NATIONAL INSTITUTE OF PUBLIC HEALTH AND THE ENVIRONMENT
BILTHOVEN, THE NETHERLANDS

RIVM report 728001008

Greenhouse gas emissions in the Netherlands 1990-1996: Updated methodology

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December 1997

A report on the International Commitments
with respect to
Greenhouse Gas Emission Inventories
for the
United Nations Framework Convention on Climate Change
and the
European Union's Greenhouse Gas Monitoring Mechanism

This study was commissioned by the Directorate-General for Environmental Protection, Department of Air and Energy, of the Netherlands' Ministry of Housing, Spatial Planning and the Environment, project number 728001, project title 'climate change'.

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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, CCl_4)
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 = 3.67
$C \rightarrow CH_4$:	x 16/12 = 1.33
$C \rightarrow CO$:	x 28/12 = 2.33
$N \rightarrow N_2O$:	x 44/28 = 1.57
$N \rightarrow NO$:	x 30/14 = 2.14
$N \rightarrow NO_2$:	x 46/14 = 3.29
$N \rightarrow NH_3$:	x 17/14 = 1.21
$N \rightarrow HNO_3$:	x 63/14 = 4.50
$S \rightarrow SO_2$:	x 64/32 = 2.00

From full molecular mass to element basis:

$CO_2 \rightarrow C$:	x 12/44 = 0.27
$CH_4 \rightarrow C$:	x 12/16 = 0.75
$CO \rightarrow C$:	x 12/28 = 0.43
$N_2O \rightarrow N$:	x 28/44 = 0.64
$NO \rightarrow N$:	x 14/30 = 0.47
$NO_2 \rightarrow N$:	x 14/46 = 0.30
$NH_3 \rightarrow N$:	x 14/17 = 0.82
$HNO_3 \rightarrow N$:	x 14/63 = 0.22
$SO_2 \rightarrow S$:	x 32/64 = 0.50

ABSTRACT

This inventory of greenhouse gas emissions in the Netherlands has been prepared according to the IPCC Guidelines and complies with the obligations under the European Union's Greenhouse Gas Monitoring Mechanism and the UN-FCCC for emission reports on greenhouse gases not covered under the Montreal protocol.

The temperature corrected total emissions of non-ODP greenhouse gases were found to increase by 7% from 1990 to 1996, mainly due to increasing emissions of CO_2. In 1996, the temperature- corrected carbon dioxide emissions were 7.6% higher than in 1990. In the period 1990-1996, methane emissions decreased by 9%, but nitrous oxide emissions *in*creased by 13%. The emissions of HFCs were 47% higher in 1996 than in 1990, while the CO_2-equivalent emissions of HFCs, PFCs, and (potential) SF_6 increased by 26%. In 1996, CO_2 contributed 75% to all CO_2-equivalent emissions in the Netherlands, CH_4 contributed about 11%, N_2O about 9% and the non-ODP halocarbons about 5%. 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.

SUMMARY

The Netherlands' government stated in a letter to parliament in September 1995 that greenhouse gas emissions should be calculated in compliance with the IPCC Guidelines. On request of the Ministry of Housing, Spatial Planning and the Environment, national institutes involved have written a report on the methodology for the calculation of greenhouse gas emissions in the Netherlands. All parties involved in the Netherlands (institutes, ministries) have accepted this methodology, based on the IPCC Guidelines, as the only method to calculate the official Netherland's greenhouse gas emissions. This commitment should prevent confusion caused by different figures on Netherlands' greenhouse gas emissions that were used. The new methodology also incorporates the most recent information about emission sources and emission factors which has led to some significant changes in emission levels.

Because of a recent re-calculation of the emissions with a revised methodology, this report contains emission figures for the years 1990-1996. It is in compliance with the obligations under the European Unions' Greenhouse Gas Monitoring Mechanism. The EU-monitoring mechanism provides a means for the European Commission to monitor progress towards its stabilisation target concerning CO_2-emissions. The mechanism is based on annual emission inventories provided by the Member States, and national programmes which set out emission trajectories and policy measures to mitigate greenhouse gas emissions or to increase CO_2-sinks. This report is also in compliance with United Nations Framework Convention on Climate Change (UN-FCCC).

With the revised methodology, emissions of carbon dioxide (CO_2) appear to be 4% (about 6 Mton) lower than was estimated in earlier reports. This is mainly the result of higher carbon storage in petrochemical products like plastics. A detailed analysis showed that this carbon storage was underestimated, resulting in too high process emissions of CO_2 from the use of coal, oil and gas as industrial feedstock. CO_2 emissions from energy conversion processes in the industry were also overestimated in earlier reports. Due to the application of aggregated emission factors in the past, the CO_2 emissions of refineries and chemical industries were overestimated in earlier reports while the emissions from powerplants were underestimated. Emissions from road traffic used to be based on vehicle.km, whereas in the revised methodology fuel consumption figures are used, leading to higher CO_2 emissions from transport.

With the revised methodology, emissions of methane (CH_4) are about 15% (165 kton) higher than was estimated in earlier reports, especially due to new knowledge on emissions from landfills. The emissions of nitrous oxide (N_2O) were found to be 25% (14 kton) higher than was estimated earlier. This is the result of recent measurements for chemical industries (production plants of nitric acid, caprolactam and acrylonitril). These new Netherlands measurements confirm the default N_2O emission factors for nitric acid production as published in the revised IPCC Guidelines.

In 1996, temperature-corrected carbon dioxide emissions were 7.6% higher than in 1990. The increase in CO_2 emissions occurred especially within the transport and energy sectors. In addition there was a significant growth in CO_2 emissions from energy consumption that was not allocated to sectors (the so-called 'statistical differences'). Since 1990, the international carbon dioxide

emissions from bunkers in the Netherlands have increased by 13% to the level of 46 Mton in 1996. The main reason for this growth is the almost doubling of kerosene sales at airports.

In the year 1996, methane emissions were about 9% lower than in 1990. This is mainly the result of decreased CH_4 emissions from landfills, due to less waste deposition, lower content of degradable carbon in the deposited waste, and increased landfill gas recovery. The emissions of nitrous oxide increased by 13% in 1990-1996 because of further penetration and ageing of catalysts in gasoline cars and because of the increased incorporation of manure in agricultural soils.

The emissions in kg of the group [HFCs, PFCs and SF_6] has increased by 75% since 1990, mainly as as a result of the increased use of HFC-134a. The CO_2-equivalent emissions of the group increased by 26%, especially due to higher HFK-23 emissions from industrial processes.

Table S.1 presents the CO_2-equivalent greenhouse gas emissions in the Netherlands from anthropogenic sources for the period 1990-1996, with emissions of carbon dioxide corrected for temperature.

Table S.1 Direct greenhouse gas emissions in the Netherlands, 1990-1996 (T-corrected) (Mton CO_2-eq.)

Direct greenhouse gas	1990	1991	1992	1993	1994	1995	1996
CO_2 (T-corrected)	167.6	167.3	169.5	168.6	172.1	179.5	180.4
CH_4	27.1	27.5	26.4	25.7	25.3	24.6	24.8
N_2O	19.8	20.3	21.0	21.0	21.7	22.3	22.4
Total [CO_2+CH_4+N_2O]	**214.5**	**216.1**	**216.9**	**215.3**	**219.1**	**226.4**	**227.6**
HFCs	4.9	4.9	5.0	5.0	6.5	6.7	7.2
PFCs	2.5	2.4	2.2	2.2	2.4	2.4	2.3
SF_6 (potential)	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Total [HFCs +PFCs +SF_6]	**8.8**	**8.7**	**8.6**	**8.7**	**10.4**	**10.6**	**11.0**
Total [group of six]	**223.3**	**223.9**	**225.4**	**224.0**	**229.5**	**237.0**	**238.7**

When interpreting this table one should take into account the following observations: (1) the contribution of non-CO_2 gases is very uncertain, and (2) 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:

- When corrected for temperature, total emissions of compounds covered under the UN-FCCC increased by 7% from 1990 to 1996 mainly due to increasing emissions of CO_2 , to 239 Mton CO_2-eq.
- CO_2 emissions are showing an upward trend (+7.6 % in 1996 relative to 1990);
- The reduction in CH_4 emissions (-2.4 Mton CO_2-eq. in 1996 relative to 1990) is more than compensated by the increase in N_2O emissions by 2.6 Mton CO_2-eq.

- emissions of HFCs, PFCs and SF_6 are increasing (about +26% in 1996 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;
- non-CO_2 gases contributed about 25% to total CO_2-equivalent emissions in 1996; of this methane contributed about 11% and nitrous oxide about 9%. HFCs, PFCs and potential SF_6 contributed about 4% in 1994.

Furthermore, the emissions of ozone precursors are all decreasing (-16 to -31% in 1996 relative to 1990) while SO_2 emissions substantially decreased by 33% since 1990.

Appendix A presents the IPCC Standard Data Tables '7B' for the whole 1990-1996 period. Appendix B summarises the revised methodology for the calculation of greenhouse gas emissions in the Netherlands. Appendix C shows the relationship between IPCC emission categories and the Netherlands Target Groups. The methodology for temperature correction of CO_2 emissions is explained in Appendix D.

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).

Het Bewakingsmechanisme biedt de Europese Commissie de mogelijkheid de vorderingen op weg naar haar doel van stabilisatie van CO_2-emissies te volgen, op basis van een jaarlijkse inventarisatie van emissies van broeikasgassen. 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.

Deze rapportage bevat de emissiecijfers van alle jaren tussen 1990 tot 1996 omdat de emissies recentelijk zijn herberekend met een geactualiseerde methodiek. Nadat de regering in een brief aan de Tweede Kamer (september 1995) had laten weten dat alleen de 'IPCC-methode' dient te worden gehanteerd, hebben betrokken instituten op verzoek van het ministerie van VROM een rapport geschreven waarin op eenduidige wijze is vastgelegd hoe de emissies van broeikasgassen in Nederland moet worden worden berekend. Uitgangspunt voor deze methodiek vormen de IPCC-richtlijnen. Deze nieuwe methode is bindend voor alle betrokken partijen (instituten, ministeries) en zal er toe leiden dat eenduidige cijfers worden toegepast waar het gaat om Nederlandse broeikasgasemissies. In deze nieuwe methodiek zijn, naast kleine aanpassingen t.g.v. de IPCC-richtlijnen, tevens de nieuwste inzichten rond emissies en emissiefactoren verwerkt. Dit heeft geleid tot enkele belangrijke wijzigen in de emissieschattingen.

De emissies van kooldioxyde (CO_2) blijken 4% (ca. 6 Mton) lager uit te komen dan voorheen is gerapporteerd. Dit is vooral een gevolg van de veel grotere vastlegging van koolstof in chemische producten (kunststoffen e.d.) dan voorheen werd verondersteld. Ook de emissies bij energieconversie processen in de basisindustrie blijken voorheen te zijn overschat. Vanwege het gebruik van geaggregeerde emissiefactoren zijn in eerdere rapportages de CO_2-emissies van raffinaderijen en chemische industrie te hoog geschat en van elektriciteitscentrales te laag. In eerdere rapportages is voor het wegverkeer gebruik gemaakt van cijfers over vervoersprestaties. In de nieuwe methodiek worden echter brandstof afzetcijfers gehanteerd, waardoor de CO_2-emissies van transport hoger uitvallen.

Methaan emissies (CH_4) zijn met de nieuwe methodiek circa 15% (165 kton) hoger dan in voorgaande rapportages. Vooral nieuwe inzichten over emissies uit afvalstortplaatsen dragen hiertoe bij (ruim 100 kton méér). De emissies van lachgas (N_2O) komen met de nieuwe methodiek zo'n 25% (14 kton) hoger uit dan voorheen is aangenomen. Dit komt doordat recente metingen van deze emissies in de chemische industrie (produktie van salpeterzuur, caprolactam en acrylonitril) hebben laten zien dat in het verleden met beduidend te lage waarde is gerekend. Deze Nederlandse metingen bevestigen overigens de waarden van de standaard emissiefactoren die het IPCC hanteert voor N_2O-emissies uit salpeterzuurfabrieken.

Temperatuur-gecorrigeerde kooldioxyde emissies in 1996 waren ruim 7% hoger dan in 1990. De groei van CO_2-emissies trad vooral op bij de energiesector, het verkeer en de chemische industrie alsmede door toename van het energiegebruik dat niet aan sectoren valt toe te wijzen (de zogenaamde 'statistische verschillen'). De internationale CO_2-emissies uit Nederlandse bunkers voor de scheep- en luchtvaart groeide in de periode 1990-1996 met 13%, voornamelijk doordat de afzet van kerosine bijna verdubbelde. Deze internationale emissies bedragen thans 46 Mton.

In 1996 waren de emissies van methaan bijna 9% lager dan in 1990. Dit is grotendeels het gevolg van afnemende methaanemissies uit stortplaatsen. Deze nemen af vanwege een sterk verminderd stortvolume, een afnemend gehalte aan afbreekbaar koolstof in het afval en toegenomen stortgaswinning. De emissies van lachgas stegen tussen 1990 en 1996 met 13% vanwege de toename en veroudering van katalysatoren bij auto's alsmede door het onderwerken van dierlijke mest in landbouwbodems.

De emissies van de 'nieuwe' broeikasgassen [HFK's, PFK's en SF_6] namen in totaal met 75% toe tussen 1990 en 1996. Deze groei is vooral een gevolg van het toenemend gebruik van HFK-134a als CFK-vervanger. De emissie in CO_2-equivalenten van deze groep nam met 26% toe, vooral door hogere HFK-23 -emisies. Deze komen vrij als ongewenst bijprodukt van HCFK-22.

In Tabel S.2 zijn de Nederlandse emissies van broeikasgassen uit antropogene bronnen in CO_2-equivalenten gepresenteerd voor de periode 1990-1996, met temperatuur-gecorrigeerd emissies van kooldioxyde.

Tabel S.2 Emissies van directe broeikasgassen in Nederland, 1990-1996, T-gecorrigeerd, (Mton CO_2-eq.)

Direct broeikasgas	1990	1991	1992	1993	1994	1995	1996
CO_2 (T-gecorrigeerd)	167.6	167.3	169.5	168.6	172.1	179.5	180.4
CH_4	27.1	27.5	26.4	25.7	25.3	24.6	24.8
N_2O	19.8	20.3	21.0	21.0	21.7	22.3	22.4
Totaal [CO_2 + CH_4 + N_2O]	**214.5**	**216.1**	**216.9**	**215.3**	**219.1**	**226.4**	**227.6**
HFK's	4.9	4.9	5.0	5.0	6.5	6.7	7.2
PFK's	2.5	2.4	2.2	2.2	2.4	2.4	2.3
SF_6 (potentieel)	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Totaal [HFK's + PFK's + SF_6]	**8.8**	**8.7**	**8.6**	**8.7**	**10.4**	**10.6**	**11.0**
Totaal [groep van zes]	**223.3**	**223.9**	**225.4**	**224.0**	**229.5**	**237.0**	**238.7**

Bij de interpretatie van de tabel dient het volgende opgemerkt te worden: (1) de bijdrage van niet-CO_2 broeikasgassen is tamelijk onzeker, (2) de bijdrage van ozon-veroorzakende stoffen en van SO_2 zijn in het geheel niet opgenomen. Met inachtneming van deze beperkingen kunnen de volgende conclusies worden getrokken:

- de totale emissies van de directe broeikasgassen die onder het Klimaatverdrag vallen, zijn na temperatuurcorrectie tussen 1990 en 1996 met 7% gestegen tot 239 Mton CO_2-eq., voornamelijk door toename van de emissies van CO_2;
- de emissies van CO_2 nemen toe, met 7,6 % tussen 1990 en 1996;
- de afname van de emissies van CH_4 in de periode 1990-1996 met 2,4 Mton CO_2-eq. wordt teniet gedaan door de toename van de emissies van lachgas (N_2O) met 2.6 Mton CO_2-eq.
- de emissies van HFK's, PFK's en SF_6 nemen toe vanwege de vervanging van CFK's en halonen. Deze toename bedraagt 26% tussen 1990 en 1996. Dit is met name een gevolg van stijgende HFK-gebruik en van de emissie van HFK-23 als bijproduct van de productie van HCFK-22;
- in 1996 was de bijdrage van niet-CO_2 broeikasgassen ongeveer 25%. Methaan had een aandeel van 11%, lachgas van 9% en de bijdrage van emissies van HFK's, PFK's en (potentieel) SF_6 bedroeg in 1996 ca. 5%;

Verder nemen de emissies van ozon-veroorzakende stoffen alle af (van -16% tot -31% tussen 1990 en 1996) terwijl ook de emissie van SO_2 is substantieel verminderd, met 33% sinds 1990.

In Appendix A worden de standaard IPCC-tabellen '7B' gepresenteerd voor de jaren 1990-1996. Appendix B bevat een samenvatting van de herziene methode om Nederlandse broeikasgas emissies te berekenen. In Appendix C wordt een kruistabel gepresenteerd waarin het verband tussen IPCC emissiecategorieën en Nederlandse doelgroepen wordt aangegeven. De methode voor het corrigeren van CO_2-emissies voor temperatuurvariaties wordt beschreven in Appendix D.

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). In 1997 an update has been published by the Netherlands' Government (VROM, 1997a). 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 and the UN-FCCC was published in 1994 (Van Amstel, 1994). This is the third report for the EU monitoring mechanism and the UN-FCCC.

This report has been commissioned by the Netherlands' Ministry of Housing, Spatial Planning and Environment, to comply with the obligations under the UN-FCCC and the European Union. It documents the official Netherlands' greenhouse gas inventories for the UN-FCCC and for the European Union. Time series of emissions are given for 1990 to 1996.

This report does not document the inventory methodology, the relevant activity levels, or the applied emission factors. These items have recently been described in detail in a special report on the application of IPCC Guidelines by the Netherlands (Spakman *et al.*, 1997: "Method for the calculation of greenhouse gas emissions", in Dutch: "Methode voor de berekening van broeikasgasemissies"). That methodology report was written by the Netherlands' institutes involved in the compilation of the annual emission inventory. It was published on request of the Ministry of Housing, Spatial Planning and the Environment (VROM) with the goal to prevent confusion caused by different figures that circulate on Netherlands' greenhouse gas emissions, both in the Netherlands and abroad. In a letter to parliament, September 1995, the Government declared that greenhouse gas emissions should be calculated according to IPCC-Guidelines. The methodology report is the basis for these calculations.

