IMPROVEMENT IN THE DETERMINATION OF METHANE EMISSIONS FROM GAS DISTRIBUTION IN THE NETHERLANDS

Main Author

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ABSTRACT

Methane is the second most serious greenhouse gas next to carbon dioxide contributing to global warming and climate change. As part of the national greenhouse gas emissions inventory, methane emission data have to be reported to the European Union (EU) and to the UN Climate Secretariat. Until 2004 the methane emissions from gas distribution in the Netherlands were quantified by a gas consumption based average emission factor approach, a so-called IPCC Tier 1 method.

The gas distribution utilities in the Netherlands have had several objections against the IPCC Tier 1 method for principal reasons. The IPCC Tier 1 method was based on the amount of gas consumption and was not source-specific. Instead, a IPCC Tier 3 method was proposed, a rigorous source-specific approach.

The IPCC Tier 3 method is composed of detailed inventories of the amount and types of process infrastructure and typical design and operating practices. The consolidated emissions are assessed by applying appropriate emission factors based on field measurements. The assessment is carried out by acquiring the following data:

- Grid length per material and pressure range
- Number of leakages per year, per grid length and material
- Leakage rate determination per material and pressure range

Since 2005, the gas distribution utilities in the Netherlands have supplied accurate data concerning the composition of their gas grids as well as the results of their leakage detection activities over the past year. The aggregated result of the grid composition and the number of leakages is presented. In the spring of 2005 measurements were performed to determine the mean leakage rate per leak for a number of pressure ranges and materials at 25 locations.

The total quantity of methane emissions from gas distribution in the Netherlands, calculated according to the IPCC Tier 3 method as described, amounts to 18.3 * 10^6 m^3 or 12.7 Gg (kiloton) methane per year in 2004. This is significantly lower than the emissions of about 100 * 10^6 m^3 or 60 kiloton methane per year estimated with the IPCC Tier 1 method, which was based on a best-guess estimate of the fraction of gas distribution losses, e.g. 0.44% in 2004. Because of this much lower figure, methane emissions from gas distribution are no longer a so-called key source category in the Dutch greenhouse gas emissions inventory.

For official emission calculation and reporting purposes the Dutch authorities use the following emission factors for gas distribution:

- 610 m^3 or 436 Gg methane/km per year for grey cast iron
- 120 m^3 or 86 Gg methane/km per year for other materials

The order of magnitude of the result is comparable with the medium scenario of the IPCC Good Practice Guidance for grey cast iron and with the low scenario for other materials of 1000 and 100 m^3 methane/km per year respectively.

It is expected that in the near future the quality and reliability of reported data will improve further.
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1. INTRODUCTION

Methane is the second most serious greenhouse gas next to carbon dioxide contributing to global warming and climate change. As part of the national greenhouse gas emissions inventory, methane emission data have to be reported to the European Union (EU) and to the UN Climate Secretariat, using guidelines provided by the United Nations Framework Convention on Climate Change (UNFCCC) (1,2) and by the Intergovernmental Panel on Climate Change (IPCC) (3,4). In the so-called Kyoto Protocol the EU-15 countries all have a collective target to reduce the emissions of greenhouse gases in the period between 1990 – 2008/2012 by 8% on average, compared to 1990 as the reference year. A few years ago, the government in the Netherlands strived to improve the method of quantification of methane emissions from the gas distribution system, an improvement which was strongly supported by the gas distribution utilities.

To begin, this paper will describe the conventional IPCC Tier 1 method to quantify methane emissions and this method’s main drawbacks. Subsequently a new approach will be presented, according to the far more accurate IPCC Tier 3 method, a rigorous source-specific approach for the quantification of methane emissions from gas distribution systems in the Netherlands. This method is then elaborated for the year 2004 and the period 1990-2004.

2. REASON FOR CHANGE

Until 2004 the methane emissions from gas distribution in the Netherlands were quantified using a method based on the gas consumption per year and one emission factor, by a so-called IPCC Tier 1 method (3,4). This was obtained by multiplying the distributed amount of natural gas with an emission factor, based on an average emission rate of 0.44 – 0.60% of the distributed volume. The result for 2004 (emission rate 0.44%) would be $100 \times 10^6 \text{m}^3$ or about 60 Gg (kiloton) of methane per year. This meant a significant contribution to the greenhouse gas emissions in the Intergovernmental Panel on Climate Change (IPCC) category 1B2 (process emissions from oil- and gas production/transmission). Gas distribution therefore was a so-called key source category in the yearly national greenhouse gas emission inventory, due to the annual emission level. For key source categories, the IPCC Good Practice Guidance (4) recommend using a higher IPCC Tier method for estimating the emissions, since IPCC Tier 1 methods are generally far less accurate than higher IPCC Tier methods. These Tier 1 methods are also more fallible and may include biases, both in annual emissions and in emission trends. To comply with the IPCC Good Practice Guidance, which the UNFCCC guidelines refer to, the Dutch government included this source category in its inventory improvement programme.

