CERCARBONO
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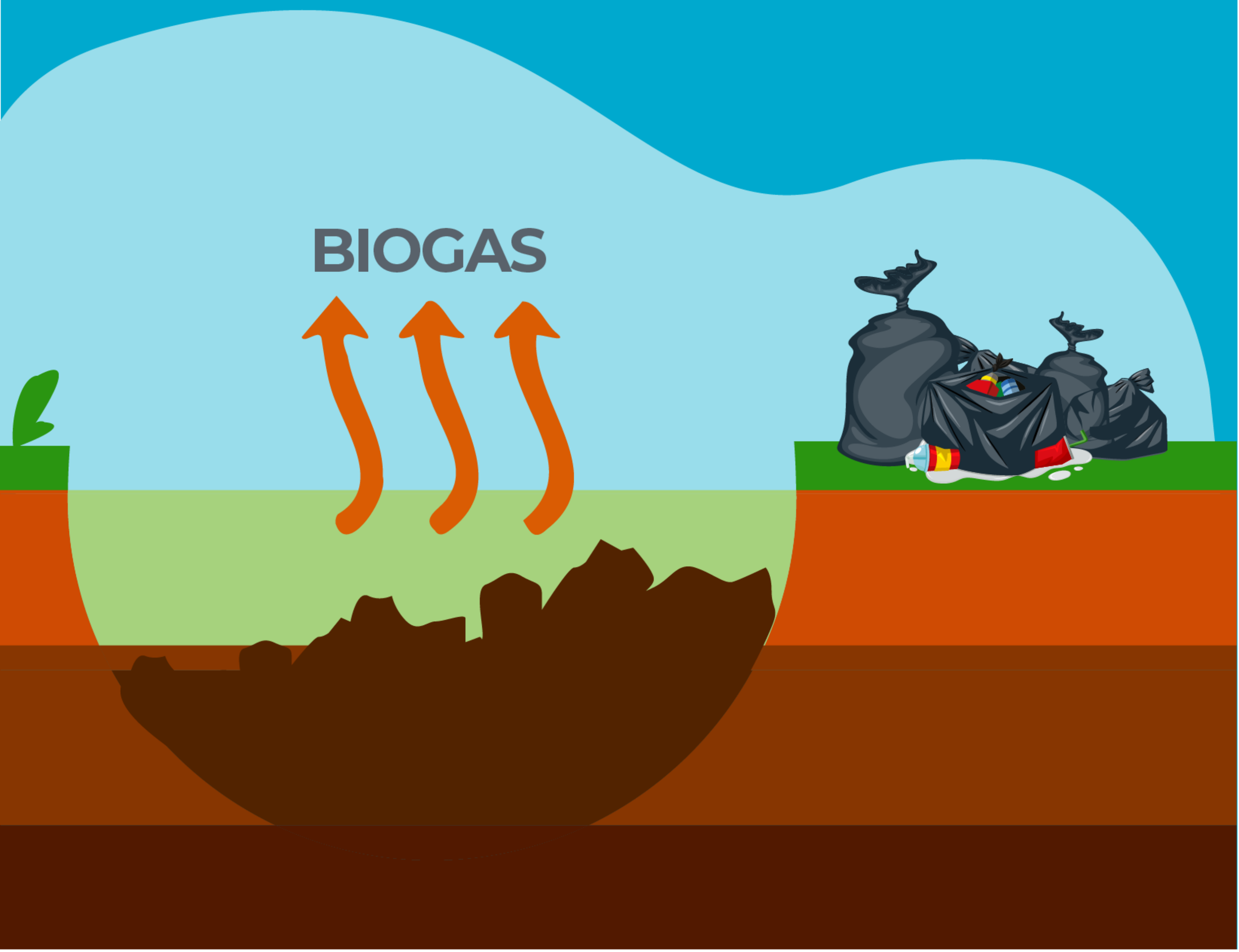
M/WM-RE_ED01

METHODOLOGY FOR THE EXECUTION OF PROJECTS FOR CAPTURE, DESTRUCTION OR USE OF BIOGAS PRODUCED IN SANITARY LANDFILLS



METHODOLOGY M/WM-RE_ED01

FOR THE EXECUTION OF PROJECTS FOR CAPTURE, DESTRUCTION OR USE OF BIOGAS PRODUCED IN SANITARY LANDFILLS

VERSION 1.1

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Acronyms

CARBONCER	Greenhouse gas emission reduction or removal certificate credit
CERCARBONO	Voluntary carbon certification programme
CMNUCC	United Nations Framework Convention on
CREG	Energy and Gas Regulatory Commission
GEI	Greenhouse Gas(es)
INGEI	National and Departmental Greenhouse Gas Inventory of Colombia
IPCC	Intergovernmental Panel for Climate Change
MRV	Measurement/Monitoring, Reporting and Verification System
ONN	National Standards Body
OVV	Validation and Verification Body
PDD	Project Description Document
PR-GEI/MR-ER_DE	Project for the Reduction (including avoidance or destruction) of GHG emissions from the capture or utilisation of biogas (including renewable
RENARE	National GHG Emission Reduction Registry
UPME	Mining and Energy Planning Unit

Foreword

Cercarbono, as a voluntary carbon certification programme, has supported and financed the development of this methodology, developed by an external consulting company and its internal technical team, endorsed by its board of directors and its general manager:

Development	
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This methodology document will be updated when its scope needs to be extended or adapted to national circumstances, in line with improving the MRV in terms of quality and efficiency.

A draft of this methodology has been made available to the public, through public consultation published on the Cercarbono website and through invitations to individuals and public and private organisations and their contributions have been considered for the preparation of the final version. The entities that participated in the public consultation are listed below, and their valuable contributions are gratefully acknowledged:

- ALLCOT
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- MUTEK
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- SENA
- UAESP
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- WRI ECDBC MINAMBIENTE

[1] Consultancy firm contracted under a contract between Cercarbono and ICONTEC.

Summary

This methodology was developed to enable the generation of carbon credits from projects that carry out the destruction of methane (CH_4) by combustion of biogas produced by the anaerobic degradation of organic matter in landfills, with or without energy use. Methane destruction or exploitation projects must have been in operation for up to five years before the registration of the initiative with the Cercarbono certification programme. They must also comply with the principles described below.

For projects to be eligible, in addition to meeting additionality requirements, they must chemically oxidize methane present in biogas with or without biogas use (displacing in the latter case the use of a fossil energy source for energy purposes or electric energy produced from fossil energy sources), if it can be demonstrated that in the absence of the project it would be released directly into the atmosphere, without any treatment. These may include new, existing projects, modernization, rehabilitation or replacement of capture or combustion systems and energy use in landfills.

This methodology also provides general guidelines associated with data handling, project documentation and monitoring.

1 Introduction

Climate change is one of the greatest challenges societies are facing now, which is affecting, among others, the continuity of life on Earth in the way we know it. Energy use is one of the main causes of this problem, considering that it is responsible for about half of the world's total greenhouse gases emissions, according to information from the Intergovernmental Panel on Climate Change (IPCC).

Methane (CH_4) is the second-largest greenhouse gas (GHG) in terms of the amount emitted and is present in the Earth's atmosphere equivalent to 20 % of the amount of CO_2e emitted in the world (IPCC, 2014). One of the main emission sources related to methane is that produced by the anaerobic degradation of solid waste in landfills, whose proper management would result in a significant reduction of these emissions.

Considering this problem and the need to advance in its solution, actions have been taken to reduce the environmental impact through mitigation and adaptation processes to climate change, among others, by developing carbon market-oriented projects that seek to reduce or destroy GHG emissions, by capturing or exploiting methane from biogas generated in landfills.

To energize carbon transactions, companies have been created to accompany or advise the development of climate change mitigation projects from their formulation and implementation to certification. In this sense, Cercarbono with its voluntary certification programme, to facilitate companies and individuals that can contribute to the reduction of GHG emissions that cause the climate crisis, stimulates the creation, and use of methodological tools for the development of investment projects, to generate and support carbon certificates that guarantee the quality of each unit of reduction achieved.

Thus, the present methodology for the development of projects to reduce (including avoidance or destruction) GHG emissions by capturing, destroying, or exploiting methane from biogas produced in landfills, seeks to present an alternative for them to access the carbon market, keeping all the principles required for the development of such actions.

This methodology applies to the capture and destruction of methane by combustion, its use for the production and use of thermal energy and electricity, the injection of biogas into the natural gas distribution network or its distribution through exclusive biogas networks or tankers.

2 Object and field of application

This methodology applies to any natural or legal person, public or private, who develops projects related to the capture, destruction or energy use of methane contained in biogas produced in landfills, who complies with all other applicable legal requirements, and who is eligible for payments for similar results or compensation because of climate change mitigation actions that result in GHG emission reductions.

This methodology establishes basic recommendations based on the principles of completeness, reliability, conservatism, consistency, evidence, accuracy and transparency for the design and implementation of projects for the reduction (including avoidance or destruction) of GHG emissions by capture and use of biogas (including renewable energy generation) produced in landfills in the Waste Management sector (project).

The types of projects that fall within the conditions and guidelines related to this methodology include new or existing installations, modernizations, refurbishments, or replacements of systems of:

- Capture and destruction of the methane contained in the gas produced in landfills by combustion (in torches, internal combustion engines, burners, among others) that, in the absence of the project, would be released directly into the atmosphere.
- Electricity generation using methane contained in gas from landfills.
- Thermal energy generation by burning methane contained in gas from landfills.
- Production of biofuel by capturing gas generated in landfills for injection into natural gas distribution networks, partially displacing this fuel.
- Production of biofuel by capturing gas generated in landfills for injection into natural gas distribution networks, partially displacing this fuel.
- Biofuel production by capturing gas generated in landfills to distribute natural gas directly to users, partially displacing this fuel.
- Capture and use of the methane contained in the gas produced in landfills for distribution by tankers to users who, if the project did not exist, would use fossil fuels instead.

Projects not listed above may use this methodology, if they meet all the criteria set out therein. A combination of the above measures, if applicable, may also be implemented according to project conditions.

For a project to apply this methodology, it must meet the following conditions:

- No biogas capture system should be in operation before the implementation of the project activity, or if one is in operation, it should be verified that it did not allow biogas utilization or that it will be optimized or improved in operation to optimize its capture conditions.

- The installation of project should not lead to a reduction in the amount of organic waste that is or would be recovered in its absence.
- The amount of methane produced in the landfill should not be deliberately increased by operation strategies, compared to the identified base conditions.
- The baseline scenario of the project should lead to the conclusion that, in the absence of the activity, the biogas (i) would have been released directly into the atmosphere; or (ii) destroyed for safety or to avoid odours.

The project must be in Colombia and meet the criteria of additionality and all other related criteria, which are described in Resolution 1447 of 2018 of the Ministry of Environment and Sustainable Development and other applicable Colombian legislation, in the Protocol for Voluntary Cercarbono Carbon Certification, in its current version and any other complementary methodological tool used. All applicable specific requirements and criteria identified in the current version of the Cercarbono Protocol should also be met.

The start date of operations of the project may be a maximum of five years before the registration of the initiative in the Cercarbono certification programme.

3 Terms and definitions

The following terms and definitions guiding the understanding of this methodology and the carbon market context have been deposited in the document "***Terms and definitions of the voluntary Cercarbono certification programme***", available on its website: www.cercarbono.com, section: Certification: Documentation.

activity data
additionality
baseline scenario
biogas
biogas capture
biogas capture system
biogas destruction
biogas processing facility
biogas utilisation
closed flare
destruction of greenhouse gas emissions
double counting
exhaust gas
flare
greenhouse gas information system
Interconnected zone
managed landfill
methodological tool
non-interconnected zone
open flare
project activity

4 Principles

Consistent with the guidelines of ISO 14064-2 and the Cercarbono Protocol, the principles of this document aim at a fair representation and credible accounting of the reduction (including avoidance or destruction) of project GHG emissions. The principles set the basis for the justifications and explanations required in this document and the developers of project should refer to the relevant principles and how they have been applied.

