Technical Appendix - Colombia:

Methods for estimating community-scale sectoral data from national and regional statistics for the purpose greenhouse gas accounting and climate action planning

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Buildings and Stationary Energy Sector

This document details the calculation approaches and data sources for producing community-level activity data and emission factors for the buildings and stationary energy sector in Colombia. This sector includes the following subsectors:

Buildings and Stationary Energy Sector	
Residential buildings	Estimated
Commercial buildings	Not Estimated
Municipal buildings	Not Estimated
Industry	Not Estimated
Agriculture, forestry and fisheries	Not Estimated
Fugitive emissions	Not Estimated

Residential Buildings

Subsector Summary

The residential buildings subsector encompasses all GHG emitting activities from energy use in households,[1] including heating, cooling, cooking, and lighting. The two primary categories of GHG emitting activities within the subsector are: scope 1) emissions from fuel combustion associated with residential buildings within the community boundary and scope 2) emissions from consumption of grid-supplied electricity.

Inclusions:

For Colombia, based on data availability and occurrence in-country, estimates for the following activity data points were produced:

- **Natural gas**, **liquid petroleum gas, wood**, **kerosene and charcoal** consumption by households, based on annual fuel consumption from residential customers at National level.
- **Grid-supplied electricity** consumption by households, based on annual electricity consumption from residential customers at national level.

Exclusions:

Due to lack of data availability or occurrence in-country, estimates for the following activity data points were not produced:

- **Off-highway motor gasoline** consumption, e.g. for use in lawn and gardening equipment
- **Distillate fuel oil** or **liquefied biofuels** consumption for use in residential buildings
- **District heating, cooling,** or other non-electricity grid-supplied energy

Activity Data Coverage:

The specific data points and energy sources covered by the methodology are outlined in the table below.

Fuels/Energy Source	Definition	Units	Scope
Natural Gas	All-natural gas consumption within community boundary for a single year for all households.	MJ	Scope 1
Liquid Petroleum Gas	All Liquid Petroleum Gas consumption within community boundary for a single year for all households.	MJ	Scope 1
Kerosene	All kerosene consumption within community boundary for a single year for all households.	MJ	Scope 1
Wood	All Wood consumption within community boundary for a single year for all households.	MJ	Scope 1

[1] For the purposes of this methodology, households correspond to all categories of "housing" as defined in the National Institute of Statistics (INE Spanish acronym), including, single person, one couple, with children, etc.

Charcoal	All Charcoal consumption within community boundary for a single year for all households.	MJ	Scope 1
Grid Electricity	All grid-supplied electricity consumption within community boundary for a single year for all households	MJ	Scope 2

Calculation Methodologies:

Scope 1: Liquid Petroleum Gas

Methodology Notes

Residential building Liquid Petroleum Gas consumption is taken from Colombia´s National Energy Balance 2017. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to national totals, and
- a computed **weighted (urban or rural) community intensity** relative to the national.

Total counts of households, by housing type, are sourced from the 2005 DANE Census data. In addition, the annual national Liquid Petroleum Gas consumption is weighted with two community categories (urban and rural) that are derived from the 2005 DANE Census. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context within individual communities.

Equation 1

The below equation represents the calculation method utilized to estimate household Liquid Petroleum Gas consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{LPG}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\textit{Weighted community fuel intensities})$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All Liquid Petroleum Gas consumption within community boundary for a single year for all households	Equation 1	MJ
Aggregate residential consumption (LPG)	All LPG consumption among residential customers nationally	UPME 2016	MJ

$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Estimated number of households within the community	DANE, 2005	households
Weighted community fuel intensities	Percentage associated with weighted fuel use by fuel type per housing demographic	Estimated	percentage

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of households is proportionally related to the amount of Liquid Petroleum Gas consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban or rural) remain consistent within national weighted energy intensities (urban or rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- National totals are assumed to encompass all LPG national residential consumption.

Scope 1: Natural Gas

Methodology Notes

Residential building Natural Gas consumption is taken from Colombia´s National Energy Balance 2017. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to national totals, and
- a computed **weighted (urban or rural) community intensity** relative to the national.

Total counts of households, by housing type, are sourced from the 2005 DANE Census data. In addition, the annual national Natural Gas consumption is weighted with two community categories (urban and rural) that are derived from the 2005 DANE Census. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context within individual communities.

