Technical Appendix – Costa Rica:

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, 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 in the Costa Rica. This sector includes the following subsectors:

<table>
<thead>
<tr>
<th>Buildings and Stationary Energy Sector</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential buildings</td>
<td>Estimated</td>
</tr>
<tr>
<td>Commercial buildings</td>
<td>Estimated</td>
</tr>
<tr>
<td>Municipal buildings</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Industry</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Agriculture, forestry and fisheries</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Fugitive emissions</td>
<td>Not Estimated</td>
</tr>
</tbody>
</table>
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.

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

- **Liquid Petroleum Gas, Biogas, Wood, Kerosene and Charcoal** consumption by households, based on annual fuel consumption from residential customers at National level.
- **Grid-supplied electricity** consumption by households, based on annual electricity consumption from residential customers at national level.

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

- **Off-highway motor gasoline** consumption, e.g. for use in lawn and gardening equipment
- **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.

<table>
<thead>
<tr>
<th>Fuels/Energy Source</th>
<th>Definition</th>
<th>Units</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Petroleum Gas</td>
<td>All Liquid Petroleum Gas consumption within community boundary for a single year for all households.</td>
<td>MJ</td>
<td>Scope 1</td>
</tr>
<tr>
<td>Kerosene</td>
<td>All kerosene consumption within community boundary for a single year for all households.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>All Wood consumption within community boundary for a single year for all households.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biogas</td>
<td>All Biogas consumption within community boundary for a single year for all households.</td>
<td>MJ</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) 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.
<table>
<thead>
<tr>
<th>Charcoal</th>
<th>All Charcoal consumption within community boundary for a single year for all households.</th>
<th>MJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Electricity</td>
<td>All grid-supplied electricity consumption within community boundary for a single year for all households</td>
<td>MJ</td>
</tr>
</tbody>
</table>

Calculation Methodologies:

Scope 1: Liquid Petroleum Gas

**Methodology Notes**

Residential building Liquid Petroleum Gas consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the Secretaría de Planificación Subsector Energía. This initial input data is then allocated to communities based on:

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

Total counts of households, by housing type, are sourced from the 2011 INEC Census data. In addition, the annual national Liquid Petroleum Gas consumption is weighted (MJ * community type) with two community categories (urban and rural) that are derived from the Encuesta Nacional de Hogares. These data are then combined to calculate weighted community fuel intensities. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context (rural or urban) within individual communities.

**Equation 1**

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

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

**Equation Data Elements**

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale household consumption</td>
<td>All liquefied petroleum gas consumption within community boundary for a single year for all households.</td>
<td>Equation 1</td>
<td>MJ</td>
</tr>
</tbody>
</table>
aggregate residential consumption\textsubscript{LPG} & Amount of liquefied petroleum gas fuel consumed by the residential sector in an entire country & SPSE 2017 & MJ \\
\( \left( \frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{national}}} \right) \) & Ratio representing the number of households within the community over the number of households within the entire country & INEC 2011 & households \\
Weighted community fuel intensities & Percentage associated with weighted fuel use by fuel type per housing demographic & Equation 6 & 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/rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- SPSE national totals are assumed to encompass all LPG national residential consumption.
- The number of households by type at community level from 2016 can be improved with a more recent census.

Scope 1: Wood

Methodology Notes

Residential building wood consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the Secretaría de Planificación Subsector Energía. This initial input data is then allocated to communities based on:

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

Total counts of households, by housing type, are sourced from the 2011 INEC Census data. In addition, the annual national wood consumption is weighted (MJ * community type) with two community categories (urban and rural) that are derived from the Encuesta Nacional de Hogares. These data are then combined to calculate weighted community fuel intensities. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context (rural or urban) within individual communities.
Equation 2

