CITY OF LAKEWOOD

Greenhouse Gas Emissions Inventory
&
Sustainable Energy Benchmarking and Actions
2007

University of Colorado Denver
Center for Sustainable Infrastructure Systems
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EXECUTIVE SUMMARY

Background

At the beginning of 2011, the City of Lakewood (Lakewood) partnered with the University of Colorado Denver (UCD) and the Colorado Municipal League (CML) through a generous donation from the Wal-Mart Foundation to begin the process of quantifying energy and materials consumption. This process has grown out of concern about the availability of increasingly scarce non-renewable natural resources, rising energy costs, and the adverse effects of burning fossil fuels. The City of Lakewood has recently been exploring ways to address these concerns.

Inventory Objective

The objective of this Greenhouse Gas (GHG) emissions inventory is to establish a community-wide baseline from which future emission reduction goals can be set.

Inventory Method

This inventory covers the three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), and nitrogen oxides (N2O). The unit of measure used throughout this report is metric tons of CO_2 equivalent (abbreviated mt-CO_2e) in order to express total emissions of all three GHG gasses in one comparable unit.

This report assesses 2007 GHG emissions for the City of Lakewood, Colorado using a hybrid demand-center life cycle assessment methodology developed by Ramaswami et. al. (Ramaswami, Hillman, Janson, & Thomas, 2008). The method uses the standard Local Government Operations Protocol (LGOP) released by ICLEI[1]-Local Governments for Sustainability to report GHG emissions from in-boundary activities. Out-of-boundary activities critical to a community such as the provision of food, water, fuels and dwellings are added to the in-boundary activities to yield an expanded inventory that becomes a more comprehensive "carbon emissions footprint".

Inventory Results

In 2007, the population of the City of Lakewood was estimated to be 143,109 people. The activities of these people were summed together to find the total community-wide GHG emissions and the per capita emissions. There are many activities within the community that cause greenhouse gas emissions, the majority of which are easily tracked through economic, utility, and other public data. In 2007, electricity and natural gas consumption from the residential and commercial sectors made up about 1,213 thousand mt-CO_2e, or 44% of the total community-wide GHG emissions. Emissions from transportation (gasoline, diesel from surface travel and jet fuel from air travel) resulted in 754 thousand mt-CO_2e or 27% of total community-wide GHG emissions. Finally, key urban materials such as food, cement, fuel production,

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1 ICLEI is the International Council for Local Environmental Initiatives, an international membership association of local governments dedicated to climate protection and sustainable development.

water fugitive emissions, and waste emitted 782 thousand mt-CO_2e or 28% of total community-wide GHG emissions. In 2007, emissions totaled 2,750 thousand mt-CO_2e for the entire Lakewood community and the per capita emissions were 19.22 mt-CO_2e/capita.

Figure 1. Greenhouse Gas emissions summary by sector for Lakewood, 2007

Inventory includes all emissions from the processing of transportation fuel: extraction, refining, transportation and engine combustion of fuel.

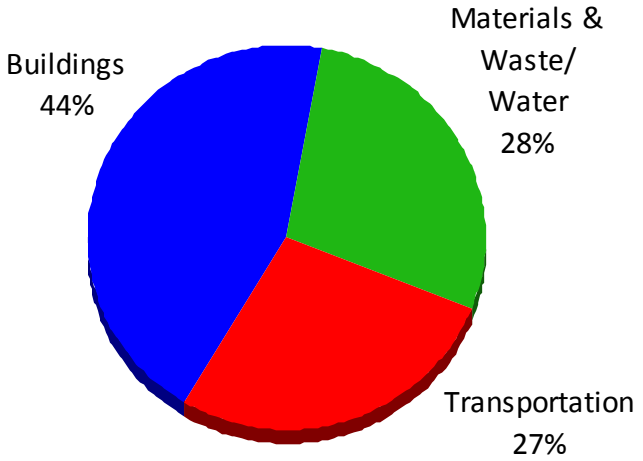
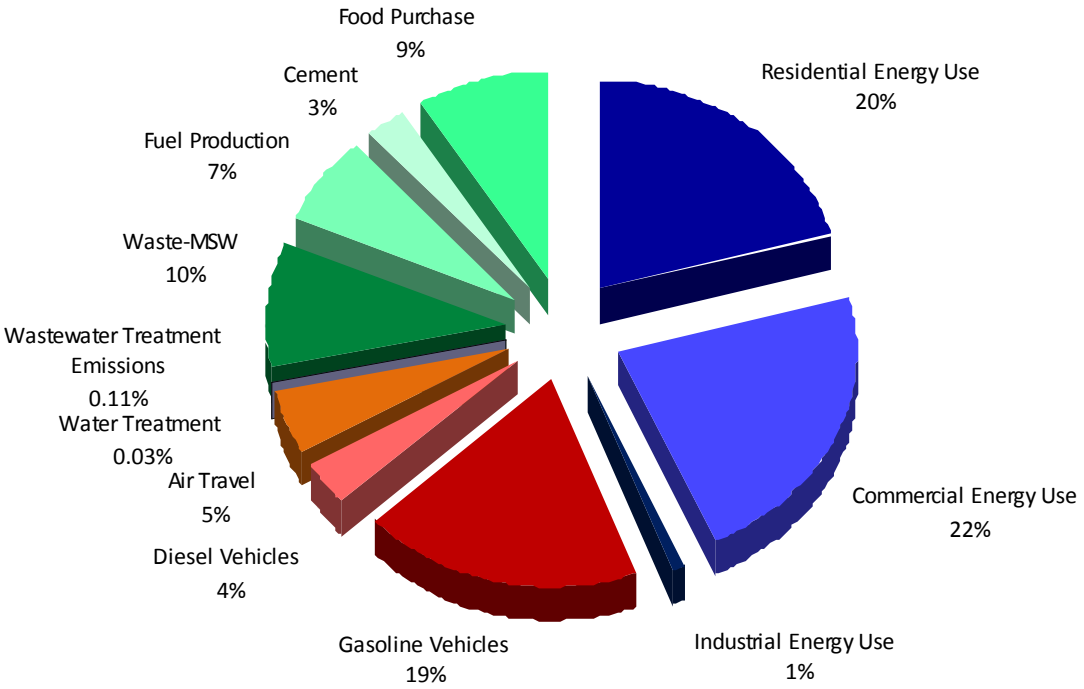


Figure 2 2007 greenhouse gas emissions summary by source type

2007 total GHG emissions = 2,750.12 thousand metric tons of CO_2e



Comparisons with Other Cities

In order to compare one city to another, it is useful to compare "per capita emissions" as opposed to "total emissions". Per capita emissions bring conceptually difficult numbers (i.e., millions or billions of tons) into line and establish a common standard of comparison. For example, if two countries have the same total emissions of 20 billion tons each, but one country has three times the population, then per capita emissions in that country will be 1/3 that of the other. There could be many reasons for the per capita differences, including more or less development or prosperity, warmer versus colder climate, different urban planning policies, or higher renewable versus fossil-fueled power generation.

Key Findings

The City of Lakewood's 2007 GHG emissions are compared with national data; the State of Colorado; the City of Denver, CO; the City of Golden, CO; and the City of Aurora, CO. Since all of these areas have different populations and services, GHG emissions can be relatively compared on a per capita basis. The City of Denver emitted 25.3 mt-CO2e/capita in 2007, the City of Golden emitted 27.0 mt-CO2e/capita in 2007, The City of Aurora emitted 15.0 mt-CO2e/capita in 2007, while the State of Colorado emitted 24.5 mt-CO2e/capita and the nation emitted 25.2 mt-CO2e/capita in 2005. Similar to the City of Aurora, the City of Lakewood may have lower per capita emissions due to a higher share of residential energy use and lower share of commercial energy use.

Table 1 Lakewood's GHG emissions compared to the National average, State of Colorado average, and other cities

Description of Benchmark	CO State (2007)	Denver, CO (2005)	Golden, CO (2007)	Aurora, CO (2007)	Lakewood, CO (2007)	Units of Measurement (*source*)
Avg. Home Sq. Ft. (people/home)	-- (2.53)	-- (2.3)	938 (2.24)	1,395 (2.58)	1,319 (2.4)	Sq.ft./hh (people/home)
Avg. Residen. Electricity Use	674	528	615	614	614	kWh/hh/mo (*Xcel*)
Avg. Residen. Natural Gas Use	47	65	62	47	59	therms/hh/mo (*Xcel*)
Avg. Commercial Buildings Energy Use Intensity	104*	179	140	117	200	kBTU/ft^2/yr (*Xcel*)
Vehicle Miles Traveled (VMT)	24.5	25	31	15	24	VMT/person/d (*DRCOG*)
Water[1]	154	168	200	147	165	gal/person/day (*Denver Water, MWRD*)
Municipal Solid Waste (MSW)	6.3	6.9	6.6	6.3	6.3	lbs/person/day (CDPHE)
Airline Travel Efficiency at DIA1	19 (US)	18.1	17.6	17.6	17.6	Gal./enplaned passenger DIA
Food (1997$)	$2,709	$3,000	$2,682	$3,452	$2,682	$/hh/yr West CES
Cement Use / Capita	--	0.53	0.57	0.49	0.57	mt/person/year Denver-Aurora Economic Statistical Area
GHG Emissions per resident	24.5	25	27	15	19.2	mt-CO2e /resident/yr

* This number applies to mountain regions in the State only.

