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GREENHOUSE GAS EMISSIONS IN THE NETHERLANDS
Methodology and data for 1993 and provisional for 1994

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A report for the International Committments with respect to Greenhouse Gas Emission Inventories for the Climate Convention and for the European Unions Greenhouse Gas Monitoring Mechanism

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CONTENTS

SUMMARY

This report was written at the request of the Dutch Ministry of Housing, Physical Planning and Environment to comply with the European Unions Greenhouse Gas Monitoring Mechanism (Council Decision 93/389/EEC). The European Community and its member states have adopted the objective of stabilising CO_2 emissions in the Community as a whole by 2000 at 1990 levels. The monitoring mechanism provides a means whereby the Commission can monitor progress towards this target on the basis of annual emission inventories supplied by the member states and national programmes which set out emission trajectories and policy measures to limit CO_2 or to increase sinks. It also requires member states to report inventories of other greenhouse gases.

Under the monitoring mechanism each member state reports its greenhouse gas emissions by the 31st of July each year. By each reporting deadline member states should supply inventories based on provisional data for the previous year and final data for the year previous to that. The first submission of provisional inventories in 1995 should also include data for the base year 1990. A review will be carried out under the responsibility of the European Commission.

This report is also written to comply with the obligations under the United Nations Framework Convention on Climate Change. The inventory is compatible with the reporting requirements under the United Nations Framework Convention on Climate Change. It contains a greenhouse gas emissions inventory for the years 1993 and 1994, together with a short description of how the internationally adopted IPCC Guidelines have been applied in the Netherlands.

Temperature corrected carbon dioxide emissions in 1993 and emissions of methane and nitrous oxide were slightly higher than 1990. A dip in the economic development especially in the chemical industry sector prevented a further growth in emissions. Provisional data for 1994 suggest a significant increase in carbon dioxide emissions due to the prosperous economic developments. Energy efficiency improvements prevented an even further growth in emissions.

SAMENVATTING

Dit rapport is geschreven op verzoek van het Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, afdeling Klimaatverandering 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). De lidstaten van de Europese Unie hebben afgesproken de totale CO_2 emissie van de Europese Unie te stabiliseren in 2000 ten opzichte van 1990. Het bewakingsmechanisme biedt de Commissie de mogelijkheid vorderingen op weg naar dit doel te volgen op basis van een jaarlijkse inventarisatie van broeikasgasemissies.

Deze rapportage bevat een korte beschrijving van de methoden zoals toegepast in Nederland, de definitieve cijfers voor 1993 en de voorlopige cijfers voor 1994. Tevens zijn cijfers voor het basisjaar 1990 gegeven. De rapportage is conform de internationaal afgesproken IPCC guidelines. De rapportage is gebaseerd op de Milieubalans cijfers, maar levert op een aantal plaatsen meer details. Daarnaast wordt de CO_2-emissie in de Milieubalans volgens de bruto NMP-methode gegeven, terwijl deze hier volgens de internationaal aanvaarde IPCC methode is bepaald.

Temperatuur gecorrigeerde kooldioxide emissies en emissies van methaan en lachgas in 1993 waren iets hoger dan in 1990. Een kleine dip in de economische groei, vooral in de chemie, voorkwam dat de emissies verder groeiden. Voorlopige cijfers voor 1994 suggereren een significante groei in de kooldioxide emissies, hetgeen samenhangt met een voorspoedige economische ontwikkeling. Verbeteringen in de energie efficientie voorkwamen een nog grotere groei in emissies.

1. INTRODUCTION.

Greenhouse gas emissions have been reported to the Climate Convention Secretariate in 1994 through the first Netherlands' National Communication on Climate Change Policies and to the European Union Monitoring mechanism for Greenhouse Gases. In this report the methodology as applied in the Netherlands for 1993 and 1994 is given, together with the emission data for 1993 and provisional for 1994.

In September 1994 the National Institute of Public Health and Environmental Protection (RIVM) published a background document on Greenhouse gas emissions for the first Netherlands' National Communication on Climate Change Policies (Van Amstel et al, 1994). This background document contained a description of methodologies and emission estimates for 1980, 1985, 1990, 1991 and 1992 and projections for 1990 - 2010. More detail can be found in RIVM background documents on methods for national emission inventories on carbon dioxide (Van Amstel et al., 1994), methane (Van Amstel et al, 1993) and nitrous oxide (Kroeze, 1994) and on IPCC methods for national emission inventories and options for control (Van Amstel ed. 1993). The official IPCC methodology can be found in the IPCC/OECD Guidelines (3 Volumes, 1994). Since the publication of these documents a database on activity levels, emission factors and emissions was completed. It must be acknowledged here that this database was a combined effort of many researchers at RIVM, with cooperation of CBS, TNO and RIZA. From this database, Greenhouse gas emissions for 1993 and provisional data on emissions in 1994 are here reported to the European Union Monitoring Mechanism and to the United Nations Framework Convention on Climate Change. Within a short period of time we will be able to publish a complete time series for greenhouse gas emissions from 1980 to 1994. The main differences in methodology compared to the 1994 Greenhouse gas emissions background report (Van Amstel et al., 1994) are:

1. Carbon dioxide emissions are calculated now with fuel specific emission factors.
2. Methane emissions from animal manure are updated as new information has become available on manure production, and a new assumption was made on manure produced in the meadow period. 30% of the manure produced in the meadow period is stored because part of the cattle is kept inside.
3. New emission factors were used for nitrous oxide emissions from sewage treatment and from polluted inland and coastal surface waters.
4. The carbon sink in forests estimate is based now on total net volume increment. In the earlier reports only the sink in forest extensions was calculated.

The purpose of this document is to give an overview of the IPCC methodology (IPCC/OECD, 1994) as applied in the Netherlands for 1993 and 1994, and of the emissions in these years.

2. DEFINITIONS.

Greenhouse gases are carbon dioxide, methane, nitrous oxide, carbon tetrafluoride, dicarbon hexafluoride, sulfur hexafluoride, hydrofluorocarbons, fluoroiodocarbons, and various gases with direct and/or indirect greenhouse warming effects like CFCs, non-methane volatile organic carbons, carbon monoxide, nitrogen oxides. The methods to estimate emissions of carbon dioxide, methane and nitrous oxide are reported here. The methods for the other groups of gases are poorly developed at the moment, or reported in other Conventions like those on CFCs or on long range transboundary air pollution.

The territory of the Netherlands from which emissions are reported is the legal territory including a three miles zone from the coastline, this includes emissions from inland water bodies like the IJsselmeer, the estuaries and the Waddensea. Natural emissions are not reported. Emissions from offshore oil and gas production at the Dutch part of the continental shelf are included. Emissions from international aviation and sea transport are reported in the bunker emissions and not included in the totals. Carbon stored in products like plastics and bitumen is estimated from feedstock use and an estimate of percentage storage. Estimates are made of carbon emissions from plastics (and other fossil origin) in incinerated waste. Emissions from the generation of electricity are accounted for, including exported electricity. In transport, emissions abroad from fuel sold in the Netherlands are not calculated, but included in the difference between fuel supply and demand. Carbon embedded in imported (tropical) wood is not reported. The increase in carbon stock of the forests in the Netherlands is reported, but not included in the total.

3. CARBON DIOXIDE

As a first step in the method, carbon dioxide emissions are calculated top-down, using energy statistics of the Netherlands according to the IPCC method and the method used in the National Environmental Policy Plan. In the last method potential emissions from feedstocks are completely accounted for in the year of use of the feedstock. In the IPCC method however, totals are corrected for carbon storage from feedstocks in products like plastics and bitumen. In the data for 1993 and 1994 fuel specific emission factors are used, although in the summary tables the aggregate emission factors are reported. The fuel specific emission factors used, and a comparison with IPCC defaults and European average factors used by Eurostat, can be found in Table 1. Related differences with earlier documents, where aggregate emission factors were used for solid, liquid and gaseous fuels, are small, in the order of 1 Mton CO_2.

The net actual emissions according to the IPCC method can be derived from the data by subtracting CO_2-storage in plastics and bitumen. (All potential emissions from feedstock use are divided in three categories: 1. storage; 2. process emissions and 3. emissions from products with a short life expectation). An estimate is made of storage and actual emissions from feedstock use per year, see Table 2. Actual emissions are the sum of 2 and 3. Further, CO_2 emissions from industrial processes and waste incineration (only fossil origin) are added. In the IPCC method statistical differences between total energy supply and demand are included. In the Netherlands a temperature correction is applied on natural gas for heating and related CO_2 emissions. The temperature correction method is explained here.

