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Application of the Oeko-Institut/WWF-US/ EDF methodology for assessing the quality of carbon credits

This document presents results from the application of version 3.0 of a methodology, developed by Oeko-Institut, World Wildlife Fund (WWF-US) and Environmental Defense Fund (EDF), for assessing the quality of carbon credits. The methodology is applied by Oeko-Institut with support by Carbon Limits, Greenhouse Gas Management Institute (GHGMI), INFRAS, Stockholm Environment Institute, and individual carbon market experts. This document evaluates one specific criterion or sub-criterion with respect to a specific carbon crediting program, project type, quantification methodology and/or host country, as specified in the below table. Please note that the CCQI website Site terms and Privacy Policy apply with respect to any use of the information provided in this document. Further information on the project and the methodology can be found here: www.carboncreditquality.org

Sub-criterion:	1.3.2 Robustness of the quantification methodologies applied to determine emission reductions or removals
Project type:	Landfill gas utilization
Quantification methodology:	Clean Development Mechanism (CDM) ACM0001, Versions 19, and relevant tools
Assessment based on carbon crediting program documents valid as of:	30 June 2021
Date of final assessment:	20 May 2022
Score:	2

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Assessment

Relevant scoring methodology provisions

The methodology assesses the robustness of the quantification methodologies applied by the carbon crediting program to determine emission reductions or removals. The assessment of the quantification methodologies considers the degree of conservativeness in the light of the uncertainty of the emission reductions or removals. The assessment is based on the likelihood that the emission reductions or removals are under-estimated, estimated accurately, or over-estimated, as follows (see further details in the methodology):

Assessment outcome	Score
It is very likely (i.e., a probability of more than 90%) that the emission reductions or removals are underestimated, taking into account the uncertainty in quantifying the emission reductions or removals	5
It is likely (i.e., a probability of more than 66%) that the emission reductions or removals are underestimated, taking into account the uncertainty in quantifying the emission reductions or removals OR The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) and uncertainty in the estimates of the emission reductions or removals is low (i.e., up to ±10%)	4
The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) but there is medium to high uncertainty (i.e., ±10-50%) in the estimates of the emission reductions or removals OR It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, but the degree of overestimation is likely to be low (i.e., up to ±10%)	3
The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) but there is very high uncertainty (i.e., larger than ±50%) in the estimates of the emission reductions or removals OR It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, and the degree of overestimation is likely to be medium (±10-30%)	2
It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, and the degree of overestimation is likely to be large (i.e., larger than ±30%)	1

Information sources considered

None of the CDM TOOLs referred to in the methodology are evaluated.[1]

Further literature:

1 Abushammala et al 2014: Methane Oxidation in Landfill Cover Soils: A Review. https://www.researchgate.net/publication/264153104_Methane_Oxidation_in_Landfill_Cover_Soils_A_Review

2 Bo-Feng et al. 2014 "Estimation of Methane Emissions from Municipal Solid Waste Landfills in China Based on Point Emission Sources; Advances in Climate Change Research", Volume 5, Issue 2, 2014, Pages 81-91. https://www.sciencedirect.com/science/article/pii/S1674927814500147#t0015

3 Cames et al, 2016 "How additional is the Clean Development Mechanism? Analysis of the application of current tools and proposed alternatives." https://ec.europa.eu/clima/sites/clima/files/ets/docs/clean_dev_mechanism_en.pdf

4 IPCC 2001 "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", Chapter Waste. https://www.ipcc.ch/site/assets/uploads/2018/03/5_Waste-1.pdf

5 IPCC 2002 "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", Background paper, Chapter Waste. https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_1_CH4_Solid_Waste.pdf

6 IPCC 2006 "Guidelines for National Greenhouse Gas Inventories (NIR).", Volume 5 https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/5_Volume5/19R_V5_3_Ch03_SWDS.pdf

7 Kühle-Weidemeier und Bogon, 2008 "Wirksamkeit von biologischen Methanoxidationsschichten auf Deponien." http://www.wasteconsult.net/files/referenzen/Bimetox.pdf

Assessment outcome

The methodology is assigned a score of 2.