In addition, the gas distribution utilities in the Netherlands have had also several objections against the IPCC Tier 1 method, because it is in principle incorrect to relate the amount of methane emissions to the distributed volume. In figure 1, the curve for the distributed volume of natural gas and the calculated methane emissions in the period 1990-2004 is represented (5). In this figure two trends can clearly be distinguished:

- The distributed volume and the emission both peak in 1996;
- The distributed volume and the emission divert from each other towards 2004.

The effect of the cold winter at the end of 1996 is clearly visible. The consumption of natural gas in this year is higher than average. However, with a higher consumption a lower methane emission rate would be expected, caused by the mean gas pressure in the distribution networks being lower than expected, due to the cold winter. On the contrary, the reported methane emission rate is higher than normal. The IPCC Tier 1 method shows one of its main disadvantages here. The method is based on the total amount of gas distributed annually and not source-specific.

The decrease of the methane emission rate, compared to the distributed volume, is caused by the assumption that the average emission rate of 0.6% of the distributed volume in 1990, decreased with
a yearly rate of 0.02% absolute. This decrease continued until a value of 0.44% was reached in 1998, due to a scenario of replacement of grey cast iron. This assumed trend was partly compensated by the yearly increase in the total length of the gas distribution networks in the Netherlands.

3. IDEAL APPROACH

In the rigorous source-specific approach of the IPCC Good Practice Guidance\(^{(4)}\) no specific emission factors are given for the emission rates of methane from gas distribution grids for the application of a IPCC Tier 3 method; only an emission factor range based on North American data is presented. In addition, this IPCC report provides a classification of emission factors as low, medium or high. This information is based on a study performed by the International Gas Union (IGU) WOC 8 Study Group 8.1 (Methane Emissions), presented at the 21st World Gas Conference in June 2000 in Nice\(^{(6)}\). The IPCC Tier 3 method is composed of detailed inventories of the amount and types of process infrastructure and typical design and operating practices. The consolidated emissions are assessed by applying appropriate emission factors based on field measurements. This IPCC Tier 3 method was followed to generate reliable data for the emissions of methane from gas distribution in the Netherlands\(^{(7)}\).

In the gas distribution system, natural gas is transported at different levels of pressure. The system consists of (underground) mains supply, service lines and (above ground) gas regulating and metering stations, operating as one system. The natural gas is locally distributed between the gas transport system and the consumer. The studied gas distribution system is located between the city gate station and the local gas meter with the consumer. In contrary to the IPCC Good Practice Guidance, city gate stations in the Netherlands are considered part of the gas transport system. The emissions of the gas transport system and from the installations at the end consumers are reported separately. Distribution stations are not taken into account in this study due to the lack of reliable data.

The advised IPCC Tier 3 emission factor from the IPCC Good Practice Guidance is the amount of methane emitted per unit of pipe length per year per type of pipeline (material and/or pressure). The activity data is the length of the gas grid (pipe length of the gas distribution network). As a validation method and to assess completeness, the IPCC Good Practice Guidance suggests comparing country-specific emission factors with three scenarios for the height of the emission factor: a low, medium and high emission factor. In the case of gas distribution this amounts to 100, 1,000 and 10,000 m\(^3\).
methane/km per year. The applicable scenario depends on the quality of the gas grid, its materials, the maintenance and repair schedules, etc. IPCC Good Practice Guidance suggests improving reliability and accuracy by using self-acquired data. This is the method presently used for gas distribution in the Netherlands.

