Protocol
1A1 1A2 1A4: CO_2 N_2O and CH_4 from stationary combustion of fossil fuels

IPCC Category:	1A1 (excluding waste incineration non-fossil) 1A2 (excluding mobile equipment) 1A4 (excluding mobile equipment and fisheries)
NFR Code:	Not applicable
NOSE Code:	Not applicable
NACE Code 2008	Various

Foreword

Under the Kyoto Protocol, the Netherlands is required to set up and maintain a national system to monitor its greenhouse gas emissions. One of the elements of this system is a transparent and verifiable description of the methods and processes used in this monitoring system. These methods must meet international guideline criteria, which have been defined by the United Nations (UN) and the European Union (EU).

The Netherlands meets the aforementioned requirement, for example, by defining a series of Monitoring Protocols, which describe the methods and work processes used to determine greenhouse gas emissions and the amounts of carbon sinks available. Protocols have been written for about 40 greenhouse gas sources or sinks. This document describes the protocol for one of these sources or sinks.

The protocols have been compiled in close collaboration with experts from various sectors of society in the Netherlands, particularly experts from the Emissions Registration (ER). The ER is a collaborative group that includes institutions such as CBS, WUR, RIVM and PBL. Until 31 December 2009 this was coordinated by PBL (Planbureau for the Leefomgeving, or the Netherlands Environmental Assessment Agency), but on 1 January 2010 this coordination task was taken over by RIVM (the Netherlands institute for public health and the environment). Other institutions that have contributed to the protocols include NL Agency; Ministry of Agriculture, Nature and Food Quality; and the Ministry of VROM (Housing, Spatial Planning and the Environment).

1 Scope and significance of emission sources/activities

1.1 Scope and definition

This protocol describes methodologies and working processes for defining CO_2 , N_2O and CH_4 emissions formed through stationary combustion of fossil fuels (1A excluding waste incineration non-fossil and a part of the emissions of refineries (see also the protocol Fossil Process emissions), 1A2 and 1A4 excluding mobile equipment and fisheries).

Stationary combustion concerns the combustion from fuels in the energy conversion sector (including power plants, cogeneration (CHP) and refineries), the industrial and construction sectors, as well as from residences and non-residential buildings (mainly central heating boilers and the production of domestic hot water) and the agricultural sector.

Fossil fuels can be split into the following three main groups:

1. Natural gas

Natural gas is extracted within the Netherlands and, partly as a result of this situation, it is therefore used extensively throughout the country, both in the energy sector (to generate electricity and heat) and in other sectors for spatial heating, domestic hot water and cooking.

2. Solid fuels

These mainly concern coal and its by-products: blast furnace gas (including oxy gas) and coke oven gas. The Netherlands stopped mining coal in the 1960s and now imports all its requirements. Solid fuels are used in the energy sector to generate electricity and heat, and in the blast furnace industry to produce cokes and pig iron/steel.

3. Crude oil raw materials and products

Only a limited amount of crude oil is extracted in the Netherlands; the majority is imported. However, the country's strategic position means that the Netherlands has a considerable crude oil industry and is one of the largest exporters of crude oil products in the world. Crude oil materials and products are only used on a limited scale for stationary combustion applications. This almost always concerns using the captured residual gases from refineries, the chemical industry and the surrounding CHP plants.

The following do not fall under this protocol:

- $CO_{2,}$ N_2O and CH_4 emissions resulting from stationary combustion of fuels other than fossil fuels (biomass, waste).
- $CO_{2,}$ N_2O and CH_4 emissions from mobile combustion applications (transport, mobile equipment and fisheries).
- $CO_{2,}$ N_2O and CH_4 emissions from venting and flaring.
- CO_2 emissions released through the use of fossil fuels as raw material (e.g. ammonia production).
- Other greenhouse gas emissions.

These other emission categories are discussed in other protocols.

1.2 Significance and influences

1.2.1 Contribution to total national emissions

CO_2 emissions from stationary combustion contribute about 60% to the Netherlands annual greenhouse gas emissions.Both CH_4 and N_2O emissions from stationary combustion contribute less than 0.5% to the Netherlands annual greenhouse gas emissions.

1.2.2 Importantr developments that infuence emissions

Not applicable

2 Method, emission factors and activity data

2.1 Calculation method

A sectoral approach, otherwise known as a *National Approach* (NA) is used to determine the Netherlands' CO_2, CH_4 and N_2O emissions from combustion. This NA is similar to the 'sectoral approach' described in the IPCC Good Practice Guidance [IPCC 2001]. For CO_2 and CH_4 this is a Tier 2 method, for N_2O a Tier 1 method.

