Protocol
4B: CH_4 FROM MANURE MANAGEMENT

IPCC Category:	4B1, 4B3, 4B4, 4B6, 4B8, 4B9
NFR Code:	n.a.
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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 methodology and working processes for determining CH_4 emissions from management of manure produced by the following source categories:
4B1 cattle
4B3 Sheep
4B4 Goats
4B6 Horses
4B8 pigs
4B9 Poultry

The source categories 4B2 (buffalo), 4B5 (camels and lamas) and 4B7 (mules and donkeys) are reported under the CRF (common reporting format) as NO (not occurring), because these are not kept commercially in the Netherlands.

The SBI codes for these activities are:
0141 and 0142 (raising and breeding of cattle)
0145 (raising and breeding of sheep and goats)
0143 (raising and breeding of horses)
0146 (raising and breeding of swine)
0147 (raising and breeding of poultry)

Methane emissions from animal manure are caused by fermentation processes that occur in anaerobic conditions. These conditions generally occur when storing liquid manure in manure cellars under animal houses and in manure storage facilities outside the stables. The conditions for solid manure and pasture manure are usually aerobic, and the production of CH_4 is relatively low.

- Cattle manure can be split into liquid stable manure, solid stable manure, and meadow manure. Some dairy cows spend part of the day inside the animal house, even during the summer months, particularly at night and at milking times. This means that stable manure is produced even during the summer grazing period.
- Pig manure in the Netherlands generally consists of liquid manure.
- Poultry consists of several animal categories. In addition to (breeding) laying hens and broilers, ducks and turkeys, this group also includes rabbits, mink and foxes. All poultry animal categories are kept inside the animal house throughout the year and produce solid manure, with the exception of part of the laying hens. Since the 1980s a trend can be seen for this category, i.e. switching over from liquid manure management systems to solid manure management systems.
- The source category goats consists primarily of milking goats, which are kept inside the animal house throughout the year and produce solid manure.
- Sheep are grazing animals and only spend the cold winter months inside the animal house, where they produce solid manure.
- For Horses and ponies a distinction is made between stable and grazing periods. Solid manure is produced in the period inside the animal house.

Liquid stable manure is stored in the manure cellars under the animal houses and in manure storage facilities outside the animal houses. Solid stable manure is stored in the stable and in outside storage facilities. In both cases anaerobic conditions can occur, which result in the emission of methane. These emissions can be reduced by preventing anaerobic conditions, for example through aeration or periodic conversion. However, the resulting aerobic processes lead to higher emissions of ammonia and laughing gas. Solid manure forms only a small part of the total manure production in the Netherlands.

Meadow manure is produced by the animals in the grazing period during the summer months. Methane emissions from meadow manure are relatively low, due to the mostly aerobic conditions.

In addition to the anaerobic circumstances, methane formation also depends on other storage conditions, such as the amount of manure already present (“inocculum”), plus the storage period and temperature. The manure cellar can be seen as a so-called accumulation system: there is a constant input of manure in the 'reactor' (= manure cellar), and the volume of manure in the cellar increases up to the point where it is

emptied, and the manure is distributed over the land, or up to the point where the manure is transferred to the manure storage facility outside the animal house.
The methane emissions in such a system increase as the amount of manure that is (still) in the storage facility (= inocculation) increases, as the manure temperature rises and the manure is stored for longer periods (Zeeman, 1994).

The methane emissions from manure also partially depend on the (chemical) composition of the manure. The CH_4 emissions primarily depend on the amount of organic matter in the manure.

1.2 Significance and influences

1.2.1 Contribution to total national emissions

The CH_4 emissions from manure management contribute about 1% to the Netherlands annual greenhouse gas emissions.