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

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

Equation Data Elements

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale household consumption</td>
<td>All wood consumption within community boundary for a single year for all households.</td>
<td>Equation 2</td>
<td>MJ</td>
</tr>
<tr>
<td>aggregate residential consumption_{wood}</td>
<td>Amount of wood fuel consumed by the residential sector in an entire country</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>( \frac{\text{total households}<em>{\text{community}}}{\text{total households}</em>{\text{national}}} )</td>
<td>Ratio representing the number of households within the community over the number of households within the entire country</td>
<td>INEC 2011</td>
<td>households</td>
</tr>
<tr>
<td>Weighted Community Fuel intensities</td>
<td>Percentage associated with weighted fuel use by fuel type per housing demographic</td>
<td>Equation 6</td>
<td>percentage</td>
</tr>
</tbody>
</table>

Methodology Assumptions

General assumptions and limitations

- Number of households, by housing type, is proportionally related to the amount of wood consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban/rural) remain consistent within national weighted energy intensities (urban/rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- SPSE national totals are assumed to encompass all wood national residential consumption.
- The number of households by type at community level from 2016 can be improved with a more recent census.
Scope 1: Biogas

Methodology Notes

Residential building biogas consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the Secretaría de Planificación Subsector Energía. This initial input data is then allocated to communities based on:

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

Total counts of households, by housing type, are sourced from the 2011 INEC Census data. In addition, the annual national biogas consumption is weighted (MJ * community type) with two community categories (urban and rural) that are derived from the Encuesta Nacional de Hogares. These data are then combined to calculate **weighted community fuel intensities**. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context (rural or urban) within individual communities.

Equation 3

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

\[
\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{biogas}} \times \left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{national}}}\right) \times (\text{Weighted community fuel intensities})
\]

**Equation Data Elements**

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale household consumption</td>
<td>All biogas consumption within community boundary for a single year for all households.</td>
<td>Equation 3</td>
<td>MJ</td>
</tr>
<tr>
<td>aggregate residential consumption_{biogas}</td>
<td>Amount of biogas fuel consumed by the residential sector in an entire country</td>
<td>SPSE 2016</td>
<td>MJ</td>
</tr>
<tr>
<td>\left(\frac{\text{total households}<em>{\text{community}}}{\text{total households}</em>{\text{national}}}\right)</td>
<td>Ratio representing the number of households within the community over the number of households within the entire country</td>
<td>INEC 2011</td>
<td>households</td>
</tr>
</tbody>
</table>
Weighted Community Fuel Intensities | Percentage associated with weighted fuel use by fuel type per housing demographic | Equation 6 | percentage

Methodology Assumptions

General assumptions and limitations

- Number of households, by housing type, is proportionally related to the amount of biogas consumed in the residential sector at national level.
- Average weighted energy intensities by community type (urban/rural) remain consistent within national weighted energy intensities (urban/rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- SPSE national totals are assumed to encompass all biogas national residential consumption.
- The number of households by type at community level from 2016 can be improved with a more recent census. Because, it was calculated by extrapolating INEC 2016 Census with the national growth rate. As a result, the number of households by community lightly defers from the national and state 2016 totals.

Scope 1: Kerosene

Methodology Notes

Residential building Kerosene consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the Secretaría de Planificación Subsector Energía. This initial input data is then allocated to communities based on:

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

Total counts of households, by housing type, are sourced from the 2011 INEC Census data. In addition, the annual national kerosene consumption is weighted (MJ * community type) with two community categories (urban and rural) that are derived from the Encuesta Nacional de Hogares. These data are then combined to calculate weighted community fuel intensities. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context (rural or urban) within individual communities.