4.1 Completeness

All significant sources of GHG emissions generated and to be mitigated by the project **should be included.** It should also include all relevant information supporting decision-making and the results expected or achieved by the project, as well as the procedures for achieving those results.

Sources that, when added together, do not exceed 10 per cent of the total GHG emissions generated over the accounting period are non-significant.

4.2 Consistency

Significant comparisons of the information associated with the calculation and reporting of GHGs should be allowed. The assumptions, values and procedures used for the calculation of GHG emissions, reductions or destruction should be technically correct, consistent, and reproducible.

4.3 Reliability

Data and parameters from recognized sources should be included, as well as technically supported models that support the reduction (including avoidance or destruction) of GHG emissions. Data, variables, and parameters should be representative of the local reality of the GHG project, which is why they are preferred to be obtained by direct measurement methodologies and to be statistically representative.

Data and parameters from recognized sources should be included, as well as technically supported models that support the reduction (including avoidance or destruction) of GHG emissions. Recognized sources are those included in the most up-to-date IPCC good practice methodologies or previous versions, if technically justified. Academic articles published in indexed journals are also valid.

4.4 Conservatism

Conservative assumptions, values and procedures should be used to ensure that GHG project emissions are not underestimated and that GHG emission reductions (including avoidance or destruction) of project **are not overestimated.**

The assumptions, values and procedures used for the calculation of GHG emissions, reductions or destruction should be technically correct, consistent, and reproducible. On the feasibility of using two values of the same parameter at the same scale, the choice of the most conservative is recommended.

4.5 Evidence

The evidence used should be sufficient and appropriate to ensure that rational, reliable, and reproducible methods are used to ensure that GHG emission reductions (including avoidance or destruction, as appropriate to the type of project) are real and properly calculated.

4.6 Transparency

Genuine, truthful, appropriate, and sufficient information related to the entire project cycle should be used so that stakeholders and the public can be assured that there is no deliberate deception or imprecision.

The data, assumptions and methodologies used to construct a baseline scenario and the corresponding monitoring of results, must be available permanently and publicly, so that any calculation contained in the project **can be reconstructed.** This availability of information is essential for the evaluation of the other principles of this methodology. Therefore, the information is expected to include:

- Definitions used in the quantification of activity data, emission factors, projection methods and uncertainty calculation.
- Methodologies used for area estimation, area changes, emission factors, projections, and uncertainty calculations.
- Assumptions, academic and implementation support in other mitigation actions (see reliability principle).
- Data used for area estimation, area changes, emission factors, projections, and uncertainty calculation.

5 Applicability and inclusion requirements

This methodology has been developed to be used in projects of reduction (including avoidance or destruction) of GHG emissions by capture or use of methane contained in biogas produced in landfills in the sector of Waste Management (RP-GHG/WM-RE-ED)**,** oriented to the generation of carbon credits, whose equipment for the use or destruction of methane has entered operation until five years before the registration of the initiative before the programme of certification of Cercarbono. The following basic criteria must be met:

1. Capture the biogas produced in a landfill, using a collection and conduction system that reduces or minimizes methane losses and leads it to the facilities where it is burned or used.
2. Combusting methane present in the captured biogas or implementing a strategy to exploit it, including any of the measures considered in this methodology, be it electric or thermal energy production from biogas, biogas injection in natural gas networks, distribution of biogas in independent networks, distribution in tankers or a combination of these.
3. To be applied in, as appropriate, landfills of any capacity where: (i) new facilities for the capture, destruction or use of biogas; (ii) existing biogas capture, destruction or use facilities where rehabilitation, modernization or replacement of biogas equipment takes place; and (iii) biogas capture, destruction or use facilities that enhance biogas capacity or efficiency.
4. To relate and complement each other with all the guidelines outlined in the current version of the Cercarbono Protocol.

An update of the sources that can be considered under the guidelines of this methodology can be found on the Cercarbono website.

5.1 Additionality

The concept of additionality in this methodology is based on what is defined in the Cercarbono[2] Protocol and the Resolution 1447 of 2018 of the Ministry of Environment and Sustainable Development. Considering the above, the additionality in the framework of this methodology is based on the demonstration that when developing project is reduced or destroyed methane present in biogas produced in landfills, preventing it from being emitted directly into the atmosphere, or exploiting the methane present in biogas produced in the landfill, displacing the use of fossil fuels, and preventing methane from being released directly into the atmosphere.

[2] Cercarbono develops continuous improvement processes that include strengthening the additionality criteria that PRR-GHGs must meet. Once new tools are available, they will be applicable in this methodology.

The project must demonstrate that they have procedures for assessing and testing additionality and that these procedures provide reasonable assurance that GHG emission reductions or destruction would not have occurred in the absence of the project.

5.2 Ownership

The initiative holder must obtain and provide the express authorization of the owner(s), or holder(s) of the facilities (whether private, public, or mixed) for the realization of the project (including those associated with the land and the capture, destruction or harvesting infrastructure).

Evidence of rights or ownership of the project facilities should be included and, if applicable, evidence that the respective environmental license is available for operation.

Ownership of GHG emission reductions among stakeholders should be evidenced, i.e., participation, claim or assignment of GHG emission reductions should be supported by a document signed between the parties.

The results of consultations between the owners and participants of the project initiative in question should be described in the Project Description Document (PDD) as required.

5.3 Effective participation and environmental impact

The project must provide the documents certifying the completion of the prior consultation for the environmental license process, in the terms of Colombian law, and include a written summary in the PDD supported with evidence on the environmental impacts that the implementation of the project had or continues to have. The project should have an effective participation protocol including:

- A map of actors, that is, an institutional map of the other governance structures or institutions and leaders associated with decision-making in the territory, associated with the project activities.
- Decisions agreed with local governance structures.
- Traceability of consensus processes.
- Handling of petitions, complaints, complaints and requests and their traceability.
- A framework schedule of meetings for project decision-making.
- A protocol for conflict management.

In addition to the above, the project should follow the guidelines described in the current version of the Cercarbono Protocol.

5.4 Overall objective of the project

The overall objective of the project should be to describe the main positive impact expected by the implementation of project activities and the mitigation potential of project outcomes.

The objective should also include, at a minimum, the main activity, the place of implementation, the actors involved and the period of execution of actions.

6 Baseline Scenario

Possible baseline scenarios associated with biogas management in the landfill may be as follows:

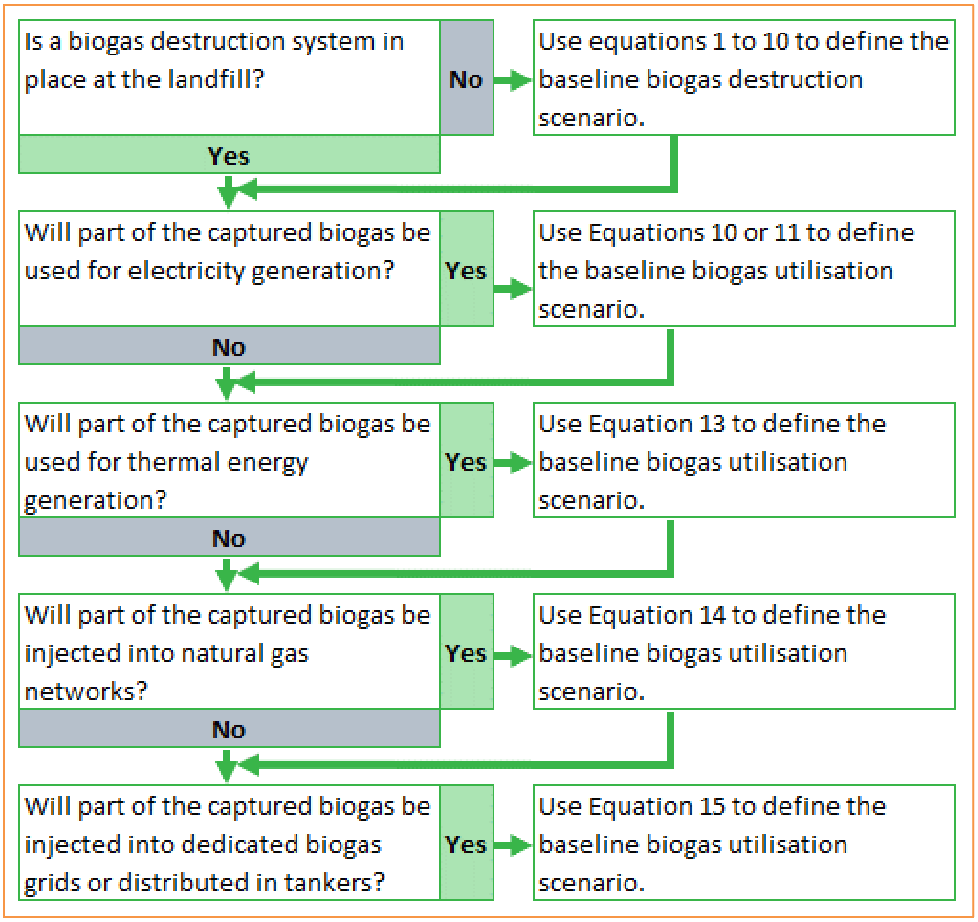
1. Before the development of project, biogas produced in the landfill, or a larger proportion of it, is being released into the atmosphere directly. In this case, project alternatives might lead to the following situations in the project scenario (and therefore require associated information to build your baseline scenario):
    a. Biogas is captured and destroyed in a controlled manner by combustion.
    b. Biogas is captured and used for electricity generation.
    c. Biogas is captured and used for thermal power generation.
    d. Biogas is captured and exploited by injection into a natural gas distribution network.
    e. Biogas is captured and used through distribution in networks dedicated exclusively to biogas or through tankers.

2. Before the development of project, biogas produced in the landfill, or a larger proportion of it, is being captured and destroyed through combustion in a torch, without any use.

    In this case, project alternatives might lead to the following situations in the project scenario (and therefore require associated information to build your baseline scenario):
    a. The captured biogas is used for electricity generation, or the efficiency associated with this process is increased.
    b. The captured biogas is used for thermal energy generation, or the efficiency associated with this process is increased.
    c. The captured biogas is exploited by injection into a natural gas distribution network, or the efficiency associated with this process is increased.
    d. The captured biogas is exploited by distribution in networks dedicated exclusively to biogas or through tankers or the efficiency associated with this process is increased.

To better understand the project's baseline scenario and associated equations, see ***Figure 1*****.**

Figure 1. Flowchart for the definition of the baseline scenario for biogas projects.



Whatever the situation of project, the associated methodological guidelines must be followed and guidelines that do not apply to the type of project carried out must be discarded or dismissed.

In cases where other biogas management systems exist, such as aeration treatment (*in situ* or passive) in the landfill, oxidation layers in the landfill, hydrogen production from biogas, among others, the biogas that can be included in this methodology will be related exclusively to surpluses of such treatments that are not managed by them.

The developer of the project should describe, specifically in the PDD, the conditions of the baseline scenario and the status of the project that has led to the collection of information.

6.1 Delimitation of the project

6.1.1 Spatial limits

The project boundary refers to the physical and geographical location of biogas capture, destruction, or utilization facilities as appropriate in the project. The spatial extension of the project includes biogas capture systems, biogas conduction to the places where it is destroyed or where treatments are carried out for its use and if applied, facilities for the utilization of biogas, its injection into networks or delivery to tankers.

Project site data must be specified, such as country, department, municipality, among others, including its geographical coordinates (in the official reference system for Colombia: MAGNA-SIRGAS).

6.1.2 Time limits for RP-GHG/WM-RE_ED

Project duration: is the period (in years) between the start (day.month.year) of the project mitigation actions and the end (day.month.year) of these actions.

