

## METHOD FOR CALCULATING GREENHOUSE GAS EMISSIONS

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## FOREWORD

This report describes the method now used for calculating the emissions of direct greenhouse gases in the Netherlands.<sup>1</sup> The report was adopted by the Coordination Committee for Monitoring of Target Groups (CCDM) on 5 February 1997. The importance of the report lies in the fact that the institutes involved have reached agreement on the way the internationally adopted 'IPCC method' is to be applied in the Netherlands. Now that this report has been formally adopted by the CCDM, all the institutes will use the described method in the same way and use the same basic data set. This is all the more important given the fact that the method is used not only for reporting under the UN Framework Convention on Climate Change (UNFCCC) and to the European Union, but also because emissions calculated according to the IPCC method form the basis for national climate policy and Dutch climate targets. This was decided by the Dutch Government in the letter of 15 September 1995 to the Second Chamber of Parliament (Parliamentary Papers 1994–1995, 22 232, no. 7). When interpreting the IPCC guidelines in the manner described in this report, some aspects will require special attention.

### **Classification of sectors / target groups**

The IPCC's classification in source categories differs from the target group classification used in Dutch environmental policy. The annexes to this report include a table for converting IPCC source categories into the Dutch target groups.

### **Relation with monitoring under the long-term agreements**

The long-term agreements (LTA) for energy saving are designed to increase energy efficiency generally and within specific sectors, for example by expanding the use of combined heat and power (CHP). Efficiency gains are measured by monitoring efficiency improvements made by the users of energy; the place where the energy is generated is of less importance. In the IPCC method CO<sub>2</sub> emissions from a CHP plant are allocated to the owner of the plant. This means that CO<sub>2</sub> emissions within a sector can rise substantially although the LTA monitoring method indicates that the efficiency has increased. Both reporting methods (IPCC and LTA monitoring) may generate apparently conflicting results for the sector in question. Without background information on the efficiency improvements, the IPCC reporting method may give sector an unjustified negative image regarding its CO<sub>2</sub> emissions. To assess whether environmental objectives have been achieved, the CO<sub>2</sub> emissions from CHP plants can be presented separately to supplement the total picture.

### **Transport emissions**

The IPCC approach to registering transport emissions differs from the method prescribed by Dutch policy. Emission figures in Dutch transport policy are based on vehicle-kilometres travelled in the Netherlands. The IPCC method is based on deliveries of fuel in the Netherlands; in other words, the number of litres sold at filling stations. These approaches lead to different results for greenhouse gas emissions. In its letter of 15 September 1995, the Dutch Government stated that the IPCC method would be used. The Ministry of Transport, Public Works and water Management (VenW), the Ministry of Housing, Spatial Planning and the

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<sup>1</sup> Where necessary, this electronic version has been brought up to date for the project year 2002 and incorporates some additions and corrections to describe the method used for the Environment Monitor 2002. In all tables the actual values may have been adjusted after publication in 1997. This is the source text for the English translation of report 'ER-37' for use by foreign experts when reviewing the National Inventory Report on greenhouse gas emissions at the request of the UN Climate Secretariat. No complete update of this report was made because new, detailed descriptions ('protocols') for key sources are under development, which will in time effectively replace this methodology report.

Environment (VROM) and the National Institute of Public Health and the Environment (RIVM) have indicated that they will continue to use the current method in national policy development. This means that the IPCC method will be used when reporting greenhouse gas emissions data in national surveys and policy documents. Reports may also include supplementary results based on vehicle-kilometres travelled. The models will be adapted accordingly.

#### **CO<sub>2</sub> fixation in biomass stocks**

In its letter of 15 September 1995, the Government indicated that it will count the fixation of CO<sub>2</sub> by forests as an emission reduction for meeting the reduction target for 2000. According to the IPCC reporting method, the fixation of CO<sub>2</sub> should be reported separately. When reporting according to the IPCC method, therefore, this fixation cannot simply be included as a negative emission in the statement of total national CO<sub>2</sub> emissions.

#### **Summing up**

The IPCC method will continue to be used when reporting on emissions of direct greenhouse gases. This means that, at least in formal reports, the IPCC method as described in this report must be used. If, however, a specific interpretation of Dutch environmental policy is required, reports may contain separate supplementary information accompanied by a clear explanation of where, how and why an additional reporting method is used alongside the IPCC method. This may be the case in reports concerning LTAs and the transport sector. This does not alter the requirement to use the IPCC method as described in this report for all national and international reports.

The method described in this report will be implemented in consultation with the target groups and the CCDM protocol working groups.<sup>2</sup>

Coordination Committee for Monitoring of Target Groups (CCDM)

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<sup>2</sup> To meet the requirements of the Kyoto Protocol's National System and the UNFCCC/IPCC Good Practice guidelines on time new methods and protocols must be developed. From 2000, this will be coordinated by the *Working Group for Monitoring Emissions of Greenhouse Gases (WEB)*, which functions within the CCDM.

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## SUMMARY

This report describes the method for calculating Dutch emissions of direct greenhouse gases. It has been compiled by the National Institute for Public Health and the Environment (RIVM), Statistics Netherlands (CBS), the Netherlands Organisation for Applied Scientific Research (TNO) and the Netherlands Energy Research Foundation (ECN) at the request of the Ministry of Housing, Spatial Planning and the Environment (VROM). Its use is compulsory for national and international reporting with respect to climate policy. One of the goals of the report is to prevent the use of different emission data by the various institutes and ministries. To this end the report has also been endorsed by the ministries of VROM, Economic Affairs (EZ), Transport, Public Works and Water Management (VenW) and Agriculture, Nature Management and Fisheries (LNV).

The report is limited to direct greenhouse gases that do not fall under the Montreal Protocol. Ozone depleting greenhouse gases (HCFCs, etc.), indirect greenhouse gases (the 'ozone precursors': CO, NO<sub>x</sub>, NMVOC) and SO<sub>2</sub> are not considered. The report briefly describes the emission inventory system in the Netherlands. Besides the emission inventory methods described in this report, separate protocols will be produced stating the institutes that are to carry out the inventory and how data flows will be managed (see also footnote 2).

Using the method described here, CO<sub>2</sub> emissions are about 5% lower than previously calculated (Environmental Balance 1996, report to the EU 1996). This is because detailed emission factors are used, a higher proportion of carbon fixation in organic chemical products is assumed, and because it is no longer assumed that losses from the transformation of energy carriers outside combined heat and power plants (CHP) lead to CO<sub>2</sub> emissions. The calculation of emissions from energy consumption is based on the CBS's Netherlands Energy Statistics (NEH). The allocation of combustion emissions is in line with the energy consumption by sectors registered in the NEH. Transport emissions are calculated from fuel consumption derived from fuel deliveries statistics in the NEH.

Emissions of CH<sub>4</sub> and N<sub>2</sub>O, like those of CO<sub>2</sub>, are derived by multiplying the emission factors by activity levels. The activity levels for CH<sub>4</sub> include fuel consumption, the production volumes of oil and gas, the amount of landfilled waste, livestock numbers and the amount of manure produced. These figures have to be determined each year. Emissions of N<sub>2</sub>O depend, in addition to fuel consumption, on the production volume of nitric acid, the use of artificial fertilisers, manure production and ammonia emissions in agriculture and the amount of exported manure.

Emissions of HFCs, PFCs, FICs and SF<sub>6</sub> are calculated using a dynamic model into which data on the use of these compounds over a period of years are entered. Currently, these data are not updated regularly, but on an ad hoc basis. This should be addressed in the upcoming protocol.

Emissions calculated using the methods described are stored in a detailed data file. From this file, data can be aggregated according to the IPCC categories and the Dutch target groups. The file can also, in principle, be used to aggregate data for other reporting purposes, such as CORINAIR and ECE. The conversion tables required for this are included in the annexes.



## 1. INTRODUCTION

This report describes the method for calculating Dutch emissions of direct greenhouse gases. It establishes how, within the framework of Target group Monitoring, Emission Registration and Emission Inventories, a total figure for actual emissions of direct greenhouse gases is compiled according to the latest addition to the IPCC guidelines agreed in Mexico 1996 (IPCC Intergovernmental Panel on Climate Change).

In the past the various institutes and ministries used different figures for greenhouse gas emissions. In 1995 the Dutch government decided to adopt the internationally accepted IPCC method for both international and national purposes. In doing this it abandoned, among other methods, the gross NEPP method for CO<sub>2</sub> (the method adopted for the National Environmental Policy Plan, NEPP), which, although simple and unequivocal, made it difficult to compare Dutch emission statistics with those of other countries.

Given the different opinions held by the various institutes on the size of the CO<sub>2</sub> emissions from various sources, consultations were held, at the request of VROM, between CBS, the Netherlands Organisation for Applied Scientific Research (TNO), the Netherlands Energy Research Foundation (ECN) and RIVM to reach a consensus on the method to be followed. A draft report was drawn up early in 1996. The method described in that report was used in the preparation of the Annual Emissions Report (AER) and the Environmental Balance in 1997. Following further consultations between the institutes in the second half of 1996, the Directorate-General for Environmental Protection (VROM/DGM) established a supervisory committee for the preparation of this report.

The supervisory committee has discussed and approved the method presented in this report, which has been adopted by the Coordination Committee for Monitoring of Target Groups (CCDM). The method is now binding on all parties taking part in the monitoring of environmental policy and replaces all previously used methods, in line with the desire of the institutes and ministries to produce a single valid series of statistics on greenhouse gas emissions. Monitoring protocols are drawn up by working groups of the CCDM. Greenhouse gas emissions are calculated and adopted according to protocols based on the method described in this report (see also footnote 2).

Formal reports must follow the method described in this report. In addition to the results of the IPCC method, separate emissions figures calculated by other methods may be presented for specific target groups or compartment analyses at the local, regional or national level. These must be accompanied by a clear explanation of where the method used, how it differs from the IPCC method and why it has been used. All reports, though, must always include the results obtained by following the IPCC method described here.

The method described here differs from the IPCC method that has been used so far to determine national emissions. This is due to alterations in the IPCC guidelines and because other – approved – differences of detail permitted by the guidelines have been chosen for use in the Netherlands. Annex A lists the differences from previously used methods. The recalculated annual series for 1990 to 1995 will be presented in a separate report.



## 2. DEFINITIONS

As described in various National Environmental Policy Plans (NEPPs), Dutch environmental policy has switched from the compartment approach to an integrated approach to environmental problems. This approach led to the definition of environmental themes and target groups. Three coordination committees have been established to determine whether objectives are being achieved of which the Coordination Committee for Monitoring of Target Groups (CCDM) is responsible for annual monitoring and approval of Dutch emissions to air, water and soil. Seven target-sector working groups, under the responsibility of the CCDM, are compiling protocols for the monitoring methods. This is described in detail in the Terms of Reference for the CCDM.

Given the fact that the scope of climate change as an environmental theme transcends any single target group, all the CCDM working groups and all the task forces of the Working Group Emission Monitor (WEM) (which coordinates the collection of emission data for the annual Emissions Monitor) must use the methods described in this report. This is to ensure that all data are comparable, unequivocal and uniform. An important consideration is that the target group approach is definitive when reporting on domestic policy and that the IPCC categories should be used when reporting under international obligations on climate change. The target groups and IPCC categories are not based on the same principles and so they are not equivalent (Annex B contains a table for converting the Dutch target groups into IPCC source categories, table B.2).<sup>3</sup> In addition, under other international frameworks (UN Economic Commission for Europe [UN-ECE] for the Convention on Long-Range Transboundary Air Pollution) the Netherlands reports on the emissions of a number of substances for which other categories are used.

### 2.1 Greenhouse gases

Greenhouse gases are divided into five categories according to their effects on climate change.

- A1: Substances with a direct greenhouse effect: CO<sub>2</sub>, CH<sub>4</sub> en N<sub>2</sub>O.
- A2: Substances with direct greenhouse and ozone-depleting effects which are regulated by the Montreal Protocol: CFCs, HCFCs, halons, 1,1,1-trichloroethane, carbon tetrachloride and methyl bromide.
- A3: Substances with a direct greenhouse effect but with no ozone-depletion effect and which are not regulated by the Montreal Protocol: HFCs, PFCs, FICs (the non-ODP halogenated hydrocarbons) and SF<sub>6</sub>.
- B: Substances with an indirect greenhouse effect: CO, NO<sub>x</sub> en NMVOC (ozone precursors).
- C: Substances with indirect cooling effects: SO<sub>x</sub>.

Maintaining emission inventories and providing background information on substances in categories A1 and A3 is compulsory under UN and EU agreements. This report, therefore, confines itself to these two categories. Under the provisions of various conventions (for example the Convention on Long-Range Transboundary Air Pollution and the National Emission Ceiling Direction)

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<sup>3</sup> In later years this was refined slightly to bring Dutch reporting more into line with the prescribed classification and allocation to IPCC source categories. This refinement mainly concerns the Dutch target groups Construction, Water Supply Companies, Waste Water Treatment Plants and Waste Disposal.

and the reporting and/or regulatory obligations they impose, the emissions of substances in categories A2, B and C have been determined for some years. No systematic determination of emissions for the substances in category A2 has taken place since the expiry of the CFC action programme in 1995. This category is excluded from the obligations under the UNFCCC. In 1995 KPMG carried out an inventory of the use of the substances in categories A2 and A3 in 1995. A similar inventory is planned for 1996 and possibly for subsequent years.

## 2.2 Sources of greenhouse gas emissions in the Netherlands

The IPCC guidelines on emission sources identify a large number of sectors grouped into seven main source categories, which should be used for international reporting. Using previous inventories, IPCC categories in which emissions occur in the Netherlands were selected for each greenhouse gas. Table B.1 in Annex B lists these categories.

## 2.3 Data collection

Emissions in the Netherlands are registered in the Emissions Register (ER) for the VROM Inspectorate (VI). The ER is the national database for target group monitoring and forms the basis for the Annual Emissions Report (AER)<sup>4</sup> and the Environmental Balance (EB). In cooperation with various research institutes, emission data are collected and stored in two linked information systems: the Emission Registration for Individual Companies (ER-I) and the Emission Registration for Collective Data (ER-C).

The ER-I contains data on large industrial point sources (large companies). These point source data are combined with emissions from non-industrial emission sources and supplementary estimates for companies which are not registered individually (the so-called collectively registered companies) and included in the ER-C. The ER-C database is compiled and aggregated by WEM task forces when the Emission Monitor is compiled. The WEM task forces are composed of representatives from the scientific institutes.

The ER-C database, therefore, contains a complete record of Dutch emissions for a particular year and consists of a large number (approx. 1100) of 'cells', or emission sources. Each cell includes the following information: the Standard Industrial Classification code (SBI-code) and industrial subsector, separate information on process and combustion emissions, the relevant environmental compartment and location expressed in normalised coordinates or indicated on maps. These cells can be selectively aggregated, for example by IPCC category or national target group. Annex B contains a table of the IPCC categories and a table for converting IPCC source categories into the Dutch target groups. Annex C contains a table showing the (partly aggregated) emission sources per target group.

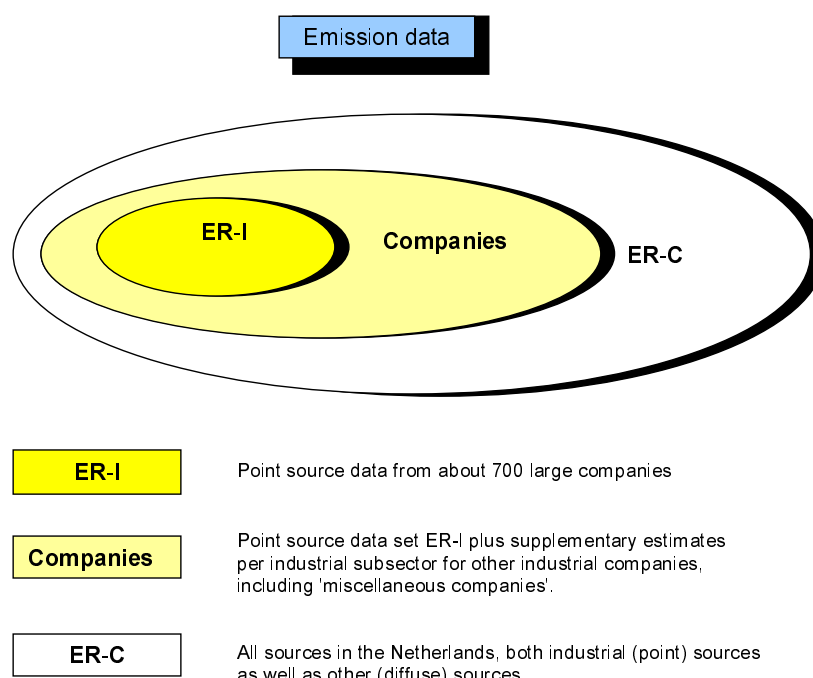
In section 3.1.1 it was stated that the Netherlands Energy Statistics (NEH) [presently: Netherlands Energy Monitor] compiled by Statistics Netherlands (CBS) should be used as the basis for determining CO<sub>2</sub> emissions resulting from the consumption of fossil energy carriers. Exceptions to this are the target groups Refineries and Chemical Industry because the consumption of residual gases in

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<sup>4</sup> Now called the 'Emission Monitor'.

these sectors remains partially hidden in the NEM statistics. Despite the resulting difficulties for calculating CO<sub>2</sub> emissions, until 1999 the ER-I has been shown to deliver reliable emission data. Since the introduction of the Annual Environmental Report (in Dutch: 'MJV') the quality of the ER-I has been eroded. Therefore, actions are being started to rise the quality of the MJV data to the original level. The NEM is used as the basic data set (or boundary condition) for the determination of CO<sub>2</sub> emissions. The data flows are illustrated diagrammatically in Figure 2.1

**Figure 2.1** Diagram illustrating the process of data collection in the Emission Registration system



The ER-I contains point source data. These are supplemented with data from supplementary estimates per industrial subsector and then entered in their entirety into the ER-C (the supplementary estimates are made by CBS, RIVM and TNO). The ER-C, therefore, contains the whole ER-I plus supplementary estimates. For reporting purposes any combination of emission sources in the ER-C can be aggregated (for example IPCC categories or target groups for the Emission Monitor and Environmental Balance). The size of the ovals is not representative for the relative contributions of the emissions.