Equation 4

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

\[
\text{Community-scale household consumption} = \text{aggregate residential consumption}_{\text{kerosene}} \times \\
\left(\frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{national}}}\right) \times (\text{Weighted community fuel intensities})
\]
Equation Data Elements

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale household consumption</td>
<td>All kerosene consumption within community boundary for a single year for all households.</td>
<td>Equation 4</td>
<td>MJ</td>
</tr>
<tr>
<td>aggregate residential consumption (kerosene_{residential})</td>
<td>Amount of kerosene fuel consumed by the residential sector in an entire country</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>(\frac{\text{total households}<em>{\text{community}}}{\text{total households}</em>{\text{national}}})</td>
<td>Ratio representing the number of households within the community over the number of households within the entire country</td>
<td>INEC 2011</td>
<td>households</td>
</tr>
<tr>
<td>Weighted Community Fuel Intensities</td>
<td>Percentage associated with weighted fuel use by fuel type per housing demographic</td>
<td>Equation 6</td>
<td>percentage</td>
</tr>
</tbody>
</table>

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/rural) remain consistent within national weighted energy intensities (urban/rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
- SPSE national totals are assumed to encompass all kerosene national residential consumption.
- The number of households by type at community level from 2016 can be improved with a more recent census. Because, it was calculated by extrapolating INEC 2016 Census with the national growth rate. As a result, the number of households by community lightly defers from the national and state 2016 totals.

Scope 2: Electricity

Methodology Notes

Residential building electricity consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the Secretaria de Planificación Subsector Energía. This initial input data is then allocated to communities based on:
• the number of households (by type) in the municipality relative to national totals, and
• a computed weighted (urban or rural) community fuel intensity relative to the national.

Total counts of households, by housing type, are sourced from the 2011 INEC Census data. In addition, the annual national electricity consumption is weighted (MJ * community type) with two community categories (urban and rural) that are derived from the Encuesta Nacional de Hogares. These data are then combined to calculate weighted community fuel intensities. Weighted averages are calculated for all communities relative to their national average. This is done so that estimates are reflective of the housing context (rural or urban) within individual communities.

**Equation 5**

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

\[
\text{Community-scale household consumption} = \frac{\text{aggregate residential consumption}}{\text{total households}_{\text{community}}} \times \frac{\text{total households}_{\text{community}}}{\text{total households}_{\text{national}}} \times (\text{Weighted community fuel intensities})
\]

**Equation Data Elements**

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale household consumption</td>
<td>All electricity consumption within community boundary for a single year for all households.</td>
<td>Equation 5</td>
<td>MJ</td>
</tr>
<tr>
<td>aggregate residential consumption(_{\text{Elect}})</td>
<td>Amount of electricity fuel consumed by the residential sector in an entire country</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>(\frac{\text{total households}<em>{\text{community}}}{\text{total households}</em>{\text{national}}})</td>
<td>Ratio representing the number of households within the community over the number of households within the entire country</td>
<td>INEC 2011</td>
<td>households</td>
</tr>
<tr>
<td>Weighted Community Fuel Intensities</td>
<td>Percentage associated with weighted fuel use by fuel type per housing demographic</td>
<td>Equation 6</td>
<td>percentage</td>
</tr>
</tbody>
</table>

**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/rural) remain consistent within national weighted energy intensities (urban/rural) and are an appropriate weighting factor in determining consumption patterns from one community to the next.
• SPSE national totals are assumed to encompass all electricity national residential consumption.
• The number of households by type at community level from 2016 can be improved with a more recent census. Because, it was calculated by extrapolating INEC 2016 Census with the national growth rate. As a result, the number of households by community lightly defers from the national and state 2016 totals.

Weighting Factors
This method uses national-level values for fuel use by residential sector and incorporates weighting factors, which help control for unexpected variation in fuel use across populations in various city types. Costa Rica’s 2011 census identifies a proportion of urban and rural areas in each canton, however for the purpose of this methodology, we have bucketed communities into one of two categories:
• Rural – cantons where rural population is above 50% of the total population in that canton
• Urban – cantons where urban population is above 50% of the total population in that canton
These housing types, and the associated fuel use, are compared against the national average fuel use and the results are integrated into one combined weighting factor formula identified below:

Equation 6

\[
\text{Weighing Factor}_{\text{city type, fuel type}} = \frac{M_{\text{city type, fuel type}} * C_{\text{city type}}}{\sum_{\text{city type}}(M_{\text{city type, fuel type}} * C_{\text{city type}} * \text{HH}_{\text{city type}})}
\]

Equation Data Elements

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M_{\text{city type, fuel type}} )</td>
<td>The average residential fuel mix in 2017, by city type</td>
<td>SPSE 2017</td>
<td>%</td>
</tr>
<tr>
<td>( C_{\text{city type}} )</td>
<td>The average annual energy consumption of one household in 2017, by city type</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
</tbody>
</table>
### 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 Costa Rica.