Accreditation period: shall be 20 years or the same as the useful life of the system, if less than 20 years, counted from the moment when the system for catching, destroying, or exploiting biogas has entered operation. Projects that have been in operation for more than five years cannot be certified under the Cercarbono certification programme.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol should be followed.

6.2 GHG emission sources from the baseline scenario

The GHG emission sources to be considered in the baseline scenario of the project, are described in **Table 1**.

Table 1. GHG emission sources considered in the baseline scenario.

Source	GHG	Included	Explanation
Biogas generation in the landfill	CO_2	No	The decomposition of organic solid waste in landfills produces biogas with these three types of GHG. CO_2 is not considered as a biogenic origin nor N_2O because the quantity produced is negligible. In the baseline scenario, there may or may not be biogas capture.
	CH_4	Yes	
	N_2W	No	
	CO_2	No	

Source	GHG	Included	Explanation
Destruction of biogas by combustion	CH_4	No	The destruction of biogas by combustion produces these three types of GHG. CO_2 is not considered biogenic in origin. Methane and N_2O are not considered because the amount of these GHGs produced is negligible.
	N_2W	No	
Consumption of fossil fuels for electricity generation	CO_2	Yes	All fossil fuels used for electricity production produce these three types of GHG in their combustion. Methane and N_2O are not considered because the amount of these GHGs produced is negligible.
	CH_4	No	
	N_2W	No	
Consumption of fossil fuels for thermal energy generation	CO_2	Yes	All fossil fuels used for thermal energy production generate these three types of GHG in their combustion. Methane and N_2O are not considered because the amount of these GHGs produced is negligible.
	CH_4	No	
	N_2W	No	
Consumption of natural gas from distribution networks (or pipelines)	CO_2	Yes	The combustion of natural gas produces these three types of GHG in its combustion. Methane and N_2O are not considered because the amount of these GHGs produced is negligible.
	CH_4	No	
	N_2W	No	
Fuel consumption that would be displaced using methane obtained from networks dedicated exclusively to biogas or distributed in tankers	CO_2	Yes	Any fossil fuel that is displaced by biogas produces these three types of GHG in its combustion. Methane and N_2O are not considered because the amount of these GHGs produced is negligible.
	CH_4	No	
	N_2W	No	

The project must ensure the identification of GHGs and emission sources.

If the project identifies in its baseline scenario a GHG emission source other than those described above, it may be included, if its inclusion and the results obtained associated with it are justified.

In addition to the guidelines described above, in any case, all other guidelines described in the current version of the Cercarbono Protocol should be followed.

6.3 Calculation of GHG emissions from the baseline scenario

The calculation of GHG emissions from the baseline scenario relates to the management alternatives given to methane present in biogas captured in the landfill. According to the above, emissions from the baseline scenario of the project can be obtained with ***Equation 1***.

$$BLE_t = BLBE_t + BLEE_t + BLFFTP_t + BLNGE_t + BLFFE_t \quad \textbf{\textit{Equation 1}}$$

Variable	Units	Description
BLE_t	$t\text{-}CO_2e$	GHG emissions in period t of baseline scenario.
t	*Months or years*	Project period index.
$BLBE_t$	$t\text{-}CO_2e$	GHG emissions from biogas produced at landfill that is expected to be captured for use or recovery in period t of baseline scenario.
$BLEE_t$	$t\text{-}CO_2e$	GHG emissions from electricity generation expected to be produced in period t of baseline scenario.
$BLFFTP_t$	$t\text{-}CO_2e$	GHG emissions from fossil fuel thermal power generation expected to be displaced during period t of the baseline scenario.
$BLNGE_t$	$t\text{-}CO_2e$	GHG emissions from natural gas expected to be displaced by methane use in landfill biogas in period t of baseline scenario.
$BLFFE_t$	$t\text{-}CO_2e$	Emissions from fossil fuel consumption that is expected to be displaced using methane in biogas from dedicated biogas pipelines or from distribution in tanker trucks in period t of baseline scenario.

6.3.1 Generation of biogas in the landfill that is captured for use

The generation of biogas in the landfill is calculated using the following equation:

$$BLBE_t = \left((PBMC_t \times (1 - FOM_t)) - BLGDC_t\right) \times MGWP \quad \textbf{Equation 2}$$

Variable	Units	Description
$BLBE_t$	$t\text{-}CO_2e$	GHG emissions from biogas produced at landfill that is expected to be captured for use or recovery in period t of baseline scenario.
$PBMC_t$	t	Methane in biogas expected to be captured, destroyed, or used in period t of project scenario.
FOM_t	N/A	Fraction of methane oxidised in period t.

Variable	Units	Description
$BLGDC_t$	t	Methane in biogas expected to be destroyed by combustion in period t of baseline scenario.
$MGWP$	N/A	Global warming potential of methane.

The level of disaggregation for period t can be determined by the project, but in general annual values are used. The total period for which the baseline scenario is calculated shall correspond directly to the useful lifetime of the technology used in the GHG project, without exceeding the duration time of this maximum comparison period.

The value of **$BLGDC_t$** corresponds to the amount of methane destroyed by combustion before the development of the project that would be expected to continue to be destroyed during the development of the project and is therefore applicable in cases where the biogas was already burned in the baseline scenario and in the project scenario the destruction is exploited or increased efficiency. In case no methane destruction was done before the project development, the value of **$BLGDC_t$** would be zero. **$BLGDC_t$** and **$PBMC_t$** must have the same period.

The value of **FOM_t** corresponds to the oxidation factor in the t period, which reflects the amount of methane from the landfill that is oxidized before being emitted into the atmosphere. The oxidation report shall include an analysis of oxidized and non-oxidized contents escaping through cracks and fissures or by lateral diffusion to avoid overestimation of oxidation processes (IPCC, 2019). According to the IPCC (2019), the default value for the oxidation factor is zero and the use of the oxidation value of 0.1 will be justified for well-managed landfills. Oxidation values above 0.1 shall be fully documented, referenced and supported by data. Information on the choice of **FOM_t** should be documented in the PDD.

The **PBMCt** value corresponds to the total amount of methane contained in the biogas that is captured and that will be used in the project scenario, either because it will be destroyed in its entirety, because it will be used in its entirety, or because part of it will be destroyed and part of it will be used. The first is the estimation of **PBMCt** before the development of the project (ex-ante scenario), and the second is the estimation of **PBMCt** after the development of the project (ex-post scenario), in which the designation $\boldsymbol{PBMC_{i,j}}$ is given.

a. In the *ex-post* scenario, it is calculated using the following equation:

$$\boldsymbol{PBMC_{i,j} = PBMDF_{i,j} + PBMEE_{i,j} + PBMTE_{i,j} + PBNG_{i,j} + PBMI_{i,j}}$$ ***Equation 3***

Variable	Units	Description
$\mathbf{PBMC_{i,j}}$	t	Methane in biogas captured, destroyed, or used in period ***j*** of verification ***i***.
$\boldsymbol{i}$	N/A	Verification index.
$\boldsymbol{j}$	N/A	Index of the measurement/monitoring period.
$\boldsymbol{PBMDF_{i,j}}$	t	Methane in biogas destroyed by flaring in the project in period ***j*** of verification ***i***.
$\boldsymbol{PBMEE_{i,j}}$	t	Methane in the biogas used for electricity production in the project in period ***j*** of verification ***i***.
$\boldsymbol{PBMTE_{i,j}}$	t	Methane in biogas used for thermal energy production in the project in period ***j*** of verification ***i***.
$\boldsymbol{PBNG_{i,j}}$	t	Methane in biogas used for injection into natural gas distribution systems in period ***j*** of verification ***i***.
$\boldsymbol{PBMI_{i,j}}$	t	Methane in biogas injected into distribution systems dedicated exclusively to methane contained in biogas or for distribution in tank cars in period ***j*** of verification ***i***.

b. In the ex-ante scenario, it is calculated using the following equation:

$$\boldsymbol{PBMC_t = BLMBTW_t \times \eta SC}$$ ***Equation 4***

Variable	Units	Description
$\boldsymbol{PBMC_t}$	t	Methane in biogas expected to be captured, destroyed or used in period ***t*** of project scenario.

Variable	Units	Description
$BLMBTW_t$	t	Methane in the biogas expected to be produced by the total waste deposited in the landfill in period t of baseline scenario.
ηSC	N/A	Efficiency of the biogas capture system (or of the system to be installed in the landfill).

The **$BLMBTW_t$** is calculated with ***Equation 5*** which is based on the IPCC (2019) methodology.

$$BLMBTW_t = BLOCSW_t \times F \times 16/12 \qquad \textbf{Equation 5}$$

Variable	Units	Description
$BLMBTW_t$	t	Methane in the biogas expected to be produced by the total waste deposited in the landfill in period t of baseline scenario.
$BLOCSW_t$	$t\text{-}C$	Mass of degradable organic carbon available in the solid waste expected to be landfilled and degraded in period t of baseline scenario.
F	N/A	Methane fraction by volume in the gas generated in the landfill.

The **$BLOCSW_t$** is calculated with ***Equation 6*** (IPCC, 2019).

$$BLOCSW_t = BLAOCSW_{TV_{i-1}} \times \left(1 - \left(e^{-k}\right)\right) \qquad \textbf{Equation 6}$$

Variable	Units	Description
$BLOCSW_t$	$t\text{-}C$	Mass of degradable organic carbon available in the solid waste expected to be landfilled and degraded in period t of baseline scenario.
$BLAOCSW_{TV_{i-1}}$	$t\text{-}C$	Mass of degradable organic carbon accumulated in the solid waste expected to be deposited in the landfill at the end of the year preceding the year of verification TV_i, i.e., TV_{i-1}.

Variable	Units	Description
TV_{i-1}	N/A	Year prior to the verification year of period i (counted from the start of the project).
i	N/A	Verification index.
k	N/A	Reaction constant in period $t\text{-}1$.

Where k is calculated as

$$k = Ln(2)/ALL \qquad \textbf{\textit{Equation 7}}$$

Variable	Units	Description
k	N/A	Reaction constant in period $t\text{-}1$.
ALL	$year$	Average lifetime of the landfill.

In turn, the value $CODDRSLB_{TV_i}$ is calculated with ***Equation 8*** (IPCC, 2019).

$$\mathrm{BLAOCSW}_{TV_i} = \mathrm{BLDOCSW}_t \times \left(\mathrm{BLAOCSW}_{TV_{i-1}} - \left(e^{-k}\right)\right) \qquad \textbf{\textit{Equation 8}}$$

Variable	Units	Description
$BLAOCSW_{TV_i}$	$t\text{-}C$	Mass of degradable organic carbon accumulated in the solid waste expected to be deposited in the landfill at the end of the verification period TV_i.
TV_i	N/A	Verification year of period i (counted from the start of the project).
i	N/A	Verification index.
$BLDOCSW_t$	$t\text{-}C$	Mass of degradable organic carbon deposited in solid waste expected to be landfilled at the end of period t of the baseline scenario.
$BLAOCSW_{TV_{i-1}}$	$t\text{-}C$	Mass of degradable organic carbon accumulated in the solid waste expected to be deposited in the landfill at the end of the year preceding the year of verification TV_i, i.e., TV_{i-1}.

Variable	Units	Description
k	N/A	Reaction constant in period ***t-1***.

