.00	0.00	0.39	0.39
	bitumen	20	1.45	0.00	0.00	0.00
	petroleumcokes	6	0.00	0.00	0.42	0.42
	TOTAL		**13.81**	7.95	6.90	**14.85**
1991	coal and coke steel industry	4	0.00	0.00	0.41	0.41
	coal (other)	6	0.55	0.00	0.00	0.00
	natural gas (fertilizer)	74	0.00	4.14	0.00	4.14
	natural gas (other)	28	0.87	0.31	0.39	0.71
	solvents	4	0.00	0.00	0.30	0.30
	monomers	281	11.29	4.11	5.13	9.24
	lubricants	7	0.00	0.00	0.53	0.53
	bitumen	17	1.23	0.00	0.00	0.00
	petroleumcokes	6	0.00	0.00	0.42	0.42
	TOTAL		**13.93**	8.56	7.19	**15.76**
1992	coal and coke steel industry	4	0.00	0.00	0.39	0.39
	coal (other)	6	0.55	0.00	0.00	0.00
	natural gas (fertilizer)	75	0.00	4.21	0.00	4.21
	natural gas (other)	26	0.80	0.29	0.36	0.66
	solvents	4	0.00	0.00	0.30	0.30
	monomers	258	10.37	3.77	4.72	8.49
	lubricants	6	0.00	0.00	0.45	0.45
	bitumen	17	1.26	0.00	0.00	0.00
	petroleumcokes	6	0.00	0.00	0.42	0.42
	TOTAL		**12.99**	8.28	6.63	**14.91**
1993	coal and coke steel industry	4	0.00	0.00	0.34	0.34
	coal (other)	8	0.71	0.00	0.00	0.00
	natural gas (fertilizer)	73	0.00	4.10	0.00	4.10
	natural gas (other)	23	0.72	0.26	0.33	0.59
	solvents	4	0.00	0.00	0.30	0.30
	monomers	205	8.25	3.00	3.75	6.75
	lubricants	3	0.00	0.00	0.23	0.23
	bitumen	17	1.26	0.00	0.00	0.00
	petroleumcokes	6	0.00	0.00	0.42	0.42
	TOTAL		**10.93**	7.36	5.36	**12.72**
1994	coal and coke steel industry	18	0.00	0.00	1.65	1.65
	coal (other)	6	0.55	0.00	0.00	0.00
	natural gas (fertilizer)	77	0.00	4.28	0.00	4.28
	natural gas (other)	26	0.80	0.29	0.37	0.66
	solvents	4	0.00	0.00	0.30	0.30
	monomers	205	8.22	2.99	3.74	6.72
	lubricants	4	0.00	0.00	0.29	0.29
	bitumen	18	1.28	0.00	0.00	0.00
	petroleumcokes	6	0.00	0.00	0.42	0.42
	TOTAL		**10.86**	7.56	6.77	**14.34**
1995	coal and coke steel industry	4	0.00	0.00	0.38	0.38
	coal (other)	7	0.66	0.00	0.00	0.00
	natural gas (fertilizer)	76	0.00	4.24	0.00	4.24
	natural gas (other)	34	1.03	0.38	0.47	0.85
	solvents	4	0.00	0.00	0.29	0.29
	monomers	232	9.31	3.39	4.23	7.62
	lubricants	4	0.00	0.00	0.29	0.29
	bitumen	18	1.31	0.00	0.00	0.00
	petroleumcokes	5	0.00	0.00	0.37	0.37
	TOTAL		**12.32**	8.00	6.03	**14.03**

APPENDIX F.

Other tables on CH_4 and N_2O emissions

Table F.1: **Methane emission factors for oil and gas production and transmission in the Netherlands 1980-1995.**

