CITY OF BOULDER

BOULDER COMMUNITY-WIDE GREENHOUSE GAS EMISSIONS SUMMARY REPORT

CALENDAR YEAR 2023

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), Nʉmʉnʉʉ (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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Glossary of Terms

Note that the following terms are sourced from the Global Protocol for Community-scale GHG Emission Inventories (GPC).[1]

Carbon Sequestration

Process by which atmospheric carbon dioxide is taken up by plants through photosynthesis and stored as carbon in biomass and soils.

Circular Economy

Circular economies are resilient and regenerative systems that rethink how materials are produced, used, and discarded. They reuse, repair, and recirculate existing products and materials for as long as possible. Once materials reach the end of their life, they are recycled and transformed into new products.[2]

Consumption-based Emissions Inventory

A consumption-based emissions inventory (CBEI) is a calculation of all the GHG emissions associated with producing, transporting, using, and disposing of products and services consumed by a particular community or entity in a given time period (typically one year). A CBEI is a way to tally up a comprehensive emissions "footprint" of a community.

Cooling Degree Day

Cooling degree days (CDDs) are a measure of how hot the temperature was on a given day or during a period of days.[3]

Emission Factor

A factor that converts activity data into GHG emissions data (e.g., kg CO_2e emitted per liter of fuel consumed, kg CO_2e emitted per kilometer traveled, etc.).

Fugitive Emissions

A small portion of emissions from the energy sector frequently arise as fugitive emissions, which typically occur during extraction, transformation, and transportation of primary fossil fuels. Where applicable, cities should account for fugitive emissions from the following subsectors: 1) mining, processing, storage, and transportation of coal; and 2) oil and natural gas systems.

Greenhouse Gas (GHG) Emissions

Gases that trap heat in the atmosphere. For the purposes of the GPC, GHGs are the seven gases covered by the UNFCCC: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulfur hexafluoride (SF_6); and nitrogen trifluoride (NF_3).

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1 See: https://ghgprotocol.org/sites/default/files/standards/GPC_Full_MASTER_RW_v7.pdf.
2 See: https://bouldercolorado.gov/guide/circular-boulder.
3 See: https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php#:~:text=Heating%20degree%20days%20(HDDs)%20are,%C2%B0F%20has%2025%20HDDs.

GPC

The Global Protocol for Community-scale GHG Emission Inventories (GPC) is a GHG protocol that provides extensive guidance on emissions calculations and reporting for local, subnational, and national governments.

Heating Degree Day

Heating degree days (HDDs) are a measure of how cold the temperature was on a given day or during a period of days. For example, a day with a mean temperature of 40°F has 25 HDDs.[4]

In-boundary Transportation

Includes all transportation of people and freight occurring within the city boundary.

Mode Shift

A shift in the way residents travel to and from locations. This often presents itself as a shift away from driving fossil-fuel powered vehicles to using public transport or other forms of carbon-free transportation like walking or biking.

Transboundary Emissions

Emissions from sources that cross the geographic boundary.

Transboundary Trips

There are typically four types of transboundary trips:

1. Trips that originate in the city and terminate outside the city.
2. Trips that originate outside the city and terminate in the city.
3. Regional transit (typically buses and trains) with an intermediate stop (or multiple stops) within the city.
4. Trips that pass through the city, with both origin and destination outside the city. These trips are not attributed to Boulder for the purposes of the inventory.

Xcel Energy

An electric and natural gas utility company that services eight states in the upper Midwest and Great Plains areas of the Unites States. Xcel Energy is the city of Boulder's primary utility provider.

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4 See: https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php#:~:text=Heating%20degree%20days%20(HDDs)%20are,%C2%B0F%20has%2025%20HDDs.

EXECUTIVE SUMMARY

Boulder's Climate Targets

The Boulder community adopted its first target to reduce its greenhouse gas emissions (GHG) in 2006 and has kept up with scientific findings to ensure their emissions reduction targets align with the effort needed to mitigate the worst impacts from climate change. In 2021 the city joined ICLEI Local Government for Sustainability (ICLEI)'s 150 Race to Zero Campaign, which encourages cities to create and adopt ambitious emissions reduction goals. Boulder currently has the following community-wide GHG reduction targets:

- Reduce emissions 70% by 2030 (against a 2018 baseline).
- Become a net-zero city by 2035.
- Become a carbon positive city by 2040.

Net-Zero Emissions

As close to zero carbon emissions as possible. Any remaining emissions sources can be sequestered naturally through the biosphere.

Carbon Positive

Above and beyond net-zero emissions. A carbon positive community takes in, or sequesters, more carbon than it emits.

Boulder's approach to climate action focuses on driving for systemic changes through policy advocacy at the regional, state, and federal level. Boulder also supports local action through voluntary and regulatory strategies to both enhance community resilience and to build replicable models that can be scaled regionally and nationally to drive market transformation.