With the new methodology for the calculation of greenhouse gas emissions, the estimates on the previously reported emission levels have changed. Carbon dioxide emissions appear to be lower, methane and nitrous oxide emissions are higher than estimated before. This is only partly caused by the modified methodology, but mainly due to the effect of the implementation of new knowledge about actual emissions or emission factors in the Netherlands. To maintain consistent time series, all emissions have been recalculated back to 1990. This report therefore focuses on the emission levels and the differences with earlier reports, especially last years' second report to the EU Monitoring Mechanism (Spakman *et al.*, 1996). In Appendix B, a summary of the new methodology is presented together with a summary of the differences with earlier inventories.

This 1997 report to the EU's Monitoring Mechanism and the UN-FCCC of Netherlands' greenhouse gas emissions does not entirely meet the requirements as set with respect to Standard Data Tables (IPCC Guidelines: reporting instructions) with volume indicators and aggregated emission factors.

2. METHODOLOGY AND 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 hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and of sulphur hexafluoride (SF_6). In addition, as requested emission estimates are presented of the indirect greenhouse gases CO, NO_x and NMVOC (the ozone precursors) and of SO_2 that has a cooling effect on the atmosphere. A temperature correction for fuel use for space heating is applied, but only to CO_2 emissions.

Carbon dioxide (CO_2)

Carbon dioxide emissions are mainly caused by the combustion of fuel and are calculated on the basis of detailed energy statistics and carbon content of the energy carriers. Carbon storage in products like plastics and bitumen is estimated from an analysis of petrochemical products, half products and feedstock use (energy carriers). 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 sectional energy use. In calculating national carbon dioxide emissions from energy use, this difference (typically < 1%) 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 has also selected 1990 as base year with a national CO_2 emission level of 166 Mton, being the temperature-corrected net emission (167.7 Mton) under subtraction of the annual increase of carbon stock in forests (1.5 Mton CO_2). In Chapter 3 more details are presented on the differences with methods used earlier.

Methane (CH_4)

Methane from combustion is estimated using the energy statistics and emission factors from the *Annual Emissions Report 1996* (EmissieJaarRapport, EJR, VROM, 1997b), 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 on the basis of 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 with a revised database on landfills maintained at RIVM and a time dependent first order decay function. Methane emissions from agricultural soils are regarded as 'natural' (non-antropogene) and are estimated on the basis of the methane background document. They are reported as anthropogenic emissions, IPCC-category [7]. Furthermore, 'natural emissions' are methane emissions from wetlands and water.

Nitrous oxide (N_2O)
The net nitrous oxide emissions estimate is based on the methods described in the nitrous oxide background document of Kroeze (1994). For emissions from the production of nitric acid, acrylonitril and caprolactam, the estimate is based on recent measurements at the individual plants as included in the Netherlands' Emission Registration system (VROM, 1997b, Spakman *et al.*, 1997b)

Halocarbons (HFCs, PFCs) and SF_6
In the Netherlands, the policy on compounds regulated by the Montreal Protocol is based on *consumption* data of halocarbons as defined according to the Protocol. However, in the FCCC/IPCC approach for greenhouse gases, the focus is on estimating actual emissions rather than potential emissions. Therefore, where possible in this report we present for these compounds emission estimates, which have been compiled by Matthijsen (1995) and subsequent reports (Spakman *et al.*, 1996).

Non-Methane Volatile Organic Compounds (NMVOC)
Emissions of NMVOC are now reported according to the definition of the Netherlands' Emission Registration (ER), as also used in the Annual Emission Reports ('EJR') of VROM. In earlier reports to the EU and FCCC, the NMVOC definition according to the Netherlands' hydrocarbons reduction program 'KWS2000' was used. This definition did not include CTC, methyl chloroform and CFC-11 while other CFCs were *only partially* (35%) included. Thus, the NMVOC figures presented in this report comply with the 'EJR', and fully include all of the compounds mentioned above. The main difference of figures is 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).

2.2 New methodology

The methodology for calculation of emissions of direct greenhouse gas emissions in the Netherlands has recently been revised. This methodology, based on the IPCC Guidelines for emission inventory of greenhouse gases, has been described in a separate report (Spakman *et al*, 1997). A background of this revision, a summary of the methodology and the differences with the methods used before are presented in Appendix B. In the 'introduction' of Chapters 3-7, the differences per gas are outlined with a focus on the difference with emission figures as presented in last years' second report to the European Union (Spakman *et al.*, 1996).

This new methodology has been applied to recalculate the Netherlands' greenhouse gas emissions 1990-1994, to adjust the preliminary figures of 1995 as well as the calculation of the emission estimates for 1996. Thus, a consistent time series was obtained. These new figures were first used in the Environmental Balance 1997 (RIVM, 1997a). The emissions presented in this report for the years 1990-1995 are final figures; the emissions for 1996 are preliminary.

2.3 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 and inland water bodies. Emissions from offshore oil and gas production at the Netherlands' part of the continental shelf are included. Emissions from all electricity generation in the Netherlands is accounted for, including the very small fraction of the produced electricity which is exported.

Allocation of emissions in the transportation sector
The transport sector comprises road traffic, mobile off-road equipment such as tractors, rail transport, ships and aircraft. The latter two can be separated into domestic (inland) transport and international transport (bunkers). In addition, pipeline transport is also included in this sector.

Road transport
For national policy purposes, air pollution from road transport is in general calculated from statistics on vehicle-km. However, fuel consumption that is based on vehicle-km is smaller than the fuel consumption as included in the energy sales statistics of the Netherlands. Since the *IPCC Guidelines* ask countries to report greenhouse gas emissions from combustion on the basis of fuel consumption within the national territory, the road traffic emissions of the direct greenhouse gases CO_2, CH_4 and N_2O are calculated and reported according to these Guidelines (i.e. a correction is made to convert emissions related to vehicle-km to emissions related to energy sales statistics). All other compounds however, including ozone precursors and SO_2, are more directly involved in air quality and are therefore calculated using traffic activity data (i.e. fuel consumption figures that are different from national energy statistics).

Shipping
In the Netherlands, the national Emission Registration (ER) distinguishes between *Inland shipping* and *International shipping*, the former based on fuel sold within the Netherlands and the latter based on fuel sold from bunkers. However, a small part of inland ships also consume 'Dutch' fuel in other countries, e.g. when moving along international waterways, of which the emissions are excluded in the ER reports. It was chosen to copy this minor correction for reports in the IPCC format (although the Guidelines want all emissions from Dutch fuel to be allocated to the Netherlands). Furthermore international ships consume a small part of their bunkered fuel in the Netherlands' territorial waters. The corresponding non-CO_2 emissions are included in the ER system and the official Netherlands' national inventory with emissions for all compounds (see Table 2.1). These (bunker) emissions are however excluded from National totals when reporting in the IPCC format. Therefore the emissions for NO_x and SO_2 of the target group transport as reported in official Netherlands' inventories, is higher than the emissions from the IPCC category transport. For other compounds however, this difference is rather small.

With respect to emissions from bunkers, only CO_2 emissions are reported. This is done because the emission factors for other compounds is quite unknown: the mix of international ships loaded with bunker fuels is much different from the mix of ships floating in Dutch territorial waters. Therefore the emission factors of the latter group are not considered to be representative for the emissions of the total group of international ships using bunker fuel loaded in the Netherlands.

Air traffic

For calculating CO_2 emissions from air transport, this report uses domestic fuel sales figures for aircraft from the Netherlands' Energy Statistics. For the emissions of other greenhouse gases, the inventory of the national Emission Registration (ER) is used. In ER-system however, the emphasis is much more on air quality and therefore on local and actual emissions. A good estimate of relevant emissions are the LTO emissions at Schiphol Airport (Amsterdam) while LTO cycles at other airports are neglected. Indeed, in the Netherlands by far the most aircraft activities (>90%) are related to Schiphol Airport. On the other hand, the main part of these LTO cycles concern the combustion of bunkered fuel, which should be reported -according to the Guidelines- as international emissions. In this report, no attempt was made to estimate specific emissions related to all *domestic* flights (including cruise emissions of these flights).

Table 2.1 Allocation of non-CO_2 emissions from shipping and aircraft in domestic national inventories (EJR/MB) and inventories submitted to the UN-FCCC.

Source/sector	ER/MB	UN-FCCC
Shipping emissions (non-CO_2)		
* National inventory	Inland shipping emissions: corrected for fuel use abroad	Ibidem
	International shipping: only the small part emitted in territorial waters	-
* International	-	All international shipping emissions according to bunker fuel sales in the Netherlands [1]
Aircraft emissions (non-CO_2)		
* National inventory	Emission from LTO cycles at Schiphol Airport: - other airports are neglected	Ibidem: - other airports are neglected - not corrected for the large fraction of LTO cycles relating to combustion of bunkered fuel - not corrected for the small emissions related to domestic cruise flights
* International	-	All international aircraft emissions according to bunker fuel sales in the Netherlands [1]

[1] Presently not reported (except for CO_2).

Off-road mobile sources

These category comprises agricultural machinery such as tractors, road and building construction machinery, etc. Emissions of these sources are included in the *Target Group 'Traffic and Transport'*. These are reported under *1A3 'Transport'*.

2.4 Allocation of emission of cogeneration from autoproducers

These emissions are allocated to the various *Target Groups* which own the cogeneration facilities. These are notably the Energy Sector (public electricity generation), Industry, Agriculture, Retail/Services/Government, and the Residential Sector. Thus, the combustion emissions due to cogeneration are reported under the *IPCC Sectors* which correspond to these *Target Groups*. Often new CHP installations are operated as a joint venture with the energy sector, in which all heat is delivered to the industrial plant and all electricity is sold to the energy sector. In this case the CHP installation is regarded as a venture with main activity to produce heat and electricity, and it is therefore allocated within the energy sector. So the stabilisation of industrial CO_2 emissions is partly caused by the allocation of emissions towards the energy sector.

2.5 Allocation of emissions from military activities

Mobile sources: Emissions of mobile military sources are included in the Target Group *'Traffic and Transport'*. These are reported under IPCC-category [*1A3*] *'Transport'*.

Stationary sources: Emissions of stationary military sources (e.g. space heating of buildings) are included in the Target Group *Retail/Services/Government*. The **combustion emissions** of this category are reported under [*1A4a*] *'Commercial / institutional'*, whereas the **process emissions** are reported under [*3*] *'Solvents and other product use'*. For these activities no separate emission estimates are available.

2.6 Netherlands' Target Groups and IPCC Sectors

By the end of the eighties, the National Environmental Policy Plan (NEPP) was published and so-called target groups were defined for the implementation of the plan. These target groups have close relationship to IPCC-sectors. In Appendix C, a cross-table of IPCC-sectors and target groups is presented. For the domestic monitoring of pressure on the environment, presentations of emissions per target group are preferred in the Netherlands. But this report is both an official document for the EU and FCCC-secretariat as well as a summary report for domestic use Therefore this report presents tables of greenhouse gas emissions according to (a) IPCC-sectors/categories and (b) Netherlands' Target Groups. A brief description of the latter is given in Table 2.2.

In general, emissions from solvent use and cogeneration of heat and power are accounted for in the target groups where they are applied. Please note that the emissions from coke ovens are included under 'Industry' 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 Description of Netherlands' Target Groups.

Target Group	Subsections included
Retail/Services/Government	Commercial and public services; excluding drinking water production and distribution, including auto- and co-generators within the commercial sector.
Waste Water Treatment Plants (WWTP)	ibid.
Waste management:	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 sector	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.
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:	ibid.
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 (CO_2) and polluted surface waters (N_2O)

3. CARBON DIOXIDE

3.1 Introduction

Carbon dioxide (CO_2) is the most important greenhouse gas in the Netherlands. It contributes 75% of the national total greenhouse gas emissions. Emissions of carbon dioxide are closely related to energy consumption. Therefore the method of emission inventory is strongly based on detailed energy statistics and on the carbon content of energy-carriers.

The revised method is described in 'Method for the calculation of greenhouse gas emissions' (Spakman *et al.*, 1997). A summary of this report is presented in Appendix B. The new methodology has been applied for the re-calculation of the Netherlands' greenhouse gas emissions. The results have first been published in the Environmental Balance 1997 (RIVM, 1997a) and the annual Dutch Emission Report (VROM, 1997b).

With the new methodology, the emissions of carbon dioxide appear to be about 6 Mton lower than was reported before. The main differences with the methods used earlier are:

- *emission factors*: whereas the old methods were based on aggregated emission factors for coal, oil and natural gas, the new methodology uses detailed information on emissions and energy consumption from large plants. From this information, fuel- and sector specific emission factors are derived. With these detailed emission factors, the CO_2-emissions from industries and refineries appear to be about 1 and 2 Mton lower than reported earlier. On the other hand, the CO_2-emissions from power plants are somewhat 1 Mton higher.
- *emissions from feedstocks*: In the Netherlands, 12% of the national energy consumption concerns industrial feedstocks. Feedstock use however leads to emissions of carbon dioxide, either during the production process or during use of the products. A detailed analyses on products, half-products and the used feedstocks (energy-carriers) has been performed by Gielen (ECN, 1996). It shows that the amount of carbon that is eventually incorporated in products such as plastics, is much larger than was presumed before. As a consequence, carbon dioxide emissions from chemical feedstocks are about 5 Mton smaller than estimated in earlier reports. See also Appendix B.
- *emissions from energy transformation*: According to the Netherlands' Energy Statistics (CBS, annual reports), significant energy-losses occur in non-CHP transformation at refineries, cookeries and some processes in basic metal and chemical industries. In earlier reports, the full potential emissions (energy-loss * aggregated emission factor) were accounted for. In the revised method however, these emissions are measured or calculated on the basis of a carbon balance. As a result, these emissions appear to be about 1-2 Mton lower than reported earlier.
- process emissions from the *dissociation of carbonate* appear to be about 1 Mton smaller than was calculated before. These emissions are now estimated on the basis of detailed information from the building material industries and on the production figures of gypsum from flue gas desulfurization.

- emissions from *transport* are now based on the fuel sold in the Netherlands, whereas in earlier methods the CO_2 emissions were calculated from transportation figures (vehicle.km). This leads to about 2 Mton higher emissions.

3.2 Emissions

The emissions of carbon dioxide in the Netherlands are listed in Table 3.1. Since 1990, the emissions of CO_2 have increased with almost 14%. However, half of this growth is caused by the effect of outdoor temperature on fuel consumption: the winter months of 1990 were extremely mild whereas in 1996 the winter was much colder than usual.

*Table 3.1 Carbon dioxide emissions in the Netherlands per IPCC-sector [Mton], 1990-1996. Figures are **not corrected** for outdoor temperature.*

IPCC sector	1990	1991	1992	1993	1994	1995	1996
TOTAL NET NATIONAL EMISSIONS	**161.4**	**166.9**	**165.2**	**167.5**	**168.4**	**176.9**	**184.9**
1. All Energy (combustion and fugitive)	**158.0**	**164.0**	**162.3**	**165.2**	**165.8**	**173.7**	**181.9**
A Fuel combustion total	157.5	163.5	161.9	164.8	165.6	173.5	181.7
1 a Electricity and heat production	40.7	40.2	41.8	42.1	43.6	45.2	44.9
1 c Other transformation: Refineries	10.4	10.6	10.9	10.6	11.2	11.5	11.4
2 a-e Industry, only combustion*	32.1	32.0	33.0	31.2	31.8	32.8	33.1
2 f Industry, actual from feedstocks	9.4	10.6	9.5	8.7	9.2	9.9	9.5
3 Transport**	28.6	28.6	29.8	30.5	30.8	31.9	33.4
4 a Commercial/Institutional	8.8	10.3	9.4	10.6	10.2	10.3	11.8
4 b Residential	19.2	21.6	19.5	20.6	19.6	20.6	23.8
4 c Agriculture / forestry / fishing	7.4	8.5	8.5	8.8	8.8	8.8	10.3
6 Biomass burned for energy	(3.1)	(2.6)	(2.6)	(3.3)	(3.5)	(3.6)	(4.3)
7 Statistical differences	1.1	1.0	-0.4	1.6	0.5	2.5	3.5
B Fugitive fuel emissions	0.4	0.5	0.4	0.4	0.2	0.2	0.1
2 Crude oil and natural gas	0.4	0.5	0.4	0.4	0.2	0.2	0.1
2. Industrial processes	**1.9**	**1.5**	**1.3**	**1.2**	**1.4**	**1.8**	**1.7**
E Non-metallic mineral-products	0.8	0.7	0.7	1.0	1.0	1.1	1.1
F Other	1.2	0.8	0.5	0.2	0.4	0.6	0.6
3. Solvent and other product use	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.1**	**0.0**
5. Land use change and forestry	**(-1.5)**	**(-1.6)**	**(-1.6)**	**(-1.6)**	**(-1.7)**	**(-1.7)**	**(-1.7)**
A Changes in woody biomass stocks	(-1.5)	(-1.6)	(-1.6)	(-1.6)	(-1.7)	(-1.7)	(-1.7)
6. Waste	**1.5**	**1.3**	**1.5**	**1.1**	**1.2**	**1.4**	**1.3**
C Waste incineration	1.5	1.3	1.5	1.1	1.2	1.4	1.3

(source: RIVM 1997, VROM- 1997b)

* Including coke ovens

** including off-road vehicles

Emission per target group

Temperature corrected carbon dioxide emissions from Target Groups as listed in table 3.2. The correction can be as large as ± 4% of the total emission level, despite the temperate sea-climate in the Netherlands. The method of temperature correction is described in Spakman *et al.*, 1997a and is summarised in Appendix D. Corrected figures gives a better view on structural developments in CO_2 emissions. As can be seen from Table 3.1, CO_2 emissions have grown mainly due to increased energy consumption. In the period 1990-1996, temperature corrected energy consumption increased on average with 1% per year. However, the Gross Domestic Product grew on average with 2.3%, so the energy-intensity of the economy as a whole decreased with 1.3% per year.