Business as Usual Projection

Current consumption patterns and Lakewood's 2020 estimates for population, housing, and employment were used to project city-wide emissions to 2020. Based on future estimates of an average annual (population and jobs) growth rate of 0.5%, in the City, total community-wide emissions in Lakewood are estimated to increase by 184,220 mt-CO_2e by 2020 reaching roughly 2,934,337 mt-CO_2e.

Without understanding where greenhouse gas emissions are coming from within the community, a strategy to reduce them cannot be established. Reducing these emissions will require a combination of personal lifestyle changes as well as policies from the local governments in combination with the State and National government. As the community continues to strive towards sustainability, it can use greenhouse gas accounting as one way to measure how current and future efforts are progressing.

Pathways to Sustainability

Local governments can greatly influence their communities' greenhouse gas emissions by exercising key powers over land use, transportation, building construction, waste management and, in many cases, energy and water supplies and management. The following are pathways that cities have taken to achieve sustainability:

1. *Visioning: In this pathway, the visioning process begins. Lakewood will develop a Sustainability Action Plan to address municipal operations and sustainability.*
2. *Public Engagement: Gathering community input is often a valuable step in creating a vision for a city. It is also helpful in order to gauge community interest and identify priorities for the community.*
3. *Set Goals: Once a community has created a vision it can set unique reduction goals that reflect the values of the community.*
4. *Document Goals: It is helpful to document a city's goals in a formal planning document such as a Community Sustainability Plan.*
5. *Action Planning: The final pathway is to select strategies to meet Lakewood's reduction goals.*

While it is important that Lakewood create a action plan based on input from the community, a Sustainability Actions Matrix which provides measures to reduce the City's GHG emissions are to be included in the final report to provide a few common options to start out with. Measures were identified based on a preliminary assessment of Lakewood's existing conditions and projected growth. The following is a brief description on potential actions:

Commercial Windsource

In 2007 Windsource Power from Xcel Energy accounted for 0.2% of total commercial power purchases in the City of Lakewood. Through education or rewards programs promoting the purchase of Windsource, an increase in total Windsource purchases to 5% of total commercial power purchases in 2020 would result in a savings of 22,319 mt-CO_2e or a 0.8% decrease from 2020 business as usual levels.

Commercial and Industrial Demand Side Management

Voluntary participation by Lakewood commercial, industrial and residential customers in Xcel Energy's Demand Side Management (DSM) Program would potentially result in a savings of 89,278 mt-CO_2e or a 3.0% decrease from 2020 business as usual levels.

Residential Windsource

In 2007 Windsource power from Xcel accounted for 1.8% of total residential power purchases in the City of Lakewood. Through education or rewards programs promoting the purchase of Green Power an increase in total Green Power purchases to 10% of total residential power purchases in 2020 would result in a savings of 33,930 mt-CO_2e or a 1.16% decrease from 2020 business as usual levels.

Residential Natural Gas Demand Side Management

Voluntary participation by Lakewood's residential customers in Xcel Energy's DSM Program could potentially result in a savings of 11,013 mt-CO_2e or a 0.38% decrease from 2020 business as usual levels.

Home Energy Meters Voluntary/Mandate

Home Energy Information Display Meters are simple devices that have proven to help reduce energy consumption in homes by 6%-12%. If a voluntary program to install home energy meters in all new homes were implemented with 3% of homes participation between 2007 and 2020, Lakewood would be a savings of 1,018 mt-CO_2e or a 0.03% decrease from 2020 business as usual levels. If a mandatory program to install home energy meters in all new homes were implemented with a 100% participation rate for new homes between 2007 and 2020, Lakewood would be a savings of 33,390 mt-CO_2e or a 1.14% decrease from 2020 business as usual levels.

Commercial Green Building for New Construction

A variety of energy efficient building codes can be adopted as mandated strategies for GHG reductions, these building codes have been found to save 20% to 30% of electricity per square foot. If Lakewood were to adopt Green Building codes for new commercial buildings (Mandatory-100% Participation) there is a potential savings of 53,883 mt-CO_2e or a 2.0% decrease from 2020 business as usual levels.

Residential Green Building for New Construction

A variety of energy efficient building codes can be adopted as mandated strategies for GHG reductions, these building codes have been found to save 20% to 30% of electricity per square foot. If Lakewood were to adopt Green Building codes for new residential buildings (Mandatory-100% Participation) there is a potential savings of 38,808 mt-CO_2e or a 1.4% decrease from 2020 business as usual levels.

Transit Oriented Development

By policy or incentive, if 50% of new development is directed to transit oriented developments a decrease VMT would be realized. Through this strategy there is a potential savings of 10,351 mt-CO_2e or a 0.38% decrease from 2020 business as usual levels.

Pay-As-You-Throw Trash Service Mandate

Communities with single-hauler waste services have the opportunity to mandate Pay-As-You-Throw Trash Services. If the City of Lakewood were to mandate Pay-As-You-Throw there would be an EPA estimated 15% to 28% decrease in total municipal solid waste. This decrease in waste would account for a decreace of 61,910 mt-CO_2e or a 2.3% decrease from 2020 business as usual levels.

Green Concrete Mandate

By mandating the use of Green Concrete (25% fly-ash) GHGs could be reduced within Lakewood by 21,895 mt-CO_2e or a 0.8% decrease from 2020 business as usual levels.

Local Food Voluntary

By promoting local food Lakewood could potentially reduce GHG emissions by 21,254 mt-CO_2e or a 0.72% decrease from 2020 business as usual levels.

Individualized Travel Marketing Program

Individualized Travel Marketing Programs help individuals reduce their vehicle miles traveled by 2%-12% through behavior change. This action could potentially decrease GHG emissions in Lakewood by 3,736 mt-CO_2e or a 0.14% decrease from 2020 business as usual levels.

ABBREVIATIONS AND ACRONYMS

CACPS	*Clean Air Climate Protection Software*
CAPPA	*Climate & Air Pollution Planning Assistant (ICLEI Software)*
CDPHE	*Colorado Department of Public Health and the Environment*
CFL	*Compact Fluorescent Light*
CH_4	*Methane*
CML	*Colorado Municipal League*
CO_2	*Carbon Dioxide*
DSM	*Demand Side Management*
EECBG	*Energy Efficiency and Conservation Block Grants*
EIA	*Energy Information Administration*
EPA	*Environmental Protection Agency*
GEO	*Governor's Energy Office (State of Colorado)*
GHG	*Greenhouse Gases*
GREET	*Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation model*
GWh	*Gigawatt hour*
HH	*Household*
IGERT	*Interdisciplinary Graduate Education Research Traineeship*
kWh	*kilowatt hour*
LCA	*Life Cycle Assessment*
LGOP	*Local Government Operations Protocol*
MSW	*Municipal solid waste*
mt-CO_2e	*Metric tons of carbon dioxide equivalents*
N_2O	*Nitrous Oxide*
NREL	*National Renewable Energy Laboratory*
P2W	*Pump-to-Wheels*
RMA	*Rocky Mountain Airport*
UCD	*University of Colorado Denver*
VMT	*Vehicle miles travelled*
WARM	*Waste Reduction Model*
WRI	*World Resources Institute*
W2P	*Wells-to-Pump*

SECTION 1 - INTRODUCTION TO SUSTAINABLE ENERGY PLANNING

Sustainability is widely understood to encompass three E's: Economics, Environment and Equity. In the context of the environment, sustainability refers to more efficient use of scarce natural resources such as water, energy and minerals. This includes reducing or avoiding emissions of toxic pollutants such as heavy metals, harmful pesticides, carcinogens, etc. Sustainability entails facilitating human activities that simultaneously promote economic development, environmental protection, and social equity in the present and into the future.

1.1 The business Case for Sustainability

There has been interest nationally, within the State of Colorado and in several Colorado communities, in developing sustainable energy plans. These plans are motivated by the projected increase in global demand for limited oil and gas resources, the increasing world-wide cost of fossil fuels, our dependence on foreign oil which impacts national energy security, and, our understanding of the global and local environmental impacts of using fossil fuel energy. The global/local impacts from using fossil fuels include local-scale air pollution from petroleum use in automobiles, which contributes to smog, local scale air pollution from coal-fired power plants, and global impacts of greenhouse gas emissions. The global impacts of greenhouse gas emissions are projected to have local impacts in Colorado, affecting snow pack, water supplies (local and regional) and agriculture. Looking toward a

future with increased cost and reduced availability of fossil fuel energy, communities are embarking on sustainable energy plans that save money through energy and resource conservation, generate jobs in the new green energy economy focused on energy efficiency and renewable energy, and promote community-wide economic development.

1.2 Greenhouse Gases and Greenhouse Gas Accounting

The U.S. EPA defines greenhouse gases as those gases that trap heat in the atmosphere. Some greenhouse gases, such as carbon dioxide, occur naturally and are emitted into the atmosphere through natural processes and human activities. Other greenhouse gases (e.g., fluorinated gases) are created and emitted solely through human activities.

Greenhouse Gases (GHGs)

The principal greenhouse gases that enter the atmosphere because of human activities are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and several industrial compounds called "chlorofluorocarbons." The first three GHGs: CO_2, CH_4, and N_2O, account for more than 98% of GHGs emitted nationally and are the focus of this report (U.S. Environmental Protection Agency, 2009).

Almost every facet of modern life emits greenhouse gases. Carbon dioxide, the largest contributor to global warming, is emitted wherever and whenever fossil fuels are burned including when we drive our cars, heat our houses, and generate our electricity. Methane is emitted from waste decomposition (naturally or in landfills) and from farms that raise the animals we eat. Nitrous oxide is emitted from landfills and wastewater treatment plants, usually as fugitive emissions. Factories that produce all of the products we use in our daily lives emit greenhouse gases and the trucks that transport these items to our cities emit more still.