Year	Natural gas Production Onshore	Natural gas Production Offshore	Natural gas Weighted Total	Transport	Distribution	Oil Production Onshore	Oil Production Offshore	Oil Weighted Total
	Emission factors in % of volume **							
1980	0.052	0.87	0.16	0.020	0.70	6.25	3.69	6.25
1981	0.051	0.85	0.17	0.020	0.69	6.13	3.61	6.13
1982	0.050	0.84	0.17	0.019	0.68	6.00	3.54	5.78
1983	0.049	0.82	0.18	0.019	0.67	5.88	3.47	4.84
1984	0.048	0.80	0.21	0.018	0.66	5.75	3.39	4.41
1985	0.047	0.78	0.19	0.018	0.65	5.63	3.32	4.06
1986	0.046	0.77	0.20	0.017	0.64	5.50	3.25	3.83
1987	0.044	0.75	0.21	0.017	0.63	5.38	3.17	3.74
1988	0.043	0.73	0.22	0.016	0.62	5.25	3.10	3.77
1989	0.042	0.71	0.22	0.016	0.61	5.13	3.02	3.68
1990	0.041	0.70	0.20	0.015	0.60	5.00	2.95	3.59
1991	0.034	0.69	0.18	0.014	0.58	4.00	2.70	3.10
1992	0.017	0.66	0.15	0.014	0.56	2.50	2.30	2.38
1993	0.009	0.63	0.14	0.013	0.54	1.30	1.95	1.67
1994	0.009	0.62	0.19	0.013	0.52	1.25	1.88	1.69
1995*	0.009	0.62	0.19	0.012	0.50	1.25	1.88	1.67
	Emission factors in g/GJ							
1980	9.5	159.6	29.6	3.7	129.0	167.7	99.0	167.7
1981	9.3	156.4	30.3	3.6	127.1	164.4	97.0	164.4
1982	9.1	153.2	31.5	3.5	125.3	161.0	95.0	155.1
1983	8.9	150.0	33.8	3.4	123.4	157.7	93.0	130.0
1984	8.7	146.8	37.7	3.3	121.6	154.3	91.0	118.4
1985	8.5	143.6	35.5	3.2	119.7	150.9	89.1	108.9
1986	8.3	140.4	36.1	3.1	117.9	147.6	87.1	102.7
1987	8.2	137.2	37.7	3.0	116.1	144.2	85.1	100.3
1988	8.0	134.0	41.2	2.9	114.2	140.9	83.1	101.2
1989	7.8	130.9	40.8	2.9	112.4	137.5	81.1	98.7
1990	7.6	127.7	37.2	2.8	110.5	134.2	79.2	96.4
1991	6.3	126.4	33.6	2.6	106.9	107.3	72.5	83.3
1992	3.2	121.7	27.9	2.5	103.2	67.1	61.7	63.9
1993	1.6	115.3	25.8	2.4	99.5	34.9	52.3	44.8
1994	1.6	114.4	35.5	2.3	95.8	33.5	50.5	45.3
1995*	1.6	114.4	35.3	2.2	92.1	33.5	50.5	44.8

Emission factors are in compliance with data used in sectoral analysis made in RIVM (1996a,b), which differ from the data used to compile the summary table for CH4 published in that report.

* Data for 1995 are preliminary figures.

** Equivalent %, for gas production including emissions due to flaring.

Conversion factors: Natural gas: 31.6 mln m^3 (st) = 1 PJ and 1 m^3 (st) contains 0.58 kg CH_4.
Crude oil: 1 m^3 (st) = 890 kg; 1 kg oil = 41.87 MJ.

Table F.2. Activity data for oil and gas production and transmission in the Netherlands 1980-1995.

Year	Activity data Natural gas Production Onshore	Offshore	[10^9 m3] Total	Transport	Distribution	Oil [1000 m^3] Production Onshore	Offshore	Total
1980	78.2	12.1	90.3	90.3	23.9	1.40	0.00	1.40
1981	70.9	11.8	82.7	82.7	22.7	1.44	0.00	1.44
1982	60.0	11.1	71.1	71.1	20.6	1.61	0.16	1.77
1983	61.5	13.2	74.7	74.7	20.4	1.62	1.21	2.83
1984	59.4	15.8	75.1	75.1	20.8	1.46	1.92	3.38
1985	64.6	16.1	80.6	80.6	22.9	1.34	2.83	4.16
1986	58.5	15.6	74.0	74.0	22.5	1.35	3.89	5.24
1987	58.1	17.3	75.4	75.4	23.4	1.25	3.61	4.85
1988	49.1	17.6	66.7	66.7	20.6	1.38	3.03	4.41
1989	52.6	19.3	71.9	72.9	20.6	1.20	2.64	3.83
1990	54.6	17.9	72.4	72.4	20.7	1.25	2.75	3.99
1991	63.7	18.7	82.4	82.4	24.0	1.14	2.53	3.67
1992	65.7	17.3	83.0	83.8	23.1	1.29	1.92	3.21
1993	66.2	17.9	84.0	84.0	24.8	1.30	1.71	3.01
1994	54.9	23.6	78.4	78.4	22.7	1.22	2.81	4.02
1995*	56.2	24.0	80.2	79.3	23.9	1.02	2.02	3.05

Emission factors are in compliance with data used in sectoral analysis made in RIVM (1996a,b), which differ from the data used to compile the summary table for CH_4 published in that report.