[1] ACM0001 refers to a variety of tools. In general, a tool should be considered in this assessment, if the relevance of the tool to determine emission reductions in the methodology is material. In this case, the assessment of the methodology should include the impact of those tool(s).

There is no such tool in the case for ACM0001, as the tools referred to in ACM0001 have a relatively low impact on total emission reductions (e.g. TOOL05 "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation").

Justification of assessment

Project type

This assessment refers to the project type “Landfill gas utilization” which is characterized as follows:

“Capture and utilization of gas from an existing and closed solid waste disposal site. The collected gas is mainly used for energy purposes, such as for electricity and/or heat generation. A smaller fraction of the gas may be flared (e.g. during maintenance of an on-site electricity generation plant).”

Solely flaring of landfill gas (LFG), without any utilization, is thus not part of this assessment even though it is allowed under ACM0001.

Focus of assessment

The project boundary, project emissions and leakage are not a major source of uncertainty:

- Project boundary: the methodology requires clearly delimitating applicable solid waste disposal sites (SWDS), power plants, heat generating equipment etc. In addition, all relevant greenhouse gases of the baseline and project activity are included.
- Project emissions account for merely 0–1% of the ex-ante estimated emission reductions (according to various examined PDDs) and even if uncertainties on this part would be substantial, they would play an insignificant role overall.
- Leakage effects are not accounted for under this methodology, which we deem appropriate, as relevant “indirect” effects have been accounted for in the baseline or project emission calculation.

In the following, we thus focus the assessment on the determination of the baseline emissions. The overall score depends on the balance of elements with the potential for over- as well as underestimation of emission reductions. We focus on these elements, as well as elements that introduce uncertainty. The methodology contains further elements, which are not discussed however, as they introduce presumable little uncertainty (e.g. the baseline emissions associated with heat generation).

Elements potentially overestimating emission reductions

OE1 Oxidation factor

In the baseline, oxidation of methane in the top-soil layer of a SWDS occurs if the SWDS is not covered by a synthetic liner or if methane does not leave the SWDS through a pre-existing collection system. The corresponding “oxidation factor” (OX) is a key parameter to determine the baseline emissions (see Eq (2) in ACM0001):

$$BE_{CH4} = \left((1 - OX_{top\_layer}) \times F_{CH4,PJ,y} - F_{CH,BL,y} \right) \times GWP_{CH4}$$

ACM0001 uses a fixed value of 0.1 for the oxidation factor. For reference, it refers to the CDM TOOL04 “Emissions from solid waste disposal sites” which in turn states as source of data “an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories”. The other published literature is not further referenced. The relevant description in the 2006 IPCC Guidelines — which have not been updated since 2006 on that issue — is shown in the following:

OXIDATION FACTOR (OX)

The oxidation factor (OX) reflects the amount of CH_4 from SWDS that is oxidised in the soil or other material covering the waste.

CH_4 oxidation is by methanotrophic micro-organisms in cover soils and can range from negligible to 100 percent of internally produced CH_4. The thickness, physical properties and moisture content of cover soils directly affect CH_4 oxidation (Bogner and Matthews, 2003).

Studies show that sanitary, well-managed SWDS tend to have higher oxidation rates than unmanaged dump sites. The oxidation factor at sites covered with thick and well-aerated material may differ significantly from sites with no cover or where large amounts of CH_4 can escape through cracks/fissures in the cover.

Field and laboratory CH_4 and CO_2 emission concentrations and flux measurements that determine CH_4 oxidation from uniform and homogeneous soil layers should not be used directly to determine the oxidation factor, since in reality, only a fraction of the CH_4 generated will diffuse through such a homogeneous layer. Another fraction will escape through cracks/fissures or via lateral diffusion without being oxidised. Therefore, unless the spatial extent of measurements is wide enough and cracks/fissures are explicitly included, results from field and laboratory studies may lead to over-estimation of oxidation in SWDS cover soils.