The emission factor is dependent on the grid length, the leakage amount and leakage frequency, according to the following formulae \(^8\):

\[
EF = 8.76 * R * N * F * (J + j)/2
\]

[m\(^3\) CH\(_4\)/km year]

and the subsequent methane emission by:

\[
E = EF * K
\]

[m\(^3\) CH\(_4\)/year]

or:

\[
EM = EF * K * C
\]

[Gg CH\(_4\)/year]

with:

- \(E\) = total amount of methane emission [m\(^3\) methane/year]
- 8.76 = factor (hours to year/1000) [hour/year]
- \(R\) = leakage per leak [litre/hour]
- \(N\) = number of leaks per kilometre per year [#/km year]
- \(F\) = percentage methane in natural gas (80%) [vol.%]
- \(J\) = leakage survey interval (standard every 5 year) [year]
- \(j\) = time between identifying leakage indication and repair of leak (assumption 0.5 year) [year]
- \(K\) = amount of kilometres mains supply [km]
- \(EM\) = total amount of methane emission [Gg methane/year]
- \(C\) = conversion factor from m\(^3\) to Gg (kton) [Gg/m\(^3\)]

For an ideal IPCC Tier 3 approach the determination of the emission factor should be completed for each individual material and each individual pressure level. All contributions from individual materials and pressures lead to the overall emissions. This ideal approach, however, is limited by the availability, accuracy and reliability of the information.

4. DATA COLLECTION

4.1 Grid length \(K\)

Since 2005, the gas distribution utilities in the Netherlands have supplied accurate data concerning the composition of their gas grids as well as the results of their leakage detection activities for the past year. The aggregated result of the grid composition is presented here and the result of the leakage detection in the next paragraph. The response of the gas distribution utilities was almost 100%, a very good result increasing the reliability for both grid length and leakage detection data.

The applied materials are for low pressure (30 – 100 mbar), medium pressure (1 - 4 bar) and high pressure (8 bar) gas distribution grids: polyethylene (PE), polyvinylchloride (PVC) (unmodified and high impact), steel, grey cast iron, ductile cast iron and asbestos cement.

In table 1 the lengths of the gas distribution network in the Netherlands are given for each material and pressure range in 2004. Less than 0.4% of the material is unidentified, indicating that the quality of the composition data is very good.
In 2004 the total length of the gas grids in the Netherlands increased by 1,700 kilometres to almost 122,000 kilometres, containing 48,650 kilometres of unmodified PVC and 22,650 kilometres of high impact PVC low pressure distribution grids. 79.7% of the total length of the distribution grids are low pressure distribution grids, 7.2% are medium pressure and 13.1% are high pressure distribution grids.

<table>
<thead>
<tr>
<th>Material</th>
<th>Pressure Range [bar]</th>
<th>Length in 2004 [km]</th>
<th>Percentage of total [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene</td>
<td>0.03 – 0.1</td>
<td>9,560</td>
<td>7.8</td>
</tr>
<tr>
<td>PVC - Unmodified</td>
<td>0.03 – 0.1</td>
<td>22,636</td>
<td>18.6</td>
</tr>
<tr>
<td>PVC - High Impact</td>
<td>0.03 – 0.1</td>
<td>48,648</td>
<td>39.9</td>
</tr>
<tr>
<td>Steel</td>
<td>0.03 – 0.1</td>
<td>5,592</td>
<td>4.6</td>
</tr>
<tr>
<td>Grey Cast Iron</td>
<td>0.03 – 0.1</td>
<td>7,184</td>
<td>5.9</td>
</tr>
<tr>
<td>Ductile Cast Iron</td>
<td>0.03 – 0.1</td>
<td>1,502</td>
<td>1.2</td>
</tr>
<tr>
<td>Asbestos Cement</td>
<td>0.03 – 0.1</td>
<td>1,828</td>
<td>1.5</td>
</tr>
<tr>
<td>Unknown</td>
<td>0.03 – 0.1</td>
<td>280</td>
<td>0.2</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>1.0 – 4.0</td>
<td>7,219</td>
<td>5.9</td>
</tr>
<tr>
<td>Steel</td>
<td>1.0 – 4.0</td>
<td>975</td>
<td>0.8</td>
</tr>
<tr>
<td>Grey Cast Iron</td>
<td>1.0 – 4.0</td>
<td>184</td>
<td>0.2</td>
</tr>
<tr>
<td>Ductile Cast Iron</td>
<td>1.0 – 4.0</td>
<td>331</td>
<td>0.3</td>
</tr>
<tr>
<td>Unknown</td>
<td>1.0 – 4.0</td>
<td>16</td>
<td>0.0</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>8.0</td>
<td>2,049</td>
<td>1.7</td>
</tr>
<tr>
<td>Steel</td>
<td>8.0</td>
<td>13,037</td>
<td>10.7</td>
</tr>
<tr>
<td>Ductile Cast Iron</td>
<td>8.0</td>
<td>630</td>
<td>0.5</td>
</tr>
<tr>
<td>Unknown</td>
<td>8.0</td>
<td>17</td>
<td>0.0</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
<td>283</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>121,971</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Table 1: Composition and length of gas distribution network in 2004 in the Netherlands