* Data for 1995 are preliminary figures, based on production data which were revised after completion of VROM (1996a,b).

** Not corrected for possible partial conversion in the soil by bacteria before the methane is emitted to the air.

Table F.3. Methane emissions from oil and gas production and transmission in the Netherlands 1980-1995.

Year	Emission of CH_4 Natural gas Production Onshore	Offshore	[mln kg] Total	Transport	Distribution **	Total Gas	Oil Production Onshore	Offshore	Total Oil	Total Oil+gas
1980	23.5	61.1	84.6	10.5	97.7	192.8	8.7	0.0	8.7	201.5
1981	20.9	58.4	79.3	9.4	91.3	179.9	8.8	0.0	8.8	188.7
1982	17.3	53.7	70.9	7.9	81.5	160.3	9.7	0.6	10.2	170.5
1983	17.4	62.5	79.9	8.1	79.6	167.6	9.5	4.2	13.7	181.3
1984	16.4	73.4	89.7	7.9	79.9	177.5	8.4	6.5	14.9	192.4
1985	17.4	73.0	90.5	8.2	86.7	185.4	7.5	9.4	16.9	202.3
1986	15.4	69.1	84.5	7.3	83.9	175.8	7.4	12.6	20.0	195.8
1987	15.0	75.0	90.0	7.2	85.8	183.1	6.7	11.4	18.1	201.2
1988	12.4	74.6	87.0	6.2	74.3	167.5	7.3	9.4	16.6	184.1
1989	12.9	79.9	92.9	6.6	73.1	172.6	6.1	8.0	14.1	186.7
1990	13.1	72.2	85.2	6.3	72.6	164.2	6.2	8.1	14.3	178.5
1991	12.7	74.8	87.5	6.7	81.1	175.3	4.6	6.8	11.4	186.7
1992	6.6	66.6	73.2	6.6	75.4	155.2	3.2	4.4	7.6	162.9
1993	3.3	65.2	68.5	6.4	77.9	152.8	1.7	3.3	5.0	157.8
1994	2.7	85.3	88.0	5.7	68.7	162.4	1.5	5.3	6.8	169.2
1995*	2.8	86.9	89.7	5.5	69.7	165.0	1.3	3.8	5.1	170.1

* Data for 1995 are preliminary figures, based on production data which were revised after completion of VROM (1996a,b).

** Not corrected for possible partial conversion in the soil by bacteria before the methane is emitted to the air.

Table F.4. **Methane emissions from enteric fermentation by ruminants 1980-1995.**

Animal type/ subtype	Emission factor (kg/head/yr)	Emission (mln kg)															
	Year:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*
Cattle dairy																	
- young <1 yr	49.25	42.8	42.1	42.7	44.0	42.7	39.2	36.8	34.0	35.5	38.0	39.7	40.4	38.1	36.3	36.2	36.4
- young female >1yr	62.80	65.2	65.3	64.4	65.1	67.0	63.7	57.6	53.8	50.4	52.1	55.2	57.0	56.1	52.5	50.4	50.7
- female	102.13	240.6	243.2	249.1	258.0	260.3	241.7	233.7	214.5	201.3	195.4	191.8	189.2	181.3	178.4	173.4	174.4
- male >1yr	93.22	4.1	3.8	3.9	4.2	4.4	4.2	4.1	3.6	3.7	3.7	4.0	4.4	4.5	3.8	3.8	3.9
Cattle beef																	
- calves	17.65	10.3	9.8	10.1	10.5	11.3	11.3	12.2	12.4	10.9	10.5	10.6	11.0	11.3	11.6	12.2	11.8
- steers	87.01	25.4	24.4	23.3	24.4	27.4	29.8	34.0	38.6	42.1	46.7	52.1	58.6	56.2	54.3	52.5	47.1
- female >1yr	102.13	4.5	3.8	3.3	3.2	3.5	4.7	4.7	6.7	7.4	8.5	12.2	14.2	14.9	16.0	14.9	14.9
Sheep	8.00	6.9	6.5	6.2	6.2	6.1	6.5	6.9	7.9	9.4	11.2	13.6	15.1	15.6	15.3	14.1	13.4
Goats	8.00	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.5	0.6	0.5	0.5	0.5	0.6
Pigs	1.50	15.2	15.5	15.4	16.0	16.7	18.6	20.2	21.5	20.9	20.6	20.9	19.8	21.2	22.4	21.8	21.6
Horses	18.00	1.2	1.1	1.1	1.1	1.2	1.1	1.1	1.2	1.2	1.2	1.3	1.4	1.6	1.7	1.8	1.8
TOTAL		**416.2**	**415.5**	**419.5**	**432.8**	**440.7**	**420.9**	**411.5**	**394.5**	**383.1**	**388.2**	**401.9**	**411.7**	**401.3**	**392.8**	**381.7**	**376.7**

