CITY OF LAKEWOOD'S 2018 GREENHOUSE GAS EMISSIONS INVENTORY SUMMARY REPORT

Report completed August 7, 2019 by
City of Lakewood Sustainability Division
using inventory results conducted by
Lotus Engineering and Sustainability

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Why a Greenhouse Gas Emission Inventory Matters

Greenhouse gas (GHG) emissions inventories provide Lakewood leaders, community members, and city staff with information necessary to understand the existing state of carbon emissions and inform decisions on where to focus climate mitigation efforts.

Naturally occurring gases dispersed in the atmosphere determine the Earth's climate by trapping solar radiation. This phenomenon is known as the greenhouse effect. Overwhelming scientific evidence clearly shows that human activities are increasing the concentration of GHGs and changing the global climate. The most significant contributions to climate change are the burning of fossil fuels for transportation and energy and the breakdown of waste, which introduce large amounts of carbon dioxide (CO_2), methane (CH_4), and other GHGs[1] into the atmosphere. Collectively, these gases intensify the natural greenhouse effect, causing global average surface and lower atmospheric temperatures to rise.

While Colorado is already experiencing some changes due to climate change, various studies[2] released in the last few years detail potentially severe impacts of climate change in Colorado. Common themes include:

- Average temperatures are expected to increase by 1.5 degrees Fahrenheit to 4.5 degrees Fahrenheit.
- Seasonal shifts in precipitation.
- Reductions in available water.
- Increase in the number of days that exceed 90 degrees and 100 degrees.
- More severe storms and flooding and more extreme wildfires.
- Increase in heat related illnesses and poor air quality.
- Increase in pine beetle and related tree-killing outbreaks.

Colorado's ecosystems, public health and safety, and economic viability (particularly tourism and agriculture industries) are at risk, and Colorado residents, businesses, and municipal operations will be impacted. A GHG inventory assesses a community's contribution to global climate change and informs community policies and programs that will reduce GHG emissions.

[1] The six GHGs include: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

[2] http://www.coclimatenetwork.org/images/ColoLocalResilienceProjectRpt-lowres.pdf.

What We Can Learn from a GHG Inventory

The United Nations estimates that cities produce 60% to 80% of all GHG emissions, making cities a critical participant and partner in the sustainability movement[3]. Lakewood's GHG inventory provides a picture of GHG emissions created by the activities of Lakewood residents, businesses, institutions, and industries. By comparing inventories over time, Lakewood can track the success of existing and future climate change related policies and programs. Progress towards Lakewood's sustainability goals and GHG emission reduction targets are provided annually to City Council and the community through the Sustainability Plan Annual Reports.

Lakewood also demonstrates accountability to the global community by annually reporting its GHG inventory results to CDP, a global platform used by cities and companies to disclose environmental data. This report also fulfills the reporting requirements of Lakewood's commitment to the Global Covenant of Mayors for Climate & Energy, a worldwide effort to highlight the leadership of cities in addressing climate change and demonstrate the collective impact of city efforts.

Inventory Methodology

The 2018 Lakewood GHG inventory uses the approach and methods provided by *Global Protocol for Community-Scale GHG Emissions* (GPC), which defines what categories of emissions must be reported and how, providing a consistent structure to enable better comparisons among different cities[4]. There are two reporting levels for the community framework:

- **BASIC**: The BASIC methodology covers stationary energy, in-boundary transportation, and community-generated waste.
- **BASIC+:** The BASIC+ level includes BASIC emission sources, as well as trans-boundary transportation; energy transmission and distribution losses; industrial processes and product use; and agriculture, forestry and other land uses.

Based on available data, Lakewood has chosen the BASIC reporting level, which is consistent with many other cities to date. To ensure consistency with previous inventories, the 2018 inventory includes additional BASIC+ sources. While the GPC protocol excludes avoided emissions from renewable energy credits and renewable energy, these avoided emissions were calculated as information-only items.

[3] http://www.unep.org/SBCI/pdfs/Cities_and_Buildings-UNEP_DTIE_Initiatives_and_projects_hd.pdf
[4] http://www.ghgprotocol.org/city-accounting.

