



Indicative simplified baseline and monitoring methodologies  
for selected small-scale CDM project activity categories

### TYPE III - OTHER PROJECT ACTIVITIES

Project participants shall take into account the general guidance to the methodologies, information on additionality, abbreviations and general guidance on leakage provided at <http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html>.

#### III.H. Methane Recovery in Wastewater Treatment

[Note: the structure of the methodology has changed. 'Baseline' now appears immediately after 'technology/measure' and 'boundary', followed by 'project emissions'. Further, only textual changes are highlighted, formatting changes and relocation of text to different section is not highlighted.]

##### Technology/measure

1. This project category methodology comprises measures that recover biogas methane from biogenic organic matter in wastewaters by means of one, or a combination, of the following options<sup>1</sup>:

- (i) Substitution of existing aerobic wastewater or sludge treatment systems with anaerobic systems with methane biogas recovery and combustion;
- (ii) Introduction of anaerobic sludge treatment system with methane biogas recovery and combustion to an existing wastewater treatment plant without sludge treatment;
- (iii) Introduction of methane biogas recovery and combustion to an existing sludge treatment system;
- (iv) Introduction of methane biogas recovery and combustion to an existing anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on site industrial plant<sup>2</sup>;
- (v) Introduction of anaerobic wastewater treatment with methane biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream;
- (vi) Introduction of a sequential stage of wastewater treatment with methane biogas recovery and combustion, with or without sludge treatment, to an existing anaerobic wastewater treatment system without methane biogas recovery (e.g. introduction of treatment in an anaerobic reactor with methane biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery).

<sup>1</sup> Under this methodology anaerobic lagoons are considered ponds deeper than 2 meters, without aeration, ambient temperature above 15°C, at least during part of the year, on a monthly average basis, and with a volumetric loading rate of Chemical Oxygen Demand above 0.1 kg COD.m<sup>-3</sup>.day<sup>-1</sup>. The residence time of the non-soluble part of the organic matter in anaerobic lagoons shall be at least 30 days.

<sup>2</sup> Other technologies in table 6.3 of Chapter 6: Wastewater Treatment and Discharge of 2006 IPCC Guidelines for National Greenhouse Gas Inventories are included.



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*III.H. Methane recovery in wastewater treatment (cont)*

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2. The recovered methane biogas from the above measures may also be utilised for the following applications instead of combustion/flaring:
- (a) Thermal or electrical energy generation directly; or
  - (b) Thermal or electrical energy generation after bottling of upgraded biogas; or
  - (c) Thermal or electrical energy generation after upgrading and distribution:
    - (i) Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints; or
    - (ii) Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or
  - (d) Hydrogen production.
3. If the recovered methane biogas is used for project activities covered under paragraph 2 (a), that component of the project activity can use a corresponding category methodology under type I.
4. If the recovered methane biogas is utilized for production of hydrogen (project activities covered under paragraph 2 (d)), that component of project activity shall use corresponding category AMS-III.O.
5. In case of project activities covered under paragraph 2 (b) if bottles with upgraded biogas are sold outside the project boundary the end-use of the biogas shall be ensured via a contract between the bottled biogas vendor and the end-user. No emission reductions may be claimed from the displacement of fuels from the end use of bottled biogas in such situations. If however the end use of the bottled biogas is included in the project boundary and is monitored during the crediting period CO<sub>2</sub> emissions avoided by the displacement of the fuels is eligible under a corresponding type I methodology, e.g. AMS-I.C.
6. In case of project activities covered under paragraph 2 (c i) emission reductions from the displacement of the use of natural gas is eligible under this methodology, provided the geographical extent of the natural gas distribution grid is within the host country boundaries.
7. In case of project activities covered under paragraph 2 (c ii) emission reductions for the displacement of the use of fuels can be claimed following the provision in the corresponding type I methodology, e.g. AMS-I.C.
8. In case of project activities covered under paragraph 2 (b) and (c), this methodology is only applicable if upgrade is done by way of absorption with water (with or without recovery of methane emissions from discharge) such that the methane content of the upgraded biogas shall be in accordance with national regulations (where these exist) or, in the absence of national regulations, a minimum of 96% (by volume). These conditions are necessary to ensure that the recovered biogas is completely destroyed through combustion in an end use.



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III.H. Methane recovery in wastewater treatment (cont)

9. New facilities (Greenfield projects) and project activities involving a change of equipment resulting in a capacity addition of the wastewater or sludge treatment system compared to the designed capacity of the baseline treatment system are only eligible to apply this methodology if they comply with the requirements in the General Guidance for SSC methodologies<sup>3</sup> concerning these topics. In addition the requirements for demonstration of the remaining lifetime of the equipment replaced as described in the general guidance shall be followed.

10. For project activities covered under paragraph 2 (b) and (c) additional guidance provided in annex 1 shall be followed for the calculations in addition to the procedures in the relevant sections below.

11. The location of the wastewater treatment plant shall be uniquely defined as well as the source generating the wastewater and described in the PDD.

12. Measures are limited to those that result in aggregate emission reductions of less than or equal to 60 kt CO<sub>2</sub> equivalent annually from all type III components of the project activity.

**Boundary**

13. The project boundary is the physical, geographical site where the wastewater and sludge treatment takes place in baseline and project situation. It covers all facilities affected by the project activity including sites where the processing, transportation and application or disposal of waste products as well as biogas takes place.

14. Implementation of the project activity at a wastewater and/or sludge treatment system will affect certain sections of the treatment systems while others may remain unaffected. The treatment systems not affected by the project activity, i.e. sections operating in the project scenario under the same operational conditions as in the baseline scenario (e.g. wastewater inflow and COD content, temperature, retention time, etc.), shall be described in the PDD, but emissions from those sections do not have to be accounted for in the baseline and project emission calculations (since the same emissions would occur in both baseline and project scenarios)<sup>4</sup>. The assessment and identification of the systems affected by the project activity will be undertaken *ex ante*, and the PDD shall justify the exclusion of sections or components of the system. The treatment systems (lagoons, reactors, digesters, etc.) that will be covered and/or equipped with biogas recovery by the project activity, but continue to operate with the same qty. of feed inflow, volume (retention time), and temperature (heating) as in the baseline scenario, may be considered as not affected i.e. the methane generation potential<sup>5</sup> remains unaltered.

<sup>3</sup> Refer to: “General guidance to Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories”.

<sup>4</sup> As per EB 22 annex 2 “Guidance regarding methodological issues” section E.

<sup>5</sup> The covering of lagoons and the installation of biogas recovery equipment may result in changes in the operational conditions (such as temperature, COD removal, etc.) of an anaerobic treatment system. These changes are considered small and hence not accounted for under this methodology.



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*III.H. Methane recovery in wastewater treatment (cont)*

15. In case of project activities covered under paragraph 2 (b) and (c), case the project activity involves bottling of biogas the project boundary includes the upgrade and compression installations, the dedicated piped network/natural gas distribution grid for distribution of biogas from the wastewater treatment plant to the end user sites and all the facilities and devices connected directly to it.

**Baseline**

9. The baseline scenario will be one of the following situations:

- (i) The existing aerobic wastewater or sludge treatment system, in the case of substitution of one or both of these systems for anaerobic ones with methane recovery and combustion;
- (ii) The existing sludge disposal system, in the case of introduction of anaerobic sludge treatment system with methane recovery and combustion to an existing wastewater treatment plant;
- (iii) The existing sludge treatment system without methane recovery and combustion;
- (iv) The existing anaerobic wastewater treatment system without methane recovery and combustion;
- (v) The untreated wastewater being discharged into sea, river, lake, stagnant sewer or flowing sewer, in the case of introducing the anaerobic treatment to an untreated wastewater stream;
- (vi) The existing anaerobic wastewater treatment system without methane recovery for the case of introduction of a sequential anaerobic wastewater treatment system with methane recovery.