## 2.4 IPCC requirements

The IPCC guidelines define source categories and set certain requirements on how emissions are to be determined. The reasoning behind this has to do with the fact that the IPCC's primary aim is to estimate global anthropogenic emissions and sinks as accurately as possible, using inventories and emission data from all countries. To minimise the likelihood of double accounting because of transboundary flows of pollutants it is very important that each country works with a clear definition of emissions. To this end the IPCC has issued some instructions relevant to this inventory. The most important are:

- Emissions from mobile sources in the road transport sector are calculated using fuel consumption figures in line with national energy balances. For the Netherlands this means deliveries of fuel within the national borders as recorded in the CBS energy statistics.
- Emissions from the combustion of all bunkered fuels are allocated to international emissions and should be reported as a separate item. This applies to both marine and aviation bunkers. It is therefore appropriate to identify the source of the fuel and not the territory where it is consumed.
- To meet the need for streamlining with the CORINAIR inventory, separate records should be maintained for domestic and international flights and for emissions during landing and take-off (LTO) cycles and cruising.
- CO<sub>2</sub> emissions must be calculated uncorrected for temperature. Temperature-corrected calculations may be presented as a separate item.
- Calculations of CO<sub>2</sub> emissions must be made for total domestic energy consumption. This means that emission data must also be provided for energy consumption that cannot be ascribed to users (target groups): this represents the statistical difference between energy consumption derived from the supply-side statistics and consumption derived from the sum of energy demand in the target groups.
- CO<sub>2</sub> emissions from the combustion of biomass is not included in the national total because this contains short-cycle carbon. IPCC requires that these emissions are presented separately.
- It is assumed that the emissions of CH<sub>4</sub> and N<sub>2</sub>O from soil are anthropogenic emissions. Although CH<sub>4</sub> emissions from agricultural land are calculated in this method, they are not included in the total if they are not anthropogenic emissions.
- Only actual (i.e. real, physical) emissions from feedstocks are included, unlike the approach used previously or the gross NEPP method, which also included potential emissions.
- The IPCC guidelines contain a large number of standard emission factors; however, countries are urged not to adopt these if they have better and more specific emission factors at their disposal. This applies in some cases in the Netherlands.
- Emissions are calculated for each calendar year. Where land use is concerned, activities can vary considerably from year to year and information on these uses is limited. For this reason, emissions for some categories should be presented as three-year averages.
- Emissions from CHP plants are included in the sector in which the plant is owned or maintained. To clarify the contributions these make to the sector totals, energy consumption by CHP and the resulting emissions should be specified separately per IPCC category.
- The sources of emissions from off-road vehicles in the transport sector (mainly mobile equipment used in road construction and agriculture) should be specified as far as possible.

## 2.5 Timetable

It has been agreed that data will be collected during the annual emission inventory, in parallel with the preparation of the Emission Monitor. The timetable for data collection will be worked out in detail in the protocols for emission inventories to be drawn up by the CCDM working groups. The schedule for the EM will contain a number of key dates:

- Mid January, year T: ER-I data available for year T-2
- Early March: Supplementary estimates to ER-I completed  
Basic data on non-industrial sources available
- End of May/early June: Data processing complete
- Mid July: Final version complete

The emission files, which are approved at the end of June, will then be used for reporting to the European Union and the secretariat of the UNFCCC. The Environmental Balance, which makes use of the same emission data, is published in mid September. The method of data collection and processing described briefly in sections 2.3 and 3.1.2 is explained in more detail in the Emission Monitor. Each CCDM working group will go into the various aspects of the process in more detail in the monitoring protocols.



### 3. EMISSIONS OF CARBON DIOXIDE (CO<sub>2</sub>)

This chapter describes, with reference to Table B.1 (Annex B), the methods to be used for determining the CO<sub>2</sub> emissions in each category. The relevant IPCC category is indicated between square brackets in each section heading.

The level of detail of data collection for all sectors is determined by the fact that the list of emission sources must be suitable for generating totals that can be used for the IPCC format and for the Dutch target group policy and CORINAIR/ECE. The last implies that for civil aviation a distinction must be made between fuel consumption during LTO cycles and other fuel consumption. This is particularly important for CORINAIR/ECE because emission factors for LTO cycles are different from those during cruising, but it is not relevant for CO<sub>2</sub> emissions. The IPCC have a different criterion: national emissions from civil aviation only include emissions from domestic flights. These emissions are calculated from domestic deliveries of (aviation) fuel recorded in the NEH. Under IPCC guidelines, all emissions from bunkered (aviation) fuel fall under international emissions, which includes LTO emissions from bunkered fuel in the vicinity of Dutch airports. The same applies to marine bunkers.

For road transport emissions, the IPCC guidelines allow a choice between calculations based on vehicle-kilometres travelled and on fuel consumption. It is expected, though, that the fuel consumption figures that correspond to the vehicle-kilometres total will be similar to the fuel consumption statistics in the national energy balance, and so the greenhouse gas emissions in the transport sector are calculated using the NEH statistics for fuel deliveries in the Netherlands.<sup>5</sup> There is some discrepancy between the CORINAIR/ECE and IPCC calculations of greenhouse gas emissions. For CORINAIR/ECE, fuel consumption within national borders is based on vehicle-kilometres travelled. Ways to streamline these inventories are being investigated.

#### 3.1 CO<sub>2</sub> emissions from the combustion of energy carriers as a fuel [1A]

Of the four CO<sub>2</sub> emission categories relevant to the Netherlands (see Annex B, Table B.1), category '1A: Fuel Combustion Activities' produces by far the largest emissions. In general, the emissions are determined by multiplying fuel consumption by the relevant emission factors.

$$\text{CO}_2 \text{ emissions (Mton)} = 10^{-3} * \text{emission factor (kg/GJ)} * \text{fuel consumption (PJ)}$$

##### 3.1.1 Basic data set: Netherlands Energy Statistics (NEH)

To determine CO<sub>2</sub> emissions from the combustion of fossil energy carriers (IPCC category 1A) use is made of the CBS energy statistics published each year in the Netherlands Energy Statistics (NEH).<sup>6</sup> Exceptions to this is are refineries and the chemical industry, which are discussed in more detail in section 3.1.2. To ensure

<sup>5</sup> This brings the Netherlands within the recently issued UNFCCC/IPCC Good Practice guidelines, which state that emissions from road transport should be calculated using energy deliveries (= energy use figures from the national energy balance) (IPCC, 2001). Section 5.2 contains further details on the conversion of emissions from the target group Transport for national use, which are based on vehicle-kilometres travelled, to emissions calculated according to international guidelines (IPCC, ECE/CLRTAP) based on fuel deliveries to road transport.

<sup>6</sup> The NEH is now published digitally under the name 'Energy Monitor'.

that the total figures for all sectors and target groups in the Netherlands are correct, it is essential to have one complete and internally consistent database for energy consumption. This means that sectoral consumption data from the NEH are also used.

The NEH is also an important source of data for calculating non-individual registered emissions. In the NEH energy consumption per economic sector and per fuel type are divided into the following four consumption categories, which make up the consumption balance.

- A. final use: energetic (NEH column 17)
- B. final use: non-energetic (NEH column 18)
- C. transformation: balance for heat/power (NEH column 14)
- D. transformation: balance of other transformation (NEH column 15)

The CBS data for industry are aggregated per SBI code (Annex D). In the NEH they are clustered into coherent sectors within the main groups of energy companies and energy consumers, for example mineral extraction companies, inorganic basic chemicals, and the transport and residential sectors.

**Combustion emissions** belong mainly to categories **A**: Final use: energetic (NEH column 17) and **C**: Transformation: balance for heat/power (NEH column 14). Emissions from CHP plant are allocated entirely to the sector in which the plant is owned or operated.

**Process emissions** belong to category **B**: Final use: non-energetic (NEH column 18) and **D**: Transformation: balance of other non-CHP transformation (NEH column 15), such as the transformation of coal to coke or of crude oil to refinery gas.

Combustion emissions are allocated to sectors in accordance with the NEH sectoral energy use figures so that NEH data can be used unambiguously and consistently for calculating national greenhouse gas emissions. This means that emissions from the use of energy carriers (combustion, transformation, feedstock) are attributed to those sectors in which the energy carriers are used. This is particularly pertinent to energy generated in CHP plant and used by industries, greenhouse horticulture and services. This practice is in line with the IPCC guidelines, but differs from methods used in the Netherlands for monitoring efficiency improvements and that account for energy flows and CO<sub>2</sub> emissions between sectors. In reports to the IPCC, CO<sub>2</sub> emissions by CHP facilities are stated separately per sector.

### 3.1.2 ER-I and supplementary estimates

Part of the fuel consumption and resulting combustion emissions are registered in the ER-I. About 700 large, mainly industrial companies, including all power stations and refineries, are registered individually.<sup>7</sup> This accounts for about half the CO<sub>2</sub> emissions (approx. 85 Mton), 50 Mton of which are emitted by the power stations and refineries. Almost all the fuel consumption registered in the ER-I is

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<sup>7</sup> Numbers given are to 1996. Since 1998 emissions figures from companies have been obtained mainly from the obligatory annual environmental reports, with no other parties involved. Data from these companies, of which there are about 250, are submitted to the provincial councils, validated and stored in a database by the *Facilitating Organisation for Industry* (FOI). This database is the key source of emission data on these companies for the ER-I (more information on this is provided in the NIR 2002).

reported by the companies themselves. The corresponding registered emissions are either measurements or calculations based on fuel input and emission factors. The emission factors used depend on the type of fuel. The resulting emission factors are detailed and essentially sector-dependent.

$$\text{emission factor ER-I}_{(\text{sector, fuel type})} = \frac{\text{emissions ER-I}_{(\text{sector, fuel type})}}{\text{consumption ER-I}_{(\text{sector, fuel type})}}$$

The emissions and fuel consumption registered in the ER are systematically examined for inaccuracies by checking the resulting emission factors. This is done by dividing the reported emissions by energy consumption per fuel type. All other companies fall outside the ER-I, including large 'collective' emitters such as the transport, agriculture and residential sectors. Their supplementary emissions have to be estimated in the EC-C system from the energy used by the sector that falls outside the ER-I and the emission factor from the formula given above.<sup>8</sup> The final calculation per sector is then:

$$\text{emission}_{(\text{sector, fuel type})} = \text{emission factor ER-I}_{(\text{sector, fuel type})} * \text{energy use NEH}_{(\text{sector, fuel type})}$$

In one case, instead of estimating total emissions based on energy use according to the NEH, the emissions and fuel use per sector reported by the ER-I companies are used. An important reason for doing this is that the NEH registers consumption balances reported by surveyed companies, while it is possible that intermediary fuels (residual gases) are burned, with associated emissions. This consumption of energy carriers produced during the manufacturing process is partly invisible to the CBS and is not always registered in full by the NEH. This is particularly problematic for refineries and the organic chemical industry.

### 3.1.3 Emission factors for estimating emissions from collective sectors

For sectors with no individual registration of emissions (the transport, agricultural and residential sectors, for example), a set of specific emission factors is used (Annex E). The CO<sub>2</sub> emission factors for these collective sectors are determined from the carbon content (percentage) and calorific value of the fuel. CBS is responsible for all supplementary estimates of combustion emissions.

### 3.1.4 Temperature correction for energy use

It is desirable to eliminate the influence of mild or cold winters on energy use and CO<sub>2</sub> emissions when evaluating policy. To this end the energy used for space heating is temperature corrected. As space heating in the Netherlands is almost entirely generated from the combustion of natural gas, no corrections are made for other energy carriers. This temperature correction is only used for domestic policy and is applied to CO<sub>2</sub> combustion emissions but not to other greenhouse gases. All reports subject to IPCC guidelines must include a table of energy use uncorrected for temperature variations.

<sup>8</sup> This applies to all substances with the exception of CO<sub>2</sub> (and to substances for which the fuels are not included in the ER-I). The estimates for CO<sub>2</sub> are the values shown in Table E.1.

The temperature correction consists of two factors:

$$\text{Gas consumption}_{(\text{year T, sector S}), \text{corrected}} = \text{gas consumption}_{(\text{year T, sector S}), \text{uncorrected}} * \text{HDD} * \text{SS}$$

The **Heating Degree Day correction factor (HDD)** for year T and the **Sector-Specific application factor (SS)**. The correction factor for energy use (natural gas use) by a sector in a certain year is equal to the product of the Heating-Degree Day correction factor (year) and the application factor (sector, year).

The **Heating Degree Day correction factor** is the number of Heating Degree Days in a 'normal' year (the average of the number of HDDs in the previous 30 years) divided by the actual number of HDDs in the year under consideration. For a relatively warm year (few HDDs) the HDD correction factor  $GT > 1$  and so gas consumption figures must be raised to obtain temperature-corrected values.

The **application factor** for a certain economic activity, for example for the residential or service sector, is the fraction of natural gas consumption by the activity for space heating. Annex F describes the temperature correction method for energy use in more detail.

### 3.1.5 Emissions from energy use outside sectors ('Statistical Differences') [1A5]

The IPCC method for calculating emissions from fossil energy carriers considers total domestic energy use. For each energy carrier this is the result of

$$\text{use} = \text{production} + \text{imports} + \text{withdrawal from stocks} - \text{exports} - \text{bunkers}$$

However, this differs somewhat from the sum of the consumption balances from all sectors (the total consumption balance). This item is zero for each energy carrier only in the ideal situation, in which all the energy used can be allocated to the consumption sectors. Both the national energy use and the consumption balance, and the resulting statistical differences, are included in the NEH.<sup>9</sup>

The statistical difference in the NEH is typically 0–20 PJ, which is <1% of total use (Table 3.1). This part of the domestic energy use, therefore, cannot be allocated to consumption sectors; this also applies to the resulting emissions. Because there is no indication that these energy carriers are fixed in products, it is assumed that they are all burned. Aggregated CO<sub>2</sub> emission factors for coal, oil and gas are used for this item (Table 3.2). Given their limited contribution to the total and the fact that emission factors for other substances are usually sector-specific, only CO<sub>2</sub> combustion emissions are calculated from the statistical differences.

<sup>9</sup> The energy balances for 1990, 1995 and subsequent years have recently been revised and improved. As a result the NEH for these years contains no statistical difference, ie it is zero, for all fuels (more information is given in the NIR 2002).

Table 3.1 Energy use outside consumption sectors ('statistical difference'), 1990–1995.

Energy carrier [PJ]	1990	1991	1992	1993	1994	1995
Coal and coal products	7	0	-4	9	-9	15
Oil and oil products	16	25	15	26	26	28
Natural gas	-13	-14	-20	-20	-8	-17
Other	5	7	8	3	2	-5
<b>Total</b>	<b>14</b>	<b>18</b>	<b>-1</b>	<b>18</b>	<b>10</b>	<b>20</b>

source: CBS (NEH, 1996)

Table 3.2 Aggregated CO<sub>2</sub> emission factors and emissions from the statistical difference for 1995.

Energy carrier	Emission factor [kg/GJ]	Statistical difference [PJ]	CO <sub>2</sub> emissions [Mton]
Coal and coal products	94	15	1.41
Oil and oil products	73	28	2.04
Natural gas	56	-17	-0.95
<b>Total</b>			<b>2.50</b>

source: CBS (NEH, 1996)

### 3.1.6 C, CO and CO<sub>2</sub>

The IPCC requires that all carbon eventually oxidised is declared as CO<sub>2</sub> emissions. This includes not only direct CO<sub>2</sub> emissions but also all carbon in atmospheric emissions of CO and hydrocarbons. This leads to deliberate double accounting in the emissions inventory: carbon is counted both in its actual emitted forms and as potential CO<sub>2</sub>. The mass balance approach based on an energy economy, therefore, assumes the transformation of C in fuels to CO<sub>2</sub>.

The IPCC guidelines contain standard values for partial combustion/oxidation of the carbon present in coal, oil and gas of 98%, 99% and 99.5% respectively. A number of scientific institutes have investigated the accuracy of these figures in the Netherlands in connection with the AER and found that under Dutch conditions the non-oxidised fractions are much smaller. With natural gas making up a high proportion of the energy supply in the Netherlands, the error involved in assuming full combustion is negligible (< 0.3 Mton/year = < 2%). For this reason the non-oxidised fraction is taken to be zero. In just a few small categories within the transport sector – two-stroke mopeds, helicopters and piston-engined aircraft – this leads to a slight overestimate of CO<sub>2</sub> emissions.

### 3.2 CO<sub>2</sub> emissions from energy carriers used as feedstocks [1A]

Energy carriers are not only used for their useful energy content released during combustion, but also as feedstocks in the industrial and construction sectors. In the Netherlands approximately 100 PJ natural gas is used to make ammonia in the production of chemical fertilisers and, after cracking, between 250 and 300 PJ of oil products, especially naphtha, aromatics and LPG are used in the organic (basic) chemicals industry. Just 20 PJ in bitumen is used in roofing material and asphalt in the (road) transport sector and about 10 PJ in coal products (coke and tar) is used in the basic metals and inorganic chemical industries. In these cases there are, in principle, three possible destinations for the carbon in the energy carrier:

1. Carbon from the energy carrier is fixed for the long term (>20 years) in the final product, as in some plastics, asphalt and steel.
2. Use of energy carriers as feedstocks for products with a short life-cycle. During the use of the product carbon is oxidised in contact with the air and released as CO<sub>2</sub>, for example from solvents.
3. Some of the carbon is oxidised during the production process, for example in the production of ammonia from natural gas and in the reduction of iron ore by coke. This leads to direct CO<sub>2</sub> emissions (process emissions) in the factory.

The IPCC method goes on to apply detailed emission factors to convert the energy content into total potential CO<sub>2</sub> (Table 3.3). The *actual* CO<sub>2</sub> emissions are determined by estimating the storage of potential CO<sub>2</sub> in products (per energy carrier), using the following equation:<sup>10</sup>

$$\text{actual CO}_2 \text{ emission} = \text{potential CO}_2 \text{ emission} - \text{storage in products}$$

The IPCC guidelines contain standard fixation percentages for the use of energy carriers as feedstocks; in other words, a standard value for the percentage stored for the long term. These percentages, however, are for general application and take no account of specific differences in applications per country. For this reason the IPCC invites reporting countries to provide specific factors where possible.

In the NEH the energy carriers that are used as feedstocks and the amounts involved are identified for each SBI sector (NEH column 18: Final use: non-energetic). However, it is usually not possible to determine the matrix of final destinations and energy carriers and so estimate emission and storage percentages. A different approach has been chosen for the Netherlands: first, the size of the emissions allocated to the Netherlands is determined accurately from a detailed material flow analysis (mainly of petrochemical semi-manufactures and products and their destinations). Special attention is paid to imports and exports of materials and energy carriers (Gielen, 1996). Then the products and semi-manufactures are calculated back into energy carriers; all oil products, with the exception of bitumen and lubricants, are clustered. The resulting figures are then used to determine the storage and emission factors. A single storage factor has been determined for a large group of oil products (Table 3.3, shaded area).

The storage percentages thus determined apply specifically to the Dutch situation and deviate considerably from the standard IPCC factors previously used in reports on Dutch greenhouse gas emissions. Under the new method, CO<sub>2</sub> process emissions from energy carriers are about 1/3 lower than the previous figures. It should be noted, though, that this analysis has only been performed for 1992 and the actual matrix of semi-manufactures and products may vary from year to year. For the time being, it is assumed that any changes in the range of products will not cause significant deviations in the estimated factors. The emissions calculated using these storage percentages should be allocated to the industrial sectors where the energy is used (excluding imports and including exports of energy carriers). The emissions are allocated to the year in which the energy carriers were used.

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<sup>10</sup> The 'storage in products' is corrected for emissions from oxidation during the useful life of the product. In this calculation, the 'actual CO<sub>2</sub> emissions from the use of energy carriers as feedstocks' also includes the 'indirect' emissions during the life of the product, i.e. emissions that take place from activities in the sectors other than the chemical industry (partly abroad) and during the life of the products (which may be many years).

