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

Mario Finch, Kevin Kurkul, Octavio Molina, Valeria Lopez-Portillo, and Aline Nolasco Escalona – World Resources Institute

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. This sector contains the following subsectors:

Buildings and Stationary Energy Sector	
Residential buildings	Estimated
Commercial buildings	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, 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 (which may be generated outside the community boundary).

Inclusions

For Mexico, based on data availability and country-specific relevance, estimates for the following activity data points are produced:

- **Natural gas**, **liquefied petroleum gas**, and **kerosene** used by households, based on annual fuel consumption by residential customers at national level.
- **Grid-supplied electricity** used by households, based on annual electricity consumed by residential customers at the national level.

Exclusions

Due to lack of data availability and country-specific relevance, estimates for the following activity data points are not produced:

- **Off-highway motor gasoline** consumption, e.g. for use in lawn and gardening equipment
- **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	GHGDP Definition	Units	Scope
Natural Gas	All natural gas consumption within community boundary for a single year for all households.	MJ	Scope 1
Liquefied Petroleum Gas (LPG)	All LPG fuel 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

[1] For the purposes of this methodology, households correspond to all categories of "housing units" as defined in the National Institute of Statistics and Geography (INEGI Spanish acronym), including single family units, apartments in multi-unit buildings, etc.

Grid Electricity	All grid-supplied electricity consumption within community boundary for a single year for all commercial buildings	MJ	Scope 2

Calculation Methodologies

Scope 1: Natural Gas (NG)

Methodology Notes

Residential building NG consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System. This initial input data is allocated to communities based on:

- the **number of households (by type)** in the municipality relative to state totals, and
- a computed **weighted community fuel intensity**, designed to account for differences in fuel mix between urban, rural, and mixed communities.

Total count of households by state and total households by municipality are sourced from the 2010 INEGI Census data and INEGI's updated state housing survey for 2016. In addition, average annual natural gas consumption estimates (in MJ/household) for discrete housing demographics (urban, mixed and rural) are derived from a combination of the Consejo Nacional de Población (CONAPO) La situation demographical de México 2016, the energy information system 2016 database and the BIEE (Base de Indicadores de Eficiencia Energética) 2016 database. These data are used to calculate **weighted community fuel intensities** that control for the average fuel mixes used in urban, mixed, and rural communities. Weighted averages are calculated for all communities relative to a national average.

The following equation is utilized to estimate household natural gas consumption.

Equation 1: Household NG Consumption

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

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 1	MJ

$\text{aggregate residential consumption}_{NG}$	Amount of natural gas fuel consumed in 2016 by the residential sector in an entire country	SIE (2016)	MJ
$\left(\dfrac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Ratio representing the number of households within the community in 2010 over the number of households within the entire state in the year 2010	INEGI (2010; 2016)	households
weighted community fuel intensity	Percentage associated with weighted community fuel intensity by fuel type per housing demographic	Equation 5	percentage

Methodology Assumptions

General assumptions and limitations

- Number of households, by housing type, is proportionally related to the amount of NG consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban, mixed and rural) remain consistent within national weighted energy intensities (urban, mixed and rural). Hence, we assume a useful relationship between community type and energy intensity
- For the purpose of this methodology, we only accessed community-specific household building stock data from the 2010 census. We therefore did not adjust for relative population changes between communities beyond that census year. Appropriate adjustments can be made when a more recent census is released.

Scope 1: Liquefied Petroleum Gas (LPG)

Methodology Notes

Residential building LPG consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System. This initial input data is then allocated to communities based on:

- the **number of households (by type)** in the municipality relative to state totals, and
- a computed **weighted community fuel intensity**, designed to account for differences in fuel mix between urban, rural, and mixed communities.

Total count of households by state and total households by municipality are sourced from the 2010 INEGI Census data and INEGI's updated state housing survey for 2016. In addition, average annual LPG consumption estimates (in MJ/household) for discrete housing demographics (urban, mixed and rural) are derived from a combination of the Consejo Nacional de Población (CONAPO) La situation demographical de México 2016, the energy information system 2016 database and the BIEE (Base de Indicadores de Eficiencia Energética) 2016 database. These data are used to calculate **weighted community fuel intensities** that control for the average fuel mixes used in urban, mixed, and rural communities. Weighted averages are calculated for all communities relative to a national average.

The following equation is utilized to estimate household LPG gas consumption.

Equation 2: Community LPG consumption

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

Equation Data Elements

Data element	Description	Source	Units
Community-scale household consumption	All liquefied petroleum gas consumption within community boundary for a single year for all households.	Equation 2	MJ
$\text{aggregate residential consumption}_{\text{LPG}}$	Amount of liquefied petroleum gas fuel consumed in 2016 by the residential sector in an entire country	SIE (2018)	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Ratio representing the number of households within the community in 2010 over the number of households within the entire state in the year 2010	INEGI (2010; 2016)	households
weighted community fuel intensity	Percentage associated with weighted community fuel intensity by fuel type per housing demographic	Equation 5	percentage

Methodology Assumptions

General assumptions and limitations

- Number of households, by housing type, is proportionally related to the amount of LPG consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban, mixed and rural) remain consistent within national weighted energy intensities (urban, mixed and rural). Hence, we assume a useful relationship between community type and energy intensity For the purpose of this methodology, we only accessed community-specific household building stock data from the 2010 census. We therefore did not adjust for relative population changes between communities beyond that census year. Appropriate adjustments can be made when a more recent census is released.

Scope 1: Kerosene

Methodology Notes

Residential building Kerosene consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System. This initial input data is allocated to communities based on:

- the **number of households (by type)** in the municipality relative to state totals, and
- a computed **weighted community fuel intensity**, designed to account for differences in fuel mix between urban, rural, and mixed communities.