15. Wastewater and sludge treatment systems equipped with biogas recovery facility in the baseline situation shall be excluded from the baseline emission calculations.

16. Baseline emissions for the systems affected by the project activity may consist of:

- (i) Emissions on account of electricity or fossil fuel used ( $BE_{power,y}$ )
- (ii) Methane emissions from baseline wastewater treatment systems ( $BE_{ww,treatment,y}$ )
- (iii) Methane emissions from baseline sludge treatment systems ( $BE_{s,treatment,y}$ )
- (iv) Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into river/lake/sea ( $BE_{ww,discharge,y}$ )
- (v) Methane emissions from the decay of the final sludge generated by the baseline treatment systems ( $BE_{s,final,y}$ )

16. For case 1 (i) 'Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion' and case 1 (ii) 'Introduction of anaerobic sludge treatment system with biogas recovery and combustion to an existing wastewater treatment plant without sludge treatment', baseline emissions shall be calculated as follows:

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## III.H. Methane recovery in wastewater treatment (cont)

$$BE_y = \{BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}\} \quad (1)$$

Where:

$BE_y$	Baseline emissions in the year $y$ (tCO <sub>2</sub> e)
$BE_{power,y}$	Emissions on account of electricity or diesel consumed in the year $y$ by the replaced aerobic wastewater or sludge treatment system.) Baseline emissions from electricity or fuel consumption in year $y$ (tCO <sub>2</sub> e)
$BE_{y,ww,treatment,i,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year $y$ (tCO <sub>2</sub> e)
$BE_{y,s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year $y$ (tCO <sub>2</sub> e)
$BE_{y,ww,discharge,treated,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year $y$ (tCO <sub>2</sub> e) calculated using the same formula as that used for calculating the project emissions ( $PE_{y,ww,treated}$ ). The value of this term is zero for the case 1 (ii).
$BE_{y,s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year $y$ (tCO <sub>2</sub> e). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term shall be neglected $BE_{y,s,final}$ calculated using the formula as for the project emission ( $PE_{y,s,final}$ ) and the end use of the final sludge will be monitored during the crediting period

17 For case 1 (iii) 'Introduction of methane biogas recovery and combustion to an existing sludge treatment system' and case 1 (iv) 'introduction of methane biogas recovery and combustion to an existing anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on site industrial plant', baseline emissions shall be calculated as follows. MCF lower values in table III.H.1 are to be used:

$$BE_y = MEP_{y,ww,bl} * GWP_{CH_4} + MEP_{y,s,treatment} * GWP_{CH_4} \quad (2)$$

Where:

$MEP_{y,ww,bl}$  Methane emission potential of the anaerobic wastewater treatment plant(s) in the baseline situation in year  $y$  (tonnes) determined as follows:

$$MEP_{y,ww,bl} \equiv Q_{y,ww} * \sum_i (COD_{y,removed,i} * B_{O,ww} * MCF_{ww,treatment,i}) \quad (3)$$

Where:

$COD_{y,removed,i}$  Chemical oxygen demand removed by the anaerobic wastewater treatment system "i" in the baseline situation in the year  $y$  (tonnes/m<sup>3</sup>)

$MCF_{ww,treatment,i}$  Methane correction factor for the anaerobic wastewater treatment system "i"



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*III.H. Methane recovery in wastewater treatment (cont)*

(MCF lower values in table III.H.1)

For determination of  $MEP_{y,o,treatment}$  see formula (8) in paragraph (16).

18 — For case 1 (v) ‘Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream’,:

- (a) — since the MCF lower value for discharge of wastewater to sea, river or lake is 0.0 as per Table III.H.1, but may vary up to 0.2, the project participants shall demonstrate by measurements or by mathematical modelling of the impact of the discharge on the receiving water body, that anaerobic conditions do appear and the baseline emissions occur (a positive MCF is found). This MCF is used to determine the baseline emission scenario:

$$BE_y = Q_{y,ww} * COD_{y,ww,untreated} * B_{o,ww} * MCF_{ww,final} * GWP_{CH_4} \quad (4)$$

19 — For the case 1 (vi) ‘Introduction of a sequential stage of wastewater treatment with methane biogas recovery and combustion, with or without sludge treatment, to an existing wastewater treatment system without methane biogas recovery’ the baseline emissions are calculated as follows:

$$BE_y = Q_{y,ww} * \sum_i (COD_{y,removed,i} * B_{o,ww} * MCF_{ww,treatment,i} * GWP_{CH_4}) \quad (5)$$

17. In determining baseline emissions using formula 1), historical records of at least one year prior to the project implementation shall be used. This shall include for example COD removal efficiency of the wastewater treatment systems, amount of dry matter in sludge, power and electricity consumption per m<sup>3</sup> of wastewater treated, amount of final sludge generated per tonne of COD treated, and all other parameters required for determination of baseline emissions.

18. In case one year of historical data is not available, the parameters shall be determined by a measurement campaign in the baseline wastewater systems for at least 10 days. The measurements should be undertaken during a period that is representative for the typical operation conditions of the systems and ambient conditions of the site (temperature, etc). Average values from the measurement campaign shall be used and the result shall be multiplied by 0.89 to account for the uncertainty range (30% to 50%) associated with this approach as compared to one-year historical data.

19. **Baseline emissions** from electricity consumption ( $BE_{power,y}$ ) are determined as per the procedures described in AMS-I.D. The energy consumption shall include all equipment/devices in the baseline wastewater and sludge treatment facility. For emissions from fossil fuel consumption the emission factor for the fossil fuel shall be used (tCO<sub>2</sub>/tonne). Local values are to be used, if local values are difficult to obtain, IPCC default values may be used. If recovered biogas in the baseline is used to power auxiliary equipment it should be taken into account accordingly, using zero as its emission factor.



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III.H. Methane recovery in wastewater treatment (cont)

20. Methane emissions from the baseline wastewater treatment systems affected by the project ( $BE_{ww,treatment,y}$ ) are determined using the methane generation potential of the wastewater treatment systems :

$$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH4} \quad (2)$$

Where:

$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system $i$ in year $y$ ( $m^3$ )
$COD_{removed,i,y}$	Chemical oxygen demand removed by baseline treatment system $i$ in year $y$ (tonnes/ $m^3$ ), measured as the difference between inflow COD and the outflow COD in system $i$
$MCF_{ww,treatment,BL,i}$	Methane correction factor for baseline wastewater treatment systems $i$ (MCF values as per table III.H.1.)
$i$	Index for baseline wastewater treatment system
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.21 kg $CH_4$ /kg.COD) <sup>6</sup>
$UF_{BL}$	Model correction factor to account for model uncertainties (0.94) <sup>7</sup>
$GWP_{CH4}$	Global Warming Potential for methane (value of 21)
	by the anaerobic wastewater treatment systems “ $i$ ” in the baseline situation in the year $y$ to which the sequential anaerobic treatment step is being introduced (tonnes/ $m^3$ )
$MCF_{ww,treatment,i}$	Methane correction factor for the existing anaerobic wastewater treatment systems “ $i$ ” to which the sequential anaerobic treatment step is being introduced (MCF lower value in Table III.H.1.)

If the baseline treatment system is different from the treatment system in the project scenario, the monitored values of the COD inflow during crediting period will be used to calculate the baseline emissions *ex post*. The outflow COD of the baseline system will be estimated using the removal efficiency of the baseline treatment systems. The removal efficiency of the baseline systems will be measured *ex ante* through representative measurement campaign, or using historical records of COD removal efficiency of at least one year prior to the project implementation as per paragraph 17 or 18.