Table 3.3 CO<sub>2</sub> storage and emission percentages for energy carriers used as feedstocks, the Netherlands, 1992<sup>11</sup>

Energy carrier	Consumption [PJ]	Emission factor CO <sub>2</sub> [kton/PJ]	Potential emission CO <sub>2</sub> [Mton]	Storage CO <sub>2</sub> [Mton]	Emissions CO <sub>2</sub> [%]	Emissions CO <sub>2</sub> [Mton]
<b>Coal:</b>						
Coke	3.9	102.0	0.40		0%	0.40
Other coal (roofing)	6.1	94.0	0.57	0.57	100%	
<b>Oil:</b>						
Bitumen	17.3	80.7	1.40	1.40	100%	
Lubricants <sup>12</sup>	6.1	73.3	0.45		0%	0.45
Naphtha	27.0	73.3	1.98			
LPG	71.4	63.1	4.51			
Aromatics	71.1	75.2	5.35			
Other light oils	25.3	70.0	1.77	15.43	82%	3.30
Petroleum	0.3	73.3	0.02			
Gas, diesel, fuel oil	2.3	74.1	0.17			
Heavy fuel oil	0.5	77.4	0.04			
Other oil products	67.3	73.3	4.93			
<b>Subtotal Oil</b>	<b>291.7</b>		<b>20.58</b>	<b>16.83</b>		<b>3.75</b>
<b>Gas:</b>						
Natural gas	101.3	56.1	5.68	0.57	10%	5.11
<b>TOTAL</b>	<b>402.9</b>		<b>27.23</b>	<b>17.97</b>		<b>9.26</b>

source: CBS (NEH, 1992), Gielen (1996)

In this method the CO<sub>2</sub> process emissions at the sector level are determined from the energy statistics in a top-down approach. Process emissions from large companies are registered in the ER-I; the usual procedure for supplementary estimates described in section 3.1 can be used to determine the CO<sub>2</sub> process emissions for the non-ER-I companies in the sector.<sup>13</sup>

### 3.3 CO<sub>2</sub> emissions from the transformation of energy carriers (non-CHP) [1A]

Energy is lost during the (non-CHP) transformation of energy carriers, for example from coal to coke and coke oven gas and from crude oil to the series of oil products (energy carriers), refinery gas, naphtha, LPG, aromatic compounds, fuel oil, etc. The (secondary) energy carriers after transformation contain less energy than the primary energy carriers, the difference being the transformation losses. In the NEH these losses can be found in column 15: 'balance of other transformations'.

Mass balance calculations for carbon show that this use of energy or these transformation losses lead to CO<sub>2</sub> emissions. All non-CHP transformations of energy carriers in the Netherlands are by companies registered in the ER-I. Calculations of CO<sub>2</sub> process emissions from energy transformation (non-CHP) should be made using a mass balance for carbon. CO<sub>2</sub> emissions calculated by this method are equal to the emissions registered in

<sup>11</sup> Figures are examples only: the most recent data set may differ slightly from the values given here.

<sup>12</sup> Excluding consumption by 'other energy consumers' (SBI 246), i.e. in Trade, Services and Government (in Dutch 'HDO') and agriculture sectors, because the lubricants used by these target groups are entirely recycled and do not oxidize during use. These amount to about 1 Mton potential emissions of CO<sub>2</sub>.

<sup>13</sup> Only supplementary estimates of emissions are made per industrial sector (fertiliser manufacture, organic basic chemicals, inorganic basic chemicals, other basic chemicals, and five other small sectors) if the sum of the ER-I returns is lower than the top-down totals calculated according to the method described here (= total, cf. the IPCC Tier 1 method). If the ER-I returns are higher they are not corrected (i.e. not adjusted downwards).

the ER-I. The IPCC categories [1A6]: 'CO<sub>2</sub> emissions from the combustion of biomass' and [-]: 'Bunkers' are explained further in Annex G.

### 3.4 Fugitive emissions from flares and vents during oil and gas production [1B2]

This item concerns the flaring and venting of residual gas flows by oil production companies. Residual gases are released during gas handling and during oil production.

Basic information on the scale of these processes is contained in the CBS data file on the amount of gas flared and vented in the oil and gas production industry.<sup>14</sup> Using this and information from the Nederlandse Aardolie Maatschappij (NAM) annual environmental report, RIVM determines the volume of gas that is flared and vented onshore and offshore by NAM and other parties. Based on normal Groningen natural gas with a combustion percentage of 99.5% on land and 97% at sea, the CO<sub>2</sub> emission factors are as follows:

Table 3.4 CO<sub>2</sub>- emission factors for flares and vents

Process	Emission factors (kg/m <sup>3</sup> )
Onshore flares	1.76
Offshore flares	1.72
Onshore and offshore vents	0.017

source: AER Methods report 1996 (1997)

### 3.5 Process emissions from the decomposition of carbonate [2A, 2E, 2F]

These are CO<sub>2</sub> emissions from non-organic carbon that is not derived from energy carriers (lime, clay, etc.). The ER-I is definitive when determining these CO<sub>2</sub> emissions from the use of lime in the production of iron and steel (IPCC category 2A) because the basic metals industry is fully represented in the ER-I. Also fully covered are the CO<sub>2</sub> process emissions from the production of clinkers for the cement industry [2E1]. CBS and TNO verify these declared process emissions by checking the use of lime as a feedstock.

The ER-I only partially covers the process emissions from the production of other building materials [2E3] (such as roofing tiles, bricks and glass). The ER-I data, multiplied by a factor related to the number of employees, are definitive. In the absence of a more accurate method, the process emissions from the sector 'Other industrial processes' [2F] are derived from the production of gypsum in flue gas desulphurisation plants (FGD) at coal-fired power stations. This is summarised in Table 3.5.

Table 3.5 Determination of CO<sub>2</sub> process emissions from non-energy carriers

IPCC category		Increase/determination
2A	Production of iron and steel	Entirely in ER-I
2E1	Clinker production (cement)	Entirely in ER-I
2E3	Other building materials	Determined from ER-I, correction via no. of employees (CBS data)
2F	Other: power station FGD plant	Derived from gypsum production (declared by Vliegasonie) and an emission factor of 0.94 ton CO <sub>2</sub> /ton gypsum

source: AER Methods report 1996 (1997)

<sup>14</sup> Emissions have been calculated differently since 1997. They are no longer linked to the specific figures for flares and vents but to the production volumes of oil and gas. The emission factor for CO<sub>2</sub> emissions per cubic metre calculated for oil and gas produced in 1996 is assumed to remain constant in the years after 1996.

### 3.6

### CO<sub>2</sub> storage in biomass [5A]

As already stated in section 2.4, CO<sub>2</sub> sinks have to be reported separately in international reports. The most important sink (and in the Netherlands the only sink) consists of the Dutch forests. These take up more CO<sub>2</sub> from the atmosphere than they expire and so the total volume of living wood in the Netherlands is increasing (the volume of biomass in the Netherlands is growing). The size of this CO<sub>2</sub> sink is calculated from the net increase in the amount of carbon in living wood. This sink comes under IPCC category [5A], 'Land use change and forestry'. The factors which influence the net growth increment in practice are:

- the composition of the forest stock (areas of broadleaved/coniferous/etc.)
- annual growth rate (volume increment) as a function of the type and age of tree (in m<sup>3</sup>/ha\*year]
- fellings, by type (in m<sup>3</sup>/ha)
- carbon content per type of tree (kg C/m<sup>3</sup>)

For the time being the following aggregated figures are used for the entire stock of living wood in the Netherlands. These are derived from reports by the Stichting Bos en Hout for the HOSP project (Timber harvest statistics and harvestable timber forecast) (Table 3.6). These are corrected for non-stem mass (branches, tree-tops and roots: +20%).

Table 3.6 Basic data for calculating CO<sub>2</sub> fixation in biomass growth, 1992.

Unit	Area	Value	Unit	
<b>Forest:</b>				
HOSP forest	281.7			
HOSP-2 forest	29.5			
Other forest	34.1			
<b>Total area with growth (1992)</b>	<b>344.8</b>		<b>kha</b>	<b>(A)</b>
<b>Other trees (NON-growing):</b>				
Other non-forest trees	10.0			
Line plantations	66.0			
Solitaires	2.0			
Orchards (fruit)	23.6			
Nurseries	5.4			
<b>Total area in the Netherlands (1992)</b>	<b>451.8</b>		<b>kha</b>	
<b>Other variables:</b>				
Average annual volume increment (stem only, 1994)		8	m <sup>3</sup> /ha/yr	(B)
Average fellings (stem only) (broadleaved / coniferous)		3-4 / 6	m <sup>3</sup> /ha/yr	(C)
Correction for branches, roots and tree-tops (incl. bark)		+20	%	(D)
Specific density of broadleaved / coniferous forests		500 / 600	kg dm/m <sup>3</sup>	(E <sub>1</sub> )
Specific carbon content		0.5	kgC/kg dm	(E <sub>2</sub> )

source: recalculated in Daamen (2002); original source: Stichting Bos en Hout (1994, 1997)

The amount of CO<sub>2</sub> fixed each year (year t) through the increase in biomass is calculated using the following formula:

$$\text{step 1: carbon fixation (kg/jaar)} = [A_t * (B_t - C_t) + (F_t - F_{t-1})] * (1+D/100) * E_1 * E_2$$

$$\text{step 2: net CO}_2 \text{ sink (kg/jaar)} = 44/12 * \text{carbon fixation (kg/jaar)}$$

where the letters A to E are defined in Table 3.6. F<sub>t</sub> is the change in the standing stocks of non-growing plantations as a result of changes in the area from year t-1 to year t.

The factors for average annual volume increment (growth increment) and fellings per hectare are not constant; the annual growth increment has slowly declined as the average age of trees increased but since 1995 has risen again as new plantations have grown rapidly. The amount of fellings is falling more quickly, resulting in a greater net fixation of CO<sub>2</sub>. This is shown in Table 3.7.

Table 3.7 Average incremental growth rate and fellings in the Netherlands, 1990–1994 in m<sup>3</sup>/ha.

	1990	1991	1992	1993	1994	1995
Specific gross growth increment	7.8	7.6	7.5	7.5	7.6	7.8
Specific fellings	4.8	4.6	4.3	4.2	4.0	5.3

source: recalculated in Daamen (2002); original source: Stichting Bos en Hout (1995)

### 3.7 CO<sub>2</sub> emissions from waste incineration [6C]

Emissions from waste incineration are determined from the amount and composition of the waste incinerated. The amount of waste incinerated each year is established by the Dutch Waste Processing Association (VVAV) and the total amount of CO<sub>2</sub> emitted from waste incineration plants (WIP) is registered in the ER-I. For climate policy only the share of CO<sub>2</sub> emissions from the incineration of fossil carbon (mainly plastics) is important; incineration of paper and wood is not relevant for national CO<sub>2</sub> emissions.

In a study for RIVM (de Jager and Blok, 1993), Ecofys calculated that CO<sub>2</sub> emissions from waste incineration plants containing carbon of fossil origin amounted to about 0.9 Mton in 1990. Since 1990 the amount of waste incinerated has risen as a result, among other reasons, of the prohibition on landfilling combustible waste. The consolidated figures given below are used in the calculations and include only the incinerated waste streams containing fossil carbon. In addition to incineration in WIPs, the figures include ship-cleaning residues (residues in tanks), hazardous waste (Afval Verbranding Rijnmond: AVR) and industrial waste incinerated on site by companies. Used oil is also incinerated; these emissions are already incorporated into the statistics to prevent double accounting. Table 3.8 contains the figures for 1995.

Table 3.8 CO<sub>2</sub> emissions from waste incineration, total and by waste stream for 1995<sup>15</sup>

A	B	C	D	E	F
Type of waste	C content	Share of fossil C in total C	Amount (1995) [kton]	= B * C * D Amount of fossil C [kton]	= 44/12 * E Emissions of fossil CO <sub>2</sub> [kton]
WIP: plastics	0.56	1.00	319.2	178.8	655
WIP: textiles	0.41	0.50	59.8	12.2	45
WIP: carpets/mats	0.30	0.90	10.8	2.9	11
WIP: leather/rubber	0.48	0.20	27.0	2.6	10
WIP: special wastes	0.01	1.00	7.2	0.1	0
Waste from ships	0.84	1.00	15	12.6	46
Hazardous waste (AVR)	0.20	0.90	210	37.8	139
Industrial wastes (own incineration)	0.20	0.80	440	70.4	258
<b>TOTAL</b>				<b>317</b>	<b>1162</b>

source: RIVM

<sup>15</sup> Example calculation: the latest data set may differ slightly from the values given here.

## 4. EMISSIONS OF METHANE (CH<sub>4</sub>)

This chapter describes the determination of CH<sub>4</sub> emissions in the Netherlands for each IPCC category. These total about 1000 kton and have a greenhouse effect equivalent to more than 20 Mton CO<sub>2</sub>. The most important sources of CH<sub>4</sub> emissions are enteric fermentation, landfills and the production and distribution of gas. Combustion emissions are calculated using data from the NEH and emission factors from the ER-C system. CH<sub>4</sub> emissions from onshore and offshore production of oil and gas are calculated separately. Calculations of CH<sub>4</sub> emissions from agricultural activities are based on the CH<sub>4</sub> background document (van Amstel *et al.*, 1993) and agricultural statistics on livestock and manure production (CBS agricultural statistics). CH<sub>4</sub> emissions from solid waste disposal sites are calculated using an RIVM file on landfill sites and a time-dependent decomposition function described by Coops *et al.* (1995). Natural CH<sub>4</sub> emissions from the soil (including agricultural land) are discussed in Annex H and are calculated using the method described in the report by van Amstel *et al.* (1993). Natural emissions are not included in the total figure for CH<sub>4</sub> emissions in the Netherlands.

### 4.1 CH<sub>4</sub> emissions from the combustion of energy carriers [1A]

The fuel combustion category accounts for about 3% of total CH<sub>4</sub> emissions. The method for determining the amounts of energy carriers that are burned per economic sector has been described in section 3.1. The CH<sub>4</sub> emission factors for the combustion of energy carriers are derived from the total emission factors for volatile organic compounds (VOC profiles), which can vary from sector to sector. It is assumed that a certain fraction of the total VOC emissions consists of CH<sub>4</sub>, depending on the type of fuel and combustion process (Table 4.1). Some emission factors for total VOC are measured directly (for large point sources), others have been derived from the literature (Bakkum *et al.*, 1987, for the stationary sources, and Veldt and van der Most, 1993, for the mobile sources). Emissions from the combustion of wood and woody biomass for power generation are only calculated for households; other emission from the combustion of biomass are not yet included.<sup>16</sup>

Table 4.1 CH<sub>4</sub> as a fraction of the emission factor for total VOC

Type of source	Fuel type	Fraction of total VOC
Stationary	Coal and coal products	0.50
	Wood	0.25
	All liquid oil products	0.20
	Natural gas	0.60
	LPG	0.35
	Other gases	0.35
Mobile	Petrol without catalytic converter	0.05
	Petrol with catalytic converter	0.12
	Diesel	0.04
	LPG	0.03
	Moped petrol	0.05
	Jet turbine	0.10
	All other oil products	0.20
	Other	0.05

source: Bakkum *et al.* (1987), Veldt and van der Most (1993)

### 4.2 Fugitive emissions of CH<sub>4</sub> from the production, transmission and distribution of oil and gas [1B2]

<sup>16</sup> Under the IPCC guidelines, national greenhouse gas emissions must be calculated using fuel delivery figures. Section 5.2 contains details on converting emissions from the Transport target group for national use, which are based on vehicle-kilometres travelled, into emissions calculated according to international guidelines (IPCC, ECE/CLRTAP) based on fuel deliveries to road transport.

Fugitive emissions from the oil and gas industry amount to about 170 kton, of which about half is vented from offshore natural gas production and about 70 kton are leaks from natural gas distribution networks. Losses of natural gas during gas transmission (Gasunie) and emissions from onshore energy production are relatively small sources of CH<sub>4</sub> emissions.

#### 4.2.1 Oil and gas production [1B2c]

A distinction is made between oil and gas production and between onshore and offshore production. In the production of energy carriers, CH<sub>4</sub> is released during flaring and venting of gas. The volume of emissions has been estimated in various publications. Although not all emissions are directly linked to the production of oil and gas, emissions can be estimated using emission factors and production volumes:

$$\text{CH}_4 \text{ emissions (kton)} = \text{emission factor (kton/m}^3 \times 10^6) * \text{production volume (m}^3 \times 10^6)$$

In these estimates the emission factor is expressed in kton CH<sub>4</sub> per billion m<sup>3</sup> natural gas or per million m<sup>3</sup> oil. Production volumes must also be known and these are supplied by the National Mines Inspectorate (Staatstoezicht op de Mijnen). Table 4.2 gives an example for 1994.

Table 4.2 Oil and gas production volumes, 1994<sup>17</sup>

	Oil production [m <sup>3</sup> x 10 <sup>9</sup> (st)]			Gas production [m <sup>3</sup> x 10 <sup>9</sup> ]		
	NAM	Others	Total	NAM	Others	Total
Onshore	1.128	0.090	1.218	47.24	7.62	54.86
Offshore	0.909	1.896	2.805	10.64	12.91	23.55
TOTAL	2.307	1.986	4.023	57.88	20.53	78.41

source: Ministerie van EZ (1991–1995), Staatstoezicht op de Mijnen (1996)

The CH<sub>4</sub> emission factors are shown in Table 4.3 and derived from information in a study by Oonk and Vosbeek (1995), NAM annual environmental reports and production figures in the annual reports of the National Mines Inspectorate. These are broken down into:

- Onshore and offshore production, which can differ considerably. For example, residual gas or process gas arising from gas conditioning or as gas associated with offshore oil production should preferably be vented to the atmosphere instead of being flared. Onshore, however, almost all this gas is flared.
- Oil and gas: gas arising from oil production is different from natural gas.
- NAM and other production companies (after 1990): NAM is the dominant company in onshore production. In its annual environmental report, NAM states that its CH<sub>4</sub> emissions have declined sharply since 1990 as a consequence of technical measures taken. This information is not available for the other companies.<sup>18</sup>

<sup>17</sup> Example calculations; the most recent data set may differ slightly from the values shown here.

<sup>18</sup> This information is no longer used in the current calculation method; aggregated data from Table 4.3 are used instead (including an update for 1993). Calculations of methane emissions for 1995 and subsequent years also use the reported figures for actual reductions achieved by technical measures, as published in the progress report on the voluntary agreement on 'Implementing environmental policy for the oil and gas production industry' by NOGEP (Netherlands Oil and Gas Exploration and Production Association). The reported reductions are subtracted from the emissions calculated from the ('gross') emission factors used since 1995 (1993).