Total count of households by state and total households by municipality are sourced from the 2010 INEGI Census data and INEGI's updated state housing survey for 2016. In addition, average annual kerosene consumption estimates (in MJ/household) for discrete housing demographics (urban, mixed and rural) are derived from a combination of the Consejo Nacional de Población (CONAPO) La situation demographical de México 2016, the energy information system 2016 database and the BIEE (Base de Indicadores de Eficiencia Energética) 2016 database. These data are used to calculate **weighted community fuel intensities** that control for the average fuel mixes used in urban, mixed, and rural communities. Weighted averages are calculated for all communities relative to a national average.

Equation 3:Community Kerosene Consumption

The following equation is utilized to estimate household kerosene consumption.

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

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 3	MJ

$\text{aggregate residential consumption}_{\text{Kerosene}}$	Amount of kerosene fuel consumed by the residential sector in an entire country in 2016	SIE (2018)	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Ratio representing the number of households within the community in 2010 over the number of households within the entire state in 2010	INEGI (2010; 2016)	households
$\text{weighted community fuel intensity}$	Percentage associated with weighted community fuel intensity by fuel type per housing demographic	Equation 5	percentage

Methodology Assumptions

General assumptions and limitations

- Number of households, by housing type, is proportionally related to the amount of Kerosene consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban, mixed and rural) remain consistent within national weighted energy intensities (urban, mixed and rural). Hence, we assume a useful relationship between community type and energy intensity For the purpose of this methodology, we only accessed community-specific household building stock data from the 2010 census. We therefore did not adjust for relative population changes between communities beyond that census year. Appropriate adjustments can be made when a more recent census is released.

Scope 2: Electricity

Methodology Notes

Residential building electricity consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System for the year 2016. This initial input data is allocated to communities based on:

- the **number of households (by type)** in the municipality relative to state totals, and
- a computed **weighted community fuel intensity**, designed to account for differences in fuel mix between urban, rural, and mixed communities.

Total count of households by state and total households by municipality are sourced from the 2010 INEGI Census data and INEGI's updated state housing survey for 2016. In addition, average annual electricity consumption estimates (in MJ/household) for discrete housing demographics (urban, mixed and rural) are derived from a combination of the Consejo Nacional de Población (CONAPO) La situation demographical de México 2016, the energy information system 2016 database and the BIEE (Base de Indicadores de Eficiencia Energética) 2016 database. These data are used to calculate **weighted community fuel intensities** that control for the average fuel mixes used in urban, mixed, and rural communities. Weighted averages are calculated for all communities relative to a national average.

Equation 4:Community Electricity Consumption

The following equation is utilized to estimate household electricity consumption.

$$\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{Electricity}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right) \times (\text{weighted community fuel intensity})$$

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 4	MJ
$\text{aggregate residential consumption}_{\text{Electricity}}$	Amount of electricity consumed by the residential sector in an entire country in 2016	SIE (2018)	MJ
$\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{state}}}\right)$	Ratio representing the number of households within the community in 2010 over the number of households within the entire state in 2010	INEGI (2010; 2016)	households
Weighted community Fuel Intensity	Percentage associated with weighted community fuel intensity by fuel type per housing demographic	Equation 5	percentage

Methodology Assumptions

General assumptions and limitations

- Number of households, by housing type, is proportionally related to the amount of electricity consumed in the residential sector at national level.

- Average weighted energy intensities by community type (urban, mixed and rural) remain consistent within national weighted energy intensities (urban, mixed and rural). Hence, we assume a useful relationship between community type and energy intensity For the purpose of this methodology, we only accessed community-specific household building stock data from the 2010 census. We therefore did not adjust for relative population changes between communities beyond that census year. Appropriate adjustments can be made when a more recent census is released.

Weighting Factors

This method uses national-level values for fuel use by residential sector and incorporates weighting factors, which help control for expected variation in fuel use across city types. According to Mexico's 2016 census, cities are classified as one of three category types:

- Rural – communities with less than 2,500 inhabitants
- Mixed – communities with more than 2,500 but less than 15,000 inhabitants
- Urban – communities with more than 15,000 inhabitants

We use data from SIE 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 community:

Equation 5: Weighting Factors

$$\text{Weighting Factor}_{\text{city type, fuel type}} = \frac{M_{\text{city type, fuel type}} * C_{\text{city type}}}{\sum_{\text{city type}}\left(M_{\text{city type, fuel type}} * C_{\text{city type}} * HH_{\text{city type}}\right)}$$

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 5	Unitless
$M_{\text{city type, fuel type}}$	The average residential fuel mix in 2016, by city type	SIE, 2018	%
$C_{\text{city type}}$	The average annual energy consumption of one household in 2016, by city type	BIEE, 2016; SIE, 2018	MJ
$HH_{\text{city type}}$	The total national count of households in 2016, by city type	INEGI, 2016	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 Mexico.

Emission Factor Data Elements

Fuel type	Carbon Dioxide (CO_2) kg/GJ	Methane (CH_4) kg/GJ	Nitrous Oxide (N_2O) kg/GJ	Heating Value Mass GJ/ton	Heating Value Liquid Volume GJ/liter	Heating Value Gaseous Volume GJ/m3
Fossil						
Natural Gas	56.1	0.005	0.0001			0.0336
Kerosene	71.9	0.01	0.0006		0.035	
Liquified Petroleum Gas (LPG)	63.1	0.005	0.0001	47.3	0.0255	0.0336

References

El Consejo Nacional de Población (2016). La situación demográfica de México. Available at https://www.gob.mx/cms/uploads/attachment/file/253187/SDM2016_web.pdf

Provides information on housing demographics

Instituto Nacional de Estadística y Geografía - INEGI (2016). Available at http://www.beta.inegi.org.mx/app/tabulados/pxweb/inicio.html?rxid=2a7423ff-cf36-4e8f-8cec-f04faba3b2a3&db=Hogares&px=Hogares_04

Provides statistics on the housing stock by community.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. 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 https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Provides default emission factor values for a range of fuel types.

Programa BIEE (Base de Indicadores de Eficiencia Energética) 2018. Available at http://www.biee-conuee.enerdata.net/index.php

Reports residential energy consumption based on fuel type for a 5-year period by state. This information is used to disaggregate each fuel type down to a municipality level.

