

Protocol

6A1: CH₄ from managed landfill sites

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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 category includes all waste landfill sites in the Netherlands since 1945¹, and concerns both historic and current public sites that are used to dump waste, plus waste dumped on private ground. Since it is sure that these waste sites are (or were) managed and monitored from around 1945 onwards, and are considered to be responsible for most of the methane emissions, these are reported under the IPCC category 6A1 (the so-called ‘*managed landfills*’).²

Unmanaged landfills fall under the IPCC category 6A2, and do not exist in the Netherlands. Local storage of GFT waste (compostable waste from households, trade/services sector, industry and agriculture), the local/central processing of GFT waste (into compost and/or biogas), plus the storage and processing of contaminated soil or dredged material, do not fall under the aforementioned category. These are reported under IPCC category 6A3 (*Other solid waste disposal on land*).

¹ The methane emissions from landfill sites before 1945 are small enough to be negligible [Van Amstel et al., 1993].

² A managed landfill is a site where solid waste is dumped in a controlled manner (i.e. in a specific location, with a certain amount of controlled degassing and hotbed management) and where one of the following management systems is used: covering materials, mechanical compacting, or spreading of the waste.

This protocol concerns the monitoring of methane emissions (CH₄) as part of the landfill gas that is created on a landfill site under anaerobic conditions as the organic substances are broken down by micro-organisms [Spakman et al., 1997]. This process has continued for many decades, although the amount of landfill gas formed annually has reduced exponentially compared to the amount of waste dumped in a specific year.

Landfill gas is constantly changing. In the Netherlands it usually consists of around 60% methane and 40% carbon dioxide. The latter is of organic origin and therefore does not fall under an IPCC source category. The methane content of extracted landfill gas has fallen over the past few years (see also Section 1.2.2), particularly due to more intensive extraction activities.

1.2 Significance and influences

1.2.1 Contribution to total national emissions

CH₄ emissions from managed landfills contribute a few percent to the Netherlands annual greenhouse gas emissions.

1.2.2 Developments that influence emissions

The Dutch government has exerted continued political pressure to discourage the dumping of waste, and particularly to discourage the dumping of flammable waste products. The amount of waste dumped has dropped considerably, from 13.9 Mton in 1990 to only 4.2 Mton in 2007 (-70%). In addition, the amount of biodegradable carbon in the waste has dropped from 130.8 kg C per ton waste in 1990, to 91,6 kg C per ton in 2007 (-30%). These two developments have already had a clear and visible effect on the methane production by landfill sites, which has fallen by 30% during the aforementioned period. This falling trend is expected to continue in the future.

Many companies in the waste sector are making more effort to extract landfill gas. The extracted amounts increased annually between 1990 and 2004 and, when these gases are combusted (flame, gas engine, natural gas) this has a positive effect on the methane emissions. Extracting the gases earlier also reduces methane. From 2002 onwards the calculations also take explicit account of these aspects.

2 METHOD, EMISSION FACTORS AND ACTIVITY DATA

2.1 Calculation method

2.1.1 General

The general formula is:

$$\text{CH}_4 \text{ emissions (t) (kton)} = [\text{CH}_4(\text{gross gas production}) \text{ (t) (kton)} - \text{CH}_4(\text{landfill gas extraction}) \text{ (t) (kton)}] * (1-\text{ox}) \quad [1]$$

where: 1-ox = (1 – oxidation factor) = the fraction of methane that is not broken down in the landfill. The value 0.1 is used as the value of ox

t = number of years after dumping

The gross methane production in year t, as a result of the waste dumped in year x, is calculated using the following formula:

$$\text{CH}_{4(\text{gross gas production, waste dumped in year } x)}(t) \text{ (kton)} = M_x * \text{DOC}_x * f * k_x * e^{-k_x(t-x)} * F * 16/12 * \text{MCF} \quad [2]$$

Where:

t	=	reporting year
x	=	year waste was dumped
Prod _x (t)	=	methane production in year t as a result of waste dumped in year x
M _x	=	amount of waste dumped in year x
DOC _x	=	fraction of biologically degradable carbon in the waste dumped in year x
f	=	fraction of biodegradable organic carbon that is actually degraded
k _x	=	constant reaction
F	=	fraction of methane in landfill gas
16/12	=	molecular weight ratio CH ₄ / C
MCF	=	methane correction factor; the Netherlands = 1 because this has been managed since 1945

The total gross landfill gas production for the reporting year is calculated via the emissions from waste that was dumped in previous sequential years, i.e.

