Protocol
1B2 and 1A1c: CO_2 AND CH_4 EMISSIONS FROM THE TRANSPORT AND DISTRIBUTION OF OIL AND GAS

IPCC Category:	1B2, 1A1c
NFR Code:	n.a.
NOSE Code:	n.a.
NACE Code	06, 0910 and 351

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 the method and working processes used to determine the CO_2 and CH_4 (1A1c and 1B2) emissions that are released during the transport and distribution of oil and gas in the Netherlands. These activities concern SBI (industrial) codes 06, 0910 and 351. Emissions released during oil and gas production in the Netherlands are covered by a separate protocol.

Gas transport

Gas Transport Services BV (a subsidiary of the NV Nederlandse Gasunie) is responsible for transporting natural gas in the Netherlands. The Gasunie has an extensive gas transport network that consists of underground pipelines (totalling around 11,600 km), dozens of plants and over 1,000 stations. Eleven mixing stations supply the gas to various groups of customers at the required quality. Nine compressor stations provided the necessary compression for transporting the natural gas to the end-users. Measurement and control stations at 77 locations throughout the national gas transport network ensure the transfer of natural gas from the main network to regional networks, which have a lower transport pressure. The gas is eventually supplied to the end-users via around 1,100 gas distribution points and 14 export stations. Compressors driven by gas turbines and gas engines ensure that the gas is transported under pressure. These activities cause various combustion emissions, including CO_2 and CH_4. Small amounts of these substances are also released during the laying of gas transport pipelines and during maintenance activities.

Gas distribution
The gas distribution system ensures that natural gas is distributed at low, medium and high pressures. The system consists of main underground pipelines and connections, plus a number of above-ground gas pressure measurement and control installations, which all function as a single system. Within this main system, there are also various local gas distribution systems that distribute the gas to the end-users.
These low-pressure networks include gas distribution systems with a working pressure of 30-100 mbar. The medium-pressure networks work at 1-4 bar, and the high-pressure gas distribution networks use a working pressure of 8 bar.
The main pipelines are made of the following types of materials: polythene (PE), hard PVC, impact-resistant PVC, steel, grey cast iron, nodular cast iron, asbestos cement, or other unknown materials.
CH_4 (and a small amount of CO_2) emissions occur during leakages and accidents with the distribution network (main pipelines and connections to the home) and/or through activities at the distribution stations. However, most emissions occur in the grey-cast-iron network (Gastec, 2004, Hendriks and De Jager, 2001). During the 1970s and 1980s the largest leaks were repaired in the old grey-cast-iron pipelines used to switch from (wet) town gas to (dry) coal gas. Many leaking lead-based connections have been replaced or permanently sealed. Urban areas in particular still have many old cast iron pipes. These are being replaced, over time, and therefore make up a smaller percentage of the total distribution network (1% in 1990, but only 6% in 2004).

1.2 Significance and influences

1.2.1 Contribution to total national emissions
Both CO_2 and CH_4 emissions from transport and distribution of oil and gas contribute less than 0.5% to the total annual greenhouse gas emissions in the Netherlands.

1.2.2 Major developments that infuence emissions

Gas transport
The (process) emissions from gas transport depend on the amount of natural gas transported and the emissions (per million m^3) from this transported natural gas. The increase in CO_2 emissions over the last few years is mainly due to the higher fuel consumption per million m^3 of natural gas transported from a number of compressor stations.

Gas distribution
Emissions have fallen due to the replacement of old cast-iron pipes, partially during town-renovation projects, but the total emissions from distribution has increased as a result of distribution losses.

2 Method, emission factors and activity data

2.1 Calculation method

Gas transport
Total emissions of both CO_2 and methane (CH_4) due to the transport of natural gas are taken from the V,G&M (safety, health and environment) annual reports submitted by the NV Nederlandse Gasunie. These emissions are not split into process and combustion emissions, but because the CO_2 emissions are primarily combustion emissions, these are reported under IPCC category 1A1c.

