

# Appendix A GHG Inventory Methodology



This appendix describes the methodology used to develop the City of Ukiah Climate Action Plan (CAP) 2005 baseline and 2010 updated inventories of greenhouse gas (GHG) emissions for the greater community and for municipal (i.e., city government) operations.

The purpose of the GHG inventories is to identify sources, distribution, and overall magnitude of GHG emissions that occur within the City and/or are caused by the community member activities. The inventories will enable policy makers to implement cost-effective GHG reduction programs pertaining to residential, commercial, industrial, and municipal sectors within the community.

These inventories use standards established by the ICLEI U.S. Community Protocol (v1.0)<sup>1</sup> and the Local Government Operations Protocol (LGOP) v.1.1.<sup>2</sup> ICLEI has worked with the California Air Resource Board (CARB), BAAQMD, and other state and regional agencies to develop standardized methods for inventorying community emissions. ICLEI, along with CARB and the Climate Registry (TCR), has also co-developed methods for quantifying and reporting GHG emissions from local government sources, which have been incorporated into the LGOP.

In keeping with these protocols, ESA's process for developing a GHG inventory is:

1. Set organizational boundaries
2. Set operational boundaries
3. Identify sources of emissions
4. Collect data on emissions for a representative period of time
5. Calculate GHG emissions from data using robust emissions factors
6. Create an inventory of CO<sub>2</sub>e emissions that is complete, transparent, and accurate.

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<sup>1</sup> U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, version 1.0, ICLEI, published October 2012. Available at: <http://www.iclei.usa.org/tools/ghg-protocol/community-protocol>

<sup>2</sup> LGOP version 1.1, published May 2010, available at: <http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/>

# Inventory Boundaries

Establishing the boundaries of an emissions analysis is an important first step in the GHG inventory process. A city exerts varying levels of control or influence over the activities occurring within its borders. At the minimum, community-wide GHG inventory should be defined broadly enough to include all emissions sources that may be significantly influenced by local government actions. These sources tend to be those that are affected by land use decisions, municipal codes, and General Plan policies, and correspondingly are included in a city's GHG reduction measures. In general, the inventory should encompass sources that are within the purview of the city's discretionary actions and regulatory authority, including sources of indirect emissions that can be influenced by the city policies or programs, such as water conservation or waste reduction.

## Ukiah's Organizational Boundary

Setting an organizational boundary for a GHG inventory involves identifying the facilities and operations that are to be included. The ICLEI U.S. Community Protocol (2012) defines the organizational boundary as the boundary that determines the operations owned or controlled by the reporting entity, which depends on the consolidation approach taken.

The City of Ukiah's 2005 and 2010 community-wide inventories encompass the GHG emissions resulting from activities taking place within the City's geopolitical boundary, where the local Ukiah government has significant direct or indirect influence. The municipal operations inventories encompass the GHG emissions resulting from actions governed directly by the local government, such as municipal buildings, vehicle fleets, and streetlights.

## Ukiah's Operational Boundary

The operational boundary is the sum of all sources of direct and indirect emissions and associated activities that are included in the organizational boundary. The 2005 and 2010 Ukiah community-wide inventories include GHG emissions (carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) from the following sectors. Other GHGs (e.g. hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF<sub>6</sub>)) were not found to be significant contributors of emissions within the City of Ukiah, and were therefore not included in this inventory.

## Community-wide Inventory

For community-wide emissions, the ICLEI U.S. Community Protocol breaks down emissions into two categories.

- **Sources:** Any physical process inside the jurisdictional boundary that releases GHG emissions into the atmosphere (e.g., combustion of gasoline in transportation; combustion of natural gas in electricity generation; methane emissions from a landfill).
- **Activities:** The use of energy, materials, and/or services by members of the community that result in the creation of GHG emissions either directly (e.g., use of household furnaces and vehicles with internal combustion engines) or indirectly (e.g., use of electricity created through combustion of fossil fuels at a power plant, consumption of goods and services whose production, transport and/or disposal resulted in GHG emissions).

