Technical Appendix - India:

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. This sector contains the following subsectors:

Stationary Energy Sector	
Residential	Estimated
Commercial	Estimated
Municipal	Not Currently Estimated
Industry	Not Currently Estimated
Agriculture, forestry and fisheries	Not Currently Estimated
Fugitive emissions	Not Currently 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 India, based on data availability and country-specific relevance, estimates for the following activity data points are produced:

- **Liquid Petroleum Gas, Kerosene, Firewood and Coal** used by households, based on annual fuel consumption by residential customers at state level.
- **Grid- supplied Electricity** used by households, based on annual electricity consumed by residential customers at the state 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
LPG	All LPG 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
Firewood	All Firewood consumption within community boundary for a single year for all households.	MJ	Scope 1
Coal	All Coal consumption within community boundary for a single year for all households.	MJ	Scope 1
Grid – Supplied Electricity	All Electricity consumption within community boundary for a single year for all households.	MJ	Scope 2

Calculations Methodologies:

Scope 1: Liquid Petroleum Gas (LPG)

Methodology Notes

Residential building LPG consumption is calculated using state wise LPG data from India's Petroleum Planning & Analysis Cell, Ministry of Petroleum & Natural Gas, Govt. of India for the year 2013. The initial input data is allocated to communities based on the number of households in the municipality relative to the number of households in the state.

Total national count of households and total households by municipality are sourced from the Census data for the year 2011 which is the latest year available. The final fuel consumption number was calculated using a per capita fuel consumption number for Rural and Urban regions for each state.

The following equation is utilized to estimate household LPG consumption.

Equation 1: Household LPG Consumption

$$
\begin{aligned}
Community\ scale\ &Household\ Consumption \\
&= Aggregate\ Fuel\ Sales_{State} \\
&\times \left(\frac{Total\ Households_{Community}}{Total\ Households_{State}} \right) \times (weighted\ community\ fuel\ intensity)
\end{aligned}
$$

Equation Data Elements

Data element	Description	Source	Units
Community scale Household Consumption	All LPG consumption within community boundary for a single year for all households.	Equation 1	MJ
Aggregate Fuel Sales_{State}	Amount of fuel distributed to residential customers within entire state	Petroleum Planning & Analysis Cell (PPAC), 2013	MJ
$\left(\frac{Total\ households_{community}}{Total\ households_{state}} \right)$	Ratio representing the households within community over the number of households in the state	India Census, 2011	households
(weighted community fuel intensity)	Weighted average of per household consumption of fuel by urban/rural division	Equation 11	percentage

Methodology Assumptions

General assumptions and limitations

- All households within state use the same quantity of LPG
- Urban and rural households were considered to have similar consumption patterns due lack of additional data on consumption patterns. Improvements can be made by adding weights, when data becomes available.
- For the purpose of this methodology, we only accessed community-specific household data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- PPAC fuel totals are assumed to encompass all LPG national residential consumption

Scope 1: Kerosene

Methodology Notes

Residential building Kerosene consumption is taken from Household Consumption of Various Goods and Services in India 2013 report published by India's Ministry of Statistics & Program Implementation. The initial input data is allocated to communities based on the number of households in the municipality relative to the state totals. Total count of households by state and total households by municipality are sourced from the Census data for the year 2011.

The following equation is utilized to estimate household kerosene consumption.

Equation 2: Community Kerosene Consumption

$$Community\ scale\ Household\ \ Consumption$$
$$= Aggregate\ Fuel\ Sales_{State} \times \left(\frac{No.\,of\ Households_{Community}}{No.\,of\ Households_{State}}\right)$$

Equation Data Elements

Data element	Description	Source	Unit
Community scale Household Consumption	All Kerosene consumption within community boundary for a single year for all households.	Equation 2	MJ

$Aggregate\ Fuel\ Sales_{State}$	Amount of fuel distributed to residential customers within entire state	Ministry of Statistics & Program Implementation (MoSPI) 2013	MJ
$\left(\dfrac{No.\ of\ households_{community}}{No.\ of\ households_{state}}\right)$	Ratio representing the households within community over the number of households in the state	India Census 2011	households

Methodology Assumptions

General assumptions and limitations

- All households within a state use the same quantity of kerosene
- For the purpose of this methodology, we only accessed community-specific household data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- MosPI fuel totals are assumed to encompass all kerosene national residential consumption.