The GPC defines emission scopes by whether emissions occur within the city boundary or outside the city boundary, whereas BASIC emission scopes are defined as follows:

- **Scope 1:** GHG emissions from sources located within the city boundary, including:
  - Energy and transportation fuel combustion.
  - Fugitive emissions.
  - Solid waste treated within the city.
  - Wastewater treated within the city.
- **Scope 2:** GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
- **Scope 3**: GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary, including:
  - Solid waste treated outside the city.
  - Wastewater treated outside the city.
- **Non-GPC Scope 3 (Consumption-Based)**: All GHG emissions that are not required to be reported per GPC protocol but may help cities better understand GHG emissions that result from consumption-based activities. For Lakewood, consumption-based emissions were originally calculated in the 2007 inventory and were calculated again for the 2015 inventory to support comparisons. These sources include:
  - Treating drinking water.
  - Well-to-pump fuel production.
  - Cement use.
  - Food purchases.

It should be noted that trans-boundary aviation, airline travel from Denver International Airport (DIA) attributed to Lakewood, was recorded as a BASIC+ Scope 3 emission source.

With the exception of electricity and natural gas emission factors, the GPC protocol uses the most up-to-date emission factors based on ICLEI's *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version* 1.0, July 2013. Electricity and natural gas emission factors are sourced from Xcel Energy's Annual Community Report[5].

[5] https://www.xcelenergy.com/working_with_us/municipalities/community_energy_reports

Emissions Analysis

Key Findings from 2018 Inventory

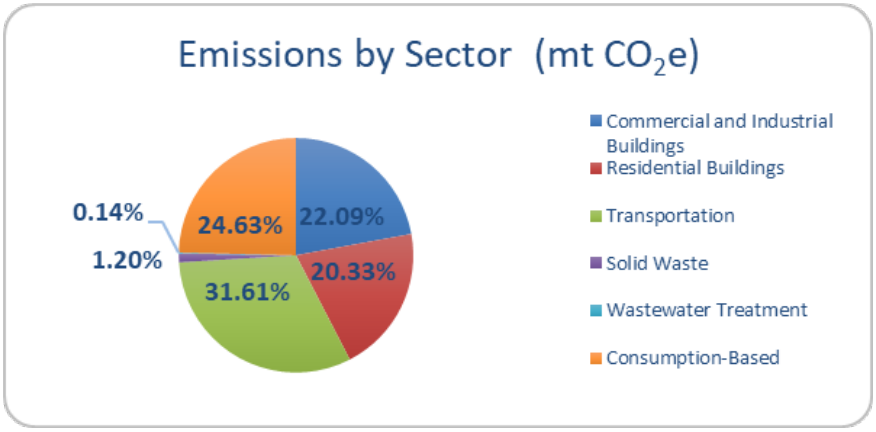
The 2018 Lakewood GHG inventory calculated a total emission value of 2,286,787 $mtCO_2e$ and a total BASIC emission value of 1,480,119 $mtCO_2e$.

FIGURE 1. TOTAL EMISSIONS AND BASIC EMISSIONS

Sector		Scope 1	Scope 2	Scope 3 (BASIC)	Scope 3 (BASIC+)	Consumption-based	BASIC Emissions	Total Emissions
Stationary Energy	Energy use	333,458	625,719				959,177	959,177
	Fugitive Emissions	10,859					10,859	10,859
	Refrigerants						0	0
Transportation	All emissions	476,676	2,808		243,452		479,484	722,936
Waste	Treated in the city						0	0
	Treated outside the city			30,599			30,599	30,599
Consumption-Based	Food					381,984	0	381,984
	Cement					176,879	0	176,879
	Water Delivery					4,353	0	4,353
Total		**820,994**	**628,527**	**30,599**	**243,452**	**563,216**	**1,480,119**	**2,286,787**

Transportation (which includes gasoline and diesel-powered vehicles, public transit, and air travel) was the largest contributor to Lakewood's emissions in 2018, contributing 32% of overall emissions. Energy use in commercial and industrial buildings were the next largest contributors at 22% of overall emissions, respectively. Emissions for all sectors are shown in Figure 2.