The community-wide inventory includes emissions from the following sectors. As shown below, emissions from most sectors derive from multiple sources and activities:

- **Commercial/Industrial Energy:** Direct stationary emissions from combustion of natural gas (source and activity), and indirect emissions from the use of electricity by the community (activity);
- **Residential Energy:** Direct stationary emissions from natural gas combustion (source and activity), and indirect emissions from purchased electricity (activity);
- **On-Road Transportation:** Emissions from on-road gasoline- and diesel-powered vehicles (source and activity);
- **Off-Road Transportation:** Emissions from off-road lawn and garden equipment, construction equipment, industrial equipment, and light commercial equipment (activity);
- **Agriculture:** Emissions from off-road gasoline- and diesel-powered agricultural vehicles (activity);
- **Generated Solid Waste:** Indirect methane (CH<sub>4</sub>) emissions from the anaerobic decomposition of organic material sent to landfill by the community (source);
- **Wastewater Treatment:** Total indirect process emissions and fugitive emissions from wastewater treatment processes at the City-operated Wastewater Treatment Plant (activity);
- **Water Conveyance:** Emissions generated by electricity used in the transport of water (activity);
- **Stationary Sources:** Emissions generated by the combustion of fossil fuels other than utility-provided natural gas within the community (source); and
- **Landfill:** Indirect methane (CH<sub>4</sub>) emissions from the anaerobic decomposition of organic material sent to the (now closed) City-operated landfill (activity).

## Municipal Operations Inventory

For municipal emissions, the LGOP divides the operational boundary into three different scopes, defined as follows:

- **Scope 1** emissions are those that come from sources that are owned or controlled by the reporting entity. Such sources include stationary emitters like furnaces and boilers, and mobile emitters like vehicles and construction equipment.
- **Scope 2** emissions are indirect GHG emissions related to the consumption of purchased energy (i.e., electricity) that is produced by third-party entities, such as power utilities.
- **Scope 3** emissions are other indirect GHG emissions not covered by Scope 2 that are associated with community activities. For a community inventory this generally includes emissions occurring upstream or downstream of a community activity, such as the methane emissions resulting from degradation of the community's solid waste deposited at a landfill outside of city limits; or the electricity used to pump water to the City from upstream reservoirs. Quantification and reporting of Scope 3 emissions is generally considered optional, but including them in a community-wide inventory is appropriate where there is local control over an activity that has an indirect emissions reduction impact, such as diverting waste from landfills.

The 2005 and 2010 municipal operations inventories include emissions from the following sectors:

- **Natural Gas:** Direct stationary emissions from natural gas combustion (Scope 1) from building and facilities, excluding from the Wastewater Treatment Plant;
- **Electricity:** Indirect emissions from purchased electricity for buildings, facilities, streetlights, traffic lights, and water pumps operated by the City (Scope 2);
- **Vehicle Fleet:** Direct emissions from fuel combustion in municipal fleet vehicles (Scope 1);
- **Generated Solid Waste:** This sector comprises solid waste sent to landfill from government-owned and/or operated facilities (Scope 3);

- **Employee Commute:** Emissions from the fuel combustion in employee-owned vehicles used by municipal staff travelling to and from work (Scope 3);
- **Stationary Sources:** Emissions from combustion in stationary generators and other equipment operated by the City government (Scope 1);
- **Wastewater Treatment:** Indirect process emissions and fugitive emissions from wastewater treatment processes (Scope 3), and direct stationary emissions from natural gas combustion (Scope 1), at the City-operated Wastewater Treatment Plant; and
- **Landfill:** Indirect methane (CH<sub>4</sub>) emissions from the anaerobic decomposition of organic material sent to the (now closed) City-operated landfill (Scope 1).

# Emissions Quantification Methodology

## 2005 Baseline and 2010 Update

ICLEI and the LGOP identify calculation-based methodologies as the most appropriate technique for quantifying GHG emissions, following the basic formula:

$$\text{GHG Emissions} = \text{Activity Data} \times \text{Emissions Factor}$$

Activity data are the relevant measurements of energy use or other processes that are associated with the emission of GHGs, such as metered annual energy consumption (kWh of electricity and therms of natural gas).

Emission factors are calculated ratios relating GHG emissions to a proxy measure of activity by emissions source. The inventories focus on the three GHGs most relevant and significant to City Government policymaking: CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O. These gases comprise the majority of GHG emissions from the community and city government operations. Most GHG reporting protocols also include methods for estimating three additional GHGs: HFCs, PFCs, and SF<sub>6</sub>. However, these GHGs, largely represent fugitive emissions that leak from equipment, are generally not included in a community or city government inventory because the data needed to quantify them is typically incomplete or difficult to obtain.

## Community-wide Inventory

### Commercial/Industrial and Residential Energy Emissions

Commercial/industrial and Residential energy activity data for 2005 and 2010 consisted of electricity consumption and metered natural gas use.