Sistema de Información Energética (2018). Available at http://sie.energia.gob.mx/bdiController.do?action=temas

Database with the national energy balance for 2016 by fuel type and end use

Commercial Buildings

Subsector Summary

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

Inclusions

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

- **Natural gas**, **liquefied petroleum gas**, and **diesel oil** used by commercial buildings, based on annual fuel consumption by customers at national level.
- **Grid-supplied electricity** used by commercial businesses, based on annual electricity consumed by commercial customers at the national level.

Exclusions

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

- **Off-highway motor gasoline** consumption, e.g. for use in landscaping equipment
- **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	Natural gas consumption within community boundary for a single year for all commercial buildings	MJ	Scope 1
Distillate Fuel Oil	Distillate fuel oil consumption within community boundary for a single year for all commercial buildings	MJ	Scope 1
Liquid Gas Petroleum	Liquid Gas Petroleum consumption within community boundary for a single year for all commercial buildings	MJ	Scope 1

Grid Electricity	Grid-supplied electricity consumption within community boundary for a single year for all commercial buildings	MJ	Scope 2

Calculation Methodologies

Scope 1: Natural Gas (NG)

Methodology Notes

Commercial building NG consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System for the year 2016. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the national totals.

Total counts of employees, by community, are sourced from the 2014 INEGI Census data. The number of employees from commerce and services at community level are sum up to estimate the number of employees from commercial sector. Furthermore, the national building Natural Gas consumption is **scaled by the percentage of employees in each community to estimate the building natural gas consumption by each community.**

The following equation is utilized to estimate commercial sector natural gas consumption.

Equation 6:Commercial Natural Gas consumption

$$\text{Community-scale commercial consumption} = \text{national fuel consumption}_{\text{commercial}} \times \left(\frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{national}}}\right)$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale commercial consumption	Natural gas consumption within community boundary for a single year for all commercial buildings	Equation 6	MJ
National fuel consumption commercial sector	Amount of fuel consumed by commercial customers within entire country in 2016	SIE (2018)	MJ
Commercial employees - community	Estimated number of commercial sector employees for the community in 2014	INEGI (2016)	Employees

Commercial employees - national	Estimated number of commercial sector employees within country in 2014	INEGI (2016)	Employees

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of commercial sector employees is proportionally related to the amount of natural gas consumed.
- SIE national totals are assumed to encompass all NG national commercial consumption.
- All natural gas sold to commercial customers is consumed within the year it is delivered
- Weights used in the current iteration partially do not take account of differences in the building context of each community in terms of the size of establishments. Additional weighting and calibration are necessary, in order to account for differences in per-employee intensities not just based on establishment sizes, but by different categories of commercial enterprises such as finance, education, and retail trade. Future iterations will incorporate these additional pieces of information into final estimates.

Scope 1: Distillate Fuel Oil (Diesel)

Methodology Notes

Commercial building distillate fuel oil consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System for the year 2016. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the national totals.

Total counts of employees, by community, are sourced from the 2014 INEGI Census data. The number of employees from commerce and services at community level are sum up to estimate the number of employees from commercial sector. Furthermore, the national building distillate fuel oil consumption is **scaled by the percentage of employees in each community to estimate the building distillate fuel oil consumption by each community.**

The following equation is utilized to estimate commercial sector distillate fuel oil consumption.

Equation 7:Commercial Distillate fuel oil consumption

$$\text{Community-scale commercial consumption} = \text{national fuel consumption}_{\text{commercial}} \times \left(\frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{national}}}\right)$$

Equation Data Elements

Data element	Description	Source	Units

Community-scale commercial consumption	Distillate fuel oil consumption within community boundary for a single year for all commercial buildings	Equation 7	MJ
National fuel consumption commercial sector	Amount of distillate fuel oil consumed by commercial customers within entire country in 2016	SIE (2018)	MJ
Commercial employees - community	Estimated number of commercial sector employees for the community in 2014	INEGI (2016)	Employees
Commercial employees - national	Estimated number of commercial sector employees within the country in 2014	INEGI (2016)	Employees

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of commercial sector employees is proportionally related to the amount of distillate fuel oil consumed.
- SIE national totals are assumed to encompass all distillate fuel oil national commercial consumption.
- All distillate fuel oil sold to commercial customers is consumed within the year it is delivered
- Weights used in the current iteration partially do not take account of differences in the building context of each community in terms of the size of establishments. Additional weighting and calibration are necessary, in order to account for differences in per-employee intensities not just based on establishment sizes, but by different categories of commercial enterprises such as finance, education, and retail trade. Future iterations will incorporate these additional pieces of information into final estimates.

Scope 1: Liquid Gas Petroleum (LPG)

Methodology Notes

Commercial building LPG consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System for the year 2016. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the national totals.

Total counts of employees, by community, are sourced from the 2014 INEGI Census data. The number of employees from commerce and services at community level are sum up to estimate the number of employees from commercial sector. Furthermore, the national building LPG gas consumption is **scaled**

by the percentage of employees in each community to estimate the building LPG consumption by each community.

The following equation is utilized to estimate commercial sector LPG consumption.

Equation 8:Commercial LPG consumption

$$\text{Community-scale commercial consumption} = \text{national fuel consumption}_{\text{commercial}} \times \left(\frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{national}}}\right)$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale commercial consumption	Liquefied Petroleum gas consumption within community boundary for a single year for all commercial buildings	Equation 8	MJ
National fuel consumption commercial sector	Amount of fuel consumed by commercial customers within entire country in 2016	SIE (2018)	MJ
Commercial employees - community	Estimated number of commercial sector employees for the community in 2014	INEGI (2014)	Employees
Commercial employees - national	Estimated number of commercial sector employees within the country in 2014	INEGI (2014)	Employees

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of commercial sector employees is proportionally related to the amount of LPG gas consumed.
- SIE national totals are assumed to encompass all LPG national commercial consumption.
- All LPG gas sold to commercial customers is consumed within the year it is delivered
- Weights used in the current iteration partially do not take account of differences in the building context of each community in terms of the size of establishments. Additional weighting and calibration are necessary, in order to account for differences in per-employee intensities not just based on establishment sizes, but by different categories of commercial enterprises such as finance, education, and retail trade. Future iterations will incorporate these additional pieces of information into final estimates.