The various GHGs have different global warming potentials, or ability to trap heat in the atmosphere. For example, one ton of methane can trap 25 times as much heat in the atmosphere as a ton of carbon dioxide. Therefore 1 mt-CH_4 is equal to 25 mt-CO_2e. In order to compare the emissions, greenhouse gases are reported together on a

common standardized basis as metric tons of carbon dioxide equivalents (mt-CO_2e). Table 1-1 shows the top three greenhouse gases in the atmosphere and their global warming potentials.

Table 1-1 Global warming potentials of Greenhouse gases

Greenhouse gas	*Chemical Formula*	*Global Warming Potential*
Carbon Dioxide	CO_2	*1*
Methane	CH_4	*25*
Nitrous Oxide	N_2O	*298*

Source: Intergovernmental Panel on Climate Change - IPCC (IPCC, 2007)

Greenhouse Gas Accounting

Greenhouse gas accounting is the practice of accounting for GHG emissions within a boundary (anything from a single home to an entire country) and those emitted on behalf of the area within that boundary (for example, electricity that is produced in a neighboring county but used in the county of interest). The end product is a greenhouse gas emissions inventory specifying how many metric tons of carbon dioxide equivalent (mt-CO_2e) were emitted in a given year, broken down by sector and source and expressed in simple terms that are comparable over time. The purpose of local GHG inventories is to identify the most promising reduction opportunities and set goals for the future.

GHG emissions inventories are a useful tool for policymakers for three reasons. First, if it is apparent which sector of a community is producing the majority of emissions, policies can be targeted at specific sectors where easy improvements can be made with little investment; inventories can help to identify the "low-hanging fruit." Second, each sector can be compared on a per-user basis (per household, per employee, per square foot, etc) to the same sector in a nearby region having similar demographics and climate in order to identify if there are specific local practices that can be modified or if there are even any improvements to be made. Third, and most importantly, once policies have been implemented, their effectiveness can be tracked over time by performing a new inventory every year or two and comparing the results.

For this reason alone, it is vitally important that any government interested in reducing its environmental impact have a "baseline" inventory to which they can make comparisons in the future.

1.3 Climate Change Mitigation

International Measures

The most widely known international response to mitigate climate change is the Kyoto Protocol, a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), which seeks to reduce six greenhouse gases[2]. The Kyoto Protocol, adopted on December 11, 1997, calls for a 5.2% reduction from 1990 emission levels by 2012. As of November 2009, 187 countries have signed and ratified the protocol.

U.S. Measures

The U.S. did not ratify the Kyoto Protocol and is therefore not bound by the Protocol's objectives. Currently, there is no Congressionally approved federal policy regarding greenhouse gas emissions reductions in the U.S. although climate legislation passed in the House in 2009 and separate legislation is currently being debated in the Senate. Many states however, have initiated statewide greenhouse gas reduction goals. Colorado Governor Bill Ritter issued a Climate Action Plan in 2007. It set a goal of reducing the state's greenhouse gas emissions 20% below their 2005 levels by 2020 and 80% by 2050.

In 2005, a coalition of U.S. mayors created the U.S. Mayor's Climate Agreement, establishing a city-scale response to the Kyoto protocol, aiming for a 10-percent per capita reduction in greenhouse gas emissions from 1990 levels by 2012. To date, 1,017 U.S. Mayors have joined the U.S. Mayor's Climate Agreement including Denver, Fort Collins, and Westminster, Colorado.

More and more communities are realizing that reducing greenhouse gas emissions can provide not only global environmental benefits, but also local economic benefits from

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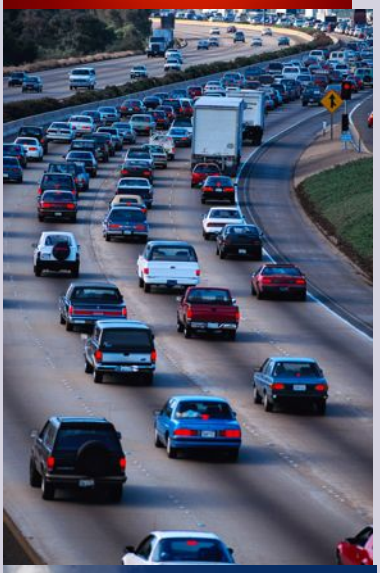
2 Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Sulfur hexafluoride (SF_6), Perfluorocarbons (PFCs).

energy efficiency measures, business competitiveness in an era of oil market volatility, as well as health and other societal benefits. Local actions can have a global impact, while the quest to reduce global GHG emissions can have a corresponding beneficial local impact.

Lakewood's Case

The City of Lakewood actively seeks to address the sustainability of their municipal government. This community wide inventory can be used to develop an action plan for community wide sustainability. The initial step to reducing GHG emissions is establishing a baseline assessment and analysis of existing conditions and trends. A citywide greenhouse gas (GHG) inventory establishes a baseline from which future emission reduction goals can be set. Additionally, an assessment of potential new impacts is also helpful in the assessment and adaptation strategies.



SECTION 2 - GHG INVENTORY AND PROJECTION

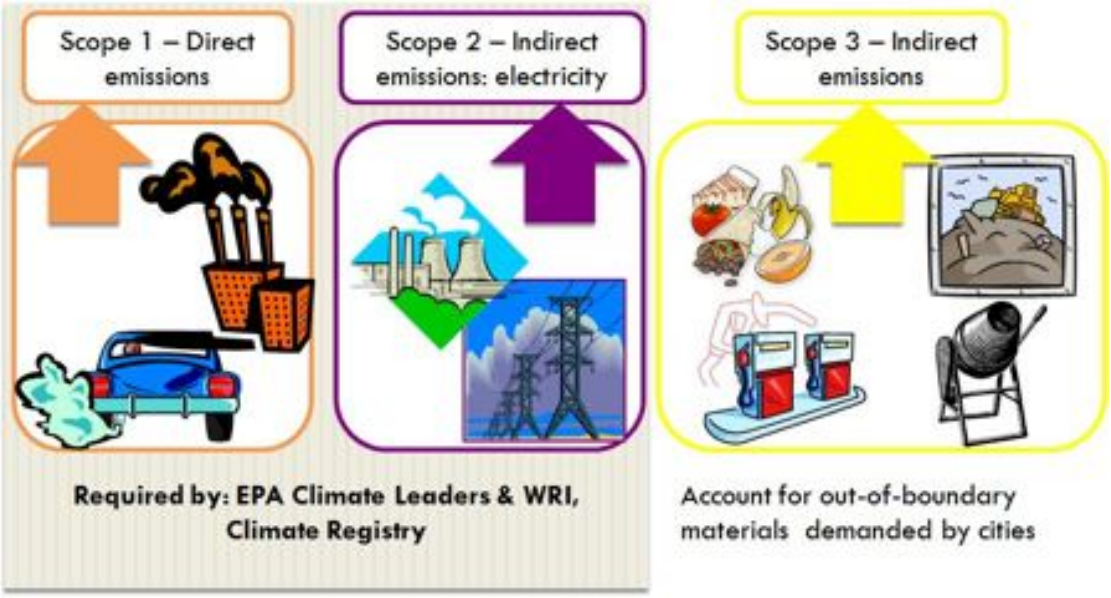
2.1 Method and Scopes

Despite high interest in city-scale GHG mitigation, GHG accounting at the scale of individual cities is confounded by spatial scale and boundary effects ((Ramaswami, Hillman, Janson, & Thomas, 2008)). National-scale accounting for GHG emissions (IPCC, 2006) primarily focuses on emissions that occur within the geospatial boundary of a country, which include: the accounting of total energy supplied at the national scale - electricity and natural gas for buildings and industry sectors; petroleum (gasoline, diesel, jet fuel, etc.) for surface and airline transport and industrial operations; as well as waste decay and other biological processes. Scaling down national GHG accounts to the city-scale is challenging, because city-scale GHG accounts primarily focus on the demand for energy and materials exerted by cities.

The Ramaswami inventory-footprint method for GHG accounting was pioneered by the University of Colorado Denver along with the City and County of Denver in 2008, building on previous in-boundary GHG accounting at the city-scale by incorporating six key cross-boundary activities which were found sufficient to yield a holistic GHG emission footprint (Hillman & Ramaswami, 2010). Since the success of the Denver inventory, the method has been utilized by other cities such as Portland, Oregon; Seattle, Washington; Arvada, Colorado; Austin, Texas; and

Minneapolis, Minnesota. The method uses the standardized Local Governments Operations Protocol (LGOP) to report GHG emissions from in-boundary (within jurisdictional boundary) activities. LGOP provides a protocol for the quantification and reporting of GHG emissions for cities Scopes 1, 2, and 3. See Figure 2-1.

Figure 2-1 Inventory scopes



Scope 1 emissions include emissions from in-boundary activities, such as on-site combustion of fuels, Scope 2 emissions are out-of-boundary emissions from purchased electricity consumed within the city, and Scope 3 emissions include other "optional" out-of-boundary activities crucial for a community such as water, food, fuels, and shelter. When activities such as airline transport, freight transport, oil refining, cement production, and food production, activities that largely occur outside city boundaries but appear in national inventories, are mapped to cities based on demand, challenges associated with truncation at the spatial boundary of cities are mitigated (Hillman & Ramaswami, 2010). This inclusion of additional out-of-boundary activities (World Resource Institute Scope 3) is highly recommended by EPA's Climate Leaders Program (World Resources Institute and World Business Council for Sustainable Development, 2004).