Equation 2

The below equation represents the calculation method utilized to estimate household Natural Gas consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{NG}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\textit{Weighted community fuel intensities})$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All Natural Gas consumption within community boundary for a single year for all households	Equation 2	MJ
Aggregate residential consumption (NG)	All NG consumption among residential customers nationally	UPME 2016	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Estimated number of households within the community	DANE, 2005	households
Weighted community fuel intensities	Percentage associated with weighted fuel use by fuel type per housing demographic	Estimated	percentage

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of households is proportionally related to the amount of Natural Gas consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban or rural) remain consistent within national weighted energy intensities (urban or rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- National totals are assumed to encompass all NG national residential consumption.

Scope 1: Wood

Methodology Notes

Residential building wood consumption is taken from Colombia´s National Energy Balance 2017. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to national totals, and
- a computed **weighted (urban or rural) community intensity** relative to the national.

Total counts of households, by housing type, are sourced from the 2005 DANE Census data. In addition, the annual national Wood consumption is weighted with two community categories (urban and rural) that are derived from the 2005 DANE Census. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context within individual communities.

Equation 3

The below equation represents the calculation method utilized to estimate household Wood consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{wood}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\textit{Weighted community fuel intensities})$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All Wood consumption within community boundary for a single year for all households	Equation 3	MJ
Aggregate residential consumption (wood)	All Wood consumption among residential customers nationally	UPME 2016	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Estimated number of households within the community	DANE, 2005	households
Weighted community fuel intensities	Percentage associated with weighted fuel use by fuel type per housing demographic	Estimated	percentage

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of households is proportionally related to the amount of wood consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban or rural) remain consistent within national weighted energy intensities (urban or rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- National totals are assumed to encompass all wood national residential consumption.

Scope 1: Kerosene

Methodology Notes

Residential building Kerosene consumption is taken from Colombia´s National Energy Balance 2017. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to national totals, and
- a computed **weighted (urban or rural) community intensity** relative to the national.

Total counts of households, by housing type, are sourced from the 2005 DANE Census data. In addition, the annual national Kerosene consumption is weighted with two community categories (urban and rural) that are derived from the 2005 DANE Census. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all

communities relative to their national average. This is done so that estimates are reflective of the housing context within individual communities.

Equation 4

The below equation represents the calculation method utilized to estimate household Kerosene consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{Kerosene}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\textit{Weighted community fuel intensities})$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All kerosene consumption within community boundary for a single year for all households	Equation 4	MJ
Aggregate residential consumption (kerosene)	All kerosene consumption among residential customers nationally	UPME 2016	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Estimated number of households within the community	DANE, 2005	households
Weighted community fuel intensities	Percentage associated with weighted fuel use by fuel type per housing demographic	Estimated	percentage

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of households is proportionally related to the amount of kerosene consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban or rural) remain consistent within national weighted energy intensities (urban or rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- National totals are assumed to encompass all Kerosene national residential consumption.

Scope 1: Charcoal

Methodology Notes

Residential building charcoal consumption is taken from Colombia´s National Energy Balance 2017. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to national totals, and
- a computed **weighted (urban or rural) community intensity** relative to the national.

Total counts of households, by housing type, are sourced from the 2005 DANE Census data. In addition, the annual national Charcoal consumption is weighted with two community categories (urban and rural) that are derived from the 2005 DANE Census. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context within individual communities.

Equation 5

The below equation represents the calculation method utilized to estimate household Charcoal consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{charcoal}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\textit{Weighted community fuel intensities})$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All charcoal consumption within community boundary for a single year for all households	Equation 5	MJ
Aggregate residential consumption (charcoal)	All charcoal consumption among residential customers nationally	UPME 2016	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Estimated number of households within the community	DANE, 2005	households
Weighted community fuel intensities	Percentage associated with weighted fuel use by fuel type per housing demographic	Estimated	percentage

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of households is proportionally related to the amount of charcoal consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban or rural) remain consistent within national weighted energy intensities (urban or rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.

- National totals are assumed to encompass all charcoal national residential consumption.