Scope 2: Electricity

Methodology Notes

Commercial building electricity consumption is taken from Mexico´s National Energy Balance 2016 data located at the Energy Information System for the year 2016. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the national totals.

Total counts of employees, by community, are sourced from the 2014 INEGI Census data. The number of employees from commerce and services at community level are sum up to estimate the number of employees from commercial sector. Furthermore, the national building electricity consumption is **scaled by the percentage of employees in each community to estimate the building electricity consumption by each community.**

The following equation is utilized to estimate commercial sector electricity consumption.

Equation 9:Commercial electricity consumption

$$\text{Community-scale commercial consumption} = \text{national fuel consumption}_{\text{commercial}} \times \left(\frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{national}}}\right)$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale commercial consumption	Electricity consumption within community boundary for a single year for all commercial buildings	Equation 9	MJ
National fuel consumption commercial sector	Amount of fuel consumed by commercial customers within entire country in 2016	SIE (2018)	MJ
Commercial employees - community	Estimated number of commercial sector employees for the community in 2014	INEGI (2016)	Employees
Commercial employees - national	Estimated number of commercial sector employees within the country in 2014	INEGI (2016)	Employees

Methodology Assumptions and Potential Improvement

General assumptions and limitations

- Number of commercial sector employees is proportionally related to the amount of electricity consumed.
- SIE national totals are assumed to encompass all electricity national commercial consumption.
- All electricity sold to commercial customers is consumed within the year it is delivered
- Weights used in the current iteration partially do not take account of differences in the building context of each community in terms of the size of establishments. Additional weighting and calibration are necessary, in order to account for differences in per-employee intensities not just based on establishment sizes, but by different categories of commercial enterprises such as finance, education, and retail trade. Future iterations will incorporate these additional pieces of information into final estimates.

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 Mexico.

Emission Factor Data Elements

Fuel type	**Carbon Dioxide (CO_2) kg/GJ**	**Methane (CH_4) kg/GJ**	**Nitrous Oxide (N_2O) kg/GJ**	**Heating Value Mass GJ/ton**	**Heating Value Liquid Volume GJ/liter**	**Heating Value Gaseous Volume GJ/m3**
Fossil						
Natural Gas	56.1	0.005	0.0001			0.0336
Distillate Fuel Oil	74.1	0.01	0.0006		0.0361	
Liquified Petroleum Gas (LPG)	63.1	0.005	0.0001	47.3	0.0255	0.0336

References

Instituto Nacional de Estadística y Geografía - INEGI (2016). Available at http://www.beta.inegi.org.mx/app/tabulados/pxweb/inicio.html?rxid=2a7423ff-cf36-4e8f-8cec-f04faba3b2a3&db=Hogares&px=Hogares_04

Provides statistics on the housing stock by community.

Instituto Nacional de Estadística y Geografía - INEGI (2016). Economic statistics. Mexico; 2014. Available at https://www.inegi.org.mx/temas/empleo/

Provides statistics on the commercial employees by community

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. 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 https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Provides default emission factor values for a range of fuel types.

Programa BIEE (Base de Indicadores de Eficiencia Energética) 2018. Available at http://www.biee-conuee.enerdata.net/index.php

Reports residential energy consumption based on fuel type for a 5-year period by state. This information is used to disaggregate each fuel type down to a municipality level.

Secretaría de Energía (Sener). Sistema de información energética. (2018). Available at http://sie.energia.gob.mx/

Provides information on the national energy balance per year

Transportation and Mobile Energy Sector

This document details the calculation approaches and data sources for producing community-level activity data and emission factors 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 consumption of fuel for on-road vehicles such as passenger cars, light trucks, motorcycles, mopeds, buses, heavy trucks, and combination 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 and diesel.

Inclusions

For Mexico, based on available data and method, activity data produced includes:

- **Gasoline** and **diesel fuel** consumption for private and commercial and publicly owned passenger cars, light trucks, motorcycles, buses, heavy trucks, and combination trucks within a community boundary.

Exclusions

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

- **Fuel consumption disaggregated by fleet type** from all on-road vehicles.
- **The vehicle kilometers traveled by** all on-road vehicles.

Activity Data Coverage

Table 1 includes the emissions sources covered by this methodology.

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

Emissions Source	Definition	Units	Scope
Private and commercial vehicle gasoline	The amount of gasoline consumed for a single year by all private and commercial vehicles in a community boundary	Liters	Scope 1
Public vehicle gasoline	The amount of gasoline consumed for a single year by publicly owned vehicles in a community boundary	Liters	Scope 1
Private and commercial vehicle diesel	The amount of diesel consumed for a single year by all private and commercial vehicles in a community boundary	Liters	Scope 1
Public vehicle diesel	The amount of diesel consumed for a single year by all publicly owned vehicles in a community boundary	Liters	Scope 1

Allocation Methodology

Fuel Consumption

The input data from the Instituto Nacional de Ecología y Cambio Climático (INECC, 2016) provides national values for gasoline and diesel consumption by all on-road vehicles. This dataset therefore required additional disaggregation to be completed using the total number of vehicle registrations by municipality in our methodology

Equation 1 includes the approach used to estimate gasoline and diesel consumption by all private and commercial and publicly owned vehicle types.

