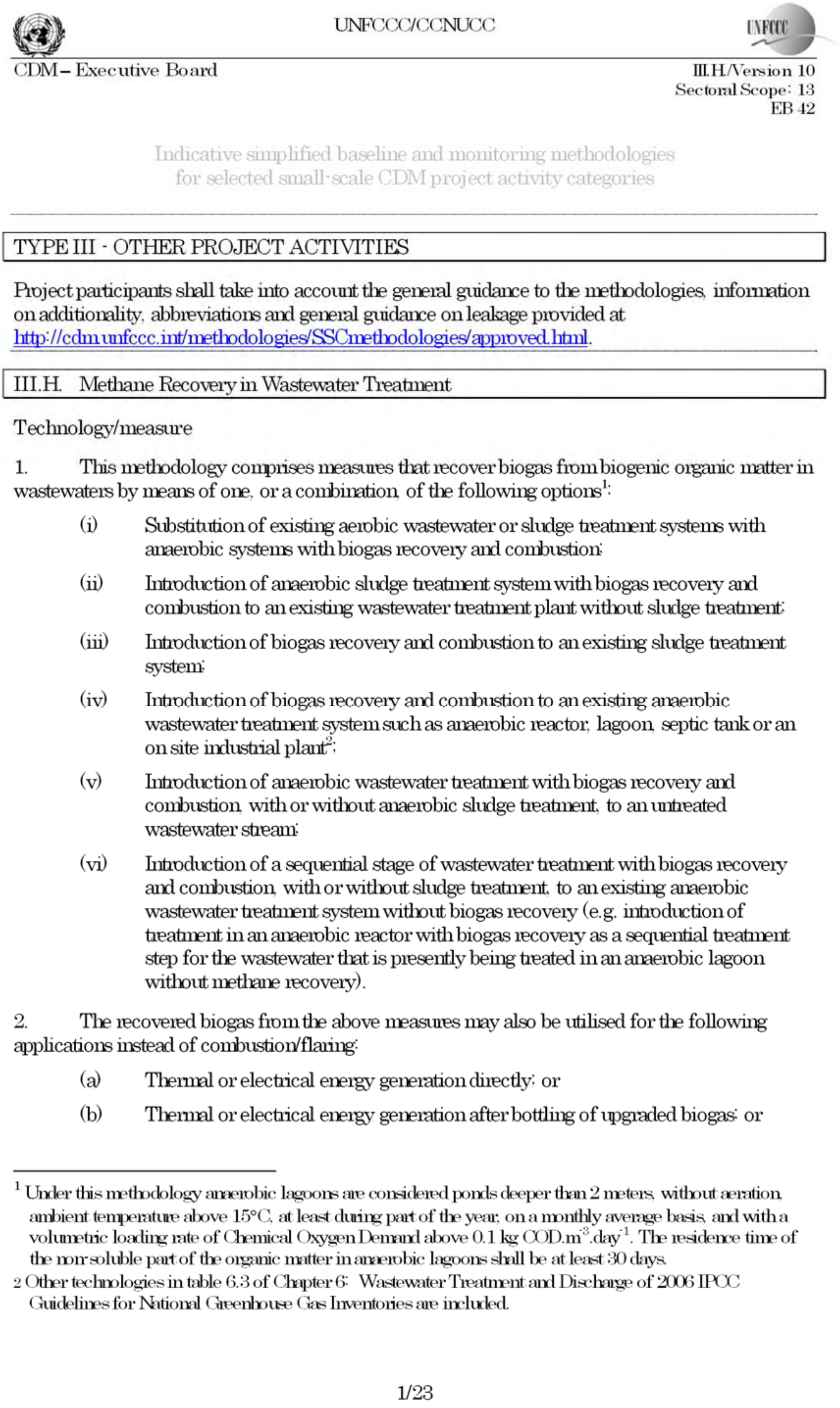
### 3.4.2 AMS-III.H: Methane recoverv in wastewater treatment



UNFCCC/CCNUCC

CDM – Executive Board

III.H/Version 10
Sectoral Scope: 13
EB 42

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

Technology/measure

1. This methodology comprises measures that recover biogas from biogenic organic matter in wastewaters by means of one, or a combination, of the following options[1]:

(i) Substitution of existing aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion;

(ii) Introduction of anaerobic sludge treatment system with biogas recovery and combustion to an existing wastewater treatment plant without sludge treatment;

(iii) Introduction of biogas recovery and combustion to an existing sludge treatment system;

(iv) Introduction of biogas recovery and combustion to an existing anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on site industrial plant[2];

(v) Introduction of anaerobic wastewater treatment with 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 biogas recovery and combustion, with or without sludge treatment, to an existing anaerobic wastewater treatment system without biogas recovery (e.g. introduction of treatment in an anaerobic reactor with biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery).

2. The recovered 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

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[1] 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$^{-3}$.day$^{-1}$. The residence time of the non-soluble part of the organic matter in anaerobic lagoons shall be at least 30 days.

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

(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 biogas is used for project activities covered under paragraph 2 (a), that component of the project activity can use a corresponding methodology under type I.

4. If the recovered 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 $CO_2$ 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.

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[3] concerning

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[3] Refer to: "General guidance to Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories".

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 $CO_2$ 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)[4]. 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[5] remains unaltered.

Baseline

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 ($BE_{power,y}$)

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[4] As per EB 22 annex 2 "Guidance regarding methodological issues" section E.

[5] 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.

(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 ($BE_{s,final,y}$)

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

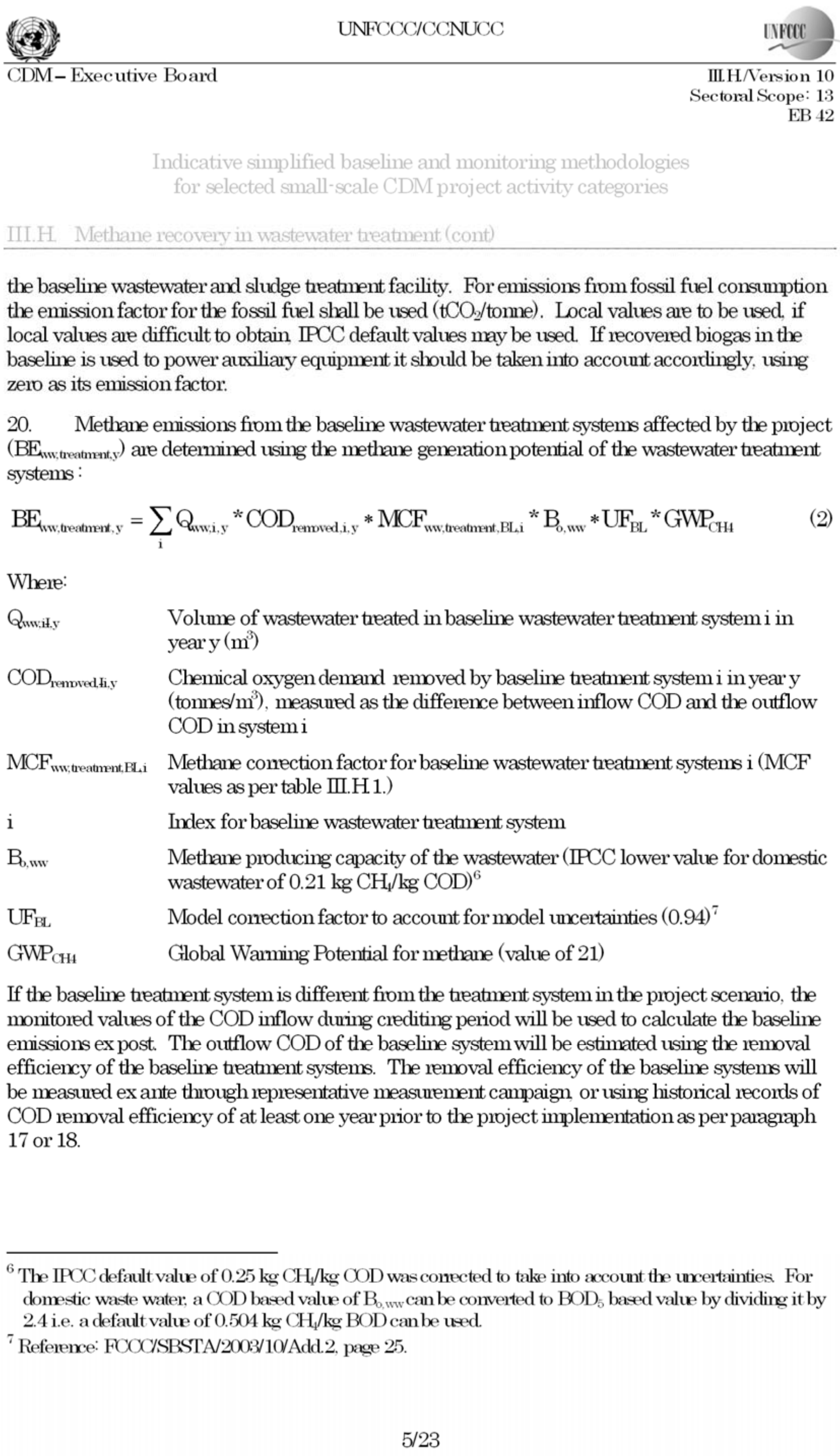
Where:

| | |
|---|---|
| $BE_y$ | Baseline emissions in year y ($tCO_2e$) |
| $BE_{power,y}$ | Baseline emissions from electricity or fuel consumption in year y ($tCO_2e$) |
| $BE_{ww,treatment,y}$ | Baseline emissions of the wastewater treatment systems affected by the project activity in year y ($tCO_2e$) |
| $BE_{s,treatment,y}$ | Baseline emissions of the sludge treatment systems affected by the project activity in year y ($tCO_2e$) |
| $BE_{ww,discharge,y}$ | Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y ($tCO_2e$). The value of this term is zero for the case 1 (ii). |
| $BE_{s,final,y}$ | Baseline methane emissions from anaerobic decay of the final sludge produced in year y ($tCO_2e$). 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. |

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 $m^3$ 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



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

the baseline wastewater and sludge treatment facility. For emissions from fossil fuel consumption the emission factor for the fossil fuel shall be used ($tCO_2$/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.

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:

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

Where:

| | |
|---|---|
| $Q_{ww,iI,y}$ | Volume of wastewater treated in baseline wastewater treatment system i in year y ($m^3$) |
| $COD_{removed,Ii,y}$ | 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)[6] |
| $UF_{BL}$ | Model correction factor to account for model uncertainties (0.94)[7] |
| $GWP_{CH4}$ | Global Warming Potential for methane (value of 21) |

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.

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[6] 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 $BOD_5$ based value by dividing it by 2.4 i.e. a default value of 0.504 kg $CH_4$/kg BOD can be used.