$MCF_{ww,j}$  — Methane correction factor for the wastewater treatment system  $i$  MCF values as per table III.H.1) For the above cases (a), (b) and (c) the methane generation

<sup>6</sup> The IPCC default value of 0.25 kg  $CH_4$ /kg COD was corrected to take into account the uncertainties. For domestic waste water, a COD based value of  $B_{o,ww}$  can be converted to BOD<sub>5</sub> based value by dividing it by 2.4 i.e. a default value of 0.504 kg  $CH_4$ /kg BOD can be used.

<sup>7</sup> Reference: FCCC/SBSTA/2003/10/Add.2, page 25.



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III.H. Methane recovery in wastewater treatment (cont)

capacity of the treated wastewater ( $B_{e,ww}$ ) shall be IPCC lower value of 0.21 kg  $CH_4$ /kg COD.

21. The Methane Correction Factor (MCF) shall be determined based on the following table:

**Table III.H.1. IPCC default values<sup>8</sup> for Methane Correction Factor (MCF)**

Type of wastewater treatment and discharge pathway or system	MCF value
Discharge of wastewater to sea, river or lake	0.1
Aerobic treatment, well managed	0.0
Aerobic treatment, poorly managed or overloaded	0.3
Anaerobic digester for sludge without methane recovery	0.8
Anaerobic reactor without methane recovery	0.8
Anaerobic shallow lagoon (depth less than 2 metres)	0.2
Anaerobic deep lagoon (depth more than 2 metres)	0.8
Septic system	0.5

22. Methane emissions from the baseline sludge treatment systems affected by the project activity are determined using the methane generation potential of the sludge treatment systems:

$$BE_{treatment,s,y} = \sum_j S_{j,BL,y} * MCF_{s,treatment,BL,j} * DOC_s * UF_{BL} * DOC_F * F * 16/12 * GWP_{CH_4} \quad (3)$$

Where:

$S_{j,BL,y}$	Amount of dry matter in the sludge that would have been treated by the sludge treatment system $j$ in the baseline scenario (tonne).
$j$	Index for baseline sludge treatment system
$DOC_{y,untreated}$	Degradable organic content of the untreated sludge generated in the year $y$ (fraction, dry basis). Default values of 0.5 for domestic sludge and 0.257 for industrial sludge <sup>9</sup> shall be used. the IPCC default values of 0.05 for domestic sludge (wet basis, considering a default dry matter content of 10 percent) or 0.09 for industrial sludge (wet basis, assuming dry matter content of 35 percent).
$MCF_{s,treatment,BL,j}$	Methane correction factor for the baseline sludge treatment system $j$ (MCF values as per table III.H.1)
$UF_{BL}$	Model correction factor to account for model uncertainties (0.94)
$DOC_F$	Fraction of DOC dissimilated to biogas (IPCC default value of 0.5)
$F$	Fraction of $CH_4$ in biogas (IPCC default of 0.5)

<sup>8</sup> Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories

<sup>9</sup> The IPCC default values of 0.05 for domestic sludge (wet basis, considering a default dry matter content of 10 percent) or 0.09 for industrial sludge (wet basis, assuming dry matter content of 35 percent), were corrected for dry basis.



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## III.H. Methane recovery in wastewater treatment (cont)

In case sludge is composted, the following formula shall be applied:

$$BE_{s,treatment,y} = \sum_j S_{j,BL,y} * EF_{composting} * GWP_{CH4} \quad (4)$$

Where:

$EF_{composting}$  Emission factor for composting of organic waste (t CH<sub>4</sub>/ton waste treated). Emission factors can be based on facility/site-specific measurements, country specific values or IPCC default values (table 4.1, chapter 4, Volume 5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories). IPCC default value is 0.01 t CH<sub>4</sub>/ t sludge treated on a dry weight basis

23. If the baseline wastewater treatment system is different from the treatment system in the project scenario, the sludge generation rate (amount of sludge generated per unit COD removed) in the baseline situation may differ significantly from the project situation. For example, it is known that the amount of sludge generated in aerobic wastewater systems is larger than in anaerobic systems, for the same COD removal efficiency. Therefore, for those cases, the monitored values of the amount of sludge generated during the crediting period will be used to estimate the amount of sludge generated in the baseline, as follows:

$$S_{j,BL,y} = S_{l,PJ,y} * \frac{SGR_{BL}}{SGR_{PJ}} \quad (5)$$

Where:

$S_{l,PJ,y}$  Amount of dry matter in the sludge treated by the sludge treatment system  $l$  in year  $y$  in the project scenario (tonne)

$SGR_{BL}$  Sludge generation ratio of the wastewater treatment plant in the baseline scenario (tonne of dry matter in sludge / tonne COD removed). This ratio will be measured *ex ante* through representative measurement campaign, or using historical records of COD removal and sludge generation of at least one year prior to the project implementation as per paragraph 17 or 18

$SGR_{PJ}$  Sludge generation ratio of the wastewater treatment plant in the project scenario (tonne of dry matter in sludge / tonne COD removed). Calculated using the monitored values of COD removal and sludge generation in the project scenario

24. Methane project activity emissions from degradable organic carbon in treated wastewater discharged in e.g. a river, sea or lake in the baseline situation are determined as follows:

$$BE_{ww,discharge,y} = Q_{ww,y} * GWP_{CH4} * B_{o,ww} * UF_{BL} * COD_{ww,discharge,BL,y} * MCF_{ww,BL,discharge} \quad (6)$$

Where:

$Q_{ww,y}$  Volume of treated wastewater discharged in year  $y$  (m<sup>3</sup>)



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*III.H. Methane recovery in wastewater treatment (cont)*

- $UF_{BL,b}$  Model correction factor to account for model uncertainties (0.94)
- $COD_{y,ww,discharge,BL,y}$  Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the baseline situation in the year  $y$  (tonnes/m<sup>3</sup>). If the baseline scenario is the discharge of untreated wastewater, the COD of untreated wastewater shall be used
- $MCF_{ww,BL,final,discharge}$  Methane correction factor based on discharge pathway in the baseline situation (e.g. into sea, river or lake) of the wastewater (fraction) (MCF higher values as per table III.H.1) for sea, river and lake discharge i.e. 0.2)

To determine  $COD_{ww,discharge,BL,y}$ : If the baseline treatment system(s) is different from the treatment system(s) in the project scenario, the monitored values of the COD inflow during crediting period will be used to calculate the baseline emissions *ex post*. The outflow COD of the baseline systems will be estimated using the removal efficiency of the baseline treatment systems, estimated as per paragraphs 17 or 18.

**Table III.H.1. IPCC default values<sup>4)</sup> for Methane Correction Factor (MCF)**

Type of wastewater treatment and discharge pathway or system	MCF lower values	MCF higher values
Discharge of wastewater to sea, river or lake	0.0	0.2
Aerobic treatment, well managed	0.0	0.1
Aerobic treatment, poorly managed or overloaded	0.2	0.4
Anaerobic digester for sludge without methane recovery	0.8	1.0
Anaerobic reactor without methane recovery	0.8	1.0
Anaerobic shallow lagoon (depth less than 2 metres)	0.0	0.3
Anaerobic deep lagoon (depth more than 2 metres)	0.8	1.0
Septic system	0.5	0.5

<sup>4)</sup> Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories

25. Methane project activity emissions from anaerobic decay of the final sludge produced are determined as follows:

$$BE_{s,final,y} = S_{final,BL,y} * DOC_s * UF_{BL} * MCF_{s,BL,final} * DOC_F * F * 16/12 * GWP_{CH4} \quad (7)$$

Where:

$PE_{y,s,final}$  Methane emissions from the anaerobic decay of the final sludge generated in the wastewater system in the year  $y$  (tCO<sub>2</sub>e)



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*III.H. Methane recovery in wastewater treatment (cont)*