Scope 2: Electricity

Methodology Notes

Residential building Electricity consumption is taken from Colombia´s National Energy Balance 2017. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to national totals, and
- a computed **weighted (urban or rural) community intensity** relative to the national.

Total counts of households, by housing type, are sourced from the 2005 DANE Census data. In addition, the annual national Electricity consumption is weighted with two community categories (urban and rural) that are derived from the 2005 DANE Census. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context within individual communities.

Equation 6

The below equation represents the calculation method utilized to estimate household electricity consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{electricity}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\textit{Weighted community fuel intensities})$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All electricity consumption within community boundary for a single year for all households	Equation 6	MJ
Aggregate residential consumption (electricity)	All electricity consumption among residential customers nationally	UPME 2016	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Estimated number of households within the community	DANE, 2005	households
Weighted community fuel intensities	Percentage associated with weighted fuel use by fuel type per housing demographic	Estimated	percentage

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of households is proportionally related to the amount of electricity consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban or rural) remain consistent within national weighted energy intensities (urban or rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- National totals are assumed to encompass all electricity national residential consumption.

Weighting Factors

This method uses national-level values for fuel use by residential sector and incorporates weighting factors, which help control for unexpected variation in fuel use across city types. Colombia's 2016 census disaggregates each municipality in terms of percentage designated as urban versus rural. Each of these percentages are applied to the total number of households in the municipality to determine urban vs rural fraction of households. Since fuel use varies in urban vs rural households, we use data from UPME on the average residential fuel mix by city type, and control for the total national housing stock in order to estimate the relative impact of city type on the average fuel consumption mix. The results are integrated into one combined weighting factor which can be applied to each municipality:

Equation 7: Weighting Factors

$$\text{Weighting Factor}_{\text{city type, fuel type}} = \frac{\text{M}_{\text{city type, fuel type}} * \text{C}_{\text{city type}}}{\sum_{\text{city type}}(\text{M}_{\text{city type, fuel type}} * \text{C}_{\text{city type}} * \text{HH}_{\text{city type}})}$$

Equation Data Elements

Data element	Description	Source	Units
$\text{Weighting Factor}_{\text{city type, fuel type}}$	Fuel consumption adjustment factor, by city type and fuel type	Equation 7	Unitless
$\text{M}_{\text{city type, fuel type}}$	The average residential fuel mix in 2017, by city type	UPME (2018)	%
$\text{C}_{\text{city type}}$	The average annual energy consumption of one household in 2017, by city type	UPME (2018)	MJ
$\text{HH}_{\text{city type}}$	The total national count of households in 2005, by city type	DANE (2005)	households

Emission Factors:

The following table provides IPCC 2006 emission factor values for the list of fuels used in the buildings and stationary sector methodology for Colombia.

Emission Factor Data Elements

Fuel type	Carbon Dioxide (CO2) kg/GJ	Methane (CH4) kg/GJ	Nitrous Oxide (N2O) kg/GJ	Heating Value Mass GJ/ton	Heating Value Liquid Volume GJ/liter	Heating Value Gaseous Volume GJ/m3
Fossil						
Natural Gas	56.1	0.001	0.0001			0.039
Kerosene	71.9	0.003	0.0006		0.038	
Liquified Petroleum Gas (LPG)	63.1	0.001	0.0001			
Non-fossil						
Solid biomass	100	0.03	0.04			

References:

Unidad de Planeacion Minero Energetica (UPME), 2017. Available at http://www1.upme.gov.co/InformacionCifras/Paginas/BECOCONSULTA.aspx

Database provides a breakdown of fuel use by fuel type and end user by year

DANE Censo 2005. Available at http://systema59.dane.gov.co/cgibin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=CG2005BASICO&MAIN=WebServerMain.inl

Database provides a breakdown of housing characteristics by housing type and municipality

Transportation and Mobile Energy Sector for Colombia

This document details the calculation approaches and data sources for producing community-level activity data for the transportation and mobile energy sector. This sector contains the following subsectors:

Transportation and Mobile Energy Sector	
On-road	Estimated
Rail	Not Estimated
Waterborne navigation	Not Estimated
Aviation	Not Estimated
Off-road	Not Estimated

On-Road

Subsector Summary

GHG emissions within the On-Road subsector result from the fuel consumption for on-road vehicles such as passenger cars, light trucks, motorcycles, buses, vans, motorcycles, machinery and heavy trucks within a community boundary. The GHG emitting activity we focus on in this subsector is fuel consumption (scope 1) from fuels such as gasoline, kerosene and diesel.

