Boulder's Municipal

Greenhouse Gas Inventory Report

Calendar Year 2023

CITY OF BOULDER

LOTUS
Engineering & Sustainability

We acknowledge with respect and gratitude that this report was created on the ancestral homelands and unceded territory of Indigenous Peoples who have traversed, lived in and stewarded lands in the Boulder Valley since time immemorial. Those Indigenous Nations include the: Di De'i (Apache), Hinono'eiteen (Arapaho), Tsistsistas (Cheyenne), Nʉ mʉ nʉʉ (Comanche), Kiowa, Čariks i Čariks (Pawnee), Sosonih (Shoshone), Oc'eti S'akowin (Sioux) and Núuchiu (Ute). We honor and respect the people of these Nations and their ancestors. We also recognize that Indigenous knowledge, oral histories, and languages handed down through generations have shaped profound cultural and spiritual connections with Boulder-area lands and ecosystems — connections that are sustained and celebrated to this day.

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INTRODUCTION

Since the turn of the 21st century, the City of Boulder has been committed to climate action. Boulder was an early signatory to the Kyoto Protocol and adopted early carbon reduction goals in 2006. The city has kept up with the latest science and methodologies and as needed has updated its targets to align with the level of carbon reduction necessary to avoid catastrophic climate impacts. Three years ago, the city joined the ICLEI 150 Race to Zero campaign (ICLEI is an organization of local governments for sustainability). The initiative encourages bold emissions reduction policies and rallies US cities to lead the fight against climate change. Boulder strengthened its Climate Action Plan in 2021 to include ambitious mitigation goals and targets for the Boulder community (Table **1**).

Table 1. Updated community-wide and current municipal operations GHG reduction targets.

Community-wide	City Organization
Reduce emissions 70 percent by 2030 using a 2018 baseline	Reduce emissions 50 percent by 2020 using a 2008 baseline
Become a Net-Zero City by 2035.[1]	Reduce emissions 80 percent by 2030 using a 2008 baseline
Become a Carbon-Positive City by 2040.[2]	

The City acknowledges that its municipal operations also contribute to global emissions and climate change. In order to track progress towards the updated targets, Boulder's city organization has been tracking greenhouse gas (GHG) emissions from its operations. Boulder completed its first municipal operations GHG inventory in 2008 and utilized the Climate Registry's Local Government Operations Protocol[3] (LGOP) framework. Inventory results are uploaded into the ICLEI ClearPath tracking system annually.[4] In 2011, the city began conducting annual GHG inventories to track our progress towards emission reduction goals. See Figure 1 below for a timeline of the city's emission tracking milestones.

As of 2023, Boulder has reduced its emissions from municipal operations by 44 percent since 2008. Emissions dropped 1 percent from 2022 levels.

[1] To be a Net-Zero City, Boulder will reduce its emissions to the highest extent possible by 2035. Any remaining emissions sources can be sequestered naturally through the biosphere.

[2] To be a Carbon Positive City, Boulder will absorb more GHGs than it emits. Examples of how Boulder may do this include regenerative agricultural practices and initiatives to dramatically increase urban forest plantings. Please see https://bouldercolorado.gov/news/boulders-new-climate-targets-explained.

[3] For more information on the Local Government Operations Protocol please see http://www.theclimateregistry.org/tools-resources/reporting-protocols/local-goverment-operations-protocol/. The inventory considers emissions generated from activities within the operational control of the city of Boulder. 'Operational control' is defined as those operations, facilities, or sources that are wholly owned by the city of Boulder, as well as those in which the city of Boulder has full authority to introduce and implement operational health, safety, and environmental policies. See: https://www.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf.

[4] For more information in ICLEI's ClearPath tool please see http://icleiusa.org/clearpath/.

REALIGNMENT OF TARGETS

Beginning in 2025 The City of Boulder will realign its municipal operations GHG targets to match community-wide GHG targets. This will result in more aggressive GHG targets for the city with no change for the community. The initial targets set by the city in 2016 were an effort to be leader in GHG reductions with its own portfolio. When the community strengthened its GHG target in 2021, that goal was slightly more aggressive due to using a 2018 baseline instead of a 2008 baseline. This is a result of GHG reductions that took place in the ten years between those baseline years setting those targets. This small change is required so the city is being held to the same standard as the community (Table **2**).

Table 2. New community-wide and municipal GHG targets.

New 2025 City Organization	Pre 2025 City Organization
Reduce emissions 70 percent by 2030 using a 2018 baseline	Reduce emissions 50 percent by 2020 using a 2008 baseline
Become a Net-Zero City by 2035.[5]	Reduce emissions 80 percent by 2030 using a 2008 baseline
Become a Carbon-Positive City by 2040.[6]	

The adjustments in targets will not result in any changes to our reporting and our commitment to climate action. This is simply an effort to make sure city GHG emission targets are at the same standard as community GHG emission targets. The short-term outcome will be that city GHG reductions will appear different at first look. This should in no way understate the progress and effort put in by countless city employees working toward meaningful climate action. The city remains committed to meeting its GHG targets in 2030, 2035, and 2040.

This report uses the 2008 baseline- where possible we have noted the differences. Moving forward, all reports will use the 2018 baseline.

[5] To be a Net-Zero City, Boulder will reduce its emissions to the highest extent possible by 2035. Any remaining emissions sources can be sequestered naturally through the biosphere.

[6] To be a Net-Zero City, Boulder will absorb more GHGs than it emits. Examples of how Boulder may do this include regenerative agricultural practices and initiatives to dramatically increase urban forest plantings. Please see https://bouldercolorado.gov/news/boulders-new-climate-targets-explained.

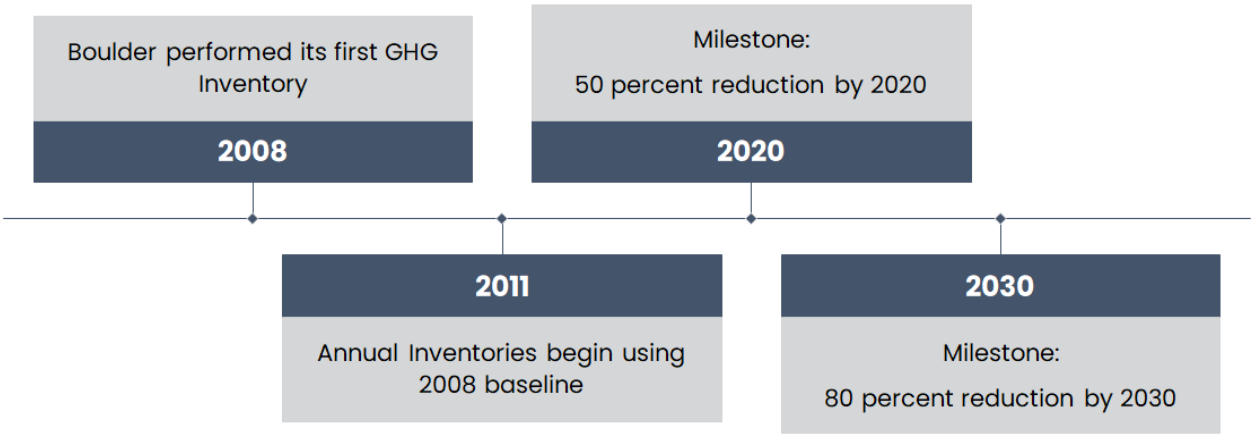

Figure 1. Timeline of Boulder's municipal emission reductions goals.

Current Emissions Snapshot

Boulder's city operations have made significant progress in recent years. Now in 2023, municipal emissions have decreased 44 percent from 2008 levels. See Figure 2. Moving forward, the city will need to reduce emissions from municipal operations 5 percent per year to meet the 2030 target of an 80 percent reduction in emissions.

