CLEAN DEVELOPMENT MECHANISM
SMALL-SCALE PROGRAM ACTIVITY DESIGN DOCUMENT FORM (CDM-SSC-CPA-DD)
Version 01

CONTENTS

Annexes

NOTE:

(i) This form is for submission of CPAs that apply a small scale approved methodology using the provision of the proposed small scale CDM PoA.

(ii) The coordinating/managing entity shall prepare a CDM Small Scale Programme Activity Design Document (CDM-SSC-CPA-DD)[1,2] that is specified to the proposed PoA by using the provisions stated in the SSC PoA DD. At the time of requesting registration the SSC PoA DD must be accompanied by a CDM-SSC CPA-DD form that has been specified for the proposed SSC PoA, as well as by one completed CDM-SSC CPA-DD (using a real case). After the first CPA, every CPA that is added over time to the SSC PoA must submit a completed CDM-SSC CPA-DD.

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[1] The latest version of the template form CDM-CPA-DD is available on the UNFCCC CDM web site in the reference/document section.

[2] At the time of requesting validation/registration, the coordinating managing entity is required to submit a completed CDM-POA-DD, the PoA specific CDM-CPA-DD, as well as one of such CDM-CPA-DD completed (using a real case).

SECTION A. General description of small scale CDM programme activity (CPA)

A.1. Title of the small-scale CPA:

CPA-1: Navarro Landfill, Cali

Version 1, dated 10/10/2011

A.2. Description of the small-scale CPA:

The present CPA is to be implemented as part of the CDM PoA "Programme for the Capture and Destruction or Utilization of Landfill Gas in Colombia". The PoA aims primarily at avoiding methane emissions from landfills in Colombia but also offers the option for emission reductions from the utilization of landfill gas.

The CPA is in its phase 1 the capture and destruction of landfill gas captured from the closed Navarro Landfill in Cali, and is therefore according to Scenario 1- "LFG Capture and Flaring" of the PoA-DD. A potential phase 2 comprises the partial use of captured landfill gas (LFG). It might be sold in order to be used as fuel for Cali's rapid bus system "MetroCali". In case of implementation, this second phase corresponds to scenario 3- "LFG Capture and Utilization without claiming CERs" detailed in the PoA-DD. Accordingly, CERs would not be claimed although emissions would be reduced below baseline levels.

The Navarro landfill site is located in the South-East of Cali in the village of Navarro on the left banks of the Cauca river, i.e., in a distance of 3.5 km to the city district of Ciudad Córdoba. It received municipal solid waste from the city of Cali and its surrounding area. It had been in operation between 1970 and 2008. In the year 1966 the company "Empresa de Servicios Varios Municipales de Cali– EMSIRVA E.S.P." was created. In the beginning of 1984, EMSIRVA bought the plots where Navarro landfill is located from the Regional Autonomous Corporation of the Cauca Valley (CVC). Three zones of the landfill had been filled as follows:

- Antique Zone: This zone occupies around 16 ha, and was operated as a dump site for municipal waste from September 1st, 1970 until September 30th, 2001. During that time it received approximately 15.4 million tons of waste (please note that this figure is not based on actual records but extrapolated backwards from quantities received after 2001). The Antique Zone was built on natural terrain without the appropriate impervious liner. A final cover consisting of a clayey material of some 50 cm strength was installed upon closure. The area supports the growth of grass, small trees and other vegetation that helps to minimize erosion.
- Transitional Zone: This zone occupies around 13 ha, and was operated as a sanitary landfill from October 1st, 2001 until September 30th, 2007. During that time it received approximately 3.9 million tons of waste according to EMSIRVA's records. The Zone was constructed with an impervious HDPE geo-membrane liner. A final cover consisting of a compressed clayey material of some 40 cm strength, a gravel of some 30 cm strength, and a cover of some 30 cm strength was installed upon closure, with vegetation upon it.

- New Zone: This zone occupies around 2 ha, and was operated as a sanitary landfill from October 1st, 2007 until June 25th, 2008. During that time it received approximately 0.5 million tons of waste according to EMSIRVA's records. The Zone was constructed with an impervious HDPE geo-membrane liner. A final cover as per the Transitional Zone was installed.

The organic share, the source of methane emissions from landfills, is very high in developing cities like Cali. Total organic share is around 82% including fast and slow decaying organic materials. The remainder is rubber, textiles, metals, plastics, glass and ceramics, and other inert material like soil and demolition material.

The landfill disposes of a leachate drainage system with treatment of leachate in oxidation ponds and passive gas venting wells. The waste accumulation varies mainly due to topography. In the two newest zones there has been some compaction with heavy bulldozers. The filling height of the landfill in combination with the mechanical compaction and the tropical climate entails anaerobic conditions in the landfill with rather high decomposition rates of organic waste compounds.

It is the purpose of Phase 1 of this CPA to capture and destroy the methane emissions entailed by the anaerobic decay. Most likely LFG will only be captured from the Transitional and New Zones of the Navarro Landfill, because in the Antique Zone the organic waste has already largely decomposed. The collection will be via an active gas collection system comprising of gas wells and connection piping between gas wells to a gas flare. The destruction of landfill gas will be via an enclosed flare located on the landfill site. Currently, the landfill only disposes of a passive venting system. The existing wells have to be supplemented by new wells and partially have to be replaced. Further, an active degassing by installation of a blower system will be implemented. This is one condition for a proper operation of the implemented flaring system. The capture efficiency of the overall system will be around 50%.

A potential Phase 2 of the CPA (which is still subject to an internal Feasibility Study) will additionally comprise the upgrading, conditioning and feeding of LFG to the fleet of urban buses "MetroCali". This Phase 2 is still in the project development stage, its implementation is currently quite uncertain, and no CERs will be claimed for the fuel switch component in the transport sector. This phase will start operation approximately one year after the operation start of phase 1. The implementation of this phase 2 is envisaged to be outsourced to a third party. The project participant(s) would only sell LFG to this third party.

The CPA can be summarised as follows:

- Phase 1: Implementation of an LFG collection and destruction system comprising of collection piping and gas wells and a flaring system at the Navarro Landfill; and
- Phase 2: Partial use of LFG by upgrading, conditioning and feeding to urban buses (LFG being sold to third party).

Contributions to sustainable development
In this CPA, the baseline scenario consists in the release of GHG emissions to the atmosphere, further contributing to global warming and its consequences. The released GHGs are mainly methane, a rather powerful greenhouse gas with a global warming potential of 21 (GWP_{100}). The implementation of the CPA will reduce the release of methane emissions from landfills directly by up to 50%.

Landfill gas capture projects are not common in Colombia. Main technology components will be imported to Colombia being a good example of technology transfer. After the installation of the technology, qualified personnel will be necessary for the operation and maintenance of the installed equipment and for the monitoring of the landfill gas collection.