Key Takeaways from the 2023 Inventory

Some key takeaways from the 2023 GHG emissions inventory include:

- Emissions decreased from 2022 levels (down 7%) and are still below 2018 levels (down 24%). Compared to the prior baseline (2005), emissions have decreased by 41%.
- To reach the 2030 target, emissions need to be reduced by an average of 7% (of the 2023 total) per year. Since the 2018 baseline, emissions have reduced on average 5% per year.
- The largest reduction in emissions comes from building electricity use, primarily due to cleaner electricity supplies, but also to reduced overall consumption.
- Transboundary travel continues to make up a large portion of emissions from the transportation sector, largely attributable to an increase in non-resident employees, increased visitors, and longer commute distances.
- Emissions from waste have been trending up since 2018 attributable to an increase in waste generation and decrease in composting, likely due to new restrictions on accepted items from the city's composting provider, leading to more waste being landfilled.

2023 Emissions

In 2023, Boulder's community-wide emissions were 24% below the 2018 baseline. This represents a 7% decrease from 2022. Since Boulder adopted its first Climate Action Plan in 2006, there has been steady progress in lowering overall emissions. See Figure 1.

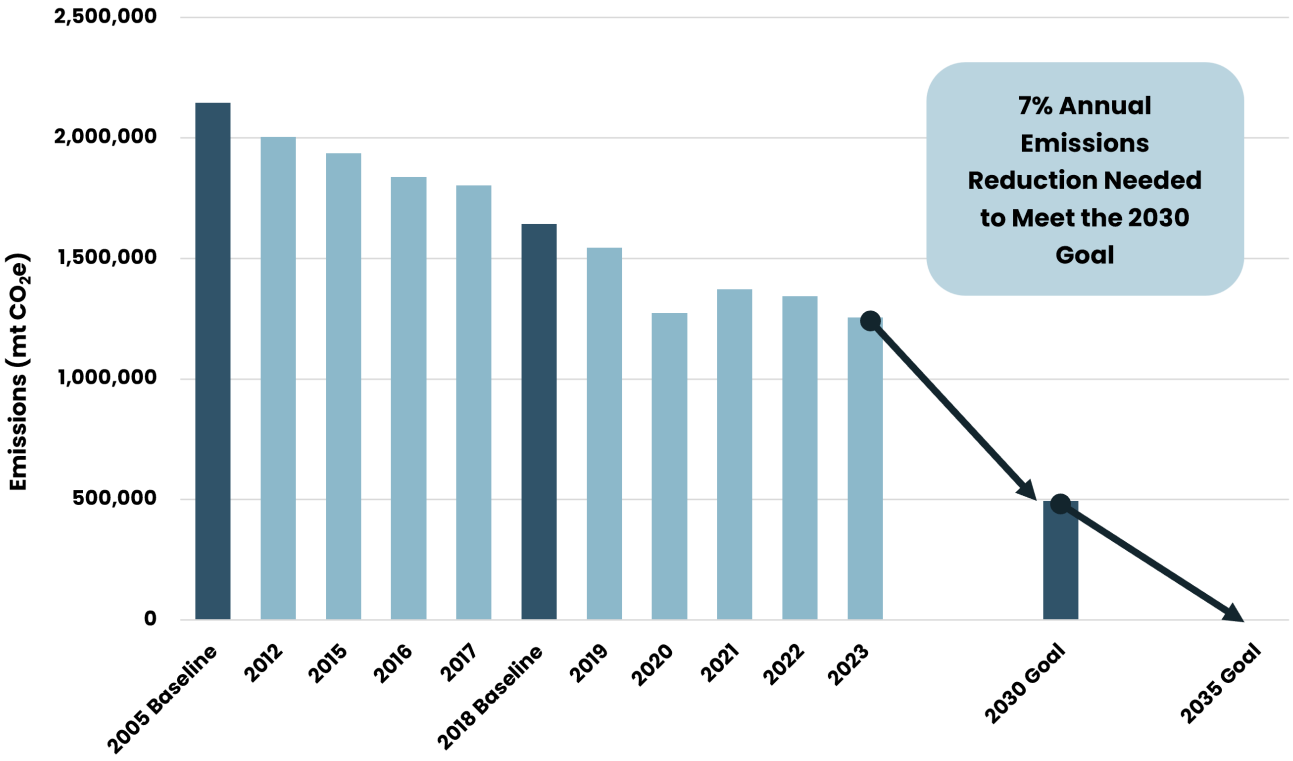

Figure 1. Total greenhouse gas emissions in Boulder since 2005, including the 2030 and 2035 emission reduction targets (mt CO_2e).