[7] Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

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

Table III.H.1. IPCC default values[8] 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:

$$BE_{treatment,s,y} = \sum_{j} S_{j,BL,y} * MCF_{s,treatment,BL,j} * DOC_{s} * UF_{BL} * DOC_{F} * F * 16/12 * GWP_{CH4} \quad (3)$$

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 |
| $DOC_s$ | 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[9] shall be used. |
| $MCF_{s,treatment,BL,j}$ | 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) |

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

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

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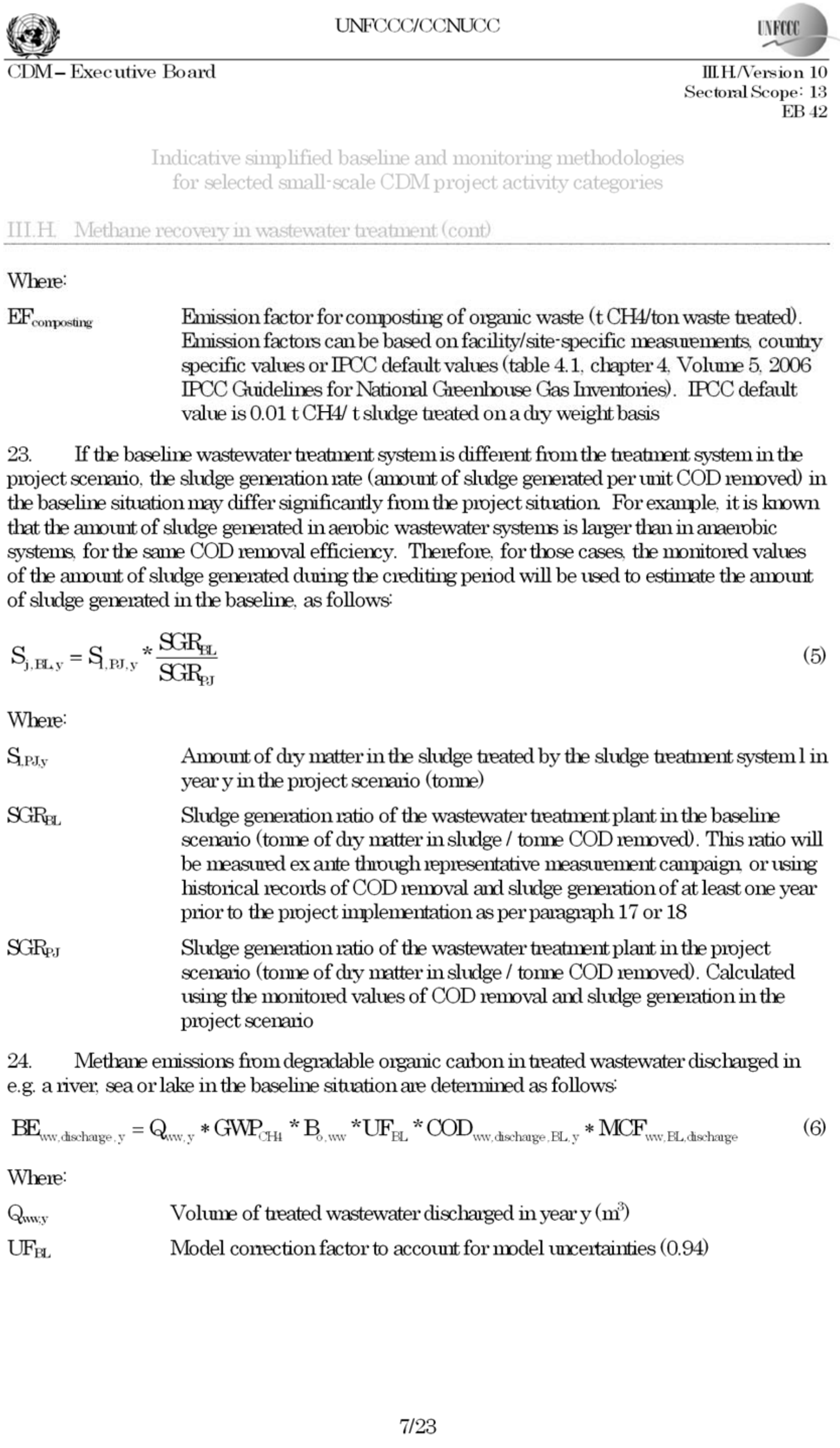
[8] Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[9] 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.



Where:

$EF_{composting}$ Emission factor for composting of organic waste (t CH4/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 CH4/ 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:

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

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

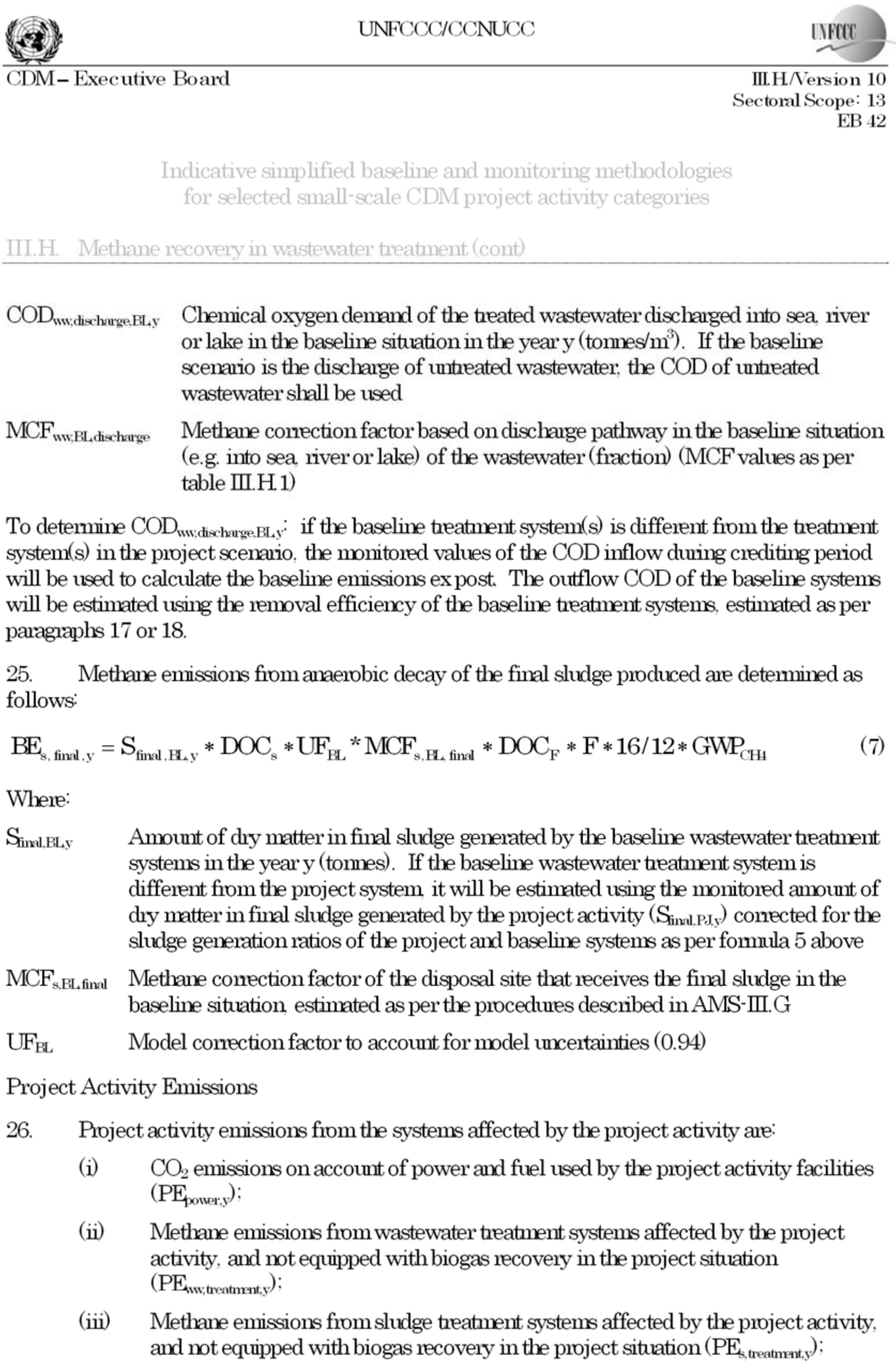
24. Methane emissions from degradable organic carbon in treated wastewater discharged in e.g. a river, sea or lake in the baseline situation are determined as follows:

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

Where:

$Q_{ww,y}$ Volume of treated wastewater discharged in year y ($m^3$)

$UF_{BL}$ Model correction factor to account for model uncertainties (0.94)



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

| | |
|---|---|
| $COD_{ww,discharge,BL,y}$ | Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the baseline situation in the year y (tonnes/m$^3$). If the baseline scenario is the discharge of untreated wastewater, the COD of untreated wastewater shall be used |
| $MCF_{ww,BL,discharge}$ | Methane correction factor based on discharge pathway in the baseline situation (e.g. into sea, river or lake) of the wastewater (fraction) (MCF values as per table III.H.1) |

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.

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

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

Where:

| | |
|---|---|
| $S_{final,BL,y}$ | 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 |
| $UF_{BL}$ | 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) $CO_2$ emissions on account of power and fuel used by the project activity facilities ($PE_{power,y}$);

(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 ($PE_{s,treatment,y}$);

(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 ($PE_{biomass,y}$).[10]

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

Where:

| | |
|---|---|
| $PE_y$ | Project activity emissions in the year y ($tCO_2e$) |
| $PE_{power,y}$ | Emissions from electricity or fuel consumption in the year y ($tCO_2e$). 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 |
| $PE_{ww,treatment,y}$ | Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year y ($tCO_2e$). 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 ($tonnes/m^3$), measured as the difference between inflow COD and the outflow COD in system k |