The potential Phase 2 will further assist to sustainable development by replacing fossil fuel by LFG.

A.3. Entity/individual responsible for the small-scale CPA:

The implementing and operating entity of the CPA will be CarbonBW Colombia S.A.S (CarbonBW). CarbonBW will also serve as Coordinating and Managing Entity of the PoA.

A.4. Technical description of the small-scale CPA:

Out of the potential components defined in the PoA, CPA-1 includes the following components:

YES	NO	Component
x	-	LFG capture
x	-	LFG destruction with enclosed flare
-	x	Utilization of LFG for direct electricity generation with flaring of excess gas
-	x	Utilization of LFG for direct heat generation with flaring of excess gas
-	x	Utilization of LFG for direct heat and electricity generation with flaring of excess gas
x	-	Utilization of LFG without claiming CERs for emissions reduced due to the utilization of the renewable fuel “LFG”

Accordingly the following technology will be applied by the CPA, Phase 1:

1. **Landfill gas collection system**

State-of-the-art gas collection technology to be included in this CPA includes the items listed below:

- A defined number of vertical and horizontal gas wells equipped with wellheads for measurements;
- Connection pipelines between gas wells and flaring station. These systems are usually designed as modular system in order to allow for future extension in case of open landfills;

2. **Flaring system**

In order to ensure high standard gas destruction efficiencies, state-of-the-art gas flares will be applied as listed:

- One electric blower with approximately 8 kW to create suction at inlet for LFG extraction and pressure at outlet for flare operation;
- Enclosed flare to ensure highest efficiency in flaring. Flaring temperature is above 900 °C under normal operation conditions. The flare accepts methane concentrations between 35% and 60%.

The flaring efficiency is above 99% under normal operation conditions; the flare capacity will be 200 m³/h (minimum) to 1,000 m³/h (maximum);

- Web-based remote supervision and control of the flare;
- Alarm system; and
- Security restart system in case of system shut down.

Potentially, the following technology will be applied by the CPA, Phase 2:

3. Landfill gas conditioning system

The system for the conditioning of the LFG to be used as CNG in transportation activities is envisaged to be implemented by a third party, in case this system is implemented, at all. The components of such a system typically comprise of:

- Gas cleaning of LFG from trace gases, e.g. through activated carbon, to purify LFG from substances harmful for the buses' internal combustion (IC) engines;
- System to extract inert gases and to increase the LFG net calorific value to a level acceptable for the buses' IC engines: separation from CO_2 and N_2 to enrich methane content;
- Bottling and fuelling station: pressure above 200 bar in bottles; at least 160 bottles à 80 litre will be required to ensure continuous operation of the plant.

A reasonable size of the conditioning system is for 300 Nm^3 of LFG input per hour (~2.6 mln Nm^3 per year). At this capacity and at 50% CH_4-content, the plant would yield around 1.2 mln Nm^3 of fuel gas per year.

Monitoring system:

The LFG collection and utilization system will include instrumentation that allows the accurate measurement of the captured and destroyed LFG. Monitoring and control will be with automatic flow meters, thermocouples on the flare, gas analyzers for inflow and exhaust gas, sampling points in the pipelines, and an internet based system for monitoring and remote control. Data storage will be onsite, in the centralized office of CarbonBW (the CME), and also on an external server.

A.4.1. Identification of the small-scale CPA:

CPAs under the PoA "Programme for the Capture and Destruction or Utilization of Landfill Gas in Colombia" are stationary and are not mobile devices. A clear identification via geo-coordinates is thus possible.

A.4.1.1. Host Party:

Colombia

A.4.1.2. Geographic reference or other means of identification allowing the unique identification of the small-scale CPA (maximum one page):

The project boundary of the CPA comprises of the Navarro landfill. The landfill is located in:

- the district of: Navarro Cali
- the province (department) of: Valle del Cauca

A unique identification is possible via the following geo-coordinates:
3°22'29.27"N
76°29'46.84"W

Figure: Navarro Landfill including Leachate Oxidation Ponds (Source: Google Earth)

The project boundary of the CPA does not include the facilities of the potential phase 2, i.e. the facilities where LFG would be utilized. This is because CERs are not claimed for this potential activity though revenues from such activities are accounted for in the assessment of additionality. This proceeding is conservative.

A.4.2. Duration of the small-scale CPA:

A.4.2.1. Starting date of the small-scale CPA:

01/07/2011 or with the registration of the PoA (whatever is later)

A.4.2.2. Expected operational lifetime of the small-scale CPA:

The CPA's operational lifetime is estimated to be 10 years.

A.4.3. Choice of the crediting period and related information:

Fixed Crediting period

A.4.3.1. Starting date of the crediting period:

Starting date of the crediting period: Date of PoA registration

A.4.3.2. Length of the crediting period, first crediting period if the choice is renewable CP:

Ten years from the starting date of the crediting period.

A.4.4. Estimated amount of emission reductions over the chosen crediting period:

Year	Total Annual estimation of emission reductions in tonnes of CO_2e
01/07/2012 – 31/12/2012	37,093
2013	58,125
2014	47,067
2015	38,438
2016	32,156
2017	27,496
2018	23,966
2019	21,232
2020	19,002
2021	17,050
01/01/2022 – 30/06/2022	7,717
Total estimated reduction (tonnes of CO_2e)	**329,342**
Total number of crediting years	10
Annual average over the crediting period of estimated reduction (tonnes of CO_2e)	**32,934**

A.4.5. Public funding of the CPA:

The CPA did not receive any public funding.

A.4.6. Information to confirm that the proposed small-scale CPA is not a de-bundled component

The proposed project activity is not deemed to be a de-bundled component of a large scale activity as there is no other activity (registered small-scale CPA, an application to register another small-scale CPA, or another registered CDM project activity) that fulfils the two following criteria at the same time:

YES	NO	Component
x	-	There is no other activity which has the same CME (CarbonBW) which also manages a large-scale PoA of the same sectoral scope.
x	-	There is no other activity of which the boundary is within 1 km of the boundary of the proposed CPA (at the closest point).

Only if both above criteria would be fulfilled by the CPA, the proposed small-scale CPA would be a de-bundled component of a large-scale activity. In this case the regulations set out in Annex II of the decision 4/CMP.1 and 5/CMP.1 would be followed

The Coordinating and Managing Entity, CarbonBW Colombia S.A.S., confirms that the CPA is neither registered as an individual CDM project activity nor is part of another registered PoA. In this context available information from the UNFCCC website and the list of registered CDM project activities serves as additional evidence. The unique identification via the geo-coordinates indicated above can thereby referred to.

A.4.7. Confirmation that small-scale CPA is neither registered as an individual CDM project activity or is part of another Registered PoA:

It is confirmed that the SSC_CPA is neither registered as an individual CDM project activity or is part of another registered PoA.

