Protocol
1B2 & 1A1C: CO_2 AND CH_4 EMISSIONS FROM OIL AND GAS PRODUCTION

IPCC Category:	1B2, 1A1c
NFR Code:	n.a.
NOSE Code:	n.a.
NACE Code 2008	0610 and 0620

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 emissions that are released during oil and gas production in the Netherlands (1B2 and 1A1c). These activities concern the SBI (industrial) code 0610 and 0620.

Oil and gas production occurs within the territorial area (onshore), on the NCP (Netherlands Continental Plateau) and in territorial waters (offshore). The surface area of the Netherlands territory amounts to around 42,000 km^2, with the NCP bringing this total to around 57,000 km^2 (FO-Industrie, 2005a).

The Netherlands concentrates mostly on gas production: in 1990 this was largely onshore, but has moved increasingly offshore. Almost all the onshore gas is produced by the NAM (Nederlandse Aardolie Maatschappij), while the percentage of offshore production is now around 40-50%.

There is also a certain amount of oil production, 60-70% of which is offshore. The onshore production is implemented entirely by NAM.

Oil and gas production activities can generally be split into two aspects:

1. Locating sources or surveying via seismic research and test drilling (the so-called ‘exploration phase’).
2. Field development and production (‘extraction’) via drilling and production equipment (the so-called ‘exploitation phase’).

Ref. Point 1:
Since 2002 these CO_2 and CH_4 emissions have been reported separately by producers in their individual annual environmental reports (AERs/MJVs) and are reported under IPCC Category 1A1c.

Ref. Point 2:
When extracting gas from the North Sea the wells are connected to production platforms, and these are connected via pipelines to the gas processing plant. When processing crude gas, it is first cooled (to separate the gas from the liquid): the gas is then dried and compressed to a sufficient pressure so that it can be injected into the GASUNIE’s transport network.

Onshore extraction of natural gas also occurs in wells. From here the gas flows through underground pipelines to a gas processing plant.

The oil production process includes pumping it up from the well and separating the gas from the oil, before making it suitable for transport. Oil is transported from offshore oil rigs via pipelines. Once onshore, the oil is transported via train from Drenthe and Groningen to the various refineries. From West Netherlands the oil is pumped to the refineries via a system of pipelines.

The majority of the CO_2 emissions occur during the company’s own use of gas to drive compressors, gas turbines etc. In addition, both CO_2 and CH_4 emissions occur through flaring equipment and venting pipes, which cannot be included in particular processes. The extent of these emissions varies considerably.

Finally, certain emissions occur as a result of a specific process. For example, gas is produced on one platform (K12), where a high CO_2 content is removed and, until 2004, this was vented into the atmosphere. However, this process changed during 2004 and the CO_2 is now stored in old gas fields rather than being vented into the atmosphere.

Emissions arising from ‘gas transport’ and ‘distribution’ are covered by a separate protocol. Emissions from mobile sources, such as helicopters and ships, do not fall under this protocol, but under the protocol ‘International bunkers’.

1.2 Significance and influences

1.2.1 Contribution to total national emissions

The CO_2 emissions from oil and gas production contribute about 1% to the total annual greenhouse gas emissions from the Netherlands.

The CH_4 emissions from oil and gas production contribute less than 0.5% to the total annual greenhouse gas emissions from the Netherlands.

1.2.2 Major developments that infuence emissions

Reduced pressure in the ageing reservoirs means that increasing amounts of energy are required (which leads to higher CO_2 emissions) in order to ensure that the gas meets the required delivery specifications (a particularly delivery pressure when the gas is supplied to the GASUNIE network).

But despite this increase, CO_2 emissions have dropped due to various energy-conservation measures taken, the closure of several locations and reduced production levels.

Over the last few years CH_4 emissions have fallen due to:

- Less ‘venting’ when releasing pressure and/or when implementing well-testing procedures.
- Increased use of the so-called ‘exhaust gas’ (pressure less than 10 bar) in plants as heating/fuel gas.
- Less need for the use of (emergency) flare torches due to increased reliability of (newly installed) exhaust gas compressors.

2 METHOD, EMISSION FACTORS AND ACTIVITY DATA

2.1 Calculation method

The Dutch oil and gas production companies are all members of NOGEPA (Netherlands Oil and Gas Exploration and Production Association). Since 1995 these companies publish annual environmental reports (AERs/MJVs) that, since 2002, also report on emissions as per the international requirements. This means that, from 2002 onwards, the following emissions sources have been separated, for both onshore and offshore applications:

- Own use, for gas production (including energy generation)
- Own use for oil production (including energy generation)
- Venting gas production
- Flaring gas production
- Venting oil production
- Flaring oil production
- Drilling activities

The various companies calculate CO_2 and CH_4 emissions for each of their plants, using company-specific emission factors and measured volumes (Grontmij, 2000). These company-specific emission factors are determined according to the (crude) gas composition. The measured volumes are the amounts of crude gas used, vented and flared. Each company totals its emissions from all plants and these are included in the annual environmental report.

For the period 1990-2001 the total CO_2 and CH_4 emissions (excluding drilling activities) are taken from the annual reports by the oil and gas production industry as drawn up by FO-I (Facilitary Organisation-Industry). The differentiation into own use, venting and flaring, for the years 1990-2001 is carried out using the CBS (Statistics Netherlands) Natural Gas Balances for the Oil and Gas Production Industry, plus the Venting (including removed CO_2) and Flaring data (1990-2003) published by the NAM and GDF.

The aforementioned method conforms to the IPCC method as described in the Good Practice Guidance (IPCC, GPG, 2001, pp. 2.79-2.93).

2.2 Emission factors

As described in Section 2.1, company-specific emission factors are used (per plant).

2.3 Activity data

Information on gas production (extraction), venting and flaring (destruction), and own use (usage) is reported by companies as fiscal statements to the Staatstoezicht op de Mijnen (SodM) and to the CBS (Statistics Netherlands). Since around 1995 companies also submit this information and the relevant emission data as part of their AER/MJV. Removed CO_2 is also reported to the SodM and in the AERs/MJVs.

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
Emission figures determined within the company (sum of all plants)	Reported in AER/MJV (annual environmental report)	AER/MJV	Company
AER/MJV	Validate AER/MJV	Validated AER/MJV	Competent authority (Ministry of Economic Affairs)
Validated AER/MJV	Enter into FO-I file	FO-I file	FO-I (Facilitary organisation-industry)
-FO-I file -FO-I files for previous years	Check emission figures: - Compare AERs/MJVs with those of previous years (trend). If unsubstantiated deviations found in AER/MJV text, contact NOGEPA and/or company → If necessary, modify emission figures and document fully	'Preliminary file' of work package leader 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 emissions $_{total}$**
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

The CO_2 emissions from own use of raw natural gas were determined up to and including 2004 (emissions for 2002) by the amount of raw gas consumed and default emission factors (Spakman, 2003). Up to and including 2004 the process emissions were determined by the amount of oil and gas extracted and default emission factors (Spakman, 2003).

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