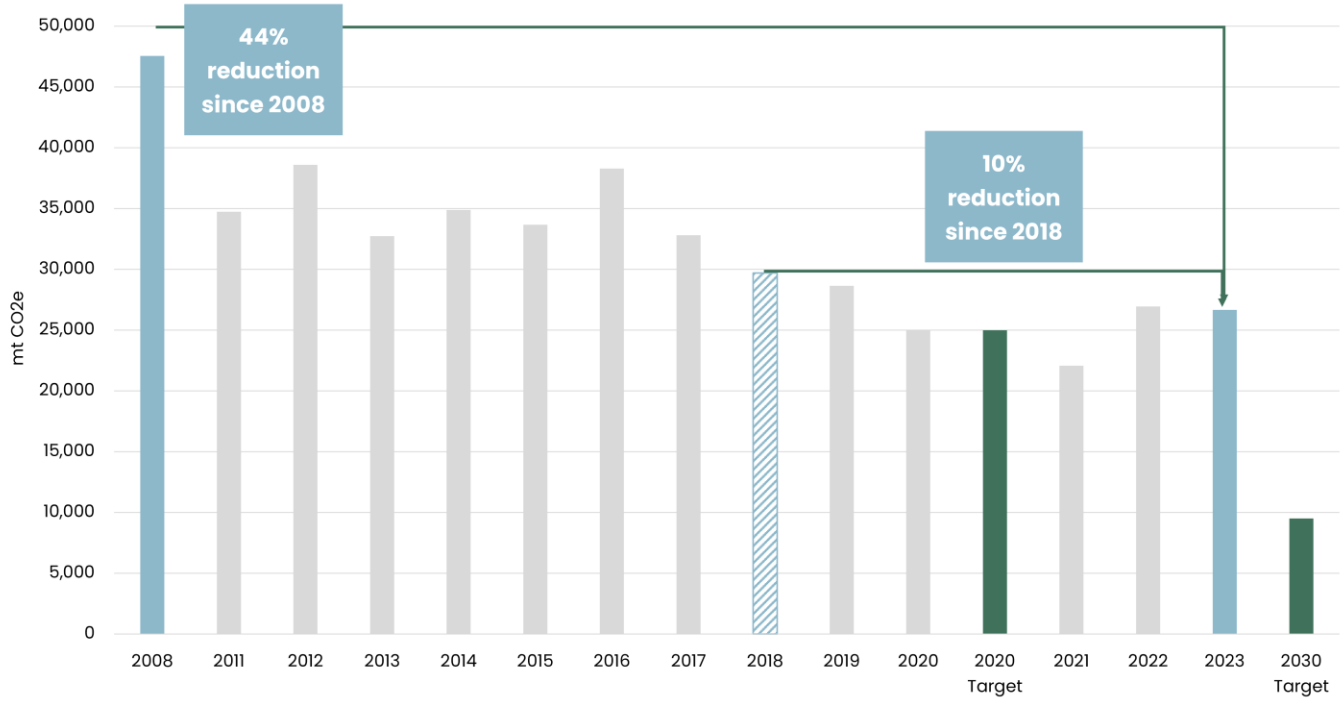

Figure 2. Total annual emissions (mt CO_2e) 2008-2023 and 2020/2030 targets. Going forward, 2018 will be the new baseline.

In 2023, Boulder's municipal operations generated a total of 27,996 metric tons of carbon dioxide equivalent (mt CO_2e) including well-to-wheel emissions. This represents about 2% of total community-wide emissions.

At 56 percent of total emissions (15,174 mt CO_2e), the stationary energy (i.e., building energy) sector made up the largest share of the city's operational emissions, followed by consumption-based emissions at 20 percent (5,690 mt CO_2e) and transportation emissions at 19 percent (5,420 mt CO_2e). Consumption-based emissions sources include well-to-wheel emissions (1,330 mt CO_2e). The remaining 4 percent of emissions were generated from wastewater treatment (2 percent), solid waste (1 percent), and the use of industrial processes and products (i.e., refrigerant use, 1 percent). See Figure 3.

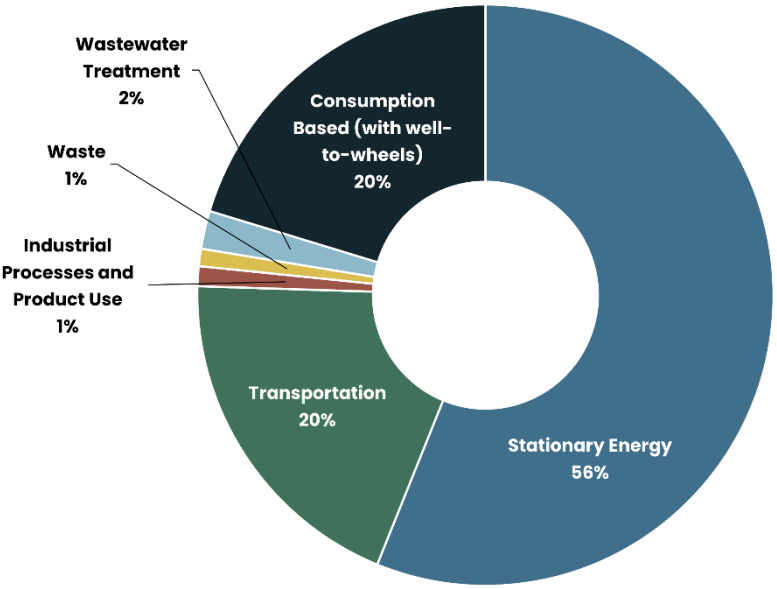

Figure 3. Municipal emissions by sector, 2023.

In terms of emissions by source (Figure 4), without well-to-wheel, the breakdown is:

- **Highest: Electricity** at 42 percent of municipal emissions (11,328 mt CO_2e).
    - Grid-supplied electricity (i.e., electricity used in streetlights, facilities, water transport, and wastewater treatment) and those associated with emissions from grid-supplied electricity consumed in the city for on-road transportation (i.e., electric vehicles in the municipal vehicle fleet and used for employee commuting).
- **Second Highest: Natural gas** usage at municipal facilities accounted for 16 percent of municipal emissions (4,216 mt CO_2e).
- **Third Highest: Gasoline** accounted for 12 percent of municipal emissions (3,221 mt CO_2e).

For more in-depth breakdowns of emissions by source, see Table 3 below.

Table 3. Municipal emissions by source detail including consumption emissions, 2023.[7]

Emission Source	Emissions (mt CO_2e)	Percent of Total
Electricity	11,328	42%
Natural Gas	4,216	16%
Gasoline	3,221	12%
Asphalt	2,424	9%
Diesel	2,022	8%
Food	1,291	5%
Wastewater	592	2%
Cement	554	2%
Refrigerants	310	1%
Solid Waste	270	1%
Propane	228	0.9%
Computers	72	0.3%
Aviation	60	0.2%
Ethanol	59	0.2%
Paper	16	0.1%
Fertilizer	3	0.01%
Biodiesel	0.2	0.001%
Total	**26,667**	**100%**