SECTION B. Eligibility of small-scale CPA and Estimation of emissions reductions

B.1. Title and reference of the Registered PoA to which small-scale CPA is added:

Programme for the Capture and Destruction or Utilization of Landfill Gas in Colombia

B.2. Justification of the why the small-scale CPA is eligible to be included in the Registered PoA :

The CPA is eligible to be included in the PoA as it fulfils all eligibility criteria listed in the following:

YES	NO	Criterion
x	-	Open or closed landfill for household/urban waste.
x	-	For the landfill gas, the baseline scenario consists of the total or partial release of LFG to the atmosphere.
x	-	Document(s) signed by the landfill owner confirming: a) the voluntary involvement in the PoA, b) his right for the utilization of the LFG, c) assignment of the right for landfill gas capture including its potential utilization to CarbonBW (the CME), and d) the assignment of the right for construction and installation of necessary equipment for a LFG capture and flaring and/or potential utilization.
x	-	Confirmation in the CPA-DD that the activity under the CPA is neither registered as an individual CDM project activity nor included as part of another registered PoA.
x	-	Document signed by the landfill owner confirming that: - the planned activity did not receive benefits through ODA; - no (financial) commitments to install the planned project activity before signing the agreement with the CME had been made.
x	-	The landfill keeps the Environmental Norms of Colombia (e.g. Law 99/93) and provides the relevant documents.
x	-	The landfill where the waste is deposited can be clearly identified.
x	-	The boundary of the landfill is not within 1 km (at its closest point) from another landfill gas activity registered within the last two years or requesting registration.
x	-	Landfill gas from hazardous waste cells (if any) is not included in the capture system.
x	-	The *ex-ante* calculated emission reduction due to methane destruction from the landfill is limited to 60 ktCO_2e/year.
x	-	Stakeholder consultation requirements are followed as per the DNA of the host country.
x	-	Additionality has been confirmed according to the below defined additionality eligibility criteria.

Data on the potential start date of the CPA and the technical specifications will be provided by the CME to the DOE.

Additional Eligibility Criteria for Inclusion of a Scenario 3-CPA

YES	NO	Criterion
x	-	If LFG is sold by CarbonBW (the CME) to third parties, a contract will be entered into that ensures that no CERs are claimed for the utilization of the LFG.

The second table of eligibility criteria only becomes relevant in the event of phase 2 being implemented.

B.3. Assessment and demonstration of additionality of the small-scale CPA , as per eligibility criteria listed in the Registered PoA:

CPA-1 is additional as per the eligibility criteria listed in the PoA. The following additionality criteria defined have been verified for the CPA:

- For phase 1: The CPA only captures and flares landfill gas. There is no utilization of landfill gas and thus revenues other than CERs are not generated. As the capture and flaring of LFG is not stipulated by national or regional regulations in Colombia, the CPA is deemed additional.
- For phase 2: The NPV is negative assuming the discount rate as detailed in the PoA-DD. In line with section E.5.2 of the PoA-DD, CPA-1 can be deemed additional for a scenario that includes the implementation of phase 2. Additionality is demonstrated by the existence of an investment barrier (the NPV without CER-revenues is negative). The robustness of this investment barrier is confirmed by a sensitivity analysis (varying the main parameters by ±10%). The details of these analyses are described in the following:

Investment Analysis for CPA-1 including phase 2:

As mentioned before, it is envisaged, in the event of implementation of phase 2, to outsource this activity and to sell LFG (in original state) to a third party which might utilized the LFG for conditioning and final utilization in Cali's bus system "MetroCali". The sales price for the LFG would be negotiated and fixed contractually. Under current conditions a price of 5.00 €/MWh seems appropriate. However, in order to not bias the investment analysis with an "assumed" price, the investment analysis is done for the entire chain of LFG conditioning and sale as CNG for transportation activities.

The following assumptions were made:

Investment: Capture and Flaring System at Cali Landfill	€ gross	Import duty	VAT	€ net
Gas capture system (initial investment cost)	65,000	0%	16%	75,000
Gas flaring system	220,000	5%	16%	268,000
Power supply to flare	20,000	0%	16%	23,000
Remote control system	5,000	0%	16%	6,000
Foundations & Housing (fence)	20,000	0%	16%	23,000
Engineering, permits, legal fees	49,500	0%	16%	57,000
Contingencies (initial investment cost)				68,000
Total (initial investment cost)				**520,000**

Investment: Gas Preparation for Transport (CNG)	€ gross	Import duty	VAT	€ net
Investment of pre-compressor, activated carbon, meters	150,000	5%	16%	183,000
Methane enrichment (CO2-, N2-separation)	2,000,000	5%	16%	2,436,000
fuelling station (incl parking lots): 140Nm3/h; 190 bottles à 80l @200bar	400,000	5%	16%	487,000
infrastructure (trafo station, gas pipeline)	100,000	0%	16%	116,000
Engineering, permits, legal fees	265,000	0%	16%	307,000
Contingencies (initial investment cost)				352,900
Total (initial investment cost)				**3,881,900**

O&M: Capture and Flaring System				€ net
18.5 kW blower	*kWh*	*h/yr*	*€/MWh*	18,313
	18.5	8,760	113	
Total (O&M)				**18,313**

O&M: Gas Preparation for Transport (CNG)				€ net
O&M activated carbon (two stages)				23,500
Power (activated carbon (2stage): 0.3 kWh/m3, CH4 enrichment 0.1 kWh/m3)	*kWh/Nm3*	*Nm3/a*	*€/MWh*	54,240
	0.4	1,200,000	113	
Total (O&M)				**77,740**

Price for CNG: 0.6 €/Nm^3

Based on the above assumptions, the Net Present Value (NPV) is -1,519,316 €. The NPV remains negative for all variations of main investment parameters. This confirms the robustness of the demonstrated additionality (through investment barrier).

Sensitivity	-10%	base	10%
Investment	(1,079,126)		(1,959,506)
O&M	(1,465,044)	(1,519,316)	(1,573,588)
Sale (price/quantity)	(1,861,847)		(1,176,786)

For the project activity, a positive NPV is only achieved if a price above 10 €/MWh is claimed. This, however, still does not reverse the sign of the NPV from negative to positive for the entire activity of utilizing LFG as intended by the potential phase 2.

Conclusion: Also with the potential implementation of phase 2, CPA-1 is additional.

B.4. Description of the sources and gases included in the project boundary and proof that the small-scale CPA is located within the geographical boundary of the registered PoA.

The CPA is located within the geographical boundary of the registered PoA. This can be proven easily as the geographical boundary encompasses the national borders of the Republic of Colombia, the host party, and the proposed CPA is located in the Republic of Colombia.