Emissions for the National Inventory Report (NIR) are also calculated using the Reference Approach. These figures are used as a calculation check. An extensive description is included in a separate protocol (Reference Approach).

This protocol describes the stationary fossil part of the National Approach, under which the extent of the fuel consumption (see also the section on '*activity data'*) is determined by the CBS Energiebalans (Netherlands energy management system). The extent of the emissions is determined by multiplying these data by the emission factors. The CO_2 emission factors are taken from the national fuels list (Vreuls et al, 2009) or from company-specific data (provided it is reliable). Appendix 1 describes the entire calculation procedure, including the use of company-specific emission factors. These data can be derived, for example, from the Annual Environmental Reports or the Annual Emissions Reports.
The CH_4 and N_2O emission factors used for the calculation of CH_4 and N_2O emissions from combustion are mentioned hereafter in Section 2.2 (Emission factors).

Determining energy consumption
The individual energy data used as a source for the CBS Energiebalans are also used to determine the activity data. In addition, the statistical increase necessary for the CBS Energiebalans is added as an extra (dummy) statistical unit.

Validation of energy consumption

A validation is carried out for a limited group of companies, defined according to the extent of their energy consumption or use of specific fossil fuels (primarily coal or residual gases). A list of validated companies is drawn up annually. Information from other sources (e.g. Annual Environmental Reports) is used to check the information taken from the energy statistics. A complicating factor here is that a statistical unit, as used by the energy statistics, is not always exactly the same as that used by a company when submitting information to the Annual Environmental Report. If there are (considerable) deviations, further research is carried out and, where necessary, the next preliminary energy figures (also for the CBS Energiebalans) are modified accordingly.

The activity data can be modified according to the findings of the trend analysis described under Section 3.

Calculating emissions
The CO_2, CH_4 and N_2O emissions are determined (both per SBI group (industrial category) and RAP (report) code) by multiplying the energy consumption by the emission factors. These emission factors can be specific to a certain company (e.g. using information taken from the Annual Environmental Reports), or can be taken from the emission factors in the national fuels list (Vreuls et al, 2009). If (a part of this) CO_2 is permanently stored underground, then the stored CO_2 is subtracted from the earlier calculated (gross) CO_2 emissions. In the reports on stored CO_2, insight is given into leakage during capture, transport and injection. Emission factors can also be modified based on the findings from the trend analysis described under Section 3.

2.2 Emission factors

CO_2 emission factors are taken from the standard factors used in the national fuels list (Vreuls et al, 2009). For substantiation of these data, please see the list itself (and the accompanying fact sheets). In addition, the company-specific emission factors from the legally required

annual environmental reports (instead of standard factors) are used for a limited number of companies. The method is explained in detail in Appendix 1.
The CH_4 and N_2O emission factors are presented in the table below.

Fuel	**Emission factor N_2O** [1)]	**Emission factor CH_4** [2)]
	(g/GJ)	(g/GJ)
Coal and coal briquettes	1.4	0.44
Lignite	1.4	4.4
Coal cokes	1.4	44.4
Coke oven gas	0.1	2.8
Blast furnace gas	0.1	0.35
Coal aromatics	0.6	1.6
Coal bitumen	0.6	1.6
Crude oil	0.6	1.4
Natural gas condensate	0.6	1.9
Other crude oil raw materials	0.6	1.4
Refinery gas	0.1	3.6
Chemical waste gas	0.1	3.6
LPG, propane, butane	0.1	0.7
Naphtha's	0.6	3.4
Crude oil aromatics	0.6	3.4
Aviation fuel	0.6	3.4
Jet fuel (gasoline base)	0.6	3.4
Jet fuel (kerosene base)	0.6	3.4
Petrol / gasoline	0.6	3.4
Other light oils	0.6	3.4
Petroleum	0.6	3.4
Gas-oil, diesel oil, heating oil < 15cSt	0.6	3.4
Heavy heating oil >= 15cSt	0.6	1.6
Lubricating oils and fats	0.6	1
Bitumen	0.6	1.6
Mineral turpentine	0.6	3.4
Mineral waxes	0.6	1.5
Raw materials for carbon black	0.6	1.6
Sulphur	0	0
Petroleum cokes	1.4	3.8
Total anticoagulants	0.6	7.5
Additives for lubricants	0.6	7.5
Other crude oil products H27	0.6	3.4
Other products (not H27)	0.6	3.4
Natural gas[1)]	0.1	5.7 [3)]

1) The N_2O emission factors are IPCC-defaults
2) The CH_4 emission factors are taken from Scheffer et al, 1997
3) The CH_4 factor for natural gas does not include start losses from cooking, domestic hot water preparation and residential heating; these are estimated separately as 35 g/GJ.