Inclusions

For Colombia, based on available data and methods, estimates of activity data produced include:

- **Gasoline, Kerosene** and **Diesel** sales for all private and commercial vehicles within each municipality.

Exclusions

Due to lack of data, this methodology does not include:

- Fuel consumption disaggregated **by fleet type** from all on-road vehicles.
- **Grid electricity** consumed for on-road vehicles used within the community boundary (scope 2). This is instead included in the Stationary Energy sector.

Activity Data Coverage

Table 1 shows the emissions sources covered by this methodology.

Table 1 – Allocated activity data, units, and emission sources

Emissions Source	Definition	Units	Scope
All registered vehicles (Gasoline consumption)	The amount of gasoline sold for a single year by all registered vehicles in a municipality boundary.	Gallons	Scope 1
All registered vehicles (Diesel consumption)	The amount of diesel sold for a single year by all registered vehicles in a municipality boundary.	Gallons	Scope 1
All registered vehicles (Kerosene consumption)	The amount of kerosene sold for a single year by all registered vehicles in a municipality boundary.	Gallons	Scope 1

Allocation Methodology

Fuel sales by fuel station in each municipality was provided by the ministry of mining an energy in Colombia. Due to limited data availability related to vehicle-specific use patterns—which include vehicle type, fuel economy (based on fuel type and vehicle type), vehicle miles travelled, and vehicle registrations—we are unable to further disaggregate the fuel consumption data by vehicle type

Methodological and Data Assumptions & Limitations

This methodology assumes that:

- All vehicles use only kerosene, gasoline and diesel
- Due to limited availability related to specific vehicle use patterns, further disaggregated emissions estimates could not be produced.

Emission Factors

This methodology uses emission factors from the IPCC *Guidelines for National Greenhouse Gas Inventories Volume 2: Energy* (IPCC, 2006). These are globally recognized default emission factor values. All passenger vehicle fuels are considered to have the same emission conversion factors despite the municipality the fuels are sold. As a result, there is no need to adapt the emission factors produced by the IPCC 2006

Table 2 shows the fuels used in Colombia and their corresponding emission factor values.

Table 2 – IPCC Emission Factors for Fuels

Fuel Type	**CO_2 Factor (kg / GJ)**	**CH_4 Factor (kg / GJ)**	**N_2O Factor (kg / GJ)**
Gasoline	69.3	0.12	0.002
Diesel	74.1	0.004	0.028

Citations

ANSV (2016). National Road Safety Observatory Available at https://ansv.gov.co/observatorio

This source provides statistical data on the national motor registrations by vehicle type and municipality for 2016.

Ministry of Energy- Hydrocarbons (2016). Excel database

This source provides data on fuel sales by fuel type, by municipality.

UPME (2014) Determinación de la demanda real de Gasolina Corriente, Gasolina Extra, Diesel Oil y GNV en el territorio nacional. Available at: https://bdigital.upme.gov.co/bitstream/001/1062/1/Informe%20final%20UPME%20DD%20Combustibles%20-%20VF.pdf

This source provides data on the demand of fuels by type and by vehicle type.

Waste Sector

This document details the calculation approaches and data sources for producing community-level activity data and emission factors for the waste sector. This sector contains the following subsectors:

Waste Sector	
Solid waste	Estimated
Biological waste	Not currently estimated
Incinerated and burned waste	Not currently estimated
Wastewater	Not currently estimated

Solid Waste

Subsector Overview

This section covers the activity data and emission factors needed for communities in Colombia to estimate emissions from the disposal of municipal solid waste (MSW). While other gases are also emitted through the collecting, sorting, and transporting of solid waste to treatment facilities—namely biogenic carbon dioxide, non-methane volatile organic compounds, and nitrous oxide—this methodology focuses on estimating values related to MSW treated at landfill facilities or open dumps only. If desired, communities may consult international resources such as the IPCC guidelines for national reporting or local guidance documents, if available, to estimate non-methane GHG emissions from solid waste disposal. Hence, emissions under this sub-sector are influenced by the following five factors:

1) The mass of community-generated waste disposed in landfills or open dumps;
2) The methane generation potential
3) The methane correction factors; influenced by waste composition
4) The oxidation factors
5) The amount of methane recovered (for facilities with existing technology to do so).