2.1.1 In-Boundary Activities

The following energy uses are considered "in-boundary" and are required to be reported as per LGOP and World Resources Institute (WRI) protocols:

- ***BUILDINGS ENERGY USE** – Use of electricity, natural gas, and propane in residential, commercial and industrial sectors in a community.*
- ***TRANSPORTATION ENERGY USE** – Includes tailpipe emissions from operating personal and commercial vehicles associated with a community.*
- ***EMISSIONS FROM WASTE DISPOSAL AND WASTEWATER TREATMENT** – In LGOP, emissions from waste disposal by residential and commercial sectors are also included in the in-boundary accounting as well as fugitive emissions from wastewater treatment.*

Formally, the GHGs emitted directly from burning natural gas in buildings and gasoline and diesel fuels in vehicles are termed "Scope 1". Since electric power plants are typically located outside the spatial boundaries of most US cities, city-scale accounting procedures include methods to spatially allocate emissions that result due to demand (or consumption) within the city but occur outside the city's boundary. Therefore, emissions from power plants to produce electricity consumed within the community are termed "Scope 2". Scopes 1+2 emissions are included in the "in-boundary" activities; LGOP requires that these emissions be reported in a GHG inventory. In-boundary activities include the following energy uses and are required to be reported by all jurisdictions as per LGOP and World Resources Institute (WRI) guidelines.

2.1.2 Out-of-Boundary Activities

WRI designates all emissions not included in Scopes 1+2 as Scope 3. The inclusion of these emissions is optional but highly recommended by the EPA and results in an expanded GHG inventory. The combination of Scope 1, 2 and 3 emissions represents the City's carbon emissions footprint. Including Scope 3 is necessary for per-capita comparison to national data. Additionally, communities that use a comprehensive inventory including all scopes are more likely to make greater reductions over time.

The following out-of-boundary, or trans-boundary activities, when added to in-boundary

activities, yield a more holistic account of a community's CO_2e footprint:

- ***Embodied Energy of Critical Urban Materials*** *– The energy use and associated GHG emissions from producing key urban materials such as water, fuels, and food, necessary to support life in cities. Some inventories, including Lakewood's, also include concrete.*

- ***Waste and Water Treatment*** *– Emissions relating to the collection, processing, and storage of solid and liquid wastes, including the operation of landfills and water and wastewater treatment plants and direct emissions from the waste/water itself, if such activities happen outside the boundary.*

- ***Airline Travel*** *– Energy use for airline travel is important as it appears in national and statewide GHG inventories and in personal calculators. At the community-scale, these appear as out-of-boundary emissions, particularly when the airport is outside jurisdictional boundaries.*

2.2 Energy Use Sectors and Data

To better communicate a community's overall energy use and GHG emissions, classifying end-use of energy in three different sectors is more useful. In this report, we consistently report energy use and GHG emissions in the following three sectors:

- ***Buildings Sector*** *– GHG emissions from residential, commercial, and government buildings and industrial facilities.*

- ***Transport Sector*** *– GHG emissions from operating cars, trucks and airplanes, termed Pump-to-Wheels (P2W) emissions.*

- ***Materials Sector*** *– GHG emissions from producing critical urban materials (food, water, cement) and fuel production (termed Wells-to-Pump, W2P) and from landfilling and water and wastewater treatment.*

For energy (or materials use) in each sector, the following data were gathered:

- *Annual Materials or Energy Consumption – Total kWh of electricity consumed annually, total water consumed annually, total natural gas use, etc. The annual*

Material/Energy Flow Analysis indicates how much is consumed as a community. Benchmarking these consumption data on a per-person or per-household basis represents how efficient the community's consumption patterns are.

- *GHG Emission Factors – GHG emissions factors express how much CO_2e is emitted per unit of energy or material consumed. For example: kilograms of carbon dioxide equivalent emitted per kilowatt-hour of electricity consumed, or kg-CO_2e/kWh.*

Total emissions are computed as the product of how much is consumed and the GHG emissions per unit of the product consumed, using the following simple equation:

∑[Material/Energy Flow Analysis (MFA) x Emission Factor (EF)] = Total Emissions

Total emissions are computed as the product of how much is consumed and the GHG emissions per unit of the product consumed. In the next section, consumption data and emission factors for all three sectors are reported and an overall community-wide GHG inventory and footprint is developed.

This section reports energy (or materials) consumption data and associated GHG emissions factor for the year 2008 (or most recent data available), for the three main sectors:

- *Buildings*
- *Transport (tailpipe emissions)*
- *Materials and Waste*

This baseline inventory can be referenced to measure Lakewood's progress in the coming years. For each sector, raw consumption data are presented, the data are normalized and compared with benchmarking metrics, and emission factors are quantified. The total GHG emissions from each sector are consolidated and reported as an overall community-wide summary in Table 2-6 GHG emissions are reported in terms of metric tons (mt) of carbon-dioxide equivalent, shown as mt-CO_2e.

2.2.1 Buildings Sector

The buildings sector energy use reports electricity and natural gas consumed in residential, commercial, and industrial facilities. The GHG Inventory revealed that buildings in Lakewood account for 44% of the City's total emissions, compared with the national average of 38% of total emissions (U.S. Green Building Council, 2010). Data were obtained from Xcel Energy, which supplies electricity and natural gas consumed within the City in 2007. Electricity used in the City accounted for 66% of buildings sector emissions with the remaining 34% attributed to natural gas use.

As illustrated in **Table 2-1**, *622 thousand mt-CO_2e or 51% of total buildings emissions are attributed to the commercial sector with the remaining 47% (570 thousand mt-CO_2e) and 2% (22 thousand mt-CO_2e) from residential and industrial energy use respectively. In order to normalize residential buildings energy use data, it is useful to express residential consumption by average monthly kWhs and therms per household. While this can provide one benchmark for regional comparison, it is also useful to determine per capita emissions associated with buildings energy use. Since Lakewood's building energy consumption is commercial/industrial intensive, the resulting per capita emissions associated with total building energy use is slightly higher compared to residential intensive communities, 8.5 mt-CO_2e per capita per year. The same is true in Denver where the commercial/industrial sector dominates total buildings energy use at 73%. The remaining 27% of total buildings energy use is attributed to the residential sector, yielding a per capita emissions rate similar to Lakewood's: 13.0 mt-CO_2e per person in 2005[3]. This benchmark indicates that the distribution of building energy consumption by residential and commercial sectors can significantly influence total per capita emissions.*

The Buildings Sector accounts for 44% of GHG emissions in Lakewood

WindSource

Xcel offers Lakewood customers the option of purchasing WindSource. In 2007, 106 Lakewood residential customers participated in the utility's WindSource program,

3 Calculated from buildings sector data in the Greenhouse Gas Inventory for the City and County of Denver (2007).

purchasing at least some renewable energy as a portion of their total power. Six commercial customers purchased 1,435 MWh of WindSource electricity in 2007. WindSource purchases in 2007 amounted to 0.89% of total electricity purchased from Xcel.

Buildings Energy Use Intensity

Based on the number of households and the square footage of commercial spaces in Lakewood (data obtained from County Assessor's office), energy use intensity (EUI) can be computed in terms of electricity and natural gas use per household, and kBtu used per commercial square foot. Calculated energy intensity for commercial buildings in Lakewood can be benchmarked with energy intensity metrics reported by the Energy Information Administration (EIA) in the Rocky Mountain region and national data. The Rocky Mountain region reports an average of 104 kBtu/sf/yr in commercial buildings while national data reports an average of 90 kBtu/sf/yr. Lakewood's energy use intensity is slightly higher at 200 kBtu/sf/yr but below Denver's EUI of 179 kBtu/sf/yr (see Table ES-1 and Table 2-1)

Table 2-1 Summary of Building Energy Use in Lakewood, CO

A. Residential Energy	**2007**
Total Number of Populations	143,109
Total Number of Households	60,017
Total Number of Customers (Electricity)	63,701
Total Grid Electricity Used including Windsource (GWh)	469.05
Total grid Electricity Used from Windsource (GWh)	8.50
Number of premises buying electricity from wind power	106
Electricity/household/month (kWh/hh/mo)	613.61
Total Number of Customers (Natural Gas)	53,629
Total Natural Gas Used (million therms)	38.24
Natural Gas/household/month (therms/hh/mo)	59.43
Total Residential GHG emissions (thousand mt-CO2e)	**569.50**
B. Commercial-Public Energy	
Total Number of Customers (Electricity)	6,442
Total Electricity Used including Windsource (GWh)	617.08
Total Electricity Used from Windsource (GWh)	1.435
Number of premises buying electricity from wind power	6
Total Natural Gas (million therms)	24.36
Total Public GHG Emissions (thousand mt-CO2e)	**5.24**
Total Commercial GHG Emissions (thousand mt-CO2e)	**616.80**
B. Industrial	
Total Number of Customers (Electricity)	13
Total Electricity Used (GWh)	27.53
Total comm-ind energy use per square foot (kBtu/sf)	200.32
Total Commercial-Industrial Area (million sf)	23.25
Total Industrial GHG Emissions (thousand mt-CO2e)	**21.70**
C. Total Buildings and Facilities GHG Emissions (thousand mt-CO2e)	**1,213.25**

Data Source: Energy data from Xcel. GWh = Giga Watt-hours of electricity = 1 million kWh. Both electricity and natural gas use can be combined and represented as kBtu (1 kWh = 3.412 kBtu; 1 therm = 100 kBtu).