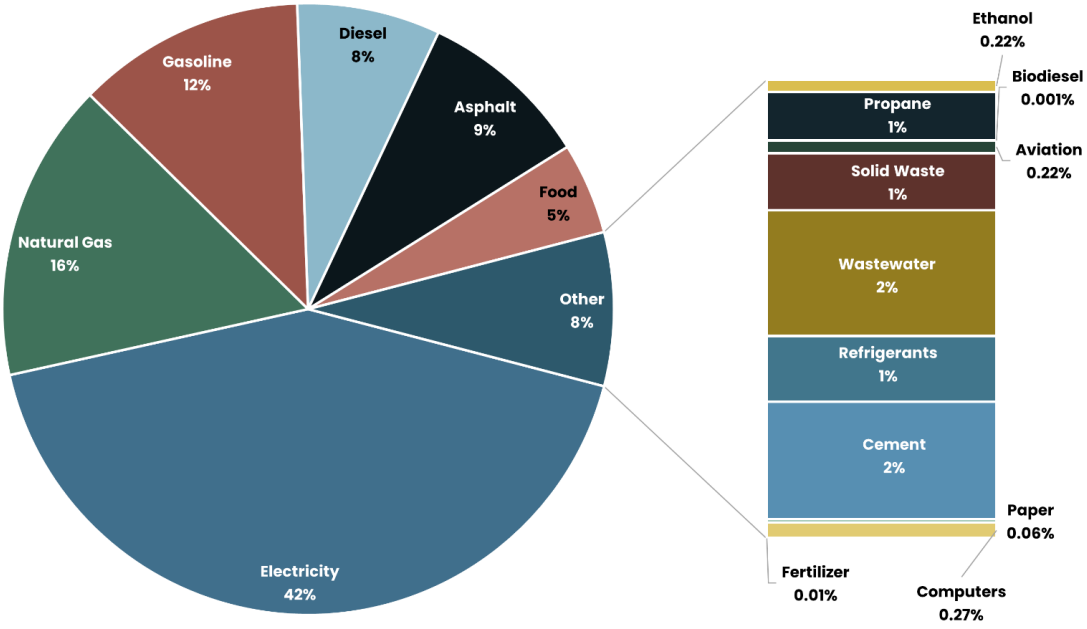

Figure 4. Boulder municipal emissions by source without well-to-wheel in 2023.

[7] Numbers in data tables may not add up to exactly 100 percent due to rounding.

How Close is Boulder Municipality to Reaching its Goals?

With the exception of 2009 and 2010, Boulder has been annually tracking emissions from municipal operations since 2008. These inventories are vital in helping the city organization understand its progress towards emission reduction goals. Inventory results are also helpful in determining new sustainability programs and policies, as well as identifying where to focus certain strategies and funding.

As discussed in the introduction, Boulder's city organization set two municipal emission reduction goals. The first goal was to reduce municipal emissions by 50 percent by 2020 and the second goal is to reduce emissions by 80 percent by 2030. Both goals are set against a 2008 baseline.

As seen below in Figure 5, city operations surpassed their 2020 goal in 2021, reducing their emissions 54 percent from 2008 levels. However, municipal emissions increased once again in 2022 and decreased slightly in 2023. With this increase in emissions, city operations have now decreased their emissions 44 percent from the 2008 baseline.

Figure 5. Year-over-year change in mt CO_2e, 2008-2023 with targets.

What Happened in 2023

Total municipal emissions increased one percent between 2022 and 2023 (including well-to-wheel emissions) but are slightly less than pre-pandemic levels. Since 2022, scope one sources increased two percent, scope two sources decreased two percent, and scope three sources decreased three percent. With a few exceptions, emissions have largely been declining since 2008.

Some notable factors and trends between 2022 and 2023 include:

- **Natural Gas Usage**: usage of natural gas in municipal buildings continues to increase year-over-year. With Xcel Energy working to clean up the grid, electricity emissions are expected to decrease over time despite the increase in usage, which will leave natural gas emissions to be dealt with. This could be due to several maintenance and meter issues being resolved between 2022-2023.
- **Increase in Business Travel:** emissions from on-road business travel increased between 2022 and 2023. This is likely part of the post-pandemic "return to normal," which could be plateauing overall, as most transportation-related emission sources decreased between 2022 and 2023.
- **Waste Tonnage:** solid waste tonnage increased between 2022 and 2023, increasing waste emissions. This highlights the importance of waste diversion initiatives.
- **Asphalt for Construction:** asphalt contributed significantly to consumption-based emissions in 2023. Finding ways to make construction projects more efficient and find materials with lower embodied carbon is vital to lowering emissions.

EMISSION TRENDS BY SCOPE

The following is an overview of all the sources that are included in the 2023 inventory,[8] classified by scope. For reference, Scope 1 emissions are direct emissions from owned or controlled sources (e.g., fuel used in buildings and fleet vehicles). Scope 2 emissions primarily consist of grid-supplied electricity. Scope 3 emissions are other indirect emissions (e.g., consumption-based sources).

- **Scope 1:** GHG emissions from sources owned and operated by the city.
    - Stationary fuel used in municipal buildings and facilities including natural gas, propane, diesel, and biodiesel.
    - Municipal vehicle fleet and equipment fuel use including gasoline, ethanol, diesel, and biodiesel.
    - Wastewater treatment by the city-owned facility.
    - Refrigerant usage in municipal buildings and facilities.
- **Scope 2:** GHG emissions occurring as a result of the use of grid-supplied electricity, heat, steam, and/or cooling within the boundary.
    - Grid-supplied electricity used in municipal buildings, facilities, and vehicle fleet.
- **Scope 3:** All other GHG emissions that occur as a result of activity by city employees as well as consumption-based sources.
    - Employee commuting fuel use (includes diesel and gasoline).
    - Reimbursed business travel (on-road) fuel use including gasoline.
    - Business travel (aviation).
    - Solid waste and compost from municipal buildings and facilities.
    - Consumption-based sources including asphalt, cement, paper, food, fertilizer, and computers.

[8] Note that Boulder was interested in understanding the avoided emissions from activities such as recycling, composting, and renewable energy (i.e., on-site solar and hydro generation). These activities are not included in the standard LGOP reporting and are therefore reported as information-only.

Over the last 15 years, scope one emissions have decreased seven percent, scope two emissions have decreased 56 percent, and scope three emissions have decreased 46 percent. See

Figure 6. Scope 1 emissions have not decreased significantly because natural gas usage in buildings has not decreased significantly. Fleet vehicles and equipment still mostly use fossil fuels but the city has switched some fleet vehicles over to hybrid and electric options—another contributor to the small decrease over time. The city organization has a goal of electrifying its fleet and buildings, so scope one emissions will likely decrease should those goals be met and become scope two emissions. Scope 2 emissions have decreased significantly, largely due to the greening of Xcel Energy's electric grid. Although electrification will bring more electricity usage and emissions, scope two emissions will still benefit from Xcel Energy's decreasing emission factor. Scope 3 emissions have fluctuated annually since the 2008 baseline, mostly due to the inconsistency of capital projects and purchasing.