From the 2009 NIR (National Inventory Report) onwards, other emission factors are used to convey the CH_4 emissions from combustion of natural gas in gas engines. National and international research has proven that gas engines do not burn natural gas as completely. The CH_4 emission factor for gas engines is defined annually based on the characteristics of the used gas engines. This differentiates between gas engines used in the greenhouse horticultural sector, and those in other sectors. The following table shows the emission factors for the period 1990-2007. Appendix 2 includes a full description of the modifications to the CH_4 emission factors.

Jaar	CH_4 EF Greenhouse horticultural sector (gr/GJ)	CH_4 EF Other sectors (gr/GJ)
1990	305	305
1991	305	305
1992	305	305
1993	305	305
1994	305	305
1995	305	305
1996	305	305
1997	305	305
1998	294	294
1999	283	283
2000	272	272
2001	261	261
2002	250	250
2003	253	250
2004	276	250
2005	314	250
2006	377	250
2007	409	250

2.3 Activity data

The following sources are used for fossil fuels used for stationary applications:

- The (confidential) individual company data and the aggregated statistical data from the CBS Energiebalans, which is published annually by the CBS (see www.cbs.nl).

3 Working processes

Process for estimating (t-1)

If preliminary figures are required at any point, the following process is used to estimate the figure for t-1. The preliminary data for the work package leader are calculated by extrapolating them from the previous years' figures, based on prognoses for the developments in the most important activity data (taken from CBS (Statistics Netherlands) or other statistical sources).

INPUT	PROCESS	OUTPUT	BY WHOM
Preliminary data work package leader (t-1)	Include t-1 data in ER database	ER-db with (t-1) data	Work package leader
ER-db with (t-1) data	Check emission figures: compare with previous years (trend), modify if required and document everything	ER-db (t-1) with any modified figures	Task force

Process for final determination of (t-2)
The final emission figures (as described in this protocol) are calculated using the following process.

INPUT	PROCESS	OUTPUT	BY WHOM
Fuel use per fuel type (www.cbs.nl, LEI, annual environmental reports (AER's), NEA)**,** including correction for - fuel use by mobile sources - production and transport&distribution of Oil and Gas (activity data from CBS Energiebalans are replaced by activity data from PBL; see separate protocols for production and transport & distribution of Oil and Gas) **(A)** Emission factors (kg/GJ) (Vreuls et al, 2009; IPCC, 1997; Scheffer et al, 1997; AER's) (**B)**	A x B	Calculated CO_2, CH_4 and N_2O emissions (=Final data Work package leader (t-2)) (C)	CBS
Final data Work package leader (t-2) **(C)**	Include t-2 data in ER database	ER-db with (t-2) data **(D)**	Work package leader
ER-db with (t-2) data **(D)**	Check, and trend analysis of air emissions: explain deviations or modify figures	Final defined emission figures t-2 **(E)**	Task forces and PBL experts

4 Uncertainty and quality

4.1 Estimating uncertainties

A Tier-1 uncertainty analysis is implemented every year before the NIR is submitted by the ER, based on the greenhouse gas inventory and in compliance with IPCC guidelines. The assumptions used and the results thereof are described in a background report to the NIR. In addition to this, where included in the QA/QC programme for the relevant period, extra analyses are implemented regularly in specific situations, which include any updating of the Tier-2 uncertainty analyses.

The Tier-2 uncertainty assessment was last updated in 2006. This assessment showed that a Tier-1 uncertainty assessment is sufficiently reliable and that Tier-2 uncertainty assessments need only be implemented at periodic intervals of around 5 years, unless a major change in an important source is sufficient to require earlier reassessment.

- Source-specific uncertainty
The uncertainty estimate-totaal concerns the root of the sum of uncertainty in the data sources used (ADonz) in the square and the uncertainty of the emission factor (EFonz) in the square.

The extent of the total uncertainty is here primarily determined by the greatest AD or EF uncertainty.

$$\text{Uncertainty estimate totaal} = \sqrt{EF_{onz.}{}^2 + AD_{onz.}{}^2}$$

The uncertainty estimates concerning the data sources (AD) and emission factors (EF) used, and the total uncertainty estimate, are listed in the following table.