Table 4.3 CH<sub>4</sub> emission factors for oil and gas production

	Emission factors in 1990		Units/remarks
	Offshore	Onshore	
Gas production: range	<b>2.97–5.10</b>	<b>0.16–0.31</b>	Kton CH <sub>4</sub> /m <sup>3</sup> × 10 <sup>9</sup> gas Middle range Oonk-Vosbeek
Average:	4.04	0.24	
- vents	3.64	0.177	
- flares	0.00	0.027	
- other process emissions	0.27	0.027	
- power generation	0.13	0.009	
Oil production: range	<b>2.88–3.03</b>	<b>4.7–5.2</b>	Kton CH <sub>4</sub> /m <sup>3</sup> × 10 <sup>6</sup> (st) oil Middle range Oonk - Vosbeek
Average:	<b>2.95</b>	<b>5.0</b>	
- vents	2.55	3.9	
- flares	0.11	0.5	
- other process emissions	0.11	0.2	
- power generation	0.18	0.4	
Emission factors since 1993 <sup>19</sup>			
	Offshore	Onshore	Units/remarks
Gas production: range	<b>2.97–5.10</b>	<b>0.045–0.075</b>	Kton CH <sub>4</sub> /m <sup>3</sup> × 10 <sup>9</sup> gas from NAM annual report
NAM	<b>3.15</b>	<b>0.048</b>	
Not NAM:	<b>4.04</b>	<b>0.060</b>	Middle range Oonk-Vosbeek
- vents	3.64	0.003	
- flares	0.00	0.023	
- other process emissions	0.27	0.023	
- power generation	0.13	0.011	
Oil production: range	<b>1.45–2.90</b>	<b>1.3</b>	kg CH <sub>4</sub> /m <sup>3</sup> × 10 <sup>6</sup> (st) oil based on NAM annual report
NAM	<b>1.54</b>	<b>1.3</b>	
Not NAM	<b>2.18</b>	<b>1.3</b>	Middle range Oonk-Vosbeek
- vents	1.78	0.1	
- flares	0.11	0.6	
- other process emissions	0.11	0.2	
- power generation	0.18	0.4	

source: Oonk and Vosbeek (1995)

#### 4.2.2 Gas transmission [1B2b]

It is assumed that CH<sub>4</sub> process emissions from the Gasunie's high-pressure transmission networks arise from the use of natural gas in technical maintenance processes such as the flushing of gas compressors as well as incidental start-up and breakdown emissions. Leaks play no role in the calculation. The CH<sub>4</sub> emissions are calculated using the following formula:

$$\text{CH}_4 \text{ emissions (kton)} = \text{loss}_{(\text{TRANSMISSION})} (\%) * \text{gas transmission (m}^3) * 0.583$$

$$\text{kg CH}_4 / \text{m}^3 * 10^{-6}$$

These emissions have been estimated for some years by Gasunie and are declining under the influence, among other factors, of recompression. Gasunie has reported that flushing losses in 1994 were about 10 million m<sup>3</sup>. As a proportion of the total transmission volume of 78.4 billion

<sup>19</sup> Under the present method onshore and offshore gas production figures for 1993 and after are calculated using 'gross' emission factors of 3.65 and 0.24 kton CH<sub>4</sub>/m<sup>3</sup> × 10<sup>9</sup> gas used instead of the values given in the table, which for 1995 and after have been corrected for actual reductions (as described in the previous footnote).

m<sup>3</sup> this is a loss of 0.013%. Annual CH<sub>4</sub> emissions are 5 to 6 kton. Table 4.4 shows the change in loss percentages, based on the estimated penetration of reduction techniques and the dataset of gas compressors.

#### 4.2.3 Gas distribution [1B2b]

Of the approx. 80 billion m<sup>3</sup> of gas traded and transmitted by Gasunie each year, about half is exported and more than 40 billion m<sup>3</sup> is for domestic use. Half the domestic deliveries are supplied directly by Gasunie to large industrial consumers and power stations. The remaining domestic gas consumption, more than 20 billion m<sup>3</sup>, is supplied to local energy companies which deliver it to 'small' consumers via their gas distribution network. Many urban areas are still served by old cast iron pipes, originally intended for town gas. These pipes are particularly prone to leaks and are responsible for about 70 kton of CH<sub>4</sub> emissions. These emissions will fall as the pipes are replaced, for example in urban renewal projects. The following formula is used to calculate the CH<sub>4</sub> emissions:

$$\text{CH}_4 \text{ emissions (kton)} = \text{losses (DISTRIBUTION) (\%)} * \text{gas distribution (m}^3\text{)} * 0.583 \text{ kg CH}_4 / \text{m}^3 * 10^{-6}$$

This takes no account of any partial oxidisation of CH<sub>4</sub> in the soil (for example by bacteria) before the CH<sub>4</sub> is emitted to the air. Nielen (1991) has calculated an aggregated leakage percentage of 0.6% for the total distribution volume. Table 4.4 shows the estimated change in loss percentages as old urban gas mains pipelines are replaced.

Table 4.4 Percentage loss (%) of natural gas during gas transmission and distribution, 1980–1995<sup>20</sup>

	1980	1985	1990	1991	1992	1993	1994	1995
Transmission	0.020	0.018	0.015	0.0145	0.014	0.0135	0.013	0.0125
Distribution	0.70	0.65	0.60	0.58	0.56	0.54	0.52	0.50

source: AER Methods report 1996 (1997)

#### 4.2.4 CH<sub>4</sub> process emission from refineries [1B2a]

In refineries VOC are emitted during process treatment and the storage and transhipment of products. An average VOC profile for refinery process emissions has been obtained from measurements, which show that the proportion of CH<sub>4</sub> by mass in total VOC process emissions is about 4%. The emissions can thus be calculated as follows:

$$\text{CH}_4 \text{ process emissions (kton)} = 0.04 * \text{VOC process emissions (kton)}$$

At the current level of about 12 kton VOC emissions, CH<sub>4</sub> process emissions amount to about 0.5 kton.<sup>21</sup>

#### 4.3 CH<sub>4</sub> emissions from enteric fermentation [4A]

Fermentation of food in the gastrointestinal tract of animals produces methane, which escapes to the atmosphere via the mouth and anus. The IPCC guidelines contain emission factors for emissions from livestock based on the weight of the animals and the ingestion of energy via feed. Table 4.5 contains the calculated emission factors for the Netherlands. The method of calculation is described in more detail in van Amstel *et al.* (1993). The recommended emission

<sup>20</sup> Including loss factors for the years after 1995. For 1998 and subsequent years the loss percentage is assumed to be constant.

<sup>21</sup> From 1999 the process emissions of CH<sub>4</sub> from all refineries are taken directly from the ER-I (as reported in their annual environmental reports).

factors for other animal species have been adopted from IPCC. Livestock numbers are taken from the Dutch agricultural statistics ('May survey').

Table 4.5 *CH<sub>4</sub> emission factors for enteric fermentation in the Netherlands (1994 data for illustrative purposes)*<sup>22</sup>

Animal type	1994		
	Emission factor [kg/animal/year]	No. animals (* 1000)	Emissions [kton]
Dairy cattle			
- young cattle <1 yr	49.25	735	36.2
- young cattle, female > 1 yr	62.80	803	50.4
- dairy cows	102.13	1698	173.4
- bulls > 1 yr	93.22	41	3.8
Beef cattle			
- fattening calves <1 yr	17.65	690	12.2
- young fatstock	87.01	603	52.5
- fattening and grazing cows >2 yr	102.13	146	14.9
Sheep	8.00	1762	14.1
Goats	8.00	63	0.5
Pigs	1.50	14400	21.6
Horses	18.00	100	1.8
<b>Total</b>			<b>381.7</b>

source: van Amstel *et al.* (1993)

#### 4.4 CH<sub>4</sub> emissions from manure management [4B]

CH<sub>4</sub> emissions from animal manure arise from fermentation during anaerobic storage of the manure. These conditions occur when manure is stored in tanks or silos or in slurry pits under animal sheds. During the grazing period some of the livestock are still kept indoors and fed with freshly mown grass and it is estimated that about 30% of the manure produced during the grazing period is stored in tanks, silos or slurry pits. Emission factors have been determined according to the IPCC method for the volatile fraction and the emission potential of various types of manure. For the Netherlands it is assumed that the emitted CH<sub>4</sub> fraction is a smaller proportion of the potential than the IPCC standard values (dairy cattle 5%, others 10%). The resulting emission factors and the emission calculations for 1994 are shown in Table 4.6. The manure production figures and the amounts of stored manure are based on the results of recent research by LEI-DLO, IKC-Landbouw, RIVM and CBS (van der Hoek *et al.*, 1997).

Table 4.6 *CH<sub>4</sub> emission factors for the storage of animal manure in the Netherlands (1994 data for illustrative purposes).*

Animal type	1994		
	Emission factor (kg/m <sup>3</sup> )	Volume of manure (* 10 <sup>6</sup> m <sup>3</sup> )	CH <sub>4</sub> emissions [kton]
Dairy cattle	0.698	33.09	23.1
Beef cattle	2.534	4.78	12.1
Sheep and goats	2.979	0.27	0.8
Fattening calves	2.534	2.41	6.1
Pigs	3.009	16.38	49.3
Poultry	4.110	2.24	9.2
<b>Total</b>		<b>59.2</b>	<b>100.6</b>

source: van der Hoek *et al.* (1997)

<sup>22</sup> Example calculation; the most recent data set may differ slightly from the values given here.

#### 4.5 CH<sub>4</sub> emissions from solid waste disposal on land [6A]

Emissions of CH<sub>4</sub> are calculated using an RIVM model which includes data on the amount and composition of landfilled waste. The calculation method was developed earlier by Hoeks (1983) and described in Coops *et al.* (1995). It is based on an equation for landfill gas produced per ton of landfilled waste.

$$A = f * k * P * e^{-k * t}$$

where:

- A = gas production (in ton C per ton landfilled waste per year)
- F = the fraction of biodegradable organic carbon that is actually broken down. For the Netherlands this factor has been set at 0.58.
- K = decomposition constant of 0.094 per year (half-life is 7.4 years) to 1990. From 1990 to 1995 this falls to 0.0693 (half-life 10 years) in connection with the increasing recycling of kitchen and garden waste and other wastes. After 1995 the constant is 0.0693.
- P = the concentration of biologically decomposable organic carbon in landfilled waste in the year of disposal (in ton C/ton waste)
- T = time since disposal (in years)

The assumption is that waste landfilled before 1990 contains 0.132 ton biodegradable organic carbon per ton of waste (P); this fraction fell to 0.120 ton C/ton waste from 1990 to 1996 as a result, among other reasons, of the prohibition on landfilling combustible waste.<sup>23</sup> Further, 60% of the carbon in landfill gas is in the form of CH<sub>4</sub> and the remaining 40% is in the form of CO<sub>2</sub> (short cycle). The conversion factor from mass C to mass CH<sub>4</sub> is 16/12. From this, gross CH<sub>4</sub> production can be calculated for year t after the waste is landfilled:

$$\text{CH}_4 \text{ (GROSS)}(t) \text{ (kton)} = A(t) * \text{amount landfilled (t) (kton)} * 0.6 * 16/12$$

Landfill gas recovery is removing an increasing amount of this gross gas production. Of the non-recovered gas it is assumed that 10% of the CH<sub>4</sub> is oxidised in the outer layers of the landfill and 90% is emitted to the atmosphere. The CH<sub>4</sub> emissions are calculated as follows:

$$\text{CH}_4 \text{ emissions (kton)} = [(\text{t CH}_4(\text{GROSS}) (t) \text{ (kton)} - \text{landfill gas recovery (kton)}) * 0.9$$

The total gross production of landfill gas in one year from waste landfilled in the past is calculated by integrating production over all years. The CH<sub>4</sub> formed is derived mainly from waste landfilled in the past. Table 4.7 gives the emissions and recovery of landfill gas from 1970 to 1996.

#### 4.6 CH<sub>4</sub> emissions from Waste Water Treatment Plants [6B] <sup>24</sup>

The amount of pollution in wastewater is often expressed as 'inhabitant equivalent'. Wastewater treated by a Waste Water Treatment Plant (WWTP) comprises domestic wastewater, industrial wastewater and possibly rain water. The wastewater is received from the sewer system. Most WWTPs (and thus also most of the polluted wastewater) apply biological treatment, along with other treatment processes. When the wastewater is treated biologically, sludge is separated from the wastewater. This sludge is often dehydrated and stabilised by fermentation. During the fermentation process methane is formed, the largest fraction of which is utilised as fuel. The fraction not used for energetic purposes is vented or flared. Thus, CH<sub>4</sub> (and CO<sub>2</sub>) emissions

<sup>23</sup> This text is an amended version of the original publication in 1997.

<sup>24</sup> Section 4.6 has been added compared with the original publication in 1997.

occur when the fermentation gases are vented in the atmosphere. For calculating methane emissions from WWTPs an emission factor of  $0.71 \times 0.65 = 0.462$  kg CH<sub>4</sub> per m<sup>3</sup> of gas vented is used (WESP, 1993).

#### 4.7 CH<sub>4</sub> emissions from soil [nature]<sup>25</sup>

Under anaerobic conditions, CH<sub>4</sub> is formed in wet soils (including agricultural land) and shallow waters. These are natural emissions and not a subject of climate policy, and so they are not discussed in this chapter. Nevertheless, the IPCC guidelines ask countries to provide an estimate of natural, non-anthropogenic CH<sub>4</sub> emissions. The estimation method for the Netherlands is described in Annex H.

Table 4.7 CH<sub>4</sub> emissions from landfill sites, 1970–1996<sup>26</sup>

Year	Landfilled waste [Mton]	Organic carbon [ton/ton]	Landfill gas recovery [10 <sup>6</sup> m <sup>3</sup> ]	CH <sub>4</sub> emissions [kton]
1970	5.9	0.132	0	184
1971	6.4	0.132	0	195
1972	6.9	0.132	0	208
1973	7.3	0.132	0	222
1974	7.8	0.132	0	236
1975	8.3	0.132	0	252
1976	8.8	0.132	0	269
1977	9.2	0.132	0	286
1978	9.7	0.132	0	304
1979	10.1	0.132	0	322
1980	10.6	0.132	0	341
1981	11.7	0.132	5	358
1982	12.9	0.132	10	379
1983	14.0	0.132	15	404
1984	15.2	0.132	20	431
1985	16.3	0.132	25	462
1986	15.8	0.132	33	493
1987	15.3	0.132	40	519
1988	14.9	0.132	48	541
1989	14.0	0.132	56	558
1990	14.0	0.131	64	562
1991	12.0	0.130	87	556
1992	11.0	0.129	111	540
1993	11.0	0.127	134	522
1994	9.0	0.126	158	505
1995	9.0	0.125	182	479
1996	7.0	0.120	199	464

source: RIVM (1997)

(Data have been collated in close consultation with Ecofys, Grontmij, J. Hoeks, RIVM, TNO and VVAV)

<sup>25</sup> Section 4.6 has been added since the original report published in 1997.

<sup>26</sup> Example calculation; the most recent data set may differ slightly from the values given here.



## 5 EMISSIONS OF NITROUS OXIDE (N<sub>2</sub>O)

In the Netherlands about 50–60 kton of N<sub>2</sub>O are emitted each year, with a greenhouse gas effect equivalent to about 15–18 Mton CO<sub>2</sub>. The most important emission sources are agricultural soils (animal and artificial fertilisers) and industrial processes (mainly the production of nitric acid). Emissions of N<sub>2</sub>O from road traffic are growing, primarily because of the increasing use of the three-way catalytic converter. The method for calculating N<sub>2</sub>O emissions is described in detail in the background document by Kroeze (1994). It should be noted that estimated N<sub>2</sub>O emissions are relatively uncertain compared with CO<sub>2</sub> and CH<sub>4</sub>. In addition to the standard IPCC categories, two other sources of anthropogenic N<sub>2</sub>O emissions are found in the Netherlands: polluted surface waters and waste water treatment plants (WWTPs).

### 5.1 N<sub>2</sub>O emissions from stationary combustion [1A]

Stationary combustion in the Netherlands generates about 1% of total N<sub>2</sub>O emissions. Emissions of N<sub>2</sub>O from stationary combustion are mainly from coal-fired power stations and to a lesser degree from refineries. All emissions from power stations and refineries are registered in the ER-I. Stationary combustion emissions not included in the ER-I are calculated using the standard formula:

$$\text{N}_2\text{O emissions (kton)} = \text{emission factor (gram/GJ)} * \text{fuel combustion (PJ)} * 10^{-3}$$

Figures for fuel consumption per sector are derived from the NEH. The emission factors used are aggregated and relate to the energy carrier phase (solid, liquid, gas), see Table 5.1.

Table 5.1 N<sub>2</sub>O emission factors for stationary combustion

Fuel type	Fuel	Emission factor [gram / GJ]
Solid <sup>27</sup>	coal, coke, petcoke, biomass for energy, including wood (households)	1.4
Liquid	all oil, tar oil from coking plants	0.6
Gas	natural gas, chemical residual gases, coke and blast furnace gas, refinery gas	0.1

source: IPCC (1995)

### 5.2 N<sub>2</sub>O emissions from mobile sources [1A3]

The formula given in section 5.1 is also used to calculate N<sub>2</sub>O emissions from the combustion of motor fuels in the transport sector. The energy-specific emissions (g/GJ) depend on the type of vehicle and type of fuel. Emissions from passenger cars with petrol engines also depend on the year of manufacture because passenger cars with petrol engines have been fitted with a catalytic converter, under European emissions legislation ('Eurostandardisation'), since the beginning of the 1990s and the first generation catalytic converters emitted more N<sub>2</sub>O than the current generation. In its guidelines for the calculation of national greenhouse gas emissions, the IPCC requires the use of fuel delivery figures. However, the Netherlands Energy Statistics (NEH) produced by CBS only records domestic deliveries of motor fuels in a highly aggregated form, per type of fuel. This means that for road transport only the total deliveries of petrol, diesel and LPG are known and not, for example, the amount of fuel consumed by passenger cars. The corresponding energy-specific N<sub>2</sub>O emission factor per fuel type must, therefore, be determined using bottom-up calculations of energy use and N<sub>2</sub>O emission factors, both for the Dutch national territory. This requires detailed information on the number of kilometres travelled, fuel consumption per travelled kilometre and N<sub>2</sub>O emission factors. A description of the way this detailed information is collected can be found in the methodology report by the transport task force (VROM, 2002).<sup>28</sup> Table 5.2.a lists the N<sub>2</sub>O emissions per kilometre used to

<sup>27</sup> With the exception of coke and coal, which are used in the iron and steel industry in the production of pig iron as a reducing agent and not as a fuel, and the non-energetic use of petcoke.

<sup>28</sup> Section 5.2 has been completely revised since with the original publication in 1997.

calculate the N<sub>2</sub>O emissions from road vehicles in the Netherlands. The emission factors for passenger cars are based on recent measurements of passenger cars by TNO-WT; the emission factors for other categories of road vehicles are the same as the IPCC default figures. As yet unpublished research by the Road Vehicles Research Institute (TNO-WT) reveals that diesel engines fitted in lorries, tractors and buses emit hardly any N<sub>2</sub>O, in any case considerably less than suggested by the IPCC defaults. This information has not yet been incorporated into the tables shown below. Table 5.2.b lists the N<sub>2</sub>O emissions per unit of energy use. The emission factors in this table have been multiplied by the energy delivery figures.