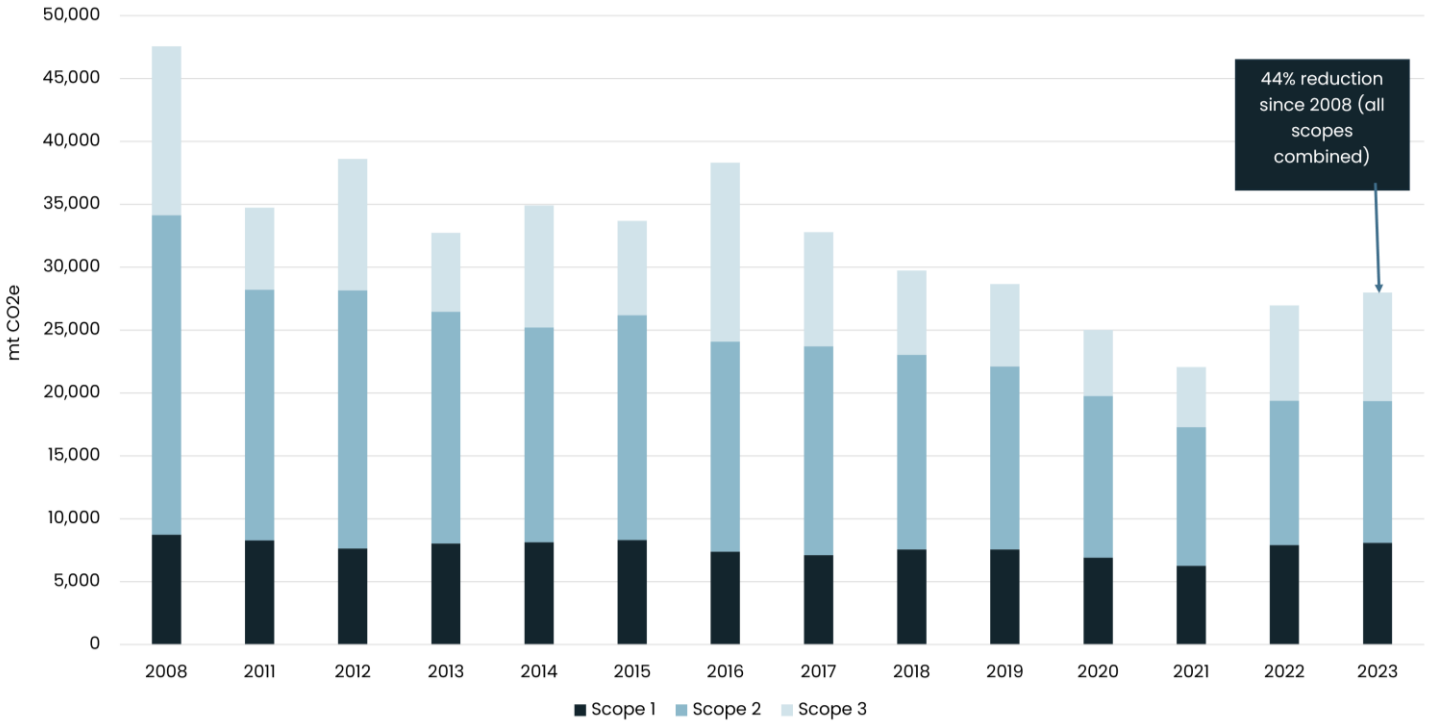

Figure 6. Emissions by scope (mt CO_2e), 2008-2023.

EMISSION TRENDS BY SECTOR

Figure 7 highlights emission trends by sector over time. The darker bars represent reductions in emissions since 2008, which came from consumption-based sources (down 62%), streetlights and traffic signals (down 56%), buildings and facilities (down 52%), and waste and wastewater treatment activity (down 44%). Lighter colored bars show increases in emissions since 2008 which came from employee commuting activity and jet fuel usage related to business travel (up 46%), solid waste disposal (up 82%), and vehicle fleet and equipment fuel usage (up 19%).

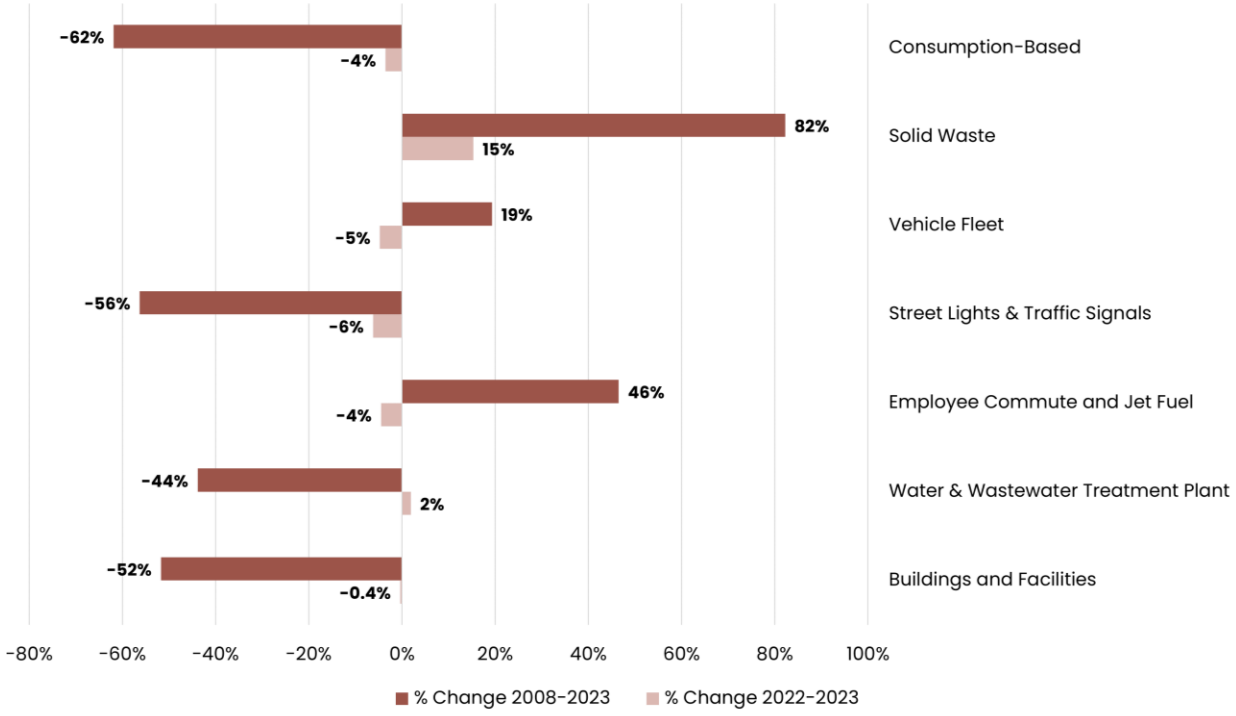

Figure 7. Percent Change in Emissions by Sector 2008-2023, 2021-2023.[9]

Emissions from several sectors increased between 2022 and 2023. The largest increases came from solid waste disposal (up 15 percent), and waste and wastewater treatment activity (up two percent). Sources that have seen decreases since 2008 include: building electricity use, gasoline, propane, biodiesel, wastewater treatment, and consumption-based sources. See Figure 8.

[9] Note that refrigerants are not included in this figure; they have shown an 821% increase between 2008 and 2023 due to better data collection efforts, updated global warming potentials, and additional square footage to cool. Excluding them from this figure provides a better scale for visualizing the increases and decreases of other sectors. Despite the large increase, refrigerant emissions make up only one percent of total municipal emissions.