IPCC	**Category**	**Gas**	**AD onz.**	**EF onz.**	**Uncertainty estimates tot**
1A1a	Stationary combustion: Public Electricity and Heat Production: liquids	CO_2	0.5	10	10
1A1a	Stationary combustion : Public Electricity and Heat Production: solids	CO_2	1	3	3
1A1a	Stationary combustion : Public Electricity and Heat Production: gases	CO_2	0.5	1	1
1A1a	Stationary combustion : Public Electricity and Heat Production: waste incineration	CO_2	10	5	11
1A1b	Stationary combustion : Petroleum Refining: liquids	CO_2	10	10	14
1A1b	Stationary combustion : Petroleum Refining: gases	CO_2	0.5	1	1
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: liquids	CO_2	20	2	20
1A1c	Stationary combustion : Manuf. of Solid Fuels and Other En. Ind.: gases	CO_2	20	5	21
1A2	Stationary combustion : Manufacturing Industries and Construction, liquids	CO_2	1	5	5
1A2	Stationary combustion : Manufacturing Industries and Construction, solids	CO_2	2	10	10
1A2	Stationary combustion : Manufacturing Industries and Construction, gases	CO_2	2	1	2
1A4	Stationary combustion : Other Sectors, solids	CO_2	50	5	50
1A4a	Stationary combustion : Other Sectors: Commercial/Institutional, gases	CO_2	20	1	20
1A4b	Stationary combustion : Other Sectors, Residential, gases	CO_2	5	1	5
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO_2	10	1	10
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO_2	20	2	20
1A4	Stationary combustion : Other Sectors, liquids excl. From 1A4c	CO_2	20	2	20
1A5	Military use of fuels (1A5 Other)	CO_2	20	2	20
1A	Emissions from stationary combustion: non-CO_2	CH_4	3	50	50
1A	Emissions from stationary combustion: non-CO_2	N_2O	3	50	50

Activity data (AD)

The uncertainties in the activity data for the energy sector were updated in 2005, based on uncertainty estimates from the energy statistics division of CBS which were published in the report on the Protocol on Energy Conservation, and on new insights gained from the energy and CO_2 recalculation project, performed by CBS (Huurman, 2005). The table shows the most recent uncertainty estimates, as used in the uncertainty assessment of the NIR 2006 [Olivier et al, 2009].

The accuracy of fuel consumption data in power generation (1A1a) and oil refineries (1A1b), generally, is considered to be very high. The used volumes of natural gas are (very) well known, therefore, the uncertainty was estimated by CBS at 0.5%. Both solid fuels used in power generation and liquid fuels used in refineries have a larger estimated uncertainty of 1% and 10%, respectively, based on the share of blast furnace gas in total solid consumption, and the ‘unaccounted-for liquids’ calculated for refineries. For other fuels, we used a 10% uncertainty, which refers to the amount of fossil-fuel waste being incinerated and, thus, to the uncertainties in the total amount of waste and the fossil and biomass fractions [Olivier et al, 2009].

The consumption of gas and liquid fuels in the 1A1c category is mainly by the oil and gas production industry itself, where splitting the consumption into use and venting/flaring proved to be quite difficult. Thus this carries a large uncertainty of 20% [Olivier et al, 2009].

The large uncertainty in activity data in the 1A4 source category, in particular, in the service sector (subcategory 1A4a), is due to the allocation of the remainder of total national energy consumption per fuel type – that is, after subtraction of the amounts attributed to the subcategories 1A1, 1A2, 1A3, 1A4b/c, and 1A5 [Olivier et al, 2009].

An uncertainty of 20% is assumed for liquid fuel use in 'Off-road Machinery and Fisheries', and in the other categories under 1A4 [Olivier et al, 2009].