Table 5.2.a N<sub>2</sub>O emissions per kilometre travelled by road vehicles (mg/km)

Vehicle type	Fuel	Year of manufacture (indicative)	Type of road built-up area		
			rural roads	motorways	
Passenger cars	petrol	to 1993 (no cat. conv.)	5	5	5
		1993–1996 (Euro1)	40	20	20
		1996–2000 (Euro2)	25	5	5
		from 2000 (Euro3)	10	5	5
	diesel	to 1993 (conventional)	5	5	5
		1993–1996 (Euro1)	5	5	5
		1996–2000 (Euro2)	10	10	10
		from 2000 (Euro3)	10	10	10
	LPG	to 1993 (no cat. conv.)	5	5	5
		1993–1996 (Euro1)	40	20	20
		1996–2000 (Euro2)	25	5	5
		from 2000 (Euro3)	10	5	5
Delivery vans	petrol	all years	ditto passenger cars		
	diesel	all years	20	20	20
	LPG	all years	ditto passenger cars		
Lorries	diesel	all years	30	30	30
Tractors	diesel	all years	30	30	30
Buses	diesel	all years	30	30	30
Motorbikes	petrol	all years	2	2	2
Mopeds	petrol	all years	1	1	1

sources: passenger cars (based on Gense and Vermeulen, 2002), others (IPCC defaults)

Table 5.2.b N<sub>2</sub>O emission factors per transport category per type of fuel (g/GJ)

	1990	1995	1999	2000	2001
road vehicles, petrol	3.3	6.0	5.4	5.1	4.8
road vehicles, diesel	2.8	2.9	3.4	3.5	3.6
road vehicles, LPG	3.7	7.7	7.3	7.0	6.5
inland shipping <sup>a)</sup>	1.9	1.9	1.9	1.9	1.9
aviation <sup>b)</sup>	2.4	2.4	2.4	2.4	2.4
rail transport <sup>a)</sup>	1.9	1.9	1.9	1.9	1.9
mobile machines <sup>a)</sup>	1.9	1.9	1.9	1.9	1.9

<sup>a)</sup> based on the IPCC default of 0.08 g/kg fuel and a calorific value of 42.7 MJ/kg

<sup>b)</sup> based on the IPCC default of 0.10 g/kg fuel and a calorific value of 43.4 MJ/kg

The N<sub>2</sub>O emission factors for road vehicles with petrol and LPG motors (mostly passenger cars) rose between 1990 and 1995 as a result of the market penetration of regulated three-way catalytic converters, which are prone to form N<sub>2</sub>O, particularly during cold start-ups. After 1995, the emission factor for these road vehicles declined slightly because newer generations of regulated three-way catalytic converters emit less N<sub>2</sub>O (see Table 5.2.b). The rise in the N<sub>2</sub>O emission factor for road vehicles with diesel engines can be explained by changes in the

composition of road traffic (more delivery vans) and because new passenger cars with diesel engines have to be fitted with an oxidizing catalytic converter which, like the regulated three-way catalytic converter for petrol and LPG engines, leads to higher N<sub>2</sub>O emissions.

### 5.3 N<sub>2</sub>O emissions from industrial processes [2]

A number of companies in the Netherlands produce nitric acid. The production process involves the release of N<sub>2</sub>O. All these emissions are registered in the ER-I and are based, in the absence of a structured measurement programme, on aggregated emission factors and nitric acid production volumes. Annual N<sub>2</sub>O emissions from this process are calculated using the following formula:

$$\text{N}_2\text{O emissions (kton)} = \text{emission factor (kg/ton)} * \text{production (kton)} * 10^{-3}$$

Nitric acid production is expressed in kton HNO<sub>3</sub> and the emission factor in kg N<sub>2</sub>O per ton produced. About 3.0 Mton of nitric acid are produced each year in the Netherlands. NO<sub>2</sub> process emissions from nitric acid production plants in the Netherlands have been measured in recent research conducted for RIVM. In 1995 emissions in the Netherlands were 24–29 kton N<sub>2</sub>O, which gives an emission factor of 9.0 kg N<sub>2</sub>O per ton of nitric acid.<sup>29</sup> In the IPCC guidelines this emission factor is given as the upper limit for the standard factors to be used and is a value measured in a production process without an end-of-pipe NSCR (non-selective catalytic reduction). This conforms closely with the measured emission factor in the Netherlands, where this emission-reducing option is not used in nitric acid production.

Annual emissions from the production of caprolactam, acrylonitrile and catalytic cracking of oil are 4–6.2 kton. A figure for these emissions is determined each year and lies within the range 5 ± 1 kton N<sub>2</sub>O.<sup>30</sup>

### 5.4 N<sub>2</sub>O emissions from the use of products [3]

The only known use of N<sub>2</sub>O as a product is as an anaesthetic in hospitals and as a propellant in aerosol cans (mainly whipped cream). Emissions of N<sub>2</sub>O anaesthetic are declared each year by a major supplier of gases (fa Hoekloos). In recent years lower dosages and the increasing popularity of spinal anaesthesia have led to a gradual decline in sales, from 500 ton (0.5 kton) N<sub>2</sub>O in 1995 (Kroeze, 1994) to 280 ton in 2000. It is assumed that all cases of its use result in emissions to the atmosphere. Emissions from aerosol cans are calculated by multiplying sales figures for the number of food aerosol cans, obtained from the annual report of the Dutch Aerosol Association, by an average amount of gas per can (7.6 g). In 2000 emissions were 117 ton N<sub>2</sub>O.<sup>31</sup>

### 5.5 N<sub>2</sub>O emissions from agriculture (excluding combustion emissions) [4B, 4D]

Agricultural emissions of N<sub>2</sub>O occur in the categories manure [4B] and agricultural soils [4D]. Within these categories, 6 emission sources can be identified:

1. increased background emissions from agricultural soils caused by lowering of the water table and past use of manure and synthetic fertilisers;
2. emissions from the use of synthetic fertilisers on agricultural soils;
3. direct emissions from livestock urine and faeces on the soil;
4. emissions from anaerobic storage of manure (silos, tanks and slurry pits);
5. emissions from agricultural soils originating from manure that has been spread, injected or worked into the soil;
6. emissions from horticultural production.

<sup>29</sup> Since the NIR 2002 emissions of nitrous oxide in the Netherlands have been calculated using company-specific emission factors determined using concentration measurements and debit factors. Based on these company-specific emission factors, N<sub>2</sub>O emissions in the Netherlands in 2000 were 19 kton.

<sup>30</sup> Since the NIR 2000 these emissions have been set at 4 kton N<sub>2</sub>O per year.

<sup>31</sup> Section 5.4 has been expanded since the original 1997 report to include information on emissions from aerosol cans.

These are discussed in the following sections. In the target group classification source 4 is counted as an emission and the other emission sources, 1, 2, 3, 5 and 6, are considered to be transfers. Transfers are material flows from one environmental compartment to another which cannot be attributed directly to a source.

### 5.5.1 Increased background emissions from agricultural soils [4D]

Kroeze (1994) has calculated that the anthropogenic increase in background emissions from agricultural soils is about 4.7 kton N<sub>2</sub>O per year. This figure is the difference between the estimated current total background emissions of about 7 kton per year and the natural background emissions of about 2.3 kton. The higher background emissions are due to anthropogenic activities because they are caused by a lowering of the water table and past applications of synthetic fertilisers. These values hardly vary at all from year to year and so for the time being the figure for these emissions of 4.7 kton can be considered to be constant.

### 5.5.2 Emissions from the use of synthetic fertilisers [4D]

The calculations by Kroeze (1994) are based on a mass balance approach to nitrogen (N), which is finally converted to N<sub>2</sub>O in a ratio of 44/28. The steps in the calculation are shown in Table 5.3, with loads for individual years (figures between brackets are for 1994 as an example):

Table 5.3 Method for calculating N<sub>2</sub>O emissions from the use of artificial fertilisers<sup>32</sup>

Step	[1994]
A. Total consumption of nitrogen fertiliser is determined (in N)	[372.0 kton]
B. Fugitive emissions of ammonia = 2% of A (in N)	[7.4 kton]
C. It is assumed that 90% of (A-B) is applied to mineral soils (in N)	[328.1 kton]
D. It is assumed that 10% of (A-B) is applied to organic soils (in N)	[36.5 kton]
E. Emissions of N <sub>2</sub> O from mineral soils is 1% of C (in N)	[3.3 kton]
F. Emissions of N <sub>2</sub> O from organic soils is 2% of D (in N)	[0.7 kton]
G. Total emissions of N <sub>2</sub> O due to the use of synthetic fertilisers is (E+F) (in N)	[4.0 kton]
H. Total emissions of N <sub>2</sub> O due to the use of synthetic fertilisers is 44/28 * G (in N <sub>2</sub> O)	[6.3 kton]

source: Kroeze (1994)

Summarizing from Table 5.3:

$$\begin{aligned} \text{N}_2\text{O emissions (kton)} &= 44/28 * [0.01 * 0.9 * 0.98 * A + 0.02 * 0.1 * 0.98 * A] \\ &= 0.0169 * \text{total consumption of nitrogen fertiliser (kton N)} \end{aligned}$$

<sup>32</sup> Example calculation; the most recent data set may differ slightly from the values given here.

### 5.5.3 Emissions from livestock urine and faeces (excretion) on land [4B]

The mass balance approach for nitrogen is also used for this item. The calculation is as follows (Table 5.4; figures between brackets are for 1994 for illustrative purposes):

Table 5.4 Method for calculating N<sub>2</sub>O emissions from livestock urine and faeces on land<sup>33</sup>

Step	[1994]
A. Total manure production (in N)	[648.0 kton]
B. Proportion deposited on land during the grazing period = 25% of A (in N)	[162.0 kton]
C. From this, fugitive emissions of ammonia N = 8% of B (in N)	[12.9 kton]
D. Fraction of urine in the net deposition on land = 60% of (B-C) (in N)	[89.4 kton]
E. Fraction of faeces in the net deposition on land = 40% of (B-C) (in N)	[59.6 kton]
F. Emissions of N <sub>2</sub> O N from urine is 2% (in N)	[1.8 kton]
G. Emissions of N <sub>2</sub> O N from faeces is 1% (in N)	[0.6 kton]
H. Total N <sub>2</sub> O N emissions from livestock urine and faeces on land = (F+G) (in N)	[2.4 kton]
J. Total N <sub>2</sub> O emissions from urine and faeces is 44/28 * H (in N <sub>2</sub> O)	[3.8 kton]

source: Kroeze (1994)

Summarizing from 5.4:

$$\begin{aligned} \text{N}_2\text{O emissions (kton)} &= 44/28 * [0.02 * 0.6 * 0.92 * 0.25 * A + 0.01 * 0.4 * 0.92 * 0.25 * A] \\ &= 0.0058 * \text{total manure production (in kton N)} \end{aligned}$$

### 5.5.4 N<sub>2</sub>O emissions from stored farmyard manure [4B]

A mass balance for nitrogen is also used to calculate emissions from stored farmyard manure (Table 5.5; figures between brackets are for 1994 for illustrative purposes). The emission factors used are not constants, but vary under the influence of policy and other factors. The variable emission factors are given in Table 5.6.

Table 5.5 Method for calculating N<sub>2</sub>O emissions from farmyard manure

Step	[1994]
A. Total manure production (in N)	[648.0 kton]
B. Proportion in the sheds = 75% of A (in N)	[486.0 kton]
C. From this, fugitive emissions of ammonia N from sheds = 14.4% of B (in N)	[70.2 kton]
D. And fugitive emissions of ammonia N from manure storage = 1.2% of (B-C) (in N)	[4.9 kton]
E. Remaining in storage = B-C-D (in N)	[410.9 kton]
F. Of this, biologically treated (in N)	[2.0 kton]
G. Remaining: anaerobic storage of manure = E-F (in N)	[408.9 kton]
H. Emissions of N <sub>2</sub> O N from biological treatment = 2% of F (in N)	[0.0 kton]
J. Emissions of N <sub>2</sub> O N from anaerobic storage = 0.1% of G (in N)	[0.4 kton]
K. Emissions of N <sub>2</sub> O from stored manure = 44/28 * (H+J) (in N <sub>2</sub> O)	[0.6 kton]

source: Kroeze (1994)

<sup>33</sup> Example calculation; the most recent data set may differ slightly from the values given here.

Table 5.6 Variable factors for calculating N<sub>2</sub>O emissions from farmyard manure

	1990	1991	1992	1993	1994	1995
D Ratio of ammonia emissions from stored manure (N/N)	0.010	0.010	0.011	0.012	0.012	0.008
F Amount of biologically treated manure [kton N]	0.0	1.0	1.0	1.0	2.0	2.0

source: Kroeze (1994)

Summarizing from Table 5.5:

$$\text{N}_2\text{O emissions (kton)} = 44/28 * \{[(1-D) * 0.856 * 0.75 * A - F] * 0.001 + 0.02 * F\}$$

This is about the same as 0.001 \* total manure production (in kton N).

### 5.5.5 N<sub>2</sub>O emissions from animal manure in agricultural soils [4B]

From 1991, manure has had to be injected or worked into agricultural soils, except the winter months (October to January, when manure may not be spread on fields). Until 1994 slurry was also sprayed onto the land. Anaerobic processes in the soil convert some of this manure into N<sub>2</sub>O, which is emitted to the air. The mass balance approach is used to calculate emissions of N<sub>2</sub>O from manure (Table 5.7). This starts with the amount of nitrogen in manure stored under anaerobic conditions, calculated using the formula given in section 5.5.4. Exogenous estimates of N lost in ammonia emissions are also required. The figures between brackets are for illustrative purposes and are for 1994. The figures and proportions used are not constants, but vary with time under the influence of policy and other factors (see Table 5.8).

Table 5.7 Method for calculating N<sub>2</sub>O emissions from manure in agricultural soils<sup>34</sup>

Step	[1994]
A. Amount of stored manure (= Table 5.5, G) (in N)	[408.9 kton]
B. Of this, exported (in N)	[18.0 kton]
C. Manure applied to agricultural soils in the Netherlands, gross = A-B (in N)	[390.9 kton]
D. Minus: ammonia N emissions from manure in agricultural soils (exogenous) (in N)	[37.3 kton]
E. Remainder: net manure in agricultural soils = C-D (in N)	[353.5 kton]
F. Of this, injected or worked into the soil = 80% of E (in N)	[294.1 kton]
G. Remainder: manure spread on soils = 20% of E (in N)	[59.5 kton]
H. Manure spread on mineral soils = 23% of G (in N)	[13.5 kton]
J. Manure spread on organic soils = 77% of G (in N)	[46.0 kton]
K. Emissions of N <sub>2</sub> O N from manure injected or worked into the soil = 2% of F (in N)	[5.9 kton]
L. Emissions of N <sub>2</sub> O N from manure spread on mineral soils = 1% of H (in N)	[0.1 kton]
M. Emissions of N <sub>2</sub> O-N from manure spread on organic soils = 2% of J (in N)	[0.9 kton]
N. Emissions of N <sub>2</sub> O from manure in agricultural soils = 44/28 * (K+L+M) (in N <sub>2</sub> O)	[10.8 kton]

source: Kroeze (1994)

<sup>34</sup> Example calculation; the most recent data set may differ slightly from the values given here.

Table 5.8 Factors and exogenous data used to calculate N<sub>2</sub>O emissions from manure on agricultural soils

		1990	1991	1992	1993	1994	1995
B	Exported manure (in kton N)	6.4	6.8	11.2	15.0	18.0	23.0
D	Emissions of ammonia from manure in agricultural soils (in kton N)	86.4	86.0	47.6	53.1	37.34	26.7
F	Fraction of manure that is injected or worked into the soil (N / N)	0.0	0.1	0.6	0.6	0.8	1.0
G	Fraction of manure that is spread on the soil = 1-F (N / N)	1.0	0.9	0.4	0.4	0.2	0.0
H	Fraction of manure that is spread on mineral soils (N / N)	0.87	0.86	0.67	0.67	0.23	-
J	Fraction of manure that is spread on organic soils	0.13	0.14	0.33	0.33	0.77	-

source: Kroeze (1994)

Summarizing from Table 5.7:

$$N_2O \text{ emissions (kton)} = 44/28 * [A-B-D] * [(0.02 * F) + (1-F) * \{0.01 * H + 0.02 * (1-H)\}] = 44/28 * [A-B-D] * [0.01 * (2-H+H * F)] \text{ (kton)}$$

#### 5.5.6 N<sub>2</sub>O emissions from horticultural production [4D]

This item covers N<sub>2</sub>O emissions from horticulture. The cultivation of leguminous crops increases the nitrogen content of the soil, which in turn leads to higher N<sub>2</sub>O emissions. Emission are calculated as a fixed fraction (1% N/N) of the total atmospheric nitrogen that is fixed in horticultural products:

$$N_2O \text{ emissions (kton)} = 0.0157 * \text{fixed nitrogen (kton)}$$

The emission factor is 44/28 \* 1% and the amount of fixed atmospheric nitrogen has been set at a constant level of 14 kton. The annual, constant, N<sub>2</sub>O emissions from this source are therefore 0.2 kton.

#### 5.6 N<sub>2</sub>O emissions from waste incineration [6C]

Emissions from waste incineration are registered in the ER-I. In addition to the regular measurements of macrocomponents, only incidental measurements have been made of N<sub>2</sub>O emissions (Spoelstra, 1993). An emission factor of 20 g per ton of incinerated waste has been determined. It is reasonable to assume that this factor is not constant but depends, among other variables, on the composition of the waste and the use of catalytic deNO<sub>x</sub> plants (these generally raise N<sub>2</sub>O emissions). However, no quantitative relations are known and so for the time being the above-mentioned emission factor is used for the calculations. For all years N<sub>2</sub>O emissions are calculated by:

$$N_2O \text{ emissions (kton)} = 20 * 10^{-6} * \text{amount of incinerated waste (kton)}$$

At the current level of about 4 Mton incinerated waste, N<sub>2</sub>O emissions are about 0.1 kton per year.

## 5.7 N<sub>2</sub>O emissions from wastewater handling [6B]

N<sub>2</sub>O emissions from water treatment arise because nitrogen is removed from the water. Most of this is in the form of ammonia (NH<sub>4</sub><sup>+</sup>), which is converted to N<sub>2</sub> and N<sub>2</sub>O in nitrification and denitrification processes. It is assumed that about 2% of the total nitrogen removals follow this route (Kroeze, 1994). Applying the conversion factor from N to N<sub>2</sub>O (= 44/28), 3.1% of the mass of the removed nitrogen is emitted as N<sub>2</sub>O. Figures for the amount of removed nitrogen are from CBS.

$$\text{N}_2\text{O emissions (kton)} = 0.031 * \text{amount of removed nitrogen (kton)}$$

## 5.8 N<sub>2</sub>O emissions from polluted surface water [7]

Anthropogenic activities cause pollution of surface waters by raising nitrogen levels, mainly through run-off and leaching of (synthetic) fertilisers from agricultural land. All waters in the territory of the Netherlands should be considered for IPCC reports, which means all inland waters and the coastal waters (to the 12 km limit). The emission factor is highly uncertain. Kroeze (1994) takes an average fraction of 1% of the nitrogen load to water emitted as N<sub>2</sub>O. Applying the conversion factor from N to N<sub>2</sub>O (= 44/28), 1.6% of the nitrogen load to surface waters is emitted as N<sub>2</sub>O.

$$\text{N}_2\text{O emissions (kton)} = 0.016 * \text{amount of nitrogen to surface waters (kton)}$$

In the Netherlands the nitrogen load to surface waters is about 240 kton N/year, making the emissions of N<sub>2</sub>O from polluted surface waters in the Netherlands about 3.8 kton per year. Figures on the nitrogen load to surface waters are calculated each year by RIZA and RIVM using the PROMISE water model.

## 6 EMISSIONS OF NON-ODP HALOCARBONS: HFCs, PFCs AND SF<sub>6</sub>

Emissions of halocarbons with a greenhouse effect and an ozone-depleting effect (such as CFCs, HCFCs, halons, and tetra, tri and methyl bromide) are reported under the Montreal Protocol. These compounds are regulated primarily by the policy for reducing the depletion of the ozone layer and not by climate policy. They are therefore not considered further in this report.

The following is a description of how emissions of HFCs, PFCs and SF<sub>6</sub> are determined.<sup>35</sup> In general these substances have a high GWP. Because they have no ozone-depleting effect they are often used as substitutes for prohibited ozone-depleting gases. It should be noted that emissions of (H)CFCs can be calculated in the same way as for HFC emissions.