Temperature correction.
A significant part of the gas consumption in the Netherlands is used for space heating. In cold winters the total amount of gas consumption will be considerably higher than in mild winters: CO_2 emissions from space heating may be 30% different in winters with a 5 degrees difference in average temperature, all other factors being constant. Without any correction factor, fluctuations in CO_2 emissions from fluctuations in winter temperature cannot be separated from other trends like for example, economic developments, effects of efficiency improvements in heating, policy measures like energy taxes. A simple but effective approximation for outside temperature correction is based on the degree-day method. The following correction procedure has been applied in the Netherlands inventories:

Nearly 100% of space heating in the Netherlands is based on natural gas. It is assumed that only gas consumption for space heating is sensitive to the outside temperature. For each economic sector, the ratio of gas consumption for space heating to total gas consumption in that sector is determined. These ratios or application factors can be derived from energy statistics. The application factors are given in table 3. They are periodically reviewed.

Gas sales show that energy use for space heating is directly proportional to the difference between the inside and outside temperature of houses and buildings and to the lenght of the cold periods. This can be expressed in the following equation:

Energy use (degree-days) = Temperature difference inside/outside (°C) x Time (days).

The temperature difference is expressed in degrees Celcius. An average inside temperature of 18 degrees is assumed. Only days with an average temperature colder than 18 degrees are counted. The energy use for space heating is proportional to the number of degree-days during the winter period. For example: day 1 has an outside temperature of 0 °C. This is (18-0)x1=18 degree-days. Day 2 has an average outside temperature of -10 °C, corresponding to (18-(-10))x1=28 degree-days. The energy consumption on day two will be 28/18=1.55 times higher than on day 1. The total degree-days of day 1 and 2 is 18+28=46. In the Netherlands the normal average annual degree days are calculated as the average over the preceeding 30 years. For the inventory base year the number of degree-days can be derived from weather statistics. In Tabel 4 the degree-days are given for 1970 to 1994 and the deviation from the mean. The following formula expresses the level of temperature-corrected CO_2 emissions:

PJ actual energy supply x correction factor x emission factor = Temperature corrected CO_2 emission.

In a year with a relatively cold winter, the actual number of degree-days will be higher than the average number of degree-days over the preceeding 30 years period. Therefore the temperature corrected CO_2 emissions will be lower than the actual emissions. In a year with a relatively warm winter, the actual number of degree-days will be lower than the average over the preceeding 30 years. In this case the corrected CO_2 emissions will be higher than the actual emissions.

This temperature correction makes it possible to analyse other effects on emissions like economic development, policy measures, energy efficiency improvements etc. The Netherlands considers temperature correction to be necessary for the development of adequate climate change and energy policies. In cases of uncorrected emission figures, the impact of CO_2 reduction efforts, for example in the year 2000, may be offset if the year 2000 was characterized by very low winter temperatures. Emission projections for 2000 are therefore made under the assumption of a normal winter.

Further development and improvement of this methodology is currently under consideration. The current method does not account for other fuels than natural gas, nor trends in time. For example it may be considered to include calculated trends in the application factor, for example for the residential sector, which may have been decreased to 75% already by 1995. Possibly disaggregated application factors are needed as more detail in the sectors is requested by the Climate Convention or the European Union. Other aspects may be considered. Due to global warming for example the average outside temperature may increase over time and solar radiation or wind may change, affecting the temperature correction.

Table 1. Comparison of Netherlands emission factors for CO_2 with IPCC defaults and Eurostat averages for Europe.

LIQUID FOSSIL	IPCC	Eurostat	Netherlands
Primary fuels	kg CO_2/GJ	kg CO_2/GJ	kg CO_2/GJ
Crude oil	73.3	75	73
Natural gas liquids	55.7	-	56
Secondary fuels/products			
Gasoline	69.3	72	73
Kerosine	71.8	72	73
White spirit	-	75	-
Jet fuel	71.5	72	-
Gas/Diesel oil	74.0	74	74
Residual fuel oil	77.3	78	77
LPG	63.0	65	66
Naphta	73.3[1]	75	-
Bitumen	80.7	75	-
Lubricants	73.3[1]	75	81
Petroleum coke	100.8	99	103
Refinery feedstocks	73.3[1]	-	-
Other oil	73.3[1]	-	-
SOLID FOSSIL			
Hard coal	94.6	94	94
Coking coal	94.6	94	94
Black lignite	95.7	99	-
Brown coal	101.2	105	103
Peat	105.9	105	-
Secondary fuels/Products			
Brown coal briquettes	94.6[1]	99	-
Patent fuel	94.6[1]	101	-
Coke	108.1	108	103
GASEOUS			
Natural gas	56	56	56
Refinery feedstock gas	56	58	46
1. Coke-oven gas	-	46	44
2. Blast-furnace gas	-	218	200
Mixtures of 1 and 2	-	-	200
Mix of 1 and 2 + nat. gas	-	-	150
Gasworks gas	-	59	46
Fosfor-oven gas	-	-	150
BIOMASS			
Solid biomass	94.6[1]	-	104
Liquid biomass	73.3[1]	-	-
BUNKER FUELS			
Jet fuel bunkers	71.5	-	-
Gas/Diesel oil bunkers	74.0	-	74
Residual fuel oil bunkers	77.3	-	77
WASTE			
Municipal solid waste	-	-	-

[1] Default IPCC until specific emission factor is calculated.

Table 2. Storage and actual emissions of CO_2 (during and after production) from feedstocks in the Netherlands in 1993.

Feedstocks/ products	PJ input	Emissions during process Mton CO_2	Emissions after production Mton CO_2	Storage percent	Storage Mton CO_2	Total Mton CO_2
Coal and cokes	3.6		0.3	0		0.3
Coal other	7.5			100	0.7	0.7
Natural gas fertilizer	73.2	4.1		0		4.1
Natural gas other	23.4	0.3	0.3	54	0.7	1.3
Bitumen	17.2			100	1.3	1.3
Lubricants	3.1		0.2	0		0.2
Petrocokes	5.8		0.4	0		0.4
Solvents	4.1		0.3	0		0.3
LPG, Naphta, Oils	213.4	2.5	2.6	66	10.4	15.6
TOTAL	351.3	6.9	4.1	54	13.1	24.2

Table 3. Part of the energy input used for space heating, also called application factor for temperature correction.

Energy sector	5%
Industry	15%
Commercial/Institutional	82.5%
Residential sector	85%
Agriculture	82.5%

Tabel 4. Number of degree-days for each year and the moving average over the foregoing 30 years period (t-31 to t-1).

Year	Number of degree-days	30 years average number of degree-days (t-31 to t-1)	Correction factor for PJ energy input
1970	3295	3250	0.99 normal winter
1971	3133	3239	1.03 mild winter
1972	3379	3228	0.96 cold winter
1973	3234	3221	0.99 etc.
1974	3033	3226	1.06
1975	3078	3221	1.05
1976	3093	3224	1.04
1977	2990	3218	1.08
1978	3299	3208	0.97
1979	3470	3217	0.93
1980	3297	3234	0.98
1981	3237	3237	1
1982	3004	3243	1.08
1983	2999	3231	1.08
1984	3174	3228	1.02
1985	3487	3224	0.92
1986	3334	3227	0.97
1987	3372	3218	0.95
1988	2897	3230	1.11
1989	2728	3217	1.18
1990	2680	3210	1.20
1991	3165	3197	1.01
1992	2831	3202	1.13
1993	3078	3180	1.03
1994	2835	3160	1.12

As a second step in the method, a bottom-up calculation of energy use in various subsectors and energy demand and supply systems is made. For 1990, detailed information is available about the specific fuel use in energy demand and supply processes within economic sectors. This information is described in a process-list of the RIVM RIM+ database (more than 450 processes, a sample of this list is given in table 5). This information, together with information on economic growth within sectors, is used to model the energy demand and supply for the years 1991 to 1994. Totals within sectors are compared with the top-down calculations. Differences are analysed. For example in road transport, differences between supply and demand are partly related to fuel supplied in the Netherlands but used abroad. From the energy data and fuel specific emission factors, carbon dioxide emissions are calculated on a detailed basis. Compared to 1990, emissions of CO_2 are lower in 1993 because of a dip in the economy. Especially the chemical industry sector was not doing well. Therefore the actual emissions from feedstocks are lower. The uncertainty in the CO_2 emission calculation is 2%. The uncertainty in the underlying energy statistics is unknown. Statistical differences between supply and demand data are given.

Sectors.

Energy 1993 and 1994
Information is available now on energy input and thus CO_2 emissions for different types of power plants, combined heat and power, and production, transport and distribution of oil and gas, onshore and offshore.