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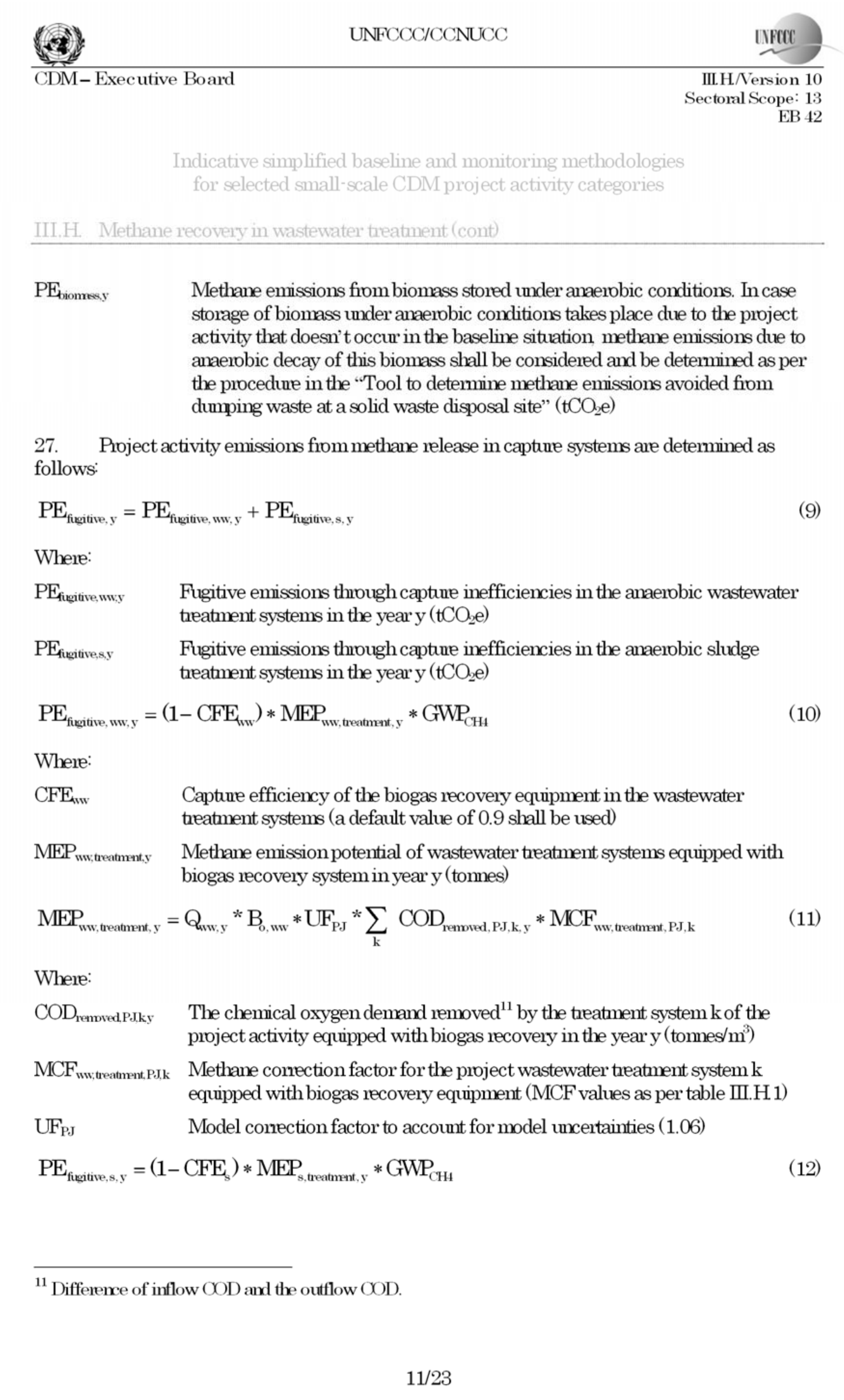
[10] For instance in the baseline situation Palm Kernel Shells (PKS) are used as fuel in a boiler. In the project situation PKS is replaced by biogas captured at a wastewater treatment system. The PKS will no longer be used as fuel in the boiler, but sold on the market. Before it is sold it is likely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

| | | |
|---|---|---|
| $PE_{s,treatment,y}$ | | Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year y ($tCO_2e$). 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) |
| $PE_{y,ww,discharge}$ | | Methane emissions from degradable organic carbon in treated wastewater in year y ($tCO_2e$). 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 ($COD_{ww,discharge,PJ,y}$, $MCF_{ww,PJ,discharge}$) and with the following changed definition of parameters: |
| | $COD_{ww,discharge,PJ,y}$ | Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the project situation in year y ($tonnes/m^3$) |
| | $MCF_{ww,PJ,discharge}$ | 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) |
| $PE_{s,final,y}$ | | Methane emissions from anaerobic decay of the final sludge produced in year y ($tCO_2e$). 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) |
| $PE_{fugitive,y}$ | | Methane emissions from biogas release in capture systems in year y, calculated as per paragraph 26 ($tCO_2e$) |
| $PE_{flaring,y}$ | | Methane emissions due to incomplete flaring in year y as per the "Tool to determine project emissions from flaring gases containing methane" ($tCO_2e$) |



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

| | |
|---|---|
| $PE_{biomass,y}$ | 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" ($tCO_2e$) |

27. Project activity emissions from methane release in capture systems are determined as follows:

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

Where:

| | |
|---|---|
| $PE_{fugitive,ww,y}$ | Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y ($tCO_2e$) |
| $PE_{fugitive,s,y}$ | Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y ($tCO_2e$) |

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

Where:

| | |
|---|---|
| $CFE_{ww}$ | Capture efficiency of the biogas recovery equipment in the wastewater treatment systems (a default value of 0.9 shall be used) |
| $MEP_{ww,treatment,y}$ | Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (tonnes) |

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

Where:

| | |
|---|---|
| $COD_{removed,PJ,k,y}$ | The chemical oxygen demand removed[11] by the treatment system k of the project activity equipped with biogas recovery in the year y ($tonnes/m^3$) |
| $MCF_{ww,treatment,PJ,k}$ | Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment (MCF values as per table III.H.1) |
| $UF_{PJ}$ | Model correction factor to account for model uncertainties (1.06) |

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

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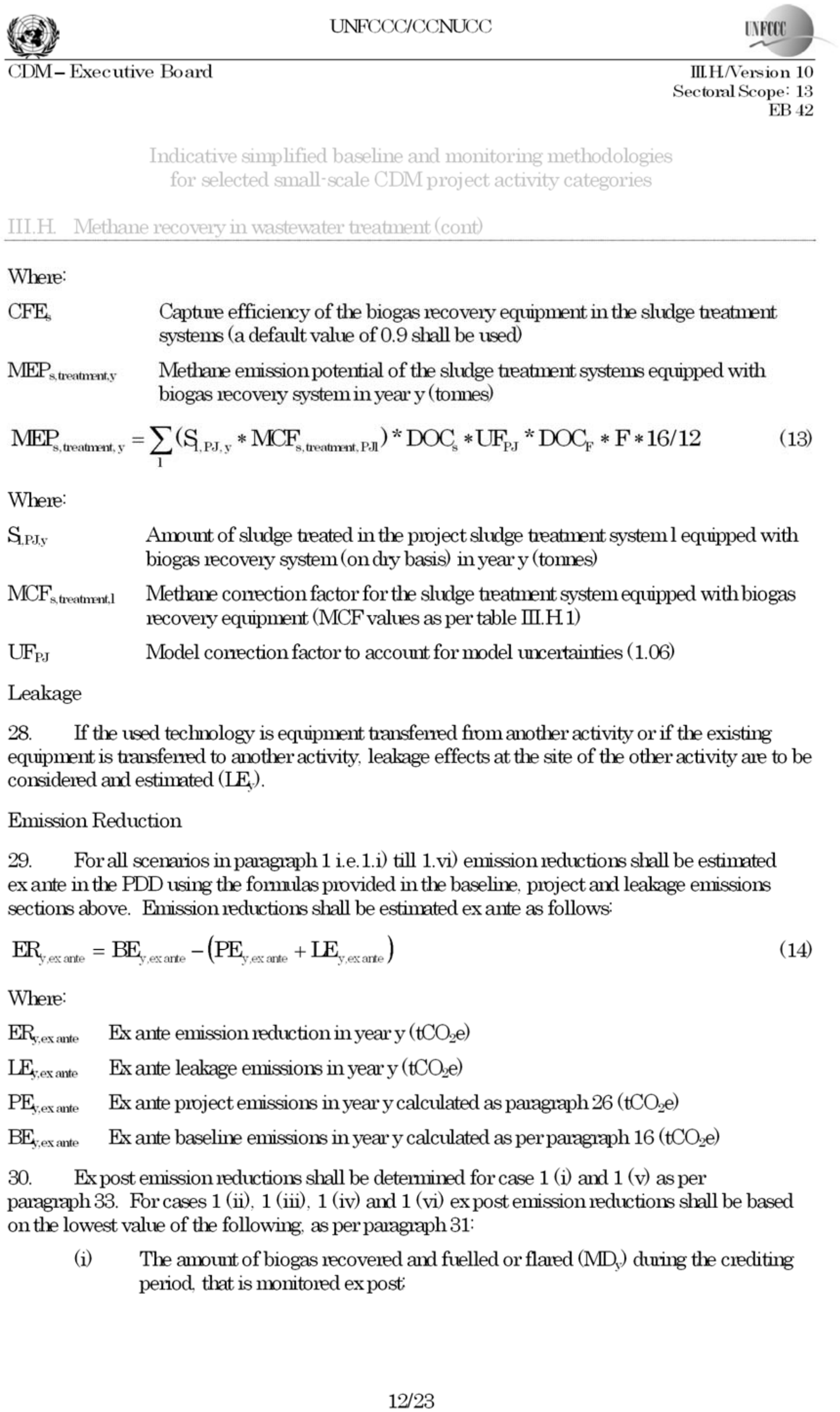
[11] Difference of inflow COD and the outflow COD.



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

Where:

| | |
|---|---|
| $CFE_s$ | Capture efficiency of the biogas recovery equipment in the sludge treatment systems (a default value of 0.9 shall be used) |
| $MEP_{s,treatment,y}$ | Methane emission potential of the sludge treatment systems equipped with biogas recovery system in year y (tonnes) |

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

Where:

| | |
|---|---|
| $S_{l,PJ,y}$ | Amount of sludge treated in the project sludge treatment system l equipped with biogas recovery system (on dry basis) in year y (tonnes) |
| $MCF_{s,treatment,l}$ | Methane correction factor for the sludge treatment system equipped with biogas recovery equipment (MCF values as per table III.H.1) |
| $UF_{PJ}$ | Model correction factor to account for model uncertainties (1.06) |

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

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:

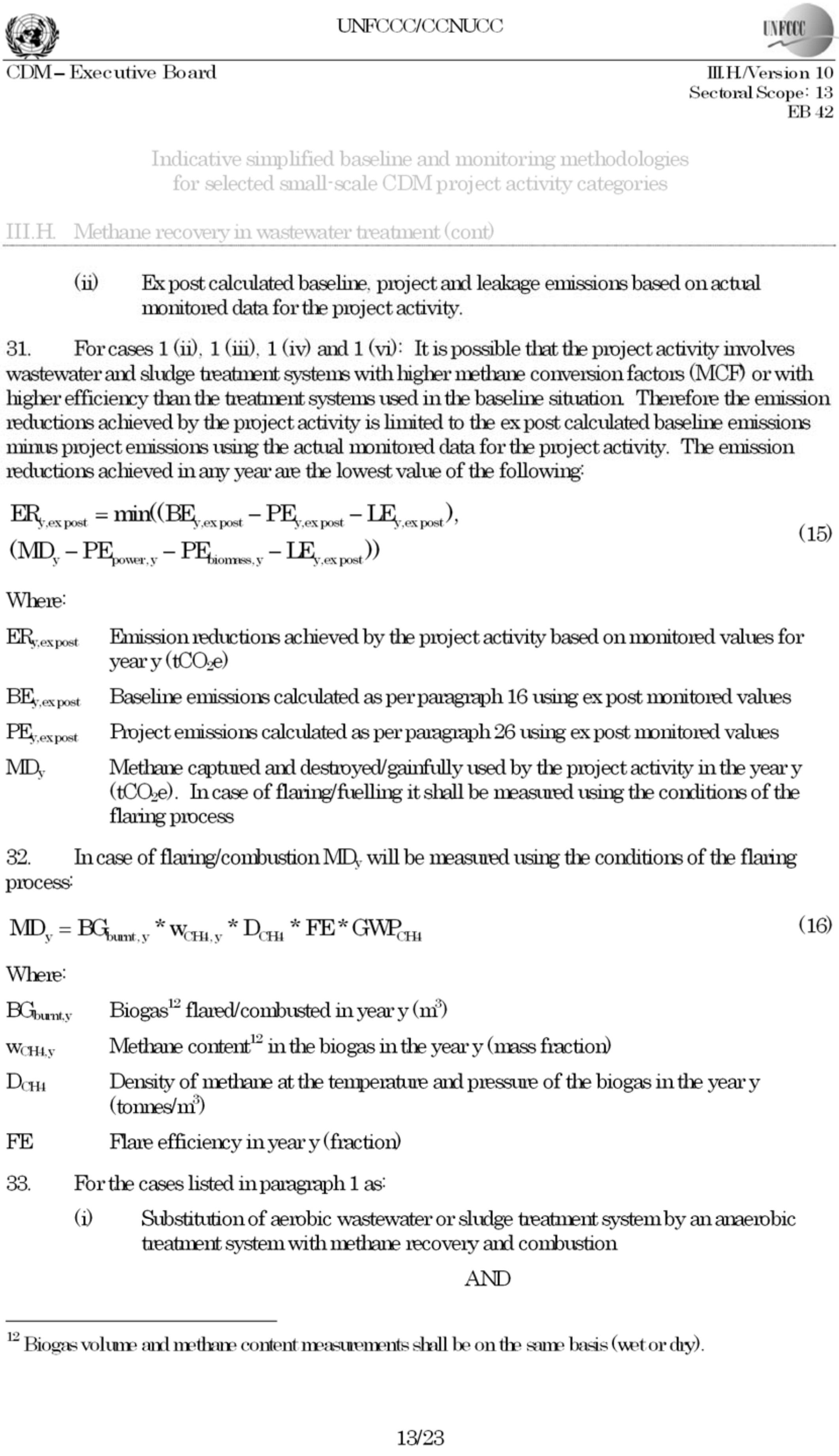
$$ER_{y,ex\ ante} = BE_{y,ex\ ante} - \left(PE_{y,ex\ ante} + LE_{y,ex\ ante}\right) \quad (14)$$

Where:

| | |
|---|---|
| $ER_{y,ex\ ante}$ | Ex ante emission reduction in year y ($tCO_2e$) |
| $LE_{y,ex\ ante}$ | Ex ante leakage emissions in year y ($tCO_2e$) |
| $PE_{y,ex\ ante}$ | Ex ante project emissions in year y calculated as paragraph 26 ($tCO_2e$) |
| $BE_{y,ex\ ante}$ | Ex ante baseline emissions in year y calculated as per paragraph 16 ($tCO_2e$) |

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;



Indicative simplified baseline and monitoring methodologies
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III.H. Methane recovery in wastewater treatment (cont)

(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 ($tCO_2e$) |
| $BE_{y,ex\,post}$ | 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 ($tCO_2e$). 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:

$$MD_y = BG_{burnt,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4} \quad (16)$$

Where:

| | |
|---|---|
| $BG_{burnt,y}$ | Biogas[12] flared/combusted in year y ($m^3$) |
| $w_{CH4,y}$ | Methane content[12] in the biogas in the year y (mass fraction) |
| $D_{CH4}$ | Density of methane at the temperature and pressure of the biogas in the year y ($tonnes/m^3$) |
| 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

AND

---

[12] Biogas volume and methane content measurements shall be on the same basis (wet or dry).

(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.

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

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

In case (i) if the volumetric flow and the characteristic properties (e.g. COD) of the inflow and outflow of the wastewater 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 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 fugitive emissions and incomplete flaring ($PE_{fugitive,y}$, $PE_{flaring,y}$) shall also be considered in the calculation of the emission reduction, however the emissions from the wastewater outflow and sludge ($PE_{ww,discharge,y}$, $PE_{s,final,y}$) may be disregarded, if they are equivalent in baseline and project scenarios.

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 ($Q_{ww,j,y}$);

(b) The chemical oxygen demand of the wastewater before and after the treatment system k affected by the project activity ($COD_{ww,untreated,y}$, $COD_{ww,treated,y}$, $COD_{ww,removed,PJ,k,y}$, $COD_{ww,discharge,PJ,y}$);

(c) The amount of sludge as dry matter in each sludge treatment system l affected by the project ($S_{l,PJ,y}$, $S_{final,PJ,y}$).

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 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[13]. 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. The amount of sludge treated in the sludge treatment system ($S_{l,PJ,y}$) 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 $S_{l,PJ,y}$. In case of mechanical sludge removal, e.g. separation of solids via a screen, or removed from lagoons, $S_{l,PJ,y}$ 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.

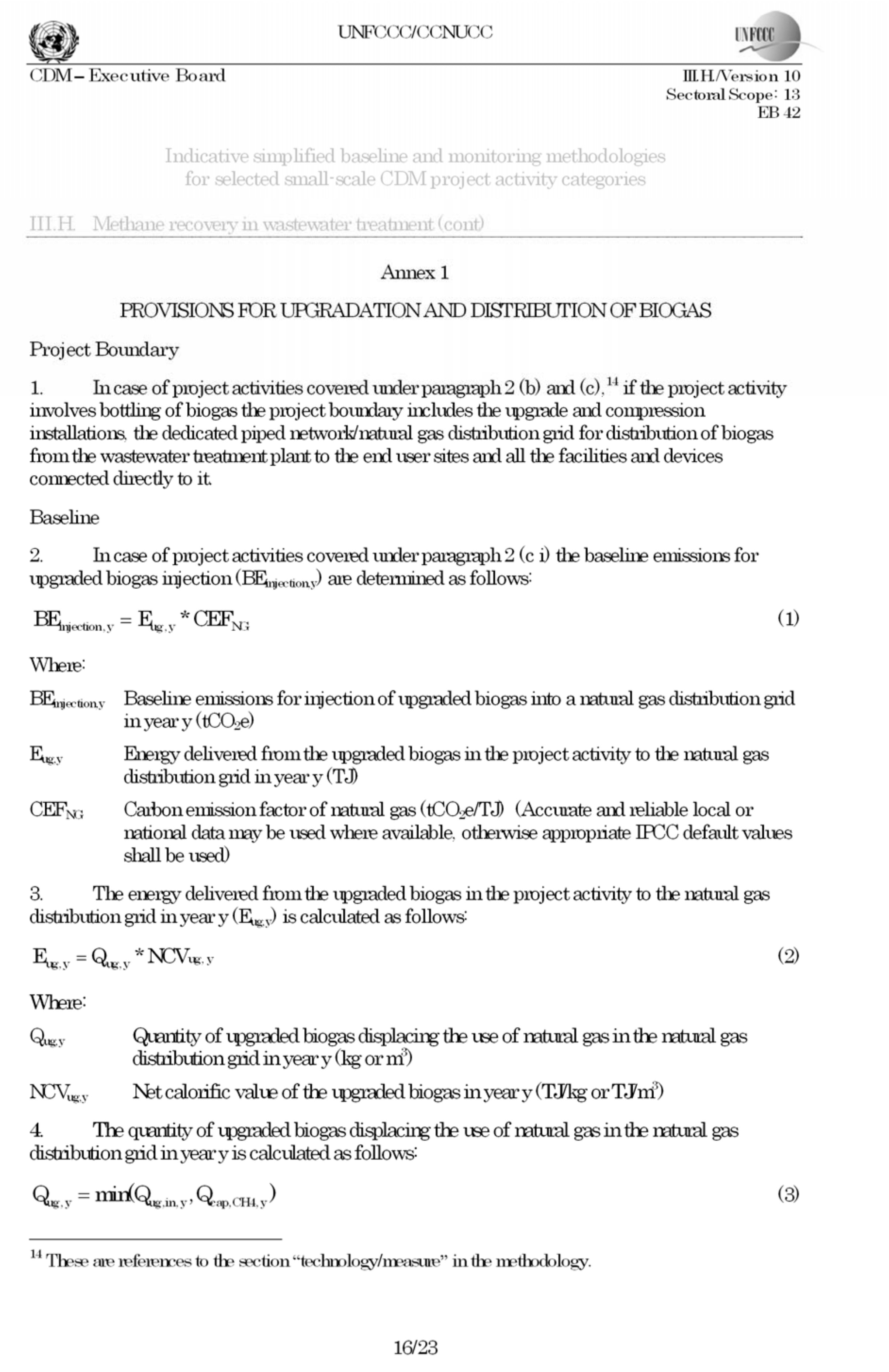
Project activity under a programme of activities

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.

---

[13] Fraction of methane ($CH_4$) 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 $CO_2$ is not permitted.



Indicative simplified baseline and monitoring methodologies
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III.H Methane recovery in wastewater treatment (cont)

## Annex 1

## PROVISIONS FOR UPGRADATION AND DISTRIBUTION OF BIOGAS

### Project Boundary

1. In case of project activities covered under paragraph 2 (b) and (c),[14] if 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 ($BE_{injection,y}$) are determined as follows:

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

Where:

| | |
|---|---|
| $BE_{injection,y}$ | Baseline emissions for injection of upgraded biogas into a natural gas distribution grid in year y ($tCO_2e$) |
| $E_{ug,y}$ | 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 ($tCO_2e/TJ$) (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:

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

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

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:

$$Q_{ug,y} = \min(Q_{ug,in,y}, Q_{cap,CH4,y}) \qquad (3)$$

---

[14] These are references to the section "technology/measure" in the methodology.