### 6.2 Definition of compounds

Table 6.1 contains a list of compounds and their GWP values for a time horizon of 100 years, as required by the IPCC (1995) (Houghton *et al.*, 1996). Not all the compounds listed are used in the Netherlands.

Table 6.1 Non-ODP halocarbons and SF<sub>6</sub>

Group	Compound	Chemical formula	GWP <sup>1</sup> (100 years)
HFCs	HFC-23	CHF <sub>3</sub>	11700
	HFC-32	CH <sub>2</sub> F <sub>2</sub>	650
	HFC-41	CH <sub>3</sub> F	150
	HFC-43-10mee	C <sub>5</sub> H <sub>2</sub> F <sub>1</sub> O	1300
	HFC-125	C <sub>2</sub> HF <sub>5</sub>	2800
	HFC-134	CHF <sub>2</sub> -CHF <sub>2</sub>	1000
	HFC-134a	CH <sub>2</sub> FCH <sub>3</sub>	1300
	HFC-143	CHF <sub>2</sub> CH <sub>2</sub> F	300
	HFC-143a	CF <sub>3</sub> CH <sub>3</sub>	3800
	HFC-152a	C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>	140
	HFC-227ea	C <sub>3</sub> HF <sub>7</sub>	2900
	HFC-236fa	C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>	6300
	HFC-245ca	C <sub>3</sub> H <sub>3</sub> F <sub>5</sub>	560
	PFCs	Perfluoromethane, PFC-14	CF <sub>4</sub>
Perfluoroethane, PFC-116		C <sub>2</sub> F <sub>6</sub>	9200
Perfluoropropane		C <sub>3</sub> F <sub>8</sub>	7000
Perfluorobutane		C <sub>4</sub> F <sub>10</sub>	7000
Perfluoropentane		C <sub>5</sub> F <sub>12</sub>	7500
Perfluorohexane		C <sub>6</sub> F <sub>14</sub>	7400
Perfluorocyclobutane		c-C <sub>4</sub> F <sub>8</sub>	8700
Perfluorohexane, PFC 51-14		C <sub>6</sub> F <sub>14</sub>	6800
FICs	Trifluoromethyl iodine	CF <sub>3</sub> I	<5
	Pentafluoroethyl iodine	CF <sub>3</sub> CF <sub>2</sub> I	<5
	Heptafluoropropyl iodine	CF <sub>3</sub> (CF <sub>2</sub> ) <sub>2</sub> I	<5
	Nonafluorobutyl iodine	CF <sub>3</sub> (CF <sub>2</sub> ) <sub>3</sub> I	<5
SF <sub>6</sub>	Sulphur hexafluoride	SF <sub>6</sub>	23900

source: Houghton *et al.* (1996).

<sup>1</sup> Direct effect only

<sup>35</sup> Chapter 6 has been completely revised since the original 1997 report.

### 6.3 Sources of HFC, PFC and SF<sub>6</sub> emissions

The sources of HFC, PFC and SF<sub>6</sub> emissions can be divided into the following two main groups:

1. Emissions during the use of HFCs, PFCs and SF<sub>6</sub> (IPCC category 2F)
2. Process emissions (as by-product) (IPCC categories 2A–E or 2G)

The UNFCCC guidelines require countries to report both the *use* of the named compounds (the Tier 1 method) – the *potential* emissions – and the calculated *actual* emissions of the compounds (the Tier 2 method). The Tier 2 method for actual emissions can be applied using detailed information on use per application over the years and emission characteristics of all the individual applications of the compounds. Calculations of the actual emissions also include process emissions.

The Tier 1 method can be used at a coarse level (Tier 1-A), in which net domestic use per compound is calculated as follows:

$$\text{potential emissions (Tier 1-A)} = \text{production} + \text{imports}_{(\text{bulk})} - \text{exports}_{(\text{bulk})} - \text{destroyed}$$

or with a more accurate estimate of domestic use (Tier 1-B), in which the figure from 1-A is corrected for imports and exports of products that contain these compounds:

$$\text{potential emissions (Tier 1-B)} = \text{emissions Tier 1-A} + \text{imports}_{(\text{in products})} - \text{exports}_{(\text{in products})}$$

The Netherlands uses the Tier 1-A method in its reports on *potential* emissions, whereas a Tier 2 or higher is used for the *actual* emissions (see section 6.3.1 and 6.3.2)

#### 6.3.1 Emissions during the use of HFCs, PFCs and SF<sub>6</sub> [2F]

Table 6.2 contains a list of the applications/activities which use HFCs, PFCs and SF<sub>6</sub>.

Table 6.2 Applications or emission sources during the use of HFCs, PFCs and SF<sub>6</sub>

	Specific application/activity	Compound (group)
1	Aerosols	HFC134a
2	Rigid foam (closed cell structure)	HFCXs <sup>1</sup>
3	Stationary cooling	HFCs
4	Air conditioning in passenger cars	HFC134a
5	Emissions during packing/packaging	HFCs
6	Insulation in circuit-breakers	SF <sub>6</sub>
7	Use in the production of double glazing	SF <sub>6</sub>
8	Use in the semiconductor industry	PFCs / SF <sub>6</sub>
9	Use in the production of electron microscopes	SF <sub>6</sub>

source: Folkert and Peek (2001)

Consumption figures are needed to calculate emissions during use. These are obtained from the annual KPMG reports (KPMG, 2002) and other sources. Since 1996 KPMG have been commissioned by the Ministry of VROM to maintain an inventory of the use of HCFCs, HFCs, methyl bromide and related compounds in the Netherlands and to report on these each year. The consumption figures for HFCs are drawn from these annual KPMG reports. Figures for the consumption and emissions of PFCs and SF<sub>6</sub> are provided by the companies and sectors concerned.

The determination of emissions for each specific application/activity are described below. Where information is lacking on the amounts used and how these are divided between the applications, assumptions are made for these figures.

### 1. Aerosols

Emissions from this source are determined according to the IPCC Tier 2 method and based on the use of aerosols in the Netherlands. In the absence of information on the imports and exports of aerosol cans, it is assumed that their use is equal to the trade in HFCs for aerosol production in the Netherlands.

### 2. Rigid foam (closed cell structure)

No HFCs are used in the production of rigid foams. It is expected that this will start in 2003. Emissions from this source will therefore be determined according to the IPCC Tier 2 method.

### 3. Stationary cooling

At the moment emissions from stationary cooling are determined as total figures per compound as follows:

$$\text{Emission (t)} = \text{TS}(t-1) * L + \text{NS}(t) * (L * 0.5)$$

where:

TS (*t-1*) = Total Stock (content) of coolant on 31 December of year *t-1*

L = Average leakage as an annual percentage

NS(*t*) = New Stock in year *t*

TS is obtained by adding the TS on 31 December to the NS for the following year. This takes no account of any decline as a consequence of the dismantling of plant because this is not yet relevant for HFCs, which have only been used since 1994.

NV in a certain year is determined by subtracting by the amount of coolant required to replace emissions (leaks) in the previous year. On the right side of the equation,  $L * 0.5$  is used because not all plants are sold on 1 January, but on average on 1 July; leakage during this year is, therefore, half the total. As yet, this does not take account of emissions during the first filling of the plant and during demolition, only emissions during the operational phase.

Until 2001, the value used for L was 10%, based on Matthijsen and Kroeze (1996); since the NIR in 2002, L = 5% has been used for the years from 1999 (De Baedits *et al.*, 2001).

The intention is to determine this source according to the IPCC Tier 2 method in 2003.

### 4. Air conditioning in passenger cars

Emissions are determined for each type of car as follows:

$$\text{Emissions (t)} = A * AC * L + (B - A) * GI * (L * 0,5)$$

where:

A = number of cars with airco on 1 January of year *t*

B = number of cars with airco on 1 January of year *t+1*

AC = average contents of the air conditioning system

L = average leakage as percentage for the year

On the right side of the equation  $L * 5$  is used because not all cars are sold on 1 January, but on average on 1 July; leakage in that year, therefore, is half the total. As yet, no account is taken of emissions during the first filling and during dismantling, only with emissions during the working life of the car. Until 2001, the value used for L was 33%, based on Matthijsen and Kroeze (1996); since the NIR 2002, L = 13% has been used for the years to 1998 and L = 9% for the years from 1999 (De Baedits *et al.*, 2001). Total emissions from this source is the sum of emissions from all types of cars.

The intention is to determine this source according to the IPCC Tier 2 method in 2003.

### 5. Emissions during packing and packaging

Emissions from this source are drawn from the Individual Emissions Register (ER-I).

### 6. Insulators in circuit-breakers

Until 1998 actual emissions of SF<sub>6</sub> in the Netherlands was determined using the formula: use = emissions (= potential emissions). Since the NIR 1999, actual emissions for all years have been calculated according to the IPCC Tier 2 method (IPCC, 2000).

It is expected that from 2003 this source will be determined using the IPCC Tier 3 mass balance method.

### 7. Use in the production of double glazing

This source was included in the emissions registration in 2002. So far only emissions during the production of double glazing have been included. Emissions during production are currently calculated as follows:

$$\text{Emissions during production} = \text{use during production} * \text{EF}$$

where:

EF = emission factor = 0.33 (IPCC default value)

Emissions from the existing stocks of double glazing – in other words, due to leaks or breakage during use – and which arise during disposal are so far not taken into account. From 2003 emissions will be determined according to the IPCC Tier 2 method (IPCC, 2000).

### 8. Use in the semiconductor industry

Emissions from this source are determined by the manufacturer according to the IPCC Tier 2-C method.

### 9. Use in the production of electron microscopes

Emissions figures are supplied by the manufacturer.

## 6.3.2 Process emissions (by-product) [2B and 2C]

Table 6.3 lists the processes which give rise to emissions. Emissions of HFC-23 during the production of HCFC-22 are determined by the sole manufacturer according to the IPCC Tier 2 method and reported each year in their Annual Environmental Report. (MJV)

Table 6.3 Processes in which HFCs and PFCs arise as a by-product

IPCC category	Process	Compound group
2B	Production of HCFC-22	HFC-23
2C	Primary aluminium production	PFCs

source: Folkert, R.J.M. and C.J. Peek (2001)

There are two aluminium producers in the Netherlands. The emissions of one manufacturer in 1999 have been determined according to the IPCC Tier 3-B method (IPCC, 2000) using the results of an extensive measurement programme conducted in 1999. Emissions of CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> are determined each year using results from the extensive measurement programme in 1999. The other manufacturer calculates emissions of CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> from a number of anode effects and their duration. This is equivalent to the IPCC Tier 2 method.

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## LIST OF ABBREVIATIONS

AER	Annual Emissions Report (Emissiejaarrapport) [now: Emission Monitor]
AVR	Rijnmond hazardous waste incineration plant (Afval Verbranding Rijnmond)
BAK	Survey of gas consumption by residential users (Basisonderzoek Aardgasgebruik Kleinverbruikers)
CBS	Statistics Netherlands
CCDM	Coordination Committee for Monitoring Target Groups (Coördinatie Commissie Doelgroep Monitoring)
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon dioxide
CORINAIR	CORe emission INventories AIR
DLO	Agricultural Research Department (Dienst Landbouwkundig Onderzoek)
EB	Environmental Balance (Milieubalans)
ECN	Netherlands Energy Research Foundation (Energie-onderzoek Centrum Nederland)
EM	<a href="#">Emission Monitor</a>
ENINA	Energy, Industry and Waste Task Force (Taakgroep ENERGIE, Industrie en Afval)
ER-C	Emission Registration for Collective Data (Emissieregistratie-Collectief)
ER-I	Emission Registration for Individual Companies (Emissieregistratie-Individueel)
EU	European Union
EZ	Ministry of Economic Affairs
FCCC	Framework Convention on Climate Change
FGD	Flue Gas Desulphurisation
FICs	Fluoriodocarbons
GWP	Global Warming Potential
HFCs	Halogenated Fluorohydrocarbons (partly halogenated)
HIMH	Inspectorate-General for Environmental Protection
IKC-Landbouw	National reference Centre for Agriculture
IPCC	Intergovernmental Panel on Climate Change
KNMI	Royal Netherlands Meteorological Institute
LEI	Agricultural Economics Research Institute
LNV	Ministry of Agriculture, Nature Management and Fisheries
LTO	Landing and Take-Off
N <sub>2</sub> O	Nitrous dioxide (Laughing gas)
NAM	Nederlandse Aardolie Maatschappij
NEH	<a href="#">Netherlands Energy Statistics (Nederlandse Energie Huishouding) [now: NEM]</a>
NEM	<a href="#">Netherlands Energy Monitor (Nederlandse Energie Monitor) [previously: NEH]</a>
NEPP	National Environmental Policy Plan (Nationaal Milieubeleidsplan, NMP)
NIR	<a href="#">National Inventory Report (annual report for the UN Climate Treaty [UNFCCC])</a>
NMVOC	Non-Methane Volatile Organic Compounds
ODP	Ozone Depleting Potential
PFCs	Perfluorocarbons (fully halogenated fluorocarbons)
RIVM	National Institute for Public Health and the Environment
RIZA	National Institute for Inland Water Management and Wastewater Treatment
SBI	Standard Industrial Classification (Standaard Bedrijven Indeling)
TNO	Netherlands Organisation for Applied Scientific Research
TNO-MEP	TNO Institute of Environmental Sciences, Energy Research and Process Innovation
TNO-WT	TNO Road Vehicles Research Institute
UN	United Nations
UN-ECE	Economic Commission for Europe (of the UN)
UU	Utrecht University
VenW	Ministry of Transport, Public Works and Water Management
VI	<a href="#">VROM Inspectorate</a>
VOC	Volatile Organic Compounds
VROM	Ministry of Housing, Spatial Planning and the Environment
VVAV	Dutch Waste Processing Association (Vereniging van Afvalverwerkers)
WEB	<a href="#">Working Group for Monitoring Emission of Greenhouse Gases</a>
WEM	<a href="#">Working Group Emission Monitor [previously: EJRI]</a>
WIP	Waste Incineration Plant
WWTP	Wastewater Treatment Plant



**ANNEXES**



## Annex A Differences from earlier methods (gross NEPP and IPCC methods)

### A.1 Differences from the gross NEPP method for CO<sub>2</sub> emissions

The method described above for determining CO<sub>2</sub> emissions in the Netherlands differs from the gross NEPP method in the following ways:

1. The gross NEPP method includes all the potential CO<sub>2</sub> emissions from the NEH item 'other transformations'. These are energy losses in the transformation of NEH energy carriers at refineries, basic metal and basic chemical industries, for example from crude oil to oil products, from coal to coke and in naphtha crackers. Potential CO<sub>2</sub> emissions from these activities amount to 3 to 4 Mton. The method described in this document takes a different approach. Close scrutiny of the carbon balance for these transformations suggests much smaller emissions; these are registered in the ER-I entirely as process emissions.
2. The method described here is based on domestic energy consumption, in line with IPCC guidelines, and therefore includes all the consumption that cannot be allocated to the sectors, the NEH item 'statistical differences'. The gross NEPP method is based on the 'total consumption balance' and so does not include the statistical differences.
3. The method described here determines combustion emissions from a combination of detailed emission factors in the statements by the ER-I companies and detailed emission factors for the supplementary consumption by industrial companies and collective sectors. The gross NEPP method uses aggregated emission factors for coal, oil and gas.
4. Potential CO<sub>2</sub> emissions from feedstocks are determined by the method described here using detailed emission factors. The gross NEPP method uses aggregated emission factors for (potential) emissions.
5. The method described here is for determining actual emissions, in line with IPCC guidelines, and so takes account of carbon fixation in feedstocks (plastics, bitumen). In contrast, the gross NEPP method includes the entire potential CO<sub>2</sub> emissions from feedstocks.
6. CO<sub>2</sub> process emissions from non-fuel use arising from the decomposition of carbonate in lime at high temperatures (cement industry, FGD plant, roof tile and brick factories) are included in the method described here. These are in fact actual CO<sub>2</sub> emissions containing fossil carbon. The gross NEPP method does not do this and is based solely on energy use.
7. Actual CO<sub>2</sub> emissions from incineration of waste, etc. are included in the method presented here. The gross NEPP method does not do this and is based solely on energy use.
8. The fixation of atmospheric CO<sub>2</sub> in the net increase in biomass (in the Netherlands, the timber stocks), as well as CO<sub>2</sub> emissions from the combustion of biomass and bunkers, should be declared separately. These items are not considered in the gross NEPP method.

Finally, all carbon in atmospheric emissions of CO and VOC and emissions of (potential) CO<sub>2</sub> should be registered. In the gross NEPP method this occurs implicitly only for CO from fossil energy carriers.

## A.2

### Differences from the IPCC method used previously

The method described in this document differs from the method used so far by RIVM for the Environmental Balances for 1995 and 1996 (RIVM, 1995, 1996), international reports, the National Communication and annual reports to the EU and FCCC (Spakeman *et al.*, 1996) in the following ways:

#### CO<sub>2</sub>

1. In earlier reports, as in the gross NEPP method, the potential CO<sub>2</sub> emissions from the NEH item 'other transformations' were included in full. As stated above under A.1.1, the amount involved is 3 to 4 Mton. In the method described in this document, this item reflects actual process emissions registered in the ER-I.
2. The method described here uses detailed emission factors, based partly on individual statements of CO<sub>2</sub> emissions by ER-I companies (via the ER-I). In the method used until now by RIVM all combustion emissions were calculated using aggregated emission factors.
3. The estimated process emissions from the use of lime (sandstone) are lower in the new method than in the method used previously by RIVM (1.27 as opposed to 2.0 Mton). Whereas in the past estimates of these process emissions were based on unreliable figures for the use of lime, the new method is based on the process emissions registered in the ER-I in combination with sector-specific multiplication factors.
4. The new method also includes CO<sub>2</sub> process emissions from brick and roof tile factories and the glass and rock-wool industries. In the method used so far by RIVM these were not included at all. The new method is based on the process emissions registered in the ER-I in combination with sector-specific multiplication factors.
5. The percentage of carbon from feedstocks that is fixed in a large group of oil products used to be estimated by RIVM at 55%. The fixation percentage in the new method is 82%.
6. Actual emissions from the use of feedstocks are calculated using detailed emission factors. In the past these factors were aggregated.
7. All carbon in atmospheric emissions of CO and VOC, as well as (potential) CO<sub>2</sub> emissions, should be registered. In the past this occurred only implicitly for CO from fossil energy carriers.

#### CH<sub>4</sub>:

1. In the new method, process emissions from refineries, a component of the VOC emissions, are allocated to category [1B2a]; previously they were – mistakenly – recorded as combustion emissions.
2. All VOC emissions released from petrol stations, including CH<sub>4</sub>, are now allocated to the transport sector. Previously these very small emissions were allocated to the service sector.

#### N<sub>2</sub>O:

The method for calculating emissions has not changed, but a new emission factor has been determined. With this new emission factor, emissions from industrial processes are almost twice as high (31 kton instead of 16 kton).