The mass of degradable organic carbon deposited in the solid waste brought to the landfill is calculated with ***Equation 9*** (IPCC, 2019).

$$\boldsymbol{BLAOCSW_t = BLW_t \times FDOC_t \times FADOC_t \times MCF} \qquad \textbf{\textit{Equation 9}}$$

Variable	Units	Description
$\boldsymbol{BLAOCSW_t}$	$t\text{-}C$	Mass of degradable organic carbon accumulated in the solid waste expected to be deposited in the landfill at the end of period $\boldsymbol{t}$ of the baseline scenario.
$\boldsymbol{BLW_t}$	t	Mass of waste expected to be deposited in the landfill in period $\boldsymbol{t}$ of baseline scenario.
$\boldsymbol{FDOC_t}$	N/A	Fraction of degradable organic carbon in the waste expected to be deposited in period $\boldsymbol{t}$.
$\boldsymbol{FADOC_t}$	N/A	Fraction of degradable organic carbon that decomposes under anaerobic conditions in period $\boldsymbol{t}$.
$\boldsymbol{MCF}$	N/A	Methane correction factor for aerobic decomposition in the year of deposition.

In turn, $\boldsymbol{FDOC_t}$ s is calculated with ***Equation 10.***

$$\boldsymbol{FDOC_t = \sum_{w=1}^{W} \left(FDOC_{w,t} \times F_{w,t}\right)} \qquad \textbf{\textit{Equation 10}}$$

Variable	Units	Description
$\boldsymbol{FCOD_t}$	N/A	Fraction of degradable organic carbon in the waste expected to be deposited in period $\boldsymbol{t}$.
$\boldsymbol{FDOC_{w,t}}$	N/A	Fraction of degradable organic carbon that decomposes under anaerobic conditions for waste groups or classes $\boldsymbol{w}$, in period $\boldsymbol{t}$ of baseline scenario.

Variable	Units	Description
w	N/A	Index of the waste group or waste type.
$F_{w,t}$	N/A	Proportion of the class or type of waste w with respect to the total waste w in the landfill in period t.
W	N/A	Total number of waste groups or classes.

Both the values included in the equation and those used to calculate them (coefficients, factors or calorific values used in the methodology) should follow the guidance of the IPCC Good Practice Guidance (IPCC, 2000).

All the values used in the above equations, as well as the decisions taken regarding the periods of the baseline scenario, must be supported by the project, complying with the principles outlined in this document and the current version of the Cercarbono Protocol.

In addition to the guidelines described above, in any case, the guidelines for the determination and quantification of GHG emissions from the baseline scenario of the current version of the Cercarbono Protocol should be followed.

6.3.2 Fossil fuel power generation

The baseline scenario of electric power generation with fossil fuels is related to whether they are connected to an interconnected grid or not, therefore two alternatives for the construction of the baseline scenario for these conditions are described below. The project should use the one that suits its conditions.

6.3.2.1 Electrical power generation of an interconnected electricity grid

In cases where, in the absence of project, electricity would have been provided by an interconnected electricity grid generated under the electric mix ("*mix*") having the catchment area, the baseline scenario of the projects should be related to the GHG emissions that would have been generated for an equivalent amount of electricity to that produced by the project, but with electricity produced in the interconnected grid and its associated emissions, in the periods for which the comparison is required. The calculation of the baseline scenario must be done with ***Equation 11.***

$$BLEE_t = PDE_t \times EFDIE_t$$ ***Equation 11***

Variable	Units	Description
$BLEE_t$	$t\text{-}CO_2e$	GHG emissions from electricity generation expected to be produced in period ***t*** of baseline scenario.
PDE_t	MWh	Electricity expected to be displaced in period ***t*** of project scenario.
$EFDIE_t$	$t\text{-}CO_2e/MWh$	CO_2 emission factor of the interconnected grid, for the electricity expected to be displaced by the electricity produced by the project in period ***t***.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***.

$EFDIE_t$ is calculated by the responsible of the interconnected electricity network (UPME, for the case of Colombia) and its last available value can be used by the responsible of the project to determine the GHG emissions of the baseline scenario, in which case the values associated with its calculation must not be demonstrated, but its origin and the reliability of the source used; or it can be calculated and supported directly by the project, in which case it will be responsible for the demonstration of the value used. All values must be chosen conservatively, and their choice must be justified. For the calculation of the emission factor of an interconnected network, where this situation is required, the methodology developed by the CDM[3] should be used.

Both the values included in the equation and those used to calculate them (coefficients, factors or calorific values used in the methodology) should follow the guidance of the IPCC Good Practice Guidance (IPCC, 2000).

All the values used in the previous equation, as well as the decisions taken regarding the periods of the baseline scenario, must be supported by the project, complying with the principles outlined in this document and the current version of the Cercarbono Protocol.

[3] Use the latest version of the CDM tool *"Methodological tool to calculate the emission factor for an electricity system"*.

6.3.2.2 Electrical power generation in a Non-Interconnected Zone (NIZ)

In cases where the project supplies electric power to a NIZ, there may be two alternatives for developing the baseline scenario: (i) the area where the electricity is supplied with the GHG project already has a supply previously with fossil sources or more GHG emission-intensive than the emissions from the project, and (ii) the NIZ does not have an electricity supply before the development of the GHG project.

If the NIZ had a supply in the past, and the supply was either from a mixture of fossil energy sources or a single source, the baseline scenario is dynamic and should be determined by the following equation:

$$BLEE_t = PDE_t \times \sum_{c=1}^{C}\sum_{t=1}^{T}\left(\left(\frac{FCNIZ_{c,t} \times CEF_c}{TGENIZ_t} \times WOM\right) + (CMEFNIZ_t \times WCM)\right)$$

Equation 12

Variable	Units	Description
$BLEE_t$	*t-CO₂e*	GHG emissions from electricity generation expected to be produced in period t of baseline scenario.
PDE_t	*MWh*	Electricity expected to be displaced in period t of project scenario.
$FCNIZ_{c,t}$	*Mass unit or fuel volume.*	Consumption of fuel c by each generation unit belonging to the Non-Interconnected Zone in period t of baseline scenario.
c	*N/A*	Fossil fuel type index.
CEF_c	*N/A*	CO_2 emission factor for fuel c with which electricity is generated in the NIZ and which is displaced by the electricity produced by the project.
$TGENIZ_t$	*MWh*	Total electricity generated in the NIZ in period t of baseline scenario.
WOM	*%*	Weighting of the operating margin emissions factor (percentage), calculated using the procedure proposed in the most up-to-date CDM methodology[6].

Variable	Units	Description
$\boldsymbol{CMEFNIZ_t}$	N/A	Emission factor of the construction margin in the Non-Interconnected Zone in period ***t***.
$\boldsymbol{WCM}$	$\%$	Weighting of the construction margin emissions factor (percentage), calculated using the procedure proposed in the most up to date CDM methodology[6].
$\boldsymbol{C}$	N/A	Total amount of fossil fuel types consumed in the project scenario.
$\boldsymbol{T}$	*Months or years*	Total duration of the **RP-GHG/WM-RE-ED**, in the same units as used for ***t***.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***. **WOM** and **WCM** can be defined according to the most current[4] CDM methodology.

For ***cEFCs***, it is recommended to use the official emission factors for the country (in Colombia, those generated by UPME)[5].

The total period for which the baseline scenario is calculated should be directly related to the useful life of the technology used in the GHG project, not exceeding 20 years as the maximum comparison period.

If the useful life of the technology used for the energy supply in the ZNI that is associated with the baseline scenario is less than the useful life of the technology used in the GHG project, the emissions of the remaining years following the obsolescence of the current ZNI technology should be estimated, identifying the option that relates more closely to what would presumably occur in the absence of the GHG project; i.e. supporting whether the area could presumably be connected to the interconnected grid (in which case ***Equation 11*** would be used to project the baseline scenario of the project) or whether electricity could continue to be supplied in a non-interconnected manner (leading to ***Equation 12* being used** with the relevant changes, according to the projection made); under

[4] See the calculation of the Combined Margin Factor in the latest version of CDM methodological tool 07.

[5] UPME publishes the emission factors for Colombian fuels on the website: http://www.upme.gov.co/calculadora_emisiones/aplicacion/calculadora.html.

no circumstances may the baseline scenario be projected for a period beyond the useful life of the technology.

All the values used in the previous equation, as well as the decisions taken regarding the periods and conditions in which the baseline scenario is proposed, must be supported by the project, complying with the principles outlined in this document.

Where the ZNI does not have an electricity supply before the start of the project, the Project may use either of the two equations described above, demonstrating that the choice is the one that relates most closely to what would presumably occur in the non-interconnected zone, in the absence of the GHG project (connecting to the interconnected grid or providing electricity in a non-interconnected manner). In either option, project additionality must be demonstrated, and the most conservative option must be chosen.

In addition to the guidelines described above, in any case, the guidelines for the determination and quantification of GHG emissions from the baseline scenario of the current version of the Cercarbono Protocol should be followed.

6.3.3 Fossil fuel thermal power generation

In cases where biogas is used to displace the use of fossil fuels in thermal power generation, the baseline scenario should be determined with the following equation:

$$\boldsymbol{BLFFTP_t = PMBFFD_t \times \frac{LCVM}{LCVDFF} \times DFEF}$$ ***Equation 13***

Variable	Units	Description
$\boldsymbol{BLFFTP_t}$	*t-CO₂e*	GHG emissions from fossil fuel thermal power generation expected to be displaced in period $\boldsymbol{t}$ of the baseline scenario.
$\boldsymbol{PMBFFD_t}$	t	Methane in the biogas expected to be used to displace fossil fuel in period $\boldsymbol{t}$ of project scenario.
$\boldsymbol{LCVM}$	MJ/t	Lower calorific value of methane.
$\boldsymbol{LCVDFF}$	*MJ/mass unit or fuel volume.*	Lower calorific value of fossil fuel displaced using biogas.
$\boldsymbol{DFEF}$	*t-CO₂e/mass unit or fuel volume.*	CO_2 emission factor for the fuel being displaced by the biogas captured by the project.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***.

For **$FSFD_s$,** it is recommended to use the official emission factors for the country (in Colombia, those generated by UPME)[6].

The total period for which the baseline scenario is calculated should be directly related to the useful life of the technology used in the GHG project, but not exceed 20 years at the most in the comparison period.

All the values used in the previous equation, as well as the decisions taken regarding the periods and conditions in which the baseline scenario is proposed, must be supported project, complying with the principles outlined in this document.

In addition to the guidelines described above, in any case, the guidelines for the determination and quantification of GHG emissions from the baseline scenario of the current version of the Cercarbono Protocol should be followed.

6.3.4 Biogas injection in natural gas distribution systems

In cases where biogas is used to inject it into natural gas distribution networks, displacing the use of this fuel, the baseline scenario should be determined with ***Equation 14***.

$$BLNGE_t = \left(PMBNGD_t \times \frac{LCVM}{LCVNG} \times DBEF\right) + \left(PMBNGD_t \times \frac{LCVM}{LCVNG} \times PPLNGN_t \times PNGPDN_t \times MGWP\right) \quad \textbf{\textit{Equation 14}}$$

[6] UPME publishes the emission factors for Colombian fuels on the website: http://www.upme.gov.co/calculadora_emisiones/aplicacion/calculadora.html.

Variable	Units	Description
$BLNGE_t$	$t\text{-}CO_2e$	GHG emissions from natural gas expected to be displaced by methane use in landfill biogas in period ***t*** of baseline scenario.
$PMBNGD_t$	t	Methane in the biogas expected to be used to displace natural gas in period ***t*** of project scenario.
$LCVM$	MJ/t	Lower calorific value of methane.
$LCVNG$	*MJ/mass unit or natural gas volume.*	Lower calorific value of natural gas displaced using methane from biogas.
$DBEF$	*$t\text{-}CO_2e$/mass unit or natural gas volume.*	CO_2 emission factor of the natural gas being displaced by the biogas captured by the project.
$PPLNGN_t$	%	Percentage of losses in the natural gas distribution network in period ***t*** of project scenario.
$PNGPDN_t$	%	Percentage of methane in the natural gas distributed in the grid in period ***t*** of project scenario.
$MGWP$	N/A	Global warming potential of methane.

The level of disaggregation in the data can be determined project, but in general annual values can be included for period ***t***.