**Emission Factor Data Elements**

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

Instituto Nacional de Estadística y Censos (INEC) 2011. Available at http://www.inec.go.cr/vivienda

Provides information on housing stock


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


Provides information on national energy balance
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 the Costa Rica, based on data availability and occurrence in-country, estimates for the following activity data points were produced:

- **Liquid Petroleum Gas, Wood, Fuel Oil and Diesel** consumption by commercial buildings, based on annual fuel consumption at national level
- **Electricity** consumption by commercial buildings, based on annual commercial electricity consumption at national level

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

- **Off-highway motor gasoline** consumption, e.g. for use in 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.

<table>
<thead>
<tr>
<th>Fuels/Energy Source</th>
<th>Definition</th>
<th>Units</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil</td>
<td>Fuel oil consumption within community boundary for a single year for all commercial buildings</td>
<td>MJ</td>
<td>Scope 1</td>
</tr>
<tr>
<td>Liquid Petroleum Gas</td>
<td>Liquid Petroleum Gas consumption within community boundary for a single year for all commercial buildings</td>
<td>MJ</td>
<td></td>
</tr>
</tbody>
</table>
Calculation Methodologies:

Scope 1: Liquid Petroleum Gas

Methodology Notes
Residential building Liquid Petroleum Gas consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the Secretaría de Planificación Subsector Energía. Initial input data is then 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 2011 INEC Census data. The national building LPG consumption is scaled by the percentage of employees in each community to estimate the building natural gas consumption by each community.

Equation 7
The following equation is utilized to estimate commercial sector natural gas consumption

Community-scale commercial consumption = national fuel consumption\textsubscript{commercial} \times \frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{state}}}

Equation Data Elements

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale commercial consumption</td>
<td>Liquid Petroleum Gas consumption within community boundary for a single year for all commercial buildings</td>
<td>Equation 7</td>
<td>MJ</td>
</tr>
<tr>
<td>National fuel consumption commercial sector</td>
<td>Amount of fuel consumed by commercial customers within entire country in 2017</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
</tbody>
</table>
Methodology Assumptions and Potential Improvement

- Number of commercial sector employees is proportionally related to the amount of LPG consumed.
- SIE national totals are assumed to encompass all NG national commercial consumption.
- All LPG sold to commercial customers is consumed within the year it was delivered.
- Finally, weights used in the current iteration 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, however, 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 into final estimates.

Scope 1: Wood

Methodology Notes


Initial input data is then 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 2011 INEC Census data. The national building wood consumption is scaled by the percentage of employees in each community to estimate the building natural gas consumption by each community.

Equation 8

The below equation represents the calculation method utilized to estimate commercial sector wood 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

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale commercial consumption</td>
<td>wood consumption within community boundary for a single year for all commercial buildings</td>
<td>Equation 8</td>
<td>MJ</td>
</tr>
<tr>
<td>National fuel consumption commercial sector</td>
<td>Amount of fuel consumed by commercial customers within entire country in 2017</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - community</td>
<td>Estimated number of commercial sector employees for the community in 2011</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - State</td>
<td>Estimated number of commercial sector employees within the state</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
</tbody>
</table>

### Methodology Assumptions and Potential Improvement

- Number of commercial sector employees is proportionally related to the amount of diesel consumed.
- SIE national totals are assumed to encompass all wood national commercial consumption.
- All diesel gas sold to commercial customers is consumed within the year it was delivered.
- Finally, 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, however, 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 into final estimates.

Scope 1: Diesel

### Methodology Notes

Residential building diesel consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the [Secretaría de Planificación Subsector Energía](#). Initial input data is then 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 [2011 INEC Census](#) data. The national building Diesel consumption is scaled by the percentage of employees in each community to estimate the building natural gas consumption by each community.