Table: Summary of Gases and Sources included in the Project Boundary

	Source	Gas	Included?	Justification/Explanation
Base line	Atmospheric emissions from	CH_4	Yes	The major source of emissions in the baseline.
		N_2O	No	N_2O emissions are small compared to CH_4

	decomposition of waste at the landfill site			emissions from landfills. Exclusion of this gas is conservative.
		CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted.
Project	Emissions from power consumption by project facilities	CO_2	Yes	The major source of emissions in the project activity.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.

B.5. Emission reductions:

BASELINE EMISSIONS

For the avoidance of methane emissions from the landfill due to the capture and combustion of landfill gas the following formulae are applied in line with AMS-III.G to calculate the annual baseline emissions (BE_y):

$$BE_y = BE_{CH4,SWDS,y} - MD_{reg,y} \cdot GWP_{CH4}$$

$MD_{reg,y}$ was set to zero for all CPAs. Thus:

$$MD_{reg,y} = 0 \text{ tCH}_4$$

$BE_{CH4,SWDS,y}$ is calculated according to the following formula:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j})$$

$BE_{CH4,SWDS,y}$	Baseline emissions of methane avoided during the year *y* at the solid waste disposal site during the period from the start of the project activity to the end of the year *y* (tCO_2e)
φ	Model correction factor to account for model uncertainties
f	Fraction of methane captured in the baseline at the solid waste disposal site (SWDS) and flared, combusted or used in another manner
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)
F	Fraction of methane in the SWDS gas (volume fraction)
DOC_f	Fraction of degradable organic carbon (DOC) that can decompose
MCF	Methane correction factor (fraction)
$W_{j,x}$	Amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (tons)

DOC_j	Fraction of degradable organic carbon (by weight) in the waste type *j*
k_j	Decay rate for the waste type *j*
j	Waste type
y	Year for which methane emissions are calculated

In line with the PoA the fixed values for the parameters φ, f, F, and DOC_f are copied to the CPA:

φ = 0.9
f = 0.0
F = 0.5
DOC_f = 0.5

The landfill is covered with soil from the local area. To be conservative this soil is deemed having oxidizing properties.
Therefore:
OX = 0.1

In line with the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", the landfill qualifies as "anaerobic managed SWDS". Accordingly the value for the Methane Correction Factor (MCF) has been set to:
MCF = 1.0

The amount of waste and the amount of waste per waste type *j* has been sampled by EMSIRVA[3]. The composition of the waste is the following:

Waste type *j*	**Shares of Waste Types (wet) (%)**
Wood and wood products	1.5
Pulp, paper and cardboard (other than sludge)	6.4
Food, food waste, beverages and tobacco (other than sludge)	75.0
Textiles	0.5
Garden, yard and park waste	7.0
Glass, plastic, metal, other inert waste	9.6
TOTAL	**100.0**

The decay rate according to waste type *j* (k_j) and the fraction of degradable organic carbon in the waste type *j* has been selected in line with AMS-III.G.

Therewith all parameters for the calculation of the baseline emissions from the solid waste disposal site are available. The calculation of the BE_y for the avoidance of methane emissions from solid waste disposal sites (landfills) can be traced in the attached MS-Excel calculation file.

[3] SCS Engineers, October 2007: "LANDFILL GAS ASSESSMENT REPORT - EL NAVARRO LANDFILL - CALÍ, COLOMBIA"

PROJECT EMISSIONS

Project emissions comprise of CO_2-emissions related to the power or electricity consumption by the project activity facilities, emissions from flaring or combustion of the gas stream, or emissions from the landfill gas upgrading process. As the latter is not relevant to this PoA project emissions can be calculated as follows:

$$PE_y = PE_{power,y} + PE_{flare,y}$$

$PE_{power,y}$	Emissions from the use of fossil fuel or electricity for the operation of the installed facilities in year *y* (tCO_2e)
$PE_{flare,y}$	Emission from flaring or combustion of the landfill gas stream in the year *y* (tCO_2e)

Project emissions from power consumption are according to the procedures described in AMS-I.D:

$$PE_{power,y} = EC_y \cdot EF_{grid,CO2,y}$$

Where:

PE_y	Project emissions during the year *y* (tCO_2)
EC_y	Electricity consumption by project equipment during the year *y* (MWh)
$EF_{grid,CO2,y}$	Carbon dioxide emission factor for grid electricity consumed by project equipment in the year *y* (tCO_2e/MWh)

The emissions from flaring are determined according to the procedures described in the "*Tool to determine project emissions from flaring gases containing methane*" and specifically for each flare installed due to the project activity:

$$PE_{flare,y} = \sum_{h=1}^{8,760} TM_{RG,h} \cdot (1 - \eta_{flare,h}) \cdot \frac{GWP_{CH4}}{1,000}$$

Where:

$TM_{RG,h}$	Mass flow rate of methane in the residual gas stream in year *y*
$\eta_{flare,h}$	Flare efficiency in hour *h*
GWP_{CH4}	Global Warming Potential of methane (valid for the commitment period)

The following stepwise approach is taken to determine the project emission from flaring while the methodological choices differ according to either *ex-ante* estimation of this emission source or *ex-post* calculation.

Tool- STEP 1. Determination of the mass flow rate of the residual gas that is flared

This step calculates the residual gas mass flow rate in each hour *h*, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h}$

Where:

$FM_{RG,h}$	Mass flow rate of the residual gas in hour *h* (kg/h)
$\rho_{RG,n,h}$	Density of the residual gas at normal conditions in hour *h* (kg/m^3)
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h* (m^3/h)

and:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} * T_n}$$

Where:

P_n	P_n Pa Atmospheric pressure at normal conditions (Pa)
R_u	Universal ideal gas constant (Pa.m^3/kmol.K)
$MM_{RG,h}$	Molecular mass of the residual gas in hour *h* (kg/kmol)
T_n	Temperature at normal conditions (K)

and:

$$MM_{RG,h} = \sum \left(fv_{i,h} * MM_i \right)$$

Where:

$MM_{RG,h}$	Molecular mass of the residual gas in hour *h* (kg/kmol)
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour *h* (ratio)
MM_i	Molecular mass of residual gas component *i* (kg/kmol)
i	Components CH_4, CO, CO_2, O_2, H_2, N_2

As a simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2).

Tool- STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

The mass fraction of carbon, hydrogen, oxygen and nitrogen of the residual gas ($fm_{j,h}$) can be calculated as follows:

$$fm_{j,h} = \frac{\sum_i fv_{i,h} * AM_j * NA_{j,i}}{MM_{RG,h}}$$

Where:

$fm_{j,h}$	Mass fraction of element j in the residual gas in hour *h* (ratio)
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour *h* (ratio)
AM_j	Atomic mass of element *j* (kg/kmol)
$NA_{j,i}$	Number of atoms of element j in component *i*
$MM_{RG,h}$	Molecular mass of the residual gas in hour *h* (kg/kmol)
j	Elements carbon, hydrogen, oxygen and nitrogen

Tool- STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
Ex-post calculation: This step is only applicable if the methane combustion efficiency of the flare is continuously monitored. This option is chosen by the project participant(s).
Ex-ante estimation: For the purpose of the *ex-ante* estimate of the project emissions from flaring, the default value efficiency for the flaring efficiency is chosen. In this case, this step is neglected.