For the **DBEF** it is recommended to use the official emission factors for the country (In Colombia, those generated by the UPME)[7].

The total period for which the baseline scenario is calculated should be directly related to the useful life of the technology used in the GHG project, not exceeding 20 years as the maximum comparison period.

All the values used in the above equation, as well as the decisions taken regarding the periods and conditions in which the baseline scenario is

[7] UPME publishes the emission factors for Colombian fuels on the website: http://www.upme.gov.co/calculadora_emisiones/aplicacion/calculadora.html.

proposed, must be supported project, complying with the principles outlined in this document.

In addition to the guidelines described above, in any case, the guidelines for the determination and quantification of GHG emissions from the baseline scenario of the current version of the Cercarbono Protocol should be followed.

6.3.5 Distribution of biogas in dedicated systems or tankers

In cases where biogas is used to inject it into exclusive biogas distribution networks or for commercialization through tankers, displacing the use of fossil fuels, the baseline scenario should be determined with the following equation:

$$BLFFE_t = \left(BLMBFFDWN_t \times \frac{LCVM}{LCVDFF} \times DFEF\right) + \left(BLMBFFDWN_t \times \frac{LCVM}{LCVDFF} \times BLPLFF_t \times BLPMFFG_t \times MGWP\right)$$

Equation 15

Variable	Units	Description
$BLFFE_t$	*t-CO_2e*	Emissions from fossil fuel consumption that is expected to be displaced using methane in biogas from dedicated biogas pipelines or from distribution in tanker trucks in period ***t*** of baseline scenario.
$BLMBFFDWN_t$	*t*	Methane in landfill biogas that is expected to be used to displace fossil fuel that would be used if there were no dedicated network or tank car distribution in period ***t*** of baseline scenario.
$LCVM$	*MJ/t*	Lower calorific value of methane.
$LCVDFF$	*MJ/mass unit or fuel volume.*	Lower calorific value of fossil fuel displaced using biogas.
$DFEF$	*t-CO_2e/mass unit or fuel volume.*	CO_2 emission factor for the fuel being displaced by the biogas captured by the project.
$BLPLFF_t$	*%*	Percentage of fossil fuel distribution network losses (if applicable) in period ***t*** of baseline scenario.

Variable	Units	Description
$BLPMFFG_t$	$\%$	Percentage of methane in the fossil fuel distributed in the grid (if applicable) in period t of baseline scenario.
$MGWP$	N/A	Global warming potential of methane.

The level of disaggregation in the data can be determined project, but in general annual values can be included for period t.

For **$FSFD_s$**, it is recommended to use the official emission factors for the country (in Colombia, those generated by UPME)[8].

The total period for which the baseline scenario is calculated should be directly related to the useful life of the technology used in the GHG project, but not exceed 20 years as the maximum comparison period.

All the values used in the previous equation, as well as the decisions taken regarding the periods and conditions in which the baseline scenario is proposed, must be supported by the project, complying with the principles outlined in this document.

In addition to the guidelines described above, in any case, the guidelines for the determination and quantification of GHG emissions from the baseline scenario of the current version of the Cercarbono Protocol should be followed.

6.4 Co-benefits

The co-benefits are the positive results that the project generates for actors that are located or intervene in the project area. These results are different from the contributions generated in the context of climate change mitigation. These may be of a social, environmental, economic, cultural, or political type, and may be identified in a format as exemplified in **Table 2**.

[8] UPME publishes the emission factors for Colombian fuels on the website: http://www.upme.gov.co/calculadora_emisiones/aplicacion/calculadora.html.

Table 2. Example of identifying and describing co-benefits that a project can generate.

Type of co-	Beneficiary	Indicator
Social	Community close to the project.	Number of jobs generated in the region.
Environmental	Community in	Reduced amount of contaminants.
Economic	Community close to the project.	Amount of taxes paid by the project to the local community.
Cultural	Community close to the project.	Number of cultural promotion events or reinforcement of ancestral knowledge.
Politician	Integrated	Number of new beneficiaries for energy

In addition to the guidelines described above, in any case, the co-benefit requirements described in the current version of the Cercarbono Protocol should be addressed.

7 Project Scenario

7.1 GHG emission sources from the project scenario

The GHG emission sources to be considered in the project scenario are described in **Table 3** below:

Table 3. GHG emission sources considered in the project scenario.

Source	GHG	Included	Explanation
Combustion destruction of methane from landfill biogas in a torch	CO_2	No	The burning of methane from landfill biogas generates emissions associated with the efficiency of destruction in the torch. Considering that CO_2 generated in combustion is biogenic, it is not counted. N_2O is not considered because the quantity produced is negligible.
	CH_4	Yes	
	N_2W	No	
Consumption of fossil fuels in auxiliary processes	CO_2	Yes	Burning of fossil fuels for electricity generation and the start-up of thermal systems. Burning fossil fuels in tankers for the distribution of methane from landfill biogas.
	CH_4	No	
	N_2W	No	
Electrical consumption of control and auxiliary systems	CO_2	Yes	Power consumption outside the plant (taken from a centralized network or a third party) of the systems controlling the project's electricity generation.
Methane losses in distribution networks	CH_4	Yes	Loss of methane present in biogas captured in landfills and distributed in nets or tankers.

7.2 Leakage

In the case of projects using methane from landfill biogas, it is not considered leakage. GHG emissions from actions such as the construction of generating plants, land-use preparation, upstream emissions from the use of fossil fuels for the transport, extraction or processing of technology used in project are considered negligible.

7.3 Calculation of GHG emissions from the project scenario

The GHG emissions from the project scenario (**PTE_t**) can be calculated with ***Equation 16***.

$$PTE_t = PMFE_t + PFFEA_t + PEE_t + PMLEN_t + PMLETC_t \quad \textbf{Equation 16}$$

Variable	Units	Description
PTE_t	$t\text{-}CO_2e$	Total GHG emissions in period ***t*** of project scenario.
$PMFE_t$	$t\text{-}CO_2e$	GHG emissions from flaring of methane from landfill biogas in period ***t*** of project scenario.
$PFFEA_t$	$t\text{-}CO_2e$	GHG emissions from fuel consumption in auxiliary processes (auxiliary electric power generation, start-up of thermal equipment, distribution of methane in biogas in tank trucks, among others) in period ***t*** of project scenario.
PEE_t	$t\text{-}CO_2e$	GHG emissions from electricity consumption in auxiliary and control systems in period ***t*** of project scenario.
$PMLEN_t$	$t\text{-}CO_2e$	GHG emissions from methane losses in networks and pipeline distribution systems in period ***t*** of project scenario.
$PMLETC_t$	$t\text{-}CO_2e$	GHG emissions from methane losses in tank car distribution systems in period ***t*** of project scenario.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***. There should be a correspondence between the ***t*** values used for the establishment of GHG emissions from the project scenario and those used for the estimation of the baseline scenario.

The GHG emission generation period of the project scenario shall be determined by the life of the core technology. This value should be defined and supported by the project and should not exceed the useful life of the technology.

The project should identify and calculate any other sources of GHG emissions that may apply to the project scenario. The choice of methodologies for calculating GHG emissions from the project scenario is the responsibility of the project owner; these should be recognized and based on the IPCC guidelines for the calculation of GHG emissions, and they should comply with all the principles outlined in this document and the current version of the Cercarbono Protocol.

All values used in the equation, as well as the results obtained, must be supported by the project.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol regarding GHG emissions from the project scenario should be followed.

7.3.1 GHG emissions from the project scenario due to the torch destruction of methane from landfill biogas

In cases where methane from biogas captured from the landfill is destroyed in a torch, this part of the GHG emissions from the project scenario should be determined by the following equation:

$$PMFE_t = \sum_{m=1}^{TTP} \left(MMBFD_{t,m} \times (1 - PEFMD_t) \times MGWP \right) \qquad \textbf{Equation 17}$$

Variable	Units	Description
$PMFE_t$	$t\text{-}CO_2e$	GHG emissions from flaring of methane from landfill biogas in period ***t*** of project scenario.
$MMBFD_{t,m}$	t	Methane in the biogas destroyed in the flare during measurement period ***m*** and in period ***t*** of project scenario.
$PEFMD_t$	%	Eficiencia de destrucción de metano en la antorcha en el período ***t*** del escenario de proyecto.
$MGWP$	N/A	Global warming potential of methane.
m	min	Index of the minute the destroyed methane is being tracked in the flare.
TTP	min	Total period for which the evaluation is performed, quantified in minutes.

The level of temporal disaggregation in the monitoring of $\mathbf{MMBFD_{t,m}}$ and $\mathbf{PEFMD_t}$ data, should be recorded minute by minute, and the monitoring period can be defined by the project developer, but in general annual values can be included for that period. There should be a correspondence between the ***t*** values used for the establishment of GHG emissions from the project scenario and those used for the estimation of the baseline scenario.

The GHG emission generation period of the project scenario shall be determined by the life of the main technology used for the burning of biogas. This value should be defined and supported by the GHG project and should not exceed the useful life of the landfill.

All values used in the equation, as well as the results obtained, must be supported by the project.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol regarding GHG emissions from the project scenario should be followed.

7.3.2 GHG emissions from the project scenario by fossil fuel consumption in ancillary processes

Where fossil fuel consumption is generated under the project scenario for the development of ancillary activities, such as the generation of electric power, the operation of thermal systems, the transport of methane recovered in tankers, among other possible uses, this part of the GHG emissions of the project scenario must be determined with ***Equation 18***.

$$PFFEA_t = \sum_{c=1}^{C}(FFA_{c,t} \times DFEF) \qquad \textit{Equation 18}$$

Variable	Units	Description
$PFFEA_t$	$t\text{-}CO_2e$	GHG emissions from fuel consumption in auxiliary processes (auxiliary electric power generation, start-up of thermal equipment, distribution of methane in biogas in tank trucks, among others) in period t of project scenario.
c	N/A	Fossil fuel type index.
C	N/A	Total amount of fossil fuel types consumed in the project scenario.
$FFA_{c,t}$	*Mass unit or fuel volume.*	Amount of fossil fuel type c consumed in period t of project scenario.
$DFEF$	$t\text{-}CO_2e$*/mass unit or fuel volume.*	CO_2 emission factor for the fuel being displaced by the biogas captured by the project.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***. There should be a correspondence between the ***t*** values used for the establishment of GHG emissions from the project scenario and those used for the estimation of the baseline scenario.

The period of GHG emissions generation in the project scenario shall be determined by the lifetime of the main technology used for biogas capture or use. This value should be defined and supported by the GHG project and should not exceed the useful life of the landfill.

For the **FSFD** it is recommended to use the official emission factors for the country (in Colombia, those generated by the EMU)[9].

All values used in the equation, as well as the results obtained, must be supported by the project.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol regarding GHG emissions from the project scenario should be followed.

7.3.3 GHG emissions from the project scenario due to electricity consumption from an external grid

In cases where electrical energy acquired from an external grid is consumed for the operation of methane capture, destruction or utilization systems present in landfill biogas, this part of the GHG emissions from the project scenario should be determined by the following equation:

$$PEE\_t_t = 0.001 \times BLEC_t \times CEFEN$$ ***Equation 19***

[9] UPME publishes the emission factors for Colombian fuels on the website: http://www.upme.gov.co/calculadora_emisiones/aplicacion/calculadora.html.

Variable	Units	Description
PEE_t_t	$t\text{-}CO_2e$	GHG emissions from electricity consumption in auxiliary and control systems in period t of project scenario.
$BLEC_t$	kWh	Electricity consumption in period t of baseline scenario.
$CEFEN$	$t\text{-}CO_2e/MWh$	CO_2 emission factor of the operating margin of the electrical energy supply network.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period t. There should be a correspondence between the t values used for the establishment of GHG emissions from the project scenario and those used for the estimation of the baseline scenario.