## Annex B NETHERLANDS EMISSIONS IN THE STANDARD IPCC SOURCE CATEGORIES; CONVERSION TABLE FOR IPCC CATEGORIES AND TARGET GROUPS

Table B.1 IPCC categories in which emissions of greenhouse gases occur in the Netherlands, excluding the 'Montreal substances'

IPCC categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFC, PFC, SF <sub>6</sub>	NO <sub>x</sub>	CO	NMVOs	SO <sub>2</sub>
1. All energy combustion and fugitive	X	X	X	n.a.	X	X	X	X
A. Fuel combustion total	X	X	n.a.	X	X	X	X	X
1.a. Electricity & heat production	X	X	X	n.a.	X	X	i.a.c.	X
1.c. Other transformation	X	X	X	n.a.	X	X	i.a.c.	X
2. Industry (only energy)	X	X	X	n.a.	X	X	i.a.c.	X
2.f. Actual from feedstocks	X	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
3. Transport	X	X	X	n.a.	X	X	X	X
4.a. Commercial/Institutional	X	X	X	n.a.	X	X	i.a.c.	X
4.b. Residential	X	X	X	n.a.	X	X	i.a.c.	X
4.c. Agriculture/forestry/fishing	X	X	n.a.v.	n.a.	X	X	X	X
5. Other	X	n.a.	n.a.	n.a.	n.a.	n.a.	X	n.a.
5.c. Statistical differences	X	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
6. Biomass burned for energy	(x)	X	X	n.a.	X	X	X	X
B. Fugitive emissions from fuels	n.a.	X	n.a.	n.a.	n.a.	n.a.	X	n.a.v.
1. Solid fuels	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2.a. Crude Oil	X	X	n.a.v.	n.a.	X	X	X	n.a.v.
2.b. Natural gas	X	X	n.a.v.	n.a.	X	X	X	n.a.v.
2. Industrial processes (non-energy)	X	X	X	X	X	X	X	X
A. Iron and steel	X	i.a.c.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
B. Non-ferrous metals	n.a.v.	i.a.c.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
C. Inorganic chemicals	n.a.v.	i.a.c.	X	n.a.	i.a.c.	i.a.c.	i.a.c.	i.a.c.
D. Organic chemicals	n.a.v.	i.a.c.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
E. Non-metallic mineral products	X	i.a.c.	n.a.v.	n.a.	i.a.c.	i.a.c.	i.a.c.	i.a.c.
F. Other	X	X	n.a.v.	X	X	X	X	X
3. Solvent and other product use	i.a.c.	n.a.v.	x	x	i.a.c.	x	x	n.a.
4. Agriculture	n.a.v.	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
A. Enteric fermentation	n.a.	X	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
B. Manure management	n.a.	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
C. Rice cultivation	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D. Agricultural soils	n.a.	X	(x)	n.a.	n.a.	n.a.	n.a.	n.a.
E. Prescribed burning of savannahs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
F. Field burning of agricultural residues	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
5. Land-use change and forestry	(x)	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
A. Changes in woody biomass stocks	(x)	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
B. Forest and grassland conversion	n.a.v.	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
C. Abandonment of managed lands	n.a.v.	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
D. Other	n.a.v.	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
6. Waste	X	X	X	n.a.	X	X	X	X
A. Solid waste disposal on land	n.a.	X	n.a.v.	n.a.	n.a.	n.a.	X	n.a.
B. Wastewater treatment	n.a.v.	X	X	n.a.	X	X	n.a.v.	X
C. Waste incineration	X	X	X	n.a.	X	X	X	X
D. Other waste	n.a.v.	n.a.v.	n.a.v.	n.a.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
7. Other	i.a.c.	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
A. Drinking-water treatment	i.a.c.	X	n.a.v.	n.a.	n.a.	n.a.	n.a.	n.a.
B. Polluted surface water	n.a.	n.a.v.	X	n.a.	n.a.	n.a.	n.a.	n.a.
- Bunkers (international shipping & aviation)	(x)	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.	n.a.v.
- Nature	(x)	X	X	X	X	X	X	X
- Organic material	(x)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

source: RIVM.

- Notes: x: applicable category and/or sector for the relevant substance  
n.a.: not applicable category and/or sector for the relevant substance  
n.a.v.: non-calculated value for the relevant substance for the category and/or sector that is applicable  
i.a.c.: included in another category



Source: TNO-MEP.

Legend:

C = combustion emissions

P = process emissions (= non-combustion emissions)

(X) = not included in total

Notes to Table B.2:<sup>37</sup>

- 1 = Water supply companies; Retail trade, Trade, services and Government, Research institutes (in Dutch 'HDO'); Construction.
- 2 = Emissions from fossil fuels are given under the waste categories. Despite the fact that most WIPs include an energy from waste component, all emissions are reported under IPCC category 6C.
- 3 = Emissions omitted in the IPCC method, particularly methane and CO<sub>2</sub> from organic matter.
- 4 = Including CO<sub>2</sub> from non-energetic use of fossil fuels (feedstocks).
- 5 = Coke ovens are included under the target group Industry (basic metals) and not under Refineries.
- 6 = N<sub>2</sub>O only.
- 7 = Emissions are based on domestic supplies.
- 8 = non-AER

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<sup>37</sup> In later years this has been refined somewhat to bring the Dutch report more closely in line with the prescribed reporting format with IPCC source categories. This relates primarily to the Dutch target groups Construction, Water supply companies, WWTPs and Waste disposal. Refineries are now included in the Target Group 'Industry'.



## Annex C EMISSION SOURCES AND TARGET GROUPS

Table C.1 Emission sources (partly aggregated) per target group

Target Group	Emission source	Compartment		
		Air	Water	Soil
<b>Agriculture</b>				
	Input of N, P, Cd, Cu, Zn (mineral balances)			B
	Use of N <sub>2</sub> O	P		
	Grazing - N <sub>2</sub> O	P		
	Soil emissions input/output			A
	CFC cooling	P		
	Corrosion of galvanised steel in greenhouses		W	B
	Manure - CH <sub>4</sub> , NH <sub>3</sub>	P	W	B
	Emissions from the use of agricultural pesticides – water	P	W	B
	Use of carbolineum	P		
	Use of sewage sludge on agricultural soils			B
	Timber treated with carbolineum	P		
	Angling – sinkers in freshwater angling		W	
	Ruminants, fermentation - CH <sub>4</sub>	P		
	Hunting – lead and zinc emissions – soil		W	B
	Synthetic fertiliser - N <sub>2</sub> O, NH <sub>3</sub>	P		
	Agricultural soils	P		
	Agricultural crops	P		
	Storage and/or livestock sheds - N <sub>2</sub> O	P		
	Stock of creosoted timber in construction	P		B
	Application of creosoted timber in construction	P		B
	Leaching/run-off from agricultural soils to water		W	
	Leaching from creosoted timber used in hydraulic engineering projects – soil		W	B
	Leaching from existing older stocks of creosoted timber used in hydraulic engineering - soil		W	B
	Leguminous plants - N <sub>2</sub> O	P		
	Combustion appliances, Agriculture (Combustion emissions)	C		
<b>Industry</b>				
	ER-I	P,C	W	
	Corrosion stainless steel industry		W	B
	Supplementary estimates (non ER-I)	P,C	W	
<b>Refineries <sup>38</sup></b>				
	ER-I	P,C	W	
	Supplementary estimates (non ER-I)	P,C	W	
<b>Energy sector</b>				
	Supplementary estimates (non ER-I)	P,C	W	
	Emissions of oil and gas: handling and distribution, onshore and offshore	P		
	ER-I processes	P,C	W	
	Combustion on the continental shelf	C		
<b>Transport</b>				
	Anti-fouling pleasure craft			D
	Car products	P		
	Shipping on inland waterways: bilge water			D
	Shipping on inland waterways: coating			D
	Shipping on inland waterways: corrosion of zinc anodes		W	
	Shipping on inland waterways: propeller shaft grease		W	
	Shipping on inland waterways: combustion	C		
	Corrosion of galvanised lamp posts in road construction		W	B
	Corrosion of steel vehicle safety fences in road construction		W	B
	Corrosion of zinc anodes on sluice gates		W	
	Use of buses, petrol/LPG and diesel delivery vans, mopeds, petrol/LPG and diesel passenger cars, special petrol vehicles, tractors for trailers, lorries:		W	B
	Emissions of exhaust gases on the roadway inside and outside the built-up area			
	Uses of buses, petrol-engined delivery vans, petrol passenger cars, special petrol vehicles, tractors for trailers: Evaporation losses inside and outside the built-up area	P		

<sup>38</sup> Refineries are now included in the Target Group 'Industry'.

Table C.1 Emission sources (partly aggregated) per target group (continued)

DG	Emission source	Compartment		
		Air	Water	Soil
	Use of buses, delivery vans, mopeds, passenger cars, tractors for trailers, lorries: Leakage of motor oil inside and outside the built-up area		W	B
	Use of buses, delivery vans, mopeds, passenger cars, special vehicles, tractors for trailers, lorries: Wear and tear of road surface inside and outside the built-up area	P	W	B
	Use of buses, delivery vans, mopeds, passenger cars, tractors for trailers, lorries: Tyre dust inside and outside the built-up area	P	W	B
	Use of buses, delivery vans with LPG or petrol engines with/without cat. converter and diesel IDI and diesel, mopeds, passenger cars LPG and petrol with/without cat. converter and Diesel IDI and diesel, petrol and diesel special vehicles, lorries for trailers, lorries: Combustion inside and outside built-up areas	C		
	Generators	C		
	Military Airfields	C		
	Mobile machinery, agriculture and other	C		
	Spills in inland waterways			D
	Stock of creosoted timber in the construction industry	P		B
	Railways - combustion	V		
	Railways – Spark emissions and spark erosion in overhead lines	P		
	Berthed ships	C		
	Use of creosoted timber in construction	P		B
	Exhaust gases from pleasure boats with petrol and diesel engines	C	W	
	Leaching of creosoted timber used in construction		W	B
	Leaching from existing older stocks of creosoted timber in hydraulic engineering structures		W	B
	Aircraft – combustion and fugitive emissions	P1C		
	Airfields for service traffic	C		
	International shipping: combustion in port and at sea	C		
	International shipping in port : leaching		W	
	<b>Consumers</b>			
	Fireworks	P	W	B
	Car products	P		
	Space heating by wood burning – inside and outside the built-up area	C		
	Consumer glues	P		
	Corrosion of lead strips and flashing, zinc roofs/gutters in homes		W	B
	Corrosion of water pipes during circulation in homes and during vacancy and warming up of homes		W	
	Cosmetics and articles for personal hygiene	P		
	Emissions from wall panelling - dioxins	P		
	Use of carbolineum and timber treated with carbolineum	P		
	Data on use of household pesticides			U
	Manure from pets	P		
	Household wastewater		W	
	Office equipment	P		
	Cooking	C		
	Leather and furniture treatment	P		
	Stock of creosoted timber in the construction industry and use of creosoted timber in construction	P		B
	Cigarette smoke	P		
	Cleaning products	P		
	Aerosol cans, various CFCs	P		
	Transpiration and respiration	P		
	Use of paint by consumers	P		
	Preparation of meat: frying, roasting and barbecuing	P		
	Stoves	C		
	<b>Construction</b>			
	Building adhesives	P1C	W	
	ER-I			
	Use of foams CFC11	P		
	Aerosol cans, various CFCs	P		
	Use of paints in construction	P		
	Road marking paint inside and outside the built-up area	P		
	Supplementary estimates (non ER-I) for construction emissions to water		W	
	Supplementary estimates (non ER-I) for furnaces, construction	V		
	<b>Waste disposal companies</b>			
	Recycling/disposal of refrigerators/freezers	P		
	WIPs – organic CO <sub>2</sub>	O		

Table C.1 Emission sources (partly aggregated) per target group (continued)

DG	Emission sources	Compartment		
		Air	Water	Soil
	Emissions from landfills		W	
	ER-I	P1C	W	
	Use of foams CFC11	P		
	Sewage sludge/landfill			B
	Supplementary estimates (non ER-I)	P	W	
	<b>Water Supply Companies</b>			
	Supplementary estimates (non ER-I) for water supply companies	C	W	
	<b>Sewage and Water Treatment</b>			
	Effluent and WWTPs		E	
	ER-I	P1C		
	Households w/o a connection to the mains sewer (incl. deposition)		W	
	Overflows (incl. deposition)		W	
	Rainwater sewers (incl. deposition)		W	
	WWTP emissions	P		
	Supplementary estimates (non ER-I) for furnaces, WWTPs	C		
	<b>Trade, Services, Government and Other Target Groups</b>			
	Anti-rust treatment companies	P		
	Car products	P		
	Car spraying – use of paint and varnish	P		
	Bread baking	P		
	Petrol distribution depots	P		
	Fire-fighting apparatus	P		
	CFC solvents/cleaning	P		
	Dry cleaning clothing/textiles	P	W	
	Corrosion of lead strips, flashing and zinc roofs in public utility buildings		W	B
	Corrosion of water pipes in office buildings		W	
	Cosmetics and personal hygiene articles	P		
	Crematoria	P		
	ER-I processes	P1C	W	
	Office equipment	P		
	Cooling and freezing	P		
	Spills/leaks from filling car tanks	P		
	Discharges from dental surgeries			I
	Sterilizing medical components	P		
	Sterilizing transports	P		
	Stock of creosoted timber in the construction industry	P		B
	Cleaning new cars - processes	P	W	
	Cleaning of tankers	P		
	Shooting			B
	Cleaning products	P		
	Petrol station filling losses, car and storage tanks	P		
	Use of creosoted timber in construction	P		B
	Supplementary estimates (non ER-I)	P1C	W	
	<b>Nature</b>			
	Biogenic processes in surface waters	P		
	Forest and vegetation in nature areas	P		
	Deposition of N, P, Cd, Cu, Zn (mineral balance) from agriculture			B
	Deposition of N, P, Cd, Cu, Zn (mineral balance) from other			B
	Non-agricultural soils	P		
	<b>Other Processes</b>			
	Input from foreign rivers		R	
	Deposition on surface waters		W	
	Statistical differences NEH - CO <sub>2</sub>	P		

source: TNO-MEP

**Key:**

A:	soil emissions minus output via crops
B:	emissions from soil
C:	combustion emissions
D:	direct emissions
E:	effluent
I:	indirect emissions
O:	CO <sub>2</sub> from organic sources
P:	non-combustion emissions
R:	input from foreign rivers
U:	combustion emissions
W:	emissions to water

## Annex D DEFINITION OF DUTCH TARGET GROUPS, WITH SBI CODES [IN DUTCH]

Definition of target groups for environmental policy (target group monitoring).

### **Landbouw, Natuurbeheer en Visserij**

<i>SBI'93</i>	<i>SBI'74</i>	<i>Omschrijving</i>
01	01	Productie van landbouwproducten (exclusief inzet mobiele werktuigen)
011/013	011	Productie van akker- en overige tuinbouwgewassen
011	011	Verwerking van akker- en overige tuinbouwgewassen op het eigen bedrijf
012/013	011	Fokken en houden van dieren (beroepsmatig)
012/013	011	Verwerking van dierlijke producten op het eigen bedrijf
0112	012	Productie van glastuinbouwproducten
014	014	Loonwerkbedrijven (exclusief inzet mobiele werktuigen)
0141.1	013	Hoveniersbedrijven
0141.2		Reinigen sloten ten behoeve van de landbouw
div lb		Productie van energie bij landbouw (WKK)
div lb		Niet industriële verwerking van dierlijke mest
div lb		Toepassing slib, compost, ov. org. mest in de landbouw
02	02	Bosbouw, exclusief inzet mobiele werktuigen
05	03	Beroepsmatig vissen, kweken van vis en schaaldieren
05	03	Recreatief vissen
9000.3		Mestverwerking
9000.3		Mestfabrieken
9253.2		Beheren van grond of water gericht op natuurbehoud (exclusief bijvoorbeeld reinigen van sloten ten behoeve van de landbouw; beheer bermen, sloten, binnenwater gericht op onderhoud van infrastructuur; overheidsdiensten (SBI 75).
015	015	Jacht
div lb		Natuurbeheer op LB-gronden

### **Industrie**

<i>SBI'93</i>	<i>SBI'74</i>	<i>Omschrijving</i>
144	192	Winning van zout
15-16	20-21	Voedings- en genotmiddelen
17-18	22-23	Textielindustrie
19	24	Lederindustrie
20	25	Hout- en meubelindustrie
21	26	Papier- en papierwarenindustrie
22	27	Grafische industrie
23	28-1992	Aardolie- en steenkoolverwerkende industrie; bewerking van splijt- en kweekstoffen (exclusief SBI 232 en 233).
231	2821	Vervaardiging van cokesovenproducten
24	29	Chemische industrie
24	30	Kunstmatige garen- en vezelindustrie
25	31	Rubber- en kunststofverwerkende industrie
26	32	Bouwmaterialen-, aardewerk- en glasindustrie
27	33	Basismetalenindustrie
28	34	Metaalproductenindustrie
29-30	35	Machine-industrie
30-31-32	36	Elektronische industrie
34-35	37	Transportmiddelen
33	38	Instrumenten- en optische industrie

36	39	Meubelindustrie, vervaardiging overige goederen
div ind	div ind	Productie van energie door de industrie (WKK)
div ind	div ind	Gebruik van bedrijfskantoren
div ind	div ind	Afvalwaterzuivering door de industrie
div ind	div ind	Bodemsanering op eigen terrein
<b>Raffinaderijen</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
2320.1	281	Raffinaderijen
2320.1	281	Op- en overslag van ruwe olie
<b>Energiesector</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
10-11	11-12-199	Winning van energiehoudende delfstoffen
10	1991	Turfwinning
11	12	Aardolie- en gaswinning
3	28-1992	Aardolie- en steenkoolverwerkende industrie; bewerking van splijt- en kweekstoffen (exclusief vervaardiging van cokesovenproducten (SBI 231))
2320.2	2829.2	Aardolieverwerking (exclusief aardolieraffinage)
2330	1992	Bewerking van splijt- en kweekstoffen
40	40 ex 403	Productie en distributie van elektriciteit, aardgas, stoom en warmwater
40	401	Elektriciteit producerende bedrijven (inclusief transport elektriciteit door de SEP)
40	40	Distributie van elektriciteit en dergelijke (uitpandig: tot aan de woning)
40	40	Productie WKK door distributiebedrijven (decentrale WKK)
40	40	Productie WKK door elektriciteitscentrales (centrale WKK)
603		Transport van olie en gas door leidingen (exclusief transport van niet energiedragers)
<b>Detailhandel</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
50-51-52		Reparatie van consumentenartikelen en handel
50	63-66-68	Handel in en reparatie van auto's en motorfietsen; benzineservicestations
51	61-62-64	Groothandel en handelsbemiddeling (exclusief in auto's en motorfietsen)
52	65-68-68	Detailhandel en reparatie ten behoeve van particulieren (exclusief in auto's, motorfietsen en motorbrandstoffen)
<b>Verkeer en Vervoer</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
60	71-75	Vervoer over land
601	71	Vervoer per spoor
602	72	Vervoer over de weg
6021/2/3	-	Personenvervoer over de weg
6024	-	Goederenvervoer over de weg
div	-	Gebruik overige mobiele bronnen
01	01	Gebruik van mobiele werktuigen bij de productie van landbouw-producten
02	02	Gebruik van mobiele werktuigen bij de bosbouw
div ind.	div.ind.	Gebruik van mobiele werktuigen door de industrie
45	51-52	Gebruik van mobiele werktuigen in de bouw

div	-	Gebruik overige mobiele werktuigen (inclusief in gebouwen)
603	7243	Gebruik van pijpleidingen voor vervoer (exclusief distributie van energie-dragers energiesector en water ten behoeve van drinkwatervoorziening - drinkwaterbedrijven)
61	73-74	Vervoer over water
611	73	Gebruik zeeschepen
612	74	Gebruik binnenschepen
62	75	Vervoer door de lucht
<b>Consumenten</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
-	-	Gebruik van woningen
-	-	Ruimteverwarming
-	-	Gebruik aardgas, stoom en warm water
-	-	Overige binnenmilieu (radon, emissies leidingen in woningen en dergelijke) (Exclusief elektriciteitsverbruik energiesector (SBI E40))
-	-	Gebruik producten
-	-	Het houden van huisdieren (recreatief)
99	99	Verrichten van particuliere huishoudelijke diensten (Bejaardenhuizen en dergelijke vallen onder "gezondheids- en welzijnszorg" (SBI'93 85))
<b>Bouw</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
14	19	Winning van niet-energiehoudende delfstoffen
14	191-192	Winning van zand, grind, klei, en dergelijke, exclusief winning van zout (SBI 144)
45	51-52	Bouwnijverheid en bouwinstallatiebedrijven
451	51	Bouwrijp maken van terreinen, inclusief slopen en grondverzet
452	51	Burgerlijke en utiliteitsbouw; grond-, water- en wegenbouw (exclusief grondverzet, inclusief aanleg van riolering)
454	51	Afwerken van gebouwen
453	52	Bouwinstallatie
455		Verhuur van bouw- en sloopmachines, alleen indien met bedienend personeel (exclusief emissies door gebruik van mobiele voertuigen -> verkeer en vervoer)
<b>Afvalverwijderingsbedrijven</b>		
<b>SBI'93</b>	<b>SBI'74</b>	<b>Omschrijving</b>
37	-	Vorbereiden tot recycling
371	-	Vorbereiden tot recycling van metaalafval
372	-	Vorbereiden tot recycling van afval (exclusief metaalafval), onder meer puinbrekerij
9000.2	9811	Afvalinzameling (exclusief afvalwater)
9000.3	9813	Afvalbehandeling (exclusief afvalwater)
9000.3	9813	Compostering
9000.3	9813	Storten (inclusief slib)
9000.3	9813	Verbranden
9000.3	-	WKK-toepassing bij afvalverwijderingsbedrijven