Where:

| | |
|---|---|
| $Q_{ug,in,y}$ | Quantity of upgraded biogas injected into the natural gas distribution grid in year y (kg or $m^3$) |
| $Q_{cap,CH4,y}$ | 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:

$$Q_{cap,CH4,y} = w_{CH4,ww} * Q_{cap,biogas,y} \quad (4)$$

Where:

| | |
|---|---|
| $w_{CH4,ww}$ | 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 ($PE_{process,y}$) shall be included:

(i) Methane emissions from the discharge of the water wash upgrading equipment ($tCO_2e$);

(ii) Fugitive methane emissions from leaks in compression equipment ($tCO_2e$);

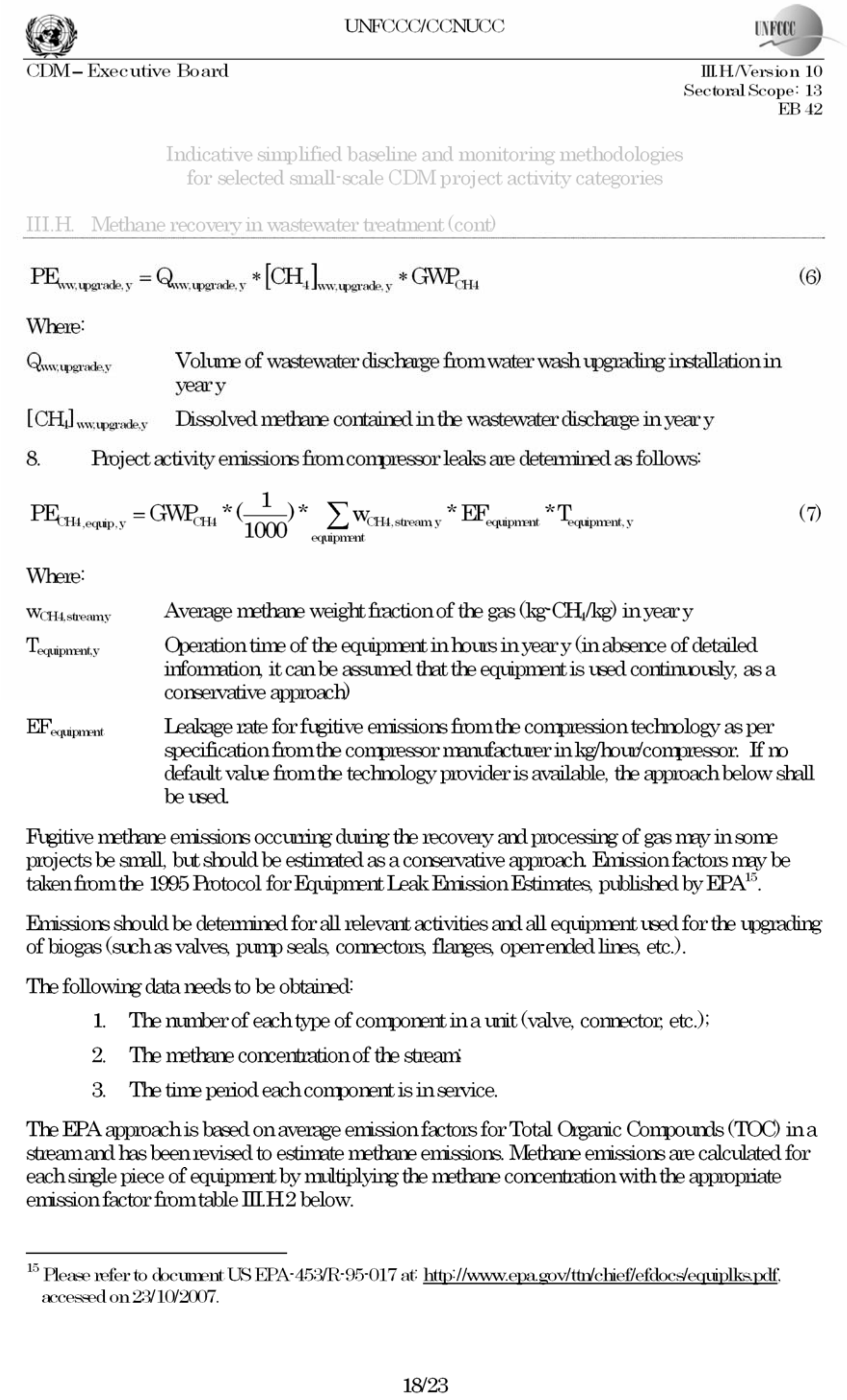
(iii) Emissions on account of vent gases from the water wash upgrade equipment ($tCO_2e$).

$$PE_{process,y} = PE_{ww,upgrade,y} + PE_{CH4,equip,y} + PE_{ventgas,y} \quad (5)$$

Where:

| | |
|---|---|
| $PE_{process,y}$ | Project emissions related to the upgrading and compression of the biogas in year y ($tCO_2e$) |
| $PE_{ww,upgrade,y}$ | Emissions from methane contained in waste water discharge of water wash upgrading installation in year y ($tCO_2e$) |
| $PE_{CH4,equip,y}$ | Emissions from compressor leaks in year y ($tCO_2e$) |
| $PE_{ventgas,y}$ | Emissions from venting gases retained in water wash upgrading equipment in year y ($tCO_2e$) |

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



Indicative simplified baseline and monitoring methodologies
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## III.H. Methane recovery in wastewater treatment (cont)

$$PE_{ww,upgrade,y} = Q_{ww,upgrade,y} * [CH_4]_{ww,upgrade,y} * GWP_{CH4} \quad (6)$$

Where:

| | |
|---|---|
| $Q_{ww,upgrade,y}$ | Volume of wastewater discharge from water wash upgrading installation in year y |
| $[CH_4]_{ww,upgrade,y}$ | Dissolved methane contained in the wastewater discharge in year y |

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

$$PE_{CH4,equip,y} = GWP_{CH4} * (\frac{1}{1000}) * \sum_{equipment} w_{CH4,stream\,y} * EF_{equipment} * T_{equipment,y} \quad (7)$$

Where:

| | |
|---|---|
| $w_{CH4,stream\,y}$ | Average methane weight fraction of the gas (kg-$CH_4$/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[15].

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.

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.

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

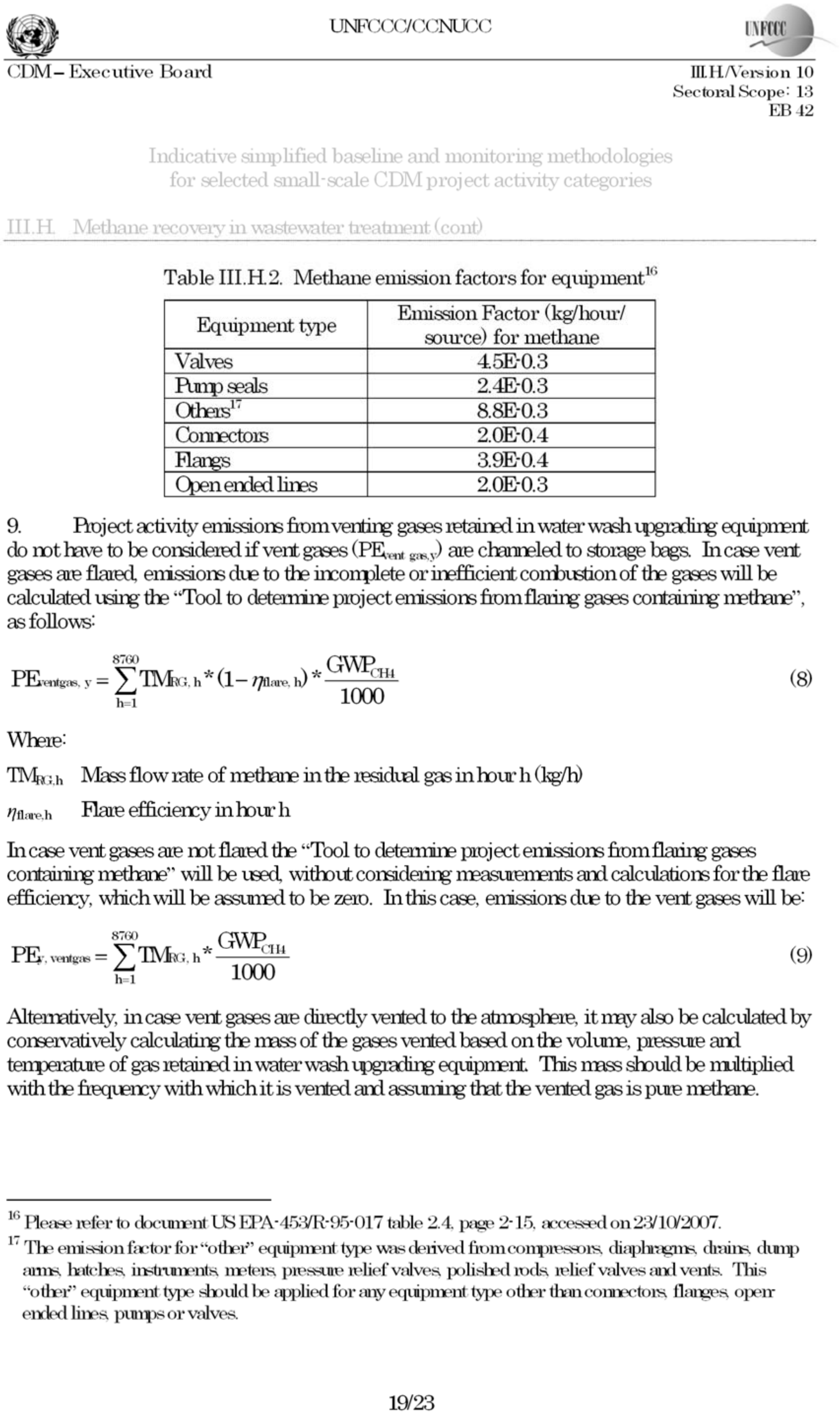


Table III.H.2. Methane emission factors for equipment[16]

| Equipment type | Emission Factor (kg/hour/ source) for methane |
|---|---|
| Valves | 4.5E-0.3 |
| Pump seals | 2.4E-0.3 |
| Others[17] | 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 ($PE_{vent\ gas,y}$) 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:

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

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:

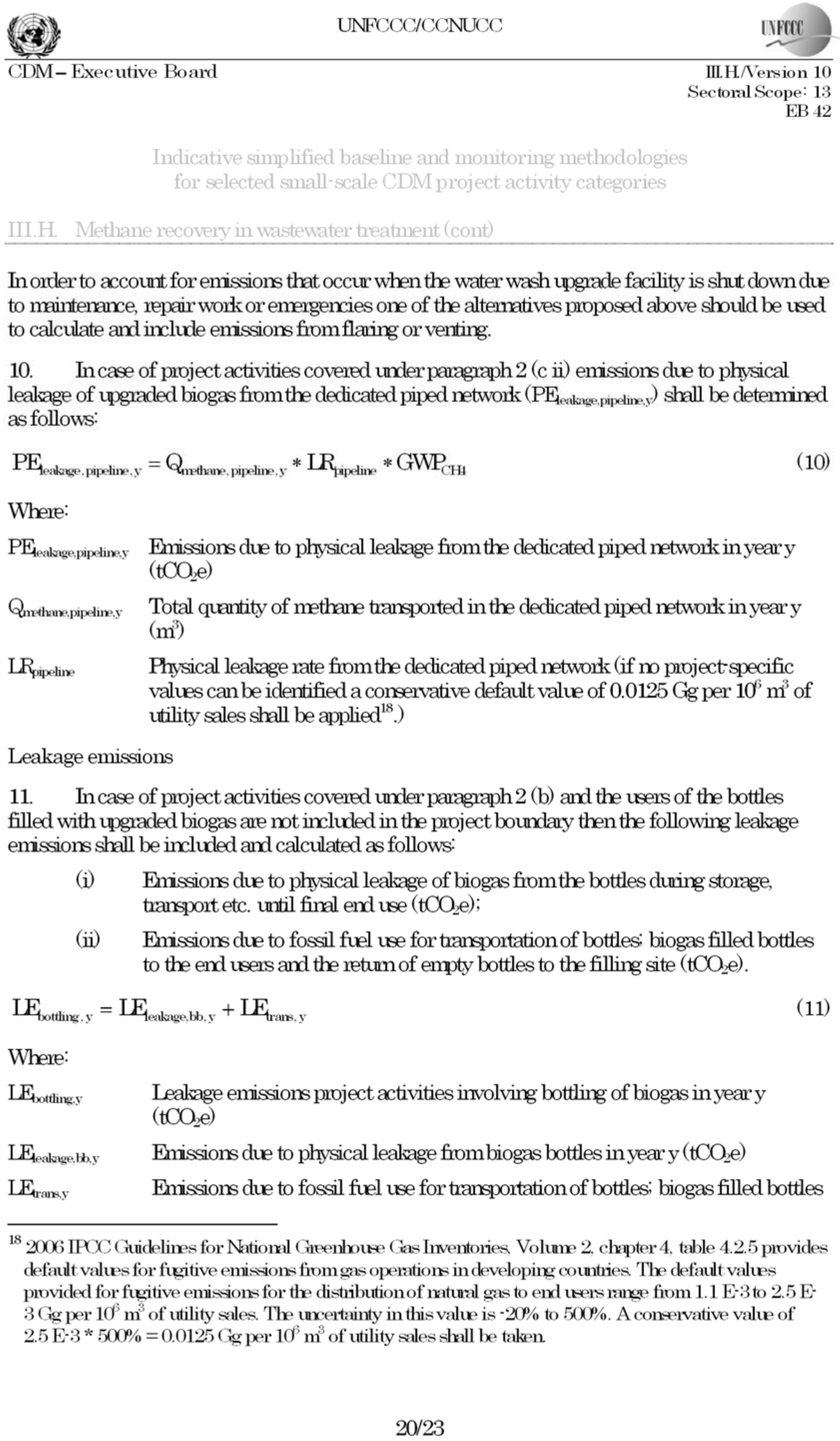
$$PE_{y,\ ventgas} = \sum_{h=1}^{8760} TM_{RG,\ h} * \frac{GWP_{CH4}}{1000} \qquad (9)$$

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 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.

---

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

[17] 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.



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 ($PE_{leakage,pipeline,y}$) shall be determined as follows:

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

Where:

| | |
|---|---|
| $PE_{leakage,pipeline,y}$ | Emissions due to physical leakage from the dedicated piped network in year y ($tCO_2e$) |
| $Q_{methane,pipeline,y}$ | Total quantity of methane transported in the dedicated piped network in year y ($m^3$) |
| $LR_{pipeline}$ | 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 $10^6$ $m^3$ of utility sales shall be applied[18].) |

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 ($tCO_2e$);

(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 ($tCO_2e$).

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

Where:

| | |
|---|---|
| $LE_{bottling,y}$ | Leakage emissions project activities involving bottling of biogas in year y ($tCO_2e$) |
| $LE_{leakage,bb,y}$ | Emissions due to physical leakage from biogas bottles in year y ($tCO_2e$) |
| $LE_{trans,y}$ | Emissions due to fossil fuel use for transportation of bottles: biogas filled bottles |

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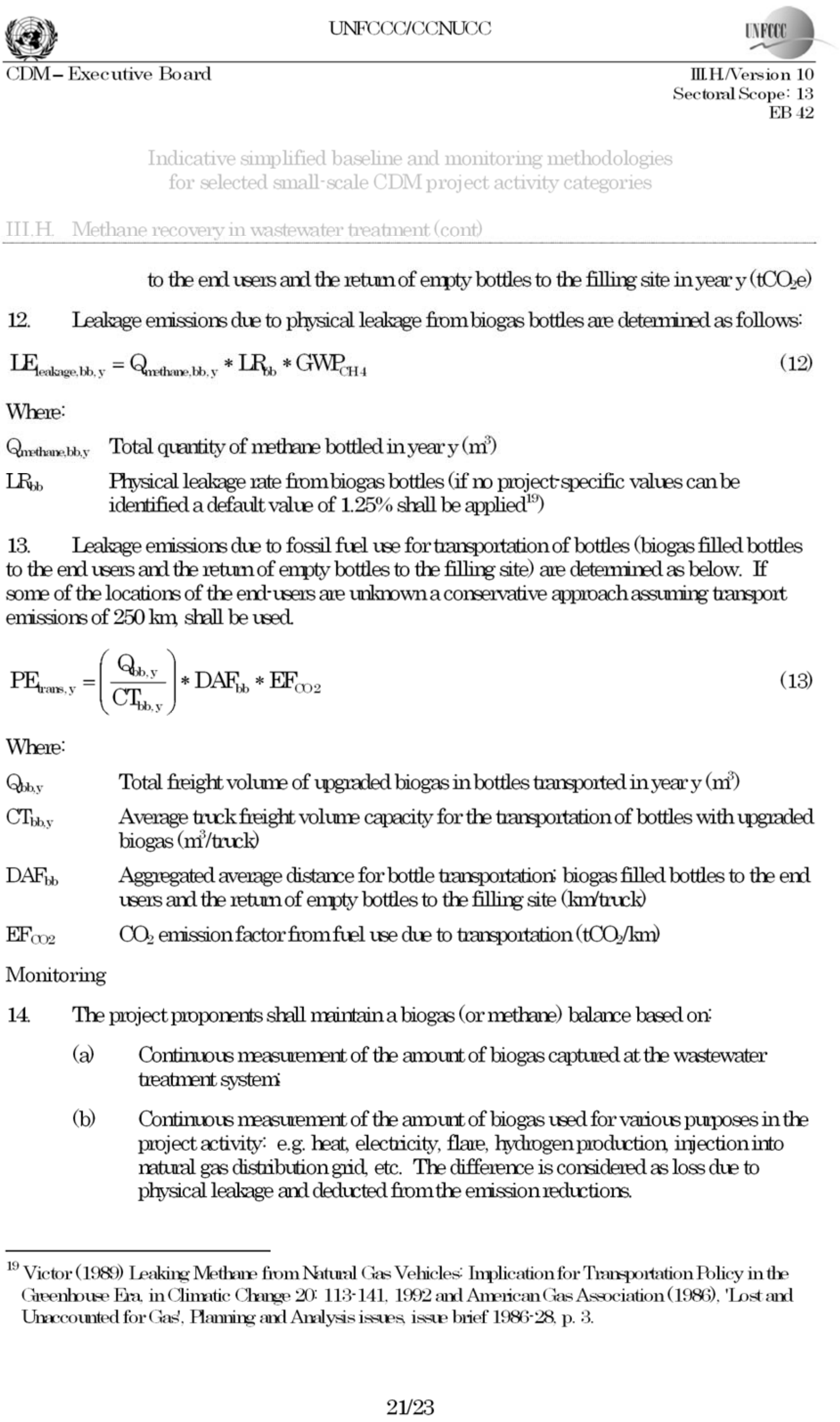
[18] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, chapter 4, table 4.2.5 provides default values for fugitive emissions from gas operations in developing countries. The default values provided for fugitive emissions for the distribution of natural gas to end users range from 1.1 E-3 to 2.5 E-3 Gg per $10^6$ $m^3$ 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 $10^6$ $m^3$ of utility sales shall be taken.



to the end users and the return of empty bottles to the filling site in year y ($tCO_2e$)

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:

| | |
|---|---|
| $Q_{methane,bb,y}$ | Total quantity of methane bottled in year y ($m^3$) |
| $LR_{bb}$ | Physical leakage rate from biogas bottles (if no project-specific values can be identified a default value of 1.25% shall be applied[19]) |

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:

| | |
|---|---|
| $Q_{bb,y}$ | Total freight volume of upgraded biogas in bottles transported in year y ($m^3$) |
| $CT_{bb,y}$ | Average truck freight volume capacity for the transportation of bottles with upgraded biogas ($m^3$/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) |
| $EF_{CO2}$ | $CO_2$ emission factor from fuel use due to transportation ($tCO_2$/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 natural gas distribution grid, etc. The difference is considered as loss due to physical leakage and deducted from the emission reductions.