Emission Factors for Electricity & Natural Gas

The GHG emissions factor for electricity use was provided by Xcel as 0.79 kg-CO_2e/kWh. Xcel is also the only company that provides pipelined natural gas to Lakewood and the emissions factor is reported as 5.4 kg-CO_2e/therm. These emission factors are in line with the factors reported by the Environmental Protection Agency (EPA) and EIA (U.S. Environmental Protection Agency, 2010). The total consumption of electricity or natural gas is multiplied by the emissions factor to yield the total GHG emissions in mt-CO_2e.

2.2.2 Transportation Sector

The transportation energy use in Lakewood includes two main modes of transport:

1. ***Personal and Commercial Motor Vehicles:*** *Cars and trucks, modeled for the entire Lakewood county, were separated to assign estimated vehicle miles traveled of personal and commercial traffic attributable to Lakewood.*
2. ***Airline Transport:*** *Energy use associated with jet fuel and fleet operations at the Lakewood Regional Airport in 2008 attributable to Lakewood.*

The transportation sector accounted for 27% of the City's total emissions, just shy of the national average of 30% of total emissions (Shuford, Rynne, & Mueller, 2010). A summary of the miles traveled, fuel consumed and GHG emissions for both modes of transport are presented in Table 2-2.

The Transportation Sector accounts for 27% of GHG emissions in Lakewood

Table 2-2 Transport Distances, Fuel Use (P2W) and GHG Emissions by Modes of Transport

A. Personal & Commercial Motor Vehicles	**2007**
Annual Vehicle Miles Traveled (million VMT)	1,210.29
VMT/person/day*	24.40
Annual Fuel Use	
Gasoline (million gallons)	57.20
Diesel (million gallons)	9.61
Total GHG Emissions from Personal and Commercial Motor Vehicle Transport (thousand mt-CO2e)	**618.52**
B. Airline Travel (3.25% of all DIA trips allocated to Lakewood in 2007)	
Enplaned Passengers	780,970.71
Jet Fuel (million gallons)	13.73
Total GHG Emissions from Airline Travel Allocated to Lakewood (thousand mt-CO2e)	**135.94**
C. Total GHG Emissions from Transportation Sector (thousand mt-CO2e)	**754.46**

A. *Data Source: VMT for personal-commercial vehicles obtained from DRCOG Method. Vehicle loading and fuel economy data from CDPHE to calculate PMT and fuel use.*
B. *Data Source: Fuel data for airport operations provided by DIA for 2007.*
C. **Miles traveled are normalized to Lakewood's entire population, including children, and therefore do not reflect actual average travel distances per driver or air traveler.*

Surface Travel Miles and Travel Intensity

Annual vehicle miles traveled (VMT) for Lakewood was computed by the demand-method from the DRCOG 2007 model run. The travel demand model is comprised of thousands of individual roadway links that are mapped spatially and organized in slightly larger travel analysis zones (TAZs). These travel demand models produce estimates of VMT by tracking: 1) the number of vehicles daily on any roadway; 2) the length of all roadway links; 3) the origin and destination of each vehicle trip; and 4) the travel distance between the origin and destination of every trip (this distance is approximated in the model by taking the shortest travel time path between the origin

and destination). The method is sensitive to local travel demand features of the individual cities and takes into account many variables including: population, average household size, percent of population between 18 – 64 years of age, land area, housing density, employment intensity, land area, and percentage of urbanized land area, among other variables (Hillman, Janson, & Ramaswami, Spatial Allocation of Transportation Greenhouse Gas Emissions at the City-Scale, 2009).

Consistent with modeling the City as a demand center for travel, only those trips that either originated or ended in Lakewood were included, amounting to an average of 3,538,856 daily surface VMT in 2007 and 1,210[4] million annual VMT . Pass-through trips in the Lakewood area, including those on major interstates were not included in Lakewood's inventory, as they do not relate to Lakewood-based activities.

The VMT intensity is the total annual VMT allocated to Lakewood per resident of the City. VMT intensity was determined by dividing Lakewood's annual VMT by the 2007 population[5]. Normalizing the total annual VMT results for personal and commercial vehicles per Lakewood resident allowed the data to be compared with regional and national transportation data[6]. As Table 2-3 indicates Lakewood's VMT intensity (per person/per day) is slightly lower than national data but comparable to state data.

Table 2-3 Lakewood's VMT compared to the National average, State of Colorado average, and other cities

Description of Benchmark	*US National (2007)*	*CO State (2007)*	*Denver (2007)*	*Arvada (2006)*	*Lakewood (2007)*	*Units of measurement*
Vehicle Miles per person per day	*27.0*	*24.5*	*25.0*	*12.3*	*24.4*	*VMT/person/day*

Fuel use (gasoline and diesel) was computed by allocating the annual VMT to an average State of Colorado Vehicle mix as reported by the Colorado Department of Public Health and the Environment (CDPHE); 95% gasoline-powered cars and 5% diesel-fueled vehicles,

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4 Average daily surface VMT is based on average weekday travel. Annual VMT was determined by multiplying the daily surface VMT by 342 in order to normalize the data for yearly travel that includes weekends and holidays.
5 Population data from City of Lakewood.
6 Per person normalization distributes total miles equally across total population. This method does not correlate exactly with vehicle miles traveled per vehicle.

with average fuel economies as reported in ICLEI CACP software. Fuel consumption was computed by dividing the total annual VMT by the average fuel economy (ICLEI-Local Governments for Sustainability, 2009)[7].

Airline trips

Energy use associated with jet fuel and fleet operations at Montrose in 2008 was allocated to Montrose using tourism destination data. In 2008, 423 million gallons of jet fuel were consumed at Denver International Airport, of which, 3.25%, or 13.73 million gallons was attributable to Montrose.

Emission Factors for Diesel, Gasoline and Jet Fuel

Diesel and gasoline emissions factors were obtained from ICLEI calculations (ICLEI-LGOP, 2008) and jet fuel emission factors were obtained from the Energy Information Administration. The following emissions factors were used to calculate total transportation emissions: 9.1 kg-CO_2/gallon for gasoline fuel, 10.2 kg-CO_2/gallon for diesel fuel, 9.7 kg-CO_2/gallon for jet fuel (Jet A) and 8.3 kg-CO_2/gallon for AvGas (California Air Resources Board, California Climate Action Registry, ICLEI - Local Governments for Sustainability, The Climate Registry, 2008). The emissions factors for transportation fuels were multiplied by the total demand for transport to compute the total transport sector tailpipe emission in *Table 2-4 shows the consumption or material flow of gasoline, diesel, and jet fuels, emission factors associated with each fuel type, and GHG emissions associated with transportation. In 2007 Lakewood emitted 755 thousand mt-CO_2e from transportation. Details are provided in* Table 2-4.

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7 Fuel economy data from ICLEI-CACP.

Table 2-3 Consumption and emission factors for gasoline, diesel, and jet fuels

Sector/ Use	Community-wide annual urban material/energy flows, MFA		GHG emission factor (EF)		Total GHG emitted = MFA x EF	
Surface Vehicle Miles Traveled, VMT	1,210	Million VMT		PTW kg-CO2e/gal	619	thousand mt-CO_2e
	20.1	Avg. Gasoline fuel economy (mpg)	9.1			
	6.3	Avg. Diesel fuel economy (mpg)	10.2			
Airline Travel PTW	13,731	Jet Fuel (thousand gallons)	9.9	PTW kg-CO2e/gal	136	thousand mt-CO2e
Total					**755**	**thousand mt-CO2e**

2.2.3 Materials and Waste Sector

The Materials and Waste Sector accounts for 28% of GHG emissions in Lakewood

The materials sector comprises several sources of GHG emissions including cement, water and wastewater fugitive emissions, fuel production, food production, and municipal solid waste (MSW).

Sources for Annual Consumption of Key Materials

The consumption of food was tracked in terms of money spent on food expenditures as reported in the Consumer Expenditure Survey for residents ($2,930 per home) (Consumer Expediture Survey, 2003-2004). Cement use per person was obtained using the Colorado Economic Census data. Water flow data were obtained from the Denver Water with 8.6 billion gallons of water. The curbside trash pickup to is offered within the city. Municipal solid waste volumes were estimated from the State data. Recycling drop-off centers are offered, however accurate quantities of recycling that can be attributed to Lakewood were not readily available.

Emission Factors for Well-to-Pump

This inventory also included emissions from producing the fuel, which includes the energy for production and the energy in transporting the fuels to the pump. The GHG

emissions factors for producing transport fuels were obtained from the GREET[8] model, well-to-pump (W2P) analysis as 2.3 kg-CO_2e/gallon for gasoline, diesel, and jet fuels. Lakewood emitted 131.6 thousand mt-CO_2e from gasoline fuel production, 22.1 thousand mt-CO_2e from diesel fuel production and 31.5 thousand mt-CO_2e from jet fuel production.

Water and Wastewater Emissions

Lakewood's portion of emissions from treating water at Denver Water's water treatment plants have were broken out and attributed to the materials sector. Data for Wastewater Treatment was not readily available for this analysis.

Most of Lakewood's total emissions associated with wastewater and water treatment, 0.84 thousand mt-CO_2e, in 2007 were attributed to electricity and natural gas use of treating the water. Fugitive emissions include stationary and process emissions (methane and nitrous oxide) associated with municipal wastewater treatment plants.