- $S_{y,final,BL,y}$  Amount of dry matter in final sludge generated by the baseline wastewater treatment systems in the year  $y$  (tonnes). If the baseline wastewater treatment system is different from the project system, it will be estimated using the monitored amount of dry matter in final sludge generated by the project activity ( $S_{final,PJ,y}$ ) corrected for the sludge generation ratios of the project and baseline systems as per formula 5 above
- $MCF_{s,BL,final}$  Methane correction factor of the disposal site that receives the final sludge in the baseline situation, estimated as per the procedures described in AMS-III.G
- $UF_{BLb}$  Model correction factor to account for model uncertainties (0.94)

### Project Activity Emissions

26. Project activity emissions from the systems affected by the project activity are:
- (i) CO<sub>2</sub> emissions on account of power and fuel used by the project activity facilities. Emission factors for grid electricity or diesel fuel use as the case may be shall be calculated as described in category AMS I.D.; ( $PE_{power,y}$ )
  - (ii) Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ( $PE_{ww,treatment,y}$ )
  - (iii) Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ( $PE_{y,s,treatment,y}$ )
  - (iv) Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater; ( $PE_{ww,discharge,y}$ )
  - (v) Methane emissions from the decay of the final sludge generated by the project activity treatment systems; ( $PE_{s,final,y}$ )
  - (vi) Methane fugitive emissions on account of inefficiencies in capture systems ( $PE_{fugitive,y}$ )
  - (vii) Methane emissions due to incomplete flaring ( $PE_{flaring,y}$ )
  - (viii) Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation ( $PE_{biomass,y}$ )<sup>10</sup>
- $PE_{y,fugitive}$  Emissions from methane release in capture and utilization/combustion/flare systems in year  $y$

<sup>10</sup> For instance in the baseline situation Palm Kernel Shells (PKS) are used as fuel in a boiler. In the project situation PKS is replaced by biogas captured at a wastewater treatment system. The PKS will no longer be used as fuel in the boiler, but sold on the market. Before it is sold it is likely it will be stored for a period of time (few months or longer) on site which might lead to methane emissions from anaerobic decay.

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## III.H. Methane recovery in wastewater treatment (cont)

 ~~$PE_{y,dissolved}$  Emissions in treated wastewater in year  $y$ : (i), (v) and (vi) of paragraph 1~~

$$PE_y = \left\{ \begin{array}{l} PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + \\ PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y} \end{array} \right\} \quad (8)$$

Where:

 $PE_y$  Project activity emissions in the year  $y$  (tCO<sub>2</sub>e)

$PE_{y,power,y}$  Emissions from electricity or diesel fuel consumption in the year  $y$  (tCO<sub>2</sub>e). These emissions shall be calculated as per paragraph 19, for the situation of the project scenario, using energy consumption data of all equipment/devices used in the project activity wastewater and sludge treatment systems and systems for biogas recovery and flaring/gainful use

$PE_{y,ww,treatment,y}$  Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year  $y$  (tCO<sub>2</sub>e). These emissions shall be calculated as per formula 2 in paragraph 20, using an uncertainty factor of 1.06 and data applicable to the project situation ( $MCF_{ww,treatment,PJ,k}$  and  $COD_{removed,PJ,k,y}$ ) and with the following changed definition of parameters:

$MCF_{ww,treatment,PJ,k}$  Methane correction factor for project wastewater treatment system  $k$  (MCF values as per table III.H.1.)

$COD_{removed,PJ,k,y}$  Chemical oxygen demand removed by project wastewater treatment system  $k$  in year  $y$  (tonnes/m<sup>3</sup>), measured as the difference between inflow COD and the outflow COD in system  $k$

$PE_{y,s,treatment,y}$  Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year  $y$  (tCO<sub>2</sub>e). These emissions shall be calculated as per formulas 3 and 4 in paragraph 22, using an uncertainty factor of 1.06 and data applicable to the project situation ( $S_{l,PJ,y}$ ,  $MCF_{s,treatment,l}$ ) and with the following changed definition of parameters:

$S_{l,PJ,y}$  Amount of dry matter in the sludge treated by the sludge treatment system “ $l$ ” in the project scenario in year  $y$  (tonne)

$MCF_{s,treatment,l}$  Methane correction factor for the project sludge treatment system  $l$  (MCF values as per table III.H.1)

$PE_{y,ww,treateddischarge}$  Methane emissions from degradable organic carbon in treated wastewater in year  $y$  (tCO<sub>2</sub>e). These emissions shall be calculated as per formula 4 in paragraph 25, using an uncertainty factor of 1.06 and data applicable to the project situation ( $COD_{ww,discharge,PJ,y}$ ,  $MCF_{ww,PJ,discharge,y}$ ) and with the following changed definition of parameters:

$COD_{ww,discharge,PJ}$  Chemical oxygen demand of the treated wastewater

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## III.H. Methane recovery in wastewater treatment (cont)

	$y$	discharged into sea, river or lake in the project situation in the year $y$ (tonnes/m <sup>3</sup> )
	$MCF_{ww,PJ,discharge}$	Methane correction factor based on discharge pathway in the project situation (e.g. into sea, river or lake) of the wastewater (fraction) (MCF values as per table III.H.1)
$PE_{ys,final,y}$		Methane emissions from anaerobic decay of the final sludge produced in the year $y$ . (tCO <sub>2</sub> e) These emissions shall be calculated as per formula 7 in paragraph 25, using an uncertainty factor of 1.06 and data applicable to the project situation ( $MCF_{s,PJ,final}$ , $S_{final,PJ,y}$ ). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in aerobic conditions in the project activity, this term shall be neglected, and the sludge treatment and/or use and/or final disposal shall be monitored during the crediting period and with the following changed definition of parameters:
	$MCF_{s,PJ,final}$	Methane correction factor of the disposal site that receives the final sludge in the project situation, estimated as per the procedures described in AMS-III.G.
	$S_{final,PJ,y}$	Amount of dry matter in final sludge generated by the project wastewater treatment systems in the year $y$ (tonnes).
$PE_{y,fugitive,y}$		Methane emissions from methane release biogas release in capture and utilization/combustion/flare systems in year $y$ , calculated as per paragraph 26 (tCO <sub>2</sub> e)
$PE_{flaring,y}$		Methane emissions due to incomplete flaring in year $y$ as per the “Tool to determine project emissions from flaring gases containing methane”(tCO <sub>2</sub> e) <del><math>PE_{y,dissolved}</math> emissions from dissolved methane in treated wastewater in year <math>y</math>. Project emissions from this source are only considered for project activities involving measures described in cases 23 (i), (v) and (vi) of paragraph</del>
$PE_{biomass,y}$		Methane emissions from biomass stored under anaerobic conditions. In case storage of biomass under anaerobic conditions takes place due to the project activity that doesn't occur in the baseline situation, methane emissions due to anaerobic decay of this biomass shall be considered and be determined as per the procedure in the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site” (tCO <sub>2</sub> e)

27. Project activity emissions from methane release in capture and utilization/combustion/flare systems are determined as follows:

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y} \quad (9)$$

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## III.H. Methane recovery in wastewater treatment (cont)

Where:

$PE_{y,fugitive,ww,y}$  Fugitive emissions through capture and utilization/combustion/flare inefficiencies in the anaerobic wastewater treatment systems in the year  $y$  (tCO<sub>2</sub>e)

$PE_{y,fugitive,s,y}$  Fugitive emissions through capture and utilization/combustion/flare inefficiencies in the anaerobic sludge treatment systems in the year  $y$  (tCO<sub>2</sub>e)

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) * MEP_{ww,treatment,y} * GWP_{CH4} \quad (10)$$

Where:

$CFE_{ww}$  Capture and utilization/combustion/flare efficiency of the methane biogas recovery and combustion/utilization equipment in the wastewater treatment systems (a default value of 0.9 shall be used, given no other appropriate value)

$MEP_{y,ww,treatment,y}$  Methane emission potential of wastewater treatment plant systems equipped with biogas recovery system in the year  $y$  (tonnes)

$$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * UF_{PJ} * \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad (11)$$

Where:

$COD_{y,removed,PJ,k,y}$  The chemical oxygen demand removed<sup>11</sup> by the treatment system  $j$   $k$  of the project activity equipped with methane biogas recovery in the year  $y$  (tonnes/m<sup>3</sup>)

$MCF_{ww,treatment,PJ,kj}$  Methane correction factor for the project wastewater treatment system  $j$   $k$  equipped with methane biogas recovery and combustion/flare/utilization equipment (MCF higher values in as per table III.H.1)

$UF_{PJ}$  Model correction factor to account for model uncertainties (1.06)

$$PE_{fugitive,s,y} = (1 - CFE_s) * MEP_{s,treatment,y} * GWP_{CH4} \quad (12)$$

Where:

$CFE_s$  Capture and utilization/combustion/flare efficiency of the methane biogas recovery and combustion/utilization equipment in the sludge treatment systems (a default value of 0.9 shall be used, given no other appropriate value)

$MEP_{y,s,treatment,y}$  Methane emission potential of the sludge treatment systems equipped with biogas recovery system in the year  $y$  (tonnes)

$$MEP_{s,treatment,y} = \sum_l (S_{l,PJ,y} * MCF_{s,treatment,PJl}) * DOC_s * UF_{PJ} * DOC_F * F * 16/12 \quad (13)$$

<sup>11</sup> Difference of inflow COD and the outflow COD.

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## III.H. Methane recovery in wastewater treatment (cont)

Where:

$S_{y,l,PJ,y,untreated}$  Amount of untreated sludge treated in the project sludge treatment system  $l$  equipped with biogas recovery system (on dry basis) generated in the year  $y$  (tonnes)

$DOC_{y,s,untreated}$  Degradable organic content of the untreated sludge generated in the year  $y$  (fraction). It shall be measured by sampling and analysis of the sludge produced, and estimated *ex ante* using the IPCC default values of 0.05 for domestic sludge (wet basis, considering a default dry matter content of 10 percent) or 0.09 for industrial sludge (wet basis, assuming dry matter content of 35 percent)

$MCF_{s,treatment,l}$  Methane correction factor for the sludge treatment system that will be equipped with methane biogas recovery and combustion/utilization/flare equipment (MCF Higher value of 1.0 as per table III.H.1). values as per table III.H.1)

$UF_{PJ}$  Model correction factor to account for model uncertainties (1.06)

26. Project activity emissions from dissolved methane in treated wastewater are determined as follows:

$$PE_{dissolved,y} = Q_{ww,y} * [CH_4]_{ww,treated,y} * GWP_{CH_4} \quad (14)$$

Where:

$[CH_4]_{y,ww,treated}$  Dissolved methane content in the treated wastewater (tonnes/m<sup>3</sup>). In aerobic wastewater treatment default value is zero, in anaerobic treatment it can be measured, or a default value of 10e<sup>-4</sup> tonnes/m<sup>3</sup> can be used.

## Leakage

28. If the used technology is equipment transferred from another activity or if the existing equipment is transferred to another activity, leakage effects at the site of the other activity are to be considered and estimated ( $LE_y$ ).

## Emission Reduction

## Monitoring

29. For all scenarios in paragraph 1 i.e. 1.i) till 1.vi) emission reductions shall be estimated *ex ante* in the PDD using the formulas provided in the baseline, project and leakage emissions sections above. Emission reductions shall be estimated *ex ante* as follows:

$$ER_{y,ex\ ante} = BE_{y,ex\ ante} - (PE_{y,ex\ ante} + LE_{y,ex\ ante}) \quad (14)$$

Where:

$ER_{y,ex\ ante}$  *Ex ante* emission reduction in year  $y$  (tCO<sub>2</sub>e)

$LE_{y,ex\ ante}$  *Ex ante* leakage emissions in year  $y$  (tCO<sub>2</sub>e)



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III.H. Methane recovery in wastewater treatment (cont)

$PE_{y,ex\ ante}$  Ex ante project emissions in year  $y$  calculated as paragraph 26 (tCO<sub>2</sub>e)

$BE_{y,ex\ ante}$  Ex ante baseline emissions in year  $y$  calculated as per paragraph 16 (tCO<sub>2</sub>e)

30. Ex post emission reductions shall be determined for case 1 (i) and 1 (v) as per paragraph 33. For cases 1 (ii), 1 (iii), 1 (iv) and 1 (vi) ex post emission reductions shall be based on the lowest value of the following, as per paragraph 31:

- (i) The amount of biogas recovered and fuelled or flared ( $MD_y$ ) during the crediting period, that is monitored ex post;
- (ii) Ex post calculated baseline, project and leakage emissions based on actual monitored data for the project activity.

31. For cases 1 (ii), 1 (iii), 1 (iv) and 1 (vi): It is possible that the project activity involves wastewater and sludge treatment systems with higher methane conversion factors (MCF) or with higher efficiency than the treatment systems used in the baseline situation. Therefore the emission reductions achieved by the project activity is limited to the ex post calculated baseline emissions minus project emissions using the actual monitored data for the project activity. The emission reductions achieved in any year are the lowest value of the following:

$$ER_{y,ex\ post} = \min((BE_{y,ex\ post} - PE_{y,ex\ post} - LE_{y,ex\ post}), (MD_y - PE_{power,y} - PE_{biomass,y} - LE_{y,ex\ post})) \quad (15)$$

Where:

$ER_{y,ex\ post}$  Emission reductions achieved by the project activity based on monitored values for year  $y$  (tCO<sub>2</sub>e)

$BE_{y,ex\ post}$  Baseline emissions calculated as per paragraph 16 using ex post monitored values

$PE_{y,ex\ post}$  Project emissions calculated as per paragraph 26 using ex post monitored values

$MD_y$  Methane captured and destroyed/gainfully used by the project activity in the year  $y$  (tCO<sub>2</sub> e). In case of flaring/fuelling it shall be measured using the conditions of the flaring process

32. In case of flaring/combustion  $MD_y$  will be measured using the conditions of the flaring process:

$$MD_y = BG_{burnt,y} * w_{CH_4,y} * D_{CH_4} * FE * GWP_{CH_4} \quad (16)$$

Where:

$BG_{burnt,y}$  Biogas<sup>12</sup> flared/combusted in year  $y$  (m<sup>3</sup>)

$w_{CH_4,y}$  Methane content<sup>12</sup> in the biogas in the year  $y$  (mass fraction)

<sup>12</sup> Biogas volume and methane content measurements shall be on the same basis (wet or dry).





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*III.H. Methane recovery in wastewater treatment (cont)*

$D_{CH_4}$  Density of methane at the temperature and pressure of the biogas in the year  $y$  (tonnes/m<sup>3</sup>)

$FE$  Flare efficiency in year  $y$  (fraction)

33. For the cases listed in paragraph 1 as:

(i) Substitution of aerobic wastewater or sludge treatment system by an anaerobic treatment system with methane recovery and combustion

or

(v) Introduction of an anaerobic wastewater treatment system with methane recovery and combustion to an untreated wastewater stream;

the emission reduction achieved by the project activity (*ex post*) will be the difference between the baseline emission and the sum of the project emission and leakage.

$$ER_y = BE_{y,ex\ post} - (PE_{y,ex\ post} + LE_{y,ex\ post}) \quad (17)$$

The historical records of electricity and fuel consumption, COD content of untreated and treated wastewater, and quantity of sludge produced by the replaced aerobic units will be used for the baseline calculation in case (i).