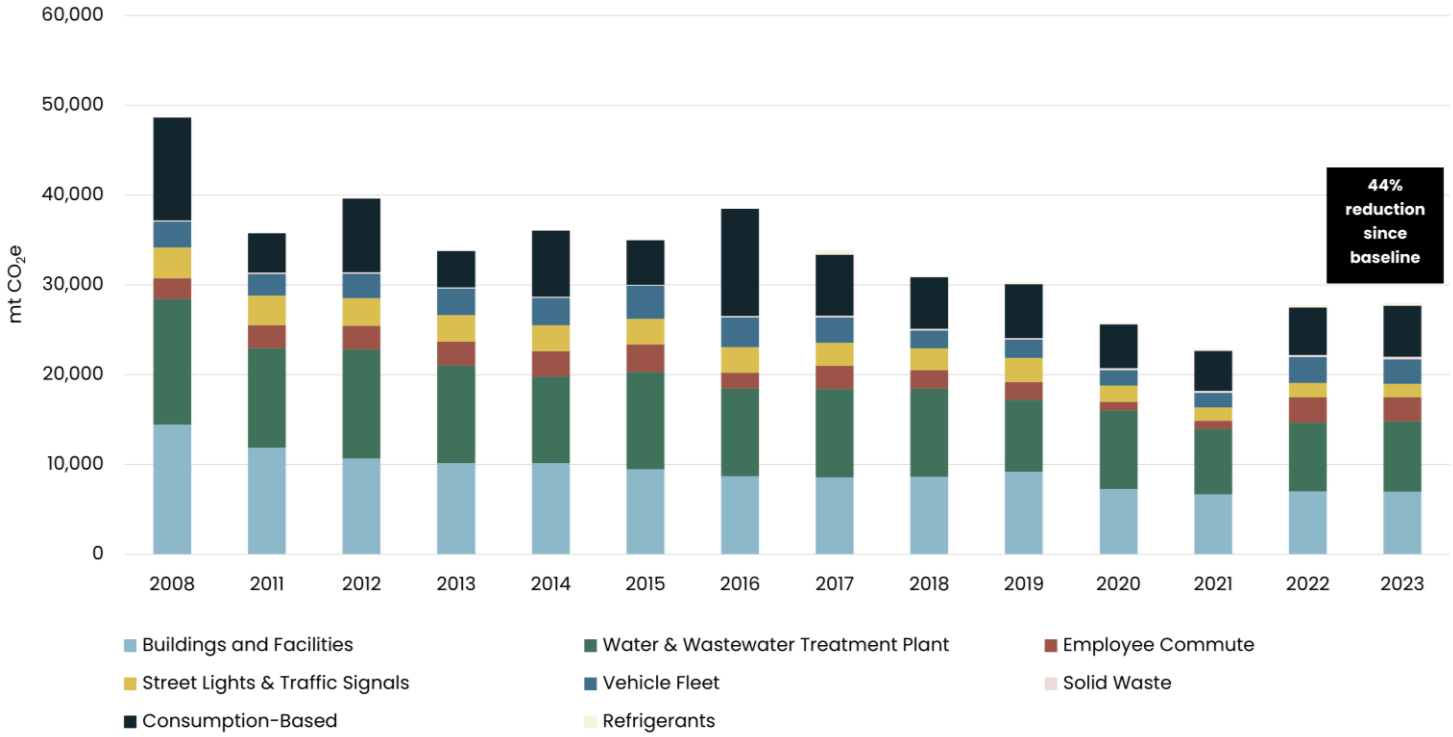

Figure 8. Emissions by sector (mt CO_2e), 2008-2023.

Stationary Energy Emissions

Water and wastewater treatment ("utilities") electricity usage[10] is the largest emission source in the stationary energy sector at 38 percent (5,941 mt CO_2e), followed by facilities electricity use at 24 percent (3,807 mt CO_2e), facilities stationary fuel usage at 20 percent (3,172 mt CO_2e), streetlights electricity usage at 10 percent (1,497 mt CO_2e), water treatment stationary fuel usage at seven percent (1,053 mt CO_2e), and wastewater treatment stationary fuel usage at two percent (245 mt CO_2e). Stationary fuels, such as natural gas, stationary diesel, and propane, differ from other fuels in that they are used in stationary objects, such as buildings, generators, and pumps rather than in mobile objects. Refer to Table 4.

Table 4. Stationary energy emissions detail (mt CO_2e), 2023.

Emission Source	Emissions (mt CO_2e)	Percent of the Total
Utilities Electricity	5,941	38%
Facilities Electricity	3,807	24%
Facilities Natural Gas	3,172	20%
Streetlights Electricity	1,497	10%
Utilities Natural Gas	1,053	7%

[10] Utilities include Public Works and Wastewater Treatment departments.

Water Transport Natural Gas	245	2%
Wastewater Treatment Natural Gas	0.2	0.001%
Total	**15,714**	**100%**

A major source of municipal operations emissions over the years is electricity use. This trend has been shifting over time. Electricity use at municipal facilities has decreased alongside emissions, though in 2023 electric use at municipal facilities increased compared to 2022. Even with this increase in use, emissions remained steady. This stabilization of emissions and the overall downward trend is largely driven by energy efficiency measures and more renewable energy sources on the grid. See Figure 9.

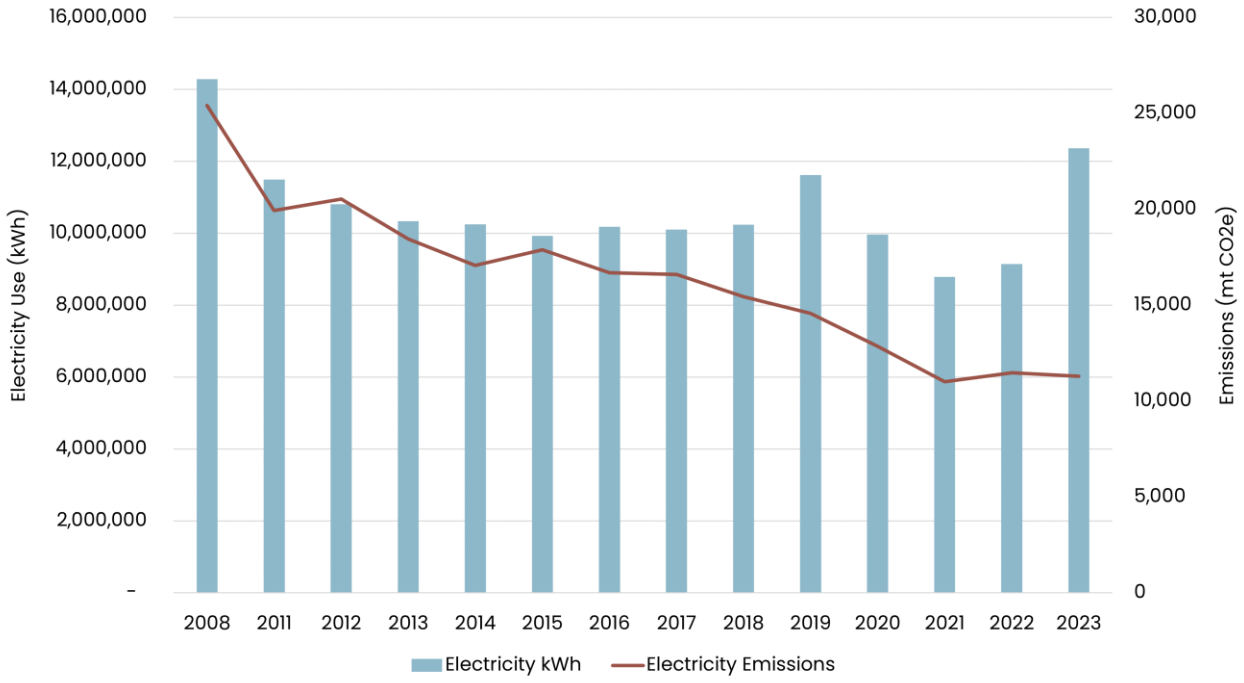

Figure 9. Total electricity usage and change in electricity emissions from the 2008 baseline.

What Happened in 2023

Stationary energy emissions remained stable in 2023, only increasing 0.2% overall. Nearly all stationary energy sources decreased between the two years, while facility natural gas emissions increased 11 percent and utilities electricity emissions increased four percent.

Some notable trends include:

- **Building Electrification**: The city organization has been working on converting some of its municipal buildings to run fully on electricity. This could be why kilowatt-hours increased year-over-year, although emissions remained nearly the same. Without significant investment in building infrastructure to aid electrification, scope one emissions are unlikely to decrease significantly in coming years. Additionally, without electrifying space and water heating in

municipal buildings, there will still be emissions from buildings when Xcel Energy achieves 100% renewable energy on the grid.

- **Renewable Energy on the Grid:** Colorado House Bill 19-1261 requires that investor-owned utilities like Xcel Energy reduce emissions 80% from 2005 levels by 2030. Xcel Energy's emission reduction goals are even more ambitious aiming to reduce emissions by 85% from 2005 levels and deliver more than 80% of energy from renewable sources by 2030. Xcel Energy also has a carbon-neutrality goal for 2050. Assuming that Xcel Energy stays on track with their goals, the city organization can expect electricity emissions to continue decreasing annually, even while electricity use increases. Table 5 shows the overall change in the electricity emissions factor between 2008 and 2023.

Table 5. Electricity emission factor over time, 2008-2023.

Year	Electricity Emission Factor (mt CO2 / MWh)	Year-over-Year Change	Change Since 2008
2011	0.747	-2%	-2%
2012	0.732	-4%	-6%
2013	0.7	-1%	-8%
2014	0.657	-5%	-12%
2015	0.676	3%	-10%
2016	0.599	-11%	-20%
2017	0.593	-1%	-21%
2018	0.552	-7%	-26%
2019	0.514	-7%	-31%
2020	0.474	-8%	-37%
2021	0.470	-1%	-37%
2022	0.449	-4%	-40%
2023	0.426	-5%	-43%

TRANSPORTATION EMISSIONS

Transportation sector emissions come from the following sources: electric and fossil fuel-powered fleet vehicles and equipment, employee commuting, on-road business travel in employee-owned vehicles, and airline business travel. Since 2022, transportation sector emissions decreased six percent. In order to further decrease emissions from the transportation sector, the city should continue to replace fossil fuel-powered vehicles with electric vehicles and should support employees in doing the same. Emissions from transportation-related sources are outlined in Table 6.