Transformation 1993 and 1994
No detail is available yet on energy input in different energy systems in refineries, nor in coke production. So an overall estimate is based on the energy statistics of the Netherlands.

Industry 1993 and 1994.
The CO_2 emissions of 1990, and more recent years, can be calculated for a detailed number of energy supply processes. Fuel supply and the percentage distribution over the demand processes is known for 1990 and calculated by using a constant distribution and information on totals per sector for the following years (1991-1994). Since 1993 more detailed energy statistics are also available. Therefore all kinds of aggregations can now be made. Here an aggregation has been made according to the proposal of the European Commission. See Table 6.

Table 5. Sample of process list of RIVM RIM+ database.

RESIDENTIAL SECTOR
Energy demand for cooking
- Supplied by furnace fired with natural gas

Energy demand for heating existing houses
- Supplied by central heating fired with natural gas
- Supplied by central heating fired with gasoil

Energy demand for heating new houses
- Supplied by central heating fired with natural gas
- Supplied by central heating fired with gasoil

Energy demand for warm water in existing houses
- Supplied by combi (integrated system for hot water and space heating) fired with natural gas

CHEMICAL INDUSTRY
Energy demand of organic chemical industry
- Supplied by furnace fired with refinery gas
- Supplied by boiler for steam and hot water (natural gas)
- Supplied by boiler for steam and hot water (residual oil)
- Supplied by boiler for steam and hot water (coal)
- Supplied by cogeneration STEG (natural gas)
- Supplied by cogeneration (oil)
- Supplied by cogeneration (coal)
- Supplied by cogeneration gasturbine and boiler on tail gas

AGRICULTURE
Energy demand of greenhouse horticulture
- Supplied by central heating fired with gasoil
- Supplied by boiler for steam and hot water fired with natural gas
- Supplied by cogeneration gas engine (natural gas)

Energy demand of other agriculture
- Supplied by central heating fired with gasoil
- Supplied by boiler for steam and hot water fired with natural gas
- Supplied by little boiler for steam and hot water fired with residual oil

Table 6. Aggregation in the Industry sector

Iron and steel
Non-ferrous metals
Organic chemicals
Inorganic chemicals
Other chemicals
Paper, pulp and print
Food processing, beverages and tobacco
Non-metallic mineral products
Ore extraction industry
Textile, leather and clothing
Engineering and other metal industry
Other industry
Autoproducers (combined heat and power)

Residential sector 1993 and 1994.
Detailed information is available now on energy demand for different purposes in existing and new houses and on the penetration of new, highly efficient central heating systems on natural gas.
An aggregation is made in energy use for heating, cooking, and warm water in existing or new houses. Most heat is supplied by central heating fired with natural gas, some fired with gasoil. Temperature correction is applied to the RIM+ process: Energy demand supplied by central heating fired with natural gas.

Commercial/Institutional 1993 and 1994.
Detailed information is available now on energy demand for different heating systems. Most heat is supplied by central heating fired with natural gas. A substantial amount is still delivered by central heating fired with gasoil. An aggregation is made in energy use in commercial offices, retail and restaurants, other services, and hospitals. Here temperature correction is also applied to central heating fired with natural gas.

Agriculture 1993 and 1994.
Most energy is used in the greenhouse horticulture. Information is available now on the different energy systems used. Most of the heating is supplied by systems on natural gas. An aggregation is made in greenhouse horticulture and other agriculture (mainly dairy cattle).

Transport 1993 and 1994.

Road transport.
A bottom-up detailed aproach was followed for 1993 and 1994. Information on vehicle kilometers driven in the Netherlands and energy use per kilometer was used to calculate CO_2 emissions. Transport consumed a total of 392 PJ, of which road transport consumed 352 PJ. Special vehicles consumed 26 PJ, but these are reported in the relevant sectors: Commercial/Institutional 10 PJ and Agriculture 16 PJ.

Rail
Diesel supply is used to calculate CO_2 from rail. Electricity consumption was 5 PJ. CO_2 emissions from electricity generation are included in the energy sector because there the fossil fuels are combusted.

Water
Fuel supply to ships for inland waters is used to calculate CO_2 emissions. From sea going vessels the fuel use in the 3 miles zone is calculated: 0.7 Mton CO_2 but not included in transport, while this is part of bunkers.

Air
CO_2 from internal flights in the Netherlands have been calculated from fuel supply data. CO_2 from landing and take off from all flights have been calculated from average fuel use in LTO cycles of different plane types (0.6 mln. ton CO_2). In the IPCC Guidelines for National Greenhouse Gas Inventories officially adopted by the Parties to the Climate Convention, it is stated that these emissions should be left out of the totals. So these are included in the air bunker emission category.

Bunkers
CO_2 emissions have been calculated from fuel supply according to general trade statistics and a fuel specific emission factor. Emissions from international aviation and marine bunkers are presented separately. According to internationally adopted reporting guidelines (IPCC/OECD, 1994), these are kept out of the total carbon dioxide emissions from a country. The CO_2 emissions from ship movements in territorial waters have been calculated but left out of transport (0.7 Mton CO_2).

Carbon dioxide sink in forests.

In earlier reports the carbon sink was estimated at about 120 mln. kg CO_2. This was based on the sink of the extra area and tree types planted in the Netherlands. A new estimate is based now on the total increment of the volume of the biomass minus extraction through fellings. This is according to the IPCC guidelines. The sink for 1990 is estimated now to be 1500 mln.kg CO_2. The sink for 1993 and 1994 is estimated to be 1700 mln.kg CO_2. For 1993 and 1994 this is based on an estimate of total gross volume increment of 3.1 mln. m^3 and total fellings of 1.5 mln. m^3 (Ministry of Agriculture and Foundation Forest and Wood, 1995). So a net increment is estimated of 1.6 mln. m^3. For a volume including tree tops, branches and roots an extra 20% is estimated. This is a total of 1.9 mln.m^3, or 1700 mln.kg CO_2. A reduction in growth because forests are maturing is slightly overcompensated by the planting of fast growing species like poplar and douglas. Fellings are reduced in recent years but may increase in 1995-2000. It seems reasonable to assume this sink to increase with 100 to 1800 mln.kg in the coming years.

4. METHANE.

Methods for the estimation of methane emissions are described in a background document (Van Amstel et al, 1993) and summarized by Van Amstel et al. (1994). Some assumptions are different from earlier estimates and new information on emission factors have been used in some cases:
A more detailed estimation has been made of methane from combustion with a more detailed distribution over subsectors based on energy consumed. The most important emissions from combustion stem from residents and from the commercial/institutional sectors. Methane emissions from transport are estimated as a percentage of total-VOC per proces per fuel. In agriculture new statistical information about manure production has become available. Therefore an update has been made for the 1990 figure, see summary table 7. The decrease of total methane emissions in 1994 is partly explained by the warm winter with a decrease of natural gas production, transport and distribution. The decrease is not explained by measures taken to reduce leakage.

Methane from combustion 1993

Methane emissions from combustion of fuels is estimated. An aggregate emission factor of 15.3 ton/PJ is used in industry (530 PJ, only energy from coal, oil and gas), 15.6 ton/PJ in transport (392 PJ oil input), 34.7 ton/PJ in commerce and services with an input of 193 PJ of oil and gas, and 13.7 ton/PJ in the residential sector with 366 PJ mainly gas input. An overall emission factor is calculated of 11.2 ton/PJ, with an energy input of 2416 PJ. The estimate will be improved in the near future for all sectors and fuels. Disaggregated emission factors for coal, oil, gas and biomass will then be applied. The high emission factor for Comm/Inst. is explained by aggregation.

Fugitive methane from oil and gas 1993

The estimate is based on the amounts of oil produced (134 PJ), gas produced (2659 PJ), gas transported (2659 PJ plus 270 PJ Norwegian gas for Belgium and France) and gas distributed (775 PJ). Emission factors are 119.4 ton/PJ oil produced, 22.94 ton/PJ natural gas produced, 3 ton/PJ gas transported, and 110 ton/PJ natural gas distributed (CBS and Ministry of Econ. Affairs, 1994)
A distinction in onshore and offshore production will be made in the future. At onshore sites less methane is emitted because flaring is practiced. Offshore, methane venting is predominant, because flaring is considered to be too dangerous. Emissions from leaks are high during distribution and use by consumers.

Enteric fermentation 1993 and 1994

Enteric fermentation produces methane that escapes the ruminants e.g. through belching. In the recommended IPCC methodology for cattle emission factors are based on the weight of the animals and the energy intake for maintenance and milk/meat production. Calculated emission factors are given in summary table 5. Recommended emission factors for the other animal types are adopted from IPCC. Numbers of animals are based on the official Netherlands agricultural statistics.