Methane (CH_4) is the main gas emitted during the MSW treatment processes. The following section discusses methods for estimating the mass of waste, methane correction factor, oxidation factor and methane recovery fraction—where applicable—at a community level. All of these variables impact the final total of methane emissions reported in Chile.

Inclusions

For the Colombia, based on available data and methods, the data provided includes:

- Community-specific **mass of waste landfilled at managed landfill facilities**
- Community-specific **mass of waste landfilled at unmanaged/open dumping facilities**.
- **Methane Correction Factor** based on historical landfill management characteristics such as managed, unmanaged deep, unmanaged shallow, and uncategorized landfills.
- **Methane Generation Potential (L_0)** based on degradable organic carbon, landfill management type and fraction of methane in landfill gas nationally.
- **Oxidation Factors (OX)** based on waste disposal management practice.

Exclusions

Due to the unavailability of data, the data provided excludes:

- Community-specific **mass of industrial, sludge, clinical, and fossil liquid waste.**

- **Landfill methane recovery fraction** at landfill facilities with recovery systems in place.
- The combustion, or flaring, of landfill gas for non-energy purposes[2]
- The combustion of solid waste for non-energy purposes[3]

Activity Data Coverage

Nationally reported data on community specific mass of waste sent to various landfill treatment facilities is available for Colombia. As a result, this MSW section provides final estimations which fall under Scope 1 emissions).

Table 1: Activity data, units, and scope covered under solid waste disposal

Activity Data	Definition	Units	Gases Reported	Emissions Scope
Mass of Waste	The mass of waste disposed at unmanaged, managed and uncategorized landfills and open dumps within a community boundary, regardless of where the waste was generated.	Tonnes	CH_4	Scope 1
	The mass of waste generated within a community boundary but diverted to an external landfill or open dump for disposal	Tonnes	CH_4	Scope 3

Allocation Methodology

Activity Data – Mass of Waste (Sanitary Landfills)

In Colombia, waste data is collected by the competent local environmental authorities (municipal or departmental) and the National "Solid Waste Final Disposal Report" is generated. For the preparation of the 2017 report, there was information from 820 municipalities, 74% of the total municipalities in the country, information gaps remain from the municipalities that did not report any data or partially reported. It is important to note that in the Report, waste collected and transported by the public household cleaning service, illegal dumps and incineration are not accounted for. Hence, this methodology only provides estimates for the existing municipalities from which information was available for.

[2] While the flaring of landfill gas is typically reported under the waste sector, to burning of landfill gas for energy purposes is reported under the stationary energy sector

[3] Similar to above, the burning of waste for non-energy purposes falls under the waste sector, whereas any waste burned for energy (e.g. heat or electricity generation) falls under the stationary energy sector

Activity Data – Mass of waste (Open-dumping)

Mass of waste landfilled and preferred management type at a community level was taken from the Solid Waste Final Disposal Report 2017

Activity Data – Methane Correction Factor (MCF)

Since CH_4 generation rates are dependent on landfill management practices, therefore this methodology uses the IPCC (2006) default landfill management types to determine an appropriate community-specific methane correction factor. Colombia waste is diverted to two different disposal sites: managed and unmanaged shallow/open air dumps. Because data on both managed and unmanaged landfills is provided by in the Final Disposal Report for Colombia, the IPCC (2006) unitless MCF values of 1.0 and 0.4 is used.

Emission Factors

Under this method the solid waste disposal emission factor (EF) is a combination of two factors, the methane generation potential (L_0) and the oxidation factor (OX). In the absence of data on facility-specific emission factors, this methodology relies on the default factor for OX derived from IPCC (2006).

Equation 1

$$EF = L_o * (1 - OX)$$

Table 2: Data elements and sources

Data Element	Definition	Units	Data Source
L_O	Methane Generation Potential – the amount of methane generated per tonne of waste	Tonnes CH_4/tonne waste	Equation 2
OX	Oxidation factor (Methane Oxidized in top layer)	Unitless	IPCC (2006)

Oxidation Factor (OX)

The oxidation factor—the percentage of carbon that is oxidized during decomposition—is another EF value utilized in the estimation of methane from landfilled/or open-dumped MSW. Since landfills in Colombia are either managed or unmanaged shallow, both managed and unmanaged oxidation values are used in this methodology.