In case (i) if the volumetric flow and the characteristic properties (e.g. COD) of the inflow and outflow of the wastewater and the produced sludge are equivalent in the project and the baseline scenarios (i.e. the project and baseline systems have the same efficiency for COD removal for wastewater treatment), then higher energy consumption and sludge generation in the case of baseline scenario is are the only significant differences contributing to emission reduction in the project case. In this case the emission reduction can be simply calculated as the difference between the historical energy consumption of the replaced unit and the recorded energy consumption of the new system, plus the difference in emissions from sludge treatment and/or disposal. Project emissions from dissolved methane and fugitive emissions and incomplete flaring ( $PE_{y,fugitive,y}$ ,  $PE_{flaring,y}$  and  $PE_{y,dissolved}$ ) shall also be considered in the calculation of the emission reduction, however the emissions from the wastewater outflow and sludge ( $PE_{y,ww,treated\ discharge,y}$  and  $PE_{y,s,final,y}$ ) may be disregarded, if they are equivalent in baseline and project scenarios.

For the cases listed in paragraph 1 as of (ii) introduction of anaerobic sludge treatment with methane recovery and combustion to untreated sludge; (iii) and (iv) introduction of methane recovery and combustion unit to an existing anaerobic wastewater or sludge treatment system, and (vi) introduction of a sequential stage of wastewater treatment with methane recovery and combustion to an existing wastewater treatment, the calculation of emission reductions shall be based on the amount of methane recovered and fuelled or flared, that is monitored *ex post*. Also for these cases, the project emissions and leakage will be deducted from the emission reductions calculated from the methane recovered and combusted, except where it can be demonstrated that the technology implemented does not increase the amount of methane produced per unit of COD



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*III.H. Methane recovery in wastewater treatment (cont)*

removed (COD removed is the difference between the inflow COD ( $COD_{y,ww,untreated}$ ) and outflow COD ( $COD_{y,ww,treated}$ )), compared with the technology used in the baseline

For cases covered under paragraph 2 (b) and 2 (c), project and leakage emissions due to those activities cannot be ignored and have to be considered.

**Monitoring**

34. For the cases listed in paragraph 1, where required by the provisions of project emission calculations, the following parameters shall be monitored and recorded:

- (a) The flow of wastewater ( $Q_{ww,i,y}$ ) and The amount of fossil fuel and electricity used by the project activity facilities;
- (a) The degradable carbon content chemical oxygen demand of the wastewater and/or sludge before and after the treatment system “k”, affected by the project activity ( $COD_{y,ww,untreated,y}$ ,  $COD_{y,ww,treated,y}$ ,  $COD_{y,ww,removed,PJ,k,y}$ ,  $COD_{ww,discharge,PJ,y}$ ,  $DOC_{y,s}$ ,  $DOC_{y,s,treated}$ );
- (b) The flow of wastewater and/or The amount of sludge as dry matter in each sludge treatment system “l” affected by the project treated ( $Q_{y,ww,i,y}$ ,  $S_{y,l,PJ,y,final}$  and  $S_{y,untreated,final,PJ,y}$ );
- (d) Where relevant, the dissolved methane in the wastewater just leaving the anaerobic reactor (if the default value for dissolved methane is not used).

35. The annual fossil fuel or electricity used to operate the facilities or power auxiliary equipment shall be monitored. Alternatively it shall be assumed that all relevant electrical equipment operate at full rated capacity, plus 10% to account for distribution losses, for 8760 hours per annum.

36. In all cases, the amount of methane biogas recovered, fuelled, flared or utilized (e.g. injected into a natural gas distribution grid or distributed via a dedicated piped network) shall be monitored *ex post*, using continuous flow meters. The fraction of methane in the gas should be measured with a continuous analyser or, alternatively, with periodical measurements at a 95% confidence level<sup>13</sup>. Temperature and pressure of the gas are required to determine the density of methane combusted.

37. Regular maintenance should ensure optimal operation of flares. The flare efficiency (FE), defined as the fraction of time in which the gas is combusted in the flare, multiplied by the efficiency of the flaring process, shall be monitored and calculated as per the provision in the “Tool to determine project emissions from flaring gases containing methane”.

38. One of the two following options shall be used to determine the efficiency of the flaring process in an enclosed flare:

<sup>13</sup> Fraction of methane (CH<sub>4</sub>) in biogas shall be measured using equipment that can directly measure methane content in the biogas, estimation of methane content of biogas based on measurement of other constituents of biogas such as CO<sub>2</sub> is not permitted.



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III.H. Methane recovery in wastewater treatment (cont)

(a) — To adopt a 90% default value, or

(b) — To perform a continuous monitoring of the efficiency.

38. If option (a) is chosen continuous check of compliance with the manufacturers specification of the flare device (temperature, biogas flow rate) should be done. If in any specific hour any of the parameters is out of the range of specifications 50% of default value should be used for this specific hour. For open flare 50% default value should be used, as it is not possible in this case to monitor the efficiency. If at any given time the temperature of the flare is below 500°C, 0% default value should be used for this period. The amount of sludge treated in the sludge treatment system ( $S_{1,Pj,y}$ ) is monitored by measuring the total quantity of sludge fed to each system on a dry basis. In case of sludge extracted in a slurry phase, the volume ( $m^3$ ) and dry matter content (tonnes/ $m^3$ ) shall be used to calculate  $S_{1,Pj,y}$ . In case of mechanical sludge removal, e.g. separation of solids via a screen, or removed from lagoons,  $S_{1,Pj,y}$  is measured by direct weighing of the sludge and measuring its dry matter content through sampling.

39. If the methane emissions from anaerobic decay of the final sludge were to be neglected because the sludge is controlled combusted, disposed in a landfill with methane recovery, or used for soil application, then the end-use of the final sludge will be monitored during the crediting period.

40. In case of storage of biomass under anaerobic conditions which does not take place in the baseline situation, monitoring of the biomass shall take place as per the “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”.

41. If the baseline emissions included the anaerobic decay of final sludge generated by the baseline treatment systems in a landfill without methane recovery, the baseline disposal site shall be clearly defined, and verified by the DOE.

**Project activity under a programme of activities**

The following conditions apply for use of this methodology in a project activity under a programme of activities:

42. In case the project activity involves the replacement of equipment, and the leakage effect of the use of the replaced equipment in another activity is neglected, because the replaced equipment is scrapped, an independent monitoring of scrapping of replaced equipment needs to be implemented. The monitoring should include a check if the number of project activity equipment distributed by the project and the number of scrapped equipment correspond with each other. For this purpose scrapped equipment should be stored until such correspondence has been checked. The scrapping of replaced equipment should be documented and independently verified.

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## III.H. Methane recovery in wastewater treatment (cont)

## Annex 1

## PROVISIONS FOR CASES INVOLVING THERMAL OR ELECTRICAL ENERGY GENERATION AFTER UPGRADING AND DISTRIBUTION, EITHER VIA UPGRADING AND INJECTION OF BIOGAS INTO A NATURAL GAS DISTRIBUTION GRID OR VIA UPGRADING AND TRANSPORTATION OF BIOGAS VIA A DEDICATED PIPED NETWORK TO A GROUP OF END USERS

## Project Boundary

1. In case of project activities covered under paragraph 2 (b) and (c)<sup>14</sup>, in case the project activity involves bottling of biogas the project boundary includes the upgrade and compression installations, the dedicated piped network/natural gas distribution grid for distribution of biogas from the wastewater treatment plant to the end user sites and all the facilities and devices connected directly to it.

## Baseline

2. In case of project activities covered under paragraph 2 (c i) the baseline emissions for upgraded biogas injection ( $BE_{y, injection,y}$ ) are determined as follows:

$$BE_{injection,y} = E_{ug,y} * CEF_{NG} \quad (1)$$

Where:

$BE_{y, injection,y}$  Baseline emissions for injection of upgraded biogas into a natural gas distribution grid in year  $y$  (tCO<sub>2</sub>e)

$E_{ug,y}$  Energy delivered from the upgraded biogas in the project activity to the natural gas distribution grid in year  $y$  (TJ)

$CEF_{NG}$  Carbon emission factor of natural gas (tCO<sub>2</sub>e/TJ) (Accurate and reliable local or national data may be used where available, otherwise appropriate IPCC default values shall be used)

3. The energy delivered from the upgraded biogas in the project activity to the natural gas distribution grid in year  $y$  ( $E_{ug,y}$ ) is calculated as follows:

$$E_{ug,y} = Q_{ug,y} * NCV_{ug,y} \quad (2)$$

Where:

$Q_{ug,y}$  Quantity of upgraded biogas displacing the use of natural gas in the natural gas distribution grid in year  $y$  (kg or m<sup>3</sup>)

$NCV_{ug,y}$  Net calorific value of the upgraded biogas in year  $y$  (TJ/kg or TJ/m<sup>3</sup>).