Equation 1

$$\text{Community fuel sales}_{vehicle} = \text{State fuel sales} \times \frac{(\text{Municipal vehicle count} \times \text{Vehicle fuel fraction} \times \text{VKT} \div \text{Fuel Efficiency})}{\sum_{\text{State}}(\text{Municipal vehicle count} \times \text{Vehicle fuel fraction} \times \text{VKT} \div \text{Fuel Efficiency})}$$

Table 2 – Data sources to estimate gasoline consumption

Data element	Definition	Units	Source
Community fuel sales	Gasoline or diesel sales within the community boundary, by vehicle type (passenger car, light truck, heavy truck, bus, or motorcycle) and fleet type (private and commercial or public)	Liters	Equation 1
State fuel sales	Gasoline or diesel sales within the state boundary, by vehicle type (passenger car, light truck, heavy truck, bus, or motorcycle) and fleet type (private and commercial or public)	Liters	INECC, 2016
Municipality Vehicle Count	Municipal-level motor vehicle registration numbers for the private and commercial fleet by vehicle type in a single year	Vehicles	INECC, 2016
Vehicle Kilometers Travelled (VKT)	The average vehicle kilometers travelled by each vehicle type by fuel type	Kilometers	BIEE, 2016

Fuel Efficiency	Proportion of vehicles, by vehicle type that use either gasoline or diesel	Percentage	LEDS, 2017

Methodological and Data Assumptions & Limitations

This methodology assumes that:

- Gasoline and diesel are the only fuels used by vehicles
- All motorcycles use gasoline

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. Table 2 includes the fuels used in Mexico and their corresponding emission factor values.

Table 2 – IPCC Emission Factors for Fuels

Fuel type	**Carbon Dioxide (CO2) kg/GJ**	**Methane (CH4) kg/GJ**	**Nitrous Oxide (N2O) kg/GJ**
Diesel	74.1	0.01	0.0006
Gasoline	69.3	0.01	0.0006

Citations

Base de indicadores de eficiencia energetica (2016)

Database developed by to promote the evaluation of Energy Efficiency in Mexico. This database was used for obtaining VKT for the transport sector.

Eggleston, S., Buendia, L., Miwa, K., Ngara, T., & Tanabe, K. (Eds.). (2006). “2006 IPCC guidelines for national greenhouse gas inventories (Vol. 2): Energy.” Hayama, Japan: Institute for Global Environmental Strategies. Retrieved from https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

This webpage provides standard GHG emission factor variables for each fuel type used.

Instituto Nacional de Ecología y Cambio Climático (INECC, 2016). Programa Para El Desarrollo De Emisiones Bajas En México . Available at http://www.plataformaleds.org/images/images/0326944001471877932.pdf

This webpage provides information on fuel proportions by vehicle type.

Instituto Nacional de Estadística y Geografía (INEGI, 2017) Estadisticas de Vehiculos de motor registrados en circulacion. Available at http://www.inegi.org.mx/lib/olap/consulta/general_ver4/MDXQueryDatos.asp?#Regreso&c=

This webpage provides information on vehicle registrations by vehicle type and ownership type (private vs public).

Plataforma Leds (2017). Available at http://www.plataformaleds.org/images/images/0326944001471877932.pdf

This webpage provides information on the diesel vs gasoline fleet, by vehicle type, between 2010 and 2016.

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	Estimated
Incinerated and burned waste	Not currently estimated
Wastewater	Estimated

Solid Waste

Subsector Overview

This section covers the activity data and emission factors needed for communities in Mexico 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 Mexico.

Inclusions

For Mexico, based on available data, this methodology provides estimates on:

- 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 methods exclude:

- 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 Mexico. 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 managed, unmanaged, and uncategorized landfills and open dumps within a community boundary, regardless of where the waste is generated.	Tonnes	CH_4	Scope 1

Allocation Methodology

Activity Data – Mass of Waste (Sanitary Landfills)

The community-specific mass of waste sent to sanitary landfills is obtained from the Instituto Nacional de Ecología y Cambio Climático (INECC) y Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) from their 2015 report "Base de datos del Inventario Nacional de Emisiones de Gases de Efecto Invernadero 2013 del sector Residuos, subsector Disposición de residuos sólidos urbanos." This dataset provides information up to 2013 on the major municipalities where waste is disposed at sanitary landfills. To obtain 2015 estimates, a national growth rate is applied to the 2013 values to estimate the mass of waste up in the year 2015 per the following equation.

Equation 1

$$Community\ mass\ of\ waste\ (2015) = \frac{National\ Population\ (2015) - National\ Population\ (2013)}{National\ Population\ (2013)}\ x\ Community\ mass\ of\ waste\ (2013)$$

[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

Data Element	Definition	Units	Data Source
Community mass of waste (2015)	Estimated mass of waste deposited in landfill facilities in 2015	Tonnes	Equation 1
National Population (2015)	Total censused population in 2015	People	INEGI (2016)
National Population (2013)	Total censused population in 2013	People	INEGI (2016)
Community mass of waste (2013)	Total waste deposited at community landfill facilities in 2013 for treatment	Tonnes	INECC; SEMARNAT (2015)

Activity Data – Mass of waste (Unmanaged Shallow Landfills/Open-dumps)

Similar to the landfill data, the community-specific mass of waste sent to open dumps is obtained from the Instituto Nacional de Ecología y Cambio Climático (INECC) y Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) from their 2015 report "Base de datos del Inventario Nacional de Emisiones de Gases de Efecto Invernadero 2013 del sector Residuos, subsector Disposición de residuos sólidos urbanos." This dataset provides information up to 2013 on the major municipalities where open dumping takes place. To obtain 2015 estimates a national growth rate is applied to the 2013 values to estimate the mass of waste up in the year 2015. Since these estimates were already at the municipality level no additional disaggregation methods were employed.

Activity Data – Mass of waste (Uncategorized Landfills)

The community-specific mass of waste sent to uncategorized landfills is obtained from the Instituto Nacional de Ecología y Cambio Climático (INECC) y Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) from their 2015 report "Base de datos del Inventario Nacional de Emisiones de Gases de Efecto Invernadero 2013 del sector Residuos, subsector Disposición de residuos sólidos urbanos." This dataset provides information up to 2013 on the major municipalities where waste is disposed of at an uncategorized landfill site. To obtain 2015 estimates a national population growth rate is applied to the 2013 values to estimate the mass of waste up in the year 2015. Since these estimates were already at the municipality level no additional disaggregation methods were employed.