Animal waste 1993 and 1994

Methane from animal manure escapes during anaerobic storage and resulting fermentation. These circumstances exist in manure collected in tanks or silos outside or under the stables. Part of the manure produced during the meadow period in the Netherlands is collected in these same storages as part of the dairy cattle is kept inside, while the fresh grass is cut and directly fed. It is estimated that 30% of the manure from the meadow period of dairy cattle is collected in the stables, because animals are kept inside. Emission factors are calculated according to the IPCC method from the volatile solids fraction and the emission potential of different manure types. The methane fraction that is emitted from the potential is assumed lower than the IPCC defaults (dairy cattle 5%, others 10%). The resulting emission factors are: 0.698 kg/m^3 for dairy cattle manure that is collected in covered silos near the stable, 2.534 kg/m^3 for beef cattle/calves manure that is collected in silos near the stable, 3 kg/m^3 for manure from pigs, sheep and goats. From pigs it is collected under the stables, under relatively warm circumstances. The emission factor is 4.11 kg/m^3 for poultry manure. The manure production data are based on a recent research of the Central Bureau of Statistics. The earlier reported methane emissions from manure are now updated (See summary table 5, 1990: 98.3 mln.kg).

Landfills

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

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

A = production in m^3 waste gas or tonne per year
P = concentration of degradable organic carbon in kg/tonne refuse
k = degradation rate constant of 0.1 per year (half degraded in 7 years)
t = time after landfilling

The current production potential of waste gas from waste dumped in the past is accounted for by integrating the production potential over time. Other assumptions are that waste contains 17% or 170 kg/tonne degradable carbon in 1990 to 1995, thereafter decreasing with 5% per year, because organic material is separately collected and composted. Methane content of waste gas is 50%. Specific weight of methane gas is 0.58 kg methane/m^3. The methane oxidation in the soil cover is 20%. In the model, expected methane recovery for energy purposes was assumed at 25% of the potential, which is 43 mln.kg methane in 1990, 50 mln.kg in 1994 and 37 mln.kg in 2000. Actually 26 mln.kg was recovered in 1990. A fast growth of recovery occurred to 59 mln.kg in 1994 (Landfill Gas Advisory Centre, 1994). Under the same assumption of 25% of the potential, in 1995 51 mln.kg methane is expected to be recovered. The landfill gas Advisory Centre aims at 60 mln.kg per year of methane recovery.

The amount of waste landfilled is reduced considerably in recent years, but the methane generated is from earlier placed material. The aggregated time dependent emission factor is 29 kg/tonne in 1993 and 41 kg/tonne in 1994. The amounts landfilled are 13900 mln.kg in 1990, 13000 mln.kg in 1993 and 9000 mln.kg in 1994. The emissions were 377 mln. kg in 1990, 372 mln.kg in 1993 and 371 mln. kg in 1994.

5. NITROUS OXIDE.

Methods for a national emission inventory for nitrous oxide are described in a report from Kroeze (1994). Some earlier estimates, as described by Van Amstel et al. (1994) are now downscaled. The emission from sewage treatment plants is estimated now at about 0.5 million kg/yr instead of 4.0 million kg/yr as reported for 1990. The estimate of nitrous oxide from polluted inland and coastal waters is 3.8 million kg/yr instead of earlier estimates of 10.9 million kg for 1990. These reduced estimates result from measurement information as recently published in scientific literature and summarized by Kroeze.

Nitrous oxide emission from combustion
Emission factors are 42 g N_2O/GJ coal combusted in fluidized bed systems, 1.5 g N_2O/GJ for coal in other systems, 0.6 g N_2O/GJ for oil and 0.1 g N_2O/GJ for natural gas. In waste incineration an emission factor of 80 g N_2O/tonne waste is assumed. The resulting calculation is given in Table 7.

Nitrous oxide emission from nitric acid production
An emission factor is used of 26.7 g N_2O per mln. kg HNO_3-N produced. In caprolactam production an extra emission is measured of 1.7 mln. kg N_2O. Total from these processes in 1990, 1993 and 1994 are 18.2, 18.7 and 18.7 mln.kg.

Nitrous oxide emission from waste water treatment and polluted surface water.
An emission is assumed of 2% of the total nitrogen removed from the waste water.
An emission of 1.57% of the N-load to surface water is assumed in polluted inland and coastal surface water.

Nitrous oxide emission from transport.
For road transport emission factors are expressed in g N_2O per km. Emission factors are increasing

with increasing penetration and ageing of three-way catalytic converters in passenger cars. In table 8 an overview of activity data and emission factors is given.

In Summary tables the activity data, aggregate emission factors and greenhouse gas emissions are given for 1993 and provisional for 1994.

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Table 7. Nitrous oxide from combustion, waste incineration, nitric acid production, caprolactam production, waste water treatment and polluted surface water in 1990, 1993 and 1994 in the Netherlands.

	Emission factor	1990	1993	1994	1990	1993	1994
	g N_2O/GJ	PJ	PJ	PJ	mln. kg N_2O	mln. kg N_2O	mln. kg N_2O
Energy							
Coal FBC	42	1.6	1.6	1.6	0.1	0.1	0.1
Coal	1.5	263	235	235	0.4	0.4	0.4
Oil	0.6	152	166	166	0.1	0.1	0.1
Gas	0.1	281	364	364	0.0	0.0	0.0
					0.6	0.6	0.6
Transformation							
Coal	1.5	14	14	14	0.0	0.0	0.0
Oil	0.6	162	162	163	0.1	0.1	0.1
Gas	0.1	23	23	23	0.0	0.0	0.0
					0.1	0.1	0.1
Industry							
Coal	1.5	92	90	90	0.1	0.1	0.1
Oil	0.6	83	100	100	0.1	0.1	0.1
Gas	0.1	346	327	357	0.0	0.0	0.0
					0.2	0.2	0.2
	g N_2O/tonne	mln. kg	mln. kg	mln. kg			
Waste incineration	80	3413	3400	3400	0.3	0.3	0.3
	g N_2O/mln. kg HNO_3-N/yr	mln. kg HNO_3-N	mln. kg HNO_3-N	mln. kg HNO_3-N			
Nitric acid production	26.7	617	638	638	16.5	17.0	17.0
Caprolactam	?	measured	measured	measured	1.7	1.7	1.7
	2%	mln. kg N removed	mln. kg N removed	mln. kg N removed			
Waste water treatment	0.02	25.7	27	27	0.5	0.5	0.5
	1.57%	mln. kg N-load	mln. kg N-load	mln. kg N-load			
Polluted inland and coastal surface water	0.0157	258	240	240	4.0	3.8	3.8

Table 8. Nitrous oxide emissions from transport in 1990, 1993 and 1994 in the Netherlands.

TRANSPORT	Emission factor	Emission factor	Emission factor	Emission factor	Activity data	Activity data	Activity data	Emission	Emission	Emission
	1990	1993	1994	2000	1990	1993	1994	1990	1993	1994
Passenger cars	g N_2O/km	g N_2O/km	g N_2O/km	g N_2O/km	Mln. km	Mln. km	Mln. km	Mln.kg N_2O	Mln.kg N_2O	Mln.kg N_2O
gasoline	0.034	0.049	0.057	0.087	50519	56224	58145	1.7	2.8	3.3
diesel	0.031	0.031	0.031	0.107	15293	15495	16144	0.5	0.48	0.5
LPG	0.034	0.040	0.040	0.031	14233	12427	13083	0.5	0.5	0.52
Freight										
Low duty gasoline	0.045	0.017	0.016	0.045	1698	1707	1619	0.1	0.029	0.026
Low duty diesel	0.031	0.031	0.031	0.031	5551	7980	8407	0.2	0.25	0.26
Low duty LPG	0.045	0.040	0.040	0.045	440	458	430	0.0	0.018	0.017
Heavy duty trucks	0.200	0.200	0.200	0.200	3700	3945	3707	0.7	0.79	0.74
Heavy duty trailers	0.200	0.200	0.200	0.200	2304	2741	2772	0.5	0.548	0.554
Other										
Special vehicles gasoline	0.015	0.020	0.015	0.087	48	23	18	0.0	0.0	0.0
Special vehicles diesel	0.200	0.166	0.200	0.200	307	270	253	0.1	0.045	0.042
Buses	0.200	0.193	0.200	0.200	628	627	615	0.1	0.121	0.123
Motorcycles	0.010	0.010	0.010	0.010	946	1206	1324	0.0	0.012	0.013
Mopeds	0.010	0.010	0.010	0.010	1710	1280	1340	0.0	0.013	0.013
	kg N_2O per mln.kg fuel				Mln. kg fuel			Mln.kg N_2O		
Non-road (water/rail)	690	650	650	690	1517	1510	1537	1.0	0.98	1.0
TOTAL								5.4	6.6	7.1

SUMMARY TABLES
GREENHOUSE GAS EMISSIONS

Table 1. GREENHOUSE GASES IN THE NETHERLANDS 1990 ($Gg\ a^{-1}$ full molecular weight).