Determine the average volumetric flow rate of the exhaust gas in each hour h based on a stochiometric calculation of the combustion process, which depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas, as follows:

$$TV_{nFG,h} = V_{n,FG,h} \times FM_{RG,h}$$

Where:

$TV_{n,FG,h}$	Volumetric flow rate of exhaust gas in dry basis at normal conditions in the hour *h* (m^3/h)
$V_{n,FG,h}$	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour *h* (m^3/kg)
$FM_{RG,h}$	Mass flow rate of the residual gas in the hour *h* (kg/h)

$$V_{nFG,h} = V_{a,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h}$$

Where:

$V_{n,FG,h}$	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour *h* (m^3/kg)
$V_{n,CO2,h}$	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* (m^3/kg)
$V_{n,N2,h}$	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* (m^3/kg)
$V_{n,O2,h}$	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* (m^3/kg)

$$V_{n,O_2,h} = n_{O_2,h} * MV_n$$

Where:

$V_{n,O2,h}$	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* (m^3/kg)

$N_{O2,h}$	Quantity of moles of O_2 in the exhaust gas of the flare per kg of residual gas flared in hour *h* (m^3/kg)
MV_n	Volume of one mole of any ideal gas at normal temperature and pressure (m^3/kmol)

$$V_{n,N2,h} = MVn * \left\{ \frac{fm_{N,h}}{200 AM_N} + \left(\frac{1 - MF_{O2}}{MF_{O2}} \right) * [F_{h+nO2,h}] \right\}$$

Where:

$V_{n,N2,h}$	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* (m^3/kg)
MV_n	Volume of one mole of any ideal gas at normal temperature and pressure (m^3/kmol)
$fm_{N,h}$	Mass fraction of nitrogen in the residual gas in the hour *h* (ratio)
AMn	Atomic mass of nitrogen (kg/mol)
MF_{O2}	O_2 volumetric fraction of air (ratio)
F_h	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h* (m^3/kg)
$n_{O2,h}$	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour *h* (m^3/kg)

$$V_{nCO2,h} = \frac{fm_{C,h}}{AM_c} * MV$$

Where:

$V_{n,CO2,h}$	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour *h* (m^3/kg)
MV_n	Volume of one mole of any ideal gas at normal temperature and pressure (m^3/kmol)
$fm_{C,h}$	Mass fraction of carbon in the residual gas in the hour *h* (ratio)
AM_C	Atomic mass of carbon (kg/mol)

$$n_{o2,h} = \frac{t_{O2,h}}{\left(1 - \left(t_{O2} / MF_{O2}\right)\right)} * \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2 AM_N} + \left(\frac{1 - MF_{O2}}{MF_{O2}} \right) * F_h \right]$$

Where:

$n_{O2,h}$	Quantity of moles of O_2 in the exhaust gas of the flare of residual gas flared in hour *h* (kmol/kg)
$t_{O2,h}$	Volumetric fraction of O_2 in the exhaust gas in the hour *h* (ratio)
MF_{O2}	Volumetric fraction of O_2 in the air (ratio)
Fh	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg of residual gas in hour *h* (kmol/kg)
$fm_{j,h}$	Mass fraction of element j in the residual gas in hour *h* (ratio)
AM_j	Atomic mass of element *j* (kg/kmol)
j	The elements carbon (index C) and nitrogen (index N)

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O}$$

Tool- STEP 4. Determination of methane mass flow rate in the exhaust gas on a dry basis
Ex-post calculation: This step is only applicable if the methane combustion efficiency of the flare is continuously monitored. This option is chosen by the project participant(s).
Ex-ante estimation: For the purpose of the *ex-ante* estimate of the project emissions from flaring, the default value efficiency for the flaring efficiency is chosen. In this case, this step is neglected.

The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$TM_{FG,h} = \frac{TV_{n,FG,h} \times fv_{CH4,FG,h}}{1{,}000{,}000}$$

Where

$TM_{FG,h}$	Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h* (kg/h)
$TV_{n,FG,h}$	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour *h* (m^3/h)
$fv_{CH4,FG,h}$	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour *h* (mg/m^3)

Tool- STEP 5. Determination of methane mass flow rate in the residual gas on a dry basis
The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis).

$$TM_{RG,h} = FV_{RG,h} \text{ x } fv_{CH4,RG,h} \text{ x } \rho_{CH4,n}$$

Where:

$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h* (kg/h)
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h* (m^3/h)
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to $fv_{i,RG,h}$ where *i* refers to methane) (ratio)
$\rho_{CH4,n}$	kg/m^3	Density of methane at normal conditions (kg/m^3)

Tool- STEP 6. Determination of the hourly flare efficiency

Ex-post calculation: The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature) and the type of flare used (open or enclosed). In the project activity an enclosed flare will be installed. Therefore, the flare efficiency in hour *h* is:

- 0% if the temperature in the exhaust gas of the flare (T_{flare}) is below 500 °C for more than 20 minutes during the hour *h*.
- Determined as follows in cases where the temperature of the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes:

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}}$$

Where:

$\eta_{flare,h}$	Flare efficiency in the hour *h* (ratio)
$TM_{FG,h}$	Methane mass flow rate in exhaust gas averaged in a hour h (kg/h)
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour *h* (kg/h)

The destruction efficiency for landfill gas combusted for energy is assumed as 100%. This is in line with paragraph 12 of AMS-III.G.

Ex-ante estimation: The flare efficiency in the hour *h* is assumed as:

- 90% as the temperature in the exhaust gas of the flare is assumed to be above 500 °C for more than 40 minutes during the hour *h* in any hour of the year *y*.

The destruction efficiency for landfill gas combusted for energy is assumed as 100%. This is in line with paragraph 12 of AMS-III.G.

Tool- STEP 7. Calculation of annual project emissions from flaring

The emissions will be determined according to the above mentioned formula (before Tool-Step 1).

<u>LEAKAGE EMISSIONS</u>

Equipment will not be transferred from another activity. Thus leakage emissions from this source are zero:

LE_y = 0 tCO_2e

<u>EMISSION REDUCTION</u>

The actual emission reductions from “methane avoidance” will be estimated *ex-ante* as follows:

$$ER_{y,estimated} = BE_y - PE_y - LE_y$$

In order to account for the fact that not all landfill gas generating on the landfill according to the FOD-model applied in the determination of $BE_{CH4,SWDS,y}$ will be actually captured by the capture system the parameter R_r is introduced. It represents the recovery rate for landfill gas. Landfill gas not recovered continues to emit to the atmosphere (e.g. through the surface of the landfill). Therefore:

$$ER_{y,estimated} = BE_y \cdot R_r - PE_y - LE_y$$

Where:

R_r Recovery rate of the landfill gas, i.e. ratio of landfill gas/methane captured (ratio)

R_r: The recovery rate R_r is usually up to 50%. For the issuance of CERs this parameter is irrelevant as it is not applied in the *ex-post* calculation of CERs. The exact value for Rr is set according to landfill zone in this CPA.