Activity Data – Methane Correction Factor (MCF)

Since CH_4 generation rates are dependent on landfill management practices, this methodology uses the IPCC (2006) default landfill management types to determine an appropriate community-specific methane correction factor. Since INEEC (2015) identifies that Mexico's waste has been deposited into managed, unmanaged shallow, and uncategorized landfills the IPCC (2006) unitless MCF values of 1.0, 0.4, and 0.6 respectively are 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 2

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

Table 3: 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 3
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 Mexican landfills are managed, unmanaged shallow, and uncategorized, 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 the Mexico using equation 4 below:

Equation 3

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

Table 4: 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 4
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. Since state specific information on mass of waste is already available from SEMERNAT and INECC, our method allowed us to downscale the data and provide municipality-level estimates within each state. This is done by using the fraction of the total mass of the waste and apportioning it with the DOC fractions. Equation 4 below provides the IPCC designated DOC fractions while table 5 provides the final DOC's estimated under each of the 33 Mexican states.

Equation 4

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

Table 5: Data elements and sources

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 6: State-specific DOC applied to each municipality

State	State-Specific DOC
Aguascalientes	0.2156
Baja California	0.2154
Baja California Sur	0.2321
Campeche	0.2215
Chiapas	0.2215
Chihuahua	0.2458
Coahuila de Zaragoza	0.2424
Colima	0.2174
Distrito Federal	0.2321
Durango	0.2250
Guanajuato	0.2174
Guerrero	0.2197
Hidalgo	0.2015
Jalisco	0.2099
México	0.2075
Michoacán de Ocampo	0.2174
Morelos	0.2174
Nayarit	0.2282
Nuevo León	0.2174
Oaxaca	0.2177
Puebla	0.2356
Querétaro	0.2029
Quintana Roo	0.2321
San Luis Potosí	0.2480
Sinaloa	0.2205
Sonora	0.2215
Tabasco	0.2084

Tamaulipas	0.2197
Tampico	0.2066
Tlaxcala	0.2649
Veracruz de Ignacio de la Llave	0.2321
Yucatán	0.2156
Zacatecas	0.2154

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.

DOC

- DOC values estimated for each state are applied to each municipality within that respective state.

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 Mexico. 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 *relleno sanitario* and *sitio controlado* sites are assumed to fall under the managed anaerobic IPCC landfill characteristic and were therefore assigned an MCF of 1.0.
- All *sitio no controlado* (open dumps) are assumed to fall under the unmanaged shallow IPCC landfill characteristic and were therefore assigned an MCF of 0.4
- All *sin sito* sites are assumed to fall under the uncategorized IPCC landfill characteristic and were therefore assigned an MCF of 0.6

Methane Recovery

INECC (2015) does not provide information for methane recovered, therefore our methodology does not estimate it.

Citations

Instituto Nacional de Ecología y Cambio Climático (INECC) y Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (2015). Base de datos del Inventario Nacional de Emisiones de Gases de Efecto Invernadero 2013 del sector Residuos, subsector Disposición de residuos sólidos urbanos. Available at https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-convention/biennial-update-reports-0

This national report presents values for the mass of waste by municipality and locality and the fraction of degradable waste going to landfills based on waste and landfill categories.

Instituto Nacional de Estadística y Geografía - INEGI (2016). Available at https://www.inegi.org.mx/temas/estructura/

Provides statistics on the population by community from 2010-2015.

IPCC (1996). IPCC Guidelines for National Greenhouse Gas Inventories. Volume. 1: Greenhouse gas inventory reporting instructions. Volume. 2: Greenhouse gas inventory workbook. Volume 3: Greenhouse gas inventory reference manual. Available at http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

Provides a method for estimating methane emissions from MSW using the methane commitment estimate model.

IPCC. (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Chapter 5: Waste. Available at https://www.ipcc-nggip.iges.or.jp/public/gp/english/5_Waste.pdf

Includes an updated method for estimating methane emissions from MSW using the methane commitment estimate model.

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.

Biological Waste

Subsector Overview

This section covers the activity data and emission factors needed for communities in Mexico to estimate emissions from the biological treatment of solid waste (biological waste). Biological waste estimates are influenced by two factors:

1) The mass of community-generated waste treated in a calendar year, via compost production and anaerobic digestion, and
2) The amount of methane recovered.

Methane (CH_4) and nitrous oxide (N_2O) are the main gases emitted during these treatment processes. The methods for estimating the mass of waste, methane recovery, and GHG-specific emission factors in Mexico are outlined below.

Inclusions

For Mexico, based on available data and methods, the data produced includes:

- Community-specific **mass of waste for biological treatment** at permitted facilities based on national data allocated proportionally with population.
- Community-specific **emission factors** based on location-specific assumptions of the biological treatment technique and the moisture content of waste sent to facilities.

Exclusions

Due to the unavailability of data, the methods exclude:

- **Facility-specific mass of waste composted**
- **Community-specific mass of waste anaerobically digested.**
- **Mass of waste composted outside of designated waste facilities** (e.g., private home composting)
- **Methane Gas Recovery** at compost facilities with recovery systems in place.

Activity Data Coverage

Communities should report emissions from the mass of waste treated based on emissions scope. For biological waste, this includes all methane recovered and organic waste disposed of and treated within a community boundary, through composting or anaerobic digestion techniques, regardless of where the waste is generated (scope 1), as well as all methane recovered and organic waste generated within a community boundary which is treated through composting or anaerobic digestion techniques at facilities outside the community boundary (scope 3).

Table 3: Activity data, units, and scope covered under biological waste

Activity Data	Definition	Units	Gases Reported	Emissions Scope
Biological Waste	The mass of organic waste disposed of and treated within the community boundary, through composting or anaerobic digestion techniques, regardless of where the waste is generated	Tonnes	CH_4, N_2O	Scope 1
	The mass of organic waste generated within the community boundary which is treated through composting or anaerobic digestion techniques at facilities outside the community boundary.	Tonnes	CH_4, N_2O	Scope 3

Allocation Methodology

Based on available data, this methodology uses a population-based approach instead of a facility-based approach to allocate state-level biological waste activity data to the community level.