Table 6. Transportation emissions detail (mt CO_2e), 2023.

Emission Source	Emissions (mt CO_2e)	Percent of Total
Employee Commuting	2,602	48%
Municipal Owned Vehicles	2,323	43%
Municipal Owned Equipment	413	8%
Business Air Travel	60	1%
On-Road Business Travel[11]	23	0.4%
Total	**5,420**	**100%**

What Happened in 2023

Transportation emissions decreased six percent between 2022 and 2023. On-road business travel emissions almost doubled in 2023 (12 mt CO_2e to 23 mt CO_2e) while all other transportation sources decreased between the two years.

Some notable trends include:

- **Business Travel Shift:** Fewer flights were taken for conferences and other business travel purposes in 2023. On the other hand, the number of miles driven for meeting and business purposes doubled in 2023 compared to 2022. This could indicate a shift to prioritize more local meetings, conferences, and other trips compared to out-of-state trips.
- **Increased EV adoption:** In 2023, the city added 14 new electric vehicles to its fleet, increasing the total number of EVs in the fleet to 55. This replacement of fossil fuel powered vehicles with electric vehicles could be playing into the small decrease year-over-year in municipal owned vehicle emissions (from 2,457 mt CO_2e to 2,323 mt CO_2e).

[11] On-Road Business Travel includes reimbursements for employees that drove a fleet vehicle and needed to refill at a non-Boulder owned fueling station.

Waste and Wastewater Treatment Emissions

Emissions from the treatment of wastewater have decreased by 63 percent since 2008 and increased by 0.4 percent between 2022-2023. The decrease in wastewater treatment emissions from 2008-2023 is an important trend to note and deserves recognition. There have been concerted efforts to reduce the emissions impact of treating wastewater and implementing processes that help to bring down emissions. Processes to reduce treatment emissions include utilizing nitrification/denitrification, which reduces the quantity of process nitrogen emitted in the treatment of wastewater and discharged effluent, and the use of a digester on the treatment plant to capture and flare methane gas created during treatment.

Flaring methane gas converts emissions from methane to carbon dioxide, which is 30 times less intensive in terms of global warming potential. It is also important to note that this sector includes emissions just from the treatment processes themselves; emissions from electricity and other stationary fuels to operate the facility are included in the Stationary Energy sector emissions.

Emissions from solid waste collected at municipal facilities have increased by 82 percent since 2008 and increased 15 percent between 2022 and 2023. The tonnage of solid waste collected at facilities increased 17 percent between 2022 and 2023, while recycling generation increased 98 percent and compost generation decreased 12 percent. Tonnages of waste, recycling, and composting collected since 2008 are shown in Figure 10. While the percentage of waste diverted for recycling and composting has increased from 2008 to 2023, overall waste generation has increased over time.

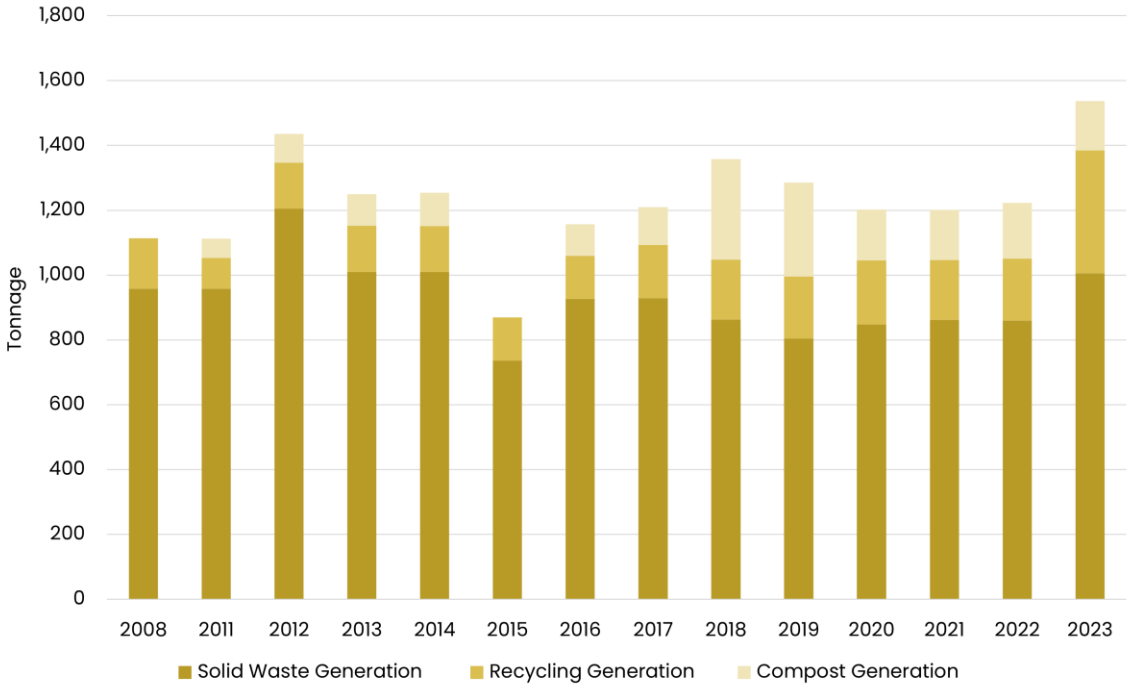

Figure 10. Reported Waste, Recycling, and Composting Tonnage.

What Happened in 2023

Wastewater emissions largely plateaued in 2023. In the waste sector, there was an increase in landfilled tonnage while there was a decrease in compost tonnage. This is a notable change; 2023 was the first year that A1 Organics, the city's compost servicer, stopped accepting compostable paper and plastic products due to high rates of contamination historically in the waste stream. This will be an important trend to track over time and may continue to influence the decrease in compost tonnage and increase in landfilled tonnage. One positive trend is that recycling tonnage increased by 95 percent year over year and has increased 105 percent since 2018.

REFRIGERANT EMISSIONS

Since 2008, reported refrigerant emissions have increased by 821 percent. Since 2022, they have increased by 35 percent. Despite this increase, it is important to note that refrigerants make up one percent of the city organization's total 2023 emissions.

What Happened in 2023

Some notable trends include:

- **More building refrigerant refills:** In 2023, more refrigerant refills in building HVAC equipment were reported by MTech, the city's HVAC contractor, compared to 2022 (51 lbs in 2022 compared to 174 lbs in 2023). This could be tied to a longer-term warming trend in the city. Since 2018, there has been a 56 percent increase in cooling degree days, or days where the average daily temperature is higher than 65˚F, a temperature that is assumed to need neither cooling nor heating (See Figure 11).[12]

[12] See: https://www.weather.gov/key/climate_heat_cool.

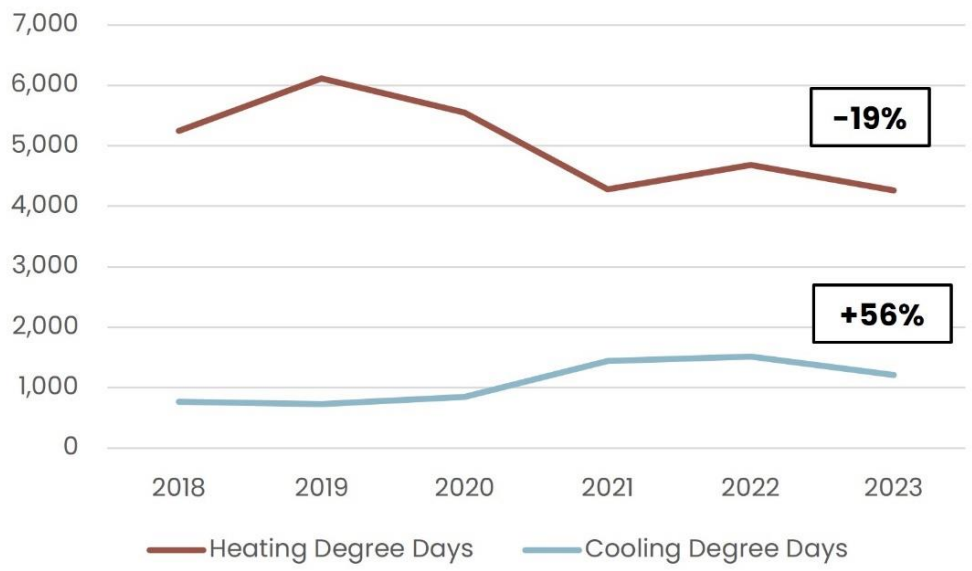

Figure 11. Trends in heating and cooling degree days in the City of Boulder from 2018-2023.