**Drinkwaterbedrijven**

<i>SBI'93</i>	<i>SBI'74</i>	<i>Omschrijving</i>
41	403	Winning en distributie van water (Distributie voor zover uitpandig (tot aan de woning))

**Riolering en Waterzuiveringsinstallaties**

<i>SBI'93</i>	<i>SBI'74</i>	<i>Omschrijving</i>
9000.1	9812	Afvalwaterinzameling en -behandeling (onder meer Afvalwaterbehandeling afkomstig van kalvermesterijen) (Niet meenemen industriële waterzuivering)

**Researchinstellingen**

<i>SBI'93</i>	<i>SBI'74</i>	<i>Omschrijving</i>
80	92	Onderwijs
8030	-	Universiteiten (inclusief landbouwonderzoeks- en onderwijsinstellingen)

**Horeca, Dienstverlening en Overheid**

<i>SBI'93</i>	<i>SBI'74</i>	<i>Omschrijving</i>
div ov.	div.ov.	Gebruik van kantoren
<b>55</b>	<b>67</b>	<b>Horeca</b>
55	67	Logies-, maaltijden- en drankverstrekking
<b>60-64</b>	<b>71-77</b>	<b>Vervoer, opslag en communicatie</b>
60	71-72	Vervoer over land (exclusief gebruik (vracht)auto's, trein en dergelijke)
603		Transport met leidingen (exclusief transport energiedragers energiesector en water ten behoeve van drinkwatervoorziening drinkwaterbedrijven)
61	73-74	Vervoer over water (exclusief gebruik schepen)
62	75	Vervoer door de lucht (exclusief gebruik vliegtuigen en dergelijke)
63	71-75	Dienstverlening ten behoeve van het vervoer
631	7421	Laad-, los- en overslagactiviteiten en opslag
632	742	Overige dienstverlening ten behoeve van het vervoer n.e.g.
633	761	Reisorganisatie en -bemiddeling; informatieverstrekking op het gebied van toerisme
634	762	Expediteurs, cargodoors en bevrachters; weging en meting (exclusief gebruik van vervoermiddelen: Verkeer en Vervoer)
64	77	Post en telecommunicatie
641	7701	Post- en koeriersdiensten (exclusief gebruik van vervoermiddelen: Verkeer en Vervoer)
642	7702	Telecommunicatie
<b>65-67</b>	<b>81-84</b>	<b>Financiële instellingen</b>
65	81	Financiële instellingen (exclusief verzekeringswezen en pensioenfondsen)
66	82	Verzekeringswezen en pensioenfondsen (exclusief verplichte sociale verzekeringen)
67	81-84	Activiteiten ten behoeve van of verwant aan financiële diensten
<b>70-74</b>	<b>div</b>	<b>Verhuur van en handel in onroerend goed, verhuur van roerende goederen en zakelijke dienstverlening</b>
70	83	Verhuur van en handel in onroerend goed

71	85-95-96	Verhuur van transportmiddelen, machines en werktuigen zonder bedienend personeel en van overige roerende goederen
72	84	Computerservice- en informatietechnologiebureau's en dergelijke
73	975	Speur- en ontwikkelingswerk
7310.1		onder meer Speur- en ontwikkelingswerk op het gebied van landbouw en visserij
74	844 - 849	Overige zakelijke dienstverlening
7430.1		onder meer Keuring en controle van agrarische producten en voedingsmiddelen
7484.3		onder meer Veilingen van land-, tuinbouw- en visserijproducten
<b>75</b>	<b>90</b>	<b>Openbaar bestuur, overheidsdiensten en verplichte sociale-verzekeringen</b>
<b>85</b>	<b>93-94</b>	<b>Gezondheids- en welzijnszorg</b>
852	939	onder meer veterinaire diensten
8531.7	941	onder meer bejaardentehuizen
<b>92</b>	<b>95</b>	<b>Toerisme en recreatie</b>
92	95	Cultuur, sport en recreatie
-	-	Vrije recreatie (Exclusief reisorganisaties en dergelijke (SBI 633))
<b>div</b>	<b>div</b>	<b>Overige sectoren</b>
91	97	Werkgevers- en werknemers- en beroepsorganisaties; levensbeschouwelijke en politieke organisaties; overige ideële organisaties en dergelijke
93	div	Overige dienstverlening onder meer chemische wasserijen
99	902	Extra-territoriale lichamen en organisaties



## Annex E Specific CO<sub>2</sub> emission factors for the collective sectors

Table E.1 Specific average CO<sub>2</sub> emissions for the collective sectors

	Carbon content %	Calorific value GJ/ton	Emission factor gram CO <sub>2</sub> /kg or /m <sup>3</sup>	Emission factor kg CO <sub>2</sub> /GJ
Coal				
Households	90	32.0	3300	103
Metals industry	74	27.0	2720	101
Other activities <sup>1</sup>	69	27.0	2540	94
Coke	84	28.5	3080	103
Petrocoke	99	35.2	3630	103
Brown coal	58	21.0	2130	101
Wood		15.5	1610	104
Household waste		10.5	780	74
Petrol <sup>39</sup>	86	44.0	3180	73
Diesel <sup>37</sup>	86	42.7	3130	73
Petroleum	87	43.1	3190	73
H.B.O. I	86	42.7	3130	73
H.B.O. II	86	42.7	3130	73
Heavy fuel oil	86	41.0	3160	77
Natural gas	58	31.65	1768	56
LPG <sup>37</sup>	82	45.2	3000	66
Coke oven gas		19.7	870	44
General refinery gas		38.1	1676	46
Chemical residual gas		31.65	2109	46
Blast furnace gas				200

source: Wieleman (1994)

1 including electricity companies

(Data have been obtained in cooperation with CBS, ECN, EZ, RIVM, UU, TNO, VROM.)

<sup>39</sup> For domestic mobile sources the CO<sub>2</sub> emission factors are determined to 3 figures: 72.3 for petrol, 73.3 for diesel and 66.4 for LPG.



## Annex F TEMPERATURE CORRECTION METHOD FOR NATURAL GAS CONSUMPTION

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<sub>2</sub> trend of up to 4%. For domestic policy purposes, however, it is desirable to separate these climatic disturbances from fluctuations in CO<sub>2</sub> 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<sub>2</sub> emissions are corrected for outside temperature variations using a method outlined below. For other greenhouse gases, the contribution from energy consumption is much less than in the case of CO<sub>2</sub>; the uncertainty of emission estimates for these gases is also much larger than for CO<sub>2</sub>. Therefore no temperature correction is carried out for non-CO<sub>2</sub> gases. The calculation is described in detail below.

### 1. Limitation to natural gas

Nearly all the space heating in the Netherlands is done with natural gas. Thus, only natural gas consumption is corrected for outside temperature variations.

### 2. Correction formula

The temperature correction requires two multiplication factors, one for each economic sector:

- the *Heating Degree Day (HDD) correction factor*  $G_T$
- the sector-specific *application factor*  $T_S$ .

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  $T_S$ . To give corrected energy consumption as:

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

The **Heatin Degree Day correction factor** 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 HDD average of the 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 numbers of HDDs of a 'normal' year are presented in *Table B.1* for the period 1970-1996.

### 3. Calculation of Heating Degree Days

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 Celsius 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 by EnergieNed using data on mean daily temperature provided by the Royal Netherlands Meteorological Institute (KNMI) (see *Table F.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 F.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 1970-2001 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	1986	3333	3228	0.969
1971	3133	3239	1.034	1987	3372	3219	0.955
1972	3379	3228	0.955	1988	2823	3231	1.144
1973	3234	3221	0.966	1989	2729	3219	1.179
1974	3033	3226	1.046	1990	2677	3211	1.199
1975	3083	3221	1.045	1991	3163	3198	1.011
1976	3097	3225	1.041	1992	2829	3203	1.132
1977	2997	3218	1.074	1993	3076	3177	1.033
1978	3304	3209	0.971	1994	2835	3156	1.113
1979	3476	3217	0.926	1995	2917	3140	1.076
1980	3301	3235	0.980	1996	3504	3123	0.891
1981	3244	3238	0.998	1997	2929	3135	1.070
1982	3005	3244	1.080	1998	2821	3133	1.111
1983	2999	3232	1.078	1999	2676	3118	1.165
1984	3177	3229	1.016	2000	2659	3098	1.165
1985	3487	3226	0.925	2001	2880	3076	1.068

Source: EnergieNed, 1995 (pers. comm.) and www.energiened.nl

#### 4. Definition of normal Heating Degree Days

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 1990 to 1995 and 1997 to 2000 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. The moving 30-year average number of HDDs decreased by 3.5%, from 3231, to 3098 between 1990 and 2000 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.

#### 5. Fraction of energy consumption used for space heating

The application factor 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 2000. 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, 1995) (see Table F.3). Other sectors use fixed application factors provided by the Ministry of Economic Affairs (see Table F.2) (Wieleman, 1994).

Table F.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 F.3. Application factors for dwellings for the years 1980-1985 and 1990-2001

	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Residential sector	0.88	0.87	0.80	0.80	0.78	0.77	0.77	0.76	0.80	0.79	0.78	0.76	0.76	0.77

source: EnergieNed, 1995-2001

### 6. Example calculation of temperature correction in 1990

As an example in Table F.4 the calculation of the temperature correction of sectoral CO<sub>2</sub> emissions for 1990 has been summarised. In addition, Table F.5 presents the variation of this correction over the last ten years, showing that in this period a difference up to 10 Mton occurs between the maximum and the minimum correction.

Table F.4 Example of temperature correction of energy consumption and CO<sub>2</sub> emissions in 1990 (using an emission factor for CO<sub>2</sub> from natural gas of 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 <sub>2</sub> emissions [Mton]
Agriculture	129	0.825	1.199	0.164	+ 21.1	+ 1.18
Industry	430	0.16	1.199	0.032	+ 13.8	+ 0.77
Services	137	0.825	1.199	0.164	+ 22.5	+ 1.26
Energy sector	278	0.05	1.199	0.010	+ 2.8	+ 0.16
Residentials	329	0.79	1.199	0.157	+ 51.7	+ 2.90
Total	1303				+ 111.9	+ 6.27

Source: Spakman *et al.* (1997). Please note that due to elimination of the statistical differences in the energy balances gas consumption figures, and thus CO<sub>2</sub> related temperature correction, has changed somewhat.

Table F.5. Temperature correction of carbon dioxide emissions per sector 1990-2001 (Gg)

Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1A1a Energy sector	160	10	110	30	110	80	-120	60	140	210	210	90
1A2 Industry	770	50	450	120	400	290	-300	160	400	590	590	230
1A4a Commercial and public services	1000	80	900	240	800	540	-930	510	760	1000	1190	610
1A4b Residential sector	2950	180	2020	510	1670	1200	-2020	1120	1550	2290	2330	1010
1A4c Agriculture	1350	70	840	220	760	490	-880	490	670	950	960	390
Total CO <sub>2</sub> correction	6230	390	4320	1120	3740	2600	-4250	2340	3520	5040	5270	2320
As % of uncorrected national total	3.9%	0.2%	2.6%	0.7%	2.2%	1.5%	-2.4%	1.4%	2.0%	3.0%	3.1%	1.3%



## Annex G CO<sub>2</sub> EMISSIONS FROM THE COMBUSTION OF BIOMASS [1A] AND BUNKERS [-]

### G.1 CO<sub>2</sub> emissions from the combustion of biomass [1A]

Reports that follow IPCC guidelines should state CO<sub>2</sub> emissions from biomass combustion, but not include these emissions in the national total figure for CO<sub>2</sub> because this CO<sub>2</sub> is from the short carbon cycle. However, the other emissions from biomass combustion do have to be included in the national totals. The IPCC sector for biomass combustion [1A] only covers combustion for energy supply and includes organic agricultural waste, wood for burning in furnaces, fireplaces and woodstoves (households, industry, supplementary fuel in coal-fired power stations). Care should be taken to avoid double accounting with CO<sub>2</sub> emissions caused by felling, which affects the size of the net sink through biomass growth (IPCC sector [5]). The burning of thinnings or other felled timber from the Dutch flora, therefore, may not be included in this item. These emissions are calculated by:

$$\text{emissions (Mton)} = \text{emission factor (ton/ton)} * \text{consumption (Mton)}$$

The emission factor is determined by the dry matter content of the relevant biomass as well as its carbon content. Complete oxidation is assumed when calculating CO<sub>2</sub> emissions. With an average dry matter content of 70%, of which 50% consists of carbon, the emission factor is about 1.3 ton CO<sub>2</sub>/ton wood.

In the Netherlands about 1 Mton is burned by households each year (Slob *et al.*, 1993). An estimated additional 0.1 Mton wood is incinerated by industry (CBS, 1994) and in power stations. Due to a lack of further data, it is assumed that none of this is derived from Dutch forests. The resulting total volume of wood for burning is 1.1 Mton.

For the incineration of biomass in the form of agricultural waste it is assumed that the dry matter content is 40%, of which 50% consists of carbon. This results in an emission factor of 0.73 ton CO<sub>2</sub> / ton biomass. The amount of agricultural waste incinerated for energy recovery is negligible.

### G.2 CO<sub>2</sub> emissions from bunkers [-]

The IPCC guidelines require countries to report emissions from the combustion of marine and aviation bunker fuels separately from the national total. These emissions must be reported by the country where the bunker fuel is supplied (loaded). The IPCC guidelines allocates these emissions to international emissions, so they do not count towards the national total. These emissions are calculated as follows:

$$\text{emissions (Mton)} = 10^{-3} * \text{emission factor (kg/GJ)} * \text{bunker volume (PJ)}$$

Data on bunker volumes are published annually in the NEH. Different CO<sub>2</sub> emission factors are applied to the relatively light aviation fuel (almost all jet fuel based on kerosene) and the heavy marine bunkers (heavy fuel oil with a viscosity > 15 centi Stokes). The factors are 73 kg/GJ for aviation bunkers and 77 kg/GJ for marine bunkers.



## ANNEX H CH<sub>4</sub> EMISSIONS FROM WET SOILS [NATURE]

CH<sub>4</sub> is formed under anaerobic conditions in wet soils and shallow water. Measurements have shown that hardly any CH<sub>4</sub> is formed in brackish and saline soils (Bartlett and Harris, 1993). Van Amstel *et al.* (1994) have estimated CH<sub>4</sub> emissions from wet soils. These are not anthropogenic emissions, but come under the category Nature. Since 1950 peatlands in the Netherlands have been drained for agricultural use and the water table has fallen by on average 30 cm across the whole country since 1950 (van Amstel *et al.*, 1989). As a consequence of this human intervention emissions of CH<sub>4</sub> have fallen (Table H.1).

The calculated emission data in Table H.2 are based on statistics on land use and waterways (Bakker *et al.*, 1989) and on emission factors from Bartlett and Harris (1993). In 1950 about 2000 km<sup>2</sup> of wet soils had not been drained but by 1995 only 375 km<sup>2</sup> of this remained and about 1500 km<sup>2</sup> had been drained. The inland waters are the IJsselmeer (1657 km<sup>2</sup>) and all other waters more than 6 metres wide (1498 km<sup>2</sup>). The estuaries and the Wadden Sea are saline or brackish and produce negligible CH<sub>4</sub> emissions. Natural wetlands together cover about 600 km<sup>2</sup> (Bakker *et al.*, 1989). The CH<sub>4</sub> emissions from agricultural soils have been estimated at about 50 kton, and emissions of CH<sub>4</sub> from other wet soils at about 75 kton in 1994. As mentioned previously these are not anthropogenic emissions and come under the category Nature.

Table H.1 CH<sub>4</sub> emission factors for wet soils (including agricultural soils) in 1950 and 1990–1995.

soil type	Surface [km <sup>2</sup> ] In period		Emission factor [mg CH <sub>4</sub> /m <sup>2</sup> /day]			Emission factor [ton/km <sup>2</sup> /year] <sup>3</sup>		
	1950	1990–1995	High	Low	Middle	High	Low	Middle
Wet soils <sup>1</sup>	2000	373	80	200	180	20.4	51.0	45.9
Drained soils <sup>2</sup>	0	1500	10	200	110	2.6	51.0	28.1
Inland water >6 m wide	3155	3155	20	50	45	5.1	12.8	11.5
Water <6 m wide	600	600	80	200	180	20.4	51.0	45.9
<b>TOTAL</b>	<b>5755</b>	<b>5628</b>						

source: Spakman *et al.*, 1996

- 1 Water Table class 0 and 1
- 2 Water Table class >1
- 3 Growing season of 255 days

Table H.2 CH<sub>4</sub> emissions from wet soils (including agricultural soils) in 1950 and 1990–1995

Soil type	Emissions 1950 [kton]			Emissions 1990–1995 [kton]		
	Low	High	Middle	Low	High	Middle
Wet soils <sup>1</sup>	40.8	102.0	91.8	7.6	19.0	17
Drained soils <sup>2</sup>	0.0	0.0	0.0	3.8	76.5	42
Inland water >6 m wide	16.1	40.2	36.2	16.1	40.2	36
Water <6 m wide	12.2	30.6	27.5	12.2	30.6	28
<b>TOTAL</b>	<b>69.1</b>	<b>172.8</b>	<b>155.5</b>	<b>39.8</b>	<b>166.3</b>	<b>123</b>

source: Spakman *et al.*, 1996.

- 1 Water Table class 0 and 1.
- 2 Water Table class >1.