CO_2 combustion emissions are calculated as follows:

$$CO_2 \text{ emissions [kg/year]} = \text{natural gas used } [m^3/\text{year}] * \text{Emission factor } CO_2 \text{ (kg } CO_2/m^3)$$

CH_4 emissions are calculated as follows:

$$CH_4 \text{ emissions [kg/year]} = \text{natural gas losses } [m^3/\text{year}] * \text{Emission factor } CH_4 \text{ (kg } CH_4/m^3)$$

Gas distribution
Methane (CH_4) emissions as a result of leakages at household connections and distribution stations are not known, but these amounts are negligible and have no influence on total emissions. Methane (CH_4) and CO_2 emissions from main pipelines are calculated using the following formula:

$$CH_4 \text{ emissions [kg/year]} = \text{pipe length (km)} * \text{Emission factor } [m^3/\text{km/year}] * \text{Density of material (kg/}m^3)$$

The above formula is used for two types of pipes, i.e. ‘grey cast iron’ and ‘other materials’. Results from these two groups are added together to form the total CH_4 and CO_2 emissions from gas distribution.

This complies with the calculation method for determining methane emissions from gas transport and distribution, as defined in the IPCC Good Practice Guidance (GPG) § 2.7.1.1 (IPCC, 2001, box 3, p. 2.79 onwards). For further information on the activity data and emission factors used, see Sections 2.2 and 2.3 of this protocol.

2.2 Emission factors

Gas transport
The default emission factor is used for CO_2 from natural gas combustion (Vreuls, 2006). When determining the CH_4 emissions, it is assumed that 1 m^3 of natural gas contains 583 gram CH_4 (Gasunie, 2004).

Gas distribution
The emission factors are calculated annually using the amount of leaks/km and the emissions per leak for the year 2005:

EF(m^3/km/year) = number of leaks(/km/year) * average amount of leakage per pipe category (m^3)

The pipelines are split into two types of materials: grey cast iron (with an EF of 610 m^3 methane/km/yr) and other materials (with an EF of 120 m^3 methane/km/yr). Differentiating between more types of materials is not useful, considering the information available and the uncertainties as to whether this is representative for the entire country (Gastec, 2005). The EF for 2005 is also used for the years 1990-2004.

2.3 Activity data

Gas transport
The amount of natural gas transported and used, plus the CH_4 emissions that result from these activities, are all taken from the V,G&M annual report submitted by the Gasunie.

Gas distribution
The time range for the length of the gas distribution network (for each type of pipe) is based on figures for 1988, 1993, 1998 and 2004, as produced and published by Gastec (2005). Figures for intervening years are interpolated. EnergieNed (Federation of Energy Companies in the Netherlands) has agreed with the network companies that, from 2004 onwards, the following information will be made available on a yearly basis, to be used as input for the annual national emission reports:

- Pipe lengths of the main pipelines, in two categories, i.e. ´grey cast iron´ and ´other materials´.
- Number of leaks per km; every year 1/5 of the total distribution network is checked and the results are used to extrapolate the total number of leaks.

In order to determine the amount of methane and CO_2 emissions from gas losses, it is assumed that the methane percentage is 80% (Gasunie, 2004) and CO_2 amounts to 0.9% (Spakman, 2003).

3 Working processes

***Gas transport*:**

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
Emission figures determined within the company	Report in V,G&M annual report	V,G&M annual report	NV Nederlandse Gasunie
V,G&M annual report	Check emission figures: - Compare with previous years (trend) If unsubstantiated deviations found in the text, contact the company → if necessary, modify emission figures and document fully	Approved emission figures Final data Work package leader (t-2)	Work package leader
Final data Work package leader (t-2)	Include (t-2) data in ER database	ER-db with (t-2) data	Work package leader
ER-db with (t-2) data	Check, and trend analysis of air emissions: explain deviations or modify figures	Final defined emission figures (t-2)	Task forces and PBL experts