In 2023, the biggest contributors to emissions came from:

- Building electricity use (36%)
- Building natural gas use (27%)
- On-road transportation fuels (27%)
- Aviation fuels (8%)

Boulder's community-wide emissions totaled 1,255,278 mt CO_2e in 2023. Building energy use accounted for the majority of emissions (793,105 mt CO_2e), followed by transportation (436,725 mt CO_2e) and solid waste (25,448 mt CO_2e).

Figure 2 provides an overview of total emissions broken out by sector and source.

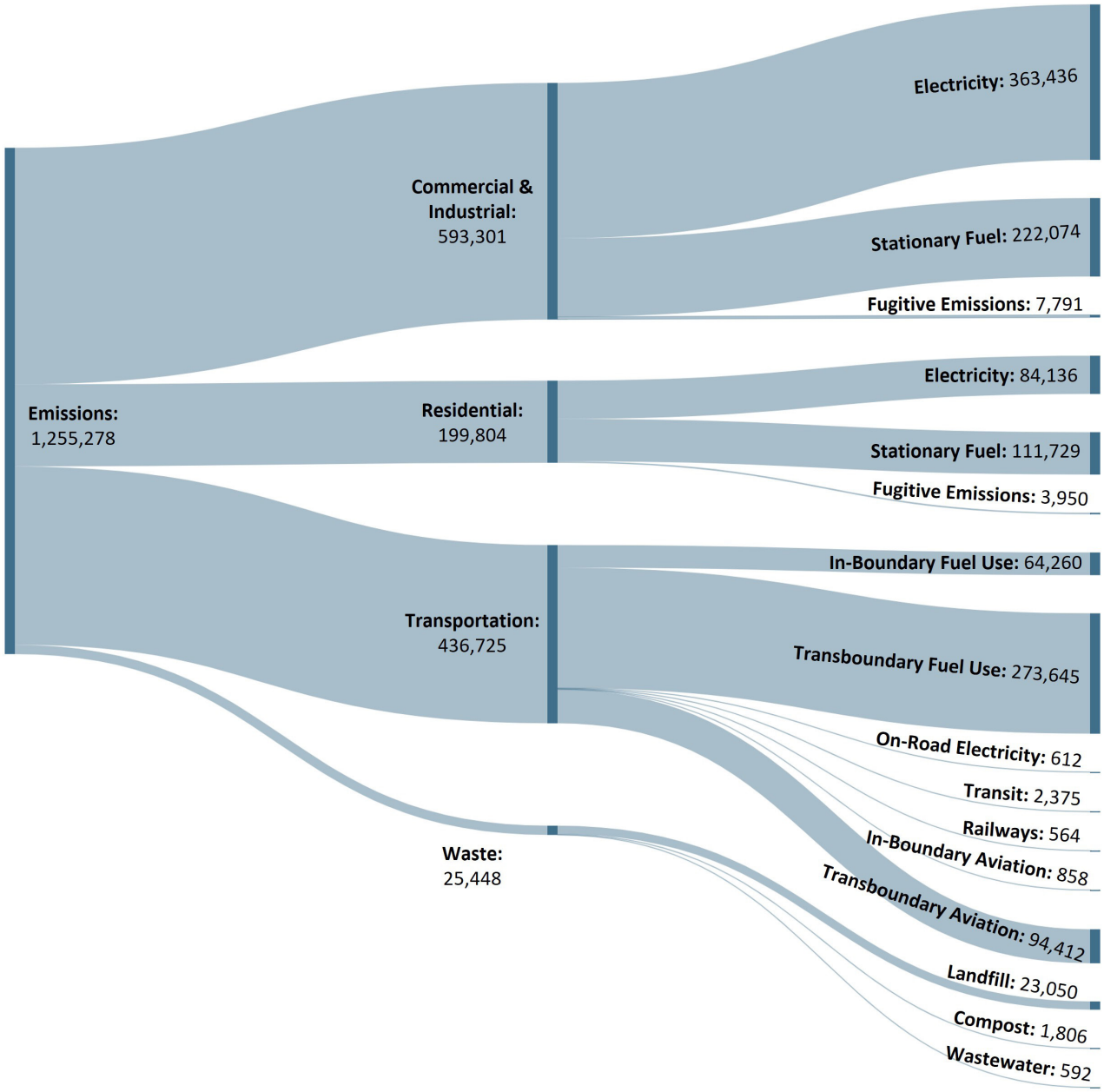

Figure 2. Snapshot of Boulder's 2023 GHG Emissions (mt CO_2e).

Emissions Changes from the Baseline (2018)

Most emissions sources have seen a decrease since 2018. Overall building sector emissions have decreased by 31%; while emissions from building electricity use have gone down 44% since 2018, emissions from building natural gas use emissions have increased 2% (Table 1). Other notable emissions trends include:

- Transportation, including transboundary travel (down 45%).
- Solid Waste (up 17%).
- Wastewater Treatment (down 16%).