$$\text{CH}_{4(\text{gross gas production})} \text{ in year } t = \sum_{x(1945, t)} \text{CH}_{4(\text{gross gas production, waste dumped in year } x)}(t-x) \quad [3]$$

2.1.2 Comparison to IPCC method

The methane emissions in the Netherlands are calculated using a first-order degradation model, as per the IPCC Good Practice Guidance (IPCC, 2001), tier-2 method. Input values are taken from specific Netherlands circumstances. This first-order degradation is used for all landfill sites together in the Netherlands, as part of the emissions determination process for the annual emissions and waste report. It is not possible to calculate emissions from individual landfill sites, because there are insufficient accurate historic data available concerning the waste composition of individual landfill sites.

The normalisation factor ($A = (1 - \exp(-k))/k$) = correction factor for the sum in formula [3]) used in the tier 2 method is not used by the Netherlands model. When validating the first-order model against the situation in the Netherlands, the outcome of the model (excluding this factor) was fitted to the actual situation. This is factored into the Netherlands model in the values of DOC_f and k. Including this correction factor again would lead to a deviation rather than an improvement. Appendix 3 briefly explains the function of the normalisation factor (as per the IPCC), compared to the Netherlands model for landfill gas production.

2.2 Emission factors

The Netherlands assumptions used in the model were first developed by Hoeks in 1983, as described in [Van Amstel et al., 1993] and [Coops et al., 1995], the latter also including an expansion to individual landfill sites. Table 1 shows the parameters used.

Table 1: Comparison of IPCC default values and those used in the Netherlands

Parameters used (IPCC-names)	Parameter values		References
	IPCC default	Netherlands situation	
Oxidation factor (OX)	Maximum 0.1 for National Inventory	0.1 (10%)	[Coops et al., 1995]
f = fraction of degradable organic carbon (DOC _f)	0.5 – 0.6	0.58	[Oonk et al., 1994]
Degradable speed constant k		0.094 from 1945 through 1989 (half-life time 7.5 yr); from 1990 reducing to 0.0693 in 1995; thereafter constant 0.0693 (half-life time 10 yr)	[Oonk et al., 1994]
DOC_(x) = concentration of biodegradable carbon in waste that was dumped in year x	Maximum 210 kg C/ton dumped waste	132 kg C/ton dumped waste from 1945 through 1989, from 1990 linear, reducing to 125 kg C/ton in 1995. 120 kg/ton in 1996 and 1997 and after 1997 determined annually by SenterNovem.	Based on [De Jager et al., 1993], determined by [Spakman et al., 1997] and published in [Klein Goldewijk et al., 2004]
F (fraction of CH ₄ in landfill gas)	0.4 – 0.6	0.6 from 1945 through 2001 and thereafter determined annually by SenterNovem based on practical measurements	Source: landfill gas survey, working group for waste registration WAR
MCF(x) = Methane correction factor for management	1	1	

It is assumed that, for the Netherlands, an average 10% of the methane in the non-extracted landfill gas in the top layer will be oxidised, and thus 90% will be emitted. The oxidation factor is thus set at 0.1, as per the IPCC guidelines.

The value for DOC_(x) is published annually in de NIR.

For the normalisation factor used in the tier-2 method, ($MCF_{(x)} = (1 - \exp(-k))/k$) = correction factor for the sum in formula [3]) the Netherlands model for methane emission uses the IPCC default value of 1. When validating the first-order model for the Netherlands situation, the result of the model (without this factor) is matched to the production that is observed in practice. This is also factored into the Netherlands model in the values of DOC_f and k. Including this correction factor would also probably lead to a deviation rather than to an improvement. The correction factor for the Netherlands situation is around 0.97. This small deviation from the value (of 1) is very limited in comparison to other uncertainties generally associated with modelling landfill gases.

2.3 Activity data

The input for the model consists of the following datasets:

- Annual amounts of waste dumped (from 1945).
Landfill site operators systematically monitor the amount of waste dumped (weight and composition) for each waste site. Since 1993³ monitoring has occurred by weighing the amount of waste dumped, via weighing bridges (= compulsory environmental permits). Dividing the waste into categories is usually implemented by the operator, based on the compulsory permits. Data are entered into the company's administration system. Information for the specific reporting year

³ The obligation to weigh incoming waste at the landfill site started when the Dumping Decree came into force in 1993.

is supplied to the relevant authorities, e.g. to SenterNovem via the WAR (working group for waste registration) survey⁴.

- The amounts of landfill gas extracted (in m³), from which the amounts of methane (kton) can be obtained.