PG&E provided community-wide natural gas data, in therms, for both years. Direct emissions from natural gas combustion were calculated using standard emission factors for natural gas published by the LGOP.

The City of Ukiah Finance Department (Department) provided community-wide electricity consumption in megawatt hours (MWh) for both 2005 and 2010. The Department also provided a breakdown (by percentage) of the various sources of electricity that contributed to the City's electricity portfolio for each year. This included electricity generated from the following sources:

- Renewables (Biomass and waste, geothermal, small hydroelectric, solar and wind)
- Coal
- Large Hydroelectric

- Natural Gas
- Nuclear

This mix includes electricity generated by the City-operated Lake Mendocino Hydroelectric plant, as well as electricity purchased from individual suppliers including wholesale power suppliers and PG&E. Renewable energy generation and hydroelectric plants provide approximately 80% of Ukiah's power. Indirect emissions from electricity generation were calculated using energy source-specific emission factors<sup>3</sup>, and were adjusted to include emissions from transmission and distribution. Total electricity use was assumed to reflect a transmission and distribution loss of 3.5 percent, based on correspondence with the City's Electric Utility Director.

### Transportation (On-road and Off-road) Emissions

As with many cities, vehicle travel in Ukiah is the City's largest single source of GHG emissions. Most methods for estimating transportation emissions are based on vehicle miles traveled (VMT). Community-wide VMT estimates are highly dependent on the accounting rules and analytical tools used.

For Ukiah, Fehr & Peers' provided estimates of VMT for on-road vehicular transportation based on the Mendocino Council of Governments (MCOG) travel demand model and origin-destination calculation methods<sup>4</sup>. VMT were provided for 2010, and future projections were provided for the years 2020, 2030, and 2035. 2005 VMT was conservatively estimated by assuming VMT was the same in 2005 as it was in 2010. CARB's EMFAC2011 model was used to calculate 2005 base year and 2010 CO<sub>2</sub> emissions factors. CH<sub>4</sub> and N<sub>2</sub>O emissions were calculated with default vehicle mix values and emission factors from ICLEI's U.S. Community Protocol.

To estimate mobile off-road emissions, non-point source off-road emissions were obtained from CARB's OFFROAD2007 Vehicle Model for all of Mendocino County. Off-road emissions sources include lawn and garden equipment, construction equipment, industrial equipment, and light commercial equipment. Emissions were apportioned to Ukiah based on the City's population as a percentage of overall County population (note: except for lawn and garden equipment, which was apportioned based on number of households).

### Agricultural Equipment

CARB's OFFROAD2007 Vehicle Model provided agriculture off-road vehicle emissions for all of Mendocino County for 2005 and 2010. Emissions were apportioned to Ukiah based on the City's percentage of total County population.

### Solid Waste Generated

Calrecycle (CRiS) provided community-wide solid waste in annual tons for 2005 and 2010<sup>5</sup>. CH<sub>4</sub> emissions from solid waste were calculated using EPA's LandGEM software<sup>6</sup> using the following assumptions:

- 100-year timeframe for waste decomposition;
- Landfill gas capture rate = 75%;
- Oxidation Rate = 10%

<sup>3</sup> For this inventory, renewable sources of electricity were assumed to have an emissions factor of zero.

<sup>4</sup> Quantifying emissions associated with the use of travel by the community involves estimating emissions associated with the entire length of in-boundary and trans-boundary trips, and allocating a portion of those emissions to the community for which emissions are being reported. See Appendix B for more information about VMT calculations for Ukiah.

<sup>5</sup> CRiS: CalRecycle Countywide, Regionwide, and Statewide Jurisdiction Diversion Progress Report

<sup>6</sup> EPA's Landfill Gas Emissions Model (LandGEM version 3.02, released May 12, 2005) is available at <http://www.epa.gov/lmop/publications-tools/>



- LandGEM parameters:
  - ♦ Methane generation rate (k) = 0.04;
  - ♦ Potential methane generation capacity (Lo) = 100;
  - ♦ NMOC concentration = 4000;
  - ♦ Methane content = 50%

### Water Conveyance

Emissions from water conveyance were estimated based on historical water use and average electricity used to convey water from a reservoir to the tap. The Ukiah 2010 Urban Water Management Plan provides 2005 and 2010 estimates of annual water use in million gallons (MG) of water consumed. The annual electricity required to transport water was calculated using the Northern California Average Conversion factor of 1,811 kWh/MG.<sup>7</sup> Associated GHG emissions were then calculated using a Ukiah-specific emission factor for local electricity that takes into account the City's diverse mix of electricity sources, and high percentage of renewable electricity.