Activity Data – Mass of Waste Composted

This methodology calculates the community-specific mass of waste generated in Mexico using Equation 10 below:

Equation 10

$$\text{Composted MSW}_{municipality} = \text{Composted MSW}_{national} * \frac{\text{Community Population}}{\text{National Population}}$$

Table 1: Data elements and sources

Data Element	Definition	Units	Data Source
$\text{Composted MSW}_{municipality}$	Mass of municipality-generated organic waste composted	Tonnes	Equation 10

Composted $MSW_{national}$	Mass of nationally-generated organic waste composted	Tonnes	INECC (2012)
Community Population	Total number of residents living within a Mexico municipality boundary	People	INEGI (2016)
National Population	Total number of persons living in Mexico	People	INEGI (2016)

As outlined in Equation 10, Instituto Nacional de Estadística y Geografía population datasets are used to divide the number of persons living within the municipality boundary by the total Mexico population reported in a calendar year. This result is scaled by the mass of composted waste reported nationally, INECC (2012) Diagnostico Básico Para la Gestión Integral de los Residuos, 2012, to estimate the municipality-specific mass of organic composted.

Activity Data – Mass of Waste Anaerobically Digested

Currently, there are no national or state level datasets available on the mass of waste treated through anaerobic digestion. As a result, the amount of waste treated through anaerobic digestion is not estimated.

Activity Data – Methane Recovery

The amount of methane recovered at composting facilities is subtracted from the total amount of CH4 generated before CH4 emissions from biological treatment are reported. If facilities do not have the technology to recover CH4, then methane recovery should be omitted from the emission estimates. Avedoy & Hernández (2012) does not document any CH4 recovery at biological treatment facilities in Mexico. Therefore, CH4 recovery at a community level is not estimated.

Emission Factors

CH_4 and N_2O emissions from the biological treatment of waste are calculated using emission factors provided in the 2006 IPCC guidelines. These factors are recorded in grams per kilogram of waste treated and identified below in Table 2. The wet weight emission factors of 4 g CH_4/kg compost (methane) and 0.3 g N_2O/kg compost (nitrous oxide) were used.

Table 2: 2006 IPCC Emission Factors per treatment type in g GHG/kg waste

Treatment Type	**CH_4** (g per kg of waste treated)	**N_2O** (g per kg of waste treated)
Compost (dry weight)	10	0.6

Compost (wet weight)	4	0.3
Anaerobic Digestion (dry weight)	2	None
Anaerobic Digestion (wet weight)	1	None

General Assumptions & Limitations

Mass of Waste

- Complete data on community-specific composting plants were unavailable in INECC (2012) *Diagnostico Básico Para la Gestión Integral de los Residuos, 2012.* As a result, the mass of waste composted nationally is disaggregated using the population numbers in each municipality. It is assumed that composting is a practice observed in every municipality and the mass assigned is proportional to the number of inhabitants located within that municipality's boundary.
- Due to lack of data, the mass of waste treated by anaerobic digestion is not estimated.

Emission Factors

- IPCC (2006) provides emission factor data for biological treatment via composting. For methane, a wet weight waste EF of 4.0 g CH_4/kg compost is used, and for nitrous oxide, a wet weight waste EF of 0.3 g N_2O/kg compost is used.

Citations

Instituto Nacional de Ecologia y Cambio Climático (INECC) Centro Nactional de Investigación Capacitación Ambiental (2012). Diagnostico Básico Para la Gestión Integral de los Residuos, Versión Ejecutiva. Available at http://biblioteca.semarnat.gob.mx/Documentos/Ciga/libros2009/CD001408.pdf

This report provides some data on biological treatment facilities and information on the mass of waste treated via composting.

Instituto Nacional de Estadística y Geografía - INEGI (2016). Available at https://www.inegi.org.mx/temas/estructura/

Provides statistics on the population by community from 2010-2015.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5: Waste, Chapter 4: Biological Treatment of Solid Waste, 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_4_Ch4_Bio_Treat.pdf

This report provides the range of default emission factors for methane and nitrous oxides based on moisture content and biological treatment type.

Wastewater

Subsector Overview

This section covers the activity data and emission factors needed for communities in Mexico to estimate emissions from the treatment and discharge of domestic and industrial wastewater effluent. Wastewater treatment and discharge emission estimates are influenced by five factors:

1) The organic content in the wastewater - domestic biological oxygen demand (BOD) and industrial chemical oxygen demand (COD),
2) the degree of utilization/discharge pathway,
3) the annual per capita protein consumption,
4) the amount of methane recovered, and
5) the amount of nitrogen sludge removed.

Methane (CH_4) and nitrous oxide (N_2O) are the main gases emitted during the treatment process. The methods for estimating the organic content, degree of utilization, protein consumption, methane recovery, and nitrogen sludge removal in Mexico are outlined below.

Inclusions

For Mexico, based on available data and methods, the data produced includes:

- **Community-specific domestic BOD values** present in effluent treated.
- **Community-specific emission factors** based on location-specific assumptions on discharge pathways.
- **Average annual per capita protein consumption** based on population-specific assumptions on consumption.
- **Amount of nitrogen removed as sludge.**

Exclusions

Due to the unavailability of data, the methods exclude:

- **The facility-specific volume of industrial wastewater effluent treated** and associated COD values.
- **The volume of effluent treated outside of designated wastewater treatment facilities** (e.g., stagnant water bodies and latrines)
- **Methane gas recovery** at wastewater facilities with recovery systems in place.

Activity Data Coverage

Communities should report emissions from wastewater based on emissions scope. For wastewater treatment and discharge, this includes the mass of methane recovered and municipal wastewater treated within a community boundary regardless of where the wastewater is generated (scope 1), as well as the mass of methane recovered and municipal wastewater generated by a community and treated at facilities outside the community boundary (scope 3).

Table 1: Activity data, units, and scope covered under wastewater treatment and discharge

Activity Data	Definition	Units	Gases Reported	Emissions Scope
Municipal Wastewater	The mass of municipal wastewater treated within a community boundary regardless of where the wastewater is generated.	Tonnes	CH_4, N_2O	Scope 1
	The mass of municipal wastewater generated by a community and treated at facilities outside the community boundary	Tonnes	CH_4, N_2O	Scope 3

Allocation Methodology

Based on available data, this methodology uses a population-based approach instead of a facility-based approach to allocate state-level wastewater treatment and discharge activity data to the community level.