***Gas distribution*:**

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
Annual data on pipe lengths, number of leaks per km (Kiwa Gastec Technology/ EnergieNed)	Check annual data: - Compare with previous years, look at the trend and, if required, modify the EFs (emission factors) based on leakage data from the distribution companies. If unsubstantiated deviations are found, contact the supplier of the figures → If necessary, modify the figures and document fully	Approved figures	Work package leader
Approved figures	Enter into tier 3 formula and calculate emissions	Final data Work package leader (t-2)	Work package leader
Final data Work package leader (t-2)	Include (t-2) data in ER database	ER-db with (t-2) data	Work package leader
ER-db with (t-2) data	Check, and trend analysis of air emissions: explain deviations or modify figures	Final defined emission figures (t-2)	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 (AD_{onz}) in the square and the uncertainty of the emission factor (EF_{onz}) in the square. The extent of the total uncertainty is here primarily determined by the greatest AD or EF uncertainty.

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

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 $_{tot}$
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
1B2	Fugitive emissions venting/flaring	CH_4	2	25	25
1B2	Fugitive emissions from oil and gas operations: gas distribution	CH_4	2	50	50
1B2	Fugitive emissions from oil and gas operations: other	CH_4	20	50	54
1B2	Fugitive emissions venting/flaring: CO_2	CO_2	50	2	50

- *Methane from gas distribution (1B2) activity data and emission factors*

The IPCC Tier 3 approach for CH_4 from 'gas distribution' (1B2) was based on two country-specific emission factors: 610 m^3 (437 Gg) methane from grey cast iron, and 120 m^3 (86 Gg) from other materials per 1000 kilometres of pipeline, both due to leakages. These emission factors were based on seven measurements of leakage per hour from grey cast iron, at one pressure level, and on 18 measurements, at three pressure levels, from other materials (PVC, steel, nodular cast iron and PE). Subsequently, the results were aggregated to factors for the material mix in 2004. From 2004 onwards, the gas distribution sector annually recorded the number of leaks found per substance, and any future trends in the emission factors will be derived from these data.

For CH_4 from gas distribution, the uncertainty in the emission factors was estimated at 50%. This uncertainty referred to the limited number of measurements, per gas leak, for different types of substances and pressures, on which the Tier 3 approach of methane emissions from gas distribution was based. The uncertainty in the length of pipeline, per substance, was estimated at 2% (based on apparent inconsistencies in the time series of subsequent surveys) [Olivier et al, 2009].

- *Emission factors for venting and flaring (1B2)*

The uncertainty in the emission factor of CO_2 from gas flaring and venting (1B2) was estimated at 2%, for flaring, taking into account the variability in the gas composition at the smaller gas fields, and, for venting, taking into account the variability in CO_2 gas produced at a few locations where CO_2 is extracted and subsequently vented.

For CH_4 from fossil fuel production, the uncertainty in the emission factors was estimated at 25% for gas venting, and 50% for gas distribution. These uncertainties referred to the changes in reported emissions from venting in the oil and gas production industry, over the previous years, and to the limited number of measurements, per gas leak, for different types of substances and pressures, on which the Tier 2 approach for methane emissions from gas distribution was based.

- Emissions from non-combustion or related sources
The uncertainty in annual CO_2 emissions from coke production (1B2) was estimated to be about 50%. For the annual CO_2 emissions from gas flaring and venting this was about 50%. The uncertainty in annual methane emissions was estimated to be 25% from oil and gas production (venting), and 50% from gas transport and distribution (leakage).

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].

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.

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

Up to and including 2004 the methane and CO_2 emissions for gas distribution were calculated using the following formula (Tier 1 method):

Emission(kton) = natural gas distribution (GJ) * emission factor (kton /substance/GJ)

The emission factor for gas distribution is based on a loss percentage of the total annual sales to end-users.

4.4.2 Future

Not applicable

5 Remaining aspects

5.1 Point source criteria

Not applicable

5.2 Component profiles

Not applicable

5.3 Regionalisation

Not applicable

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
Not applicable