Cement in Urban Concrete

Cement is included in GHG inventories because in order for a city to function, it imports large amounts of cement and emits about 1-mt-CO_2e for every 1 mt-cement. When cement is made, the reaction with the limestone produces carbon dioxide, which can comprise about 3% of a city's total GHG emissions. The flow of cement was determined based upon consumption data collected from the 2007 Colorado Economic. The per capita cement consumption for Lakewood was determined by multiplying the total expenditure of cement products in Colorado by the cost of cement per kilogram ($/2.32kg). The kilograms of cement attributed to the Lakewood population were calculated by taking the proportion of the total Colorado population. The emissions factor for cement is about 1 mt-CO_2e/mt-cement from the National Renewable Energy Laboratory's (NREL) Life Cycle Inventory Database (LCI) (NREL, 2001)[9]. In 2007, Lakewood emitted 82 thousand mt-CO_2e from cement.

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8 GREET refers to Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model developed by the U.S. Department of Energy's Transportation Technology R&D Center, Argonne National Laboratory.

9 The U.S. Life-Cycle Inventory (LCI) database contains data modules that quantify the material and energy flows into and out of the environment for common unit.

Food Consumption

Food is another product that is usually not produced within city limits and is brought in from thousands of miles away. The embodied energy from food and food packaging was determined from "food consumed at home" for the Lakewood area. Food expenditures were determined on a per-household from the Consumer Expenditure Survey (U.S. Census Bureau, 2005). Total citywide expenditure is determined using a bottom-up method for the households in Lakewood. The average Lakewood food expenditures are $2,930 per household per year, and the total estimate for Lakewood is $22 million (all figures are in 1997 dollars). Using an emission factor for food of 2 kg-CO_2e/$1, the total GHG emissions from food production in Lakewood in 2007 were 241.5 thousand mt-CO_2e (Carnegie Mellon University Green Design Institute, 2008)[10].

Municipal Waste and Recycling

Lakewood's waste generation was calculated based on the State data. In 2007 Lakewood generated an estimated 234,680 short tons of waste, averaging to approximately 6.59 lb of waste per person per day, resulting in 269.9 thousand mt-CO2e. Refer to the Technical Appendix of this report for further detail.

Total Urban Materials Emissions

Total emissions from fuel production, water, wastewater, cement, food production, and municipal solid waste and recycling are shown in Table 2-5.

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10 Emission factor derived from: Economic Input-Output Life Cycle Assessment (EIO-LCA) tool which estimates the materials and energy resources required for, and the environmental emissions resulting from, activities in the U.S. economy.

Table 2-1 GHG Emissions from manufacture of key urban materials consumed in Lakewood

Material	2007	
	Annual Material Flow	GHG Emissions (thousand mt-CO2e)
Fuel Production (WTP for all fuels)	80.54	185.24
Gasoline (million gallons)	57.20	131.57
Diesel (million gallons)	9.61	22.09
Jet fuel (million gallons)	13.73	31.58
Water (million gallons - energy use)	8,623.43	0.84
Wastewater (million gallons)	N/A	2.92
Cement in Urban Concrete (thousand mt)	82.08	82.08
Food & Packaging ($ million)	160.97	241.45
Municipal Solid Waste (thousand mt/year)	234.68	269.88
Recycling per person-day (lb/person/day	N/A	N/A
Total GHG Emissions for Producing Key Urban Materials		**782.41**

2.2.4 Community-Wide and Per Capita GHG Emissions Footprint

Table 2-6 presents a comprehensive tally of GHG emissions from the buildings, transportation, and material sectors. The table includes materials flows, tracking metrics (in parenthesis after each consumption figure), and emissions factors as well as the total GHG emissions. The total community-wide emissions for the City of Lakewood in 2007 were 2,750 thousand mt-CO_2e. The per-capita emissions (population of 143,109) were 19.2 mt-CO_2e/person.

Table 2-6 Comprehensive Scope 1-2-3 GHG Emissions for Lakewood, 2007[11]

	Sector/Use	Community-wide annual urban material/energy flows, MFA		GHG emission factor (EF)		Total GHG emitted = MFA x EF	
Scopes 1 + 2 + Waste	Buildings Electricity Use	1,110	GWh	0.79	kg CO_2e/kWh	875	thousand mt-CO_2e
	Buildings Natural Gas	63	Million therms	5.4	kg-CO_2e/therm	338	thousand mt-CO_2e
	Surface Vehicle Miles Traveled, VMT	1,210	Million VMT		PTW kg-CO2e/gal	618.52	thousand mt-CO_2e
		20.1	Avg. Gasoline fuel economy (mpg)	9.1			
		6.3	Avg. Diesel fuel economy (mpg)	10.2			
	Water	8,623.4	Million gallons (energy use)	Varies		1	thousand mt-CO_2e
	Wastewater	N/A	Million gallons	Varies		2.92	thousand mt-CO_2e
	Municipal Solid Waste	234,676	short tons/year	1.15	mt-CO2e/mt-waste	270	thousand mt-CO_2e
Scope 3	Airline Travel PTW	13,731	Jet Fuel (thousand gallons)	9.9	PTW kg-CO2e/gal	135.9	thousand mt-CO2e
	Fuel Production (WTP)	14	Jet Fuel (million gallons)	2.3	Gasoline WTP (kg CO_2e/gal)	185	thousand mt-CO2e
		9.6	Diesel fuel (million gallons)	2.3	Jet fuel WTP (kg-CO_2e/gal)		
		57.2	Gasoline fuel (million gallons)	2.3	Diesel fuel WTP (kg-CO2e/gal)		
	Cement Use	82,083	Mt-cement	1.0	mt-CO_2e per mt cement	82.08	thousand mt-CO2e
	Food Purchases	$ 160,966	(million 1997 $)	1.5	kg-CO_2e/$ (1997 $)	241	thousand mt-CO2e
Total Community Wide Emissions:					**2,750**		**thousand mt-CO_2e**
Community wide per capita emissions					**19.2**		**mt-CO_2e per capita**

11 Table is adapted from Ramaswami et al, ES&T, 2008.

SECTION 3: SUSTAINABILITY ACTION RECOMMENDATIONS

3.1 Business as usual 2020 Projection

From 2007 to 2020, the Lakewood has a projected average annual growth rate of 0.5%. With this population growth rate, by 2020 the population will increase by 9,586 for a total population of 152,695.

Using the assumption that per capita emissions stay constant, Lakewood community-wide emissions are expected to increase to nearly 2,934 thousand mt-CO_2e in 2020.

The suggested strategies for reduction of greenhouse gas emissions are based on voluntary and mandated compliance that encourage investment in renewable energy and energy conservation.

3.1.1 Demand-Side Management Program (Electricity)

Demand Side Management (DSM), is an energy conservation effort put forth by utility companies that targets the reduction of peak demand by incentivizing conservation and efficiency. A utility uses a DSM program to circumvent having to build additionally power plants or use expensive fuel sources such as natural gas to supply electricity during peak periods. DSM programs can be designed for either commercial or residential customers and employ various strategies that either 1) shift peak demand; or 2) reduce total energy load demand. The result of a successful DSM is a win-win situation, the customer is rewarded either

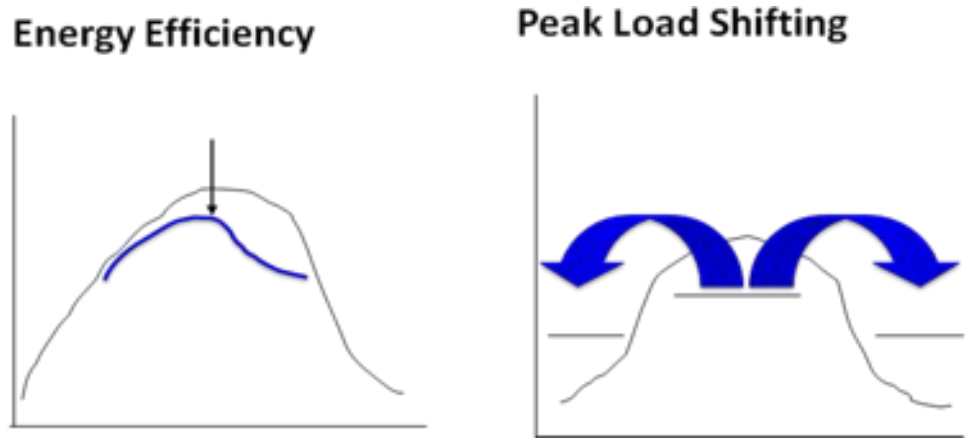
through an energy efficiency rebate or a reduction from their bill and the utility avoids utilizing a more expensive power source to meet peak demand which may occur seasonally or daily.

Xcel's Saver's Switch program is a peak load shifting mechanism that uses smart grid technology to power down a participant-customer's air conditioner for brief periods (typically between the hours of 2 PM to 7 PM on weekdays) on hot summer days when the utility's grid approaches a critical level (Xcel Energy, 2009). The program deploys switches with varying load control strategies. For example, a switch may be cycled 15 minutes out of every 30 minutes (a 50% cycling strategy) during the control period - a relatively minor inconvenience to the customer and none at all if the household is empty during week-day business hours. Residential participants receive a $40 annual reduction on their October bills for participating in the Saver's Switch program. The graph on the right in Figure 5-1 illustrates the impact of peak load shifting.

In addition to the Saver's Switch program, Xcel Energy's residential DSM programs include a portfolio of prescriptive residential programs including energy efficiency rebates for: energy efficient shower heads, evaporate cooling, home lighting, refrigerator recycling, insulation, and hot water heaters. The goal of these initiatives is to reduce Xcel's overall energy demand load through energy efficiency, illustrated by the graph on the left in Figure 5-1.