Activity Data – Organic Content in Wastewater (Biological Oxygen Demand)

This methodology calculates the community-specific biological oxygen demand (BOD) present in the domestic wastewater effluent treated in Mexico using equation 1 below:

Equation 11

$$\mathrm{BOD}_{\ community} = \mathrm{BOD}_{\ national} * \frac{\text{Community Population}}{\text{National Population}}$$

Table 2: Data elements and sources

Data Element	Definition	Units	Data Source
$\mathrm{BOD}_{\mathrm{community}}$	Community-generated BOD in treated wastewater effluent	g/person/day	Equation 1
$\mathrm{BOD}_{\mathrm{national}}$	Nationally generated BOD in treated wastewater effluent	g	Conagua (2015)

Community Population	Total number of residents living within community boundary	People	INEGI (2016)
National Population	Total number of persons living in Mexico	People	INEGI (2016)C

From Equation 1, datasets provided by the 2016 Instituto Nacional de Estadística y Geografíaare we scale national BOD to communities based on share of the population.

Activity Data – Methane Recovered

The amount of methane recovered at wastewater facilities is subtracted from the total amount of methane generated before methane emissions from wastewater treatment and discharge are reported. If facilities do not have the technology to recover methane, then the value of methane recovery should be omitted from the emission estimates.

Activity Data – Nitrogen in Sludge Removal

We calculate the community-specific nitrogen removed as sludge from domestic wastewater effluent using equation 2 below:

Equation 2

$$\text{Nitrogen sludge}_{community} = \text{Nitrogen sludge}_{national} * \frac{\text{Community Population}}{\text{National Population}}$$

Table 3: Data elements and sources

Data Element	Definition	Units	Data Source
Nitrogen $\text{sludge}_{\text{community}}$	Community-generated nitrogen removed from wastewater as sludge	kg-N/year	Equation 2
Nitrogen $\text{sludge}_{\text{national}}$	Nationally generated nitrogen removed from wastewater as sludge	kg-N/year	Conagua (2015)
Community Population	Total number of residents living within a community boundary	People	CONAPO (2016)
National Population	Total number of persons living in Mexico	People	CONAPO (2016)

Activity Data – Protein Consumption

The method used in this report requires the annual per capita protein intake variable to be included in the final equation. This information for Mexico is provided by the OECD-FAO Agricultural Outlook database 2016-2025 and included to generate a final estimation

Emission Factor – Methane

Domestic wastewater effluent is either discharged to treated systems (wastewater treatment facilities) or untreated systems (stagnant waterbodies). For methane emissions, emission factors for the wastewater subsector are derived from the following equation:

Equation 3

$$EF = B_o * MCF_j * U_i * T_{i.J}$$

Table 4: Data elements and sources

Data Element	Definition	Units	Data Source
EF	The emission factor for each treatment/discharge pathway or handling system utilized within a community.	kg CH_4/kg BOD	Calculated
B_o	Maximum methane producing capacity of the organics present in domestic wastewater under optimal conditions.	kg CH_4/kg BOD	IPCC (2006)
MCF_j	Methane correction factor - The fraction of BOD that will ultimately degrade anaerobically	Unitless	IPCC (2006)
U_i	The fraction of population in income group i in inventory year	Unitless	United Nations (2014)
$T_{i.J}$	The degree of utilization of treatment/discharge pathway (septic, sewer, latrine, other) of system j for each income group fraction i in inventory year	Unitless	United Nations (2014)

In the absence of Mexico Specific data on B_0, the maximum CH_4 producing capacity value of 0.6 kg CH_4/kg BOD is obtained from the IPCC 2006 guidelines.

Community-specific methane correction factors are based on estimates of Ui and Ti,j. The IPCC (2006) identifies specific utilization rates (Ti,j) based on the fraction of the population in urban and rural communities (Ui).

The selected methane correction factors (MCF), which represents the fraction of BOD that will ultimately degrade anaerobically, are dependent on the treatment system used – either sewer, septic, or latrine. The IPCC (2006) includes the following MCF values.

Table 5: IPCC (2006) MCF values

Treatment Type and discharge pathway or system	MCF (Unitless)
Centralized aerobic treatment plant (well-managed)	0
Septic system	0.5
Latrine (small family)	0.1

Emission Factor – Nitrous Oxide

This methodology also captures the small amount of nitrous oxide emissions present in domestic wastewater nitrogen effluent. In the absence of an estimated Mexico specific emission factor, the default IPCC (2006) value, 0.005 kg N_2O-N/kg sewage-N produced, is used.

General Assumptions & Limitations

Activity Data

- Data on BOD levels have not been reported at the community level. Hence, it is assumed that national-level BOD values are similar to what takes place within communities.
- Data on population income group and degree of utilization were only available from the UN World Urbanization Prospects (2014) for Mexico. Therefore same metrics are applied to the community level in this methodology.
- Nitrogen removed in 2015 are held constant for 2016 estimates

Emission Factors

- The In the absence of methane recovery datasets, methane recovery at a community level are not estimated.
- The IPCC MCF values of 0 for centrally treated well-managed aerobic treatment systems and 0.5 for septic systems. This methodology assumes the same MCF values.

Citations

CONAGUA, 2016. Estadisticas del Agua en México 2015. Available at https://www.gob.mx/conagua#959

Report provides sludge removal values for domestic wastewater.

Instituto Nacional de Estadística y Geografía - INEGI (2016). Available at https://www.inegi.org.mx/temas/estructura/

Provides statistics on the population by community from 2010-2015.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 6: Wastewater Treatment and Discharge, 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_6_Ch6_Wastewater.pdf

The report provides the range of methane correction factors for domestic wastewater based on the type of treatment and discharge pathway or system.

OECD-FAO, Agricultural Outlook 2016-2025, Available at http://stats.oecd.org/Index.aspx?datasetcode=HIGH_AGLINK_2016

This database provides a breakdown of information on protein consumption for each country.