FIGURE 2. TOTAL EMISSIONS BY SECTOR



Comparison between Inventories

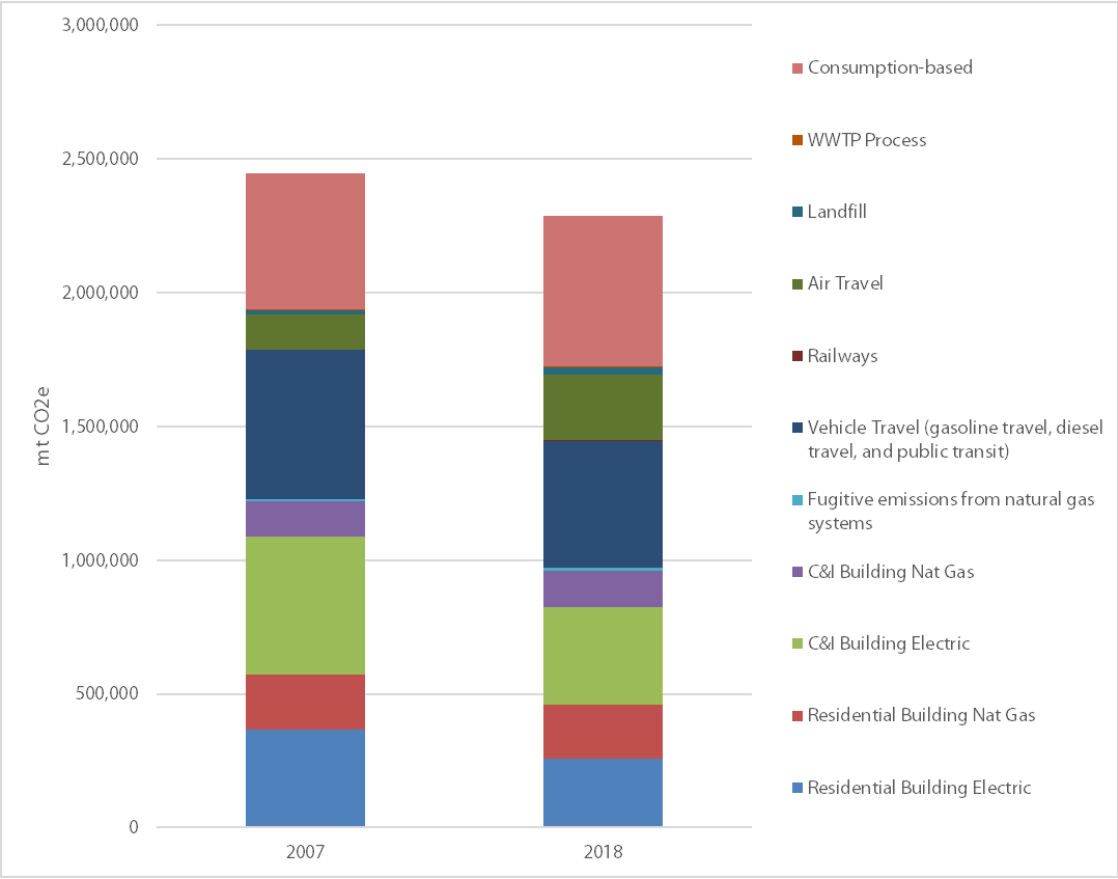
Between 2007 and 2018, overall GHG emissions in Lakewood reduced by 6.6%. Excluding consumption-based GHG emissions (i.e. a BASIC emission total), Lakewood's emissions decreased by 18.1% between 2007 and 2018. See Figure 3 for more information.

FIGURE 3. COMPARISON BETWEEN 2007 AND 2018 GHG INVENTORIES

EMISSIONS	Units	2007	2018	% Change 2007-2018
Total Buildings	*MTCO 2e*	*1,228,916*	*970,036*	**-21.1%**
Total Transportation	*MTCO 2e*	*688,082*	*722,936*	**5.1%**
Total Waste	*MTCO 2e*	*21,096*	*30,599*	**45.0%**
Total Consumption-based	*MTCO 2e*	*509,652*	*563,216*	10.5%
Total with Consumption-based	*MTCO 2e*	*2,447,746*	*2,286,787*	**-6.6%**
Total without Consumption-based	*MTCO 2e*	*1,938,094*	*1,723,571*	**-11.1%**
Total BASIC	*MTCO 2e*	*1,806,359*	*1,480,119*	**-18.1%**

When emissions are broken down by sector, we see that each sector's contribution has changed between 2007 and 2018. Emissions from buildings have decreased by 21.1%. However, the total reduction was offset by an increase in transportation (5.1% increase), waste emissions (45% increase), and consumption-based emissions (10.5% increase). An even further breakdown of emissions by sector is illustrated in Figure 4.