Landfill site operators (or managers of landfill gas extraction plants, if outsourced) mainly monitor the electricity production of the utility plants or the amount of natural gas produced. Amounts of (unused) landfill gas burnt off via an open flame are not registered. Data are entered into the company's administration system. The data for the reporting year are supplied (on request) to the working group for waste registration WAR, which uses all these data to estimate the total extracted amounts of landfill gas in the Netherlands and, in turn, submits this to the ENINA task force (SenterNovem) before the third quarter of the year following the reporting year.

SenterNovem gathers information on the amounts and composition of a large number of waste flows, as part of its work to draw up the annual Netherlands Waste in Figures report. Information concerning these amounts of dumped waste is used for this protocol. The results of several other research projects also help to determine the composition of the waste dumped.

Part of the information required is not available until one year later (figures for t are only available in December of the year $t+1$). Ensuring the necessary harmonisation between the various data sources (particularly in order to avoid double entries) means that the total general picture of t is only available in January/February of the year $t+2$. Data for the CRF format for t are therefore not submitted in December of $t+1$, but during the modification session in March of $t+2$.

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.

⁴ ENINA only uses information concerning the total amounts of waste from the WAR data. Data on the composition of waste and the determination of DOC(x) are entered in another manner.

INPUT	PROCESS	OUTPUT	BY WHOM
NAIC (Netherlands waste in figures)	Data collection	Dumped waste in t-2 per waste category	SenterNovem
Sorting analyses	Data collection	Composition household waste (in fractions)	SenterNovem
Survey corporate waste	Data collection	Composition corporate waste (in fractions)	CBS
Landfill gas survey	Data collection	-Extracted amounts of landfill gas -Methane content of extracted landfill gas	working group for waste registration WAR
The above, plus other data	Data processing	Amount of biodegradable C (DOC)	ENINA (SenterNovem)
All aforementioned data	Data processing	Netherlands emissions of CH ₄ from landfill sites	ENINA (SenterNovem)
Netherlands emissions of CH ₄ from landfill sites	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

The ENINA (air emissions from energy, industry and waste disposal) task force (SenterNovem) checks the data for the reporting year and processes this, together with the data from previous years (historic data) into a total national emissions figure for CH₄ from landfill sites. The ENINA task force reports and documents the emissions data and relevant information, as per the IPCC Good Practice Guidance (IPCC, 2001, Chapter 5, Waste). Under the framework of the international reports on greenhouse gas emissions, these emissions are reported according to the guidelines for the National Inventory Report and the Common Reporting Format (NIR/CRF; UNFCCC, 2004).

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}
6A1 CH ₄ emissions from solid-waste disposal sites	CH ₄	30	15	34

The uncertainty in CH₄ emissions from solid-waste disposal sites was estimated at about 35% in annual emissions. In the Tier 1 uncertainty analysis, we used uncertainty estimates in the activity data and the emission factor of 30 and 15%, respectively. The main factors influencing the quantity of CH₄ produced were the amount of waste disposed on land, and the concentration of C (carbon) in that waste. The amount of methane recovery was the main other factor influencing the actual CH₄ emissions [Olivier et al, 2009].

To calculate the methane emissions from all the landfill sites within the Netherlands, the simplifying assumption was made that all the wastes are assumed to be landfilled on one landfill site, starting in 1945. However, as stated above, characteristics of individual sites vary substantially. Methane emissions from this 'national landfill' are then calculated by using a first-order decomposition model (first-order decay model, i.e. IPCC Tier 2 methodology) with an annual input of the total amount deposited, and the characteristics of the landfilled waste and the amount of landfill gas extracted [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

Recovering k-values and the effect on base year 1990

In 2003 the calculation model was harmonised with the information concerning k-values in Table 1. The lower k-values for 1990-1995 are only used for waste that was dumped in that particular year, and where the k-values continue to be used in later years for the waste from that particular year. Before 2003, a lower k-value was used (from 1990-1995) for all waste that was dumped up to that point, thus including waste from previous years. This has been retroactively corrected, and also affects emissions from 1990, as reported up to 2002.

Modifications regarding the carbon content (from 1993)

In 2003 the figures for waste dumped since 1993 were modified with respect to the carbon content. The values used in the calculation model until then by RIVM (Dutch national institute of public health and the environment) deviate from the values as described in [Spakman et al., 1997].

Modifications regarding the amount of extracted landfill gas

In 2003 the values concerning the amount of landfill gas extracted since 1997 were corrected based on data provided by the (former) VVAV (association of waste processing companies). These values were previously extrapolated by RIVM from data for previous years.