### Stationary Sources

Methodology followed U.S. ICLEI Community Protocol (2012) methodology for estimating emissions for stationary sources. Stationary source emissions may include industrial, residential and commercial emissions sources.

For residential emissions, this inventory includes propane/liquefied petroleum gas (LPG) emissions. County-level energy consumption figures for other residential stationary sources (i.e. wood and fuel oil/kerosene) were unavailable from the U.S. Energy Information Administration (EIA). 2010 propane/LPG emissions were estimated based on EIA energy consumption and Census household data (number of homes utilizing propane/LPG). Propane/LPG consumption was converted into emissions using the LGOP emission factor for CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emission. Year 2005 emissions were backcast using an average of population and household growth from 2005 to 2010.

Industrial emissions from stationary sources were determined to be de minimis based on correspondence with the Mendocino Air Quality District (Chris Brown), and were thus not calculated. Commercial stationary source emissions were not estimated because local-level building characteristics, which are required for estimates of commercial stationary source emissions, were not attainable.

### Wastewater Treatment

Ukiah owns and operates a Wastewater Treatment Plant (WWTP). A WWTP supervisor provided information regarding plant processes, standard cubic feet of gas flared from March to December of 2010, and the fraction of CH<sub>4</sub> in biogas (65%). The Ukiah 2010 Urban Water Management Plan provided the 2005 and 2010 population served by the WWTP.

Wastewater emissions were calculated following ICLEI U.S. Community Protocol (2012) methodology, and were based on process data and WWTP service population within Ukiah City boundaries. The nine months of 2010 gas data were extrapolated to represent the entire calendar year, and 2005 levels were estimated commensurate with local population, housing, and employment levels. GHG emissions from wastewater include stationary CH<sub>4</sub> and N<sub>2</sub>O stationary emissions from the combustion of digester gas, process N<sub>2</sub>O emissions from plant processes, and fugitive N<sub>2</sub>O emissions from effluent discharge.

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<sup>7</sup> California Energy Commission: Refining Estimates of Water Related Energy Use in California. Available at: <http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF>

## Landfill

Emissions were quantified for indirect methane (CH<sub>4</sub>) emissions from the anaerobic decomposition of organic material sent to the City-operated landfill, for years 2005 and 2010. Although the landfill stopped accepting waste in 2000, waste-in-place continues to generate emissions, at annually decreasing rates. The California Air Resource Board's Landfill Emissions Model was used to calculate emissions. The City of Ukiah provided an estimate for total closure year waste-in-place Emissions Model inputs.

## Municipal Operations Inventory

### Electricity

The City Finance Department provided activity data for electricity that includes electricity used in all buildings and facilities, streetlights, and water supply operated by the City of Ukiah, for both 2005 and 2010. Indirect emissions from electricity generation were calculated using a weighted emission factor based on the breakdown of electricity sources within the City's electricity portfolio in 2005 and 2010.

### Natural Gas

PG&E provided activity data for natural gas that includes metered natural gas usage for all buildings and facilities operated by the City, including the WWTP, for both 2005 and 2010. Emissions from natural gas consumption were calculated using the PG&E emission factor for CO<sub>2</sub>, and the LGOP emission factors for CH<sub>4</sub> and N<sub>2</sub>O.

### Vehicle Fleet

This sector includes emissions from on-road and off-road fuel consumption from vehicles operated by the City of Ukiah, including the City vehicle fleet. The City provided fuel consumption data for gasoline and diesel vehicles for years 2008 and the first seven months of 2012, which was interpolated to estimate fuel consumption for calendar year 2010. Emissions were calculated using CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emission factors from the LGOP for gasoline and diesel vehicles. Miles per gallon (MPG) factors for gasoline and diesel vehicles were taken from EMFAC 2011 software Mendocino County model run for year 2010. Year 2005 emissions were backcast using the growth rate in City full-time-equivalent (FTE) workers from 2005 to 2010.

### Generated Solid Waste

This sector includes solid waste generated by the City government facilities that is sent to landfill. Emissions for the sector were estimated by apportioning community solid waste emissions based on the proportion of city full-time-equivalent (FTE) employees as a proportion of total City population, for years 2005 and 2010.