Emission factors (EF)

CO_2 Natural gas
The 1% uncertainty in the emission factor of 56.1 kg CO_2/GJ from natural gas, is based on information by Gasunie (a large European gas infrastructure company). Van Harmelen et al. (2002) analysed the emission factor for standard Groningen gas (G-gas, a mixture of gas from the Slochteren reservoir and high calorific gas from other small gas fields), and so-called High calorific gas (H-gas), produced from other, smaller gas fields. The study concluded that the average mix had an emission factor very close to that of pure Slochteren gas (with an emission factor of 56.1 kg CO_2/GJ), since G-gas is the most-used gas in the Netherlands, and analysed H-gases differed only by up to about 0.5% for the 56.1 kg CO_2/GJ value for G-gas. This value falls within the uncertainty range of 1% estimated by Gasunie for Slochteren gas. Also, for one Dutch importer of British H-gas, the average emission factor appeared to be within this uncertainty range. This 1% uncertainty for natural gas was also used in the study by Olsthoorn and Pilaat (2003). This study also showed the sensitivity of the CO_2 emission factor in the methane/ethane ratio, and, for comparison (in their Table 3.21), presented emission factors for natural gas from other sources: H-gas from Ekofisk (56.7), L-gas Enriched (56.4), and gas from Algeria (56.3) [Olivier et al, 2009].

Recently, Gasunie Transport Services (GtS) provided new information on the emission factor of natural gas. This information was based on routine measurements carried out in 2003 and 2004, at 35 distribution stations. The results indicate that the average CO_2 emission factor for natural gas (56.1 kg/GJ) is underestimated. Further analyses showed that both qualities of natural gas delivered to customers within the Netherlands – G-gas and H-gas – have significantly larger average CO_2 emission factors than the factor for pure Slochteren gas (Vreuls, 2006). A very detailed analysis of the measurement data showed that, for 2003 and 2004, the national average weighted emission factor was 56.8 kg CO_2/GJ. A second analysis of the data showed that the national average emission factor for 1990 had the same value. Therefore, the value of 56.8 was applied to the whole time series of 1990 to 2004. For natural gas, the uncertainty in the CO_2 emission factor is now estimated to be 0.25%, based on the recent fuel quality analysis reported by Heslinga and Van Harmelen (2006); however this value has not been used yet in the recent NIRs (2006, 2007, 2008) [Olivier et al, 2009].

CO_2 Solid fuels
For hard coal (bituminous coal), an analysis was made of its use in power generation (Van Harmelen et al., 2002); for coking coal, the analysis was done for coke ovens (CO) and blast furnaces (BF). For CO gas and BF gas, the emission factors were based on a three-year average (2000 to 2002) of plant-specific values, reported by Corus (2004). For the default

power plant factor, 94.7 CO_2/GJ was the mean value of 1270 samples in 2000, with an accuracy of about 0.5%. For 1990 and 1998, the emission factor varied by about 0.9 CO_2/GJ (see Table 4.1 in Van Harmelen et al., 2002), so in applying the default factor to other years, the uncertainty is apparently larger, about 1%. For coke production (1B1), based on the variability of the accuracy in the C contents, the uncertainty in the default factors for the coking coal was about 3%, whereas for coking coal injected in blast furnaces. in the iron and steel production (1A2a), the uncertainty was about 7% (average of plant-specific values for three subsequent years). The same analysis for the default CO_2 emission factors for coke oven gas and blast furnace gas showed uncertainties of about 10% and 15%, respectively (data reported by Corus, 2004). Since BF/OF gas has a share of 15 to 20% in total solid-fuel emissions from power generation, the overall uncertainty in the emission factor for that subcategory is about 3%. For the CO_2 emission factor for solid-fuel use in category 1A4, an uncertainty of 5% was assigned [Olivier et al, 2009].

CO_2 Liquid fuels
For the other major oil uses in refineries and in the (chemical) industry, the uncertainty is estimated at 10% and 5%, respectively, taking into account that 40 to 50% of the refinery CO_2 from liquid fuel stems from refinery gas (or 70-85% including unaccounted for liquid fuel) and that about half of the CO_2 emissions in the (chemical) industry stem from residual chemical gases. An uncertainty of 2% was assigned to the CO_2 emission factor for liquid fuel use in category 1A4 [Olivier et al, 2009].

CH_4 and N_2O from stationary combustion
The uncertainty in the methane (CH_4) factor for stationary combustion was estimated at 50%, since the emission factors were made up from a multi-sectoral aggregate, except for biofuels where we used the IPCC default uncertainty of 80%. For nitrous oxide (N_2O) from stationary combustion the uncertainty in the emission factor was estimated at 50% [Olivier et al, 2009].

Annual emissions

Energy industries (1A1) and Manufacturing industries (1A2)
The uncertainty in the source categories Energy industries (1A1) and Manufacturing industries (1A2) was estimated to be 4% and 3%, respectively, in annual CO_2 emissions from combustion. The ‘other’ manufacturing industry (1A2f) included the use of off-road machinery in building and construction, and other uses (except in agriculture) [Olivier et al, 2009].