Methane content in landfill gas

Up to the end of 2001 the model included a 60% methane content in the extracted landfill gas. However, in practice, this percentage has fallen due to increasing attention to (early) extraction. From 2002 onwards the content is defined annually based on the landfill gas survey implemented by SenterNovem.

4.4.2 Future

For the national and international emissions reports the Netherlands continues to use the IPCC defined first-order model. It is generally assumed that a multi-phase model for landfill gas formation better describes the formation of CH₄ than the first-order model, particularly for recently dumped waste. However, recent studies (Scharff, 2003a) have delivered no real evidence to confirm this assumption. Validation of the first-order model (using a multi-phase model) for recently dumped waste, plus any parameter modifications for monitoring, will therefore not be implemented.

The model currently used by the Netherlands offers no insight into the effect of individual emission-reducing measures apart from intensifying the extraction of landfill gas⁵, although this could also be realised. It is therefore necessary to modify the model or currently used methodology. As yet, no action has been taken to improve matters.

The assumption that, on average, 10% of the methane in the top layer of the landfill is oxidised, is an important factor when estimating emissions. Opinions on this are divided. Methane oxidation is generally estimated as greater than this. Research into actual oxidation of methane in top layers could reduce the uncertainty in emissions estimates. A number of trial projects are currently taking place at landfill sites, which could offer better insight into oxidation capacity. The first project to be finalised (Scharff, 2003a) shows that the oxidation could be as high as 20-40% of the methane flux. However, a second project (Scharff, 2003b) indicates that (through active ventilation) the current percentage could be increased (13-20%). A third project focusing on encouraging oxidation through optimising the composition of the top layer was finalised in 2004. In the light of these results, it might be advisable to increase the standard figure of 10% in future. International acceptance of the results is then indispensable. As yet, no actions have been taken to improve matters.

As indicated above, the amount of extracted landfill gas has an uncertainty factor of 10-20%. Better registration and reporting of these amounts would considerably reduce the uncertainty with respect to the emissions figure. As yet, no actions have been taken to improve matters.

5 REMAINING ASPECTS

5.1 Point source criteria

Not applicable

5.2 Substance profiles

Not applicable

5.3 Regionalisation

Methane emissions from landfill sites have been reported (since 1945) as a single figure, i.e. as emissions from one large landfill site in the Netherlands. Individual waste or emissions data per landfill site are therefore not available.

5.4 Time-based variations in source strength

Not applicable

6 REFERENCES AND ADDITIONAL INFORMATION

6.1 References

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⁵ E.g. encouraging oxidation in the top layer, ventilating the waste, setting up aerobic landfill sites etc.

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6.2 Additional information

Appendix 1 – Background datasets

Appendix 2 – Improvement measures and effects of time periods

Appendix 3 – Normalisation factor IPCC vs. the model used in the Netherlands

APPENDIX 1 – BACKGROUND DATASETS

This appendix discusses the establishment of the datasets used in the model for landfill gas formation.

Dataset 1: amounts of waste dumped in year x

1945 – 1990

For 1945-1990 the estimated annual amount of waste and the composition thereof was based on data from RIVM (National institute of public health and the environment) and CBS (Statistics Netherlands) concerning the amount of industrial and household waste, and the fraction thereof which was dumped on landfills (SVA, 1973; CBS, 1988; CBS, 1989). Interpolation and extrapolation techniques allow the range for 1945-1990 to be reconstructed [Van Amstel et al., 1993].

1991 - today

Data concerning the amounts of waste dumped since 1991 are supplied by the Working Group for Waste Registration (WAR), included as part of the annual report 'Afvalverwerking in Nederland' (Waste processing in the Netherlands). Information concerning the way in which these data are gathered and the scope of the information used can be found in the annual publications 'Afvalverwerking in Nederland', available since 1991 from the WAR (SenterNovem).