In the Netherlands, the policies on the reduction of greenhouse gas emissions include efforts to increase the carbon sinks in forests. For this reason, at the bottom line of Table 3.2 the total emission level is presented as 'policy relevant emission level'. This levels equals the net emission level under the subtraction of the effectuated carbon dioxide sink (IPCC sector 5A). The national target is to reduce emissions between 1990 and 2000 by 3%. Since 1990, the temperature corrected carbon dioxide emissions in the Netherlands have increased with 7.6%. The most important developments per target group are highlighted below.

Table 3.2 Carbon dioxide emissions in the Netherlands per target group [Mton], 1990-1996. Figures are corrected for outdoor temperature.

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	9.2	9.5	9.5	9.8	10.0	10.0	9.9
WWTP	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Waste management	1.6	1.4	1.6	1.2	1.3	1.4	1.4
Construction	0.6	0.7	0.6	0.8	0.7	0.7	0.7
Residential	22.1	21.8	21.5	21.2	21.2	21.9	21.8
Drinking Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy sector	41.3	40.7	42.2	42.5	44.2	45.8	45.3
Industry	44.1	44.2	44.2	41.3	42.5	44.5	43.8
Agriculture	8.6	8.5	9.3	9.0	9.5	9.4	9.4
Refineries	10.4	10.6	10.9	10.6	11.2	11.5	11.4
Transport	28.6	28.6	29.8	30.5	30.8	31.9	33.4
Statistical differences	1.1	1.0	-0.4	1.6	0.5	2.5	3.5
Total net emissions	**167.6**	**167.3**	**169.5**	**168.1**	**172.1**	**179.5**	**180.4**
Carbon dioxide sinks	-1.5	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7
Total, policy-relevant	**166.2**	**165.7**	**167.9**	**166.5**	**170.4**	**177.9**	**178.7**

(source: RIVM 1997, VROM 1997b)

Carbon dioxide emissions from *residential dwellings* have decreased substantially in the eighties, despite population growth and increase in the number of dwellings. This was caused by the replacement of coal and oil by natural gas in combination with a nation wide program on thermal insulation of dwellings. In recent years however, the emission level stabilises and the volume-effect seems to be more dominant than the further penetration of insulation measures.

With respect to carbon dioxide emissions in the *energy sector*, the power plants are dominant. Their production, efficiency and fuel mix have hardly changed since 1990, leading to almost stable CO_2 emission levels from central power plants The significant increase of electricity consumption in the Netherlands has mainly been covered by new CHP installations. These installations are usually owned by either the energy distribution sector or operated as joint-ventures. Therefore the majority of the CHP-installationsis allocated to the energy sector. The 10% growth of CO_2 emission reflects the increasing role of CHP installations in the Netherlands' energy system, improving total efficiency and reducing net CO_2 emission in the Netherlands.

As can be seen from Table 3.2, *industrial* carbon dioxide emissions are almost stable. Indeed, energy consumption within the sector hardly grows due to energy conservation and efficiency improvements. The most important efficiency measure is Combined Heat and Power (CHP). Often new CHP installations are operated as a joint venture with the energy sector, in which all heat is delivered to the industrial plant and all electricity is sold to the energy sector. In this case the CHP installation is regarded as a venture with main activity to produce heat and electricity, and it is therefore allocated within the energy sector. So the stabilisation of industrial CO_2 emissions is partly caused by the allocation of increases emissions towards the energy sector.

Energy consumption within the *agriculture* is mainly due to greenhouse horticulture. This sector is still expanding and it's energy consumption increases, despite succesfull programs on efficiency improvements. Just like in the industrial sector, the CO_2-emissions that are allocated to agriculture are influenced by Combined Heat and Power. About 70% of these installations, all gas engines, are property of the energy sector. As a consequence, 0.8-1 Mton of carbon dioxide that is physically emitted within the greenhouse horticulture, is allocated to the energy sector.

The CO_2 emissions from *refineries* have increased with 10% since 1990. This is less than the increase in energy consumption (+16%) and production (+22%) due to tightening of the product specifications (leading to more cracking and desulphurisation). Energy conservation and a fuel shift towards gas have made this decrease of emissions per product possible.

The emissions from *transport* are rapidly increasing (+17% since 1990). This is mainly due to road transport. Fuel efficiency has improved but the volume effect of increased passenger and freight transport is dominant. Without the increase on fuel tax, the CO_2-emission from passenger cars would have been even 7% higher (Annema, 1997).

Another category with increasing carbon dioxide emissions is '*statistical differences*'. It concerns a small part of the national energy consumption (import + winning -exports - stock change) that is not covered by target groups. From the Netherlands Energy Statistics, this is called the statistical difference between top-down and bottom-up national total energy consumption. This figure is essentially different for coal, oil and natural gas, both in magnitude and sign. In recent years, the statistical differences for coal have increased. This has led to increasing CO_2 emissions.

3.3 Sinks

Trees in the Netherlands are, on the average, getting older and heavier: the maturing of forests. Also, the total forest area is increasing because of forest extension. Besides this growth, there are fellings that reduce woody livestock. In recent years fellings have been reduced and the net volume increment of woody biomass in the Netherlands has increased from 1.6 to 1.8 $*10^6$ m^3 per year. Under the assumption of a carbon content of 250 kg/m^3, this leads to a sink of carbon dioxide increasing from 1.5 to 1.7 Mton per year in the period 1990 - 1996. As was stated before, in the Netherlands this carbon sink is regarded as part of the policy field for greenhouse gases. For domestic policy purposes, this carbon dioxide sink is therefore subtracted from the net emissions.

3.4 Bunkers

Air and marine bunkers contribute to emissions of anthropogenic carbon dioxide. They are, however, not allocated to one country but regarded as 'international emissions'. The international emissions from Netherlands' bunkers have increased with 12% since 1990. These emissions are relatively large when compared with national carbon dioxide emissions. This is partly due to the fact that Rotterdam, the largest harbour in the world, is also the worlds' largest marine bunker location. Furthermore, traffic on Amsterdam airport has significantly increased over the period 1990-1996: 44% more flights and 68% more passengers. This is the main reason why aviation bunkers have almost doubled since 1990.

Table 3.3 Bunkers and international carbon dioxide emissions, 1990-1996.

		1990	1991	1992	1993	1994	1995	1996
Marine bunkers	[PJ]	466	476	478	495	474	487	488
Aviation bunkers	[PJ]	61	68	81	89	92	97	113
Total bunkers	[PJ]	527	544	559	584	566	584	601
Marine bunkers CO_2	[Mton]	35.9	36.7	36.8	38.1	36.5	37.5	37.6
Aviation bunkers CO_2	[Mton]	4.5	5.0	5.9	6.5	6.7	7.1	8.2
Total bunkers CO_2	**[Mton]**	**40.4**	**41.7**	**42.7**	**44.6**	**43.2**	**44.6**	**45.8**

(source: CBS)

4. METHANE

4.1 Introduction

Methane (CH_4) is the second important greenhouse gas in the Netherlands. It contributes to about 11% in the total greenhouse gas emissions, though emission level and share are decreasing. The main sources of methane emissions are landfills and agriculture (fermentation and manure from animals), which both contribute to about 40% of the national total. About 15% of the Netherlands' CH_4 emission is caused by the production and distribution of oil and gas.

The inventory methodology for the emissions is described in (Spakman *et al.*, 1997). A summary of this report is presented in Appendix B. In that report, improved knowledge about specific factors and processes have been incorporated. This has resulted in better emission estimates. When compared with earlier reports, methane emissions in the Netherlands appear to be higher than was estimated before. The results have first been published in the Environmental Balance 1997 (RIVM, 1997) and the Dutch Annual Emission Report (VROM, 1997b). The main differences with the methods used before are:

- Emissions from *landfills* are higher, especially in the early nineties, because new specific factors are used in the calculation. These factors concern: (a) the concentration of degradable carbon in waste: now estimated to be 132 kg/ton waste up till 1990 and 125 kg/ton between 1990 and 1995 (estimate in earlier reports: all years 85 kg/ton), (b) adjustment of the estimate of the fraction that actually degrades to 58% (old estimate: 80%), (c) adjustment of the CH_4-fraction that oxidises in the covering layer of soil to 10% (earlier it was estimated: 20%), (d) new figures of total deposited waste in the eighties (up to 20% more). As a result, the new estimate for methane emissions from landfills in 1990 is about 20% or 100 mln kg higher than reported before.
- In the new method, emissions from *fuel stations* are allocated to the transport sector. In methods used earlier, they were allocated to 'services'.
- The emissions from *oil and gas* have been recalculated with aggregated, time dependent factors for the four combinations of oil/gas * onshore/offshore. This leads to adjustments of 2-3 mln kg.

4.2 Emissions

In Table 4.1 the methane emissions in the Netherlands in the period 1990-1996 are listed. In this period, emissions decreased with more than 8% to the level of 1234 mln kg. The main cause of this decrease concerns landfills: having maximum emissions in 1990, the level has gone down with 98 mln kg (-17%) due to successful policy measures like landfill gas recovery and the stimulation of recycling which leads less waste deposition.

Methane emissions from agriculture have gone down in the period 1990-1996 because of less emissions from enteric fermentation. Fugitive emissions from the oil and gas sector however have increased in recent years due to the enlarged offshore activities. As can be seen from Table 4.1, emissions from fuel combustion [1A] only contribute to about 3% of the total methane emissions in the Netherlands. Within this category, emissions from residential food preparation (cooking) and heating systems are dominant.

Table 4.1 Methane emissions in the Netherlands per IPCC-sector [mln kg], 1990-1996.

IPCC sector	1990	1991	1992	1993	1994	1995	1996
TOTAL NET NATIONAL EMISSIONS	**1292**	**1309**	**1256**	**1225**	**1203**	**1173**	**1179**
1. All Energy (combustion and fugitive)	**214**	**224**	**199**	**192**	**202**	**209**	**231**
A Fuel combustion total	35	36	36	34	34	35	39
1 a Electricity and heat production	3	3	3	3	3	4	6
1 c Other transformation: Refineries	0	0	0	0	0	0	0
2 Industry	4	4	5	3	3	3	3
3 Transport	8	7	7	6	6	6	6
4 a Commercial/Institutional	1	1	1	1	1	1	1
4 b Residential	13	15	13	14	13	14	16
4 c Agriculture / forestry / fishing	2	3	3	3	3	3	3
6 Biomass burned for energy	4	4	4	4	4	4	4
B Fugitive fuel emissions	179	188	163	158	168	174	192
2 Crude oil and natural gas	179	188	163	158	168	174	192
2. Industrial processes (ISIC)	**3**	**4**	**4**	**5**	**5**	**5**	**5**
F Other	3	4	4	5	5	5	5
4. Agriculture	**505**	**517**	**505**	**497**	**483**	**476**	**476**
A Enteric fermentation	402	412	401	393	382	377	377
B Manure management	103	105	104	104	101	99	99
6. Waste	**568**	**562**	**546**	**528**	**510**	**481**	**466**
A. Landfills (solid waste disposal)	562	556	540	522	505	479	464
B Waste water treatment plants	6	6	6	6	5	2	2
7. Other (specified)	**2**	**2**	**2**	**2**	**2**	**2**	**2**
A Drinking water plants	2	2	2	2	2	2	2

(source: RIVM 1997, VROM- 1997b)

Emission per target group

In Table 4.2 the time series of methane emissions are listed per target group. The focus below is on the main sources: landfills, agriculture (cattle) and the energy sector.

Waste management. Clearly, the 8% reduction of methane emissions in the period 1990-1996 is mainly the result of emission reduction within the target group waste management. The methane is almost entirely resulting from anaerobe degradation processes of biowaste within landfills and results from waste deposited in the past. Indeed the dynamic model that was used to calculate these emissions, shows an emission peak in 1990 and reduction hereafter. Methane emissions from landfills have decreased with 17% from 562 mln kg in 1990 to 464 mln kg in 1996 as a result of the following measures:

(1) due to the policy to recycle a larger fraction of the waste, the amount of waste deposited in landfills is drastically decreasing (-50% since 1990), especially due to more re-use of food and garden waste
(2) the composition of the waste is gradually changing towards a smaller amount of degradable carbon per ton
(3) landfill gas recovery is rapidly expanding, from 19 mln kg CH_4 in 1990 to 57 mln kg in 1996.

It is expected that the methane emissions from landfills in the Netherlands will further decrease in the near future.

Agriculture. Since 1990, the volume of the dairy cattle has been reduced with about. 10% as a result of the policy to tackle the problem of over-production within the European Union, a development that already started in the eighties. Dairy cattle still is the main source of methane emissions from enteric fermentation. The fermentation emissions from other animals have not changed significantly. In total, the methane emissions from enteric fermentation have decreased with 6% (25 mln kg) since 1990 to the level of 377 mln kg in 1996. The other important source of agricultural methane emissions (about 100 mln kg) is stored manure. Emissions have dropped 4% (4 mln kg) since 1990, mainly because of the reducing manure production from dairy cattle.

Energy sector. The total of 197 mln kg (1996) is caused by transportation / distribution of natural gas and from oil and gas production. The methane emissions from oil and gas have been fluctuating since 1990. Emissions from gasdistribution are decreasing. The natural gas is partly distributed in old pipelines that were originally designed for the distribution of coalgas. The joints of these pipelines are slightly diffuse for methane, the main component of natural gas. Due to the gradual replacement of these pipes, general loss percentage of distributed gas in the

Table 4.2 Emissions of methane in the Netherlands per Target Group [mln kg], 1990-1996..

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	1	1	1	1	2	1	1
WWTP	6	6	6	6	5	2	2
Waste management	562	556	540	522	505	479	464
Construction	0	0	0	0	0	0	0
Residential	17	18	17	18	17	18	20
Drinking Water	2	2	2	2	2	2	2
Energy sector	181	191	166	161	172	178	197
Industry	7	7	9	8	8	8	7
Agriculture	507	520	508	500	486	479	479
Refineries	1	1	1	1	1	1	1
Transport	8	7	7	6	6	6	6
Total net emissions	**1292**	**1309**	**1256**	**1225**	**1203**	**1173**	**1179**
Nature[1)]	125	125	125	125	125	125	125
Total, including nature	1417	1434	1381	1350	1328	1298	1303

(source: RIVM 1997a, VROM 1997b)

[1)] natural emissions include emissions from managed agricultural lands. Due to drainage and the lowering of water tables, these emissions have dropped from 85 kton in 1950 to 55 kton in recent years.

Netherlands has gone down from 0.7 to 0.5% (vol). The effect of less leakage is partly compensated by the increased volume of distributed natural gas. The latter is mainly due to changed weather conditions: the winter months of 1990 were extremely mild while the 1996 winter was colder than usual (no temperature correction has been applied here).

The methane emissions from oil and gas production are mainly caused by the offshore production of gas. When the raw gas is processed (drying, removing contamination), large quantities of secondary gasstreams are produced. Onshore, these gasstreams are flared. In offshore winning however, the main part of these process gasstreams is still vented, resulting in significant emissions of methane. Despite technical measures to prevent emissions, they increased during the years 1993-1996 because the offshore production volume of natural gas in the Netherlands (North Sea) increased with about 40 %.

5. NITROUS OXIDE

5.1 Introduction

Nitrous oxide (N_2O) is a third direct greenhouse gas. The emissions of N_2O in the Netherlands have increased with 13% since 1990 to the level of 72.4 mln kg in 1996. Nitrous oxide contributes to more than 9% (22.4 Mton CO_2-eq.) of the total Netherlands' greenhouse gas emissions. This is almost as large as the contribution of methane.

In earlier reports, the Netherlands' emissions of nitrous oxide were estimated to be about 58 mln kg. The new estimates presented here, are about 25% (14 mln kg) higher:

- An important difference with earlier reports of nitrous oxide emissions in the Netherlands concerns the process emissions from *chemical industries*. Recently, new information about N_2O emissions from Dutch production plants of nitric acid and caprolactam became available. This information is based on measurements. It appeared that emissions are significantly higher) than was estimated before (31 instead of 16 mln kg, Spakman *et al.*, 1997).
- A second difference with earlier reports is the estimate of nitrous oxide emissions from *transport*. In the new method, transport emissions are calculated on the basis of national fuel consumption data whereas in earlier reports vehicle-km figures were used. This would have resulted in slightly higher estimates of N_2O emissions from transport. However, in the new method also the emission factors have been adapted (significantly decreased) due to new knowledge about combustion in engines. The result of the new method is that the total N_2O emission (= $\Sigma_{vehicles}$ Fuel consumption * emission factor) is about 10% or 0.7 mln kg less in 1995 than was reported earlier.

5.2 Emissions

In Table 5.1 a summary table is presented with the trend of N_2O emissions per IPCC sector. This trend of emissions is also presented per so-called Target Group in Table 5.2. Total emissions have increased in 1996 by 13% compared to 1990. This increment is the result of two developments:

(1) the incorporation of manure in the soil,

(2) further penetration and ageing of the three-way catalyst converters in gasoline cars.

Agriculture. The strong increase of emissions of the agricultural sector in 91/92 is caused by the direct incorporation of manure in the soil (from 10% in 1991 to 69% in 1992) as prescribed by environmental legislation. The purpose of this measure is to prevent the emissions of ammonia that go with surface spreading of manure. A by-effect however is that incorporation leads to an extra nitrogen load in the soil and thus to higher emissions of nitrous oxide (the emission factor of N_2O from manure *in* the agricultural soil is twice the emission factor from manure on that soil surface).

Transport. The increase in emissions in the transport sector, notably in 91/92 and 92/93, is caused by the introduction and further penetration of catalytic converters in passenger cars. All new gasoline cars are equipped with a three-way catalyst as to cope with the problem of VOC and NO_x emissions. A secondary undesired effect on nitrous oxide stems from the ageing of catalysts: nitrous oxide emissions increase as the catalyst gets older.

Table 5.1 Emissions of nitrous oxide (N_2O) in the Netherlands per IPCC sector, 1990-1996 (mln kg).