Greenhouse gas emissions ($Gg = 10^9\ g$)	CO_2 not corr.	CO_2 temp.corrected	CH_4	N_2O	NO_x	CO	NMVOC
Total net national emissions	167600	174000	1060	51.5	575	1059	444
1. All energy combustion and fugitive	164800	171200	179	6.1	575	1059	444
A. Fuel combustion total	164800	171200	30	6.1	575	1059	444
Energy and transformation	51400	51600	2	0.85	100	17	35
Industry	33400	34100	9	0.25	76	248	102
Actual from feedstocks	14800	14800	NE	NE	NE	NE	NE
Transport	26900	26900	7	5	352	706	197
Commercial/institutional	9500	10900	7	0.05	12	3	62
Residential	19200	22300	5	0.05	21	80	47
Agriculture/forestry	8600	9700	NE	NE	10	3	1
Other	0	0	NE	NE	0	0	0
Statistical differences	1100	1100	NE	NE	IE	IE	IE
Biomass burned for energy	NE	NE	NE	NE	NE	NE	NE
B. Fugitive fuel emissions	NA	NA	149	NA	NA	NA	IE
Crude oil	NA	NA	19	NA	NA	NA	IE
Natural gas	NA	NA	130	NA	NA	NA	IE
Coal mining	NA	NA	NA	NA	NA	NA	IE
2. Industrial processes (ISIC)	1900	1900	NE	18.2	IE	NA	IE
A. Chemicals	NE	NE	NE	18.2	IE	NA	IE
B. Non-metallic mineral products	1900	1900	NE	NE	IE	NA	NE
C. Other	NE	NE	NE	NE	IE	NA	IE
3. Solvents and other product use	NE	NE	NE	0.5	IE	NA	IE
4. Agriculture	0	0	500	22.2	NA	NA	NA
A. Enteric fermentation	0	0	402	NA	NA	NA	NA
B. Animal wastes	0	0	98	IE	NA	NA	NA
C. Rice cultivation	NA	NA	NA	NA	NO	NO	NO
D. Agricultural soils	0	0	NE	22.2	NA	NA	NA
E. Agricultural waste burning	0	0	NA	NA	NO	NO	NO
F. Savanna burning	NA	NA	NA	NA	NO	NO	NO
5. Land-use change and forestry	(-1500)	(-1500)*	NE	NE	NE	NE	NE
A. Forest clearing	NE	NE	NE	NE	NE	NE	NE
B. Conversion of grass to cult.	NE	NE	NE	NE	NE	NE	NE
C. Plantation establishment	(-1500)	(-1500)	NE	NE	NE	NE	NE
D. Logging/managed forests	NE	NE	NE	NE	NE	NE	NE
E. Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE
6. Waste	900	900	379	0.7	5	2	0
A. Landfills	NE	NE	376	NE	NA	NA	NA
B. Sewage treatment	NE	NE	3	0.5	NA	NA	NA
C. Waste incineration	900	900	0	0.2	5	2	0
7. Other specify	IE	IE	2	3.8	NA	NA	NA
A. Drinking-water treatment	IE	IE	2	NE	NA	NA	NA
A. Polluted surface waters	NA	NA	NE	3.8	NA	NA	NA

Notes: a. NMVOC = Non-methane volatile organic compounds. b. ISIC = International standard industrial classification c. CO_2 from biomass burning is not included in the energy category total. If net CO_2 emissions result from unsustainable bioenergy use, this will appear in the land-use change category. d. NE = not estimated, small e. NA = not applicable. f. IE = included elsewhere

* Not included in national Total.

Halocarbons (Gg)

HFCs	0
CF_4	0.5
C_2F_6	0.05

International bunkers (Gg)

CO_2 from marine bunkers	35900
CO_2 from aviation bunkers	4500

Uncertainty: CO_2 2%; CH_4 25%; N_2O 50%

Table 2. GREENHOUSE GASES IN THE NETHERLANDS 1993 ($Gg\ a^{-1}$ full molecular weight). Temperature corrected for CO_2.

Greenhouse gas emissions ($Gg = 10^9\ g$)	CO_2 not corr.	CO_2 temp.corrected	CH_4	N_2O	NO_x	CO	NMVOC
Total net national emissions	173500	174450	1067.2	58.0	543	917	394
1. All energy combustion and fugitive	170700	171650	198	7.7	537	915	394
A. Fuel combustion total	170700	171650	27	7.7	537	915	394
Energy	40300	40300	NE	0.65	70	12	32
Transformation	10600	10600	NE	0.2	18	2	IE
Industry (only energy)	36000	36200	8.1	0.25	68	237	98
Actual from feedstocks	11000	11000	NE	NE	NE	NE	NE
Transport	28300	28300	6.1	6.6	337	566	160
Commercial/institutional	11700	11800	6.7	0.0	12	4	54
Residential	20680	21240	5.0	0.0	22	91	48
Agriculture/forestry	10600	10700	NE	NE	10	4	2
Other	0	0	0.7	NE	0	0	0
Statistical differences	1500	1500	NE	NE	NE	IE	IE
Biomass burned for energy	NE	NE	NE	NE	NE	NE	NE
B. Fugitive fuel emissions	NA	NA	171	NA	NA	NA	IE
Crude oil	NA	NA	19	NA	NA	NA	IE
Natural gas	NA	NA	152	NA	NA	NA	IE
Coal mining	NA	NA	NA	NA	NA	NA	IE
2. Industrial processes (ISIC)	1900	1900	NE	18.7	IE	NA	IE
A. Chemicals	NE	NE	NE	18.7	IE	NA	IE
B. Non-metallic mineral products	1900	1900	NE	NE	IE	NA	NE
C. Other	NE	NE	NE	NE	IE	NA	IE
3. Solvents and other product use	NE	NE	NE	0.5	IE	NA	IE
4. Agriculture	0	0	492	26.6	NA	NA	NA
A. Enteric fermentation	0	0	393	NA	NA	NA	NA
B. Animal wastes	0	0	100	IE	NA	NA	NA
C. Rice cultivation	NA	NA	NA	NA	NO	NO	NO
D. Agricultural soils	0	0	NE	26.6	NA	NA	NA
E. Agricultural waste burning	0	0	NA	NA	NO	NO	NO
F. Savanna burning	NA	NA	NA	NA	NO	NO	NO
5. Land-use change and forestry	(-1700)	(-1700)*	NE	NE	NE	NE	NE
A. Forest clearing	NE	NE	NE	NE	NE	NE	NE
B. Conversion of grass to cult.	NE	NE	NE	NE	NE	NE	NE
C. Plantation establishment	(-1700)	(-1700)	NE	NE	NE	NE	NE
D. Logging/managed forests	NE	NE	NE	NE	NE	NE	NE
E. Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE
6. Waste	900	900	375	0.7	6	2	0
A. Landfills	NE	NE	372	NE	NA	NA	NA
B. Sewage treatment	NE	NE	3	0.5	NA	NA	NA
C. Waste incineration	900	900	0	0.2	6	2	0
7. Other specify	IE	IE	2	3.8	NA	NA	NA
A. Drinking-water treatment	IE	IE	2	NE	NA	NA	NA
A. Polluted surface waters	NA	NA	NE	3.8	NA	NA	NA

Notes: a. NMVOC = Non-methane volatile organic compounds. b. ISIC = International standard industrial classification c. CO_2 from biomass burning is not included in the energy category total. If net CO_2 emissions result from unsustainable bioenergy use, this will appear in the land-use change category. d. NE = not estimated, small e. NA = not applicable. f. IE = included elsewhere

* Not included in national Total.

Halocarbons (Gg)

HFCs	0.1
CF_4	0.5
C_2F_6	0.05

International bunkers (Gg)

CO_2 from marine bunkers	38100
CO_2 from aviation bunkers	6500

Uncertainty: CO_2 2%; CH_4 25%; N_2O 50%

Table 3. GREENHOUSE GASES IN THE NETHERLANDS 1994 (Gg a^{-1} full molecular weight). Temperature corrected for CO_2. PROVISIONAL.