Other sectors (services, residential, agriculture and fisheries) (1A4)
The energy consumption data on the total category 1A4 ‘Other sectors’, is much more accurate than the data on the subsectors. In particular, energy consumption in the commercial subsector, and - to a lesser ex-tent - the agricultural subsector, was less accurately monitored than in the residential sector. Therefore, trend conclusions for these subcategories should be treated with some caution. The uncertainty for the 1A4 category as a whole was estimated to be 10% in annual emissions of CO_2, the uncertainty in CH_4 and N_2O emissions was estimated to be much larger (about 50% and 100%, respectively) [Olivier et al, 2009].

4.2 Quality assurance and quality control (QA/QC)

The ER work package leaders check that:
1. the basic data are well documented and adopted (check for typing errors, use of the correct unit sizes and correct conversion);
2. the calculations have been implemented correctly;

3. assumptions are consistent, also whether specific parameters (e.g. activity data) are used consistently;
4. complete and consistent data sets have been supplied.

Any actions that result from these checks are noted on an ‘action list’. Before defining the data, supervisors check whether the relevant actions on this list, plus the QC checks, have all been completed. Defining the data is carried out by the WEM (working group on emissions monitoring), and confirmed in writing via an e-mail from the institute representatives to the ER project leader at PBL.

The work package leaders fill out a new documentation sheet when adding new data. For reasons of efficiency a minimum level has been set for obligatory documentation, i.e. 5% changes at target group level, and 0.5% at levels concerning the national total. These documentation sheets form part of the trend analysis, as well as the eventual definition of the data set.

The ER work package leaders communicate by e-mail regarding these QC checks, results and actions. They send a printed copy to the ER secretary, who keeps a logbook and compiles these e-mails into an ‘action list’. This shows explicitly that the required checks and corrections have been carried out.

Sector-specific QC
In 2009 the CBS, NEa, PBL and SenterNovem finalised the first study [Guis *et al.*, 2009], which compared CO_2 emissions from the EU-ETS reports and other documents (MJV and CBS Energiebalans). These reports explained 95% of the differences found, particularly as a result of differences in scope between the various reports. At the end of this project, the various institutes involved agreed that a similar study would be conducted each autumn, as an extra check on the emission figures.

4.3 Verification

In order to check the quality of the emission figures for the sources in this protocol, general QA/QC procedures have been followed that are in line with the IPCC guidelines. These are described further in the QAQC programme used by the National System, and the annual working plans published by the ER.

- Sector-specific QC
No additional specific verification procedures are implemented for the sources defined in this protocol.

4.4 Possibilities for improvement compared to the current calculation method

4.4.1 History

Major recalculations have been carried out three times. Once in 2004, which resulted in the working method described above, and once in 2001 and once in 2006. In the 2004 procedure, all years from 1990 onwards were recalculated based on the (partially revised) figures for the CBS Energiebalans and using standard (or company-specific) emission factors. Storage factors for non-energetic use were also modified, and product-related emissions in the usage phase were moved from the products to the consumers. The statistical difference in the energy data (for 1991-1994) was cancelled, with respect to the emission calculations (Boonekamp, 2005). This recalculation process is further documented by Huurman, 2005.

Recalculations were also carried out in 2001 for the years 1990 and 1995-2000, as a result of methodological changes. These recalculations included:

- Cancelling the statistical difference.
- Assigning the energy consumption to the various sectors.
- Splitting the energetic and non-energetic emissions.
- Adjusting the leakage losses for natural gas.
- Modifying the trade element in order to include import/export of energy (also for 1990).
- Another allocation of bunkers in 1990 [RIVM 2002].

A readjustment also took place in 2001 in order to better harmonise the applied RAP codes with the IPCC categories. Further refinement continued in 2003 and 2004.

In 2006 a study was carried out into the methods of determining CO_2 emission factors for natural gas (TNO, 2006). This led to the recommendation that a country-specific factor should be used for natural gas, from the base year 1990 onwards (SenterNovem, 2006). The ER (Emissions Registration) Steering Group approved this recommendation at its meeting of 25 April 2006, thus confirming an update of the fuel list. This country-specific emission factor for natural gas is maintained from the NIR 2006 onwards (Brandes *et al*., 2006).

In addition, up to the year 2002 an extra modification was made for conversion losses by refineries (these are calculated under the protocol for Fossil Process Emissions), where the associated CO_2 emissions are added to the activity data and emissions.