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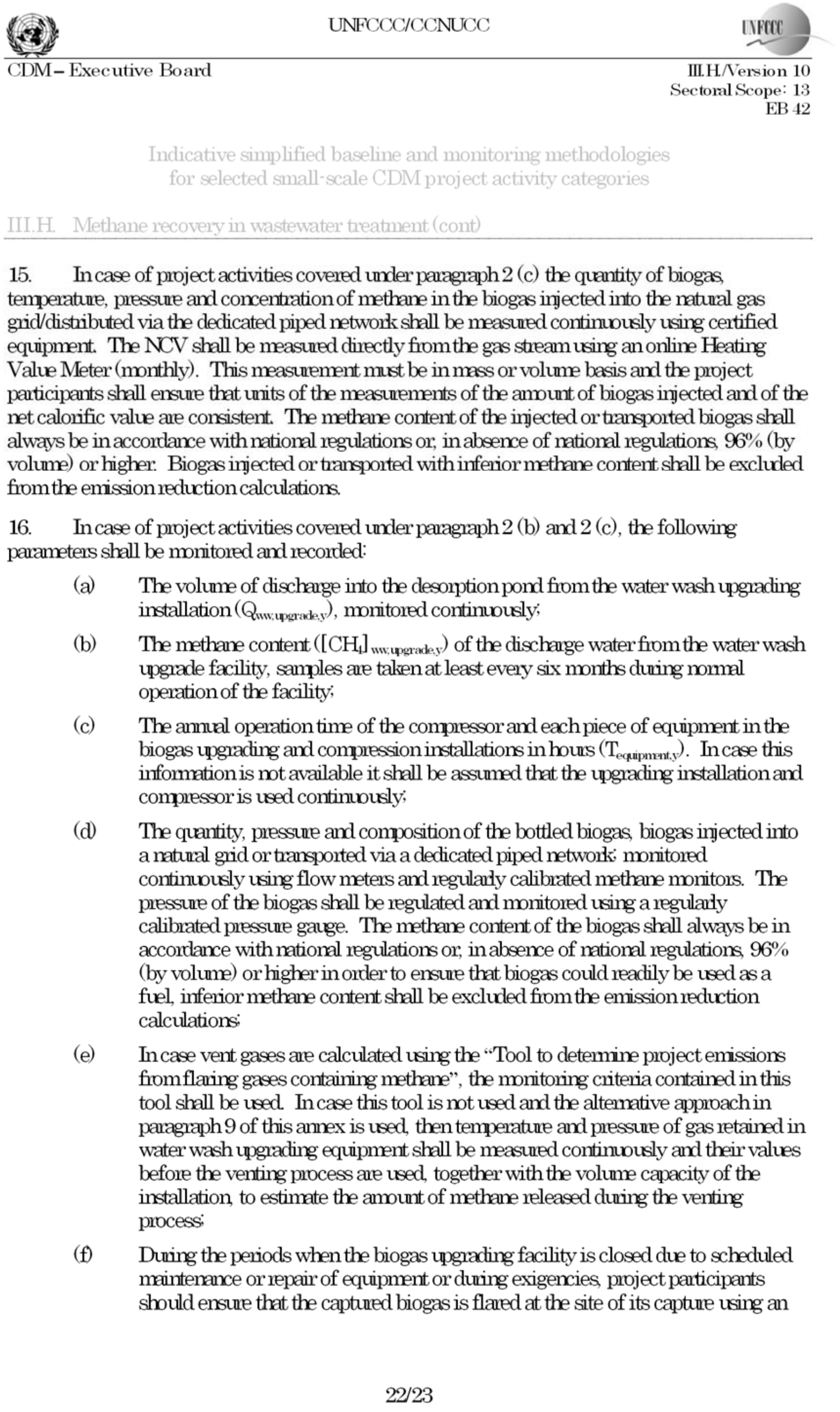
[19] Victor (1989) Leaking Methane from Natural Gas Vehicles: Implication for Transportation Policy in the Greenhouse Era, in Climatic Change 20: 113-141, 1992 and American Gas Association (1986), 'Lost and Unaccounted for Gas', Planning and Analysis issues, issue brief 1986-28, p. 3.



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 ($Q_{ww,upgrade,y}$), monitored continuously;

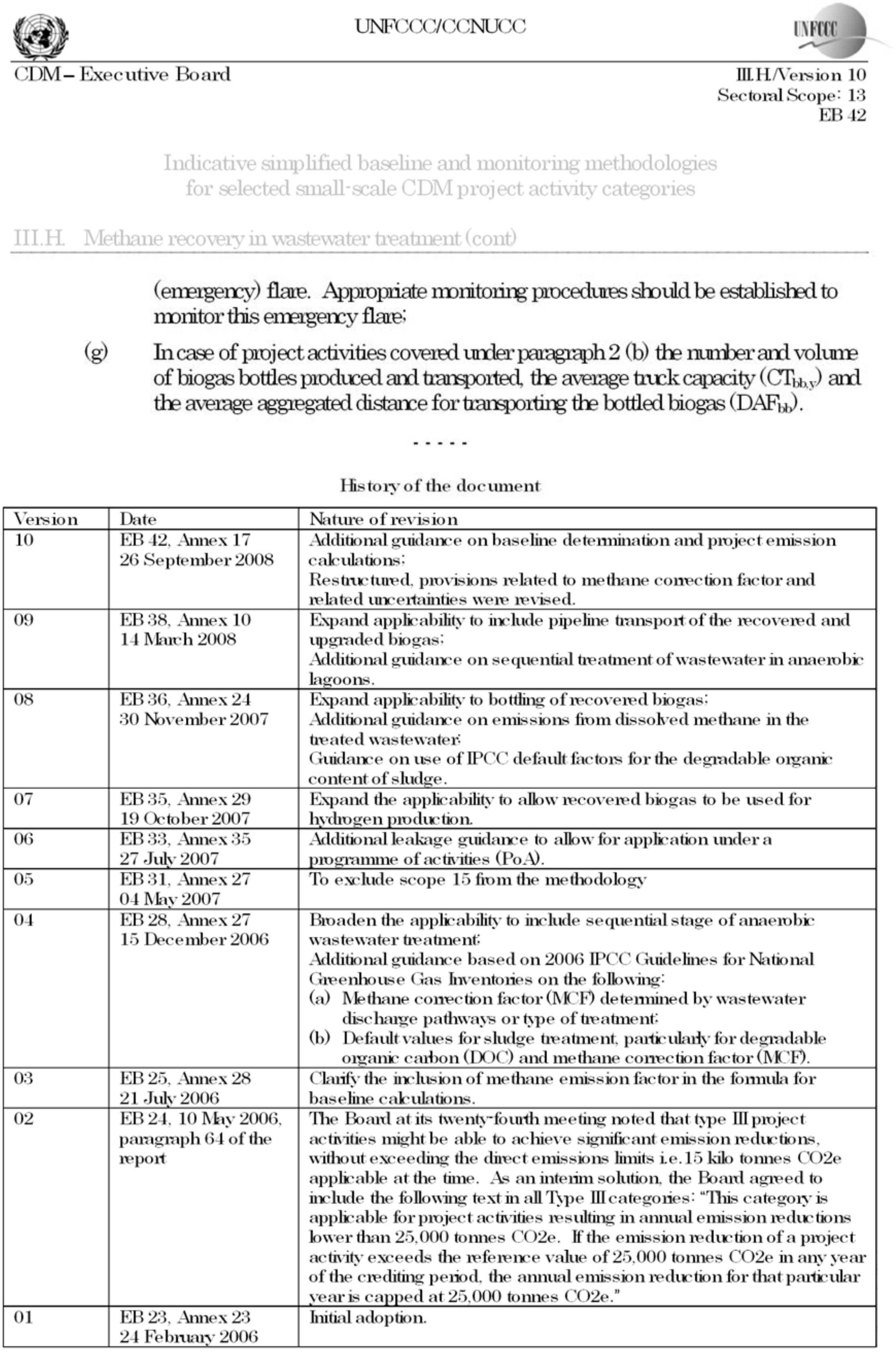
(b) The methane content ($[CH_4]_{ww,upgrade,y}$) of the discharge water from the water wash upgrade facility, samples are taken at least every six months during normal operation of the facility;

(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 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 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



Indicative simplified baseline and monitoring methodologies
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III.H. Methane recovery in wastewater treatment (cont)

(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 ($CT_{bb,y}$) and the average aggregated distance for transporting the bottled biogas ($DAF_{bb}$).

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History of the document

| Version | Date | Nature of revision |
|---|---|---|
| 10 | EB 42, Annex 17<br>26 September 2008 | Additional guidance on baseline determination and project emission calculations;<br>Restructured, provisions related to methane correction factor and related uncertainties were revised. |
| 09 | EB 38, Annex 10<br>14 March 2008 | Expand applicability to include pipeline transport of the recovered and upgraded biogas;<br>Additional guidance on sequential treatment of wastewater in anaerobic lagoons. |
| 08 | EB 36, Annex 24<br>30 November 2007 | Expand applicability to bottling of recovered biogas;<br>Additional guidance on emissions from dissolved methane in the treated wastewater;<br>Guidance on use of IPCC default factors for the degradable organic content of sludge. |
| 07 | EB 35, Annex 29<br>19 October 2007 | Expand the applicability to allow recovered biogas to be used for hydrogen production. |
| 06 | EB 33, Annex 35<br>27 July 2007 | Additional leakage guidance to allow for application under a programme of activities (PoA). |
| 05 | EB 31, Annex 27<br>04 May 2007 | To exclude scope 15 from the methodology |
| 04 | EB 28, Annex 27<br>15 December 2006 | Broaden the applicability to include sequential stage of anaerobic wastewater treatment;<br>Additional guidance based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories on the following:<br>(a) Methane correction factor (MCF) determined by wastewater discharge pathways or type of treatment;<br>(b) Default values for sludge treatment, particularly for degradable organic carbon (DOC) and methane correction factor (MCF). |
| 03 | EB 25, Annex 28<br>21 July 2006 | Clarify the inclusion of methane emission factor in the formula for baseline calculations. |
| 02 | EB 24, 10 May 2006, paragraph 64 of the report | The Board at its twenty-fourth meeting noted that type III project activities might be able to achieve significant emission reductions, without exceeding the direct emissions limits i.e. 15 kilo tonnes CO2e applicable at the time. As an interim solution, the Board agreed to include the following text in all Type III categories: "This category is applicable for project activities resulting in annual emission reductions lower than 25,000 tonnes CO2e. If the emission reduction of a project activity exceeds the reference value of 25,000 tonnes CO2e in any year of the crediting period, the annual emission reduction for that particular year is capped at 25,000 tonnes CO2e." |
| 01 | EB 23, Annex 23<br>24 February 2006 | Initial adoption. |

## 3.4.3 The calculation of calorie energy

### DESIGN CALCULATIONS OF CO-GENERATION SYSTEM

### 1 Design Bases

Thicken Sludge from Gravity Sludge Thickener

Input sludge solids = 39,004 kg/d
Input sludge volume = 1,300 $m^3/d$
Input sludge solids concentration = 3 %
Hydraulic retention time = 24 days
Sludge heating temperature = 35 ℃
Volatile material contents = 70 %
Digestion rate = 50 %
Gas production rate = 0.5 $m^3$/kg-vs
Gas calorific value = 21,000 kJ/$m^3$

Temperature of air

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.3 | 2.5 | 8.0 | 12.5 | 17.9 | 22.0 | 24.3 | 23.3 | 18.4 | 13.4 | 6.8 | 2.8 |

Temperature of wastewater

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.0 | 13.3 | 14.7 | 16.0 | 17.3 | 18.7 | 20.0 | 18.7 | 17.3 | 16.0 | 14.7 | 13.3 |

### 2 Total Calorific Value of Digested Gas

Total calorific value of digested gas is calculated below.