Greenhouse gas emissions (Gg = 10^9 g)	CO_2 not corr	CO_2 tempcor	CH_4	N_2O	NO_x	CO	NMVOC
Total net national emissions	176400	178000	1041.2	58.1	526	897	391
1. All energy combustion and fugitive	173600	175200	187.2	8.2	524	896	391
A. Fuel combustion total	173600	175200	28	8.2	524	896	391
Energy	40900	40900	NE	0.65	67	12	37
Transformation	10700	10700	NE	0.2	18	2	IE
Industry (only energy)	35800	35900	7.4	0.25	66	235	98
Actual from feedstocks	11000	11000	NE	NE	NE	NE	NE
Transport	30900	30900	6.2	7.1	331	550	152
Commercial/institutional	11800	12100	8.6	0.0	11	4	54
Residential	22000	22500	4.7	0.0	22	89	49
Agriculture/forestry	9000	9700	NE	NE	10	4	2
Other	0	0	0.7	NE	0	0	0
Statistical differences	1500	1500	NE	NE	NE	IE	IE
Biomass burned for energy	NE	NE	NE	NE	NE	NE	NE
B. Fugitive fuel emissions	NA	NA	159.2	NA	NA	NA	IE
Crude oil	NA	NA	19	NA	NA	NA	IE
Natural gas	NA	NA	140.2	NA	NA	NA	IE
Coal mining	NA	NA	NA	NA	NA	NA	IE
2. Industrial processes (ISIC)	1900	1900	NE	18.7	IE	NA	IE
A. Chemicals	NE	NE	NE	18.7	IE	NA	IE
B. Non-metallic mineral products	1900	1900	NE	NE	IE	NA	NE
C. Other	NE	NE	NE	NE	IE	NA	IE
3. Solvents and other product use	NE	NE	NE	0.5	IE	NA	IE
4. Agriculture	0	0	478	26.2	NA	NA	NA
A. Enteric fermentation	0	0	382	NA	NA	NA	NA
B. Animal wastes	0	0	96	IE	NA	NA	NA
C. Rice cultivation	NA	NA	NA	NA	NO	NO	NO
D. Agricultural soils	0	0	NE	26.2	NA	NA	NA
E. Agricultural waste burning	0	0	NA	NA	NO	NO	NO
F. Savanna burning	NA	NA	NA	NA	NO	NO	NO
5. Land-use change and forestry	(-1700)*	(-1700)*	NE	NE	NE	NE	NE
A. Forest clearing	NE	NE	NE	NE	NE	NE	NE
B. Conversion of grass to cult.	NE	NE	NE	NE	NE	NE	NE
C. Plantation establishment	(-1700)	(-1700)	NE	NE	NE	NE	NE
D. Logging/managed forests	NE	NE	NE	NE	NE	NE	NE
E. Abandonment of managed lands	NE	NE	NE	NE	NE	NE	NE
6. Waste	900	900	374.1	0.7	2	1	0
A. Landfills	NE	NE	371.1	NE	NA	NA	NA
B. Sewage treatment	NE	NE	3	0.5	NA	NA	NA
C. Waste incineration	900	900	0	0.2	2	1	0
7. Other specify	IE	IE	2	3.8	NA	NA	NA
A. Drinking-water treatment	IE	IE	2	NE	NA	NA	NA
A. Polluted surface waters	NA	NA	NE	3.8	NA	NA	NA

Notes: a. NMVOC = Non-methane volatile organic compounds. b. ISIC = International standard industrial classification c. CO_2 from biomass burning is not included in the energy category total. If net CO_2 emissions result from unsustainable bioenergy use, this will appear in the land-use change category. d. NE = not estimated, small e. NA = not applicable. f. IE = included elsewhere

* Not included in national Total.

Halocarbons (Gg)

HFCs	0.1
CF_4	0.5
C_2F_6	0.05

International bunkers (Gg)

CO_2 from marine bunkers	38100
CO_2 from aviation bunkers	6500

Uncertainty: CO_2 2%; CH_4 25%; N_2O 50%

Table 4. GREENHOUSE GASES IN THE NETHERLANDS 1993 (Overview table of estimates, quality and documentation). Temperature corrected.

Greenhouse gas emissions ($Gg\ a^{-1}$)	CO_2		CH_4		N_2O		NO_x		CO		NMVOC		Documentation
Source categories	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	
Total net national emissions	174450	H	1067	M	58.0	M	543	M	917	M	394	M	H
1. All energy, combustion and fugitive	171650	H	198	M	7.7	M	537	M	915	M	394	M	H
A. Fuel combustion total	171650	H	27	M	7.7	M	537	M	915	M	394	M	H
B. Fugitive fuel emissions	NA		171	M	NA		NA		NA		IE		H
2. Industrial processes (ISIC)	1900	H	NE		18.7	M	IE		IE		IE		H
3. Solvents and other product use	NE		NE		0.5		NA		NA		IE		H
4. Agriculture	NA		492	M	26.6	M	NA		NA		NA		H
A. Enteric fermentation	NA		392	M	NA		NA		NA		NA		H
B. Animal wastes	NA		100	L	IE		NA		NA		NA		H
C. Rice cultivation	NO		NO		NA		NA		NA		NA		H
D. Agricultural soils	NA		NE		26.6	M	NA		NA		NA		H
E. Agricultural waste burning	NO		NO		NO		NA		NA		NA		H
F. Savanna burning	NO		NO		NO		NA		NA		NA		H
5. Land-use change and forestry	(-1700)*	M	0	M	0	M	0	M	0	M	NA		H
6. Waste	900	M	375	M	0.7	M	6	M	2	M	0	M	H
A. Landfills	NA		372	M	NE		NA		NA		NA		H
B. Sewage treatment	NA		3	M	0.5	M	NA		NA		NA		H
C. Waste incineration	900	M	0	M	0.2	M	6	M	2	M	0	M	H
7. Other specify	IE		2	M	3.8	M	NA		NA		NA		H
A. Drinking-water treatment	IE		2	M	NE		NA		NA		NA		H
A. Polluted surface waters	NA		NE		3.8	M	NA		NA		NA		H

Notes:
a. NMVOC = Non-methane volatile organic compounds. b. ISIC = International standard industrial classification
c. CO_2 from biomass burning is not included in the energy category total. If net CO_2 emissions result from unsustainable bioenergy use, this will appear in the land-use change category. d. NE = not estimated, small e. NA = not applicable. f. IE = included elsewhere, NO = not occuring
Quality of data: H=high confidence in estimate, M=medium, L=low.
Disaggregation : CO_2: Subsectoral split; Other gases: sectoral split.

* Not included in national Total.

Halocarbons (Gg)

HFCs	0.1	L
CF_4	0.5	L
C_2F_6	0.05	L

International bunkers (Gg)		
CO_2 from marine bunkers	38100	H
CO_2 from aviation bunkers	6500	H

Table 5. GREENHOUSE GASES IN THE NETHERLANDS 1994 (Overview table of estimates, quality and documentation). Temperature corrected.

Greenhouse gas emissions (Gg a⁻¹)	CO_2		CH_4		N_2O		NO_x		CO		NMVOC		Documentation
Source categories	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	
Total net national emissions	178000	H	1041	M	58.1	M	526	M	897	M	391	M	H
1. All energy, combustion and fugitive	175200	H	187	M	8.2	M	524	M	896	M	391	M	H
A. Fuel combustion total	175200	H	28	M	8.2	M	524	M	896	M	391	M	H
B. Fugitive fuel emissions	NA		159	M	NA		NA		NA		IE		H
2. Industrial processes (ISIC)	1900	H	NE		18.7	M	IE		IE		IE		H
3. Solvents and other product use	NE		NE		0.5		NA		NA		IE		H
4. Agriculture	NA		478	M	26.2	M	NA		NA		NA		H
A. Enteric fermentation	NA		382	M	NA		NA		NA		NA		H
B. Animal wastes	NA		96	L	IE		NA		NA		NA		H
C. Rice cultivation	NO		NO		NA		NA		NA		NA		H
D. Agricultural soils	NA		NE		26.2	M	NA		NA		NA		H
E. Agricultural waste burning	NO		NO		NO		NA		NA		NA		H
F. Savanna burning	NO		NO		NO		NA		NA		NA		H
5. Land-use change and forestry	(-1700)*	M	0	M	0	M	0	M	0	M	NA		H
6. Waste	900	M	374	M	0.7	M	2	M	1	M	0	M	H
A. Landfills	NA		371	M	NE		NA		NA		NA		H
B. Sewage treatment	NA		3	M	0.5	M	NA		NA		NA		H
C. Waste incineration	900	M	0	M	0.2	M	2	M	1	M	0	M	H
7. Other specify	IE		2	M	3.8	M	NA		NA		NA		H
A. Drinking-water treatment	IE		2	M	NE		NA		NA		NA		H
A. Polluted surface waters	NA		NE		3.8	M	NA		NA		NA		H

Notes: a. NMVOC = Non-methane volatile organic compounds. b. ISIC = International standard industrial classification
c. CO_2 from biomass burning is not included in the energy category total. If net CO_2 emissions result from unsustainable bioenergy use, this will appear in the land-use change category. d. NE = not estimated, small e. NA = not applicable. f. IE = included elsewhere, NO = not occuring
Quality of data: H=high confidence in estimate, M=medium, L=low.
Disaggregation : CO_2: Subsectoral split; Other gases: sectoral split.