IPCC Sector	1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion total	5.3	5.6	6.2	6.7	6.9	7.9	8.5
A1 Energy & Transformation	*0.5*	*0.5*	*0.4*	*0.4*	*0.1*	*0.5*	*0.5*
A2 Industry (only combustion)	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
A3 Transport	*4.6*	*4.9*	*5.5*	*6.1*	*6.6*	*7.2*	*7.8*
A4 Small combustion	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
A5 Other	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
A6 Biomass burned for energy	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
1B Fugitive fuel emissions	0.0	0.0	0.0	0.0	0.4	0.0	0.0
2. Industrial processes (ISIC)	31.5	32.3	30.4	30.0	31.6	31.6	31.6
3. Solvent and other product use	0.5	0.5	0.5	0.5	0.5	0.4	0.4
4. Agriculture	22.2	22.9	26.2	26.2	26.4	27.6	27.5
5. Land use change and forestry	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	0.5	0.5	0.5	0.5	0.5	0.5	0.6
7. Other (polluted surface water)	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Total	**63.9**	**65.6**	**67.6**	**67.8**	**70.1**	**71.9**	**72.4**

(source: RIVM 1997, VROM 1997b)

As can be seen from Table 5.1, there are three significant sources of nitrous oxide emissions. Transportation contributes to about 11% and has an increasing share. Agriculture and the associated nitrogen loads on soils contributes to 38%. The most important source of nitrous oxide however is the *chemical industry* (44%). At Netherlands' nitric acid plants and other inorganic chemical industries (production of caprolactam, acrylonitril and the catalytic cracking of oils), the emissions of nitrous oxide have recently been measured. It appeared that these measurements confirmed the IPCC default emission factors (9 kg N_2O per ton of nitric acid produced) and that emissions in the Netherlands have been underestimated in the past.

Minor sources are stationary fuel combustion (mainly coal-fired power plants), the use of N_2O as anaesthesia and emissions from polluted surface water. Open waters are polluted especially as the result of agricultural activities. It is calculated that about 240 mln kg of nitrogen from fertilisers and manure eventually end up in water systems. This results in N_2O emissions of 3.8 mln kg, this is a contribution of 5% to the national total (VROM, 1997a).

Table 5.2 Emissions of nitrous oxide (N_2O) in the Netherlands per Target Group, 1990-1996 (mln kg).

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	0.5	0.5	0.5	0.5	0.5	0.4	0.4
WWTP	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Waste management	0.1	0.1	0.1	0.1	0.1	0.0	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Drinking Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy sector	0.4	0.4	0.4	0.3	0.4	0.4	0.4
Industry	31.6	32.4	30.5	30.1	31.7	31.7	31.7
Agriculture	22.2	22.9	26.2	26.2	26.4	27.6	27.5
Refineries	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transport	4.7	4.9	5.5	6.1	6.6	7.2	7.8
Other	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Total	**63.9**	**65.6**	**67.6**	**67.8**	**70.1**	**71.9**	**72.4**

(source: RIVM 1997, VROM 1997b)

6. Halocarbons (HFCs, PFCs) and SF_6

6.1 Introduction

Within the framework of the Montreal Protocol and subsequent amendments, CFC substitutes without Ozone Depletion Potential (ODP) are not subject to annual reporting. They are, however, strong greenhouse gases and their emissions are increasing. Therefore, emissions of these compounds must be reported under the FCCC obligations. The emissions of the non-ODP halocarbons (HFCs and PFCs) and SF_6 are the result of: (1) use as CFC-substitute, (2) process emissions from the production and packaging of these substances, (3) by-product from the production of other substances, (4) use for specific PFC and SF_6 applications. In the Netherlands, no emissions of FICs occur.

Differences to earlier reports are:
- Emissions estimates of HFCs and PFCs for 1995 onwards are based on actual emission calculations per application.
- The estimate of HFC-134a emissions for 1994 has been revised.

6.2 Emissions and consumption

The total CO_2-eq. emissions of the group of HFCs, PFCs and SF_6 increased in 1996 by 26% compared to 1990 (Table 6.1). They contribute to less than 5% in the total emissions of greenhouse gasses, but this share is increasing. Since 1995, the consumption of HFCs and PFCs per application in the Netherlands is reported annually through a survey by an independent auditor at the request of the Ministry of Housing, Spatial Planning and the Environment (VROM). From these *consumption* figures, the associated *emissions* are calculated, taking into account delay factors for various applications as described in Spakman *et al.* (1997). In addition, emissions of PFCs (that is, CF_4 and C_2F_6) from aluminium production are estimated using a global weighted, average of default IPCC emission factors. Therefore the uncertainty in the actual factors is very high.

Emissions of SF_6 are estimated based on trend estimates of consumption in 1990. The consumption and emission level in 1990 was estimated by Matthijsen and Kroeze (1995), based on a study by Annema (1989). It has been assumed that the annual emissions are equal to annual consumption; thus, *potential* emissions are reported here. In future updates, estimates of actual emissions will be provided too. Furthermore, it is assumed that in the

Table 6.1 Emissions per group of HFCs, PFCs and SF_6, 1990-1996 (Mton CO_2-eq.).

Compound	1990	1991	1992	1993	1994	1995	1996
HFCs	4.9	4.9	5.0	5.0	6.5	6.7	7.2
PFCs	2.5	2.4	2.2	2.2	2.4	2.4	2.3
SF_6 (potential emissions)	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Total CO_2-eq. (Mton)	**8.8**	**8.7**	**8.6**	**8.7**	**10.4**	**10.6**	**11.0**

Netherlands no FIC emissions occur. In Table 6.2, a summary table is presented with the trend of HFC, PFC and potential SF_6 emissions per compound, rather than per IPCC sector, because consumption was reported *by application*, not by sector. The trend of consumption per compound is presented in Table 6.3.

Table 6.2 Actual emissions of HFCs and PFCs and potential emissions of SF_6 in the Netherlands per individual compound, 1990-1996 (1000 kg).

Compound	*GWP*	1990	*1991*	*1992*	1993	1994	1995	1996*	
HFC-23	*11700*	410	*414*	*418*	423	536	536	536	b) e)
HFC-32	*650*	0			0	1	1	1	b)
HFC-43-10mee	*1300*	0					PM	PM	b)
HFC-125	*2800*	20	*16*	*12*	7	20	30	48	
HFC-134a	*1300*	30	*24*	*18*	12	124	250	549	
HFC-143a	*3800*	4	*4*	*4*	3	6	13	29	
HFC-152a	*140*	25	*27*	*28*	29	24	24	24	b)
HFC-227ea	*2900*	0					PM	PM	b)
Unspecified HFCs							23	56	b)
Total HFCs		**489**	***485***	***480***	**474**	**711**	**855**	**1187**	f)
CF_4 emission from aluminum	*6500*	310	*305*	*272*	278	300	300	300	
C_2F_6 emission from aluminum	*9200*	31	*30*	*27*	28	30	30	30	
PFC use d)	*7200*	22	*22*	*23*	23	23	23	13	a) d)
Total PFCs		**363**	***357***	***322***	**329**	**353**	**353**	**343**	
SF_6 (potential emissions)	*23900*	**58**	***58***	***59***	**60**	**61**	**61**	**61**	
Total HFCs, PFCs and SF_6		**910**	***900***	***861***	**863**	**1125**	**1269**	**1591**	

Notes:
* Data for 1996 are preliminary figures.
a) For 1995 and 1996, we assume that use = emission; use for PFC also for previous years.
b) Amount of individual compounds is confidential: total use of HFC-23, 32, 43-10mee, 152a and 227ea amounts to 23 and 56 ton in 1995 and 1996, respectively (excluding emissions as by-product of HCFC-22 production).
d) Excluding PFCs emitted during primary aluminium production .
e) Emissions as by-product of HCFC-22 production.
f) Totals for 1995 and 1996 exclude amounts for HFC-43-10mee and HFC-227ea as mentioned under note b).

Table 6.3 Consumption of HFCs, PFCs and SF_6 in the Netherlands per compound, 1990-1996 (1000 kg).

Compound	1990	1991	1992	1993	1994	1995	1996
HFC-23							
HFC-32							
HFC-125						50	102
HFC-134a					274	454	913
HFC-143a						34	83
HFC-152a							
Unspecified HFCs *)						23	56
PFCs (unspecified)						23	12
SF_6	58	58	59	60	61	61	61

(Source: Matthijsen, 1995)

7. OTHER INDIRECT GREENHOUSE GASES AND SO_2

7.1 Carbon monoxide

In Table 7.1a summary table is presented with the trend of CO emissions per IPCC sector. This trend of emissions is also presented per so-called Target Group in Table 7.2. Total emissions dropped in 1996 by 24% compared to 1990. Emissions of the 'Other industry' decreased due to measures by the iron and steel industry. Please note the that the small difference in the total of the two tables is caused by a somewhat different definition of domestic emissions in the transport sector (see Section 2.3). The main differences with CO figures reported previously (Spakman *et al.*, 1996; VROM, 1997a) are:

- sectoral total: notably in the transport sector;
- sectoral calculation: revised calculation of sectional emissions for the period 1990-1996, the latter now excluding the emissions of international shipping in territorial waters;
- allocation to sectors: modified due to refined scheme for allocation of Target Group emissions to IPCC Sectors (see Appendix C), in particular improved division between combustion and process sources.

Table 7.1 Emissions of carbon monoxide (CO) in the Netherlands per IPCC sector, 1990-1996 (mln kg).

IPCC Sector	1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion total	974	880	854	838	789	779	754
A1 Energy & Transformation	*15*	*16*	*15*	*14*	*14*	*16*	*16*
A2 Industry (only combustion)	*114*	*108*	*115*	*139*	*114*	*118*	*117*
A3 Transport	*749*	*658*	*626*	*582*	*560*	*541*	*515*
A4 Small combustion	*11*	*12*	*11*	*15*	*12*	*14*	*15*
A5 Other	*0*	*0*	*0*	*0*	*0*	*0*	*0*
A6 Biomass burned for energy	*85*	*86*	*87*	*88*	*89*	*90*	*91*
1B Fugitive fuel emissions	6	8	6	6	8	10	7
2. Industrial processes (ISIC)	154	127	101	99	102	98	95
3. Solvent and other product use	2	2	2	2	2	2	2
4. Agriculture	0	0	0	0	0	0	0
5. Land use change and forestry	0	0	0	0	0	0	0
6. Waste	4	4	3	3	4	2	2
7. Other (specified)	0	0	0	0	0	0	0
Total	**1 139**	**1 022**	**966**	**949**	**905**	**890**	**860**

(Source: RIVM 1997, VROM 1997b)

Table 7.2 Emissions of carbon monoxide (CO) in the Netherlands per Target Group, 1990-1996 (mln kg).

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	3	3	3	5	4	4	3
WWTP	0	0	0	0	0	0	0
Waste	4	4	14	14	4	2	2
Construction	0	0	0	2	0	3	2
Residential	94	95	96	97	98	99	101
Drinking Water	0	0	0	0	0	0	0
Energy sector	15	19	18	17	20	23	21
Industry	268	236	216	238	216	216	212
Agriculture	1	2	2	2	2	2	2
Refineries	5	6	3	2	2	2	2
Transport	751	660	628	584	562	543	517
Total	**1141**	**1024**	**979**	**960**	**907**	**892**	**862**

(Source: RIVM 1997, VROM 1997b)

7.2 Nitrogen oxides

In Table 7.3 a summary table is presented with the trend of NO_x emissions per IPCC sector. This trend of emissions is also presented per so-called Target Group in Table 7.4. Total emissions dropped in 1996 by 16% compared to 1990. Please note the that the small difference in the total of the two tables is caused by a somewhat different definition of domestic emissions in the transport sector (see Section 2.3).

The main differences with NO_x figures for reported previously (Spakman *et al.*, 1996; VROM, 1997a) are:

- sectoral total: notably in the transport sector, now excluding the emissions of international shipping in territorial waters, which is also the reason why IPCC Sector totals and Target Group sums differ significantly;
- sectoral calculation: revised calculation of sectional emissions for the period 1990-1996;
- allocation to sectors: modified due to refined scheme for allocation of Target Group emissions to IPCC Sectors (see Appendix C), in particular improved division between combustion and process sources.

The decrease in emissions of the industry (chemical and other) in various years is due to strengthening of the standard for the maximum NO_x content in flue gases. In 95/96, residential emissions increased strongly due to higher fuel consumption caused by a cold winter. Emissions of the 'Energy sector' decreased due to implementation of $DeNO_x$ and other low NO_x techniques.

Table 7.3 Emissions of nitrogen oxides (NO_x) in the Netherlands per IPCC sector, 1990-1996 (mln kg).

IPCC Sector	1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion total	544	533	520	498	479	467	460
A1 Energy & Transformation	*99*	*91*	*91*	*86*	*79*	*75*	*75*
A2 Industry (only combustion)	*66*	*60*	*61*	*55*	*54*	*52*	*51*
A3 Transport	*337*	*336*	*326*	*312*	*304*	*297*	*284*
A4 Small combustion	*41*	*42*	*40*	*44*	*40*	*40*	*46*
A5 Other	*0*	*0*	*0*	*0*	*0*	*0*	*0*
A6 Biomass burned for energy	*2*	*2*	*2*	*2*	*2*	*2*	*2*
1B Fugitive fuel emissions	1	1	1	1	1	1	0
2. Industrial processes (ISIC)	14	13	13	13	10	11	10
3. Solvent and other product use	0	0	0	0	0	0	0
4. Agriculture	0	0	0	0	0	0	0
5. Land use change and forestry	0	0	0	0	0	0	0
6. Waste	5	.5	5	6	3	3	2
7. Other (specified)	0	0	0	0	0	0	0
Total	**563**	**552**	**539**	**519**	**493**	**481**	**471**

(source: RIVM 1997, VROM 1997b)

Table 7.4 Emissions of nitrogen oxides (NO_x) in the Netherlands per Target Group, 1990-1996 (mln kg).

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	12	10	9	11	9	8	9
WWTP	0	0	0	0	0	0	0
Waste	5	5	5	6	3	3	2
Construction	1	1	1	1	1	1	1
Residential	22	24	22	23	22	23	27
Drinking Water	0	0	0	0	0	0	0
Energy sector	80	72	74	69	62	58	58
Industry	79	74	74	68	65	63	61
Agriculture	9	10	10	10	10	10	12
Refineries	21	21	18	18	17	18	18
Transport	353	352	342	328	321	314	301
Total	**579**	**568**	**555**	**535**	**510**	**498**	**488**

(source: RIVM 1997a, VROM 1997b)

7.3 NMVOC

In Table 7.5 a summary table is presented with the trend of NMVOC emissions per IPCC sector. This trend of emissions is also presented per so-called Target Group in Table 7.6 Total emissions dropped in 1996 by 31% compared to 1990. Please note the that the small difference in the total of the two tables is caused by a somewhat different definition of domestic emissions in the transport sector (see Section 2.3). Please also note that we used here a definition of NMVOC which is slightly different from the one used in previous reports (see section 2.1). The main differences with NMVOC figures for reported previously (Spakman *et al.*, 1996; VROM, 1997a) are:

- different definition of NMVOC has been applied, related to the recalculation of the emissions for the period 1990-1996; in previous reports the NMVOC definition according to 'KWS-2000' was used, which excludes CFCs and halons. As a consequence, emissions are higher in this report (1990: +12 kton, 1996: +2 kton);
- sectoral total: notably in the industrial processes sector;
- sectoral calculation: revised calculation of sectoral emissions for the period 1990-1996;
- allocation to sectors: modified due to refined scheme for allocation of Target Group emissions to IPCC Sectors (see Appendix C), in particular improved division between combustion and process sources.

The emissions of the industry (chemical and other), residential and Retail / Services / Government sectors, and refineries decreased due to various measures taken as described in the policy plan 'KWS 2000'. In the 'energy sector' the decrease of 91/92 was due to increased gas flaring at onshore gas production sites, while the increase in 93/94 and 94/95 was caused by the strongly increasing share of offshore gas production, where flaring is far more rare.

Table 7.5 Emissions of NMVOC in the Netherlands per IPCC sector, 1990-1996 (mln kg).

IPCC Sector	1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion total	219	199	193	180	174	170	167
A1 Energy & Transformation	*3*	*3*	*3*	*3*	*3*	*5*	*7*
A2 Industry (only combustion)	*5*	*4*	*6*	*3*	*3*	*3*	*3*
A3 Transport	*201*	*180*	*172*	*162*	*157*	*151*	*144*
A4 Small combustion	*5*	*6*	*6*	*7*	*5*	*6*	*7*
A5 Other	*0*	*0*	*0*	*0*	*0*	*0*	*0*
A6 Biomass burned for energy	*6*	*6*	*6*	*6*	*6*	*6*	*6*
1B Fugitive fuel emissions	48	47	43	42	42	45	41
2. Industrial processes (ISIC)	130	121	115	100	88	76	71
3. Solvent and other product use	101	92	83	80	82	71	67
4. Agriculture	0	0	0	0	0	0	0
5. Land use change and forestry	0	0	0	0	0	0	0
6. Waste	1	2	2	1	1	1	1
7. Other (specified)	0	0	0	0	0	0	0
Total	**500**	**460**	**436**	**403**	**388**	**363**	**347**

Table 7.6 Emissions of NMVOC in the Netherlands per Target Group, 1990-1996 (mln kg).

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	48	45	42	37	32	29	27
WWTP	0	0	0	0	0	0	0
Waste	1	2	2	1	1	1	1
Construction	30	26	22	25	29	26	24
Residential	41	39	37	37	40	33	33
Drinking Water	0	0	0	0	0	0	0
Energy sector	25	25	22	22	24	29	29
Industry	135	125	121	103	91	79	74
Agriculture	2	2	2	2	2	2	3
Refineries	15	15	14	13	11	12	11
Transport	202	182	174	164	158	153	146
Total	**500**	**461**	**437**	**404**	**388**	**364**	**348**

(source: RIVM 1997a, VROM 1997b)

7.4 Sulphur dioxide

In Table 7.7 a summary table is presented with the trend of SO_2 emissions per IPCC sector. This trend of emissions is also presented per so-called Target Group in Table 7.8. Total emissions dropped in 1996 by 34% compared to 1990. Please note the that the small difference in the total of the two tables is caused by a somewhat different definition of domestic emissions in the transport sector (see Section 2.3).

The main differences with SO_2 figures for reported previously (Spakman *et al.*, 1996; VROM, 1997a) are:

- sectoral total: notably in the energy and transformation and in the transport sector, the latter now excluding the emissions of international shipping in territorial waters which is also the reason why IPCC Sector totals and Target Group sums differ significantly;
- sectoral calculation: revised calculation of sectional emissions for the period 1990-1996;
- allocation to sectors: modified due to refined scheme for allocation of Target Group emissions to IPCC Sectors (see Appendix C).