Gas production = 39,004 x 0.70 x 0.50 = 13,652 $m^3/d$
Total calorific value = 13,652 x 21 = 286,683 MJ/d

### 3 Required Calorific Value for Heating Digester

Required calorific value for heating digester is estimated as:

$$Qtotal = Q_1 + Q_2 + Q_3$$

where

$Q_1$ = Calorific value required for heating sludge (kJ/day)
$Q_2$ = Calorific value required for radiation loss from digester (kJ/day)
$Q_3$ = Calorific value required for other loss (kJ/day)

### (1) Calorific Value for Heating Sludge

$Q_1$ = Q (m3/day) x (t2 - t1) x C (kJ/kg ℃) [ MJ/d ]

where

C = 4.2 kJ/kg ℃
Q = 1,300 $m^3/d$
t2 = 35 ℃
t1 = ℃ (from Jan to Dec)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 125,594 | 118,313 | 111,033 | 103,752 | 96,471 | 89,190 | 81,909 | 89,190 | 96,471 | 103,752 | 111,033 | 118,313 |

### (2) Calorific Value for Radiation Loss from Digester

$Q_2 =$ (A1 x (t2 - t3) / k1 + A2 x (t2 - t3) / k2 + A3 x (t2 - t4) / k3 + A4 x (t2 - t4) / k4 ) x $\alpha$ x 24 /1000 [ MJ/d ]

where

A1 = 3,446 $m^2$ (for top slub)
A2 = 3,048 $m^2$ (for wall in air)
A3 = 1,524 $m^2$ (for wall in air)
A4 = 3,446 $m^2$ (for base slub)
k1 = 0.41 ℃ $m^2$ h /kJ (for top slub)
k2 = 0.41 ℃ $m^2$ h /kJ (for wall in air)
k3 = 0.56 ℃ $m^2$ h /kJ (for wall in soil)
k4 = 0.56 ℃ $m^2$ h /kJ (for base slub)
t3 = ℃ (temperature of air from Jan to Dec)
t4 = ℃ (temperature of soil from Jan to Dec)
$\alpha$ = 1.2

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25,688 | 24,124 | 20,213 | 17,013 | 13,188 | 10,273 | 8,581 | 9,320 | 12,790 | 16,388 | 21,024 | 23,910 |

### (3) Calorific Value for Other Loss

$Q_3 =$ 0.1 x $Q_2$ [ MJ/d ]

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,569 | 2,412 | 2,021 | 1,701 | 1,319 | 1,027 | 858 | 932 | 1,279 | 1,639 | 2,102 | 2,391 |

### (4) Required Total Calorific Value

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 153,851 | 144,849 | 133,267 | 122,466 | 110,978 | 100,490 | 91,348 | 99,442 | 110,540 | 121,778 | 134,158 | 144,615 |

Required calorific value for heating digester considering efficiency of heating equipment as:

Energy efficiency of heat exchanger 90%

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 170,945 | 160,944 | 148,074 | 136,074 | 123,309 | 111,656 | 101,498 | 110,491 | 122,822 | 135,309 | 149,065 | 160,683 |

## 4 Energy Balance in Case of Introduction of Co-Generation System

If co-generation system is introduced, recovery rate of heat energy from effluent gas is about 30 % of total calorific value.

| | | | |
|---|---|---|---|
| Total calorific value of digested gas | 286,683 | MJ/d | |
| Recovered calorific value | 86,005 | MJ/d | |
| Required maximum calorific value | 170,945 | MJ/d | (Jan) |
| Required minimum calorific value | 101,498 | MJ/d | (Jul) |

Therefore, recovered calorific value can not meet required calorific value for heating digester.

## 3.4.4 The calculation of production of electricity and reduction of $CO_2$ emission

### DESIGN CALCULATIONS OF DIGESTED GAS GENERATOR

### 1 Design Bases

Thicken Sludge from Gravity Sludge Thickener

Input sludge solids = 39,004 kg/d
Input sludge volume = 1,300 $m^3$/d
Input sludge solids concentration = 3 %
Hydraulic retention time = 24 days
Sludge heating temperature = 35 ℃
Volatile material contents = 70 %
Digestion rate = 50 %
Gas production rate = 0.5 $m^3$/kg-vs
Gas calorific value = 21,000 kJ/$m^3$

Temperature of air

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.3 | 2.5 | 8.0 | 12.5 | 17.9 | 22.0 | 24.3 | 23.3 | 18.4 | 13.4 | 6.8 | 2.8 |

Temperature of wastewater

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.0 | 13.3 | 14.7 | 16.0 | 17.3 | 18.7 | 20.0 | 18.7 | 17.3 | 16.0 | 14.7 | 13.3 |

### 2 Total Calorific Value of Digested Gas

Total calorific value of digested gas is calculated below.

Gas production = 39,004 x 0.70 x 0.50 = 13,652 $m^3$/d
Total calorific value = 13,652 x 21 = 286,683 MJ/d

### 3 Required Calorific Value for Heating Digester

Required calorific value for heating digester is estimated as:

$$Qtotal = Q_1 + Q_2 + Q_3$$

where

$Q_1$ = Calorific value required for heating sludge (kJ/day)
$Q_2$ = Calorific value required for radiation loss from digester (kJ/day)
$Q_3$ = Calorific value required for other loss (kJ/day)

#### (1) Calorific Value for Heating Sludge

$Q_1$ = Q (m3/day) x (t2 - t1) x C (kJ/kg ℃) [ MJ/d ]

where

C = 4.2 kJ/kg ℃
Q = 1,300 $m^3$/d
t2 = 35 ℃
t1 = ℃ (from Jan to Dec)

(MJ/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 125,594 | 118,313 | 111,033 | 103,752 | 96,471 | 89,190 | 81,909 | 89,190 | 96,471 | 103,752 | 111,033 | 118,313 |

#### (2) Calorific Value for Radiation Loss from Digester

$Q_2 =$ (A1 x (t2 - t3) / k1 + A2 x (t2 - t3) / k2 + A3 x (t2 - t4) / k3 + A4 x (t2 - t4) / k4 ) x $\alpha$ x 24 /1000 [ MJ/d ]

where

A1 = 3,446 $m^2$ (for top slub)
A2 = 3,048 $m^2$ (for wall in air)
A3 = 1,524 $m^2$ (for wall in air)
A4 = 3,446 $m^2$ (for base slub)
k1 = 0.41 ℃ $m^2$ h /kJ (for top slub)
k2 = 0.41 ℃ $m^2$ h /kJ (for wall in air)
k3 = 0.56 ℃ $m^2$ h /kJ (for wall in soil)
k4 = 0.56 ℃ $m^2$ h /kJ (for base slub)
t3 = ℃ (temperature of air from Jan to Dec)
t4 = ℃ (temperature of soil from Jan to Dec)
$\alpha$ = 1.2

(MJ/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25,688 | 24,124 | 20,213 | 17,013 | 13,188 | 10,273 | 8,581 | 9,320 | 12,790 | 16,388 | 21,024 | 23,910 |

### (3) Calorific Value for Other Loss

$Q_3 =$ 0.1 x $Q_2$ [ MJ/d ]

(MJ/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,569 | 2,412 | 2,021 | 1,701 | 1,319 | 1,027 | 858 | 932 | 1,279 | 1,639 | 2,102 | 2,391 |

### (4) Required Total Calorific Value

(MJ/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 153,851 | 144,849 | 133,267 | 122,466 | 110,978 | 100,490 | 91,348 | 99,442 | 110,540 | 121,778 | 134,158 | 144,615 |

Required calorific value for heating digester considering efficiency of heating equipment as:
Enargy efficency of heater : 85%
Energy efficiency of heat exchanger 90%

(MJ/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 201,112 | 189,346 | 174,205 | 160,087 | 145,069 | 131,360 | 119,409 | 129,990 | 144,497 | 159,187 | 175,371 | 189,039 |

## 4 Calculation of Capacity of Digested Gas Generator

Excess calorific value for digested gas generator is calculated as:

(MJ/d)

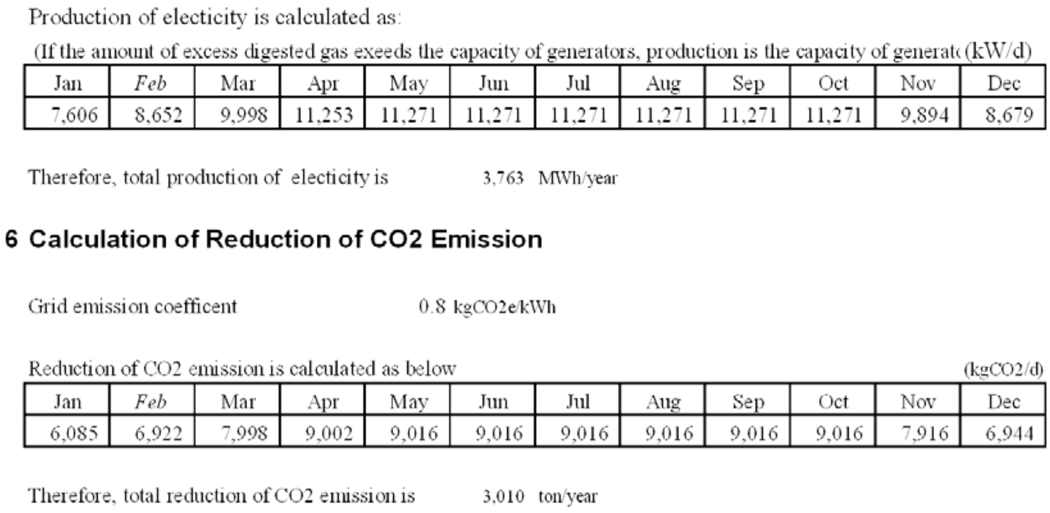
| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 85,570 | 97,337 | 112,478 | 126,596 | 141,613 | 155,323 | 167,273 | 156,693 | 142,186 | 127,495 | 111,312 | 97,644 |

The capacity of generater is caluculated based on the average of excess heat energy considering the operating ratio of equi
Average of excess heat energy 126,793 MJ/d

The energy efficency of digested gas generator is expected to be 32% and production of electricity is calculated as bellow.
Average of production of electricity 40,574 MJ/d = 11,271 kWh/d (1Wh=3600J)

The specification of digested gas generator is caluclated as below:
Capacity of digested gas generator 470 kW

## 5 Calculation of Production of Electoricity



Production of electicity is calculated as:

(If the amount of excess digested gas exeeds the capacity of generators, production is the capacity of generat( (kW/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7,606 | 8,652 | 9,998 | 11,253 | 11,271 | 11,271 | 11,271 | 11,271 | 11,271 | 11,271 | 9,894 | 8,679 |

Therefore, total production of electicity is 3,763 MWh/year

## 6 Calculation of Reduction of CO2 Emission

Grid emission coefficent 0.8 kgCO2e/kWh

Reduction of CO2 emission is calculated as below (kgCO2/d)

| Jan | *Feb* | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6,085 | 6,922 | 7,998 | 9,002 | 9,016 | 9,016 | 9,016 | 9,016 | 9,016 | 9,016 | 7,916 | 6,944 |

Therefore, total reduction of CO2 emission is 3,010 ton/year