Scope 1: Firewood

Methodology Notes

Residential building firewood consumption is taken from Household Consumption of Various Goods and Services in India 2013 published by India's Ministry of Statistics & Program Implementation. The initial input data is allocated to communities based on the number of households in the municipality relative to the state totals. Total count of households by state and total households by municipality are sourced from the Census data for the year 2011.

The following equation is utilized to estimate household firewood consumption.

Equation 3: Community Firewood Consumption

$$Community\ scale\ Household\ \ Consumption = Aggregate\ Fuel\ Sales_{State} \times \left(\frac{No.\ of\ Households_{Community}}{No.\ of\ Households_{State}}\right)$$

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 3	MJ
Aggregate Fuel Sales $_{State}$	Amount of fuel distributed to residential customers within entire state	Ministry of Statistics & Program Implementation (MoSPI) 2013	MJ
$\left(\dfrac{No.\,of\;households_{community}}{No.\,of\;households_{state}}\right)$	Ratio representing the households within community over the number of households in the state	(India Census 2011)	households

Methodology Assumptions

General assumptions and limitations

- All households within a state use the same quantity of firewood
- For the purpose of this methodology, we only accessed community-specific household data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- MosPI fuel totals are assumed to encompass all firewood residential consumption.

Scope 1: Coal

Methodology Notes

Residential building coal consumption is taken from Household Consumption of Various Goods and Services in India 2013 published by India's Ministry of Statistics & Program Implementation. The initial input data is allocated to communities based on the number of households in the municipality relative to the state totals. Total count of households by state and total households by municipality are sourced from the Census data   for the year 2011.

The following equation is utilized to estimate household coal consumption.

Equation 4: Community Coal Consumption

$$Community\ scale\ Household\ Consumption$$
$$= Aggregate\ Fuel\ Sales_{State} \times \left(\frac{No.\,of\ Households_{Community}}{No.\,of\ Households_{State}} \right)$$

Equation Data Elements

Data element	Description	Source	Unit
Community scale Household Consumption	All Coal consumption within community boundary for a single year for all households.	Equation 4	MJ
Aggregate Fuel Sales $_{State}$	Amount of fuel distributed to residential customers within entire state	Ministry of Statistics & Program Implementation (MoSPI) 2013	MJ
$\left(\dfrac{No.\,of\ households_{community}}{No.\,of\ households_{state}} \right)$	Ratio representing the households within community over the number of households in the state	(India Census 2011)	households

Methodology Assumptions

General assumptions and limitations

- All households within a state use the same quantity of coal
- For the purpose of this methodology, we only accessed community-specific household data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- MosPI fuel totals are assumed to encompass all coal residential consumption.

Scope 2: Electricity

Methodology Notes

Residential building electricity consumption is calculated from Ministry of Power India 2013. The initial input data is allocated to communities based on the number of households in the municipality relative to

the state. Total national count of households and total households by municipality are sourced from the Census 2011 data.

The following equation is utilized to estimate household electricity consumption.

Equation 5: Household Electricity Consumption

$$Community\ scale\ Household\ Consumption \\ = Aggregate\ Fuel\ Sales\ _{State} \times \left(\frac{No.of\ Households_{Community}}{No.of\ Households\ _{State}} \right)$$

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 5	MJ
$Aggregate\ Fuel\ Sales\ _{State}$	Amount of fuel distributed to residential customers within entire state	Ministry of Power India 2013	MJ
$\left(\frac{No.of\ households_{community}}{No.of\ households_{state}} \right)$	Ratio representing the households within community over the number of households in the state	(India Census 2011)	households

Methodology Assumptions

General assumptions and limitations

- All households within a state use the same quantity of electricity
- For the purpose of this methodology, we only accessed community-specific household data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- Ministry of Power electricity totals are assumed to encompass all electricity national residential consumption

Weighting Factors

Weighting factors are calculated using the Ministry of Statistics and Program Implementation's National Sample Survey for Household Consumption of Various Goods and Services in India 2011-2012. The survey data gives different averages for Urban and Rural households. Weighting factors were developed for each state, city type (rural or urban) and fuel type.