The default value for oxidation factor is zero. See Table 3.2. The use of the oxidation value of 0.1 is justified for covered, well-managed SWDS to estimate both diffusion through the cap and escape by cracks/fissures. The use of an oxidation value higher than 0.1, should be clearly documented, referenced, and supported by data relevant to national circumstances. It is important to remember that any CH_4 that is recovered must be subtracted from the amount generated before applying an oxidation factor.

TABLE 3.2
OXIDATION FACTOR (OX) FOR SWDS

Type of Site	Oxidation Factor (OX) Default Values
Managed [1], unmanaged and uncategorised SWDS	0
Managed covered with CH_4 oxidising material [2]	0.1

[1] Managed but not covered with aerated material
[2] Examples: soil, compost

Source: IPCC 2006, page 14 (Source 6)

The 2001 IPCC Good Practice Guidance already recommend the same values (Source 4). Furthermore, an IPCC background paper on the waste sector states the following: “At the IPCC workshop in Washington in 1995 and at an international seminar in Chicago in 1997 there was an agreement of using 10 percent as a standard value, which later on has been subsequently implemented in several national inventories. More recent studies on oxidation have not changed the basis for this value substantially, and it is proposed to introduce this as a default value in the IPCC Guidelines. The possibility to have a variable range depending on the temperature/climate may be discussed.” (Source 5, page 429).

This default value for the oxidation factor has thus been chosen about 25 years ago based on sparse data for the purpose of national inventories and has not been changed ever since. The actual value depends on landfill management, type of the landfill, soil texture, soil thickness, soil organic content, soil moisture content, methane concentration or the prevailing climate among other things (see also Sources 3, 5 and 9). To calibrate a FOD model for Chinese landfills, Bo-Feng et al. 2014 (Source 2) used oxidation factors between 0 and 0.3, depending on the landfill type and location.

While the IPCC has chosen a value of 0.1 (for covered SWDS) or 0 (for uncovered SWDS) for the oxidation factor, these values are not necessarily a conservative choice in the context of crediting mechanisms, as a lower oxidation factor increases the baseline emissions. Given the high uncertainties, a value of 0.1 is thus unlikely to be a conservative choice if top-soil oxidation is relevant in the baseline. Correspondingly, this choice of the oxidation factor is an element that may overestimate emission reductions.

OE2 Perverse incentives

Landfill gas projects can potentially generate two types of perverse incentives, which may lead to an overestimation of baseline emissions:

a. A project owner may change the management in landfills to generate more methane (e.g., increasing the hight of a landfill or injecting water/ leachate into a landfill which both creates increasingly anaerobic conditions and thus more methane). For that reason, the methodology has an applicability criterion that excludes projects in which the management is changed in order to increase methane generation[2] and there is a monitoring parameter “Management of SWDS”. Verifying this requirement may be difficult in practice. Therefore, we estimate that this may cause overestimation of emissions reduction (at a low degree, but with high variance among projects).

b. In order to increase the potential for issuing carbon credits, carbon revenues’ beneficiaries may influence policy makers and private actors (i) to engage less in recycling (or other ways of preventing waste generation), (ii) to engage less in compositing of organic material or (iii) even to prevent waste incineration. Also, there may be less access of waste pickers to managed SWDS and thus less recycling of materials. Policy related perverse incentives can hardly be accounted for in a methodology such as ACM0001. It is thus likely that a substantial overestimation occurs in case this perverse incentive is relevant (especially if the installation of a waste incineration plant would be prevented). It is unclear how many projects are affected by this type of perverse incentive, as it is unknown to what extent the carbon revenues’ beneficiaries can influence the recycling sector and the policy process. It depends on how prone the policy system is to be influenced by particular interests.