Dataset 2: amounts of extracted landfill gas in year x

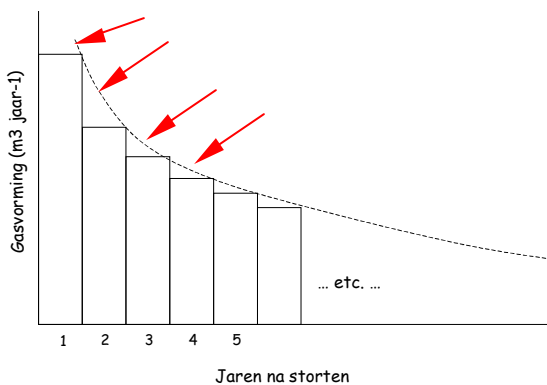
Data concerning amounts of extracted landfill gas were supplied (up to 1998) by the Adviescentrum Stortgas (Landfill Gas Advice Centre), which was an independent organisation from 1992-1997, when it was merged with the (former) VVAV. There are no figures available concerning amounts of extracted landfill gas for the years 1999 and 2000. Figures for these years were estimated by the ENINA task force based on the figures from previous years. Today (2003) the monitoring of landfill gas projects has been restarted by working group for waste registration. Specific figures (retroactive from 1997) are supplied by the ENINA task force.

APPENDIX 2 – IMPROVEMENT ACTIONS AND THE EFFECT ON TIME PERIODS

In 2003 the responsibility for establishing the methane emissions figure from landfill sites was transferred from the RIVM to the Afval Overleg Orgaan (AOO, or waste consultation group, now SenterNovem). The AOO determined that the calculation method used at that point in time did not allocate the k-value correctly to the relevant years. Correcting this error has consequences for emissions figures in the base year (1990) as well as for the entire period. This correction has been implemented since 2003.

APPENDIX 3 – NORMALISATION FACTOR IPCC VS. THE MODEL USED IN THE NETHERLANDS

The model used by the Netherlands to calculate methane emissions does not use the normalisation factor generally used under the tier 2 method ($A = (1 - \exp(-k))/k$). The following overview shows the mathematical function of this normalisation factor, according to the IPCC, and the reasons why this is not used in the Netherlands.

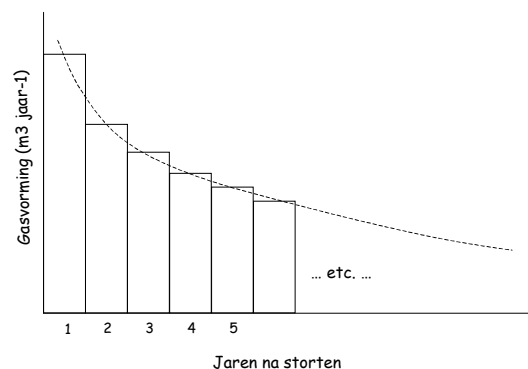


Function of the normalization factor

The normalization factor is meant to correct a mathematical problem of the model compared to the (assumed!) first order decay. The model without the factor calculates the methane production after each year and uses this result for the whole year. This approach is mathematically not correct as is shown in the figure. The (assumed) first-order formation is presented by the dotted line whereas the results of the model is presented by the rectangular blocks. The model leads to an underestimation of the methane production since every year the triangle between the dotted line and the rectangular block is not accounted for. The normalization factor is meant to correct this mathematical error.

The model used in the Netherlands

In the Netherlands the parameters used in the model, especially the DOC_f and k , were determined in a model validation study in the nineties. In this study the model was fitted (best-fit) on the expected methane production of a few landfill-sites of which the amount of methane produced could accurately be predicted. In this validation-study no normalization-factor was used (did not exist at that time; introduced in GPG2000). It is important to realize that this fit was done based on the actual formation of gas over the year and not on the calculated formation after a year. The result of this procedure is shown in the figure beside the text. As becomes clear in this case the underestimation by ignoring the triangle from the first figure is not present. The mathematical difference between the (assumed) actual first order decay and the IPCC1996-model (based on yearly values, instead of a full integration) is in the Dutch approach corrected via the parameters DOC_f (mainly) and k . If the validation had been carried out using the GPG2000 normalization factor other values for these parameters had been found. Using the GPG2000-factor the DOC_f -value found would have been higher, together leading to the same result as the model we use now.



Conclusion

The conclusion so far is that the model used in the Netherlands (without the GPG2000 normalization factor) does not overestimate the methane production since the values of the other parameters used (especially DOC_f) already compensate for the mathematical problems of the IPCC1996-model. In fact the Netherlands use parameter-values that are determined especially for the Dutch situation which in general is to be preferred over using IPCC-defaults and is therefore in line with IPCC-guidelines.

The use of the normalization factor in the Dutch model would only introduce an unnecessary correction, thus only creating extra difference between the results of the model and the (assumed) first order decay instead of decreasing the difference. The only way to overcome the introduction of an error while introducing the normalization factor is to change the value of DOC_f simultaneously, thus compensating for the introduction of the GPG2000-factor. The resulting emission would then remain unchanged.