1.2.2 Developments that infuence emissions

- Methane emissions from cattle manure fell slightly between 1990 and 2004. This emissions reduction primarily results from smaller cattle herds, which then produce less manure.This emissions reduction primarily results from farmers keeping fewer cattle, which then produce less manure. The dairy cattle herds, in particular, have been drastically reduced. This situation results from the milk quotas set by the European agricultural policy, in combination with an increase in the milk production per cow. As the milk production per dairy cow increases, so too does the manure production per cow (as a result of more food intake), although to a lesser extent. Here too, the amount of organic substances in the manure has increased during the period 1990-2004. Both developments lead to relatively higher methane emissions per kg animal.
  Another development involves a shorter grazing period for dairy cattle: on the one hand to improve the cost-efficiency of milk production, and on the other hand to increase the efficiency of manure production (under influence of the government's manure policy). This results in relatively more liquid manure ending up in the manure cellars or outside storage facilities than in the meadow itself. Since methane formation from liquid manure is higher than from meadow manure, this development leads to higher methane emissions. On balance, as a result of all these developments, the smaller herds of dairy cattle only cause a slight drop in methane emissions.
- During the period 1990-1997 methane emissions from pig manure increased, but then fell in the following years. In 2004 emissions were around 20% lower than in 1990. This development is primarily the result of changes in pig numbers over the years and, to a lesser extent, from changes in manure production per animal. The drop of the number of pigs during the last years is the result of stricter manure and ammonia policies in the Netherlands.
- CH_4 emissions from poultry manure fell by around 75% between 1990 and 2004. This is primarily associated with the switch to other manure management systems with more dry manure like manure belt drying and perchery. The amount of solid manure almost doubled (from 44% to 86%) during the period 1990-2004 (Brandes *et al.*, 2006). The emission factor for solid manure is much lower than that for liquid manure.

- Emissions from sheep manure have fallen by around 30%, which corresponds to the reduction in the number of animals in this category (Brandes et al., 2006).
- CH_4 emissions from goat and horse manure increased during the period 1990-2004, which corresponds to an increase in the number of animals (Brandes et al., 2006).

2 Method, emission factors and activity data

2.1 Calculation method

Methane emissions from manure are calculated using three steps. The amount of manure is calculated annually for each animal category and each manure management system. The country-specific emission factor is then calculated for each animal category and manure management system. Multiplying the emission factor and annual manure production results in the annual methane emissions from manure storage. For more detailed information, see the Background Document (Van der Hoek and Van Schijndel, 2006).

The total CH_4 emissions from manure management are calculated by adding the CH_4 emissions per animal category and manure management system.

$$CH_4 \text{ emissions} = \sum_{ij} [EF_{ij}]$$
$$* \text{ [amount of manure per animal in animal category (i) and manure management system (j)]}$$
$$* \text{ [number of animals per animal category (i) and manure management system(j)]}$$

CH_4 emissions	: CH_4 emissions from manure management, in kg
EF_{ij}	: emission factor for the defined animal category (i) and manure management system (j) in kg CH_4/kg manure

Comparison with the IPCC GPG method

The aforementioned method complies to a large extent with the IPCC method as described in the Good Practice Guidance (GPG, IPCC, 2001, p. 4.30). However, the formula used deviates slightly from the IPCC formula, as the amounts of manure per animal category are taken as the main starting point, rather than the number of animals. The country-specific emission factors (EF) for the Netherlands are based on emissions per amount of manure (kg CH_4 per kg manure), rather than absolute annual amounts of methane per animal (in kg per animal per year). The Netherlands' country-specific emission factors therefore need to be multiplied by the amount of manure per animal category, per manure management system.

The division into animal categories and determination of the associated animal numbers is carried out using the Tier-2 method. Country-specific emission factors (Tier-2) are used to differentiate between animal categories and manure management systems. For goats, sheep and horses, the 'Landbouwtelling' (annual agricultural census) divides animals into several animal categories (tier 2), but the reporting of manure production is coupled to one of the categories. For goats and sheep, data used for the manure production of the entire group (including lambs and adult male animals) are coupled to the data for adult female animals. For the timeseries from 1990 up to 2005, all horses and ponies are assumed to produce the same amount of manure per animal, because no emasurement were available. From 2006 the calculation will contain specific manure production figures.

2.2 Emission factors

The national methane emissions as a result of manure management are calculated by multiplying the total manure production per animal category and manure management system by a country-specific emission factor (Van der Hoek and Van Schijndel, 2006). The formula for the emission factor is as follows:

$$EF_{ij} = VS_{ij} * B_{oij} * MCF_j * \text{methane density } (0.662 \text{ kg/m}^3)$$

EF_{ij} : emission factor (kg CH_4/kg manure) per animal category (i) and manure management system (j)

OS_{ij} : fraction of volatile solids (kg VS/kg manure) produced by animal category (i) and manure management system (j)

B_{oij} : maximum methane production potential (m^3 CH_4/kg VS) for the manure produced by animal category (i) and manure management system (j)

MCF_j : methane conversion factor for a manure management system j (% of B_0).