* Not included in national Total.

Halocarbons (Gg)

HFCs	0.1	L
CF_4	0.5	L
C_2F_6	0.05	L

International bunkers (Gg)

CO_2 from marine bunkers	38100	H
CO_2 from aviation bunkers	6500	H

DETAILED SUMMARY TABLES
GREENHOUSE GAS EMISSIONS

Summary table 1

ENERGY 1993
Greenhouse gas emissions in the Netherlands from fuel combustion

		Energy use Subtotal PJ	Total PJ	Temp. corrected Energy use Subtotal PJ	Total PJ	Emission CO_2 million kg	Temp.corr Emission CO_2 million kg	Emission CH_4 million kg	Emission N_2O million kg	Aggregate Emission factors CO_2 mln kg/PJ	CH_4 kg/PJ	N_2O kg/PJ	kg/PJ
IA	Fuel combustion activities		2416		2437	170680	171640	27	7.7				
	Coal									94	10000	1500	
	Oil									73	15000	600	
	Gas									56	17000	100	
	Biomass	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
IA1a	Energy (including production and distribution)		566		567	40300	40300	NE	0.65				
	Coal	221								94		1500	42000(FBC)
	Oil	3								73		600	
	Gas	342								56		100	
IA1b	Transformation		185		185	10600	10600	NE	0.2				
	Coal	0								94		1500	
	Oil	162								73		600	
	Gas	23								56		100	
IA2	Industry (only energy use)		530		531	36000	36200	8.1	0.25				
	Coal (incl.coke 14 PJ)	104		104						94	10000	1500	
	Oil	101		101						73	15000	600	
	Gas	325		326						56	17000	100	
IA2a	Iron and steel		97		97	8660	8660	NE	NE				
	Coal (incl. coke 14 PJ)	85								94			
	Oil	0								73			
	Gas	12								56			
IA2b	Non-ferrous metals		3		3	200	200	NE	NE				
	Coal	0								94			
	Oil	0								73			
	Gas	3								56			
IA2c1	Organic chemicals		94		94	6330	6330	NE	NE				
	Coal	0								94			
	Oil	63								73			
	Gas	31								56			
IA2c2	Inorganic chemicals		42		42	2410	2410	NE	NE				
	Coal	1								94			
	Oil	1								73			
	Gas	40								56			
IA2c3	Other chemicals		13		13	755	755	NE	NE				
	Coal	0								94			
	Oil	1								73			
	Gas	12								56			
IA2d	Paper, pulp and print		10		10	560	560	NE	NE				
	Coal	0								94			
	Oil	0								73			
	Gas	10								56			
IA2e	Food processing, Beverages and Tobacco		50		51	2960	2990	NE	NE				
	Coal	2		2						94			
	Oil	2		2						73			
	Gas	46		47						56			
IA2f1	Non-metallic mineral products		32		32	1980	1980	NE	NE				
	Coal	2								94			
	Oil	4								73			
	Gas	26								56			
IA2f2	Ore extraction industry		0		0	0	0	0	0				
	Coal	0								94			
	Oil	0								73			
	Gas	0								56			
IA2f3	Textile, leather and clothing ind.		6		6	325	325	NE	NE				
	Coal	0								94			
	Oil	0								73			
	Gas	6								56			
IA2f4	Engineering and other metal ind.		23		23	1320	1320	NE	NE				
	Coal	0								94			
	Oil	1								73			
	Gas	22								56			
IA2f5	Other industry		21		21	1130	1130	NE	NE				
	Coal	0								94			
	Oil	7								73			
	Gas	14								56			
IA2f6	Autoproducers (combined heat and power)		139		139	8690	8690	NE	NE				
	Coal	14								94			
	Oil	22								73			
	Gas	103								56			
IA2g	Actual from feedstocks					11000	11000	NE	NE				
	Coal												
	Oil												
	Gas												
IA3	Transport		392		392	28300	28300	6.1	6.6				
	Oil	392		392						73	14600	15800	
IA4	Commercial/Institutional		193		198	11700	11800	6.7	0				
	Coal	2		2						94			
	Oil (incl. 10 PJ Spec. vehicles)	23		23						73			
	Gas	168		173						56	30200		
IA5	Residential		366		376	20680	21300	5	0				
	Coal	0		0						94			
	Oil	10		10						73	15000		
	Gas	356		366						56	13000		
IA6	Agriculture/Forestry		170		174	10600	10700	NE	NE				
	Coal	0		0						94			
	Oil (incl. 16 PJ Spec. vehicles)	20		20						73			
	Gas	150		154						56			
IA7	Other		0		0	0	0	0.7	NE				
IA8	Statistical differences		14		14	1500	1500	NE	NE				
IA9	Bunkers marine		495			38100	38100			77			
	Bunkers aviation		89			6500	6500			73			

Summary table 2

ENERGY 1993
Greenhouse gas emissions in the Netherlands from fuel combustion (sector totals)

		Energy use Total PJ	Temp. corr. Total PJ	Emission CO2 million kg	Temp.corr Emission CO2 million kg	Emission CH4 million kg	Emission N2O million kg	Aggregate Emission factors CO2 mln kg/PJ	CH4 kg/PJ	N2O kg/PJ
IA	Fuel combustion activities	2416	2437	170680	171640	27	7.7	71	11175	3187
IA1a	Energy (including production and distribution)	566	567	40300	40300	NE	0.65	71		1148
IA1b	Transformation (refineries)	185	185	10600	10600	NE	0.2	57		1081
IA2	Industry (only energy use, incl. coke 14 PJ)	530	531	36000	36200	8.1	0.25	68	15283	472
IA2f6	of which Autoproducers (comb. heat and power)	139	139	8690	8690	NE	NE	63		
IA2g	Actual from feedstocks			11000	11000	NE	NE			
IA3	Transport	392	392	28300	28300	6.1	6.6	72	15561	16837
IA4	Commercial/Institutional	193	198	11700	11800	6.7	0	61	34715	
IA5	Residential	366	376	20680	21240	5	0	57	13661	
IA6	Agriculture/Forestry	170	174	10600	10700	NE	NE	62		
IA7	Other	0	0	0	0	0.7	NE			
IA8	Statistical differences	14	14	1500	1500	NE	NE	107		
	Total according to IPCC format	2416	2437	170680	171640	27	7.7	71	11175	3187
IA9	Bunkers marine	495	495	38100	38100	NE	NE	77		
	Bunkers aviation	89	89	6500	6500	NE	NE	73		

Summary table 3

ENERGY 1993
Greenhouse gas emissions in the Netherlands combustion and fugitive (sector totals)

		Energy use Total PJ	Temp. corr. Total PJ	Emission CO2 million kg	Temp.corr Emission CO2 million kg	Emission CH4 million kg	Emission N2O million kg	Aggregate Emission factors CO2 mln kg/PJ	CH4 kg/PJ	N2O kg/PJ
1	Combustion and fugitive			170680	171640	197	7.7			
1A	Fuel combustion	2416	2437	170680	171640	27	7.7		11175	3187
1B	Fugitive fuel emissions					170				
	Crude oil production	134				16			119403	
	Natural gas total	2659				153			57540	
	Natural gas production	2659				61			22941	
	Natural gas transport	2659				8			3009	
	Natural gas distribution	775				85			109677	

Summary table 4

INDUSTRIAL PROCESSES 1993
Greenhouse gas emissions in the Netherlands

	Activity data million kg	Emission CO2 million kg	Temp.corr Emission CO2 million kg	Emission CH4 million kg	Emission N2O million kg	Aggregate Emission factors CO2 Kg/mlnKg	CH4 Kg/mlnKg	N2O g/mlnKg
2 Industrial processes								
a Iron and steel								
b Non-ferrous metals								
aluminium production	260*							
c Inorganic chemicals								
nitric acid (HNO3-N/yr)	638				17			26.7
d Organic chemicals								
adipic acid	0				0			
other (measured)					1.7			NE
e Non-metallic mineral products	2375	1900				0.8		

* Aluminium production gives CF4 emission: 0.5 mln kg (2 kg/ton) and C2F6 emission: 0.05 mln. kg (0.2 kg/ton).