For the *ex-post* calculation monitored values will be used and the calculation will be done according to the following formula:

$$ER_{y,calculated} = (MD_y - MD_{reg,y}) \cdot GWP_{CH4} - PE_y - LE_y$$

Where:

MD_y Methane captured and destroyed/gainfully used by the project activity in the year *y* (tCO_2e)

PE_y Project emissions common to all scenarios (i.e. according to AMS-III.G) (tCO_2e)

LE_y Leakage emissions common to all scenarios (i.e. according to AMS-III.G) (tCO_2e)

MD_y (the methane captured and destroyed or gainfully used) shall be measured and parameters applied in the following formula:

$$MD_y = D_{CH4,y} \cdot \omega_{CH4,y} \cdot \sum_i LFG_{i,y}$$

Where:

$LFG_{i,y}$ Landfill gas destroyed via method *i* (e.g. flaring or fuelling) in the year *y* (m^3).

$\omega_{CH4,y}$ Methane content in landfill gas in the year *y* (m^3 CH_4/m^3 LFG).

$D_{CH4,y}$ Density of methane at the temperature and pressure of the landfill gas (tonnes/m^3).

B.5.1. Data and parameters that are available at validation:

Data / Parameter:	OX
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Value applied:	0.1
Source of data used:	Conduct a site visit at the solid waste disposal site in order to assess the type of cover of the solid waste disposal site. Use the IPCC 2006 Guidelines for National Greenhouse Gas Inventories for the choice of the value to be applied.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Determined once at inclusion of CPA into PoA. Value for oxidizing cover material.
Any comment:	

Data / Parameter:	MCF
Data unit:	-
Description:	Methane correction factor
Value applied:	1.0
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Justification of the choice of data or description of measurement methods and procedures actually applied :	Determined once at inclusion of CPA to PoA. Value for managed anaerobic SWDS.
Any comment:	

Data / Parameter:	DOC_j
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type j
Value applied:	(see table below)
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Justification of the	Determined once at inclusion of CPA to PoA

Waste type *j*	Wet waste	Dry waste
Wood and wood products	43	50
Pulp, paper and cardboard (other than sludge)	40	44
Food, food waste, beverages and tobacco (other than sludge)	15	38
Textiles	24	30
Garden, yard and park waste	20	49
Glass, plastic, metal, other inert waste	0	0

choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

<table>
<tr><td>Data / Parameter:</td><td>k_j</td></tr>
<tr><td>Data unit:</td><td>-</td></tr>
<tr><td>Description:</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Value applied:</td><td>
<table>
<tr><th>Waste type j</th><th>Wet (MAP< 1,000mm)</th></tr>
<tr><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.035</td></tr>
<tr><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Food, food waste, sewage sludge, beverages and tobacco</td><td></td></tr>
</table>
</td></tr>
<tr><td>Source of data used:</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Justification of the choice of data or description of measurement methods and procedures actually applied :</td><td>Determined once at the inclusion of the CPA into the PoA. Value for tropical wet climates.</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Data / Parameter:	**$W_{j,x}$**
Data unit:	tons
Description:	Amount of waste type *j* deposited in year *x*
Value applied:	See attached excel file.
Source of data used:	Sampling
Justification of the choice of data or description of measurement methods and procedures actually applied :	Waste composition was determined through sampling
Any comment:	

Data / Parameter:	**Rr**
Data unit:	Ratio
Description:	Recovery rate of the project's landfill gas capture system
Value applied:	0.5 for the new and transitional zone 0.2 for the old zone ("cerro antiguo")
Source of data used:	Own estimation by project participants.
Justification of the choice of data or description of measurement methods and procedures actually applied :	A value of up to 0.5 is regarded reasonable. Determined once at inclusion of CPA into PoA.
Any comment:	Only applied for the *ex-ante* estimation of emission reductions.

B.5.2. Ex-ante calculation of emission reductions:

In the following *ex-ante* calculation of emission reductions values from the first (complete) year of project operation have been inserted to applicable formulae, provisionally year 2013 if project operation can be started in July 2012.

BASELINE EMISSIONS

Due to the complexity of the FOD-model applied by the "Tool to determine methane emissions avoided from the disposal of waste at a solid waste disposal sites", the *ex-ante* calculation can be retraced in the attached MS-excel file.

$$BE_y = BE_{CH4,SWDS,y} - MD_{reg,y} \cdot GWP_{CH4}$$

Where:

$MD_{reg,2013}$ = 0 tCH_4

And:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_j W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j})$$

For the old zone of the landfill ("Cerro Antiguo"):

$$BE_{CH4,SWDS,2013} = 0.9 \cdot (1 - 0.0) \cdot 21\ tCO_2e/tCH_4 \cdot (1 - 0.1) \cdot 16/12 \cdot 0.5 \cdot 0.5 \cdot 1.0 \cdot \sum_{x=1}^{y} \sum_j W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j})$$

$$= 108{,}462\ tCO_2e$$

For the new and transitional zone of the landfill:

$BE_{CH4,SWDS,2013}$ $= 0.9 \cdot (1 - 0.0) \cdot 21\ tCO_2e/tCH_4 \cdot (1 - 0.1) \cdot 16/12 \cdot 0.5 \cdot 0.5 \cdot 1.0 \cdot$

$$\sum_{x=1}^{y}\sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j})$$

$= 46,902\ tCO_2e$

Thus:

BE_{2013} = 108,462 tCO_2e + 46,902 tCO_2e – 0 tCO_2e

= **155,364 tCO_2e**

PROJECT EMISSIONS

Project emissions comprise of CO_2-emissions related to the power or electricity consumption by the project activity facilities and emissions from flaring or combustion of the gas stream and they calculate as:

$$PE_y = PE_{power,y} + PE_{flare,y}$$

With:

$$PE_{power,y} = EC_y \cdot EF_{grid,CO2,y}$$

and:

$$PE_{flare,y} = \sum_{h=1}^{8,760} TM_{RG,h} \cdot (1-\eta_{flare,h}) \cdot \frac{GWP_{CH4}}{1,000}$$

The power consumption of the facilities installed to capture and flare landfill gas will be monitored during the project activity and project emissions are estimated as follows:

PE_{2013} = $EC_{2013} \cdot EF_{grid,CO2,2013}$

= 320.9 MWh·0.2849 tCO_2e/MWh

= 112 tCO_2e

The emissions from flaring take into account that some gas might be destroyed by combustion for energy and not by flaring. However, as the destruction efficiency is assumed to be 100% in case of destruction by combustion for energy (in line with AMS-III.G, paragraph 12), the part of landfill gas that is utilized for this purpose is irrelevant to determine project emissions from flaring.