Equation 11: Weighting Factor

$$\text{Weighting Factor}_{\text{state, city type, fuel type}} = \frac{M_{\text{state, city type, fuel type}} * \Sigma_{\text{City type}}(HH_{state})}{\Sigma_{\text{city type}}(M_{\text{state, fuel type}} * HH_{\text{state, city type}})}$$

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 5	Unitless
$M_{\text{city type, fuel type}}$	Average amount of a fuel consumed by a household in a month, by state and city type (urban/ rural)	MOSPI, 2012	%
$HH_{\text{city type}}$	The total state count of households in 2011, by city type	Census, 2011	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 India.

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	0.005	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

Emission Factor Data Elements

References

Census of India 2011. Office of the Registrar General & Census Commissioner, India (Ministry of Home Affairs, Government of India). "Primary Census Abstract Data Tables (India & States/UTs - Town/Village/Ward Level)", Population Enumeration Data (Final Population)

http://www.censusindia.gov.in/2011-Common/CensusData2011.html

The Primary Census Abstract Data Tables contain population, households, rate of literacy and rates of employment by sector at the town/village level which represents the lowest level of administrative classification in India.

Ministry of Power India 2013. Electricity Consumption by Region for India, "Electricity consumption by state and by sector for the year 2013"
http://indiaenergy.gov.in/

The Consumption by Region for India contains state wise and sector wise information on the electricity consumption for the year 2013.

Ministry of Statistics & Program Implementation 2012. Household Consumption of Various Goods and Services in India2011-2012

http://mospi.nic.in/sites/default/files/publication_reports/Report_no558_rou68_30june14.pdf

Household Consumption of Various Goods and Services in India

Ministry of Statistics & Program Implementation. NITI Aayog Portal PNG Connections

http://www.indiaenergy.gov.in/edm/#gasConsumption

The portal provides total piped natural gas consumption (residential).

Petroleum Planning & Analysis Cell, Ministry of Petroleum & Natural Gas, Govt. of India.

http://www.ppac.org.in/

State-wise Diesel, Kerosene and LPG consumption is obtained from PPAC through Right to Information Act of the Parliament of India.

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

- **Natural Gas, High Speed Diesel Oil, Kerosene and Liquid Petroleum Gas** used by commercial businesses, based on the fuel consumed by commercial customers at the national level.
- **Grid-supplied electricity** used by commercial businesses, based on annual electricity consumed by commercial customers at the national level.

Exclusions:

The following could not be estimated at the community level due to the lack of appropriate data availabilities:

- **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

Fuels/Energy Source	GHGDP Definition	Corresponding contextual Data
Natural Gas	Natural gas consumption within community boundary for a single year for all commercial buildings	No. of workers in commercial sector
High Speed Diesel Oil (HSDO)	High Speed Diesel Oil consumption within community boundary for a single year for all commercial buildings	No. of workers in commercial sector
Kerosene	Kerosene consumption within community boundary for a single year for all commercial buildings	No. of workers in commercial sector
Liquid Petroleum Gas (LPG)	LPG Consumption within community boundary for a single year for all commercial buildings	No. of workers in commercial sector

Grid-Electricity	Electricity consumption within community boundary for a single year for all commercial buildings	No. of workers in commercial sector

Calculation Methodologies:

Scope 1: Kerosene

<div align="center">Methodology Notes</div>

Commercial building kerosene consumption is taken from India's Petroleum Planning & Analysis Cell (PPAC), 2013. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the state totals. Total counts of employees, by community, are sourced from the Census 2011 data.