FIGURE 4. COMPARISON OF TOTAL EMISSIONS OVER TIME BY SECTOR



Factors Influencing Emissions

Emissions are a product of emission factors and activity data. Emission factors can be changed through large system-side modifications, such as using cleaner fuel sources. Activity data is influenced by community indicators (i.e. population, economic growth, etc.) and consumption and generation behaviors. These behaviors can be positively impacted through programs, policies, and education, which are identified in the 2015 Lakewood Sustainability Plan.

The following is an overview of the drivers that effected the GHG emissions between 2007 and 2018.

Community Indicator Trends

Between 2007 and 2018, Lakewood experienced significant growth in population, revenue, and the number of jobs. Each of these trends affects GHG emissions through the increase in consumption, square footage, transportation needs, and expenditures.

FIGURE 6. CHANGES IN COMMUNITY INDICATORS

Indicator	2007	2018
Population	143,109	151,411
Retail sales tax	$58,024,910	$79,716,752
Number of jobs	66,483	82,506
Heating degree days	5,687	4,465
Cooling degree days	784	1,684

While growth can benefit the community of Lakewood through added tax revenues and raise other city indicators, it makes the task of achieving significant reductions in GHG emissions more challenging. Fortunately, Lakewood is reducing overall GHG emissions while it continues to grow.

Emission Factor Trends

Colorado's Renewable Energy Standard requires Xcel Energy to increase the efficiency of their operations and source increasing amounts of energy from low- to zero-carbon sources (i.e. renewable energy, recycled energy, etc.). As a result, the mix of energy sources that supply Xcel Energy's electric grid changes every year and the resulting electricity emission factor decreases every year. Based on data from Xcel Energy, electricity emission factors decreased 34% from 2007 to 2018. It should be noted that the while Xcel Energy publishes a natural gas emission factor, it is not expected to change annually.

FIGURE 5. CHANGES IN EMISSION FACTORS

	Units	2007	2018	% Change Against Baseline
Electricity emissions factor	MTCO2e/MWh	0.83855	0.552	-34.2%

This has an enormous impact on Lakewood's emissions. A significant portion of any reduction in electricity-generated emissions is attributable to the reduced emission factor. The reduced emission factor may result in reductions in electricity-generated emissions, even when electricity activity data increased.

Energy Use Trends

Despite a rising population, total natural gas consumption has decreased by 0.02% and electricity consumption has only slightly increased (1.42%).

FIGURE 7. CHANGES IN ENERGY ACTIVITY DATA

ENERGY INDICATOR	Units	2007	2018	% Change Against Baseline
Residential electricity	kWh	460,547,000	466,040,714	1.19%
Residential natural gas	dTh	3,824,394	3,755,223	-1.81%
C&I electricity	kWh	649,822,000	653,475,397	0.56%
C&I natural gas	dTh	2,435,527	2,503,679	2.80%
Total electricity	kWh	1,110,369,000	1,126,103,980	1.42%
Total natural gas	dTh	6,259,920	6,258,902	-0.02%
Electricity emissions factor	MTCO2e/MWh	0.83855	0.552	-34.17%

When emissions take into account community indicators (population and employees), we see emission reductions ranging from 24.1% to 37.7% (see Figure 8) and energy usage reductions ranging from 4.4% to 19% (Figure 9).

FIGURE 8. NORMALIZED EMISSION DATA

PER CAPITA EMISSIONS METRICS	Units	2007	2018	% Change Against Baseline
Residential Emissions per person	MTCO2e/person	3.99	3.03	-24.1%
C&I Emissions per employee	MTCO2e/FTE	9.75	6.07	-37.7%

FIGURE 9. NORMALIZED ENERGY DATA

PER CAPITA ENERGY METRICS	Units	2007	2018	% Change Against Baseline
Residential electricity per person	kWh/person	3,218	3,078	-4.4%
Residential natural gas per person	dTh/person	27	25	-7.2%
C&I electricity per employee	kWh/FTE	9,774	7,920	-19.0%
C&I natural gas per employee	dTh/FTE	37	30	-17.2%

Figure 7 showed that Lakewood experienced only a slight (1.42%) increase in electricity consumption between 2007 and 2018, despite a 115% increase in days needed to cool buildings (Cooling Degree Days or CDD)[6]. The residential electricity per person per CDD decreased by 55.5% and the commercial electricity per employee per CDD decreased by 62.3% (see Figure 10), indicating that building operations have become more efficient in electricity usage.