The period of GHG emissions generation in the project scenario shall be determined by the lifetime of the main technology used for biogas capture or use. This value should be defined and supported by the project and should not exceed the useful life of the landfill.

All values used in the equation must be supported project, and the results obtained must be duly supported by the project.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol regarding GHG emissions from the project scenario should be followed.

7.3.4 GHG emissions from the project scenario due to the loss of methane from landfill biogas in pipeline distribution systems

In cases where methane from landfill biogas is distributed in a network using pipelines (whether these are dedicated exclusively to distributing methane from biogas or when combined with natural gas), this part of the GHG emissions from the project scenario should be determined with ***Equation 20***.

$$PMLEN_t = PMBDP_t \times PPLBNG_t \times MGWP \qquad \textbf{Equation 20}$$

Variable	Units	Description
$PMLEN_t$	$t\text{-}CO_2e$	GHG emissions from methane losses in networks and pipeline distribution systems in period ***t*** of project scenario.
$PMBDP_t$	t	Methane in biogas distributed through pipelines in period ***t*** of project scenario.
$PPLBNG_t$	$\%$	Percentage of biogas (or natural gas as appropriate) losses in the distribution network in period ***t*** of project scenario.
$MGWP$	N/A	Global warming potential of methane.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***. There should be a correspondence between the ***t*** values used for the establishment of GHG emissions from the project scenario and those used for the estimation of the baseline scenario.

The period of GHG emissions generation in the project scenario shall be determined by the lifetime of the main technology used for biogas capture or use. This value should be defined and supported by the Project and should not exceed the useful life of the landfill.

All values used in the equation must be supported by the project, and the results obtained must be duly supported by the project. It is assumed in the case of distribution networks where there is a combination with natural gas, that the losses are equivalent in their percentage for the two fuels mixed.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol regarding GHG emissions from the project scenario should be followed.

7.3.5 GHG emissions from the project scenario due to the loss of methane from landfill biogas in tanker distribution systems

In cases where methane obtained from landfill biogas is distributed using tankers, the project scenario should be determined with the following equation:

$$PMLETC_t = (PMBLT_t - PMBUT_t) \times MGWP \qquad \textbf{Equation 21}$$

Variable	Units	Description
$PMLETC_t$	$t\text{-}CO_2e$	GHG emissions from methane losses in tank car distribution systems in period ***t*** of project scenario.
$PMBLT_t$	t	Methane from landfill biogas that is loaded into tanker trucks in period ***t*** of the project scenario.
$PMBUT_t$	t	Methane from landfill biogas that is discharged from tanker trucks in period ***t*** of the project scenario.
$MGWP$	N/A	Global warming potential of methane.

The level of disaggregation in the data can be determined by the project, but in general annual values can be included for period ***t***. There should be a correspondence between the ***t*** values used for the establishment of GHG emissions from the project scenario and those used for the estimation of the baseline scenario.

The period of GHG emissions generation in the project scenario shall be determined by the lifetime of the main technology used for biogas capture or use. This value must be defined and supported by the project and must not exceed the useful life of the landfill.

All values used in the equation, as well as the results obtained, must be supported by the project.

In addition to the guidelines described above, in any case, the guidelines described in the current version of the Cercarbono Protocol concerning GHG emissions from the project scenario should be followed.

8 GHG EMISSION REDUCTION AND DESTRUCTION

The quantification of reduced GHG emissions should be obtained by subtracting the GHG emissions from the baseline scenario and the GHG emissions from the project scenario according to the following equation:

$$\boldsymbol{TMP_t = BLE_t - PTE_t}$$ ***Equation 22***

Variable	Units	Description
$\boldsymbol{TMP_t}$	*t-CO₂e*	Total *ex-ante* mitigation potential in period $\boldsymbol{t}$.
$\boldsymbol{BLE_t}$	*t-CO₂e*	GHG emissions in period $\boldsymbol{t}$ of baseline scenario.
$\boldsymbol{PTE_t}$	*t-CO₂e*	Total GHG emissions in period $\boldsymbol{t}$ of project scenario.

The GHG emission reductions obtained by the project will be inscribed on the RENARE platform, provided that they correspond to the GHG emission reduction commitments assumed by Colombia, which is in addition to the efforts of Monitoring, Reporting and Verification of Colombia, defined in the Climate Change Law and in Resolution 1447 of 2018 of the Ministry of Environment and Sustainable Development, which regulates the system of monitoring, reporting and verification of mitigation actions at the national level.

9 Project Monitoring

The project owner should have all the necessary information to demonstrate that the results and assertions related to the project comply with all the principles and are in line with the methodological requirements of this document, with those identified in the Cercarbono Protocol and with paragraphs 6.9 and 6.11 and Annexes A.3.5, A.3.6 and A.3.8 of ISO Standard 14064-2:2019.

All information and data associated with the project should be subject to validation and verification, following ISO 14064-3:2019 and the Cercarbono Protocol.

Projects should perform an uncertainty assessment during the planning phase and uncertainty analysis in their implementation phase, in line with the guidelines of Annexes A.3.5, A.3.6 and A.3.8 of ISO 14064-2:2019. The project should seek to reduce the uncertainty of information related to the project. The project must develop and implement a monitoring plan for this, which must comply with the conditions set out in the Cercarbono Protocol and paragraph 6.10 of ISO Standard 14064-2:2019.

The monitoring plan should contain:

a) Purpose of monitoring.
b) List of measured and monitored parameters.
c) Types of data and information to report, including units of measurement.
d) Source of data.
e) Monitoring methodologies (estimation, modelling or measurement), calculation approaches and uncertainty. In case of measurement, calibration, and maintenance protocols for measuring equipment should be established or included, as appropriate.
f) Frequency of monitoring, considering the needs of stakeholders.
g) Defining roles and responsibilities, including procedures for authorizing, approving, and documenting changes to logged data.
h) Controls including internal evaluation of input, transformation and output data, and procedures for corrective actions (calibration and maintenance frequency must be related to the manufacturer's indications of the measuring elements and related machinery).
i) GHG information management systems, including the location and retention of stored data and data management including a procedure for the transfer of data between different forms of systems or documentation.
j) Structure of the monitoring report.

The following are the data to be monitored:

Data or parameter	$PBMC_t$
Units	t
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**). Minimum, daily records.
Description	Methane in biogas expected to be captured, destroyed, or used in period ***t*** of the project scenario.
Data source	Measured by the project on volumetric meters of natural gas. To determine the mass flow from volumetric flow data, use the latest version of CDM methodological tool 08 *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*.
Calibration frequency	At least annually.

Data or parameter	$BLGDC_t$
Units	t
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**). Minimum, daily records.
Description	Methane in biogas expected to be destroyed by combustion in period ***t*** of the baseline scenario.
Data source	Estimated by the project from $PBMC_t$ measurements performed on volumetric meters. To determine the mass flow from volumetric flow data, use the latest version of CDM methodological tool 08 *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*.
Calibration frequency	At least annually.

Data or parameter	FOM_t
Units	N/A

Data or parameter	FOM_t
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Fraction of methane oxidised in period t.
Data source	IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5 Waste. Chapter 3: Solid Waste Disposal. Table 3.2 Oxidation factor (OX) for SWDS.

Data or parameter	ηSC
Units	N/A
Periodicity	N/A
Description	Efficiency of the biogas capture system (or of the system to be installed in the landfill).
Data source	Technical specifications of the biogas capture system to be installed (if available) or a value of 50 per cent by default.

Data or parameter	F
Units	N/A
Periodicity	The lowest possible frequency shall be applied according to the landfill's ability to obtain the value. Minimum, monthly.
Description	Methane fraction by volume in the gas generated in the landfill. The default data proposed by the IPCC (2019) can be used or it can be a value calculated directly by project. a) Default values: according to the IPCC (2019), most waste in landfills generates a gas with approximately 50% methane. Only material that includes substantial amounts of fat or oil can generate gas with substantially more than 50% methane. Therefore, the use of the IPCC default value for methane fraction in landfill gas (0,5) is recommended. b) Measured value: the fraction of methane in the landfill gas generated should not be confused with the methane measured in the gas emitted by landfills. In the landfill, CO_2 is absorbed in the filtration water and the

Data or parameter	F
	neutral condition of the landfill transforms much of the CO_2 absorbed into bicarbonate; therefore, it is good practice to adjust CO_2 absorption in filtration water, if the methane fraction in the landfill gas is based on measurements of methane concentrations measured in the landfill gas emitted by the landfill (IPCC, 2019; Bergman, 1995; Kämpfer and Weissenfels, 2001; IPCC, 1997). The measured values should be supported by the DDA.
Data source	Default value: IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5 Waste. Chapter 3: Solid Waste Disposal. Measured value: measured by the project.
Calibration frequency	Measured value: at least annually.

Data or parameter	BLW_t
Units	t
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Mass of waste expected to be deposited in the landfill in period t of the baseline scenario.
Data source	Measured by the project. Scales for the reception of waste at the entrances of landfills.
Calibration frequency	Defined by the project, according to its metrology plan. At least annually.

Data or parameter	$FDOC_t$
Units	N/A

Data or parameter	$FDOC_t$
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Fraction of degradable organic carbon in the waste expected to be deposited in period ***t***. The **$FDOC_t$** fraction is estimated as the average among groups or classes of waste (types) or materials within a landfill. It is calculated from **Equation 10**.
Data source	For the total estimation of the **$FDOC_t$** fraction, it is important to have precision with the inert or non-degradable content of the waste contained in a landfill. This calculation should be supported step by step and the specific values obtained from the secondary information should be correctly referenced (IPCC, 2019).

For a specific year of **TVi** monitoring, the degradable organic carbon fraction in the waste expected to be deposited in that year is calculated as:

(Equation 23)

Data or parameter	$FDOC_{w,t}$
Units	***N/A***
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	A fraction of degradable organic carbon that decomposes under anaerobic conditions for groups or classes of ***r*** residue in the ***t*** period of the baseline scenario. According to the IPCC (2019), it is good practice to use values of the fraction **$FDOC_{w,t}$** estimated for the different types of waste. It is recommended to use the values proposed by the IPCC (2019) for the different types of waste, with different degrees of biodegradability. In the absence of this information for a landfill the default value of **$FDOC_{w,t}$** will be 0,5 as recommended in the IPCC Guidelines (2019). It is recommended to follow the other guidelines of the IPCC (2019) methodology for the presentation of the value of **$FDOC_{w,t}$**.
Data source	IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5 Waste. Chapter 3: Solid Waste Disposal. Table 3.0 (new)Fraction of degradable organic carbon which decomposes (**DOC_f**) for different waste types.

Data or parameter	$FDOC_{w,t}$
Data or parameter	*MCF*
Units	***N/A***
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Methane correction factor for aerobic decomposition in the year of deposition. This correction factor was determined by the IPCC (2019), for the default values of landfills with and without active aeration. The latter known as semi-aerobic fillings can be superficial or deep and, in their design, active aeration is not contemplated. Despite this, in both types of filler, there is a significant reduction of the **$FDOC_t$** fraction due to aerobic degradation processes, which justifies the estimation of correction factors increasingly accurate. Aeration processes mainly affect microbial activity resulting in high fluctuations in methane emission, therefore, the use of values from *in situ* measurements is recommended, to monitor this effect and obtain a more accurate measurement (IPCC, 2019). The IPCC (2019) publishes the average values for the **MCF** according to the conditions indicated, which are recommended to be used in situations where no associated measurement is performed.
Data source	IPCC. 2019. Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5 Waste. Chapter 3: Solid Waste Disposal. Table 3.1 (updated) SWDS classification and methane correction factors (**MCF**).
Calibration frequency	Not applicable.