### Employee Commute

This sector comprises emissions from fuel consumption from City government employee vehicle travel. The City conducted a survey to determine travel mode of City employees in 2012. The City collected data on vehicle type, model, make, and year, as well as annual mileage traveled. 2005 and 2010 emissions were back-cast from 2012 emissions levels based on the number of FTEs in each year.

### Stationary Sources

Stationary source emissions include emissions from generators operated by the City government. The City provided recent (year 2011 and/or 2012) fuel consumption data for the five generators that burned fuel in 2005 and/or 2010, which were used as proxy data for calendar year 2010. Emissions were calculated from

fuel consumption totals using LGOP emission factors for CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O. Year 2005 emissions were backcast using the growth rate in City full-time-equivalent (FTE) workers from 2005 to 2010.

### Wastewater Treatment

Emissions were quantified as described in the Community Wastewater Treatment sector (see above). However, since the municipal government maintains operational control of the Wastewater Treatment Plant, total Plant service population was used for calculation purposes for this inventory. Year 2005 emissions were backcast using the growth rate in City full-time-equivalent (FTE) workers from 2005 to 2010.

### Landfill

Emissions were quantified as described in the Community Landfill sector (see above).

## 2020 and 2030 Business-as-Usual Projections

Table 3 in the Ukiah GHG Inventory shows the growth proxies used project future emissions (for years 2020 and 2030) for community-wide and municipal operations, under business-as-usual conditions. Table A-1 shows the specific projections data used for City-wide population, housing, employment, and municipal staff. Annual growth rates were derived for the periods 2005 to 2010 (to backtrack 2005 emissions when 2005 data was unavailable), as well as 2010 to 2020 and 2010 to 2030, to project future emissions for 2020 and 2030. The sources of data and numbers used are shown in [Table A-1](#).

**Table A-1: City of Ukiah Population, Housing, and Employment Projections Data and Growth Rates**

Source	2005	2010	2020	2030	Annual Growth Rate, 2005-2010	Annual Growth Rate, 2010-2020	Annual Growth Rate, 2010-2030
<b>Population (# of people)</b>							
California Department of Finance	16,020	16,042	No data	No data	0.03%	N/A	N/A
Ukiah Urban Water Management Plan (UWMP)	No data	15,682	17,323	19,135	N/A	1.00%	2.01%
<b>Employment (# of jobs)</b>							
2010-2011 Mendocino County Economic & Development Profile <sup>a</sup>	7,080	6,700	No data	No data	-1.10%	N/A	N/A
Mendocino Council of Governments (MCOG) Model <sup>b</sup>	No data	12,007	13,169	13,075	N/A	0.93%	0.86%
<b>Housing (# of households)</b>							
California Department of Finance	6,389	6,482	No data	No data	0.29%	N/A	N/A
Mendocino Council of Governments (MCOG) Model	No data	6,512	6,762	6,752	N/A	0.38%	0.36%
<b>Municipal Government Staff (full-time-equivalent employees)</b>							
City of Ukiah Fiscal Year FTE Data <sup>c</sup>	163	171	183 <sup>d</sup>	195 <sup>d</sup>	0.96%	0.67% <sup>e</sup>	0.67% <sup>e</sup>

<sup>a</sup> Internal City labor force only

<sup>b</sup> Data provided by Fehr & Peers VMT Inventory Memo. See Appendix B

<sup>c</sup> 2005 reflects fiscal year 2005-2006 data; 2010 reflects fiscal year 2010-2011 data

<sup>d</sup> projected based on the estimated growth rate (0.67%)

<sup>e</sup> estimated based on prior City full-time employee growth from the fiscal years 2000-01 to 2010-11



Three sectors did not use growth proxies represented in Table A-1: Agricultural Equipment, On-road Transportation, and Landfill. Emissions from Agricultural Equipment were assumed to experience zero growth between 2010 and 2030. Future emissions for On-road Transportation were estimated using 2020 and 2030 VMT projections provided by Fehr and Peers, and emission factors from the EMFAC 2011 Model that do not include effects of the state-wide Low Carbon Fuel Standard (LCFS) and the Pavley Bill, AB 1493 (which will reduce GHG emissions in automobiles). For the City Landfill, the California ARB Landfill Emissions Tool was used to calculate emissions for 2020. Because the tool does not provide emissions out to 2030, 2030 emissions were estimated with the EPA's LandGEM software.