- **New lower GWP refrigerant:** Boulder now uses a low global warming potential (GWP) refrigerant in some of its fleet vehicles (R-1234yf). This refrigerant has a GWP of 4, which is substantially lower than other refrigerants used previously by city operations in their buildings and fleet vehicles. Using lower GWP refrigerants in vehicles and buildings will help to lower emissions from refrigerant use in the future.

Consumption-based Emissions

The consumption-based sector is highly variable year-to-year. Due to the importance of sources in this sector to maintaining infrastructure and serving daily operational needs, it is and will continue to be challenging to eliminate these emissions. Sources in this sector, such as asphalt and concrete use in infrastructure projects, paper use, food purchases and consumption, and technology purchases, can change significantly each year due to a variety of factors. Some of these factors include planned (or unexpected) infrastructure projects; adoption of new technologies or municipality-wide computer upgrades; or the need to print out updated plans (such as a comprehensive plan). Another important note is that the city organization owns large amounts of land through its Open Space and Mountain Parks Department (OSMP). Neither emissions nor carbon sequestration benefits from OSMP lands are included in this inventory, both of which could further influence overall emissions. Boulder has chosen to include consumption-based emissions in the setting of its municipal GHG reduction targets, and the inclusion of these sources of emissions are a significant factor in choosing not to have a net-zero emissions target for the municipality and can pose challenges for meeting the current goal of 80 percent emissions reductions from 2008 levels by 2030.

What Happened in 2023

Emissions from consumption-based sources increased eight percent between 2022 and 2023 and have decreased 50 percent since the 2008 baseline. The three-largest sources of consumption-based emissions in 2023 were asphalt (43 percent of consumption-based emissions), well-to-wheels (23 percent) and food (23 percent).

Some notable trends include:

- **Asphalt**: Construction projects in 2023 increased the usage of asphalt in 2023. Whereas concrete emissions were 84 percent lower in 2023 compared to 2022 due to the completion of the major reworking of the Boulder Creek bike path near 30th and Colorado. In years where no major construction projects occur, asphalt emissions could be much lower, which would significantly lower total consumption-based emissions. The high year-to-year variability makes it challenging to predict and reduce future emissions, however it should be noted that Boulder will not stop attending to and pursuing infrastructure projects to reduce these emissions. It is important to explore ways to use asphalt and concrete more efficiently in projects and to find lower embodied carbon concrete options for use in these projects.

EMISSIONS TRENDS BY SOURCE

Figure 12 breaks down emissions by source for all emission sources from 2008 to 2023. Emissions over the years can be largely attributed to the following sources: electricity, natural gas, gasoline, and consumption-based sources. Emissions from all four of these sources have decreased since 2008 due to sustainability policies initiated by the city and Xcel Energy's continuously decreasing emission factor for electricity. Smaller sources that vary over time include diesel use, jet fuel from business travel aviation, waste, and wastewater.

Annual trends in these four main emission sources can be seen in Figure 13. Between 2022 and 2023, electricity emissions decreased two percent, natural gas emissions increased four percent, gasoline emissions increased one percent, and consumption-based emissions sources decreased four percent. For more detail, see Table 7.

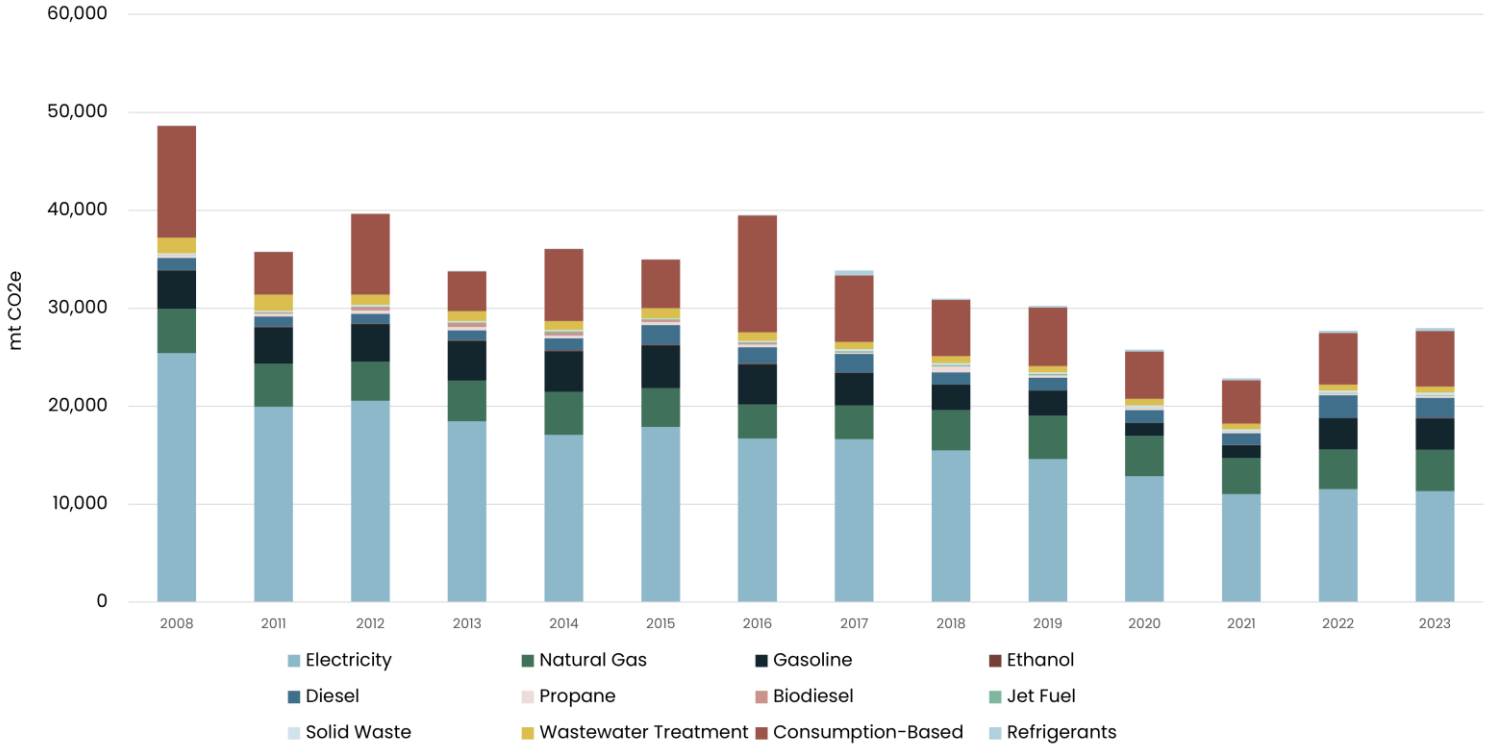

Figure 12. Emissions by source, 2008-2023 (mt CO_2e).