Data or parameter	$EFDIE_t$
Units	***t-CO2e/MWh***
Periodicity	Continuous measurement, with recording at least every hour, but with the same frequency of **$PDE_{i,j}$**.
Description	CO_2 emission factor of the interconnected grid, for the electricity expected to be displaced by the electricity produced by the project in period ***t***.
Data source	a) Data on GHG emissions produced per unit of electricity supplied may be used, provided they are provided by the organization managing the interconnected grid or by the competent energy authority. For

Data or parameter	$EFDIE_t$
	the project ***t*** period, the national emission factor of year ***t-1*** (t minus one) can be applied, because usually the official value of year ***t is published in the last month of year t + 1 (t plus one).*** b) The CDM[10] methodology can be used by the project for the calculation of emission factors for power grids or calculated from the ratio of the amount of emissions produced by fuel consumption for electricity supply in the interconnected grid to the total electricity produced, using the Combined Margin Factor tool of the most recent version of the CDM methodological tool.

Data or parameter	$FCNIZ_{c,t}$
Units	Mass unit or fuel volume.
Periodicity	It can be monitored more regularly, but in the equation, it must be reported in the same $\mathbf{PDE_{i,j}}$ temporal units.
Description	Consumption of fuel c by each generation unit belonging to the Non-Interconnected Zone in period ***t*** of the baseline scenario. If the fuel is a gas, the volume should be normalized.
Data source	The data must originate from the organization managing the non-interconnected network or the competent energy authority in the NIA.

Data or parameter	CEF_c
Units	N/A
Periodicity	Not applicable.
Description	CO_2 emission factor for fuel with which electricity is generated in the NIZ and which is displaced by the electricity produced by the project.
Data source	The data should be the same as that used for the National GHG Inventory (INGEI).

[10] Use the latest version of CDM methodological tool 07 "*Tool to calculate the emission factor for an electricity system. Methodological tool.*

Data or parameter	CEF_c
Data or parameter	*TGENIZt*
Units	***MWh***
Periodicity	It can be monitored more regularly, but in the equation, it must be reported in the same temporal units of $\mathbf{PDE_{i,j}}$.
Description	Total electricity generated in the NIZ in period ***t*** of the baseline scenario.
Data source	The data must originate from the organization managing the non-interconnected network or the competent energy authority in the NIA.

Data or parameter	*WOM*
Units	***%***
Periodicity	It can be monitored more regularly, but in the equation, it must be reported in the same temporary units of $\mathbf{PDE_{i,j}}$.
Description	Weighting of the operating margin emissions factor (percentage), calculated using the procedure proposed in the most up-to-date CDM methodology.
Data source	To calculate the operating margin emission factor, use the latest version of CDM methodological tool 07 "*Tool to calculate the emission factor for an electricity system*".

Data or parameter	$CMEFNIZ_t$
Units	***N/A***
Periodicity	It can be monitored more regularly, but in the equation, it must be reported in the same temporary units of $\mathbf{PDE_{i,j}}$.
Description	Emission factor of the construction margin in the Non-Interconnected Zone in period ***t***, calculated using the procedure proposed in the most up-to-date CDM methodology.

Data or parameter	$CMEFNIZ_t$
Data source	To calculate the construction margin factor, use the latest version of CDM methodological tool 07 "*Tool to calculate the emission factor for an electricity system*".

Data or parameter	WCM
Units	$\%$
Periodicity	It can be monitored more regularly, but in the equation, it must be reported in the same temporary units of $\mathbf{PDE_{i,j}}$.
Description	Weighting of the construction margin emissions factor (percentage), calculated using the procedure proposed in the most up to date CDM methodology.
Data source	To calculate the emission factor of the construction margin, use the latest version of CDM methodological tool 07 "*Tool to calculate the emission factor for an electricity system*".

Data or parameter	$LCVM$
Units	MJ/t
Periodicity	Not applicable.
Description	Lower calorific value of methane.
Data source	UPME. 2016. Emission Factors of Colombian Fuels FECOC 2016.
Calibration frequency	Not applicable.

Data or parameter	$LCVDFF$
Units	MJ/mass unit or fuel volume.

Data or parameter	*LCVDFF*
Periodicity	Not applicable.
Description	Lower calorific value of fossil fuel displaced by the use of biogas.
Data source	UPME. 2016. Emission Factors of Colombian Fuels FECOC 2016.
Calibration frequency	Not applicable.

Data or parameter	*DFEF*
Units	***t-CO2e***/mass unit or fuel volume.
Periodicity	Not applicable.
Description	CO_2 emission factor for the fuel being displaced by the biogas captured by the project.
Data source	The data should be the same as that used for the National GHG Inventory (INGEI).

Data or parameter	*LCVNG*
Units	***MJ***/mass unit or natural gas volume.
Periodicity	Not applicable.
Description	Lower calorific value of natural gas displaced using methane from biogas.
Data source	UPME. 2016. Emission Factors of Colombian Fuels FECOC 2016.
Calibration frequency	Not applicable.

Data or parameter	$DBEF$
Units	$t\text{-}CO2e$/mass unit or natural gas volume.
Periodicity	Not applicable.
Description	CO_2 emission factor of the natural gas being displaced by the biogas captured by the project.
Data source	The data should be the same as that used for the National GHG Inventory (INGEI).

Data or parameter	$PNGPDN_t$
Units	$\%$
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Percentage of methane in the natural gas distributed in the grid in period t of the project scenario.
Data source	Provided by those responsible for the administration of the natural gas network into which methane from landfill biogas is injected.

Data or parameter	$BLMBFFDWN_t$
Units	t
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**). Minimum, daily records.
Description	Methane in landfill biogas that is expected to be used to displace fossil fuel that would be used if there were no dedicated network or tank car distribution in period t of the baseline scenario.
Data source	Measured by the project in volumetric meters. To determine the mass flow from volumetric flow data, use the latest version of CDM methodological tool 08 *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*.

Data or parameter	$BLMBFFDWN_t$
Calibration frequency	At least annually.

Data or parameter	$BLPLFF_t$
Units	%
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Percentage of fossil fuel distribution network losses (if applicable) in period t of the baseline scenario.
Data source	Provided by those responsible for the administration of the natural gas network into which methane from landfill biogas is injected.

Data or parameter	$BLPMFFG_t$
Units	%
Periodicity	The same as defined for the quantification of GHG emissions from the baseline scenario (**BLE_t**).
Description	Percentage of methane in the fossil fuel distributed in the grid (if applicable) in period t of the baseline scenario.
Data source	Provided by the managers of the fossil fuel network into which methane from landfill biogas is injected.

Data or parameter	*PEFMDt*
Units	%
Periodicity	The same as defined for the quantification of GHG emissions from the project scenario (**PTE_t**). The records are minute by minute, as recommended by the UNFCCC.

Data or parameter	*PEFMDt*
Description	Flare methane destruction efficiency in period ***t*** of the project scenario, defined as one minus the ratio of the methane mass flow in the exhaust gas to the methane mass flow in the landfill biogas to be burned[11]. The efficiency of methane destruction in the torch depends on its combustion efficiency and the time "t_m" that the torch is operating quantified in minutes. To determine the efficiency of closed torches, project participants must determine the efficiency based on monitored data or the option of applying a default value. For open flares, a default value must be applied. The operating time of the torch must be quantified minute by minute and is determined using a flame detector. In the case of enclosed torches, in addition, the control requirements provided by the manufacturer's specifications for operating conditions must be met.
Data source	In the case of open torches, the torch efficiency in minute ***m*** ($PEFMD_t$) is 50% when the flame is detected in minute ***m***, otherwise **$PEFMD_t$** is ***0%.*** In the case of closed torches, the torch efficiency can be taken by default, such as $PEFMD_t$ equal to 90% (the previous value applies if two conditions are met: (i) the temperature of the torch and the flow of the waste gas to the torch are within the specifications of the torch manufacturer in minute ***m***, and ii) the flame is detected in minute ***m***; It cannot be measured according to the guidelines in paragraph 6.2.2.2 of the latest version of CDM methodological tool 06 *"Project emissions from flaring"*.

Data or parameter	$FFA_{c,t}$
Units	Mass unit or fuel volume.
Periodicity	The same as defined for the quantification of GHG emissions from the project scenario (PTE_t). Minimum, monthly records.
Description	Amount of fossil fuel type c consumed in period ***t*** of the project scenario.
Data source	Measured by the project in volumetric or mass meters or weighed in scales according to the fuel type.
Calibration frequency	At least annually.

[11] This information has been taken from the latest version of CDM methodological tool 06 *"Project emissions from flaring"*.

Data or parameter	$BLEC_t$
Units	***kWh***
Periodicity	The same as defined for the quantification of GHG emissions from the project scenario (**PTE_t**)*.* Minimum, monthly records.
Description	Electricity consumption in period ***t*** of the baseline scenario.
Data source	Meters totalizers located at the point of reception of energy of the national or local interconnected network.
Calibration frequency	If it is a meter of the distribution company, calibration is not applicable; if it is a gage of its own, the calibration must be at least annual.

Data or parameter	***CEFEN***
Units	***t-CO2e/MWh***
Periodicity	Same as **$BLEC_{t's}$**.
Description	CO_2 emission factor of the operating margin of the electrical energy supply network.
Data source	a) Data on GHG emissions produced per unit of electricity supplied may be used, provided they are provided by the organization managing the interconnected grid or by the competent energy authority. For the project period t, the national emission factor of year ***t -1*** (t minus one) can be applied, because usually the official value of year t***is published in the last month of year t + 1 (t plus one).*** b) The project owner may use the CDM[12] methodology to calculate the emission factors of power grids, or to calculate them from the ratio of the amount of emissions produced by fuel consumption for electricity supply in the interconnected grid to the total electricity produced, using the latest version of the tool for calculating the CDM Margin of Operation Factor.

[12] Use the latest version of methodological tool 07 of the CDM "*Tool to calculate the emission factor for an electricity system*".

10 Project validation, verification, and reporting

The validation, verification and reporting process of the project should consider the most recent version of the Cercarbono Protocol and in paragraphs 6.12 and 6.13 of ISO Standard 14064-2:2019.

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12 Document history

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Version	**Date**	**Comments/Changes**
1.0	10/26/2020	Initial version of the document presented in public consultation from 26/10/2020 to 06/11/2020.
1.1	01/20/2021	Final version with built-in public query comments and additional elements.
1.1	03/02/2021	Naming assignment M/WM-RE_ED01 on the cover of this methodology.
1.1	03/02/2021	Change of wording in the footer of the copyright back page of: "Without the permission of the editor, all or parts of this document cannot be reproduced or used in any form or by any means, electronic or mechanical, including scanning, photocopying and microfilming." Changed by: "Partial or total reproduction of this document or its use in any form or by any means, electronic or mechanical, including scanning, photocopying and microfilming, is not permitted without the permission of Cercarbono Rights Reserved."
1.1	03/02/2021	The following wording is deleted from Section 4.3: or thesis, both of which have been implemented in the construction of carbon mitigation projects and have served to generate carbon credits.
1.1	03/02/2021	The terms and definitions in Section 2 have been moved and integrated into the document: "Terms and definitions of the Cercarbono voluntary certification programme".
1.1	03/28/2021	The content of Section 2 was adjusted, Equation 4 was amended (the efficiency parameter of the biogas distribution system of a landfill was integrated within the efficiency parameter of the capture system, ***ηSC) and Equation 1 and 2 were approved (the symbolism of the term of GHG emissions by the biogas produced in the landfill, EBLBt, was adjusted).***

ANNEX 1. INDICATIVE CHECKLIST FOR THE APPLICATION OF METHODOLOGY M/WM-RE_ED 01 FOR THE IMPLEMENTATION OF RP-GHG/WM-RE_ED

The following checklist covers aspects related to the application of the MR.-DR.-DE methodology for the implementation of the project and the latest version of the Cercarbono Protocol, up to the time prior to the development of the validation process by a Validation and Verification Agency (OVV).