OS_{ij}

The fraction of volatile solids in the manure varies per animal category and depends on the feed composition. Under the Netherlands methodology, OS is expressed as a fraction, kg OS/kg manure. This is opposite to the IPCC method where the volatile solids per animal is used.

The mineral and volatile solids levels of manure are important in achieving good fertilisation recommendations. The manure composition is updated at irregular intervals. The values for 1990-1995 and 1995-2000 are taken from the Handboek voor de Rundveehouderij (Handbook for Cattle Farming, Anonymous, 1988) and the Adviesbasis voor de bemesting van akkerbouw- en vollegrondsgroentegewassen (Advisory basis for fertilising arable crops and field vegetable crops, Van Dijk, 1999) respectively. The values for 2000 and later years are taken from the latter publication, specifically the November 2002 edition (Anonymous, 2002). The OS_{ij} values vary somewhat between 1990 and today. An overview is given in the Background Document (Van der Hoek and Van Schijndel, 2006) and in the annex of the NIR.

B_{oij}

The maximum methane formation is determined by the degradability of the organic components in the manure. B_{oij} is expressed in m^3 CH_4/kg VS and the values are taken from specific research in the Netherlands (Zeeman, 1994; Zeeman and Gerbens, 2002). For the period from 1990 until now a fixed value is used.

Methane Conversion Factor (MCF)

The MCF indicates the extent to which, under certain conditions, the degradable substances will actually be converted into methane. The IPCC provides a default value of MCF = 0 for liquid manure stored for less than one month, and MCF = 0.39 for liquid manure stored for longer than one month. In fact, the value of 0.39 relates to pig manure that is stored for six months at a manure temperature of 15°C, or storage time of three months at 20°C, or cattle manure stored for 5-6 months at 20°C (see Zeeman and Gerbens, 2002).

There are no periodic statistics regarding the time that manure is kept in manure cellars and outside storage silos. There are also no periodic data available concerning the temperature of the manure in these cellars and outside storage silos. Incidental information concerning total manure storage capacity and the proportion of inside (e.g. cellar) and outside manure storage capacity (Van der Hoek, 1994; CBS, 1997; CBS, 2006), as well as manure temperatures inside (cellars) and outside storage (based on De mol and Hilhorst, 2003, 2004) is therefore used in the calculations. For cattle, it is assumed that the proportion of inside and outside manure storage capacity (from the early 1990s onwards) continued throughout the following years. It is possible that this proportion has changed, partly due to the consequences of upscaling farming capacities. However, there is currently no information available. The Netherlands uses a country-specific value for cattle manure (MCF = 0.284), based on a manure storage time of six months at a manure temperature of 15°C (Zeeman, 1994). For cattle, the Netherlands also uses a lower manure temperature for outside storage facilities, and a lower manure temperature during the winter for manure cellars under stables.
It has been assumed that the total storage capacity for animal manure is six months: four months in the manure cellar and two months in outside storage facilities. It is also assumed that all manure storage facilities are empty on 1 September and that the manure cellar is filled completely first, before manure is pumped out to the outside storage facilities. Another assumption is that both the manure cellar and the outside storage facilities are empty on 1 March (Van der Hoek and Van Schijndel, 2006). From 1997 onwards, the total storage capacity (under the animal house) for pig manure is six months.

The default IPCC value for solid cattle manure is MCF = 0.01. Since foreign research (Amon al., 2001) has shown that the methane emissions from solid cattle manure are probably higher, and because there is no other measurement information available, an MCF value has been chosen that is equal to the IPCC default value for solid poultry manure (i.e. MCF = 0.015). With respect to meadow manure, the IPCC default value (MCF = 0.01) is used.

Since the VS_i values in manure for the period 1990-2003 vary somewhat, the annual EF_{ij} also varies. The annex of the NIR shows an overview of all EF_{ij} used.

2.3 Activity data

Animal population
Livestock is classified in the following main categories:

- Mature dairy cattle
- Mature non-dairy cattle
- Young Cattle
- Swine
- Poultry
- Sheep
- Goats
- Horses and ponies

There are also various subcategories defined within these main categories in the annual Agricultural Census in the Netherlands. The annual Agricultural Census

monitors all agricultural companies if they have a head office registered in the Netherlands and are equal to (or larger than) three Netherlands size units (nge). The population statistics can be found on the CBS/Statline website (www.cbs.nl) and in the annex of the NIR.
If widespread animal diseases occurred during the reporting year, which resulted in deviations to the average number of animals, the WUM (Working group for Uniform calculations of Manure and mineral figures) adjusts these animal numbers accordingly. It is these adjusted figures that are used for the emissions calculations. The animal numbers for the period 1990-2003 are also included in the Background Document (Van der Hoek and Van Schijndel, 2006).