In order to comply with State of Colorado Renewable Portfolio Standards (RPS) Xcel has invested tremendously in DSM initiatives. Planned achievements of 120 GWh (gigawatt hours) and 335,290 Dth (dekatherms) over the two-year period account for 31% of the Company's total electric energy savings goal and 47% of the total natural gas goal (Xcel Energy, 2009). Xcel Energy provides 94% of energy in Thornton. If every Xcel customer participated in an Xcel DSM program, Thornton's total emissions could be reduced by 2,890 mt-CO_2e. Thornton could provide information and education about DSM in order to encourage resident participation.

Figure 5-1 Examples of load reduction strategies made possible by DSM



•Unit Savings: 80 kWh/Household; 1 therm/Household[12] (Summary Profile Report: Xcel Energy Custom Efficiency (DSM))

•Participation Rates: 100% of Xcel Customers

•Expected Community Wide GHG Savings: 89,278 mt-CO_2e

3.1.2 Residential WindSource

Energy produced from renewable energy such as wind, solar, or hydro does not generate air or water emissions and does not produce hazardous waste. Additionally, renewable energy does not deplete natural resources such as coal or petroleum.

WindSource Blocks is a voluntary renewable energy program offered by Xcel Energy. WindSource Blocks customers have the option of purchasing 100-kilowatt-hour (kWh) blocks for $1.00 per block.

Xcel provides Lakewood customers with electricity and therefore many residents could conceivably participate. In 2007, residential green power accounted for 1.8% of total energy purchased in Lakewood. Educational campaigns and incentive programs aimed at increasing the green purchase power four fold to 10% of total energy used in the area by 2020 could result in saving of 33,930 mt-CO_2e.

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12 Reduction was calculated based upon Thornton's portion of Xcel Energy's total residential DSM goal.

Lakewood can facilitate an education campaign on the benefits of renewable energy to encourage more purchases. Without any additionally incentives the City of Denver realized a 60% increase in Windsource® kWh blocks, a similar program to GreenPower, purchased from 2005 – 2007 due to education alone (Mayor's Greenprint Denver Advisory Council, October 2007).

3.1.3 Audit and Install with Attic Insulation

The GEO partners with local Colorado organizations to offer rebates directly to qualifying homeowners for the installation of insulation and air sealing measures through the Insulate Colorado program. The program provides a rebate to homeowners that insulate and air-seal their attics and exterior walls to the recommended R-Values presented in the 2006 International Energy Conservation Code (Insulate Colorado).

Homeowners can qualify for incentives and insulations after an authorized technician has completed a proper audit. The auditor evaluates the quality of the building structure and appliances used on a daily basis, and provides information regarding the upgrade costs and how much the owner should expect to save with the new technology in place.

The precedent cases have shown that an average home can save as much as 5.4% of an average home's electricity and 13.6% of natural gas consumption for an audit and install program (Energy $avings Partners). If 3% of Lakewood households participate in this program, community-wide GHG emissions would be reduced by approximately 0.02% or approximately 601.7 mt-CO_2e.

3.1.4 Advanced Home Upgrade

Advanced home upgrade is a voluntary action by homeowners who wish to raise their home's energy performance to higher standards. Reaching these standards, however, can be a higher cost as well, up to $10,000 per home. Few cities have their own funding for rebates and subsidies, and typically coordinate with State-level funds and, more recently, the federal block grants. Participation rates for voluntary adoption of incentives for higher cost whole home upgrades, such as energy efficient windows, solar panels, solar water heaters etc., are often very low. Denver, CO, case studies have

presented evidence that the participation rates for this type of voluntary action are in the 0.1% level.

Depending on the upgrades, advanced home upgrades can reduce greenhouse gas emissions by 1.7 mt-CO_2e per home. If 0.1% of Lakewood homes participated in this energy efficiency program, it could result in 0.004% of total GHG emissions reduction or approximately 108.9 mt-CO_2e.

3.1.5 Date Certain Energy Efficiency Upgrades: Commercial and Residential

"Date Certain" action for mitigating GHG emissions would a strategy employed by the city officials. This strategy would focus on developing building codes aimed at higher energy efficiency for the exiting residential and commercial building stock. The owner of the building would have to comply with the established rules and regulations and demonstrate the increase in building's efficiency. The demonstration of efficiency can be evaluated by a third-party certified inspection services.

"Date certain" mandate has a potential to create 5.4% electricity savings and 13.6% natural gas savings (Blasnik, 2006). Mandated participation rates are expected to be 100% of homes and 5% businesses sold if there is no square footage threshold.

Based on an anticipated energy savings of 5.4% of total household electric consumption and a 13.6% natural gas savings, and an expected mandated participation rate of 100%, 1.09% or 29,999.0 mt-CO_2e would be prevented with residential and commercial upgrades.

3.1.6 Energy Display Meter Distribution

The "Meter", is an easy-to-use plug-in device that allows for real time tracking/viewing of energy use based on kWh and/or on cost to the house. This $100 device accurately measures energy consumption of home and office electronics and appliances instantaneously and over time.

The U.S. Department of Energy reports that 20% of our electric bills come from items that are left plugged in when they are not in use, or items that are in standby mode. When an item is plugged into the Meter, the efficiency of that item (kilowatt per hour of energy) is displayed. The Meter can help households determine which items are costing the most to run and promote a user to use less energy by replacing energy inefficient items or reducing use and being more aware of consumption. Pilot studies have found that the Meter can help consumers reduce their energy consumption by up to 20% (Wood & Newborough, 2003).

The method of GHG reduction would be based on voluntary participation. If 3% of residents participated in this program, 0.03% or 1,003 mt-CO_2e would be saved.

3.1.7 LEED Silver for New Construction (New Building Codes)

To earn the LEED Silver rating, a home or a commercial entity must meet guidelines for energy efficiency set by the Leadership in Energy and Environmental Design (LEED), making them 20-30% more efficient than standard homes and commercial buildings. LEED Silver certification for New Construction requires attaining between 50 and 59 points from the seven topics bellow:

- Sustainable Sites (SS)

- Water Efficiency (WE)

- Energy and Atmosphere (EA)

- Materials and Resources (MR)

- Indoor Environmental Quality (IEQ)

- Innovation in Design (ID)

- Regional Priority (RP)

LEED[13] certification guidelines are simple to follow and easy to implement, making them an attractive alternative for communities that want to implement a green

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[13] *LEED (Leadership in Energy and Environmental Design) is a standard for green building design established by the USGBS U.S. Green Building Council. (2010). LEED for New Construction. From U.S. Green Building Council: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220.*

building code.

If the LEED Silver level is mandated for all new construction in the Lakewood, it could significantly decrease the levels of energy use and therefore the levels of GHGs emitted. A 76% participation of all new commercial construction and 76% of all new residential construction, Lakewood could realize 0.17% and 0.22% reduction of the total GHG emissions respectively. The total potential savings from LEED Silver for new construction could reach approximately 11,246 mt-CO_2e.

3.1.8 Individualized Travel Marketing Program

Individualized Travel Marketing Program is a method used to increase awareness of transportation modes alternative to car travel. This method is based on targeted, personalized, and customized marketing approach that empowers people to change their traveling behavior. It is assumed that this method will be developed and utilized as a one-time program in 2012. If the current trends continue, Lakewood could see an increase in total Vehicle Miles Traveled (VMT) by 5%. An Individualized Travel Marketing Program has a potential to affect 10% of the total VMT and result in a 7% decrease in the affected VMT (which is about 10% of total VMT). Success of this program could result in savings of 3,735.8 mt-CO_2e or 0.13% of the total 2020 business as usual scenario.

3.1.9 Pay-as-you-throw

Lakewood has an opportunity to promote a pay-as-you-throw trash services to its residents. The program charges users of the service directly on the basis of the amount of trash they throw away. Therefore, the program has a potential to encourage the users to recycle more and reduce waste. EPA estimates 15-28% reduction in the total municipal waste generation from this program and its implementation in Lakewood could result in 61,910.4 mt-CO_2e or 2.1% savings of the total 2020 business as usual scenario.

3.1.10 Waste Prevention, re-use, recycling

A voluntary program aimed at waste prevention, re-use and recycling could result in 7%

reduction in waste generation by 2020 and consequently prevent 20,157 mt-CO_{2e} or 0.69% from being emitted in the business as usual scenario.

3.1.11 High Performance Green Concrete

The production of cement used for concrete contributes to GHG emissions; green concrete uses a percentage of fly ash, a byproduct from power plants. Using this recycled material also has proven to be more durable and higher strength than traditional materials and is also less expensive.

If Lakewood used green concrete with 25% of fly ash included in the mix instead of traditional concrete for its flatwork and paving by 2020, this would reduce emissions from cement by 25%, or 21,895 mt-CO_2e, 0.75% of total GHG emissions.

3.1.12 Waste-to-Energy

Waste-to-energy is a process of incinerating waste in order to create energy to produce electricity. Current incinerators have the ability to reduce the amount of waste by 95%. By 2020 Lakewood will produce an estimated 17,490 short tons of waste per year. With 33% conversion efficiency, a waste-to-energy incinerator could produce 266,318,550 kWh a year; therefore, avoiding approximately 6.15% of total GHG emissions or 180,557 mt-CO_2e.

3.1.13 Local Food (Voluntary)

Local food reduces costs and GHG emissions through reductions in transportation; local meals have been shown to reduce emissions by 33% per plate. Local food has the added benefit that it supports the local economy.

For this action, we assumed that a goal for 2020 could be to increase local food by 25%. This would result in GHG emissions reductions of 21,254 mt-CO_2e, or 0.72% of total GHG emissions when only looking at the avoided miles of transportation. There needs to be additional analysis on local food and how the growing practices are different in one location

versus a local location.