Methane Generation Potential (L_0)

Methane generation potential (L0) is itself a combination of several components: The Methane Correction Factor (MCF); Degradable Organic Carbon (DOC), weighted by waste stream type

(discussed below); the fraction of waste degraded anaerobically (DOCf); the fraction of landfill gas that is methane (F); and the methane to carbon ratio. In the absence of facility-specific data, each of these values is derived from IPCC 2006 list of default values. Hence, this methodology calculates the methane generation potential of landfilled waste in Colombia using equation 2 below:

Equation 2

$$L_0 = MCF * DOC * DOC_F * F * {}^{16}/_{12}$$

Table 3: Data elements and sources

Data Element	Definition	Units	Data Source
MCF	Methane Correction Factor (based on management type) – part of the landfilled materials that is left to degrade anaerobically.	Unitless	IPCC (2006)
DOC	Degradable organic carbon – the portion of the waste stream that can decompose under aerobic conditions. This is estimated using the mass of waste under each waste stream and the IPCC designated DOC fractions.	Tonnes C/tonne waste	Equation 3
DOC_F	The fraction of DOC ultimately degraded anaerobically	Unitless	IPCC (2006)
F	The fraction of methane in landfill gas	Unitless	IPCC (2006)
${}^{16}/_{12}$	Methane to carbon ratio	Unitless	IPCC (2006)

Degradable Organic Carbon (DOC)

Degradable Organic Carbon represents the amount of organic carbon in the waste that can be degraded. The final DOC value **(0.234)** is estimated by using the fraction of the total mass of the waste and apportioning it with the DOC fractions. Equation 3 below provides the IPCC designated DOC fractions while table 5 provides the waste fraction percentages of total mass used for Colombia, extracted from the IPCC, 2006 regional estimates.

Equation 3

$$DOC = (0.15 * A) + (0.2 * B) + (0.4 * C) + (0.43 * D) + (0.24 * E) + (0.15 * F)$$

Table 4: Data elements and definitions

Metric	Definition
A	Mass of food waste
B	Mass of garden and plant debris
C	Mass of paper
D	Mass of wood
E	Mass of textiles
F	Mass of Industrial waste

Table 5: IPCC defaults and waste fractions

IPCC Defaults	Food waste	Paper/ cardboard	Wood	Textiles	Rubber/ leather	Plastic	Metal	Glass	Other
Waste Fractions	44.9	17.1	4.7	2.6	0.7	10.8	2.9	3.3	13.0
DOC	15	40	43	24	-	-	-	-	-

Additionally, emissions are produced from industrial wastes, which have their unique set of DOC values. However, in the absence of data for this category, this methodology omits community-specific activity data or emission factors for industrial waste.

General Assumptions & Limitations

Mass of Waste

- We only attempt to estimate scope 1 emissions, and do not attempt to estimate scope 3 emissions from the activities of the residents within the community boundary.
- IPCC values for waste composition is representative of Colombia's waste.

Emission Factors

- The IPCC (2006) *IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5: Waste, Chapter 3: Solid Waste Disposal* provides national waste composition estimates for Chile. In the absence of national or community-specific datasets on industrial, clinical, sludge, and fossil liquid waste this methodology is unable to determine a community-specific DOC estimate for these waste streams.

Methane Correction Factor

- All landfilled and controlled landfill sites are assumed to fall under the managed anaerobic IPCC landfill characteristic and were therefore assigned an MCF of 1.0.
- All unmanaged shallow (open dumps) are assumed to fall under the unmanaged IPCC landfill characteristic and were therefore assigned an MCF of 0.4

Methane Recovery

- Since there is no information on methane recovered, our method does not estimate it.

References:

"Censo General 2005." Inicio. Accessed October 7, 2019. https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/censo-general-2005-1.

Provides population and other demographic data for use in the waste disaggregation process.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5: Waste, Chapter 3: Solid Waste Disposal, The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change, H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds.). Hayama, Kanagawa, Japan. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

Provides default values for the fraction of degradable organic content present in waste stream.

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