In the proposed project activity, the quantity of LFG utilized in the considered year 2013 is 300 Nm3/h multiplied by the hours of 6 months from July 2013 to December 2013. This means a total of 1,314,000 Nm^3 (equal to 940 t of LFG (at 50% CH_4) or 470 t of CH_4)[4].

For the *ex-ante* estimation it is assumed gas was flared at the same conditions during all 8,760 hours of a year. The flaring efficiency is assumed as the default value provided for by the Tool for properly operated enclosed flares. A CPA always installs an enclosed flare.

In the proposed project activity, a total of 7,398 t of CH_4 accrue whereof 3,029 t of CH_4 are captured. From this 3,029 t of CH4 470 t of CH4 are utilized meaning that around 2,559 t of CH_4 are flared in 2013. The hourly quantities flared ($TM_{RG,h}$) are 2,559 t ÷ 8,760h/yr = 292.1 kg/h.

This ends up in the following calculation:

$$PE_{flare,2013} = [\ TM_{RG,h} \cdot (1 - \eta_{flare,h}) \cdot GWP_{CH4} \div 1{,}000\ ] \cdot 8{,}760\ h$$
$$= [\ 292.1\ kg/h \cdot (1 - 0.9) \cdot 21\ tCO2e/tCH4 \div 1{,}000] \cdot 8{,}760\ h$$
$$= 5{,}374\ tCO_2e$$

$$PE_{2013} = PE_{power,2013} + PE_{flare,2013}$$
$$= 112\ tCO2e + 5{,}374\ tCO_2e$$
$$= 5{,}486\ tCO_2e$$

<u>LEAKAGE EMISSIONS</u>

$$LE_y = 0\ tCO_2e$$

<u>EMISSION REDUCTION</u>

The actual emission reductions from "methane avoidance" were calculated *ex-ante* with the following formula:

$$ER_{y,calculated} = BE_{y,ex\text{-}ante} - PE_y - LE_y$$

For the new and transitional zone of the landfill the Rr is assumed to be 0.5.

$$BE_{2013,ex\text{-}ante} = BE_{CH4,SWDS,2013} \cdot R_r - MD_{reg,2013} \cdot GWP_{CH4}$$
$$= 108{,}462\ tCO_2e \cdot 0.5 - 0\ tCH_4 \cdot 21\ tCO_2e/tCH_4$$
$$= 54{,}231\ tCO_2e$$

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[4] The conversion from Nm^3 to tons is done via the specific density of methane of the „Tool to determine project emissions from flaring gases containing methane": 0.7156 kg/Nm^3.

For the old zone of the landfill ("Cerro Antiguo") the R_r is assumed to be rather low as gas measurements for this section showed low values. The assumed Rr is 0.2.

$$BE_{2013,ex\text{-}ante} = BE_{CH4,SWDS,2013} \cdot R_r - MD_{reg,2013} \cdot GWP_{CH4}$$
$$= 46{,}902\ tCO_2e \cdot 0.2 - 0\ tCH_4 \cdot 21\ tCO_2e/tCH_4$$
$$= 9{,}380\ tCO_2e$$

$$BE_{2013,ex\text{-}ante} = BE_{2013,ex\text{-}ante\_New\ Zone} + BE_{2013,ex\text{-}ante\_Old\ Zone}$$
$$= 54{,}231\ tCO_2e + 9{,}380\ tCO_2e$$
$$= 63{,}611\ tCO_2e$$

and:

$$ER_{2013,estimated} = BE_{2013,ex\text{-}ante} - PE_{2013} - LE_{2013}$$
$$= 63{,}611\ tCO_2e - 5{,}486\ tCO_2e - 0\ tCO_2e$$
$$= 58{,}125\ tCO_2e$$

B.5.3. Summary of the ex-ante estimation of emission reductions:

Year	Estimation of project activity emissions (tonnes of CO_2e)	Estimation of baseline emissions (tonnes of CO_2e)	Estimation of leakage (tonnes of CO_2e)	Estimation of overall emission reductions (tonnes of CO_2e)
07/12-12/12	4,184	41,277	0	37,093
2013	5,486	63,611	0	58,125
2014	3,160	50,227	0	47,067
2015	2,202	40,640	0	38,438
2016	1,504	33,660	0	32,156
2017	986	28,482	0	27,496
2018	594	24,560	0	23,966
2019	290	21,522	0	21,232
2020	112	19,114	0	19,002
2021	112	17,162	0	17,050
01/22-06/22	56	7,773	0	7,717
Total (tonnes of CO_2e)	**18,686**	**348,027**	**0**	**329,342**

B.6. Application of the monitoring methodology and description of the monitoring plan:

B.6.1. Description of the monitoring plan:

The monitoring of the SSC CPA is by the CME. Due to the attribution of monitoring obligations to the CME, the monitoring plan has been described already in the PoA-DD uniformly for all CPAs. Please refer to the relevant sections of the PoA-DD.

The following parameters will be monitored:

Data / Parameter:	**$LFG_{i,y}$**
Data unit:	Nm^3
Description:	Total amount of landfill gas (at normal conditions) destroyed via method *i* in year *y*
Source of data used:	Continuous flow meter with automated volume recording
Description of measurement methods and procedures to be applied:	The methane content measurement shall be carried out close to a location in the system where a landfill gas flow measurement takes place.
QA/QC procedures to be applied:	The flow meter will be subject to a regular maintenance according to manufacturer's indications. Calibration will be according to national standards.
Monitoring frequency:	Continuous monitoring. Daily recording.
Any comment:	No separate monitoring of temperature and pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.