Criterion	Complies	Not compliant	Not applicable
The project is related to the capture, destruction or energy use of methane contained in biogas produced in landfills.			
The project is intended to be eligible for performance payments or similar offsets because of climate change mitigation actions that result in GHG emission reductions.			
The project complies with the principles of completeness, reliability, conservatism, consistency, evidence, accuracy, and transparency.			
The project relates to new, existing facilities, upgrades, refurbishments, or system replacements, which perform at least one of the following functions: • Capture and destruction of the methane contained in the gas produced in landfills by combustion (in torches, engines, or burners, among others) that, in the absence of the project, would be released directly into the atmosphere. • Electricity generation using methane contained in gas from landfills. • Thermal energy generation by burning methane contained in gas from landfills. • Production of biofuel by capturing gas generated in landfills for injection into natural gas distribution networks, partially displacing this fuel. • Production of biofuel by capturing gas generated in landfills for injection into			

Criterion	Complies	Not compliant	Not applicable
natural gas distribution networks, partially displacing this fuel. • Biofuel production by capturing gas generated in landfills to distribute natural gas directly to users, partially displacing this fuel. • Capture and use the methane contained in the gas produced in landfills for distribution by tankers to users who, in the absence of the project, would use fossil fuels instead.			
No biogas capture system is in operation prior to the implementation of the project, or if one is in operation, it should be verified that it did not allow biogas use or was optimized or improved in operation to optimize biogas capture conditions.			
The installation of project does not lead to a reduction in the amount of organic waste that is or would be recovered in its absence.			
The project does not deliberately increase the amount of methane produced in the landfill through operation strategies, with respect to the identified base conditions.			
The objective of the project describes the main positive impact expected by the implementation of project activities and the mitigation potential of project results.			
The objective of the project includes at least the main activity, the place of implementation, the actors involved and the period of execution of actions.			
A DDA has been developed in accordance with the latest version of the Cercarbono Protocol, based on an approved methodology and including the baseline scenario, GHG emission reduction calculations and the monitoring plan for project activities that reduce GHG emissions by project type.			

Criterion	Complies	Not compliant	Not applicable
The start date of operations of the project is a maximum of five years before the registration of the initiative with the Cercarbono certification programme and the EcoRegistry platform.			
The crediting period of the project is 20 years or equal to the operational life of the same in case of less than 20 years.			
The PDD includes information from the incumbent or other project participants as appropriate, detailing their roles and responsibilities, including contact and stakeholder information.			
The PDD includes title, purpose(s) and objective(s) of the project.			
The PDD includes the sectoral scope and type of project, indicating that it is a project for capturing, destroying, or exploiting biogas produced in landfills (project).			
The PDD includes a description of the project and how it will achieve GHG emission removal or reduction, including the specific types of GHG it covers.			
The PDD includes the justification of why the proposed project is considered as additional.			
The project meets the additionality criteria set out in Resolution 1447 of 2018 of the Ministry of Environment and Sustainable Development of Colombia (or the one that modifies or replaces it), demonstrating that by developing the project methane is reduced or destroyed in biogas produced in landfills, preventing it from being emitted directly into the atmosphere or taking advantage of the methane present in biogas produced in the landfill, displacing the use of fossil fuels and preventing methane from being released directly into the atmosphere.			
It is demonstrated that procedures are in place to assess and test the additionality of the project			

Criterion	Complies	Not compliant	Not applicable
and that these procedures provide reasonable assurance that reductions or destruction of GHG emissions would not have occurred in the absence of the project.			
The PDD includes the location and boundaries of the project, including organizational, geographic, and physical location information, which allows the unique identification and delineation of the project-specific extent.			
Data from the project installation site such as country, department, municipality, among others, including its geographical coordinates (in the official reference system for Colombia: MAGNA-SIRGAS).			
The project is in Colombia.			
The PDD includes a detailed description and support of ownership or right of use of the project area.			
The owner(s), holder(s) or holder(s) of the facilities in which the project is intended are expressly authorized (including those associated with the land and the capture, destruction or harvesting infrastructure).			
Evidence of rights or ownership of the project facilities and, if applicable, evidence showing that the respective environmental license is in place for their operation has been included.			
The ownership of the GHG emission reductions of project among stakeholders is evidenced, i.e., the participation, claim or assignment of these should be supported by a document signed between the parties.			
The PDD describes the results of consultations among the owners or participants of the project initiative, as required.			
Compliance with local, regional, and national laws, statutes and regulatory frameworks that apply to project activity has been linked,			

Criterion	Complies	Not compliant	Not applicable
described, and justified, including relevant environmental requirements and registration of specific project actions.			
The documents certifying the prior consultation for the environmental licensing procedure of the project have been submitted, per Colombian law.			
The PDD includes evidence of the environmental impacts that the implementation of the project had or continues to have.			
The project has an effective participation protocol that includes: - A map of actors, an institutional map of the other governance structures or institutions and leaders associated with decision-making in the territory, associated with project activities. - Decisions agreed with local governance structures. - Traceability of consensus processes. - Handling of petitions, complaints, complaints and requests and their traceability. - A framework schedule of meetings for project decision-making. - A protocol for conflict management. - A document of agreement signed with the representative parties of the local communities for the development of the project.			
The PDD includes features or conditions before the start of the project.			
The PDD includes a description of the project technologies, products and services and the expected level of activity.			
The PDD includes the description and justification of the selection of this methodology for the implementation of the project.			
The PDD includes a detailed description of the baseline scenario for the project.			

Criterion	Complies	Not compliant	Not applicable
The PDD includes the identification of GHG emission sources from the baseline scenario for the project per **Section 6.2** of this methodology.			
Whatever the situation of project, the methodological guidelines related to this methodology are considered and the guidelines that do not apply to the type of project performed are discarded or dismissed.			
The DDA includes baseline scenario GHG emissions, estimated or calculated in tCO_2e.			
In determining the baseline scenario, existing and alternative project types, activities, and technologies providing an equivalent type and level of activity of products or services for project were considered.			
In determining the baseline scenario, data availability, reliability and limitations associated with project were considered.			
In determining the baseline scenario, other relevant information on current or future project conditions was considered, such as legislation, technical, economic, sociocultural, environmental, geographical, site-specific, and temporal assumptions, or projections.			
Criteria and procedures were selected, described, and applied to identify and justify the baseline scenario in the project.			
The justification of the project GHG emission baseline scenario considers the likely future behaviour of the baseline scenario (GHG emission sources) to comply with the conservatism principle.			
Functional equivalence in the type and activity level of methane generation (the products or services provided) has been demonstrated between the project scenario and the baseline scenario and any significant differences between the two.			

Criterion	Complies	Not compliant	Not applicable
Emissions from each relevant source in the baseline scenario have been quantified, converting the amount of each type of GHG to tCO_2e, and considering the applicable equations presented in **Section 6.3** of this methodology.			
The DDA includes baseline scenario GHG emissions, estimated or calculated in tCO_2e.			
The GHG emission reductions achieved by systems not covered by this methodology, such as aeration treatment (*in situ* or passive) in the landfill, oxidation layers in the landfill, hydrogen production from biogas, etc.			
If emission factors were developed for the calculation of the baseline scenario of the project, these: a) They are derived from a recognized origin. b) They are appropriate for the sources in question. c) They are suitable for the time of quantification. d) They produce precise and reproducible results of uncertainty quantification. e) They are consistent with the intended use of the GHG report.			
The baseline scenario of project allows concluding that, if not performed, the biogas would have been: (i) released directly into the atmosphere; or (ii) destroyed to avoid odours or for safety.			
The PDD includes co-benefits related to project.			
The PDD includes a detailed description of the project scenario.			
The DDA includes the identification of GHG emission sources from the project scenario per **Section 7.1** of this methodology.			
The DDA includes the quantification of GHG emissions that can occur by project, estimated, or			

Criterion	Complies	Not compliant	Not applicable
calculated in tCO_2e, and considering the equations described in **Section 7.3** of this methodology.			
The description of the project scenario includes a list and layout of key technologies, systems, and equipment, including information on the age and average life of the equipment according to the manufacturer's specifications and industry standards, as well as existing and planned capabilities, load factors and efficiencies.			
The description of the project scenario includes the types and service levels (in terms of mass or energy flows) provided by the systems and equipment being modified or installed, and their relationship to other equipment and manufacturing or production systems outside the project limit and describes how this would have been done in the baseline scenario.			
The description of the project scenario includes a list of facilities, systems, and equipment in operation under the existing scenario before the implementation of the project.			
The project scenario description indicates the criteria for quantifying GHG emissions or reductions during the implementation and operation of the project.			
If emission factors were developed for the calculation of the project scenario, these: a) They are derived from a recognized origin. b) They are appropriate for the sources in question. c) They are suitable for the time of quantification. d) They produce precise and reproducible results of uncertainty quantification. e) They are consistent with the intended use of the GHG report.			
The DDA includes the net GHG emission reduction that can occur by project, estimated, or			

Criterion	Complies	Not compliant	Not applicable
calculated in tCO_2e, based on the equation described in **Section 8** of this methodology.			
Criteria and procedures have been selected and applied to estimate or monitor selected sources using appropriate and reliable data.			
The PDD includes the project monitoring plan.			
The project monitoring plan includes procedures for measuring or estimating, recording, compiling, and analysing data and important information, for quantifying and reporting GHG emissions or reductions relevant to the baseline scenario and project scenario (i.e., a GHG information system using recommended technologies).			
The project monitoring plan includes the purpose of monitoring.			
The project monitoring plan includes a list of measured and monitored parameters.			
The project monitoring plan includes the types of data and information to report, including units of measurement.			
The project monitoring plan includes the source of the data used.			
The project monitoring plan includes monitoring methodologies (estimation, modelling or measurement), calculation approaches and uncertainty. In the case of measurement, calibration, and maintenance protocols for measuring equipment are established or included.			
The project monitoring plan includes monitoring frequency, considering the needs of stakeholders.			
The project monitoring plan includes defining roles and responsibilities, including procedures			

Criterion	Complies	Not compliant	Not applicable
for authorizing, approving, and documenting changes to recorded data.			
The project monitoring plan includes controls including internal evaluation of input, transformation and output data, and procedures for corrective actions.			
The project monitoring plan includes GHG information management systems, including the location and retention of stored data and data management that includes a procedure for transferring data between different forms of systems or documentation.			
The project monitoring plan includes the structure of the monitoring report.			
Evidence has been guaranteed and is available to demonstrate that the measuring equipment used in the project remains calibrated or verified, as appropriate.			
Procedures for the management and quality of project data and information have been established and implemented, including uncertainty assessment, relevant to project and baseline scenarios, as stipulated in the methodology.			
Uncertainties related to the quantification of GHG emission reductions of the project have been minimized, where possible.			
The PDD includes the identification of risks that could substantially affect the GHG emission reduction of the project, as well as measures to manage such risks.			
The PDD includes the authorizations and documents required by current legislation for the development and operation of the project, such as the Environmental License, Environmental Impact Assessment, Environmental Management Plan, among others, depending on the type of RP-GHG/WM-RE-ED.			

Criterion	Complies	Not compliant	Not applicable
Documentation is available to demonstrate compliance of the project with the latest version of the Cercarbono Protocol. This documentation must be consistent with the validation, verification, and certification processes.			
Project documentation is registered on the EcoRegistry platform.			
The PDD includes relevant results of stakeholder consultations and mechanisms for ongoing communication, if appropriate. Including the definition of when and how affected/involved persons should be consulted.			
The PDD includes the actual time plan or dates and justification for: • The start date of project activities. • The period of the GHG emission baseline scenario. • The end date of the project. • The frequency of monitoring and reporting and the project period, including relevant project activities at each step of the project cycle, as appropriate. • The frequency of checks, including the periods in which they are carried out.			
A Cercarbono account has been created through EcoRegistry to register the project.			
An identification number is available for the project.			