Amounts of manure per animal category
The amount of solid or liquid manure and meadow manure produced by an animal (of a specific sub-category) per year is determined by the WUM (a working group for uniform calculation of manure and mineral figures). These figures were first published in 1994 (WUM, 1994) and the most recent information dates from 2009 (CBS, 2009). The manure production factors are fixed factors that are not updated every year. The stable manure production per animal includes water used to clean the sheds as well as spilled drinking water.

Manure production factors for dairy cattle depend on the milk production per cow, and the allocation of stable and meadow manure depends on the timespan of the grazing period and the grazing system used. For the other types of cattle there is relatively little variation in time. As a result of the government's manure policies, the manure production factors for swine have fallen slightly over the years, generally due to transport costs for removing manure. Less cleaning water is used in order to reduce costs. These factors are modified only if and when new information becomes available. An overview of the manure production factors used is available from the CBS (www.cbs.nl), and is also included in the Background Document (Van der Hoek and Van Schijndel, 2006).
Until 2006, manure figures for horses are not determined by the WUM. Total manure production for the timeseries 1990-2005 is set equal to the manure production in 2006.

Distribution between the manure management systems
The aforementioned method of calculating amounts of manure differentiates between liquid manure from the stable period, solid manure from the stable period and that from the grazing period. Part of the manure produced during the summer grazing period actually ends up in the stable. The distribution between the stable and grazing periods is indicated by the WUM (see further under *Manure amounts per animal category).* The split between solid manure and liquid manure depends on the type of animal and housing systems.
According to the IPCC method, liquid manure is divided into two groups: storage in the manure cellar lasting less than one month, and storage lasting longer than one month. The former does not apply in the Netherlands.

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 [(t-2)], based on prognoses for the developments in the most important activity data (taken from CBS

(Statistics Netherlands) or other statistical sources). CH_4 emissions from manure are calculated using the data on animal numbers in the year (t-1), multiplied by the emission factors (as determined for the year t-2). See final determination process (t-2).

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 non-CO_2 ER working group for agriculture and land use
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	ER working group for agriculture and land use

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
Animal number per animal category Statline CBS (or WUM if modified due to animal diseases) **(A)** ***Manure production factors*** per: -animal category -manure management system (CBS, via WUM) **(B)**	Calculating manure production: **(A) x (B)**	Manure production per: -animal category -manure management system in Excel spreadsheet **(C)**	Work package leader non-CO_2 ER working group for agriculture and land use
Animal manure statistics per: -animal category -manure management system (Van der Hoek and Van Schijndel, 2006) ***Volatile solids (VS)*** **(D)** ***Maximum CH_4formation (B0)*** **(E)** ***Methane conversion factor (MCF)*** **(F)**	Calculating emission factors **(D) x (E) x (F)** (Van der Hoek and Van Schijndel, 2006)	***CH4 emission factors per*** -animal category -manure management system in Excel spreadsheet **(G)**	Work package leader non-CO_2 ER working group for agriculture and land use
Manure production per -animal category -manure management system **(C)** ***CH_4 emission factors*** per: -animal category -manure management system **(G)**	Calculating CH_4 emissions **(C) x (G)**	CH_4 emissions per: -animal category -manure management system in Excel spreadsheet **(H)**	Work package leader non-CO_2 ER working group for agriculture and land use
CH_4-emission **(H)**	First validation of emission figures via trend analysis and expert judgement	Validated emission figures in Excel spreadsheet (= Final data Work package leader (t-2)) **(I)**	Work package leader non-CO_2 ER working group for agriculture and land use

4B CH_4 from manure management (NIR 2010)

INPUT	PROCESS	OUTPUT	BY WHOM
Final data Work package leader (t-2) **(I)**	Include (t-2) data in ER database	ER-db with (t-2) data **(J)**	Work package leader non-CO2 ER working group for agriculture and land use
ER-db with (t-2) data (**J**)	Check, and trend analysis of air emissions: explain deviations or modify figures	Final defined emission figures (t-2) **(K)**	TNO

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 $_{total}$ 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.