[Figure 2: Grid length of pressure ranges of gas distribution network in the period 1990-2004 in the Netherlands]
Figure 2 shows the composition development of the gas distribution network from 1990 till 2004 in The Netherlands for the total network length and the contribution of the low, medium and high pressure distribution. The determination of leakage rates $R$ should be focussed on the low pressure distribution, as this is the largest contributor to the total network length. The contribution of grey cast iron to the total network length for the period 1990-2004 is presented in figure 3. The tendency of grey cast iron contribution in this period is downwards.

Figure 3: Length of the grey cast iron gas distribution network compared to the total length in the period 1990-2004 in the Netherlands

### 4.2 Number of leaks per grid length $N$

Gas distribution utilities survey their complete gas distribution networks for gas leakages every five years as standard. This means that every year on average 20% of the gas distribution grids in the Netherlands are surveyed.

The leakage detection measurement is first executed above ground, above the mains supply and the service lines by a methane measuring device. If methane is detected, the spot is reported as a leak indication. At this location the pipe is dug up, uncovered to detect the leakage, repaired and registered. If no leakage is found, no leakage is registered.

The aggregated data of gas leakages in the gas distribution grids for 2004 in the Netherlands is shown in table 2.

The data concerning the average number of leaks in the different sub-grids varies from 0.02 leaks per kilometre per year for low pressure High Impact PVC, medium pressure PE and steel and high pressure steel to 0.29 leaks per kilometre per year for low pressure grey cast iron sub-grids. The average data for the number of leaks per sub-grid are representative of the typical situation, and give an impression of the good condition of the gas grids and the high quality level of maintenance management in the Netherlands. This result is already very reliable, but will become even more accurate in the next few years, as data will become available covering 100% of the gas grids in the Netherlands.
Material | Pressure Range [bar] | Number of leakages per length of mains supply per year [#/km year]
--- | --- | ---
Polyethylene | 0.03 – 0.1 | 0.06
PVC - Unmodified | 0.03 – 0.1 | 0.04
PVC - High Impact | 0.03 – 0.1 | 0.02
Steel | 0.03 – 0.1 | 0.13
Grey Cast Iron | 0.03 – 0.1 | 0.29
Ductile Cast Iron | 0.03 – 0.1 | 0.11
Asbestos Cement | 0.03 – 0.1 | 0.09
Unknown | 0.03 – 0.1 | 0.13

| Polyethylene | 1.0 – 4.0 | 0.02
| Steel | 1.0 – 4.0 | 0.02
| Grey Cast Iron | 1.0 – 4.0 | 0.16
| Ductile Cast Iron | 1.0 – 4.0 | 0.13
| Unknown | 1.0 – 4.0 | 0.63

| Polyethylene | 8.0 | 0.17
| Steel | 8.0 | 0.02
| Ductile Cast Iron | 8.0 | 0
| Unknown | 8.0 | 1.80
| Unknown | Unknown | 0

Table 2: Number of leakages per length of mains supply for the different materials and pressure ranges in the Netherlands in 2004.

* These values are unreliable due to the small number of representative data.

4.3 Leakage rate R

In the spring of 2005, measurements were taken at 25 locations to determine the mean leakage rate per leak for:
- low pressure distribution grids of PVC (Unmodified and High Impact), grey cast iron, steel and ductile cast iron;
- medium pressure distribution grids of PE;
- high pressure distribution grids of steel.

It was not intended to obtain full statically reliable leakage data, but to gain insight into the order of magnitude.

These measurements were performed by using a suction method, and carried out by the German company EEM. In figure 4 the execution of a measurement in Amsterdam is shown. The suction method is based on sucking the air from the ground around a gas leak and determining the flow rate and methane level of the air. By multiplying the flow rate by the methane level the methane leakage rate is obtained. It is assumed that all methane from the leak is sucked through, when the methane level stabilizes.