3.1.14 Transit Oriented Development- 50% of new development

If 50% of new development between 2007 and 2020 were to be transit oriented development would lead to a reduction in total VMT. This reduction in VMT would result in GHG emissions reductions of 10,351 mt-CO_2e, or 0.35% of total GHG emissions.

3.1.15 CFL Giveaway

Free CFL programs giving away 2 CFLs per household reduce electricity consumption by up to 1% per home. Given a 50% participation rate in this free program, there would result GHG emissions reductions of 1,598 mt-CO_2e, or 0.05% of total GHG emissions.

3.1.16 Employer Based Programs

Employer based programs have the potential to reduce GHG emissions by 0.5 mt-CO_2e per employee per year. With an estimated 90,635 employees in Lakewood in 2020 there is a total potential savings in GHG emissions reductions of 45,317 mt-CO_2e, or 1.54% of total GHG emissions.

3.1.17 Telepresence

With an estimated 33% of travel being for business, Telepresence has the potential to offset 10% of business travel, thereby reducing jet fuel usage attributed to Lakewood. This would result in GHG emissions reductions of 4,486 mt-CO_2e, or 0.15% of total GHG emissions.

Alternate Strategies for Future Consideration

There are several other high-impact feasible actions that would increase sustainable energy and emissions reductions. The actions in this analysis are by no means exhaustive, however they are meant to help Lakewood add to their portfolio of current actions and also to prioritize what areas to target in the near term.

Alternative potential future actions:

Buildings:

- *Energy efficiency financing/mortgages (market-based)*
- *Carbon tax (policy)*
- *Tiered rate on electricity (policy)*
- *Business recognition program (voluntary)*

Transportation:

- *Travel offsets (voluntary)*
- *Pay-as-you-drive auto insurance (market-based; according to SWEEP can decrease VMT by 10%)*
- *Gas tax (policy)*
- *Parking fees (policy)*
- *Casual carpooling (voluntary)*
- *Bus retrofits (voluntary)*

Materials and Waste:

- *E-waste collection (voluntary)*

There are other factors to take into consideration when creating policies, such as political and economic feasibility.

CONCLUSION

Lakewood GHG inventory establishes 2007 as the baseline from which future emission reduction goals can be set to reduce Lakewood's carbon emissions footprint.

This GHG inventory revealed that the buildings sector contributed to 44% of total emissions in Lakewood, the largest source of emissions. Fifty-one percent of buildings sector emissions were attributed to commercial energy use while fourty-seven percent of emissions were attributed to residential energy use and two percent were attributed to industrial energy use. Of the three sectors: buildings, transportation, and materials, energy consumption attributed to the buildings sector is often the most accessible for local governments to impact since transportation and materials cross jurisdictional boundaries.

Sustainability is often defined as a balance of the environment, the economy, and social equity. This report suggested pathways to sustainability and provided a matrix of suggested actions to serve as a guide to Lakewood as the city embarks on sustainability planning. The matrix proposes practical actions to mitigate GHG emissions. Strategies in the matrix promote energy efficiency and energy conservation to Lakewood residents and businesses. Additionally, many of these strategies can provide economic opportunities for the businesses in the area. For example, Lakewood can partner with local retailers that sell ENERGY STAR appliances, Energy Meters and LEDs to promote energy efficiency and conservation.

Other cities both nationally and internationally have demonstrated that GHG emissions at the local scale can be reduced through a combination of incentives, mandates, and voluntary outreach. As Lakewood continues to grow, absolute emissions in the city will continue to rise along with the mounting risks of climate change. However, the opportunities to reduce emissions are abundant. Through innovation, leadership and public involvement, the community can benefit significantly both now and in the future from climate protection actions. This endeavor will require a staunch commitment and participation by all community sectors and forward-thinking leadership by the government. It is important for Lakewood to take action now to

ensure that the city can continue to meet the needs of today's citizens without diminishing the opportunity for future generations to be afforded the same high standard of living.

	CITY OF LAKEWOOD SUSTAINABILITY ACTIONS MATRIX						
	Item Description	**Cost per home**	**Annual Energy Savings/HH**	**Participation Rate**	**Community-wide GHG Savings (CO_2e)**	**Total Cost to the County**	**Engagement Vehicle**
EDUCATION CAMPAIGNS	**WindSource Residential** **WindSource Commercial**	$1 premium-100 kWh block	100% GHG emission savings (0kg CO_2e/kWh)	Increase Residential Purchases from 1.81% to 10% Increase commercial purchase from 0.23% to 5%)	33,930 mt-CO_2e 22,319 mt-CO_2e	Program administrative costs only	Xcel Program
	Xcel Demand Side Management	Varies $0.047/kWh	24 kWh/HH/mo	100% Xcel customers	11,013 mt-CO_2e	Program admin costs only $0.047/kWh	Xcel Program
	Audit and Install with Attic Insulation	Up to $2,800	5.4% of Electricity Use per home 13.6% of Natural gas use per home	3% of current stock	602 mt CO_2e	Program admin costs only	State Program
	Advanced Home Upgrade	$10,000 or more	1.7 mt CO_2e/hh	0.1% of current stock	109 mt CO_2e	Program costs for providing loans only	Coordinated program b/w State, County and NGO

	Item Description	Cost per home	Annual Energy Savings/HH	Participation Rate	Community-wide GHG Savings (CO_2e)	Total Cost to City	Engagement Vehicle
MANDATES	**Date Certain Residential** **Date Certain Commercial**	Varies	5.4% of Electricity Use per home 13.6% of Natural gas use per home	100% of new buildings (commercial and residential)	29,999 mt-CO_2e	Program admin costs only	Mandate
MANDATES	**LEED Silver Certified New construction residential** **LEED Silver Certified New construction commercial**	$13 - $245 per square foot	30% of energy saved / HH 30% of energy saved	76%	4,857 mt-CO_2e 6,390 mt- CO_2e	TBD	Mandate
MANDATES	**Energy Display Meters**	$100/unit	10% per meter	3% HH	1,003 mt- CO_2e	Program admin costs only	Voluntary
BEHAVIOR CHANGE	**Individualized Travel Marketing Program (one year implementation)**	TBD	7% VMT decrease from participating VMT	10% of 2012 VMT	3,736 mt- CO_2e	$24,000 for 2012 IMT Program	City Program

	Item Description	Cost per home	Annual Energy Savings/HH	Participation Rate	Community-wide GHG Savings (CO_2e)	Total Cost to City	Engagement Vehicle
	Pay-as-You-Throw	Varies	-	100%	61,910 mt-CO_2e	Program admin costs only	Marketing
	Waste Prevention, re-use, recycling	Varies	-	100%	20,157 mt- CO_2e	TBD	City Program
	Green Concrete	Save 1$ per ton purchased	-	25% of fly ash/ton cement	21,895 mt- CO_2e	TBD	Marketing
	Local Food	No Data	10% of energy used in food production	25% increase in local food consumption	21,254 mt- CO_2e	TBD	City Program
	Waste-to-Energy	No Data	-	100%	180,557 mt- CO_2e	TBD	City Program

TECHNICAL APPENDIX

Emissions from Water and Wastewater Treatment

In addition to methane, wastewater treatment plants release a small amount of nitrous oxide, the third greenhouse gas measured in this report. Approximately 7 grams of N_2O is released per person per year. Using the global warming potential of 298 mt-CO_2e for nitrous oxide and a population of 143,109 people, 2,622 mt-CO_2e associated with N_2O released during wastewater treatment was emitted in 2007.

It can be assumed that a percent of the GHGs produced by a wastewater treatment plant's anaerobic digester process escapes from incomplete combustion. Using LGOP's default-value of one cubic foot of digester gas per person/per year and the equation below, Lakewood's portion of emissions associated with incomplete combustion during anaerobic digestion at MWRD annually is 159 mt-CO_2e. Fugitive methane emissions are calculated using the following formula: Annual Methane Emissions = P x Digester Gas x F CH_4 x $\rho(CH_4)$ x (1 - DE) x 0.0283 x 365.25 x 10-6 (see Table A-1 for full equation description) (U.S. EPA, 2008).

Table A-1 Annual Methane Emissions from Wastewater Treatment Plant

Variable	Description	Value
P	Population served by the WWTP with anaerobic digesters user input	143,109
Digester Gas	Cubic feet of digester gas produced per person per day [ft^3/person/day]	1.0
F CH4	Fraction of CH_4 in biogas	0.65
ρ(CH4)	density of methane [g/m^3]	662
DE	CH_4 Destruction Efficiency	.99
0.0283	conversion from ft^3 to m^3 [m^3/ft^3]	0.0283
365.25	conversion factor [day/year] 365.25	365.25
10^{-6}	conversion from g to metric ton [metric ton/g]	10^{-6}
25	Global Warming Potential	**159.13 mt-CO_2e**

Source: (U.S. EPA, 2008)

Emissions from Municipal Solid Waste

The EPA has developed a Waste Reduction Model (WARM) to aid municipalities in calculating the emissions associated with solid waste and recycling (U.S. EPA, 2009). The emissions from solid waste are a result of the anaerobic breakdown of biodegradable material such as food waste, grass clippings, and paper. When such items are disposed of in landfills, methane emissions are produced. Based on the EPA's WARM Model, 258,686 short tons of solid waste disposed of in a landfill that manages the methane through flaring and diverts single-stream recyclables produces 269.9 mt-CO2e per short ton landfilled.

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