In the period 90-94 the emission of the ‘energy sector’ decreased strongly due to the further implementation of flue gas desurphurisation appliances in public coal-fired power plants. The increase in 95/96 was caused by an increase of the sulphur content of coals used. Emissions of the ‘Other industry’ decreased due to measures in the iron and steel industry. The decrease in 95/96 in the refinery sector was due to a strengthening of standard for the maximum SO_2 content in flue gases. The decrease in the transport sector in 95/96 was due to lowering of the sulphur standard of diesel fuels on October 1, 1996.

Table 7.7 Emissions of sulphur dioxide (SO_2) in the Netherlands per IPCC sector, 1990-1996 (mln kg).

IPCC Sector	1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion total	155	127	124	120	108	110	101
A1 Energy & Transformation	*104*	*84*	*78*	*75*	*65*	*68*	*64*
A2 Industry (only combustion)	*26*	*18*	*20*	*18*	*16*	*15*	
A3 Transport	*20*	*21*	*21*	*21*	*22*	*21*	*18*
A4 Small combustion	*4*	*4*	*4*	*6*	*5*	*6*	*6*
A5 Other	*0*	*0*	*0*	*0*	*0*	*0*	*0*
A6 Biomass burned for energy	*0*	*0*	*0*	*0*	*0*	*0*	*0*
1B Fugitive fuel emissions	8	10	12	11	11	10	9
2. Industrial processes (ISIC)	26	22	19	17	16	17	17
3. Solvent and other product use	0	0	0	0	0	0	0
4. Agriculture	0	0	0	0	0	0	0
5. Land use change and forestry	0	0	0	0	0	0	0
6. Waste	4	5	3	2	1	0	0
7. Other (specified)	0	0	0	0	0	0	0
Total	**193**	**164**	**157**	**151**	**137**	**137**	**127**

(source: RIVM 1997, VROM 1997b)

Table 7.8 Emissions of sulphur dioxide (SO_2) in the Netherlands per Target Group, 1990-1996 (mln kg).

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	2	1	1	3	3	3	3
WWTP	1	1	1	1	1	1	1
Waste	5	5	9	6	2	1	1
Construction	1	1	1	1	0	1	1
Residential	1	1	1	1	1	1	1
Drinking Water	0	0	0	0	0	0	0
Energy sector	45	35	30	24	17	17	18
Industry	52	40	39	34	33	32	30
Agriculture	0	0	0	0	0	0	0
Refineries	67	59	60	63	59	61	55
Transport	29	30	31	31	31	31	28
Total	**202**	**173**	**172**	**164**	**146**	**147**	**136**

(source: RIVM 1997, VROM 1997b)

8. TOTAL GREENHOUSE GAS EMISSIONS

8.1 Introduction

To represent the total emissions of greenhouse gases from anthropogenic sources in the Netherlands expressed as CO_2-eq., we selected the GWP values for a time horizon of 100 years from the most recent IPCC assessment (IPCC, 1996), if reported. 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 1990-1996

In Table 8.1 the CO_2 equivalent emissions of the '6' direct greenhouse gases of the Netherlands from anthropogenic sources are presented for the period 1990-1996. The data of carbon dioxide are corrected for temperature. When interpreting this table one should take account that the values for SF_6 are potential emissions; actual emissions of SF_6 may be a factor of 4 lower if used predominantly in applications with a low leakage rate. Also, we note that figures for 1996 are preliminary. The same data are in Table 8.2 expressed as indices relative to 1990, from which it can be concluded that:

- the temperature-corrected emissions of the group [CO_2, CH_4 and N_2O] have increased by 7% compared to 1990, predominantly caused by an increase of about 8% in CO_2 emissions;
- emissions of CH_4 decreased by 9% in this period;
- emissions of N_2O increases by 13% in this period;
- emissions of HFCs, PFCs and SF_6 increased by 26%, primarily due to an increase of almost 50% in HFC emissions.

Table 8.1 Direct greenhouse gas emissions in the Netherlands, 1990-1996 (T-corrected) (Mton CO_2-eq.)

Direct greenhouse gas	1990	1991	1992	1993	1994	1995	1996
CO_2 (T-corrected)	167.6	167.3	169.5	168.6	172.1	179.5	180.4
CH_4	27.1	27.5	26.4	25.7	25.3	24.6	24.8
N_2O	19.8	20.3	21.0	21.0	21.7	22.3	22.4
Total [CO_2+CH_4+N_2O]	**214.5**	**216.1**	**216.9**	**215.3**	**219.1**	**226.4**	**227.6**
HFCs	4.9	4.9	5.0	5.0	6.5	6.7	7.2
PFCs	2.5	2.4	2.2	2.2	2.4	2.4	2.3
SF_6 (potential)	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Total [HFCs +PFCs +SF_6]	**8.8**	**8.7**	**8.6**	**8.7**	**10.4**	**10.6**	**11.0**
Total [group of six]	**223.3**	**223.9**	**225.4**	**224.0**	**229.5**	**237.0**	**238.7**

Table 8.2 Index of direct greenhouse gas emissions in the Netherlands, 1990-1996 (T-corrected) (1990 = 100)

Indices (CO_2: T-corrected)	1990	1991	1992	1993	1994	1995	1996
Index CO_2	100.0	99.8	101.1	100.6	102.7	107.1	107.6
Index CH_4	100.0	101.3	97.2	94.8	93.1	90.8	91.3
Index N_2O	100.0	102.8	105.8	106.1	109.7	112.5	113.4
Index CO_2, CH_4, N_2O	**100.0**	**100.7**	**101.1**	**100.4**	**102.1**	**105.6**	**106.1**
Index HFCs	100.0	100.6	101.1	101.8	132.7	137.2	147.3
Index PFCs	100.0	98.3	88.7	90.7	97.3	97.3	94.3
Index SF_6 (potential)	100.0	100.0	101.7	103.4	105.2	105.2	105.2
Index HFCs, PFCs, SF_6	**100.0**	**99.8**	**97.8**	**99.0**	**118.4**	**120.9**	**125.8**
Index [group of six]	**100.0**	**100.3**	**100.9**	**100.3**	**102.8**	**106.1**	**106.9**

An overview of the indirect greenhouse gases (the three ozone precursors CO, NO_x and NMVOC as well as SO_2) is presented in Tables 8.3 and 8.4. The tables show a steady decrease in the period 1990-1996. The indices shown in Table 8.4 clearly show that emissions of these gases have dropped between 15% (NOx) and more than 30% (NMVOC and SO_2).

Table 8.3 Emissions of indirect greenhouse gases and SO_2 in the Netherlands, 1990-1996 (kton.)

Indirect gases and SO_2	1990	1991	1992	1993	1994	1995	1996
Total NO_x	579	568	555	535	510	498	488
Total CO	1141	1024	978	960	907	892	862
Total NMVOC	500	461	437	404	388	364	348
Total SO_2	202	173	172	164	146	147	136

Table 8.4 Index of emissions of indirect greenhouse gases and SO_2 in the Netherlands, 1990-1996 (1990 = 100)

Indices	1990	1991	1992	1993	1994	1995	1996
Total NO_x	100.0	98.0	95.9	92.3	88.1	86.0	84.2
Total CO	100.0	89.7	85.7	84.1	79.5	78.2	75.5
Total NMVOC	100.0	92.1	87.3	80.7	77.6	72.7	69.5
Total SO_2	100.0	85.4	85.0	80.8	72.3	72.5	67.2

Total greenhouse gas emission per IPCC-category

Tables 8.5 and 8.6 present the CO_2-eq. emissions of the direct greenhouse gases according to IPCC-categories. The 'Other' sector refers to CO_2 due to statistical differences and has no real meaning. Of other sectors, Transport appears to show the largest increase in the period 1990-1996 of 19%, followed by Energy & Transformation and Industrial Processes with an increase of about 10% in the last six years.

*Table 8.5 Greenhouse gas emissions per IPCC Sector, 1990-1996 (**not corrected** for temperature) (Mton CO_2-eq.)*

IPCC Sector	1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion total	159.9	166.0	164.6	167.6	168.4	176.7	185.2
A1 Energy & Transformation	*51.2*	*51.1*	*52.9*	*52.9*	*54.9*	*56.9*	*56.6*
A2 Industry	*41.6*	*42.8*	*42.6*	*40.0*	*41.0*	*42.8*	*42.8*
A3 Transport	*30.2*	*30.2*	*31.7*	*32.5*	*33.0*	*34.2*	*35.9*
A4 Small combustion	*35.8*	*40.8*	*37.7*	*40.5*	*38.9*	*40.2*	*46.3*
A5 Other	*1.1*	*1.0*	*-0.4*	*1.6*	*0.5*	*2.5*	*3.5*
A6 Biomass burned for energy	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
1B Fugitive fuel emissions	4.2	4.4	3.8	3.7	3.8	3.9	4.2
2. Industrial processes *)	20.5	20.4	19.3	19.3	21.7	22.2	22.6
3. Solvent and other product use	0.2	0.2	0.3	0.2	0.2	0.2	0.1
4. Agriculture	17.5	18.0	18.7	18.6	18.3	18.6	18.5
5. Land use change and forestry	-1.5	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7
6. Waste	13.6	13.3	13.1	12.3	12.1	11.6	11.2
7. Other (specified)	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total:	**215.5**	**221.8**	**219.4**	**221.2**	**224.0**	**232.7**	**241.3**
*) Including all HFCs/PFCs/SF6	8.8	8.7	8.6	8.7	10.4	10.6	11.0

*Table 8.6 Index of direct greenhouse gas emissions in the Netherlands per IPCC sector, 1990-1996 (**not corrected** for temperature) (1990 = 100)*

Sectional indices of CO_2-eq.	1990	1991	1992	1993	1994	1995	1996
A1 Energy & Transformation	100.0	99.4	103.0	103.0	107.0	110.9	109.9
A2 Industry	100.0	101.1	101.8	94.8	97.9	101.8	99.9
A3 Transport	100.0	100.2	105.1	107.8	109.3	113.5	119.1
A4 Small combustion	100.0	100.1	101.0	100.9	102.5	103.2	103.4
A5 Other	100.0	94.3	-36.2	147.4	48.3	226.8	314.5
A6 Biomass burned for energy	100.0	101.2	102.6	103.9	105.2	106.6	107.8
1B Fugitive fuel emissions	100.0	105.6	91.1	88.0	92.0	92.3	99.8
2. Industrial processes *)	100.0	99.4	94.3	94.1	106.0	108.6	110.5
3. Solvent and other product use	100.0	125.6	151.3	107.5	106.3	111.3	81.7
4. Agriculture	100.0	102.7	107.1	106.1	104.8	106.1	105.9
6. Waste	100.0	97.7	96.4	90.5	88.7	85.5	82.3
7. Other	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL	**100.0**	**102.9**	**101.8**	**102.8**	**103.9**	**108.0**	**112.0**

*) Including all HFCs/PFCs/SF_6.

Total greenhouse gas emission per Target Group

Tables 8.7 and 8.8 show the development of the direct greenhouse gas emissions according to Netherlands' Target Groups. Figures are corrected for temperature. The total is dominated by the follow sources: Industry (including all halocarbons), Energy sector, Transport, followed by Agriculture en Residential. Of these groups, the largest increase in absolute figures can be observed in the Transport and Industry. Waste, Refineries and Retail / Services / Government contribute to a lesser extent.

Table 8.7 Direct greenhouse gas emissions per Target Group, 1990-1996 (T-corrected) (Mton CO_2-eq.)

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	9.3	9.7	9.7	10.0	10.2	10.1	10.0
WWTP	0.4	0.4	0.4	0.4	0.4	0.3	0.3
Waste	13.4	13.1	13.0	12.2	12.0	11.5	11.2
Construction	0.6	0.7	0.6	0.8	0.7	0.8	0.7
Residential	22.5	22.2	21.9	21.6	21.6	22.2	22.3
Drinking Water	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Energy sector	45.2	44.8	45.8	46.0	47.9	49.6	49.5
Industry *)	62.8	63.2	62.4	59.4	60.2	65.0	64.6
Agriculture	26.2	26.5	28.1	27.6	27.9	28.0	28.0
Refineries	10.4	10.7	10.9	10.7	11.2	11.5	11.4
Transport	30.2	30.2	31.7	32.5	33.0	34.2	35.9
Other	2.2	2.2	0.8	2.9	1.8	3.6	4.6
Total	**223.3**	**223.9**	**225.4**	**224.0**	**229.5**	**237.0**	**238.7**
*) Including all HFCs/PFCs/SF_6	8.8	*8.7*	*8.6*	8.7	10.4	10.6	11.0

Table 8.8 Index of direct greenhouse gas emissions per Target Group, 1990-1996 (T-corrected) (1990 = 100)

Target Group	1990	1991	1992	1993	1994	1995	1996
Retail / Services / Government	100.0	104.1	103.4	107.3	109.2	108.0	107.1
WWTP	100.0	105.3	106.0	104.3	100.0	81.1	81.2
Waste	100.0	97.6	96.6	90.8	89.0	85.3	83.2
Construction	100.0	106.6	102.3	121.0	106.8	121.1	105.6
Residential	100.0	98.9	97.3	95.9	96.2	98.9	99.0
Drinking Water	100.0	94.2	91.6	94.0	107.4	94.8	97.8
Energy sector	100.0	99.2	101.5	101.7	106.0	109.9	109.6
Industry *)	100.0	100.6	99.4	94.6	100.1	103.5	102.9
Agriculture	100.0	101.5	107.5	105.7	106.7	107.1	107.0
Refineries	100.0	102.7	105.0	102.6	107.9	110.9	109.9
Transport	100.0	100.2	105.1	107.8	109.3	113.5	119.1
Other	100.0	100.0	36.4	131.8	81.8	163.6	209.1
Total	**100.0**	**100.3**	**100.9**	**100.3**	**102.8**	**106.1**	**106.9**
*) Including all HFCs/PFCs/SF_6	100.0	99.8	97.8	99.0	118.4	120.9	125.8

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APPENDIX A

Detailed Summary Report for 1990 - 1996 [IPCC Table 7B]

1990

Emissions of greenhouse gasses in the Netherlands, year 1990.
Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1990

Greenhouse gas emissions (Gg = kton = 10^9 g)	CO2 not corrected	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**161,360**	**167,630**	**1,292.3**	**63.9**	**563.2**	**1,139.2**	**499.8**	**193.2**
1. All Energy (combustion and fugative)	**157,950**	**164,220**	**213.5**	**5.3**	**545.0**	**979.7**	**266.4**	**162.5**
A Fuel combustion total	157,530	163,800	34.8	5.3	543.9	973.5	218.8	154.8
1 Energy & Transformation	51,040	51,200	3.0	0.5	98.6	14.5	2.6	104.2
a Electricity and heat production	*40,670*	*40,830*	*2.7*	*0.4*	*78.8*	*10.4*	*2.0*	*44.7*
c Other transformation	*10,360*	*10,360*	*0.4*	*0.1*	*19.8*	*4.1*	*0.6*	*59.6*
2 Industry	41,440	42,210	4.0	0.1	65.7	114.2	4.7	26.2
a-e Only combustion	*32,090*	*32,860*	*4.0*	*0.1*	*65.7*	*114.2*	*4.7*	*26.2*
f Industry, actual from feedstocks	*9,350*	*9,350*	-	-	-	-	-	-
3 Transport	28,560	28,560	7.8	4.6	336.9	748.9	200.5	20.0
4 Small combustion	35,400	40,740	16.3	0.1	40.6	11.1	5.1	4.1
a Commercial/Institutional	*8,750*	*10,010*	*1.1*	*0.0*	*12.6*	*3.0*	*1.0*	*2.7*
b Residential	*19,200*	*22,100*	*12.8*	*0.0*	*19.5*	*6.8*	*2.6*	*1.0*
c Agriculture / forestry / fishing	*7,440*	*8,620*	*2.3*	*0.0*	*8.6*	*1.3*	*1.6*	*0.4*
5 Other	1,100	1,100	-	-	-	-	-	-
a Statistical differences	*1,100*	*1,100*	-	-	-	-	-	-
6 Biomass burned for energy	[3,080]	[3,080]	3.7	0.0	2.1	84.8	5.9	0.2
B Fugative fuel emissions	420	420	178.8	-	1.1	6.2	47.6	7.8
2 Crude oil and natural gas	420	420	178.8	-	1.1	6.2	47.6	7.8
2. Industrial processes (ISIC)	**1,880**	**1,880**	**3.4**	**31.5**	**13.5**	**153.6**	**130.4**	**26.0**
C Inorganic chemicals	-	-	-	31.5	-	-	-	-
E Nonmetallic mineral-products	730	730	-	-	-	-	-	-
F Other	1,150	1,150	3.4	-	13.5	153.6	130.4	26.0
3. Solvent and other product use	**10**	**10**	**0.0**	**0.5**	**0.1**	**2.4**	**101.4**	**0.3**
4. Agriculture	-	-	**505.0**	**22.2**	-	-	**0.2**	-
A Enteric fermentation	-	-	402.0	-	-	-	-	-
B Manure management	-	-	103.0	0.7	-	-	-	-
D Agricultural soils	-	-	-	21.5	-	-	0.2	-
5. Land use change and forestry	**[-1,500]**	**[-1,500]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[-1,500]	[-1,500]	-	-	-	-	-	-
6. Waste	**1,520**	**1,520**	**568.4**	**0.5**	**4.5**	**3.5**	**1.4**	**4.4**
A Landfills (solid waste disposal)	-	-	562.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	-	-	6.3	0.5	-	-	-	-
C Waste incineration	1,520	1,520	0.0	0.1	4.2	2.1	1.3	4.4
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-
Nature	-	-	125.0	2.4	16.3	26.7	3.2	-
Total Bunkers (CO2)	**40,400**	**40,400**	-	-	-	-	-	-
Marine Bunkers (CO2)	35,900	35,900	-	-	-	-	-	-
Air Bunkers (CO2)	4,500	4,500	-	-	-	-	-	-

Uncertainty:
CO2: 2% CH4: 25% N2O: 35%
CO, NOx, NMVOC, SO2: 25%
HFCs, SF6: 50%
PFCs: 100%

1991

Emissions of greenhouse gasses in the Netherlands, year 1991.

Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1991 Greenhouse gas emissions (Gg = kton = 10^9 gram)	CO2 not corrected	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**166,890**	**167,280**	**1,308.8**	**65.6**	**551.5**	**1,022.4**	**460.4**	**163.5**
1. All Energy (combustion and fugative)	**163,980**	**164,370**	**223.9**	**5.6**	**533.7**	**888.5**	**246.2**	**136.3**
A Fuel combustion total	163,520	163,910	35.8	5.6	532.5	880.3	198.8	126.6
1 Energy & Transformation	50,860	50,870	3.3	0.5	91.4	16.1	2.7	84.1
a Electricity and heat production	*40,220*	*40,230*	*2.9*	*0.4*	*71.1*	*11.8*	*2.1*	*34.4*
c Other transformation	*10,640*	*10,640*	*0.3*	*0.1*	*20.3*	*4.3*	*0.6*	*49.7*
2 Industry	42,660	42,710	3.5	0.1	60.4	108.3	4.3	17.5
a-e Only combustion	*32,020*	*32,070*	*3.5*	*0.1*	*60.4*	*108.3*	*4.3*	*17.5*
f Industry, actual from feedstocks	*10,640*	*10,640*	-	-	-	-	-	-
3 Transport	28,550	28,550	6.9	4.9	336.2	658.4	180.3	21.0
4 Small combustion	40,410	40,740	18.3	0.1	42.3	11.7	5.5	3.9
a Commercial/Institutional	*10,320*	*10,400*	*1.1*	*0.0*	*10.6*	*2.9*	*0.9*	*2.6*
b Residential	*21,640*	*21,820*	*14.5*	*0.0*	*22.0*	*7.3*	*2.8*	*0.9*
c Agriculture / forestry / fishing	*8,460*	*8,530*	*2.7*	*0.0*	*9.8*	*1.5*	*1.8*	*0.4*
5 Other	1,040	1,040	-	-	-	-	-	-
a Statistical differences	*1,040*	*1,040*	-	-	-	-	-	-
6 Biomass burned for energy	[2,640]	[2,640]	3.7	0.0	2.1	85.8	6.0	0.2
B Fugative fuel emissions	460	460	188.1	-	1.2	8.2	47.4	9.7
2 Crude oil and natural gas	460	460	188.1	-	1.2	8.2	47.4	9.7
2. Industrial processes (ISIC)	**1,530**	**1,530**	**3.5**	**32.3**	**13.1**	**127.4**	**120.9**	**22.4**
C Inorganic chemicals	-	-	-	32.3	-	-	-	-
E Nonmetallic mineral-products	740	740	-	-	-	-	-	-
F Other	790	790	3.5	-	13.1	127.4	120.9	22.4
3. Solvent and other product use	**50**	**50**	**0.0**	**0.5**	**0.1**	**2.4**	**91.7**	**0.2**
4. Agriculture	-	-	**517.0**	**22.9**	-	-	**0.2**	-
A Enteric fermentation	-	-	412.0	-	-	-	-	-
B Manure management	-	-	105.0	0.7	-	-	-	-
D Agricultural soils	-	-	-	22.2	-	-	0.2	-
5. Land use change and forestry	**[-1,600]**	**[-1,600]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[-1,600]	[-1,600]	-	-	-	-	-	-
6. Waste	**1,330**	**1,330**	**562.4**	**0.5**	**4.5**	**4.2**	**1.5**	**4.6**
A Landfills (solid waste disposal)	-	-	556.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	-	-	6.3	0.5	-	-	-	0.0
C Waste incineration	1,330	1,330	0.0	0.1	4.2	2.8	1.4	4.5
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-
Nature	-	-	125.0	2.4	16.3	26.7	3.2	-
Total Bunkers (CO2)	**41,700**	**41,700**	-	-	-	-	-	-
Marine Bunkers (CO2)	36,700	36,700	-	-	-	-	-	-
Air Bunkers (CO2)	5,000	5,000	-	-	-	-	-	-

Uncertainty:

CO2: 2% CH4: 25% N2O: 35%

CO, NOx, NMVOC, SO2: 25%

HFCs, SF6: 50%

PFCs: 100%

1992

Emissions of greenhouse gasses in the Netherlands, year 1992.

Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1992

Greenhouse gas emissions (Gg = kton = 10^9 gram)	CO2 not corrected	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**165,170**	**169,490**	**1,256.2**	**67.6**	**539.0**	**966.3**	**436.1**	**157.4**
1. All Energy (combustion and fugative)	**162,320**	**166,640**	**199.1**	**6.2**	**521.2**	**859.6**	**236.2**	**135.2**
A Fuel combustion total	161,950	166,270	36.0	6.2	520.0	853.9	192.8	123.6
1 Energy & Transformation	52,640	52,750	3.8	0.4	91.3	14.5	2.9	77.9
a Electricity and heat production	*41,760*	*41,870*	*3.4*	*0.4*	*73.4*	*13.1*	*2.4*	*29.7*
c Other transformation	*10,880*	*10,880*	*0.4*	*0.1*	*17.9*	*1.3*	*0.5*	*48.2*
2 Industry	42,510	42,960	4.9	0.1	61.4	114.8	5.8	20.0
a-e Only combustion	*32,990*	*33,440*	*4.9*	*0.1*	*61.4*	*114.8*	*5.8*	*20.0*
f Industry, actual from feedstocks	*9,520*	*9,520*	-	-	-	-	-	-
3 Transport	29,830	29,830	6.8	5.5	325.5	626.4	172.4	21.4
4 Small combustion	37,360	41,120	16.8	0.1	39.7	11.3	5.6	4.0
a Commercial/Institutional	*9,410*	*10,310*	*1.0*	*0.0*	*10.1*	*3.2*	*1.2*	*2.9*
b Residential	*19,460*	*21,480*	*13.1*	*0.0*	*19.8*	*6.6*	*2.6*	*0.8*
c Agriculture / forestry / fishing	*8,490*	*9,330*	*2.7*	*0.0*	*9.8*	*1.5*	*1.8*	*0.3*
5 Other	-400	-400	-	-	-	-	-	-
a Statistical differences	*-400*	*-400*	-	-	-	-	-	-
6 Biomass burned for energy	[2,630]	[2,630]	3.8	0.0	2.2	87.0	6.1	0.2
B Fugative fuel emissions	370	370	163.1	-	1.3	5.7	43.4	11.6
2 Crude oil and natural gas	370	370	163.1	-	1.3	5.7	43.4	11.6
2. Industrial processes (ISIC)	**1,260**	**1,260**	**3.7**	**30.4**	**12.7**	**101.1**	**115.4**	**18.8**
C Inorganic chemicals	-	-	-	30.4	-	-	-	-
E Nonmetallic mineral-products	750	750	-	-	-	-	-	-
F Other	520	520	3.7	-	12.7	101.1	115.4	18.8
3. Solvent and other product use	**100**	**100**	**0.0**	**0.5**	**0.1**	**2.2**	**82.8**	**0.1**
4. Agriculture	-	-	**505.0**	**26.2**	-	-	**0.2**	-
A Enteric fermentation	-	-	401.0	-	-	-	-	-
B Manure management	-	-	104.0	0.7	-	-	-	-
D Agricultural soils	-	-	-	25.5	-	-	0.2	-
5. Land use change and forestry	**[1,600]**	**[1,600]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[1,600]	[1,600]	-	-	-	-	-	-
6. Waste	**1,490**	**1,490**	**546.4**	**0.5**	**5.0**	**3.3**	**1.5**	**3.2**
A Landfills (solid waste disposal)	-	-	540.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	-	-	6.3	0.5	-	-	-	0.1
C Waste incineration	1,490	1,490	0.0	0.1	4.7	1.9	1.3	3.2
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-
Nature	-	-	**125.0**	**2.4**	**16.3**	**26.7**	**3.2**	-
Total Bunkers (CO2)	**42,700**	**42,700**	-	-	-	-	-	-
Marine Bunkers (CO2)	36,800	36,800	-	-	-	-	-	-
Air Bunkers (CO2)	5,900	5,900	-	-	-	-	-	-

Uncertainty:

CO2: 2% CH4: 25% N2O: 35%

CO, NOx, NMVOC, SO2: 25%

HFCs, SF6: 50%

PFCs: 100%

1993

Emissions of greenhouse gasses in the Netherlands, year 1993.
Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1993

Greenhouse gas emissions (Gg = kton = 10^9 (	CO2 not correctec	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**167,490**	**168,610**	**1,225**	**67.8**	**519**	**949**	**403**	**151**
1. All Energy (combustion and fugative)	**165,190**	**166,310**	**192.3**	**6.7**	**499**	**844**	**222**	**132**
A Fuel combustion total	164,840	165,960	34.3	6.7	498.3	838.1	180.1	120.1
1 Energy & Transformation	52,740	52,770	3.3	0.4	86.1	13.4	2.7	75.3
a Electricity and heat production	*42,090*	*42,120*	*3.0*	*0.3*	*68.4*	*12.2*	*2.2*	*23.3*
c Other transformation	*10,640*	*10,640*	*0.4*	*0.1*	*17.7*	*1.3*	*0.4*	*52.0*
2 Industry	39,920	40,040	3.2	0.1	54.6	139.1	2.9	17.6
a-e Only combustion	*31,210*	*31,330*	*3.2*	*0.1*	*54.6*	*139.1*	*2.9*	*17.6*
f Industry, actual from feedstocks	*8,710*	*8,710*	-	-	-	-	-	-
3 Transport	30,460	30,460	6.4	6.1	311.8	582.3	162.0	21.3
4 Small combustion	40,090	41,060	17.6	0.1	43.6	15.2	6.5	5.6
a Commercial/Institutional	*10,650*	*10,890*	*0.9*	*0.0*	*12.5*	*6.8*	*1.9*	*4.5*
b Residential	*20,640*	*21,150*	*13.9*	*0.0*	*21.0*	*6.9*	*2.7*	*0.8*
c Agriculture / forestry / fishing	*8,800*	*9,020*	*2.8*	*0.0*	*10.2*	*1.6*	*1.9*	*0.3*
5 Other	1,620	1,620	-	-	-	-	-	-
a Statistical differences	*1,620*	*1,620*	-	-	-	-	-	-
6 Biomass burned for energy	[3.270]	[3.270]	3.8	0.0	2.2	88.1	6.1	0.2
B Fugative fuel emissions	350	350	158.0	-	1.0	6.0	41.9	11.5
2 Crude oil and natural gas	350	350	158.0	-	1.0	6.0	41.9	11.5
2. Industrial processes (ISIC)	**1,210**	**1,210**	**4.9**	**30.0**	**13.4**	**99.1**	**100.0**	**16.7**
C Inorganic chemicals	-	-	-	30.0	-	-	-	-
E Nonmetallic mineral-products	1,050	1,050	-	-	-	-	-	-
F Other	160	160	4.9	-	13.4	99.1	100.0	16.7
			-	-	-	-	-	-
3. Solvent and other product use	**20**	**20**	**0.0**	**0.5**	**0.1**	**2.0**	**79.8**	**0.1**
4. Agriculture	-	-	**497.0**	**26.2**	-	-	**0.2**	-
A Enteric fermentation	-	-	393.0	-	-	-	-	-
B Manure management	-	-	104.0	0.8	-	-	-	-
D Agricultural soils	-	-	-	25.4	-	-	0.2	-
5. Land use change and forestry	**[-1,600]**	**[-1,600]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[-1,600]	[-1,600]	-	-	-	-	-	-
6. Waste	**1,070**	**1,070**	**528.4**	**0.5**	**6.0**	**3.3**	**1.1**	**2.1**
A Landfills (solid waste disposal)	-	-	522.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	-	-	6.3	0.5	-	-	-	0.0
C Waste incineration	1,070	1,070	0.0	0.1	5.7	1.9	1.0	2.0
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-

Nature	-	-	**125.0**	**2.4**	**16.3**	**26.7**	**3.2**	-
Total Bunkers (CO2)	**44,600**	**44,600**	-	-	-	-	-	-
Marine Bunkers (CO2)	38,100	38,100	-	-	-	-	-	-
Air Bunkers (CO2)	6,500	6,500	-	-	-	-	-	-

Uncertainty:
CO2: 2% CH4: 25% N2O: 35%
CO, NOx, NMVOC, SO2: 25%
HFCs, SF6: 50%
PFCs: 100%

1994

Emissions of greenhouse gasses in the Netherlands, year 1994.

Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1994

Greenhouse gas emissions (Gg = kton = 10^9	CO2 not correctec	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**168,390**	**172,130**	**1,203.0**	**70.1**	**493.3**	**905.1**	**387.6**	**136.6**
1. All Energy (combustion and fugative)	**165,750**	**169,490**	**202.3**	**7.2**	**479.6**	**797.0**	**215.8**	**118.9**
A Fuel combustion total	165,560	169,300	33.7	6.9	479.1	789.4	173.5	108.3
1 Energy & Transformation	54,780	54,890	3.7	0.1	78.5	14.2	2.9	65.0
a Electricity and heat production	*43,590*	*43,700*	*3.4*	*0.0*	*61.4*	*13.0*	*2.5*	*16.2*
c Other transformation	*11,190*	*11,190*	*0.3*	*0.1*	*17.1*	*1.1*	*0.4*	*48.8*
2 Industry	40,950	41,350	2.6	0.1	54.4	114.3	2.6	16.2
a-e Only combustion	*31,800*	*32,200*	*2.6*	*0.1*	*54.4*	*114.3*	*2.6*	*16.2*
f Industry, actual from feedstocks	*9,150*	*9,150*	-	-	-	-	-	-
3 Transport	30,800	30,800	6.3	6.6	304.4	559.9	156.5	21.7
4 Small combustion	38,500	41,730	17.3	0.1	39.5	11.9	5.3	5.2
a Commercial/Institutional	*10,170*	*10,970*	*1.4*	*0.0*	*9.5*	*4.0*	*0.8*	*4.2*
b Residential	*19,560*	*21,230*	*13.2*	*0.0*	*19.9*	*6.3*	*2.6*	*0.7*
c Agriculture / forestry / fishing	*8,760*	*9,520*	*2.8*	*0.0*	*10.1*	*1.6*	*1.9*	*0.3*
5 Other	530	530	-	-	-	-	-	-
a Statistical differences	*530*	*530*	-	-	-	-	-	-
6 Biomass burned for energy	[3,500]	[3,500]	3.9	0.0	2.2	89.1	6.2	0.2
B Fugative fuel emissions	190	190	168.5	0.4	0.5	7.6	42.3	10.6
2 Crude oil and natural gas	190	190	168.5	0.4	0.5	7.6	42.3	10.6
2. Industrial processes (ISIC)	**1,430**	**1,430**	**5.3**	**31.6**	**10.4**	**101.7**	**88.2**	**16.2**
C Inorganic chemicals	-	-	-	31.6	-	-	-	-
E Nonmetallic mineral-products	1,050	1,050	-	-	-	-	-	-
F Other	390	390	5.3	-	10.4	101.7	88.2	16.2
3. Solvent and other product use	**10**	**10**	**0.3**	**0.5**	**0.1**	**2.1**	**82.3**	**0.2**
4. Agriculture	-	-	**483.0**	**26.4**	-	-	**0.2**	-
A Enteric fermentation	-	-	382.0	-	-	-	-	-
B Manure management	-	-	101.0	0.8	-	-	-	-
D Agricultural soils	-	-	-	25.6	-	-	0.2	-
5. Land use change and forestry	**[-1,700]**	**[-1,700]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[-1,700]	[-1,700]	-	-	-	-	-	-
6. Waste	**1,200**	**1,200**	**510.2**	**0.5**	**3.2**	**4.3**	**1.2**	**1.3**
A Landfills (solid waste disposal)	-	-	505.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	-	-	5.1	0.5	-	-	-	0.0
C Waste incineration	1,200	1,200	0.0	0.1	2.9	2.9	1.0	1.2
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-
Nature	-	-	125.0	2.4	16.3	26.7	3.2	-
Total Bunkers (CO2)	43,200	43,200	-	-	-	-	-	-
Marine Bunkers (CO2)	36,500	36,500	-	-	-	-	-	-
Air Bunkers (CO2)	6,700	6,700	-	-	-	-	-	-

Uncertainty:

CO2: 2% CH4: 25% N2O: 35%

CO, NOx, NMVOC, SO2: 25%

HFCs, SF6: 50%

PFCs: 100%

1995

Emissions of greenhouse gasses in the Netherlands, year 1995.

Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1995

Greenhouse gas emissions (Gg = kton = 10^9	CO2 not corrected	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**176,910**	**179,530**	**1,173**	**71.9**	**481**	**890**	**363**	**137**
1. All Energy (combustion and fugative)	**173,730**	**176,350**	**209**	**7.9**	**468**	**788**	**215**	**120**
A Fuel combustion total	173,530	176,150	35.2	7.9	467.3	778.9	170.0	109.7
1 Energy & Transformation	56,700	56,780	4.8	0.5	75.2	15.6	4.7	67.6
a Electricity and heat production	*45,200*	*45,280*	*4.2*	*0.4*	*57.8*	*14.5*	*3.6*	*16.4*
c Other transformation	*11,500*	*11,500*	*0.6*	*0.1*	*17.4*	*1.2*	*1.1*	*51.2*
2 Industry	42,710	42,990	2.7	0.1	52.0	117.9	2.7	15.0
a-e Only combustion	*32,810*	*33,090*	*2.7*	*0.1*	*52.0*	*117.9*	*2.7*	*15.0*
f Industry, actual from feedstocks	*9,900*	*9,900*	-	-	-	-	-	-
3 Transport	31,860	31,860	6.2	7.2	297.4	541.2	150.8	21.3
4 Small combustion	39,780	42,040	17.6	0.1	40.4	13.8	5.5	5.6
a Commercial/Institutional	*10,250*	*10,810*	*0.7*	*0.0*	*9.1*	*5.7*	*0.8*	*4.8*
b Residential	*20,640*	*21,810*	*14.0*	*0.0*	*21.1*	*6.5*	*2.8*	*0.5*
c Agriculture / forestry / fishing	*8,880*	*9,410*	*2.8*	*0.0*	*10.3*	*1.6*	*1.9*	*0.3*
5 Other	2,490	2,490	-	-	-	-	-	-
a Statistical differences	*2,490*	*2,490*	-	-	-	-	-	-
6 Biomass burned for energy	[3,630]	[3,630]	3.9	0.0	2.3	90.3	6.3	0.2
B Fugative fuel emissions	200	200	174.0	-	0.6	9.5	44.7	10.3
2 Crude oil and natural gas	200	200	174.0	-	0.6	9.5	44.7	10.3
2. Industrial processes (ISIC)	**1,750**	**1,750**	**5.0**	**31.6**	**10.5**	**98.0**	**76.3**	**16.6**
C Inorganic chemicals	-	-	-	31.6	-	-	-	-
E Nonmetallic mineral-products	1,130	1,130	-	-	-	-	-	-
F Other	620	620	5.0	-	10.5	98.0	76.3	16.6
3. Solvent and other product use	**50**	**50**	**0.0**	**0.4**	**0.1**	**2.1**	**70.5**	**0.2**
4. Agriculture	-	-	**476.0**	**27.6**	-	-	**0.2**	-
A Enteric fermentation	-	-	377.0	-	-	-	-	-
B Manure management	-	-	99.0	0.8	-	-	-	-
D Agricultural soils	-	-	-	26.8	-	-	0.2	-
5. Land use change and forestry	**[-1,700]**	**[-1,700]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[-1,700]	[-1,700]	-	-	-	-	-	-
6. Waste	**1,380**	**1,380**	**480.6**	**0.5**	**2.8**	**1.8**	**1.2**	**0.3**
A Landfills (solid waste disposal)	-	-	479.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	130	130	1.5	0.5	-	-	-	0.0
C Waste incineration	1,250	1,250	0.0	0.0	2.4	0.4	1.1	0.3
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-
Nature	-	-	**125.0**	**2.4**	**16.3**	**26.7**	**3.2**	-
Total Bunkers (CO2)	**44,600**	**44,600**	-	-	-	-	-	-
Marine Bunkers (CO2)	37,500	37,500	-	-	-	-	-	-
Air Bunkers (CO2)	7,100	7,100	-	-	-	-	-	-

Uncertainty:

CO2: 2% CH4: 25% N2O: 35%

CO, NOx, NMVOC, SO2: 25%

HFCs, SF6: 50%

PFCs: 100%

1996

Emissions of greenhouse gasses in the Netherlands, year 1996.
Emissions of carbondioxide are listed with and without temperature correction.

YEAR: 1996

Greenhouse gas emissions (Gg = kton = 10^9	CO2 not corrected	CO2 T-corrected	CH4	N2O	NOx	CO	NMVOS	SO2
TOTAL NET NATIONAL EMISSIONS	**184,870**	**180,410**	**1,178.9**	**72.4**	**471.4**	**860.3**	**347.3**	**126.6**
1. All Energy (combustion and fugative)	**181,870**	**177,410**	**230.8**	**8.5**	**460.0**	**761.2**	**208.3**	**109.5**
A Fuel combustion total	181,730	177,270	39.3	8.5	459.5	754.1	167.2	100.5
1 Energy & Transformation	56,340	56,200	6.2	0.5	75.1	15.9	7.1	63.6
a Electricity and heat production	*44,950*	*44,810*	*5.6*	*0.4*	*57.8*	*14.7*	*6.0*	*17.3*
c Other transformation	*11,400*	*11,400*	*0.6*	*0.1*	*17.3*	*1.2*	*1.1*	*46.3*
2 Industry	42,680	42,200	2.7	0.1	51.4	116.6	2.9	12.6
a-e Only combustion	*33,140*	*32,660*	*2.7*	*0.1*	*51.4*	*116.6*	*2.9*	*12.6*
f Industry, actual from feedstocks	*9,540*	*9,540*	-	-	-	-	-	-
3 Transport	33,370	33,370	6.0	7.8	284.3	515.2	144.3	18.3
4 Small combustion	45,880	42,040	20.4	0.1	46.4	15.1	6.5	5.8
a Commercial/Institutional	*11,780*	*10,830*	*0.8*	*0.0*	*10.2*	*5.8*	*1.3*	*5.0*
b Residential	*23,790*	*21,800*	*16.3*	*0.0*	*24.3*	*7.5*	*3.1*	*0.5*
c Agriculture / forestry / fishing	*10,300*	*9,400*	*3.3*	*0.0*	*11.9*	*1.8*	*2.2*	*0.3*
5 Other	3,460	3,460	-	-	-	-	-	-
a Statistical differences	*3,460*	*3,460*	-	-	-	-	-	-
6 Biomass burned for energy	[4,280]	[4,280]	4.0	0.0	2.3	91.4	6.4	0.2
B Fugative fuel emissions	140	140	191.6	-	0.4	7.1	41.1	9.0
2 Crude oil and natural gas	140	140	191.6	-	0.4	7.1	41.1	9.0
2. Industrial processes (ISIC)	**1,740**	**1,740**	**4.5**	**31.6**	**9.7**	**95.1**	**71.3**	**16.8**
C Inorganic chemicals	-	-	-	31.6	-	-	-	-
E Nonmetallic mineral-products	1,140	1,140	-	-	-	-	-	-
F Other	600	600	4.5	-	9.7	95.1	71.3	16.8
3. Solvent and other product use	**10**	**10**	**0.0**	**0.4**	**0.1**	**2.1**	**66.7**	**0.0**
4. Agriculture	-	-	**476.0**	**27.5**	-	-	**0.2**	-
A Enteric fermentation	-	-	377.0	-	-	-	-	-
B Manure management	-	-	99.0	0.8	-	-	-	-
D Agricultural soils	-	-	-	26.7	-	-	0.2	-
5. Land use change and forestry	**[-1,700]**	**[-1,700]**	-	-	-	-	-	-
A Changes in woody biomass stocks	[-1,700]	[-1,700]	-	-	-	-	-	-
6. Waste	**1,250**	**1,250**	**465.6**	**0.6**	**1.7**	**1.9**	**0.8**	**0.2**
A Landfills (solid waste disposal)	-	-	464.1	-	0.3	1.4	0.2	0.0
B Waste water treatment (sewage)	-	-	1.5	0.5	-	-	-	-
C Waste incineration	1,250	1,250	-	0.1	1.4	0.5	0.7	0.2
7. Other (specified)	-	-	**2.0**	**3.8**	-	-	-	-
A Drinking water treatment	-	-	2.0	-	-	-	-	-
B Polluted surface water	-	-	-	3.8	-	-	-	-
Nature	-	-	**125.0**	**2.4**	**16.3**	**26.7**	**3.2**	-
Total Bunkers (CO2)	**45,800**	**45,800**	-	-	-	-	-	-
Marine Bunkers (CO2)	37,600	37,600	-	-	-	-	-	-
Air Bunkers (CO2)	8,200	8,200	-	-	-	-	-	-

Uncertainty:
CO2: 2% CH4: 25% N2O: 35%
CO, NOx, NMVOC, SO2: 25%
HFCs, SF6: 50%
PFCs: 100%

non-ODP halocarbons

Emission [ton]

Compound	GWP (100)	1990	*1991*	*1992*	1993	1994	1995	1996*	
HFC-23	*11700*	410	*414*	*418*	423	536	536	536	b) e)
HFC-32	*650*	0			0	1	1	1	b)
HFC-43-10mee	*1300*	0					PM	PM	b)
HFC-125	*2800*	20	*16*	*12*	7	20	30	48	
HFC-134a	*1300*	30	*24*	*18*	12	124	250	549	
HFC-143a	*3800*	4	*4*	*4*	3	6	13	29	
HFC-152a	*140*	25	*27*	*28*	29	24	24	24	b)
HFC-227ea	*2900*	0					PM	PM	b)
Unspecified HFCs							23	56	b)
Total HFCs		**489**	***485***	***480***	**474**	**711**	**855**	**1187**	f)
CF_4 emission from aluminium	*6500*	310	*305*	*272*	278	300	300	300	
C_2F_6 emission from aluminium	*9200*	31	*30*	*27*	28	30	30	30	
PFC use d)	*7200*	22	*22*	*23*	23	23	23	13	a) d)
Total PFCs		**363**	***357***	***322***	**329**	**353**	**353**	**343**	
SF_6	*23900*	**58**	***58***	***59***	**60**	**61**	**61**	**61**	g)
Total:		**910**	***900***	***861***	**863**	**1125**	**1269**	**1591**	

Notes:

* Data for 1996 are preliminary figures.

a) For 1995 and, we assume that use = emission; use for PFC also for previous years.

b) Amount of individual compounds is confidential: total use of HFC-23, 32, 43-10mee, 152a and 227ea amounts to 23 and 56 ton in 1995 and 1996, respectively (excluding emissions as by-product of HCFC-22 production).

d) Excluding PFCs emitted during primary aluminium production .

e) Emissions as by-product of HCFC-22 production.

f) Totals for 1995 and 1996 exclude amounts for HFC-43-10mee and HFC-227ea as mentioned under note b).

g) Figure for SF6 is consumption (potential emission)

APPENDIX B.

Summary of revised method for GHG emission inventory in the Netherlands

REVISED METHOD FOR EMISSION INVENTORY FOR GREENHOUSE GASES

Background of revision

In the Netherlands and abroad, different figures were used with respect to Dutch greenhouse gas emissions. The origin of these differences concerned a wide range of causes, like various choices of emission factors, energy statistics, figures on agriculture, allocation of international transportation and temperature correction. This was confusing, both to policymakers and scientists. Also, the different figures led to misunderstanding about emission trends, emission levels and targets. As a consequence, there was a common and growing need to use one and unique set of emission figures for all policy purposes (both national as well as international). One of the tasks of the government is monitoring of environmental quality and pressure on the environment. This requires a reliable, consistent set of emission-series.

In a letter to parliament, September 1995, the Government declared that national greenhouse gas emissions should be calculated according to the IPCC Guidelines. The ministry of Housing, Spatial Planning and the Environment (VROM) then took the initiative to 'translate' the IPCC-Guidelines into one unambiguous description of how the emissions of greenhouse gases should be calculated in the Netherlands. This report is written by the institutes that are involved in the compilation of the annual emission inventory in the Netherlands. It was completed by the spring of 1997 and published in July 1997. In the mean time, the method has already been applied for the re-calculation of the Netherlands' greenhouse gas emissions 1990-1996. Resulting emissions have been published in the *Environmental Balance 1997* (RIVM, 1997) and the annual *Dutch Emission Report* (VROM, 1997).

Method description

Within the Netherlands' system of Emission Registration (ER), the emissions of large plants are recorded individually, together with emission-related volume indicators such as the figures concerning production, energy use and number of personnel. This record, ER-I, mainly concern data of heavy industries, power plants and refineries. Outside ER-I, the rest of the emissions (the 'complementary' part, ERC) is calculated, per economic sector and per substance, by multiplying the emission of the 'individuals' with a scale factor. In general this factor equals the ratio of the emission-related volume indicator outside and inside the individual plants. For sectors that are entirely outside ER-I (households, agriculture, traffic, services), default emission factors are used.

The substances NO_x, CO, NMVOC and SO_2 are indeed relevant for the greenhouse effect: they are ozone precursors. However, the methods to calculate their emissions is not described here, and the focus will be on the direct greenhouse gases [group of six: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6] that are not covered under the Montreal protocol concerning ozone depleting substances

Carbon dioxide (CO_2)

Emissions of carbon dioxide are closely related to energy consumption. Therefore the method is strongly based on detailed energy statistics and on the carbon content of the energy carriers. Energy carriers can be used as fuel, intermediate or feedstocks, From the Netherlands' Energy Statistics (NEH/CBS), the total consumption of energy carriers can be divided into four categories: (a) fuel combustion for final caloric use, (b) fuel combustion for transformation in combined heat and power (CHP), (c) the use of energy carriers for other transformation, and (d) the use of energy carriers as feedstock. Other sources of CO_2 with long-cycle carbon are: flares, waste incineration, carbonate-dissociation from lime use in building materials industry (cement, glass, bricks) and from fluegas desulphurisation.

(a) Energy: Fuel combustion for final caloric use.

From the ER-I database, emissions and fuel consumption from large combustion plants are known and the resulting emission factors (kg CO_2 per GJ) within ER-I can be calculated per economic sector and per fuel type. These factors are also applied for the fuel combustion of consumers outside ER-I. For sectors that are entirely outside ER-I (households, agriculture, traffic, services), default emission factors are used.

A small part of the fuel consumption can not be allocated to economic sectors. This is the so-called statistical difference between the top-down national energy consumption (winning + imports - exports - stock change) and the bottom-up total over de sectors. These differences, usually 0.5 - 1% of the national total, should - according to the Guidelines - be regarded as part of the national energy consumption. Default, aggregated emission factors for coal, oil and natural gas are used to calculate CO_2 emissions related to 'statistical differences'.

(b) Energy: Fuel combustion for transformation in Combined Heat and Power (CHP)

The method of emission inventory is the same as described in (a). For several reasons (efficiency, CO_2 reduction, electricity production), the development of CHP is important. The allocation to sectors of emissions from CHP installations is determined by the ownership. If the installation is operated in a joint venture between industry and energy sector, then it is considered as an enterprise with main activity to produce heat and electricity. In this case the CHP belongs within the energy sector.

(c) Energy: The use of energy carriers for other transformation.

This mainly concerns transformation from coal to coke and other energy carriers in the basic metal industry as well as transformation from crude oil to oil-based energy carriers in refineries and petrochemical industries. All these emissions are monitored within ER-I. At the plants, these process emissions are either measured or calculated on the basis of a carbon balance.

(d) Energy: The use of energy carriers for feedstocks.

Energy carriers which are used as chemical feedstock, can lead to CO_2 emissions, for example when natural gas is used for the production of ammonia or when oil-based solvents are (eventually) oxidised in the air. In the Netherlands, 12% of the total national energy consumption concerns industrial feedstocks. A detailed analyses on products, half-products and the used feedstocks (energy carriers) shows that the major part of the potential CO_2-emissions (energy-use x default emission factor) is incorporated as carbon for a long time in products such as plastics, steel or asphalt (Gielen, 1996). From this study, aggregated emissions factors were derived for CO_2 emissions during the production process or during the lifetime of the products.

(e) CO_2 from vents and flares.
The energy content of flared gas streams is not covered by the energy statistics. But their process emissions are almost entirely monitored within ER-I. They are either measured or calculated. The non covered part concerns flares and vents from the energy sector, which are separately monitored by CBS. The default emission factors of natural gas is then applied to calculate CO_2 emissions from vents and flares within the energy-sector.

(f) CO_2 from waste incineration.
Only anthropogenic CO_2 emissions with long-cycle (fossil) carbon are to be estimated within the IPCC-method. For waste incineration, this concerns mainly plastics and oil based industrial waste. The total CO_2 emission is calculated from the composition of the incinerated waste (carbon content and volume) while the 'long cycle' CO_2 is calculated from the fraction of fossil carbon in the total carbon imbedded in the waste.

(g) CO_2 from the dissociation of carbonate.
'Fossil' CO_2 is emitted in the building material industry (cement, bricks, glass etc.) when the carbonate in lime and clay dissociates at high temperature in kilns and ovens. The major part of the plants in this sector are monitored within ER-I. The complementary part of the emissions are estimated by using scale factors that are based on the number of employees. CO_2 emissions from Flue Gas Desulphurisation (dissociated carbonate in wet limestone) are calculated on the basis of the production of FGD-gypsum, using the specific factor of 0.94 tonne CO_2/ton gypsum. FGD in the Netherlands is only applied at the coal-fired powerstations.

The carbon dioxide emissions are corrected for the influence of cold or mild winters which affect the energy consumption for space heating. This gives a better view on structural developments in CO_2 emissions. The temperature correction can be as large as 4% of the total CO_2 emissions, despite the temperate sea climate in the Netherlands. Only the figures for the gas consumption are corrected because in the Netherlands, space heating is almost entirely done with natural gas. This correction is done on the basis of (1) a meteorological factor that reflects the relative need for space heating in a specific year, and (2) sector-specific factors that show which part of the gas consumption is used for space heating.

The IPCC Guidelines also ask countries to report their CO_2 sinks. In the Netherlands, the only sink is the increase of biomass, i.e. the growth of forests and other woody biomass. The annual

CO_2-sink is calculated from the net volume increase (growth - felling) and the carbon content of wood.

Methane (CH_4)

The emissions of methane in the Netherlands are mainly caused by three sources: agriculture (fermentation and manure from animals) and landfills both have a share of about 40% while the production and distribution of natural gas emits about 15% of the national total. Minor sources are fuel combustion, sewage treatment plants, industrial processes and drinking water treatment plants.

(a) CH_4 from fuel combustion.

Emissions are calculated from the sector and fuel specific figures on (1) energy consumption, (2) resulting VOC-emissions and (3) VOC-profile (methane content in VOC).

(b) CH_4 from production of oil and gas.

From detailed analyses on emissions from operations due to the production and treatment of oil and gas in the Netherlands and the Continental Shelf, specific emission factors for methane were derived for the four combinations of oil/gas * onshore/offshore. These emissions are due to flaring (mainly onshore) and venting (mainly offshore) of gasstreams. The emission factors are multiplied with production figures from the Ministry of Economic Affairs.

(c) CH_4 from the distribution of natural gas.

In the Netherlands, natural gas is partly distributed through old pipelines which were designed for coalgas but are slightly leak for natural gas. The emissions are calculated from the total amount of gas that is distributed in the Netherlands, and an averaged volume leakfactor (now 0.5%). This leakfactor decreases due to replacements of the old pipelines.

(d) Agriculture: CH_4 from enteric fermentation.

From measurements and modelling it is known what the averaged methane emission due to enteric fermentation per type of animal is. These figures are multiplied by the number of animals which stem from the annual agricultural statistical inventory. The contribution to the national total methane emission is about 30%.

(e) Agriculture: CH_4 from manure.

When manure is stored under anaerobe conditions, methane is formed. The emissions per m^3 of manure stored are different per type of animal, because of the composition of the manure and the storage-conditions. These specific emission factors are multiplied by the total manure production per type of animal to calculate the total CH_4-emission from manure per type of animal.

(f) CH_4 from landfills.