Elements potentially underestimating emission reductions

In ACM0001 the following relevant elements have a potential for underestimating emission reductions:

- UE1: The installation of an LFG capture system under the project activity may result in the suction of additional air into the SWDS. In some cases, such as with a high suction pressure, the air may decrease the amount of methane that is generated under the project activity. As a conservative assumption, this oxidation is neglected in calculating emission reductions in ACM0001.
- UE2: Several baseline emissions of greenhouse gases from various sources are excluded from the project boundary (e.g., N_2O emissions from the SWDS or upstream emissions associated

[2] The methodology is not applicable “ff the management of the SWDS in the project activity is deliberately changed during the crediting in order to increase methane generation compared to the situation prior to the implementation of the project activity.”

with fossil fuel use for electricity generation). This is in each case conservative, yet we estimate the effect to be relatively small.[3]

Elements with uncertain impact

Finally, the following describes elements, which introduce uncertainty but where the direction of the impact is unclear.

U1 Methane captured and destroyed in the baseline

In the baseline, methane could be captured and destroyed (by flaring) because

- of requirements (e.g. regulatory or contractual requirements or to address safety and odour concerns) or
- an LFG capture and destruction system is already in place.

For that reason, ACM0001 lists four cases which are summarized in the following Table 1. The table also provides an overview of the methodology's respective specifications on how to determine emission reductions in these cases.

3 Upstream emissions may be in the order of 10-15%. For this assessment, however, it has been agreed not to analyse the CDM tools which are relevant in this context. In a refinement of this assessment, those TOOLs could be considered in more detail.

Table 1 Cases for determining methane captured and destroyed in the baseline

Situation at the start of the project activity	Requirement to destroy methane	Existing LFG capture and destruction system	Specification to determine amount of methane in the LFG which is flared in the baseline $F_{CH4,BL,y}$
Case 1	No	No	=0
Case 2	Yes	No	Depends on requirement a) = absolute amount required or b) = percentage required x captured methane[4] c) = 0, if installing a capture system is required but flaring is not (i.e. no specified amount or percentage)[5] d) = 0.2 x captured methane, if flaring is required without any specified amount/percentage
Case 3	No	Yes	a) = amount flared, if baseline-methane can be measured separately b) = fraction destroyed last year x methane flared and/or used in project activity, if no explicit monitoring is possible c) 0.2 x methane flared and/or used in project activity, if no explicit monitoring possible and no historic data available[6]
Case 4	Yes	Yes	= Maximum from Case 2 and Case 3

These four cases and their subcases provide in principle a reasonable framework for the analysis. However, several aspects indicate that this assessment may not lead to a conservative assessment and that the amount of LFG in the baseline may be underestimated:

- The determination and validation of the correct case and subcase may be difficult in many circumstances. Consequently, case 1, or cases 2 and 3 with the fallback factor of 0.2, may be used too often.
- It is unclear whether the fallback factor of 0.2 is appropriate. The respective footnote 4 in ACM0001 does not provide any sources to justify these assumptions.[7] In particular it is not clear what the basis is for the assumption that in the existing system much less methane is collected than under the project activity.
- The fallback factor applies for both Case 2 and Case 3 and as a consequence also in Case 4. As Cases 2 and 3 are different situations, it seems inappropriate to use the same factor for Case 4. In addition, for Case 2 it seems at first glance not conservative to assume that regulation

[4] There are two options to determine captured methane: Option 1: captured methane = measured directly; Option 2: captured methane = determined as methane flared and/or used in project activity
[5] This subcase hardly fits into case 2. Nevertheless, the assigned value is reasonable.
[6] E.g. in case of passive flares for odor control or intermittent usage.
[7] Footnote 4 reads: “This default value of 20 per cent is based on assuming a situation in which: the efficiency of the LFG capture system in the project is 50 per cent; the efficiency of the LFG capture system in the baseline is 20 per cent; and, the amount captured in the baseline is flared using an open flare with a destruction efficiency of 50 per cent (consistent with the default value provided in the tool “Project emissions from flaring”). Project participants may propose and justify an alternative default value as a request for revision to this methodology.”

would require to destroy merely 20% of the methane (even though there is no existing LFG capture and destruction system).