* Data for 1995 are preliminary figures.

Table F.5. **Methane from manure 1980-1995.**

Animal type	Emission factor (kg/m^3)	Emission (mln kg)															
	Year:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*
Dairy cattle	0.698	28.8	29.0	29.5	30.4	32.0	29.8	29.0	26.7	25.3	25.0	25.5	25.4	24.5	23.8	23.1	23.3
Beef cattle	2.534	5.6	5.3	5.0	5.1	5.7	6.3	7.2	8.3	9.2	10.2	11.9	13.6	13.4	13.2	12.1	11.2
Sheep & goats	2.979	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.8	0.8	0.8	0.8	0.8	0.7
Fattening calves	2.534	5.2	4.9	5.1	5.3	5.7	5.7	6.1	6.2	5.5	5.3	5.3	5.5	5.7	5.8	6.1	5.9
Pigs	3.009	46.7	47.2	45.3	46.6	48.4	53.6	58.1	58.9	54.1	50.8	49.2	49.3	49.2	51.0	49.3	48.6
Poultry	4.11	9.2	9.4	9.9	9.5	9.8	10.4	10.6	10.9	10.4	10.1	10.3	10.4	10.6	10.2	9.2	8.9
TOTAL		**95.8**	**96.3**	**95.0**	**97.2**	**102.0**	**106.1**	**111.4**	**111.4**	**105.0**	**102.2**	**103.0**	**105.1**	**104.3**	**104.8**	**100.6**	**98.7**

* Data for 1995 are preliminary figures.

Source: Van der Hoek *et al.*, 1997.

Table F.6. N_2O emissions from agricultural soils including anthropogenic background emissions 1980-1995 (in mln kg N_2O).