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

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 $_{tot}$**
4B1	Emissions from manure management : cattle	CH_4	10	100	100
4B8	Emissions from manure management : swine	CH_4	10	100	100
4B9	Emissions from manure management : poultry	CH_4	10	100	100
4B	Emissions from manure management : other	CH_4	10	100	100

The uncertainty in the CH_4 emissions from the management of manure from cattle and swine was estimated to be approximately 100%, annually. The uncertainty in the amount of animal manure (10%) was based on a 5% uncertainty in animal numbers and a 5 to 10% uncertainty in excretion per animal (RIVM, 1999). The resulting uncertainty of 7 to 11% was rounded off to 10%. The uncertainty in the CH_4 emission factors for manure management, based on expert judgments, was estimated to be 100% [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

Country-specific emissions factors were set at the beginning of the 1990s, which were based on the initial IPCC protocol (Van Amstel *et al*., 1993). This was later summarised in Spakman *et al*., 1997. These emission factors were updated around 2004 (Van der Hoek and Van Schijndel, 2006). Three management systems were differentiated at that time: manure production in the meadow, storage of liquid manure, and storage of solid manure. The most important modification is the fact that most statistics for B_0 and MCF (see Section 2.2 for further details) now relate to the Dutch situation. The only exceptions are the use of the IPCC MCF default value for meadow manure and the modified IPCC MCF default for solid manure.
In addition, all manure management systems for the various animal categories are based on Dutch data with respect to the amount of organic substances (OS) in animal manure.

A consistent timeseries now exists:
- For cattle (1990-1994) the meat calves have been split into calves for rosé veal production and meat calves for white veal production, to comply with the data for following years.
- Data for fur-covered animals have been added for the years 1990 and 1991 (just as for the following years).
- The timeseries is also now complete since horses and ponies have been included.

The MCF for pigs has been recalculated in 2009, using new figures from the Agricultural Census ("Landbouwtelling"). This shows that the storage capacity has increased to six months. This results in an MCF of 0.39, and is no longer a combined MCF for manure storage in the cellar and outside the animal house. This change in storage capacity started after 1990, and had already reached six months by the year 1997.

Figures for horses and ponies (from 1990 onwards) have also been recalculated in 2009. Before this date the N-excretion factors used did not differentiate between horses and ponies [Van der Hoek *et al*., 2006]. However, from the NIR 2009 onwards, the N-excretion factors for horses and ponies are calculated via the same method used to calculate all other animal categories. The N-excretion factors are available from 2006 onwards. The figures for 2006 are also used for all preceding years.

In 2010 emissions will be calculated once again, because the recalculation discovered an error in the manure production volumes, which could not be corrected during 2009.

4.4.2 Future

The current calculation methods use a combined MCF for manure storage in manure cellars and outside storage facilities. This assumes a fixed share of the manure storage capacity in the cellar and outside storage throughout the entire period, and is based on incidental information derived from the early 1990s. This situation has possibly changed now, but there is currently no specific information available to substantiate this.

Methane emissions also largely depend on the time that the manure remains in both storage systems, the transfer schedule for pumping from cellar to outside facility, and the sequence in which manure from both the cellar and outside storage is distributed over the fields. The current calculation method assumes that the cellar is completely filled and then part of this manure is pumped out to the outside storage facility (which is then completely filled). It is unclear whether this really happens in practice.

Information concerning the abovementioned data are particularly important for the liquid manure produced by cattle during the summer period.
This is because, during the winter period, both storage systems are the same temperature and no manure is removed from the storage for application to soil.
The percentage of methane emissions from summer stable manure will possibly increase in the future. This is a result of an ongoing decrease in grazing period for dairy cattle, whereby during the summer months relatively more liquid manure ends up in the manure cellars or outside storage facilities, rather than in the meadow.

If (co)digestion is to play a greater role in the near future, for the amount of manure that is digested this can lead to a shorter time period in the storage facility (less than one month). The CH_4 emissions during storage would therefore be zero. However, methane emissions may occur during storage of the fermented manure, if this is not combined with a gas storage system (Angelidaki *et al*., 2004). If information becomes available concerning the amount of manure transported to the manure fermenter, this can be taken into account in the calculation rules described in Chapter 2.

5 Remaining aspects

5.1 Point source criteria
Not applicable

5.2 Substance 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