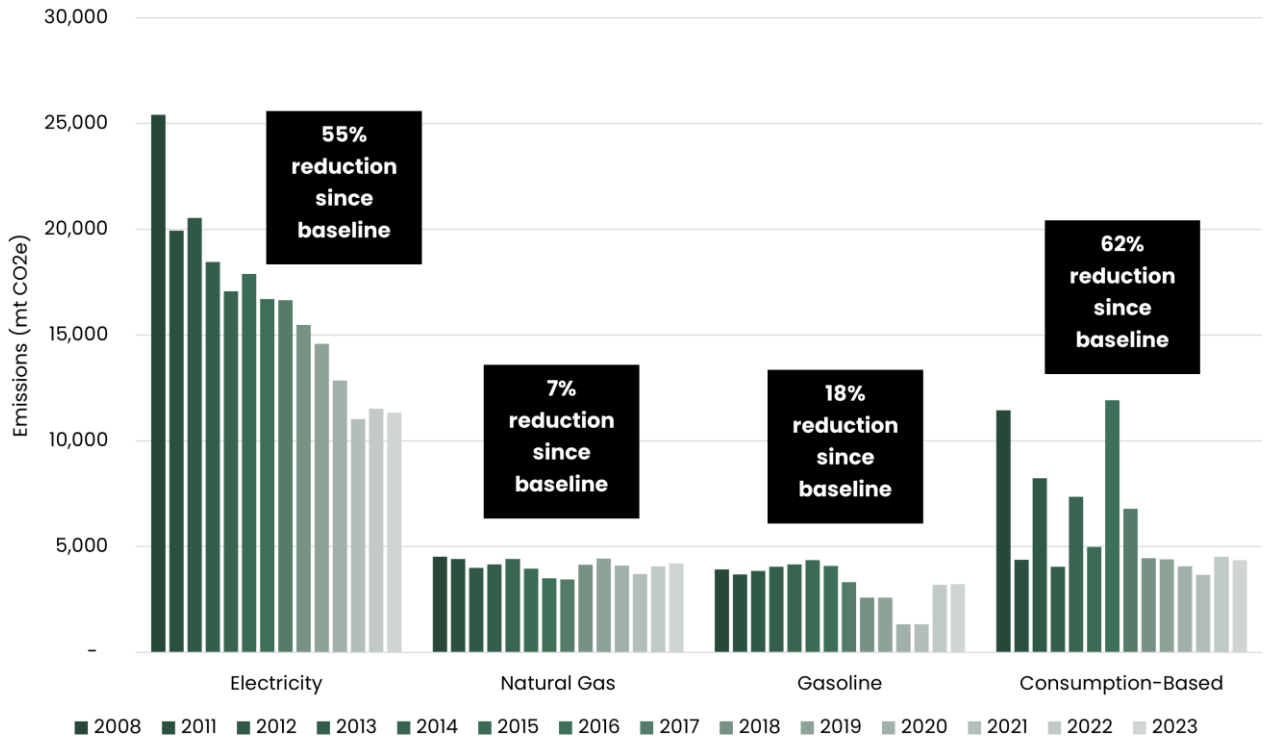

Figure 13. Emissions from Boulder's four-largest emissions sources, 2008-2023.

Table 7. Emissions by source comparison between 2008, 2022, and 2023 (mt CO_2e).

Source	2008	2022	2023	Percent Change (2008-2023)	Percent Change (2022-2023)
Electricity	25,409	11,517	11,328	-55%	-2%
Natural Gas	4,520	4,072	4,216	-7%	4%
Gasoline[13]	3,025	3,198	3,221	-18%	1%
Ethanol	35	8	59	71%	667%
Diesel (Mobile and Stationary)	1,026	2,342	2,022	62%	-14%
Propane	292	173	228	-22%	32%
Biodiesel	12	1	0	-98%	-87%
Jet Fuel	30	61	60	97%	-3%
Solid Waste	148	234	270	82%	15%
Wastewater Treatment	1,579	589	592	-63%	0%
Consumption Based	11,445	4,520	4,361	-62%	-4%
Refrigerants	34	230	310	821%	35%
Totals	**47,555**	**26,946**	**26,667**	**-44%**	**-1%**

CONCLUSION

Municipal emissions decreased one percent between 2022 and 2023. Currently, emissions need to decrease approximately five percent per year to meet the 2030 goal of 80 percent emissions reduction compared to 2008 emissions. Continually, the city is working to implement climate action strategies across its operations and the impacts have been seen over time. Additionally, the city has a Facilities Master Plan[14] (FMP), which outlines future planned improvements, consolidation, deep retrofits, and new builds. It will be important for the city to continue working on implementing the strategies listed in the plan, starting with working on facilities it has some or full control over. Other work includes transitioning its fleet vehicles to electric vehicles,[15] encouraging waste diversion at its facilities, and tracking annual emissions in order to reach the 2030 goal and fully engage in climate action.

[13] Fuel emissions from gasoline, ethanol, and diesel reflect usage by Boulder fleet vehicles and equipment as well as employee commuting fuel use.

[14] See: https://bouldercolorado.gov/media/5927/download?inline.

[15] See: https://bouldercolorado.gov/news/city-install-19-new-electric-vehicle-chargers-across-six-city-facilities#:~:text=The%20City%20of%20Boulder%20is,chargers%20across%2016%20city%20facilities.

APPENDIX A – MUNICIPAL ENERGY USE EMISSIONS

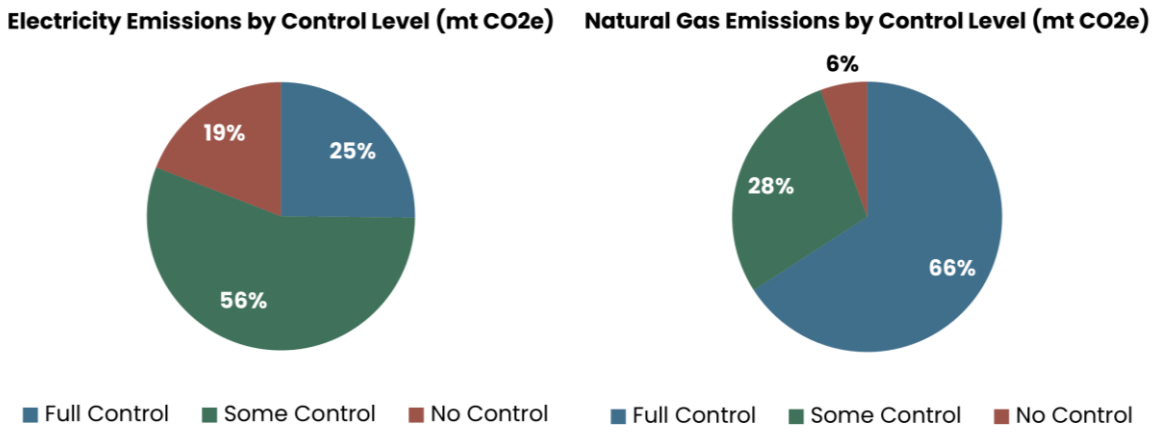

Figure 14. Breakdown of Emissions by City Organization. Full control includes police, fire, general fund facilities, and parks and recreation. Some control includes OSMP and the airport. No control includes public works, water treatment, community vitality, library, transportation, and minor and other facilities.

In the 2023 inventory, electricity and natural gas emissions have been summarized by how much control the city has over making upgrades to buildings and making decisions on switching fuel sources for building appliances like space and water heating. Facilities in full control include the following departments: police, fire, general fund facilities, and parks and recreation. Facilities in some control include these departments: Open Space and Mountain Parks (OSMP) and the airport. Facilities with limited control include those that fall under the following departments: public works, water treatment, community vitality, libraries (note: libraries transitioned to a library district and leased facilities in 2023), transportation, leased facilities, and minor facilities. See **Error! Reference source not found.** above for the percentage breakdown of electricity and natural gas emissions by control level. While 19 percent of electricity emissions are outside of the city's control to change, only six percent of natural gas emissions are fully outside of the city's control. **Two-thirds of all natural gas use is fully within the city's control; therefore, barring other roadblocks, the city should be able to make significant headway on the 2030 emissions target if work can be done to electrify the facilities they have full control over**.