4.4.2 Future
Not applicable

5 Remaining aspects

5.1 Point source criteria
Not applicable

5.2 Substance profiles
Not applicable

5.3 Regionalisation
Splitting the Netherlands into regions is important because the provinces often draw up and implement their own climate policy plans. This is currently causing considerable problems because the individual corporate data are not included in the system. This will have to be organised by the ER.

5.4 Time-based variations in source strength
Not applicable

6 References and additional information

6.1 References

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6.2 Additional information

Temperature correction: calculations and reporting of CO_2 emissions occur without correcting for temperature. The influence on energy consumption, and thus on CO_2 emissions, from mild or extra cold winters is important in explaining the (huge) differences between years. A temperature correction is therefore applied to the natural gas consumption for spatial heating. This correction only concerns CO_2 combustion emissions. The method used is described in [Spakman, 1997]. The (for degree days) temperature-corrected emissions are only meaningful for explaining the developments over time.

APPENDIX 1 Calculating CO_2 emissions from stationary sources

Activity data
Information concerning the consumption of fossil fuels was used to calculate CO_2 emissions from fossil fuels used by stationary sources. CBS publishes these statistics as part of the total Energy Balance (Netherlands energy management system, or CBS Energiebalans). When gathering information for the Energy Balance, CBS uses written surveys and also makes increasing use of registrations. Companies in the energy sector and industry are intensively observed via integral surveys. Random checks are only used for smaller industrial companies with a relatively low energy consumption.

Emission calculations
The energy used, according to the CBS Energiebalans per SBI code, is used to calculate the total CO_2 emissions for stationary sources – these figures are used in the NIR. This method is used because not all companies in the Netherlands report on their CO_2 emissions via the annual environmental reports. The CO_2 emissions are calculated from the energy consumption taken from the CBS Energiebalans and standard emission factors from the Netherlands fuel list [Vreuls et al, 2009].

Use of company-specific emission factors
The calculation is refined by including the CO_2 emissions reported by selected companies in their annual environmental reports (MJV) and incorporating this into the emissions database. This refining is primarily applied to companies with deviating fuel types (residual gases, various types of coal) and for companies with extremely high emissions. The calculation of CO_2 emissions, per fuel type, is carried out as follows.

Starting from the CO_2 emissions reported in the MJV, first the emissions are deducted of fuels with a fixed emission factor (e.g. natural gas). Emissions from remaining fuels are then divided according to their energy consumption (in the CBS Energiebalans) for each fuel. If a company only uses a few types of fuel (e.g. coals), the emission factor is calculated by dividing the CO_2 emission from the MJV by the energy consumption in the CBS Energiebalans. This approach results in the company-specific emission factor for the particular fuel used by that company. This is only possible if the statistical unit and energy consumption of both data sources are equal. If the CBS Energiebalans reports at corporate level, and the MJV reports per facility, then it is not possible to calculate the company-specific emission factor. When setting up the NIR 2005, experts started to report on residual gases at refineries. This group has now grown to around 20 companies and, in 2009, the group will be expanded to include around 30 companies.

If a company states a deviating heating value in the survey, this use is reconverted by the CBS Energiebalans into the standard heating value. Company-specific heating values are therefore not used in the NIR.

The aforementioned process compares the MJV data concerning the total fuel consumption in TJ (validated by the competent authority) and the further provisional figures from the CBS Energiebalans. If significant errors/differences are shown, the necessary modifications will be made to the further provisional CBS Energiebalans figures. However, this hardly ever happens, although a number of points are highlighted which are then taken into account during the following annual report (e.g. deviating heating value, other fuels).

APPENDIX 2 CH_4 emissions from gas engines in CHP plants: Revised CH_4 Emission Factor in the NIR 2009

Introduction

Emissions from the combustion of natural gas are reported in the NIR (National Inventory Report) under category 1A, which also includes gas engines used in CHP plants. Up to, and including, the NIR 2008, all sources using natural gas (thus also gas engines in CHP plants), used the default CH_4 emission factor (EF) for combustion of natural gas: 5.7 g CH_4/GJ. However, for gas engines in small-scale CHP plants, this is incorrect because the combustion in these systems is less complete. This results in a much higher CH_4 emission factor, which increases further as the size of the engine increases.