The individual results of the leakage rate measurements vary between 1.6 and 690 litre natural gas per hour. This is due to the different kind of leakage, material types and also due to different environmental conditions like the soil type and wetness, as the measurement locations were taken at
random all over the whole country. The determined average values for the amount of natural gas leakage per leak for the different subsystems are given in table 3. For materials and pressure ranges not covered by these measurements, the results are extrapolated.

<table>
<thead>
<tr>
<th>Material</th>
<th>Average (Min-Max)</th>
<th>No. of locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC (Unmodified and High Impact) – low pressure</td>
<td>180 (1.6-580)</td>
<td>5</td>
</tr>
<tr>
<td>Grey cast iron – low pressure</td>
<td>110 (4.6-350)</td>
<td>7</td>
</tr>
<tr>
<td>Steel – low pressure</td>
<td>20 (11-32)</td>
<td>3</td>
</tr>
<tr>
<td>Ductile cast iron – low pressure</td>
<td>160 (96-231)</td>
<td>3</td>
</tr>
<tr>
<td>PE – medium pressure</td>
<td>270 (22-690)</td>
<td>3</td>
</tr>
<tr>
<td>Steel – high pressure</td>
<td>170 (55-461)</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3: Amount of natural gas leakage per leak for the different subsystems (materials and pressure ranges).

5. RESULTS

The emission factor per material and pressure range and the total emission are calculated according to the formulae in clause 3. In table 4 the results of this calculation are given. The total quantity of methane emissions by gas distribution in the Netherlands, calculated according to the IPCC Tier 3 method as described amounts to $18.3 \times 10^6$ m$^3$ or 12.7 Gg methane per year in 2004. This is significantly lower than data obtained by the IPCC Tier 1 method. Because of this much lower figure, methane emissions from gas distribution are no longer a so-called key source category in the Dutch greenhouse gas emissions inventory.

The ideal IPCC Tier 3 approach would lead to emission factors for each individual material and pressure range. However, the diversity in leakage measurement results does not justify emission factors at such a detailed level. Also, a clear difference in pressure levels per type of material could not be distinguished.
<table>
<thead>
<tr>
<th>Material</th>
<th>Pressure Range [bar]</th>
<th>Length in 2004 [km]</th>
<th>Number of leakages per length per year [#/km year]</th>
<th>Leakage rate [litre/hour]</th>
<th>Emission factor [m³ CH₄/km year]</th>
<th>Emission [10⁶ m³ CH₄/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene (PE)</td>
<td>0.03 – 0.1</td>
<td>9,560</td>
<td>0.06</td>
<td>180</td>
<td>210</td>
<td>2.0</td>
</tr>
<tr>
<td>PVC - Unmodified</td>
<td>0.03 – 0.1</td>
<td>22,636</td>
<td>0.04</td>
<td>180</td>
<td>140</td>
<td>3.1</td>
</tr>
<tr>
<td>PVC - High Impact</td>
<td>0.03 – 0.1</td>
<td>48,648</td>
<td>0.02</td>
<td>180</td>
<td>70</td>
<td>3.6</td>
</tr>
<tr>
<td>Steel</td>
<td>0.03 – 0.1</td>
<td>5,592</td>
<td>0.13</td>
<td>20</td>
<td>50</td>
<td>0.3</td>
</tr>
<tr>
<td>Grey Cast Iron</td>
<td>0.03 – 0.1</td>
<td>7,184</td>
<td>0.29</td>
<td>110</td>
<td>620</td>
<td>4.4</td>
</tr>
<tr>
<td>Ductile Cast Iron</td>
<td>0.03 – 0.1</td>
<td>1,502</td>
<td>0.11</td>
<td>160</td>
<td>340</td>
<td>0.5</td>
</tr>
<tr>
<td>Asbestos Cement (AC)</td>
<td>0.03 – 0.1</td>
<td>1,828</td>
<td>0.09</td>
<td>180</td>
<td>320</td>
<td>0.6</td>
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<td>Unknown</td>
<td>0.03 – 0.1</td>
<td>280</td>
<td>0.13</td>
<td>180</td>
<td>440</td>
<td>0.1</td>
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<tr>
<td>Polyethylene (PE)</td>
<td>1.0 – 4.0</td>
<td>7,219</td>
<td>0.02</td>
<td>270</td>
<td>90</td>
<td>0.6</td>
</tr>
<tr>
<td>Steel</td>
<td>1.0 – 4.0</td>
<td>975</td>
<td>0.02</td>
<td>170</td>
<td>80</td>
<td>0.1</td>
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<tr>
<td>Grey Cast Iron</td>
<td>1.0 – 4.0</td>
<td>184</td>
<td>0.16</td>
<td>170</td>
<td>540</td>
<td>0.1</td>
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<tr>
<td>Ductile Cast Iron</td>
<td>1.0 – 4.0</td>
<td>331</td>
<td>0.13</td>
<td>170</td>
<td>420</td>
<td>0.1</td>
</tr>
<tr>
<td>Unknown</td>
<td>1.0 – 4.0</td>
<td>16</td>
<td>0.63</td>
<td>170</td>
<td>2,050</td>
<td>0</td>
</tr>
<tr>
<td>Polyethylene (PE)</td>
<td>8.0</td>
<td>2,049</td>
<td>0.17</td>
<td>270</td>
<td>880</td>
<td>1.8</td>
</tr>
<tr>
<td>Steel</td>
<td>8.0</td>
<td>13,037</td>
<td>0.02</td>
<td>170</td>
<td>60</td>
<td>0.8</td>
</tr>
<tr>
<td>Ductile Cast Iron</td>
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<td>0</td>
<td>170</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>8.0</td>
<td>17</td>
<td>1.80</td>
<td>170</td>
<td>5,900</td>
<td>0.1</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
<td>283</td>
<td>0</td>
<td>170</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>121,971</strong></td>
<td><strong>18.3</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 4: Determination of emission factor and methane emissions per material and pressure range for the gas distribution grids in 2004 in the Netherlands.