When waste from organic origin is deposited for years under anaerobic condition, landfill gas is formed that consists of carbon dioxide and methane. The amount of methane that is emitted is depends on (1) time-series of the total mass of waste deposited, (2) the concentration in the waste of organic carbon that can actually degrade (is decreasing due to waste management policy), (3) the specific degradation speed of organic carbon in waste (logarithmic, 50% degradation in 7.4 years), (4) the delay between deposit and emission, (5) the fraction of the gas that is oxidised in the covering layer of the landfill (10%), (6) the fraction of methane in the landfill gas. Finally an increasing part from this subtotal total is subtracted. This is the recovered gas that is used for energetic purposes.

(g) CH_4 from managed agricultural lands.

In wetlands, shallow waters and soils, methane is formed under anaerobic condition. These are all considered to be 'natural' and not included in the national total. However, methane emissions from agricultural soils have been reduced in the last decades because of drainage. As a result, the CH_4 emissions from agricultural soils have decreased from about 85 kton in 1950 to about 55 kton in recent years. The emissions from agricultural lands are calculated from a measured emission factor (mg CH_4/m^2.day) and the relevant area.

Nitrous Oxide (N_2O)

The national total is about 72 kton/year. The main sources are industrial processes (45%), agriculture (40%) and road traffic (10%). Relatively small sources are stationary fuel combustion, anaesthesia use, waste water treatment and polluted surface water.

(a) N_2O from industrial processes.

Emissions of nitrous oxide stem from the production processes of nitric acid and caprolactam / acrylonitril. From recent measurements of emissions (about 26 kton /year) it appeared that the emission factor is about 9 kg N_2O per ton nitric acid, this is close to the IPCC-default value. For reasons of confidence, not the emission factor but only the total emission from the production of caprolactam and acrylonitril is published: 5 kton/year.

(b) N_2O from agriculture.

There are several sources of nitrous oxide emissions within the agricultural sector.

- increased background emissions from soils. These emissions have been estimated to be about 5 kton/year and are due to fertiliser use in the past and the lowering of water tables.
- actual use of fertiliser: with a mass balance of nitrogen in fertilisers and with specific emission factors for the different types of soils, these emissions are estimated to be about 6 kton/year.

- manure from grazing animals: from an estimate of the total manure of grazing animals and with distinction of urine and faeces, a mass-balance calculation of the nitrogen leads to an emission estimate of about 4 kton/year
- storage of manure: from the nitrogen in anaerobe stored manure, about 0.1% is emitted in nitrous oxide. This is about 1 kton nitrous oxide.
- manure spreading: emission are calculated from a mass balance for nitrogen in stored manure. Under subtraction of export volumes of manure and of nitrogen losses from the emission of ammonium, the final destinations are: due to policy, a decreasing amount for surface application and an increasing amount for incorporation in soils. In both cases, 2% of the nitrogen is emitted as nitrous oxide (11 kton)

(c) N_2O from road traffic.

This emission source is getting more important because of growing transportation and the fact that the emission factor for gasoline cars is increasing rapidly as a result of the penetration and ageing of the three way catalyst. Emissions are calculated from emission factors that are transport category specific and from fuel consumption figures according to Netherlands' Energy Statistics.

(d) N_2O from stationary fuel combustion

Three IPCC default emission factors are applied for solid, liquid and gaseous fuels. Fuel consumption figures are according to the Netherlands' Energy Statistics. Emissions are about 0.7 kton N_2O.

(e) N_2O from anaesthesia.

One inventory of the use of nitrous oxide in hospitals in the Netherlands led to the figure of 0.5 kton. Furthermore it is assumed that use = emission.

(f) N_2O from waste water treatment plants.

Emissions occur when nitrogen is removed from waste water. It was assumed that these emissions concern 2% of the nitrogen removed. The amount of nitrogen that is removed by waste water treatment, is estimated by CBS. Emissions are about 0.5 kton N_2O.

(g) N_2O from polluted surface water.

Mainly due to water flows from agricultural soils, the concentration of nitrogen in surface water has increased. It is assumed that 1% of the nitrogen load in polluted surface waters is emitted as nitrous oxide. The total N-load to surface water (about 240 kton) is estimated by RIVM and RIZA. Emissions of N_2O are about 3.8 kton.

HFC's, PFC's and SF_6

The emissions of the non-ODP halocarbons (HFC's, PFC's) and SF_6 are a result of: (1) use as CFC-substitute, (2) emissions from the production and packaging of these substances, (3) by-product from the production of other substances (4) use for specific PFC and SF_6-applications.

(a) HFC's.

The use of halocarbons in the Netherlands is estimated by KPMG. In a dynamic model from Kroeze and Matthijsen, this use is differentiated to several applications (aerosols / foams / cleaning, fire distinguisher, etc.). The model has application-specific emission factors to calculate the emissions. A part of the emissions from production and packaging and from the production of other substances, is monitored within the ER-I system.

(b) PFC's.

The emission of PFC's is mainly caused by the production of aluminium. These emissions are monitored within ER-I and calculated with (1) specific emission factors for CF_4 and C_2F_6 (currently the weighted average of IPCC default factors) and (2) the production figures of primary aluminium. The industrial use of PFC's is estimated by KPMG, leading to 100% emissions.

(c) SF_6.

The use of SF_6 is not monitored. For the year 1989 an estimate was made of the use (mainly insulator material in high power switches). It is assumed that use = emission.

Main differences with earlier methods used

The method for calculation of greenhouse gas emissions is somewhat different from methods used earlier. As a consequence, reported emissions are different. The main differences are:

Carbon dioxide:

1. Emissions from energy-carriers used for other transformation (6.2.1.c) used to be estimated as the total potential emission according to the energy consumption from NEH. In the new method, these emissions are entirely covered by individually monitored process emissions, which are calculated from carbon-balances. In the new method, these emissions are about 1-2 Mton lower.
2. The new method uses emission factors which are specific for economic sectors and for the fuel-type, whereas in the old method only three aggregated emission factor were used for all coal, all oil(products) and natural gas. As a consequence, in the new method the emissions from refineries and industry are lower while emissions from power plants are higher. For the Netherlands as a whole, the difference is negligible.
3. Emissions from carbonate dissociation within the building material industry used to be estimated on one figure of lime consumption in the Netherlands. In the new method, the monitored process emissions are leading. This leads to an estimate of smaller emissions.
4. The process emissions from feedstock use are much lower (5 Mton) in the new method, due to a far more accurate estimate of the carbon that is trapped in products as plastics.
5. The allocation of carbon dioxide emissions from traffic is entirely based on the selling of fuel within the economic borders of the Netherlands. In methods used earlier, the physical borders of the Netherlands were the leading criteria. As a consequence, there is no emission

from bunkered fuel allocated to the Netherlands' national inventory. Also, there is no correction for vehicles that burn there fuel in the Netherlands while the fuel was bought abroad (e.g. Belgium, Germany).

Methane:

1. In the new method, emissions from fuel stations are allocated to the transportation sector. In methods used earlier, they were allocated to 'services'.
2. The specific factors to calculate methane emissions from landfills are revised. This is not a matter of new methodology, but does lead to different (higher) emissions. For 1990, the new estimate of methane emissions from landfills is about 100 kton higher.

Nitrous Oxide:

1. The estimate of emissions from industrial processes is revised on the basis of accurate measurements. This is not a new method, but leads to an important adjustment of the emission (31 kton instead of 16 kton).
2. Emission factors for traffic have been updated (lowered) while volume-indicators have been altered from vehicle.km to fuel consumption. the net result is that emission estimates are soemwhat 10% (0.7 kton) lower than was reported earlier.

APPENDIX C

Table of IPCC categories and Netherlands' Target Groups

Table B.2: Relation between IPCC-sectors and Dutch Target Groups

Target Group	C	Energy - combustion						E-fugative		Ind.proc.	Solvents	Agriculture				Land-use	Waste				Other	Bunkers	Nature	Organic
		1A1	1A2	1A3	1A4	1A5	1A6	1B1	1B2	2	3	4A	4B	4D	4C,E,F	5	6A	6B	6C	6D	7	-	-	-
	P	conversi	industry	transport	small	other	biomass	solid	gas+liqui	ind. proc.	solvents	fermentat	manure	soils		change	landfills	wwtp	incinerate	other	other			
Agriculture																								
> combustion	C				X																			
> manure	P												X											
> fermentation	P											X												
> other[6]	P													X										
Industry[5]																								
> combustion	C		X																					
> process emissions[4]	P									X														
Refineries																								
> combustion	C	X																						
> processemissions	P								X															
Energy sector																								
> combustion	C	X																						
> process emissies	P								X															
Transport																								
> aviation (national)[7]	C			X																				
> shipping (national)[7]	C			X																				
> other combustion	C			X																				
> process emissions	P			X																				
Households																								
> wood combustion, CO_2	C						(X)																	
> wood combustion, rest	C						X																	
> other combustion	C				X																			
> process emissions	P										X													
Waste management																								
> incinerators, CO_2-fossil[2]	C																		X					
> other combustion	C																		X					
> incinerators, CO_2-organ.[3]	C																							
> landfills - CO_2	P				X																			X
> landfills - other gases	P																X							
WWTP																								
> CO_2-fossil	C				X																			
> other combustion	C				X																			
> CO_2- organic[3]	P																							
> other process emissions	P																	X						X
Other Target Group[1]																								
> combustion	C				X																			
> process emission CO_2	P																				X			
> other process emission	P										X													
Polluted surface water[6]	P																				X			
Statistical diff. NEH																								
> CO_2	P					X																		
Nature	P																						X	
Aviation (international)	C																					X		
Schipping (international)	C																					X		
Remarks								N.A.							N.V.T.	niet EIR				N.V.T.				

Source: TNO-MEP

C = emission from combustion
P = process emission (= non-combustion)
(X) = not included in totals

Notes 1 - 7: see next page

Notes from *Table B.2:*

1 = Drinking water supply, retail, trade, services, public sector, construction sector.
2 = The emissions from fossil fuels is allocated to the waste categories. Although most waste incinerators are producers of heat and electricity, all emissions are reported in IPCC-category 6C.
3 = These emissions are not accounted for in the IPCC methodology (concerns mainly organic CO_2).
4 = Includes CO_2 from feedstock use of fossil energy carriers.
5 = Although coke ovens are energy-converters, they are not included within the energy-sector, but within the Industry (basic metal industry)
6 = Only N_2O (due to anthropogenic sources)
7 = Emission calculations are based on figures of domestic fuel sold.
8 = CO_2 emissions are based on domestic fuel consumption; other emissions from aviation are the total emissions related to all LTO cycles at Schiphol airport

APPENDIX D

Temperature correction of CO_2 emissions

TEMPERATURE CORRECTION OF CO_2 EMISSIONS

A significant part of the energy consumption in the Netherlands, 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 in the CO_2 trend of up to 4%. For domestic policy purposes however, it is desirable to separate these climatic disturbances from fluctuations in CO_2 emissions due to other causes like economic developments, efficiency improvements and policy measures. Therefore, in order to enable an accurate monitoring of the effectiveness of policy instruments, the Netherlands' CO_2 emissions are corrected for outside temperature variations using a method described in Spakman *et al.* (1997) and outlined below. For other greenhouse gases, the contribution from energy consumption is much less than in the case of CO_2; the uncertainty of emission estimates for these gases is also much larger than for CO_2. Therefore no temperature correction is carried out for non-CO_2 gases. The calculation method is described in detail below.

Calculation method

Nearly all the space heating in the Netherlands is done with natural gas. Thus, gas consumption is corrected only for outside temperature variations. The temperature correction requires two multiplication factors, one for each economic sector:

- the Heating-Degree Day (HDD) correction factor $\mathbf{G_T}$
- the sector-specific application factor $\mathbf{T_S}$.

The total correction factor for gas consumption in space heating of a sector S in year T is calculated by multiplying the HDD correction factor G_T in year T by the sectoral application factor T_S. The correction of the gas consumption is:

$$\text{gas consumption(year T, sector S)}_{\text{correction}} = \text{gas consumption(year T, sector S)}_{\text{uncorrected}} * G_T * T_S$$

The Heating-Degree Day correction factor HDD for a specific year is defined as the ratio of the number of Heating-Degree Days (HDDs) of a 'normal' year (defined as a 30-year moving average, i.e. the average number of HDD of the previous 30 years) to the *actual* number of HDD in the year for which the correction factor is calculated. For a relatively warm year (i.e. compared to the previous 30 years), the HDD correction factor is larger than 1. Subsequently, energy consumption and related emissions are increased to arrive at the temperature-corrected values [so-called 'addition factor' = (1- HDD correction factor) > 0]. The calculated number of HDDs of a 'normal' year are presented in *Table B.1* for the period 1970-1996.

The number of Heating Degree Days (HDD) daily is calculated uniformly for the Netherlands as a whole on the basis of the temperature record of one centrally located station, *De Bilt.* Thus, no regional calculations are carried out. Indoor space heating is assumed to take place when outdoor temperatures are below 18° C. The number of HDDs for a specific day is defined as the number of degrees Centigrade of the mean daily temperature below the 18° C threshold. If, for example, the mean daily temperature for a specific day is 12° C, the number of HDDs for that day is 18-12 = 6. For a normal year the total number of HDD is about 3200; for a calendar year with relatively cold winter months, it is higher (e.g. 3717 in 1963) and for years with relatively warm winter months, it is lower (e.g. 2677 in 1990). The total annual number of HDDs is calculated on the basis of meteorological data (see *Table D.1*). For the sake of simplicity, unweighted HDDs are used, i.e. when daily mean temperatures are the same, no correction is carried out of the observed difference in consumer behaviour of less daily fuel consumption for space heating in autumn and spring compared with daily consumption in winter months. This has the advantage that calculations can be performed on the basis of total annual, in preference to monthly, figures for both HDD and gas consumption.

Table D.1 Annual number of Heating Degree Day (HDD), 30-year moving average for normal number of HDDs and the HDD correction factor for the period 1970-1997 based on weather statistics for De Bilt

Year	Actual number of HDD	30-year 'normal' HDD	HDD correction factor	Year	Actual number of HDD	30-year 'normal' HDD	HDD correction factor
1970	3295	3250	0.986	1984	3177	3229	1.016
1971	3133	3239	1.034	1985	3487	3226	0.925
1972	3379	3228	0.955	1986	3333	3228	0.969
1973	3234	3221	0.966	1987	3372	3219	0.955
1974	3033	3226	1.046	1988	2823	3231	1.144
1975	3083	3221	1.045	1989	2729	3219	1.179
1976	3097	3225	1.041	1990	2677	3211	1.199
1977	2997	3218	1.074	1991	3163	3198	1.011
1978	3304	3209	0.971	1992	2829	3203	1.132
1979	3476	3217	0.926	1993	3076	3177	1.033
1980	3301	3235	0.980	1994	2835	3156	1.113
1981	3244	3238	0.998	1995	2917	3140	1.076
1982	3005	3244	1.080	1996	3504	3123	0.891
1983	2999	3232	1.078	1997	2929	3135	1.070

Source: EnergieNed, 1995,1996,1997 (personal communication)

The number of HDD for a 'normal' year T is defined as the average number of HDDs of the previous 30 years. This 30-year moving average has been selected in preference to a fixed reference year (e.g. the 30-year average of the period 1961-1990) to be able to account - and thus to correct - for trends in daily temperatures (i.e. caused by climatic changes). Compared to this moving average, winters in the Netherlands have in recent years been getting milder. From 1988 to 1995, each winter was milder than the average of the previous 30 years, thus making the HDD correction factor >1 for these years. The winter of 1996 was relatively cold. However, the moving 30-year average number of HDDs decreased by 3.3% between 1988 and 1996 *not only* as a result by the relatively mild winters of recent years shifting into the 30-year average, but also due to shifting from the moving average of cold winters, e.g. those of 1962-1963.

The application factor T_S for a specific sector (e.g. residential dwellings or the service sector) is defined as the fraction of fuel consumption of the space heating sector. This fraction has been derived from data provided by the Ministry of Economic Affairs for 1989 and 1991. However, the application factor may change in the course of time due to the increasing number of dwellings to which insulation measures are applied and to increasing or decreasing amounts of fuel used for other applications than space heating (e.g. cooking and hot-water supply for showers and baths). In the residential sector the space heating share in total gas consumption has also been observed to decrease, from 88% in 1980 to 76% in 1995. Therefore an application factor has been calculated for this sector by EnergieNed on an annual basis and annually reported in its 'Monitoring report of gas consumption of small users' [BAK] (EnergieNed, 1995b) (see *Table D.3*). Other sectors use fixed application factors provided by the Ministry of Economic Affairs (see *Table D.2*). As an example see *Table D.4* for the calculation of the temperature correction of sectoral CO_2 emissions for 1990. Compared to the Netherlands total in 1990, in the period 1990-1996 the temperature correction is up to about 4% of the total.

Table D.2 Sectoral application factors

Sector	Application factor
Agriculture	0.825
Commercial and public services	0.825
Industry (average)	0.16
Basic industry	*0.10*
Light industry	*0.50*
Energy	0.05

(Source: EZ, CBS)

Table D.3 Application factors for dwellings in the period 1980-1995

1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0.88	0.88	0.87	0.87	0.87	0.87	0.86	0.81	0.80	0.79	0.79	0.78	0.77	0.76	0.76	0.76	0.76

(Source: EnergieNed, 1995b)

Table D.4 Temperature correction of energy consumption and CO_2 emissions in 1990 (emission factor for CO_2 from natural gas is 0.056 Mton/PJ)

	A	B	C	D = B *(C-1)	E = D * A	F = 0.056 * E
Sector	Gas consumption uncorrected PJ]	Application factor	HDD correction factor	Addition factor	Correction of gas consumption [PJ]	Correction of CO_2 emiss. [Mton]
Agriculture	129	0.825	1.199	0.164	+ 21.1	+ 1.18
Industry	430	0.160	1.199	0.032	+ 13.8	+ 0.77
Services	137	0.825	1.199	0.164	+ 22.5	+ 1.26
Energy sector	278	0.050	1.199	0.010	+ 2.8	+ 0.16
Residential	329	0.790	1.199	0.157	+ 51.7	+ 2.90
TOTAL	**1303**				**+ 111.9**	**+ 6.27**

Source: Spakman *et al.* (1997)