This higher CH_4 emission factor and the enormous growth, particularly in larger gas engines in CHP plants used by the greenhouse horticultural sector, mean that, from the NIR 2009 onwards, a higher EF will be used for CH_4, where (from 2002) the EF for the greenhouse horticultural sector, mostly due to the higher numbers of larger engines, rises even further above the EF for industry and HDO (trade, service and government sector) as a whole.

The entire range (1990-2007) will be recalculated from the NIR 20009 onwards.

New emission factors and emissions

In 1997 the CH_4 emissions from all CHP plants located in the Netherlands amounted to 19.4 kton, and 13.3 kton in 2002, which corresponds to 0.407 and 0.280 Mton CO_2 equivalents respectively. The emission factor amounted to 305 gr CH_4/GJ natural gas (in 1997) and 250 gr CH_4/GJ in 2002 [Van Dijk, 2004]. The determination of these emissions (for both years) took place using measurement-based emission factors [De Laat and Hondeman, 2001] and the consumption of natural gas [source: CBS]. Since little is known of any changes to the characteristics of used gas engines during 1990-1996, and because the capacity during this period was considerably less, the emission factor of 305 gr CH_4/GJ natural gas is also used for emissions during this period. CH_4 emissions for 1990-1996 are calculated according to the amount of natural gas used, which is estimated using data concerning capacity during the period 1990-1997 [Rijkers *et al.*, 2002] and the natural gas used in 1997 [De Laat and Hondeman, 2001].

After 1997 the characteristics of the used gas engines changed, whereby the emission factor was reduced between 1997 and 2002. This is why the EF for this period is interpolated. The CH_4 emissions for 1998-2001 are calculated based on natural gas used during the relevant years [source: CBS].

Industry and HDO have always worked with an EF of 250 gr CH_4/GJ natural gas [Van Dijk, 2004]. However, two recent studies [Olthuis and Engelen, 2007; Dueck *et al.*, 2008] based on new measurements, determine emission factors for gas engines (installed since 2000) in CHP plants used in the greenhouse horticultural sector. These emissions factors correspond well to those used in Denmark [Nielsen *et al.*, 2008]. Based on these and other data concerning the used gas engines [Kroon and Wetzels, 2008], new average EFs have been determined for the period 2003-2007.

For the other sectors, HDO and industry, the emission factor after 2002 remains constant. The CH_4 emissions for 2003-2007 are calculated based on the natural gas used in the relevant years [source: CBS]. Table 1 shows both the old and new emission factors, plus emissions and natural gas used for all sectors. In order to continue this series over the next few years, the CH_4 emission factor for the greenhouse horticultural sector needs to be monitored regularly.

Table 1. Overview of natural gas emission factors and emissions, 1990-2007

	Use of natural gas		Emission factor CH_4 new		Emission CH_4		
	Greenhouse horticulture	Other sectors	Greenhouse horticulture	Other sectors	Old	New	
Jaar	(TJ)	(TJ)	gr/GJ	gr/GJ	kg	kg	kton CO_2-eq
1990	6.455	3.190	305	305	54.977	2.941.733	62
1991	9.163	4.528	305	305	78.038	4.175.742	88
1992	12.434	6.144	305	305	105.894	5.666.238	119
1993	16.483	8.144	305	305	140.376	7.511.364	158
1994	21.997	10.869	305	305	187.331	10.023.876	211
1995	27.883	13.777	305	305	237.466	12.706.506	267
1996	38.709	19.126	305	305	329.664	17.639.927	370
1997	42.500	20.999	305	305	361.946	19.367.279	407
1998	32.475	21.890	294	294	309.881	15.983.333	336
1999	34.757	22.289	283	283	325.167	16.144.240	339
2000	33.445	24.194	272	272	328.544	15.677.873	329
2001	32.920	21.751	261	261	311.625	14.269.166	300
2002	32.469	21.366	250	250	306.859	13.458.727	283
2003	31.301	21.637	253	250	301.741	13.328.167	280
2004	31.781	18.991	276	250	289.400	13.519.294	284
2005	34.903	19.655	314	250	310.983	15.873.409	333
2006	44.490	19.053	377	250	362.196	21.535.965	452
2007	71.234	20.047	409	250	520.302	34.146.495	717

Uncertainty

Until now the EF for 'normal' combustion of natural gas has always been used. However, because these emissions were underestimated, the uncertainty for this partial source (CHP plants) is undoubtedly greater than 100%. The current emission factor has been derived via actual measurements. As these measurements are spread across a wide range, the uncertainty of the current emissions is estimated at 50%. This will result in less uncertainty compared to the current situation.

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