FIGURE 10. COMPARISON OF ENERGY FACTORS

WEATHER NORMALIZED PER CAPITA METRICS	Units	2007	2018	% Change Against Baseline
Heating degree days	HDD	5,687	4,465	-21.5%
Cooling degree days	CDD	784	1,684	114.8%
Residential electricity per person	kWh/person/CDD	4.105	1.828	-55.5%
C&I electricity per employee	kWh/FTE/CDD	12.467	4.703	-62.3%
Residential natural gas per person	dtH/person/HDD	0.005	0.006	18.2%
C&I natural gas per employee	dTh/FTE/HDD	0.006	0.007	5.5%

Transportation Trends

As shown in Figure 3, emissions from transportation have increased by 5.1% between 2007 and 2018. The transportation value includes vehicle travel from on-road gasoline and diesel vehicles and public transit and airline travel from DIA. Emission data is based on several factors: emission factors, fuel efficiencies, vehicle miles traveled, and vehicle type distribution by vehicle fuel. The emission factors for gasoline, diesel, and jet fuel are not expected to change significantly each year, which suggests that decreases in transportation emissions are a result of changes in activity data. Figure 11 provides more information on the breakdown of transportation activity data.

[6] A Heating Degree Day (HDD) and Cooling Degree Day (CDD) are roughly proportional to the energy used for heating and cooling a building. They are calculated by taking the difference between the average daily temperature and the balance point temperature. The balance point temperature is the average daily outside temperature at which a building maintains a comfortable indoor temperature without heating or cooling. When the average daily temperature is above the balance point temperature, the result is cooling degree days (i.e. you need to cool the building to maintain the balance point temperature). When the average daily temperature is below the balance point temperature the result is heating degree days (i.e. you need to heat the building to maintain the balance point temperature).

FIGURE 11. BREAKDOWN OF TRANSPORTATION ACTIVITY DATA

TRANSPORTATION	Units	2007	2018	% Change Against Baseline
Gasoline	VMT	1,002,420,104	1,053,152,004	5.06%
Diesel	VMT	101,236,314	40,792,267	-59.71%
Public transit	Gallons	187,868	378,714	101.59%
Railways	kWh	n/a	14,110,143	n/a
Aviation	Gallons	13,751,269	24,222,571	76.15%

Vehicle Miles Traveled for on-road transportation increased between 2007 and 2018, despite an increase in public transit and light rail ridership compared to 2007[7].

Jet fuel consumption increased by 76.15% between 2007 and 2018, reflecting a record breaking year for Denver International Airport in passenger traffic in 2018[8].

Waste Trends

As shown in Figure 12, emissions from waste increased by 5.8% between 2007 and 2018. Emission data is based on the amount of waste generated, waste characterization, and emission factors. The same assumptions of waste generation per household and per business were applied for both inventories; therefore, estimated waste emissions increased in proportion to the increase in number of households and number of businesses. Improved tracking of solid waste collection would allow a more informative comparison of solid waste emissions between inventories in the future. Wastewater treatment emissions are simply a function of the population served, and the increase in associated emissions matched the increase in Lakewood's population.

FIGURE 12. BREAKDOWN OF WASTE ACTIVITY DATA

WASTE	Units	2007	2018	% Change Against Baseline
Landfilled waste	Tons	87,185	116,966	34.16%
Wastewater treatment	Population served	143,109	151,411	5.80%

Consumption-based Trends

Both the 2007 and 2018 inventories include consumption-based emissions, covering the categories of cement usage, food usage, and drinking water treatment. The consumption based emissions increased by 10.5% from 2007 to 2018 (see Figure 3); however, considerable caution should be taken in interpreting this result. The methodology used for these emissions is based on national consumption trends, rather than data on local consumption. In addition, the method does not distinguish between changes in spending because of food price changes and changes in the amount or types of food consumed (i.e. local produce, less meat consumption).

[7] This result should be interpreted with caution because the type of VMT data used was not the same between the two years. The 2007 inventory used a value produced by the Denver Regional Council of Governments (DRCOG) demand model, while the 2018 inventory used a figure for per-capita VMT, also provided by DRCOG.

[8] https://kdvr.com/2019/02/12/dia-sets-new-passenger-record-with-64-5-million-travelers-in-2018/