- The uncertainty regarding the oxidation factor $OX_{top\_layer} = 0.1$ (see above) is of less relevance if there is a LFG capture and destruction system in the baseline (Cases 2-4), as in this case less methane leaves the SWDS through the top soil layer.

The impact of the following aspects has not been analysed any further:

- An analysis whether the fallback factor of 0.2 is conservative would require in-depth research of regulatory frameworks in several jurisdictions;
- It is unclear, how often cases and subcases are chosen incorrectly;
- It is unclear how often the critical cases 2,3,4 and therein especially the fallback factor of 0.2 are chosen.

It is thus not possible to assess the impact of this element on under-estimation or over-estimation, respectively. Yet, clearly this is a potential source for introducing uncertainty.

Summary and conclusion

Table 2 summarizes the assessment. For each of the previously discussed elements it estimates the potential impact on emission reduction quantification.

Table 2 Relevant elements of assessment and qualitative ratings

Element	Fraction of projects affected by this element[8]	Average degree of under- or overestimation where element materializes[9]	Variability among projects where element materializes[10]
Elements likely to contribute to overestimating emission reductions or removals			
OE1 Oxidation factor	High	Medium	High
OE2a Perverse incentives: management	Unknown	Medium	Medium
OE2b Perverse incentives: overall policy/action related to waste	Unknown	Medium to High	High
Elements likely to contribute to underestimating emission reductions or removals			
UE1 Methane oxidation in the project through LFG capture system	Medium	Low	Medium
UE2 Exclusion of GHG from the project boundary in the baseline	All	Low	Low
Elements with unknown impact			
U1 Methane captured and destroyed in the baseline	Unknown	Unknown	Unknown

There are several elements leading to an overestimation of emission reductions as well as those leading to an underestimation. The former elements have a higher overall impact, essentially due to the non-conservative choice of the oxidation factor and the significant impact of potential perverse incentives. It is thus likely that the emission reductions across all projects are overestimated. The degree of overestimation depends above all on the inaccuracy introduced be the oxidation factor

8 This parameter refers to the likely fraction of individual projects (applying the same methodology) that are affected by this element, considering the potential portfolio of projects. “Low” indicates that the element is estimated to be relevant for less than one third of the projects, “Medium” for one to two thirds of the projects, “High” for more than two third of the projects, and “All” for all of the projects. “Unknown” indicates that no information on the likely fraction of projects affected is available.

9 This parameter refers to the likely average degree / magnitude to which the element contributes to an over- or underestimation of the total emission reductions or removals for those projects for which this element materializes (i.e., the assessment shall not refer to average over- or underestimation resulting from all projects). “Low” indicates an estimated deviation of the calculated emission reductions or removals by less than 10% from the actual (unknown) emission reductions or removals, “Medium” refers to an estimated deviation of 10 to 30%, and high refers to an estimated deviation larger than 30%. “Unknown” indicates that it is likely that the element contributes to an over- or underestimation (e. g. overestimation of emission reductions in case of an omitted project emission source) but that no information is available on the degree / magnitude of over- or underestimation. Where relevant information is available, the degree of over- or underestimation resulting from the element may be expressed through a percentage range.

10 This refers to the variability with respect to the element among those projects for which the element materializes. “Low” means that the variability of the relevant element among the projects is at most ±10% based on a 95% confidence interval. For example, an emission factor may be estimated to vary between values from 18 and 22 among projects, with 20 being the mean value. “Medium” refers to a variability of at most ±30%, and “High” of more than ±30%.

and the extent to which perverse incentives materialize. We estimate that the degree of over-estimation is likely in a range of 10-30%.

In addition, the various elements, in particular the unknown impact related to the methane captured and destroyed in the baseline, introduce high to very high uncertainty overall.

For these two reasons, the assigned score is 2.