Data / Parameter:	**$\omega_{CH4,y}$**
Data unit:	% (m^3CH_4/m^3LFG)
Description:	Methane content in the LFG in the year *y*
Source of data used:	Gas analyzer measuring methane content directly
Description of measurement methods and procedures to be applied:	The measurement shall be carried out close to where the flow measurement takes place and at the same basis (wet or dry).
QA/QC procedures to be applied:	The analyzer will be subject to a regular maintenance according to manufacturer's indications. Calibration will be according to national standards.
Monitoring frequency:	Continuous monitoring. Recording at the same frequency as for the flow values.
Any comment:	

Data / Parameter:	**T**
Data unit:	°C
Description:	Temperature of the landfill gas to normalize the volume of landfill gas destroyed
Source of data used:	Temperature sensor in gas flow
Description of measurement methods and procedures to be applied:	If the landfill gas flow meter measures flow, pressure, and temperature and displays or outputs normalised flow of landfill gas, then there is no need for separate monitoring of this parameter.
QA/QC procedures to	The sensor will be subject to a regular maintenance according to

be applied:	manufacturer's indications. Calibration will be according to national standards.
Monitoring frequency:	Shall be measured at the same time when methane content in the landfill gas is measured.
Any comment:	

Data / Parameter:	**P**
Data unit:	Pa
Description:	Pressure of landfill gas to normalize the volume of landfill gas destroyed
Source of data used:	Pressure sensor in gas flow
Description of measurement methods and procedures to be applied:	Shall be measured at the same time when methane content in the landfill gas is measured. If the landfill gas flow meter measures flow, pressure, and temperature and displays or outputs normalised flow of landfill gas, then there is no need for separate monitoring of this parameter.
QA/QC procedures to be applied:	The sensor will be subject to a regular maintenance according to manufacturer's indications. Calibration will be according to national standards.
Monitoring frequency:	Continuous.
Any comment:	

Data / Parameter:	$\mathbf{fv_{i,h}}$
Data unit:	Ratio
Description:	Volumetric fraction of component *i* in the residual gas in hour *h* (i= CH_4, CO, CO_2, O_2, H_2 and N_2)
Source of data used:	Gas analyser
Description of measurement methods and procedures to be applied:	Ensure that the same basis (dry basis) is considered here and for $FV_{RG,h}$
QA/QC procedures to be applied:	The gas analyzer will be subject to a regular maintenance according to manufacturer's indications. A zero check and a typical value check should be performed by comparison with standard certified gas. Calibration will be according to national standards.
Monitoring frequency:	Continuous monitoring. Values to be averaged hourly. Monthly recording.
Any comment:	As a simplified approach, only CH_4-content might be measured while considering the remaining part as N_2.

Data / Parameter:	$\mathbf{FV_{RG,h}}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*
Source of data used:	Flow meter
Description of measurement methods and procedures to be applied:	Ensure that the same basis (dry or wet) is considered here and for $fv_{i,h}$
QA/QC procedures to	The flow meter will be subject to a regular maintenance according to

be applied:	manufacturer's indications. Calibration will be according to national standards.
Monitoring frequency:	Continuous monitoring. Values to be averaged hourly. Monthly recording.
Any comment:	This parameter represents a fraction of $LFG_{burnt,y}$.

Data / Parameter:	**$t_{02,h}$**
Data unit:	Ratio
Description:	Volumetric fraction of O2 in the exhaust gas of the flare in hour *h*
Source of data used:	Gas analyzer
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in-situ analyzers for wet basis determination. The point of measurement shall be in the upper section of the flare (80% of total flare length). Sampling shall be conducted with appropriate probes adequate to high temperatures.
QA/QC procedures to be applied:	The gas analyzer will be subject to a regular maintenance according to manufacturer's indications. A zero check and a typical value check should be performed by comparison with standard certified gas. Calibration will be according to national standards.
Monitoring frequency:	Continuous monitoring. Values to be averaged hourly. Monthly recording.
Any comment:	

Data / Parameter:	**$fv_{CH4,FG,h}$**
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour *h*
Source of data used:	Gas analyzer
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in-situ analyzers for wet basis determination. The point of measurement shall be in the upper section of the flare (80% of total flare length). Sampling shall be conducted with appropriate probes adequate to high temperatures.
QA/QC procedures to be applied:	The gas analyzer will be subject to a regular maintenance according to manufacturer's indications. A zero check and a typical value check should be performed by comparison with standard certified gas. Calibration will be according to national standards.
Monitoring frequency:	Continuous monitoring. Values to be averaged hourly. Monthly recording.
Any comment:	Measurement instruments may read ppmv or %-values. To convert from ppmv to mg/m3 multiply by 0.716. 1% corresponds to 10,000 ppmv.

Data / Parameter:	**T_{flare}**
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data used:	Thermocouple
Description of measurement methods and procedures to be applied:	Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple.
QA/QC procedures to	Thermocouples should be replaced or calibrated every year.

be applied:	
Monitoring frequency:	Continuously.
Any comment:	

Data / Parameter:	**EC_y**
Data unit:	MWh
Description:	Electricity consumption by the project equipment installed for the capture and flaring of landfill gas during the year y.
Source of data used:	Metered
Description of measurement methods and procedures to be applied:	Electricity meter
QA/QC procedures to be applied:	The meters will be subject to a regular maintenance according to manufacturer's indications. Calibration will be according to national standards.
Monitoring frequency:	Continuous.
Any comment:	All equipment installed due to the project activity and not directly linked to the recovery of energy. In case the electricity consumption of the latter group is not directly accounted for in the calculation of the net electricity generation from the gross generation, this electricity consumption will be metered separately, i.e. not together with the consumption of electricity by equipment installed for the capture and flaring of LFG.

C.1. Please indicate the level at which environmental analysis as per requirements of the CDM modalities and procedures is undertaken. Justify the choice of level at which the environmental analysis is undertaken:

☑ This information has been provided at the PoA level. Therefore, sections C.2. and C.3. are not completed.

C.2. Documentation on the analysis of the environmental impacts, including transboundary impacts:

n.a.

C.3. Please state whether an environmental impact assessment is required for a typical CPA, included in the programme of activities (PoA), in accordance with the host Party laws/regulations:

n.a.

SECTION D. Stakeholders' comments

D.1. Please indicate the level at which local stakeholder comments are invited. Justify the choice:

☑ This information has been provided at the PoA level. However, it has been decided to provide this information also at the CPA level. Therefore, sections D.2. to D.4. will be completed as applicable to this CPA.

D.2. Brief description how comments by local stakeholders have been invited and compiled:

18/10/2011: It is planned sending invitation letters for celebrating the stakeholder consultation on 18/10/2011 to the relevant stakeholders.

10/11/2011: It is planned to have a stakeholder meeting with the interested parties in the neighbouring municipalities of Navarro (CPA-level).

11/11/2011: It is planned to have a stakeholder meeting with the local officials and private companies from Cali (CPA-level).

16/11/2011: It is planned to have a stakeholder meeting with the national stakeholders in Bogotá (PoA-level).

[List publications, invitees (groups), public events indicating number of participants and date and location, describe system of collection of comments (e.g. questionnaires, protocol)]

D.3. Summary of the comments received:

[List comments received from different events]

D.4. Report on how due account was taken of any comments received:

[Describe how comments by stakeholders were taken into account in the implementation/design of the project activity, e.g. describe mitigation measures]

Annex 1

CONTACT INFORMATION ON ENTITY/INDIVIDUAL RESPONSIBLE FOR THE SMALL-SCALE CPA

Organization:	CarbonBW Colombia S.A.S.
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Represented by:	Johannes Laubach
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Annex 3

BASELINE INFORMATION

Annex 4

MONITORING INFORMATION

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