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

<div align="center">Equation 6: Community Kerosene Consumption</div>

$$Community\ scale\ Commerical\ Consumption \\ = Aggregate\ Fuel\ Sales_{State} \times \left(\frac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$$

<div align="center">***Equation Data Elements***</div>

Data element	Description	Source	Units
$Community\ scale$ $Commerical\ Consumption$	Kerosene consumption within community boundary for a single year for all commercial buildings	Equation 6	MJ
$Aggregate\ Fuel\ Sales_{State}$	Amount of fuel distributed to commercial customers within entire state	Petroleum Planning & Analysis Cell (PPAC), 2013	MJ
$\left(\frac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$	Calculated ratio representing the estimated number of commercial sector employees within the community over the estimated state total	Computed value; (India Census, 2011)	employees

Methodology Assumptions

- Number of commercial sector employees is proportionally related to the size of a commercial facility which is in turn proportionally related to the amount of kerosene consumed.
- The employee count was extracted from the Census category "Other Workers" which consists of government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. "Other Workers" was the most appropriate Census employee category available.
- For the purpose of this methodology, we only accessed community-specific worker data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- PPAC totals are assumed to encompass all national kerosene commercial consumption.
- All kerosene sold to commercial customers is consumed within the year it is delivered

Scope 1: High Speed Diesel Oil

Methodology Notes

Commercial building HSDO consumption is taken from India's Petroleum Planning & Analysis Cell (PPAC), 2013. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the state totals. Total counts of employees, by community, are sourced from the Census 2011 data.

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

Equation 7: Community HSDO Consumption

$$\text{Community scale Commercial Consumption} = \text{Aggregate Fuel Sales}_{State} \times \left(\frac{\text{Sector Employees}_{Community}}{\text{Sector Employees}_{Prefecture}}\right)$$

Equation Data Elements

Data element	Description	Source	Units
Community scale *Commercial Consumption*	HSDO consumption within community boundary for a single year for all commercial buildings	Equation 7	MJ
$Aggregate\ Fuel\ Sales_{State}$	Amount of fuel distributed to commercial customers within entire state	Petroleum Planning & Analysis Cell (PPAC), 2013	MJ
$\left(\dfrac{Sector\ Employees_{Community}}{Sector\ Employees_{State}}\right)$	Calculated ratio representing the estimated number of commercial sector employees within the community over the estimated state total	Computed value; (India Census, 2011)	Employees

Methodology Assumptions

- Number of commercial sector employees is proportionally related to the size of a commercial facility which is in turn proportionally related to the amount of HSDO consumed.
- The employee count was extracted from the Census category "Other Workers" which consists of government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. "Other Workers" was the most appropriate Census employee category available.
- For the purpose of this methodology, we only accessed community-specific worker data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- PPAC totals are assumed to encompass all national HSDO commercial consumption.
- All HSDO sold to commercial customers is consumed within the year it is delivered

Scope 1: Liquid Petroleum Gas

Methodology Notes

Commercial building LPG consumption is taken from India's Petroleum Planning & Analysis Cell (PPAC), 2013. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the state totals. Total counts of employees, by community, are sourced from the Census 2011 data.

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

Equation 8: Community LPG Consumption

$$Community\ scale\ Commercial\ Consumption$$
$$= Aggregate\ Fuel\ Sales_{State} \times \left(\frac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$$

Equation Data Elements

Data element	Description	Source	Units
Community-scale commercial LPG consumption	LPG consumption within community boundary for a single year for all commercial buildings	Equation 8	MJ
Aggregate state LPG sales	Amount of fuel distributed to commercial customers within entire state	Petroleum Planning & Analysis Cell (PPAC), 2013	MJ
$\left(\dfrac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$	Calculated ratio representing the estimated number of commercial sector employees within the community over the estimated state total	Computed value; (India Census, 2011)	employees

Methodology Assumptions

- Number of commercial sector employees is proportionally related to the size of a commercial facility which is in turn proportionally related to the amount of LPG consumed.
- The employee count was extracted from the category Census "Other Workers" which consists of government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. "Other Workers" was the most appropriate Census employee category available.
- For the purpose of this methodology, we only accessed community-specific worker data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- PPAC totals are assumed to encompass all LPG national commercial consumption.
- All LPG sold to commercial customers is consumed within the year it is delivered

Scope 1: Natural Gas

<div align="center">Methodology Notes</div>

Commercial building NG consumption is taken from India's Petroleum Planning & Analysis Cell (PPAC), 2013. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the state totals. Total counts of employees, by community, are sourced from the Census 2011 data.