<sup>14</sup> These are references to the section “technology/measure” in the methodology.



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*III.H. Methane recovery in wastewater treatment (cont)*

4. The quantity of upgraded biogas displacing the use of natural gas in the natural gas distribution grid in year  $y$  is calculated as follows:

$$Q_{ug,y} = \min(Q_{ug,in,y}, Q_{cap,CH_4,y}) \quad (3)$$

Where:

$Q_{ug,in,y}$  Quantity of upgraded biogas injected into the natural gas distribution grid in year  $y$  (kg or  $m^3$ )

$Q_{cap,CH_4,y}$  Quantity of methane captured at the wastewater treatment source facility(ies) in year  $y$  (kg or  $m^3$ )

5. The quantity of methane captured at the waste water treatment source facility(ies) is calculated as follows:

$$Q_{cap,CH_4,y} = w_{CH_4,ww} * Q_{cap,biogas,y} \quad (4)$$

Where:

$w_{CH_4,ww}$  Methane fraction of biogas as monitored at the outlet of the wastewater treatment source facility(ies) (kg or  $m^3$   $CH_4$ /kg or  $m^3$  of biogas).

$Q_{cap,biogas,y}$  Monitored amount of biogas captured at the source facility(ies) in year  $y$  (kg or  $m^3$ )

**Project activity emission**

6. In case of project activities covered under paragraph 2 (b) and 2 (c) the following project emissions related to the upgrading and compression of the biogas ( $PE_{y,upgradingprocess,y}$ ) shall be included:

- (i) Methane emissions from the discharge of the water wash upgrading equipment (tCO<sub>2</sub>e);
- (ii) Fugitive methane emissions from leaks in compression equipment (tCO<sub>2</sub>e);
- (iii) Emissions on account of vent gases from the water wash upgrade equipment (tCO<sub>2</sub>e);

$$PE_{process,y} = PE_{ww,upgrade,y} + PE_{CH_4,equip,y} + PE_{ventgas,y} \quad (5)$$

Where:

$PE_{process,y}$  Project emissions related to the upgrading and compression of the biogas in year  $y$  (tCO<sub>2</sub>e)

$PE_{ww,upgrade,y}$  Emissions from methane contained in waste water discharge of water wash upgrading installation in year  $y$  (tCO<sub>2</sub>e)

$PE_{CH_4,equip,y}$  Emissions from compressor leaks in year  $y$  (tCO<sub>2</sub>e)



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*III.H. Methane recovery in wastewater treatment (cont)*

$PE_{y,ventgas,y}$  Emissions from venting gases retained in water wash upgrading equipment in year  $y$  (tCO<sub>2</sub>e)

7. Project activity emissions from methane contained in waste water discharge of water wash upgrading installation are determined as follows:

$$PE_{ww,upgrade,y} = Q_{ww,upgrade,y} * [CH_4]_{ww,upgrade,y} * GWP_{CH_4} \quad (6)$$

Where:

$Q_{y,ww,upgrade,y}$  Volume of wastewater discharge from water wash upgrading installation in year  $y$

$[CH_4]_{y,ww,upgrade,y}$  Dissolved methane contained in the wastewater discharge in year  $y$

8. Project activity emissions from compressor leaks are determined as follows:

$$PE_{CH_4,equip,y} = GWP_{CH_4} * \left(\frac{1}{1000}\right) * \sum_{equipment} w_{CH_4,stream,y} * EF_{equipment} * T_{equipment,y} \quad (7)$$

Where:

$w_{CH_4,stream,y}$  Average methane weight fraction of the gas (kg-CH<sub>4</sub>/kg) in year  $y$

$T_{equipment,y}$  Operation time of the equipment in hours in year  $y$  (in absence of detailed information, it can be assumed that the equipment is used continuously, as a conservative approach)

$EF_{equipment}$  Leakage rate for fugitive emissions from the compression technology as per specification from the compressor manufacturer in kg/hour/compressor. If no default value from the technology provider is available, the approach below shall be used.

Fugitive methane emissions occurring during the recovery and processing of gas may in some projects be small, but should be estimated as a conservative approach. Emission factors may be taken from the 1995 Protocol for Equipment Leak Emission Estimates, published by EPA<sup>15</sup>.

Emissions should be determined for all relevant activities and all equipment used for the upgrading of biogas (such as valves, pump seals, connectors, flanges, open-ended lines, etc.).

The following data needs to be obtained:

1. The number of each type of component in a unit (valve, connector, etc.);
2. The methane concentration of the stream;
3. The time period each component is in service.

<sup>15</sup> Please refer to document US EPA-453/R-95-017 at: <http://www.epa.gov/ttn/chieff/efdocs/equiplks.pdf>, accessed on 23/10/2007.

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III.H. Methane recovery in wastewater treatment (cont)

The EPA approach is based on average emission factors for Total Organic Compounds (TOC) in a stream and has been revised to estimate methane emissions. Methane emissions are calculated for each single piece of equipment by multiplying the methane concentration with the appropriate emission factor from table III.H.2 below.

Table III.H.2. Methane emission factors for equipment<sup>16</sup>

Equipment type	Emission Factor (kg/hour/ source) for methane
Valves	4.5E-0.3
Pump seals	2.4E-0.3
Others <sup>17</sup>	8.8E-0.3
Connectors	2.0E-0.4
Flangs	3.9E-0.4
Open ended lines	2.0E-0.3

9. Project activity emissions from venting gases retained in water wash upgrading equipment do not have to be considered if vent gases ( $PE_{y,vent\ gas,y}$ ) are channeled to storage bags. In case vent gases are flared, emissions due to the incomplete or inefficient combustion of the gases will be calculated using the “Tool to determine project emissions from flaring gases containing methane”, as follows:

$$PE_{y,vent\ gas,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1000} \tag{8}$$

Where:

$TM_{RG,h}$  Mass flow rate of methane in the residual gas in hour  $h$  (kg/h)

$\eta_{flare,h}$  Flare efficiency in hour  $h$

In case vent gases are not flared the “Tool to determine project emissions from flaring gases containing methane” will be used, without considering measurements and calculations for the flare efficiency, which will be assumed to be zero. In this case, emissions due to the vent gases will be:

$$PE_{y,vent\ gas,y} = \sum_{h=1}^{8760} TM_{RG,h} * \frac{GWP_{CH4}}{1000} \tag{9}$$

Alternatively, in case vent gases are directly vented to the atmosphere, it may also be calculated by conservatively calculating the mass of the gases vented based on the volume, pressure and

<sup>16</sup> Please refer to document US EPA-453/R-95-017 table 2.4, page 2-15, accessed on 23/10/2007.

<sup>17</sup> The emission factor for “other” equipment type was derived from compressors, diaphragms, drains, dump arms, hatches, instruments, meters, pressure relief valves, polished rods, relief valves and vents. This “other” equipment type should be applied for any equipment type other than connectors, flanges, open-ended lines, pumps or valves.



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*III.H. Methane recovery in wastewater treatment (cont)*

temperature of gas retained in water wash upgrading equipment. This mass should be multiplied with the frequency with which it is vented and assuming that the vented gas is pure methane.

In order to account for emissions that occur when the water wash upgrade facility is shut down due to maintenance, repair work or emergencies one of the alternatives proposed above should be used to calculate and include emissions from flaring or venting.