### Equation 9

The below equation represents the calculation method utilized to estimate commercial sector diesel consumption.
Community-scale commercial consumption = national fuel consumption_{commercial} \times \left( \frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{state}}} \right)

### Equation Data Elements

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale commercial consumption</td>
<td>diesel consumption within community boundary for a single year for all commercial buildings</td>
<td>Equation 9</td>
<td>MJ</td>
</tr>
<tr>
<td>National fuel consumption commercial sector</td>
<td>Amount of fuel consumed by commercial customers within entire country in 2017</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - community</td>
<td>Estimated number of commercial sector employees for the community in 2011</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - State</td>
<td>Estimated number of commercial sector employees within the state</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
</tbody>
</table>

### Methodology Assumptions and Potential Improvement

- Number of commercial sector employees is proportionally related to the amount of diesel consumed.
- SIE national totals are assumed to encompass all diesel national commercial consumption.
- All diesel sold to commercial customers is consumed within the year it was delivered.
- Finally, 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, however, 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 into final estimates.

**Scope 1: Fuel Oil**

Residential building fuel oil consumption is taken from Costa Rica’s National Energy Balance 2016 data located at the [Secretaría de Planificación Subsector Energía](https://www.secretariadelplanificaciodesubsectorenergia.go.cr/). Initial input data is then 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 [2011 INEC Census](https://www.inec.go.cr/). The national building Fuel Oil consumption is scaled by the percentage of employees in each community to estimate the building natural gas consumption by each community.
Equation 10

The below equation represents the calculation method utilized to estimate commercial sector fuel oil consumption.

\[
\text{Community-scale commercial consumption} = \text{national fuel consumption}_{\text{commercial}} \times \frac{\text{sector employees}_{\text{community}}}{\text{sector employees}_{\text{state}}}
\]

**Equation Data Elements**

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale commercial consumption</td>
<td>Fuel oil consumption within community boundary for a single year for all commercial buildings</td>
<td>Equation 10</td>
<td>MJ</td>
</tr>
<tr>
<td>National fuel consumption commercial sector</td>
<td>Amount of fuel consumed by commercial customers within entire country in 2017</td>
<td>SPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - community</td>
<td>Estimated number of commercial sector employees for the community in 2011</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - state</td>
<td>Estimated number of commercial sector employees within the state</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
</tbody>
</table>

**Methodology Assumptions and Potential Improvement**

- Number of commercial sector employees is proportionally related to the amount of natural gas consumed.
- SIE national totals are assumed to encompass all fuel oil national commercial consumption.
- All fuel oil sold to commercial customers is consumed within the year it was delivered.
- Finally, 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, however, 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 into final estimates.

**Scope 1: Electricity**

**Methodology Notes**
Residential building electricity consumption is taken from Costa Rica’s National Energy Balance 2017 data located at the Secretaría de Planificación Subsector Energía. Initial input data is then 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 2011 INEC Census data. The national building Electricity consumption is scaled by the percentage of employees in each community to estimate the building natural gas consumption by each community.

Equation 11

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

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

### Equation Data Elements

<table>
<thead>
<tr>
<th>Data element</th>
<th>Description</th>
<th>Source</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-scale commercial</td>
<td>electricity consumption within community boundary for a single year for all commercial buildings</td>
<td>Equation 11</td>
<td>MJ</td>
</tr>
<tr>
<td>consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National fuel consumption</td>
<td>Amount of fuel consumed by commercial customers within entire country in 2017</td>
<td>SEPSE 2017</td>
<td>MJ</td>
</tr>
<tr>
<td>commercial sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial employees - community</td>
<td>Estimated number of commercial sector employees for the community in 2011</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
<tr>
<td>Commercial employees - state</td>
<td>Estimated number of commercial sector employees within the state</td>
<td>INEC 2011</td>
<td>MJ</td>
</tr>
</tbody>
</table>

### Methodology Assumptions and Potential Improvement

- 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 was delivered.
- Finally, 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, however, 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 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 Costa Rica.