An examination of the emission factor and grid composition has led to two distinct emission factors: one for grey cast iron and one for other materials [10]. Therefore, the following emission factors are now used in the Dutch greenhouse gas inventory [11]:

610 m³ or 437 Gg methane/km per year for grey cast iron
120 m³ or 86 Gg methane/km per year for other materials

The order of magnitude of the result is comparable with the medium scenario of the IPCC Good Practice Guidance for grey cast iron and with the low scenario for the other materials of 1,000 and 100 m³ methane/km per year respectively [4]. This changed approach is incorporated into the reporting protocol of the Dutch authorities. The uncertainty in the emission factors is estimated at 50%. This uncertainty refers to the limited number of measurements made of gas leakage per leak for different types of materials and pressures, on which the IPCC Tier 3 methodology for methane emission from gas distribution is based [11]. This figure is in line with the uncertainty estimate made by the IPCC for IPCC Tier 3 methods [4], which suggests uncertainties of ± 25 - 50 %, whereas it expects that IPCC Tier 1 methods may be off by an order of magnitude or more.

In figure 5 the IPCC Tier 3 method is compared with the IPCC Tier 1 method for the period 1990-2004. The emissions are reduced by a factor 5 - 8 due to the method change and improvement in quality and reliability of the data. Moreover, the trend in the emissions is now captured much more accurately than in the old IPCC Tier 1 method.

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In the next years, these emission factors will be used to report methane emissions from gas distribution utilities in the Netherlands to the authorities. The general trend will be that the emission will increase slightly due to the increases in distribution grid length. However, continued grey cast iron replacement will have a decreasing effect on the reported methane emissions from gas distribution. Revision of the emission factors will also be considered because in 5 years leakage survey will cover the whole gas distribution grid and further improve the quality and reliability of the reported figures.

6. CONCLUSIONS

The change of the method to quantify the methane emissions from gas distribution from a simple IPCC Tier 1 method into a more detailed IPCC Tier 3 method resulted in a substantial improvement in the quality and the accuracy of the emissions estimate that is part of the national inventory report on the greenhouse gas emissions in the Netherlands, which is commissioned by the Dutch government for submission to the EU, the UNFCCC and the Kyoto Protocol. Due to the change in method, the reported methane emissions from gas distribution in the Netherlands have decreased from 100 * 10^6 to 18.3 * 10^6 m^3 or 60 to 12.7 Gg methane per year. Because of this much lower figure, methane emissions from gas distribution are no longer a so-called key source category in the Dutch greenhouse gas emissions inventory. It is expected that in the coming years the quality and reliability of data will improve further. This changed approach is incorporated into the reporting protocol of the Dutch authorities.

REFERENCES

IPCC/OECD/IEA. IPCC WG1 Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK.


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