SOURCE/N flow	Em. factor	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*
ANTHROPOGENIC BACKGROUND																	
agricultural soils **		**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
CHEMICAL FERTILIZER																	
total N consumption		486.0	483.0	477.0	457.0	478.0	505.0	500.0	504.0	458.0	444.0	412.0	400.0	392.0	390.0	372.0	372.0
NH3-N emission		9.7	9.7	9.5	9.1	9.6	10.1	10.0	10.1	9.2	8.9	8.2	8.0	7.8	7.8	7.4	7.4
nett N application		476.3	473.3	467.5	447.9	468.4	494.9	490.0	493.9	448.8	435.1	403.8	392.0	384.2	382.2	364.6	364.6
mineral soils 90%	0.010	428.7	426.0	420.7	403.1	421.6	445.4	441.0	444.5	404.0	391.6	363.4	352.8	345.7	344.0	328.1	328.1
organic soils 10%	0.020	47.6	47.3	46.7	44.8	46.8	49.5	49.0	49.4	44.9	43.5	40.4	39.2	38.4	38.2	36.5	36.5
subtotal N2O-N emission		**5.2**	**5.2**	**5.1**	**4.9**	**5.2**	**5.4**	**5.4**	**5.4**	**4.9**	**4.8**	**4.4**	**4.3**	**4.2**	**4.2**	**4.0**	**4.0**
MANURE																	
total N excretion		581.0	597.0	610.0	618.0	622.0	644.0	666.0	656.0	639.0	635.0	657.0	679.0	664.0	682.0	648.0	643.0
excretion in meadow		145.3	149.3	152.5	154.5	155.5	161.0	166.5	164.0	159.8	158.8	164.3	169.8	166.0	170.5	162.0	160.8
NH3-N emission grazing		11.6	11.9	12.2	12.4	12.4	12.9	13.3	13.1	12.8	12.7	13.1	13.6	13.3	13.6	13.0	12.9
share N in urine		0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
urine-N in meadow	0.020	93.5	96.1	98.2	99.5	100.1	103.7	104.2	99.6	94.1	90.6	90.7	93.7	91.6	94.1	89.4	88.7
faeces-N in meadow	0.010	40.1	41.2	42.1	42.6	42.9	44.4	49.0	51.3	52.9	55.5	60.4	62.5	61.1	62.7	59.6	59.2
subtotal N2O-N emission		**2.3**	**2.3**	**2.4**	**2.4**	**2.4**	**2.5**	**2.6**	**2.5**	**2.4**	**2.4**	**2.4**	**2.5**	**2.4**	**2.5**	**2.4**	**2.4**
STABLE + STORAGE																	
excretion in stable		435.8	447.8	457.5	463.5	466.5	483.0	499.5	492.0	479.3	476.3	492.8	509.3	498.0	511.5	486.0	482.3
NH3 emission stable		75.0	77.2	78.5	79.1	79.6	83.2	84.0	84.8	83.7	82.3	83.7	86.0	85.2	88.4	85.3	84.3
NH3 emission storage		1.8	1.7	1.7	1.7	2.2	2.5	3.0	3.7	4.6	4.8	5.2	5.5	5.8	6.2	5.9	3.9
nett N content manure		372.5	382.8	391.5	397.0	399.1	412.4	427.9	419.1	406.5	404.5	419.5	433.9	423.1	433.6	410.9	409.6
biologically treated storage	0.020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	2.0	2.0
anaerobic storage	0.001	372.5	382.8	391.5	397.0	399.1	412.4	427.9	419.1	406.5	404.5	419.5	432.9	422.1	432.6	408.9	407.6
subtotal N2O-N emission		**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**	**0.4**	**0.5**	**0.4**	**0.4**
MANURE SPREADING																	
manure-export abroad		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.4	6.4	6.8	11.2	15.0	18.0	23.0
field application		372.5	382.8	391.5	397.0	399.1	412.4	427.9	419.1	403.6	401.1	413.1	426.1	410.9	417.6	390.9	384.6
NH3 emission application		113.7	117.3	119.3	119.3	120.5	125.0	126.4	126.5	106.8	104.7	104.9	104.4	57.8	64.5	45.3	32.4
check: NH3-N emission		93.6	96.6	98.2	98.2	99.2	102.9	104.1	104.2	88.0	86.2	86.4	86.0	47.6	53.1	37.3	26.7
nett N content applied manure		278.9	286.1	293.2	298.7	299.9	309.5	323.8	314.9	315.7	314.9	326.8	340.1	363.3	364.5	353.5	357.9
surface application mineral soil 87%	0.010	242.6	249.0	255.1	259.9	260.9	269.2	281.7	274.0	274.6	274.0	284.3	265.1	93.9	94.3	13.5	0.0
surface application organic soil 13%	0.020	36.3	37.2	38.1	38.8	39.0	40.2	42.1	40.9	41.0	40.9	42.5	44.2	47.2	47.4	46.0	0.0
share incorporation (fraction)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.6	0.8	1.0
incorporation all soils	0.020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8	222.1	222.8	294.1	357.9
subtotal N2O-N emission		**3.2**	**3.2**	**3.3**	**3.4**	**3.4**	**3.5**	**3.7**	**3.6**	**3.6**	**3.6**	**3.7**	**4.2**	**6.3**	**6.3**	**6.9**	**7.2**
LEGUMES																	
total N-fixation	0.010	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	14.0	14.0	14.0	14.0	14.0
subtotal N2O-N emission		**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
TOTAL GENERAL N_2O-N emission		14.2	14.3	14.4	14.3	14.5	15.0	15.2	15.1	14.5	14.3	14.1	14.6	16.6	16.7	16.9	17.1
TOTAL GENERAL as N_2O	**1.571**	**22.3**	**22.5**	**22.6**	**22.4**	**22.8**	**23.6**	**23.9**	**23.7**	**22.7**	**22.4**	**22.2**	**22.9**	**26.0**	**26.2**	**26.6**	**26.9**

Source: Van der Hoek *et al.*, 1997.

* Data for 1995 are preliminary figures.

** Resulting from past lowering of the groundwater tables and past application of fertilizers and manure (Kroeze, 1994).