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

<div align="center">*Equation 9: Community NG Consumption*</div>

$$Community\ scale\ Commercial\ Consumption$$
$$= Aggregate\ Fuel\ Sales_{State} \times \left(\frac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$$

<div align="center">***Equation Data Elements***</div>

Data element	Description	Source	Units
Community-scale commercial Natural Gas consumption	Natural gas consumption within community boundary for a single year for all commercial buildings	Equation 9	MJ
Aggregate state Natural Gas sales	Amount of fuel distributed to commercial customers within entire state	Petroleum Planning & Analysis Cell (PPAC), 2013	MJ
$\left(\frac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$	Calculated ratio representing the estimated number of commercial sector employees within the community over the estimated state total	Computed value; (India Census, 2011)	employees

Methodology Assumptions
- Number of commercial sector employees is proportionally related to the size of a commercial facility which is in turn proportionally related to the amount of NG consumed.
- The employee count was extracted from the Census category "Other Workers" which consists of government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. "Other Workers" was the most appropriate Census employee category available.

- For the purpose of this methodology, we only accessed community-specific worker data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- PPAC totals are assumed to encompass all NG national commercial consumption.
- All NG sold to commercial customers is consumed within the year it is delivered.

Scope 2: Electricity

Methodology Notes

Commercial building electricity consumption is taken from Ministry of Power India 2013. This initial input data is allocated to communities based on the **proportion of employees** in the community relative to the state totals. Total count of employees by state and total employees by municipality for the commercial sector is sourced from the Census 2011 data.

The following equation is utilized to estimate commercial electricity consumption.

Equation 10: Community Electricity Consumption

$$Community\ scale\ Commercial\ Consumption \\ = Aggregate\ Electricity\ Consumption_{State} \times \left(\frac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$$

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 10	MJ
$Aggregate\ Electricity\ Consumption_{State}$	Amount of fuel distributed to commercial customers within entire state	Ministry of Power India 2013	MJ

$\left(\dfrac{Sector\ Employees_{Community}}{Sector\ Employees_{State}} \right)$	Calculated ratio representing the estimated number of commercial sector employees within the community over the estimated state total	Computed value; (India Census, 2011)	employees

- Number of commercial sector employees is proportionally related to the size of a commercial facility which is in turn proportionally related to the amount of electricity consumed.
- The employee count was extracted from the Census category "Other Workers" which consists of government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. "Other Workers" was the most appropriate Census employee category available.
- For the purpose of this methodology, we only accessed community-specific worker data from the 2011 census. Improvements to this method can be made when a more recent census is released.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- Ministry of Power totals are assumed to encompass all electricity national commercial consumption.
- All electricity sold to commercial customers is consumed within the year it is delivered

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 India.

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	0.005	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

Census of India 2011. Office of the Registrar General & Census Commissioner, India (Ministry of Home Affairs, Government of India). "Primary Census Abstract Data Tables (India & States/UTs - Town/Village/Ward Level)", Population Enumeration Data (Final Population)

http://www.censusindia.gov.in/2011-Common/CensusData2011.html

The Primary Census Abstract Data Tables contain population, households, rate of literacy and rates of employment by sector at the town/village level which represents the lowest level of administrative classification in India.

Ministry of Power India 2013. Electricity Consumption by Region for India, "Electricity consumption by state and by sector for the year 2013"
http://indiaenergy.gov.in/

The Consumption by Region for India contains state wise and sector wise information on the electricity consumption for the year 2013.

Ministry of Statistics & Program Implementation 2012. Household Consumption of Various Goods and Services in India2011-2012

http://mospi.nic.in/sites/default/files/publication_reports/Report_no558_rou68_30june14.pdf

Household Consumption of Various Goods and Services in India

Ministry of Statistics & Program Implementation. NITI Aayog Portal PNG Connections

http://www.indiaenergy.gov.in/edm/#gasConsumption

The portal provides total piped natural gas consumption (residential).

Petroleum Planning & Analysis Cell, Ministry of Petroleum & Natural Gas, Govt. of India.

http://www.ppac.org.in/

State-wise Diesel, Kerosene and LPG consumption is obtained from PPAC through Right to Information Act of the Parliament of India.

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 India 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 India.