10. In case of project activities covered under paragraph 2 (c ii) emissions due to physical leakage of upgraded biogas from the dedicated piped network ( $PE_{y,leakage,pipeline,y}$ ) shall be determined as follows:

$$PE_{leakage,pipeline,y} = Q_{methane,pipeline,y} * LR_{pipeline} * GWP_{CH4} \quad (10)$$

Where:

$PE_{y,leakage,pipeline,y}$  Emissions due to physical leakage from the dedicated piped network in year y (tCO<sub>2</sub>e)

$Q_{y,methane,pipeline,y}$  Total quantity of methane transported in the dedicated piped network in year y (m<sup>3</sup>)

$LR_{pipeline}$  Physical leakage rate from the dedicated piped network (if no project-specific values can be identified a conservative default value of 0.0125 Gg per 10<sup>6</sup> m<sup>3</sup> of utility sales shall be applied<sup>18</sup>.)

### Leakage emissions

11. In case of project activities covered under paragraph 2 (b) and the users of the bottles filled with upgraded biogas are not included in the project boundary then the following leakage emissions shall be included and calculated as follows:

- (i) Emissions due to physical leakage of biogas from the bottles during storage, transport etc. until final end use (tCO<sub>2</sub>e);
- (ii) Emissions due to fossil fuel use for transportation of bottles; biogas filled bottles to the end users and the return of empty bottles to the filling site (tCO<sub>2</sub>e).

$$LE_{bottling,y} = LE_{leakage,bb,y} + LE_{trans,y} \quad (11)$$

Where:

$LE_{y,bottling,y}$  Leakage emissions project activities involving bottling of biogas in year y (tCO<sub>2</sub>e)

<sup>18</sup> 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, chapter 4, table 4.2.5 provides default values for fugitive emissions from gas operations in developing countries. The default values provided for fugitive emissions for the distribution of natural gas to end users range from 1.1 E-3 to 2.5 E-3 Gg per 10<sup>6</sup> m<sup>3</sup> of utility sales. The uncertainty in this value is -20% to 500%. A conservative value of 2.5 E-3 \* 500% = 0.0125 Gg per 10<sup>6</sup> m<sup>3</sup> of utility sales shall be taken.





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$LE_{y,leakage,bb,y}$  Emissions due to physical leakage from biogas bottles in year  $y$  (tCO<sub>2</sub>e)

$LE_{y,trans,y}$  Emissions due to fossil fuel use for transportation of bottles; biogas filled bottles to the end users and the return of empty bottles to the filling site in year  $y$  (tCO<sub>2</sub>e)

12. Leakage emissions due to physical leakage from biogas bottles are determined as follows:

$$LE_{leakage,bb,y} = Q_{methane,bb,y} * LR_{bb} * GWP_{CH4} \quad (12)$$

Where:

$Q_{y,methane,bb,y}$  Total quantity of methane bottled in year  $y$  (m<sup>3</sup>)

$LR_{bb}$  Physical leakage rate from biogas bottles (if no project-specific values can be identified a default value of 1.25% shall be applied<sup>19</sup>)

13. Leakage emissions due to fossil fuel use for transportation of bottles (biogas filled bottles to the end users and the return of empty bottles to the filling site) are determined as below. If some of the locations of the end-users are unknown a conservative approach assuming transport emissions of 250 km, shall be used.

$$PE_{trans,y} = \left( \frac{Q_{bb,y}}{CT_{bb,y}} \right) * DAF_{bb} * EF_{CO2} \quad (13)$$

Where:

$Q_{y,bb,y}$  Total freight volume of upgraded biogas in bottles transported in year  $y$  (m<sup>3</sup>)

$CT_{y,bb,y}$  Average truck freight volume capacity for the transportation of bottles with upgraded biogas (m<sup>3</sup>/truck)

$DAF_{bb}$  Aggregated average distance for bottle transportation; biogas filled bottles to the end users and the return of empty bottles to the filling site (km/truck)

$EF_{CO2}$  CO<sub>2</sub> emission factor from fuel use due to transportation (tCO<sub>2</sub>/km)

### Monitoring

14. The project proponents shall maintain a biogas (or methane) balance based on:

- (a) Continuous measurement of the amount of biogas captured at the wastewater treatment system;
- (b) Continuous measurement of the amount of biogas used for various purposes in the project activity: e.g. heat, electricity, flare, hydrogen production, injection into

<sup>19</sup> Victor (1989) Leaking Methane from Natural Gas Vehicles: Implication for Transportation Policy in the Greenhouse Era, in Climatic Change 20: 113-141, 1992 and American Gas Association (1986), 'Lost and Unaccounted for Gas', Planning and Analysis issues, issue brief 1986-28, p. 3.



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III.H. Methane recovery in wastewater treatment (cont)

natural gas distribution grid, etc. The difference is considered as loss due to physical leakage and deducted from the emission reductions.

~~50. In case of project activities covered under paragraph 2 (e i) the emission reductions calculated in accordance with paragraph 33 or 34 shall be summed up with the baseline emissions calculated in accordance with paragraph 25.~~

15. In case of project activities covered under paragraph 2 (c) the quantity of biogas, temperature, pressure and concentration of methane in the biogas injected into the natural gas grid/distributed via the dedicated piped network shall be measured continuously using certified equipment. The NCV shall be measured directly from the gas stream using an online Heating Value Meter (monthly). This measurement must be in mass or volume basis and the project participants shall ensure that units of the measurements of the amount of biogas injected and of the net calorific value are consistent. The methane content of the injected or transported biogas shall always be in accordance with national regulations or, in absence of national regulations, 96% (by volume) or higher. Biogas injected or transported with inferior methane content shall be excluded from the emission reduction calculations.

16. In case of project activities covered under paragraph 2 (b) and 2 (c), the following parameters shall be monitored and recorded:

- (a) The volume of discharge into the desorption pond from the water wash upgrading installation ( $Q_{y,ww,upgrade,y}$ ), monitored continuously;
- (b) The methane content ( $[CH_4]_{y,ww,upgrade,y}$ ) of the discharge water from the water wash upgrade facility, samples are taken at least every six months during normal operation of the facility;
- (c) The annual operation time of the compressor and each piece of equipment in the biogas upgrading and compression installations in hours ( $T_{equipment,y}$ ). In case this information is not available it shall be assumed that the upgrading installation and compressor is used continuously;
- (d) The quantity, pressure and composition of the bottled biogas, biogas injected into a natural grid or transported via a dedicated piped network; monitored continuously using flow meters and regularly calibrated methane monitors. The pressure of the biogas shall be regulated and monitored using a regularly calibrated pressure gauge. The methane content of the biogas shall always be in accordance with national regulations or, in absence of national regulations, 96% (by volume) or higher in order to ensure that biogas could readily be used as a fuel, inferior methane content shall be excluded from the emission reduction calculations;
- (e) In case vent gases are calculated using the “Tool to determine project emissions from flaring gases containing methane”, the monitoring criteria contained in this tool shall be used. In case this tool is not used and the alternative approach in paragraph 24.9 of this annex is used, then temperature and pressure of gas retained in water wash upgrading equipment shall be measured continuously and their values before the venting process are



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used, together with the volume capacity of the installation, to estimate the amount of methane released during the venting process;

- (f) During the periods when the biogas upgrading facility is closed due to scheduled maintenance or repair of equipment or during exigencies, project participants should ensure that the captured biogas is flared at the site of its capture using an (emergency) flare. Appropriate monitoring procedures should be established to monitor this emergency flare.
- (g) In case of project activities covered under paragraph 2 (b) the number and volume of biogas bottles produced and transported, the average truck capacity ( $CT_{y,bb,y}$ ) and the average aggregated distance for transporting the bottled biogas ( $DAF_{bb}$ ).

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