**Emission Factor Data Elements**

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

Instituto Nacional de Estadística y Censos (INEC) 2011. Encuestas continua de empleo. Available at https://www.inec.cr/empleo?keys=&shs_term_node_tid_depth=All&field_periodo_tid=All&field_aio_documento_value%5Bvalue%5D%5Bdate%5D=2011

Provides information on the percentage of employees in the commercial and services sector

Instituto Nacional de Estadística y Censos (INEC) 2011. Available at http://www.inec.go.cr/vivienda

Provides information on housing stock and population


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


Provides information on national energy balance
Transportation and Mobile Energy Sector for Costa Rica

This document details the calculation approaches and data sources for producing community-level (canton) activity data and emission factors for the transportation and mobile energy sector in Costa Rica. This sector contains the following subsectors:

<table>
<thead>
<tr>
<th>Transportation and Mobile Energy Sector</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>On-road</td>
<td>Estimated</td>
</tr>
<tr>
<td>Rail</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Waterborne navigation</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Aviation</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Off-road</td>
<td>Not Estimated</td>
</tr>
</tbody>
</table>
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, microbuses, buses, single-unit 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 hydrous ethanol, gasoline, and diesel oil.

Inclusions
For Costa Rica, based on available data and method, activity data produced includes:

- Gasoline and diesel fuel sales for all private and commercial vehicles 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.
- Grid electricity consumed for on-road vehicles used within the community boundary (scope 2). This is instead included in the Stationary Energy sector.

Activity Data Coverage
Table 1 shows the emissions sources covered by this methodology.

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

<table>
<thead>
<tr>
<th>Emissions Source</th>
<th>Definition</th>
<th>Units</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>All registered vehicles (Gasoline consumption)</td>
<td>The amount of gasoline sold for a single year by all registered vehicles in a canton boundary.</td>
<td>m³</td>
<td>Scope 1</td>
</tr>
<tr>
<td>All registered vehicles (Diesel consumption)</td>
<td>The amount of diesel sold for a single year by all registered vehicles in a canton boundary.</td>
<td>m³</td>
<td>Scope 1</td>
</tr>
</tbody>
</table>

Allocation Methodology

Fuel Consumption
The input data from La Refinadora Costarricense de Petróleo (RECOPE) Informe Annual de Ventas 2016 provides values for the volume of gasoline and diesel oil sold within each canton. Due to limited data availability related to vehicle-specific use patterns—which include vehicle type, fuel economy (based on fuel type and vehicle type), vehicle miles travelled, and vehicle registrations—we are unable to further disaggregate the fuel consumption data by vehicle type.

Methodological and Data Assumptions & Limitations
This methodology assumes that:
• All vehicles use only diesel and gasoline fuel.
• In the absence of state or community-specific vehicle registrations, further disaggregated emission estimates could not be provided.

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

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

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Carbon Dioxide (CO2) kg/GJ</th>
<th>Methane (CH4) kg/GJ</th>
<th>Nitrous Oxide (N2O) kg/GJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>69.3</td>
<td>0.12</td>
<td>0.002</td>
</tr>
<tr>
<td>Diesel</td>
<td>74.1</td>
<td>0.01</td>
<td>0.0006</td>
</tr>
</tbody>
</table>
Citations


This source provides data on the total vehicle fleet registered by vehicle type at a national level.


This source provides data on annual national fuel sales by fuel type.


The National Energy Balance is an annual analysis of the country’s energy structure. This source provides data on fuel use in the transport sector at a national level.
### Waste Sector

*Table 1: Waste Sector categories.*

<table>
<thead>
<tr>
<th>Waste Sector</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid waste</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Biological waste</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Incinerated and burned waste</td>
<td>Not Estimated</td>
</tr>
<tr>
<td>Wastewater</td>
<td>Not Estimated</td>
</tr>
</tbody>
</table>