Inclusions

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

- Community-specific **mass of waste landfilled in uncategorized landfills**
- **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[1]
- The combustion of solid waste for non-energy purposes[2]

Activity Data Coverage

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

Activity Data	Definition	Units	Gas Reported	Emissions Scope
Mass of Waste	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

Calculations Methodology

Activity Data – Mass of Waste (Uncategorized Landfills)

Municipal solid waste data at a state level is obtained from Central Pollution Control Board as published in Status Report on Municipal Solid Waste Management for the year 2004-2005. The report provides per capita waste generation in 59 cities across India. These values were used to estimate state totals by aggregation. The state totals were extrapolated to 2013 using an annual population growth rate at a state level. These state totals were disaggregated to community level using urban total for the state. Therefore, the waste data is available for only the urban regions of each state. India's <u>Second Biennial Update Report to the United Nations Framework Convention on Climate Change has been used as reference in developing the state totals for landfilled waste.</u>

The community population from the Census data for the year 2011. The community-specific mass of waste is calculated as per the following equation.

<div align="center">Equation 1</div>

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[1] 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

[2] 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

$$Landfilled\ Waste_{Community} \ = \ Landfilled\ Waste_{State} \ \times \ \left(\frac{Community\ Population}{State\ Urban\ Population}\right)$$

Data Element	Definition	Units	Data Source
$Landfilled\ Waste_{Community}$	Mass of community-generated organic waste going to landfills	Tonnes	Equation 1
$Landfilled\ Waste_{State}$	Mass of state-generated organic waste going to landfills	Tonnes	CPCB (2005) extrapolated to 2013
Community Population	Total number of residents living within community boundary	People	India Census 2011
State Population (Urban)	Total number of persons living in the state	People	India Census 2011

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. IPCC (2006) assigns a unitless MCF value of 0.6 for uncategorized landfills and as there is no information on the landfill types in India, they were all classified as uncategorized.

Methane Generation Potential (L_0)

Methane generation potential (L_0) 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 (DOC_f); 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. This methodology calculates the methane generation potential of landfilled waste in India using equation 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	Unitless	IPCC (2006)

	on management type) – part of the landfilled materials that is left to degrade anaerobically.		
DOC	Degradable organic carbon – the portion of the waste stream that can decompose under aerobic conditions	Tonnes C/tonne waste	IPCC (2006)
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 is calculated using the fraction of the total mass of the waste and multiplying it with the DOC fractions.

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 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 5: IPCC Defaults for South Asia

IPCC Defaults	Food waste	Paper/cardboard	Wood	Textiles	Rubber/leather	Plastic	Metal	Glass	Other

Waste Fractions	40.3	11.3	7.9	2.5	0.8	6.4	3.8	3.5	21.9
DOC	15	40	43	24	-	-	-	-	-

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 4

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

Table 6: 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)

General Assumptions & Limitations

Mass of Waste

- Mass of waste generated, measured as the amount of waste disposed in uncategorized landfills in India is proportionally related to population.
- New states formed after 2013 are not represented on the portal, since the latest input data is available for 2013 and cannot be disaggregated to new states.
- Waste input data was compiled from Central Pollution Control Board as published in Status Report on Municipal Solid Waste Management for the year 2004-2005 which provided city data for 59 cities across India. This was used to aggregate State totals based on urban population.
- Waste estimates are produced only for urban communities within each state. Improvements can be made in the future, as better data becomes available.
- All waste measured is categorized under scope 3 as we do not have the data to measure scope 1 emissions.

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 South Asia. 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

- Landfill sites assumed to fall under uncategorized anaerobic IPCC landfill characteristic are assigned an MCF of 0.6

Methane Recovery

- Central Pollution Control Board does not provide information for methane recovered therefore methane recovery is not reported.

Citations

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.

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.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5: Waste, Chapter 2: Waste Generation, Composition and Management Data, The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change, Riitta Pipatti (Finland), Chhemendra Sharma (India), Masato Yamada (Japan)

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf

Provides default values for the different waste fractions for South-Central Asia

CPCB (2005). Central Pollution Control Board, Status Report on Municipal Solid Waste Management, 2004-2005.

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Provides information on the amount of municipal solid waste generated by 59 cities across India.

MoEFCC. (2018). India: Second Biennial Update Report to the United Nations Framework Convention on Climate Change. Ministry of Environment, Forest and Climate Change, Government of India.

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