Summary table 5

ANIMALS 1990, 1993 and 1994
Greenhouse gas emissions in the Netherlands

		1993 Activity data number of animals	1994 Activity data	1990 Emission CH4 million kg	1993 Emission CH4 million kg	1994 Emission CH4 million kg	Aggregate Emission factors CH4 kg/head/yr
4	Agriculture total			500	492	478	
4a	Enteric fermentation			401.9	392.7	381.7	
4b	Manure			98.3	99.7	96.4	
4a	Cattle						
	Dairy						
	Dairy young <1yr	737079	735283		36.3	36.2	49.25
	Dairy young fem. >1yr	836109	802884		52.5	50.4	62.8
	Dairy cows	1746733	1697868		178.4	173.4	102.13
	Dairy male >1yr	40508	41009		3.8	3.8	93.22
	Beef						
	Beef calves	656210	689516		11.6	12.2	17.65
	Beef steers	623670	602689		54.3	52.4	87.01
	Beef female >2yr	156459	146462		16	15	102.13
	Others						
	Sheep	1916249	1765970		15.3	14.1	8
	Goats	56798	63941		0.5	0.5	8
	Pigs	14964430	14565011		22.4	21.8	1.5
	Horses	91728	97323		1.7	1.8	18

4b	Manure	1990 revised Production mln. m3	1993 Production mln. m3	1994 Production mln. m3	1990 Emission CH4 million kg	1993 Emission CH4 million kg	1994 Emission CH4 million kg	Emission factors CH4 kg/m3
	Dairy cattle stable	36.512	34.054	33.118	25.5	23.8	23.1	0.698
	Beef cattle stable	2.865	3.165	3.111	7.3	8	7.9	2.534
	Sheep & goat stable	0.257	0.284	0.258	0.8	0.8	0.8	2.979
	Fattening calves	2.106	2.297	2.413	5.3	5.8	6.1	2.534
	Pigs	16.356	16.956	16.38	49.2	51	49.3	3.009
	Poultry	2.5	2.48	2.241	10.3	10.2	9.2	4.11
	Manure stable	60.596	59.235	57.521	98.3	99.7	96.4	
	Share of total manure	0.7	0.7	0.7				

Summary table 6

SOILS 1990, 1993 and 1994
Greenhouse gas emissions in the Netherlands

4c	Soils	1990 Million kg	1993 Million kg	1994 Million kg	1990 Emission N2O-N	1993 Emission N2O-N	1994 Emission N2O-N	Emission factor Fraction of N
	Anthropogenic background				3	3.2	3	
	Fertilizer use							
	Total N consumption	412	390	359				
	NH3-N emission	8	8	7				
	Mineral soils 90%	363	344	317	3.6	3.4	3.2	0.01
	Organic soils 10%	40	38	35	0.8	0.8	0.7	0.02
	Total N2O-N emission				4.4	4.2	3.9.	
	Manure application							
	Total N excretion	657	682	648				
	Produced in meadow	164	171	162				
	NH3-N emission	13	14	13				
	Urine in meadow	91	94	89	1.8	1.9	1.8	0.02
	Faeces in meadow	60	63	60	0.6	0.6	0.6	0.01
	Total N2O-N emission				2.4	2.5	2.4	
	Stable/storage	493	512	486				
	NH3-N emission	73	78	75				
	Biologically treated	0	1	2	0	0.02	0.04	0.02
	Anaerobic storage	420	433	409	0.42	0.43	0.41	0.001
	Total N2O-N emission				0.4	0.5	0.5	
	Applied as fertilizer	420	433	409				
	Exported abroad	6	15	24				
	NH3-N emission	86	53	37				
	Application to mineral soil 87%	285	94	13	2.9	0.9	0.1	0.01
	Application to organic soil 13%	43	47	45	0.8	0.9	0.9	0.02
	Injection to soils	0	223	289	0	4.5	5.8	0.02
	Total N2O-N emission				3.7	6.3	6.8	
	Legumes							
	Total N fixation	15	14	14	0.2	0.1	0.1	0.01
	TOTAL N2O-N emission				14.1	16.9	16.7	
	TOTAL N2O emission (*1.57)	Excluding natural background emissi			22.1	26.6	26.2	

Summary table 7

Greenhouse gas emissions in the Netherlands
WASTE and OTHER

				Emission CO2		Emission CH4		Emission N2O		Aggregate Emission factor	
	1990 mln.kg	1993 mln.kg	1994 mln.kg	1993 mln.kg	1994 mln.kg	1993 mln.kg	1994 mln.kg	1993 mln.kg	1994 mln.kg	1993 kg/tonne	1994 kg/tonne
6 Waste											
Landfills	13900	13000	9000			372	371			29	41
Sewage treatment (sludge)	315	315	315			3	3			10	10
Sewage treatment (nitrogen removed)	25.7	27	27					0.5	0.5	2%	2%
Waste incineration	3413	3400	3400	900	900					260	260
7 Drinking water treated	847000					2	2				
Polluted inland and coastal surface water (N-load	258	240	240					3.8	3.8	2%	2%

Summary table 8

ENERGY 1994
Greenhouse gas emissions in the Netherlands from fuel combustion

		Energy use PJ	Total PJ	PJ	Temp corr. Total PJ	Emission CO2 million kg	Temp.corr Emission CO2 million kg	Emission CH4 million kg	Emission N2O million kg	Aggregate Emission factors CO2 mln kg/PJ	CH4 kg/PJ	N2O kg/PJ	kg/PJ
IA	Fuel combustion activities		2420		2448	173375	174975	28	8.2				
	Coal									94	10000	1500	
	Oil									73	15000	600	
	Gas									56	17000	100	
	Biomass	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
IA1a	Energy (including production and distribution)		485		485	40900	40900	NE	0.65				
	Coal	228		228						94		1500	42000(FBC)
	Oil	2		2						73		600	
	Gas	255		255						56		100	
IA1b	Transformation		186		186	10700	10700	NE	0.2				
	Coal	0								94		1500	
	Oil	163								73		600	
	Gas	23								56		100	
IA2	Industry (only energy use)		548		550	35800	35900	7.4	0.25				
	Coal	87		87						94	10000	1500	
	Oil	104		104						73	15000	600	
	Gas	357		359						56	17000	100	
IA2a	Iron and steel		86		86	7315	7315	NE	NE				
	Coal	72		72						94			
	Oil	0		0						73			
	Gas	14		14						56			
IA2b	Non-ferrous metals		3		3	200	200	NE	NE				
	Coal	0								94			
	Oil	0								73			
	Gas	3								56			
IA2c	Chemical industry		278		278	17560	17560	NE	NE				
	Coal	10		.10									
	Oil	94		94									
	Gas	174		174									
IA2c1	Organic chemicals							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2c2	Inorganic chemicals							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2c3	Other chemicals							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2d	Paper, pulp and print							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2e	Food processing, Beverages and Tobacco							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2f1	Non-metallic mineral products							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2f2	Ore extraction industry							0	0				
	Coal									94			
	Oil									73			
	Gas									56			
IA2f3	Textile, leather and clothing ind.							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2f4	Engineering and other metal ind.							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2f5	Other industry		181		183	10500	10600	NE	NE				
	Coal	5		5						94			
	Oil	10		10						73			
	Gas	166		168						56			
IA2f6	Autoproducers (combined heat and power)							NE	NE				
	Coal									94			
	Oil									73			
	Gas									56			
IA2g	Actual from feedstocks					11000	11000	NE	NE				
	Coal												
	Oil												
	Gas												
IA3	Transport		425		425	30900	30900	6.2	7.1				
	Oil	425		425						73	14600	15800	
IA4	Commercial/Institutional		210		216	11800	12100	8.6	0				
	Coal	0		0						94			
	Oil	0		0						73			
	Gas	210		216						56	30200		
IA5	Residential		390		400	22000	22500	4.7	0				
	Coal	0		0						94			
	Oil	10		10						73	15000		
	Gas	380		390						56	13000		
IA6	Agriculture/Forestry		162		172	9000	9700	NE	NE				
	Coal	0		0						94			
	Oil	4		4						73			
	Gas	158		168						56			
IA7	Other		0		0	0	0	0.7	NE				
IA8	Statistical differences		14		14	1500	1500	NE	NE				
	Total according to IPCC format		2420		2448	173375	174975						
IA9	Bunkers marine		495			38100	38100			77			
	Bunkers aviation		89			6500	6500			73			