Table 1. GHG Emissions by Sector in Boulder in 2018, 2023, and the percent change between those years.

Emission Sector	Emissions in 2018 (mt CO_2e)	Emissions in 2023 (mt CO_2e)	Percent Change
Commercial and Industrial Building Energy Use	873,659	593,301	-32%
Residential Building Energy Use	265,337	199,804	-25%
Transportation	483,425	436,725	-10%
Solid Waste	21,316	24,856	+17%
Wastewater Treatment	704	592	-16%
Total	**1,644,430**	**1,255,278**	**-24%**

Key Priorities for Action

As Boulder works toward achieving its ambitious climate goals and reducing its remaining emissions, the city's key priorities for action include:

- **Achieve emissions-free electricity:** Continue efforts to transition to 100% emissions-free electricity supply.
- **Decarbonize buildings:** Phase out natural gas in buildings through regulations, programming and market transformation.
- **Accelerate the transition to electric vehicles:** Increase adoption of electric vehicles through enhancing access to both public and home charging, continuing to transition buses and fleet vehicles, and promoting existing incentives.
- **Reduce single-occupancy vehicle trips:** Implement strategies to encourage sustainable transportation modes, particularly for non-resident commuters, including regional and local transit investments and programs to incentivize use of sustainable modes.
- **Reduce consumption and increase material reuse:** Prioritize programs that community members minimize overall consumption and waste generation and encourage reuse throughout Boulder's material and waste streams.
- **Leverage nature-based solutions:** Protect and expand existing forests and urban trees to absorb additional carbon, while also enhancing resilience to climate impacts.

INTRODUCTION

The Boulder community has been working on climate action and reducing community-wide greenhouse gas emissions throughout this century. Since 2016, Lotus Engineering and Sustainability (Lotus) has served as the City's contractor for calculating community-wide and municipal operations greenhouse gas emissions. Lotus follows the Global Protocol for Community-Scale Greenhouse Emission Inventories (GPC), the industry standard, to conduct the annual inventories. This protocol provides a robust framework for accounting and reporting community wide GHG emissions.

This report details the emissions in the community for calendar year 2023. Activity levels in 2023 began to level out and are assumed to have returned to levels seen before the COVID-19 pandemic. Trends seen in this inventory reflect a "new normal" and include trends and impacts from federal and state legislation passed in 2022 and enacted in 2023, including the Inflation Reduction Act, the Bipartisan Infrastructure Act, Senate Bill 22-193, and Senate Bill 22-051. Additionally, the city continues to see the benefits of Xcel Energy's work to reach 100% carbon free electricity by 2050. Tracking emissions trends over time, especially from the baseline year 2018, is critical to meeting the city's goals and targets. This report focuses on 2018 as the reference point (or baseline) with which current emissions are compared. The city also continues to track emissions against its original 2005 baseline year, which remains helpful in evaluating long-term trends.

This report details GHG emission sectors and sources, as well as short- and long-term trends, so that the city is better informed on the next steps regarding climate work and sustainability goals. Tracking emissions across several different sectors, including buildings, transportation, and waste, helps the city develop specific strategies and programs to target emission sources. However, the community's economy is continually growing, increasing concerns over growing GHG emissions, or an opportunity to further reduce per-capita emissions with smart growth planning.

Even with bold action to reduce our emissions, Boulder is not exempt from the increasing intensity and frequency of climate-change-induced environmental changes and disruptions, including droughts, floods, and wildfires. Resilience and equity are vital considerations as the city develops policies to support climate adaptation. Climate change disproportionately affects those who are both least responsible for and most vulnerable to its impacts. Black, Indigenous, or People of Color (BIPOC) communities worldwide unequally bear the burden of climate change, air pollution, and environmental degradation. Communities of color are increasingly concerned about climate change, yet historically, environmental decisions on policy, communications, and programming have been siloed and within a vacuum made by those with race and class privilege. It is thus imperative that Boulder center this context when analyzing the results of this inventory and prioritize partnering with BIPOC communities to shape equitable climate policy for the city. Therefore, all climate actions—both mitigation and adaptation/resilience—must now also integrate considerations to address these intrinsic, structural inequities.

CURRENT EMISSIONS SNAPSHOT

In 2023, Boulder's community GHG emissions totaled 1,255,278 mt CO_2e, which is a 24% reduction from 2018 baseline year emissions. See Figure 3.

Emissions Snapshot

Emissions by Sector

Most of Boulder's emissions in 2023 came from building energy use (63%). Emissions from Commercial and Industrial building energy use totaled 47% of all emissions (593,301 mt CO_2e) while Residential energy use totaled 16% of emissions (199,804 mt CO_2e). Transportation-related emissions make up the majority of the remaining emissions at 35% (436,725 mt CO_2e). Solid waste and wastewater treatment emissions together comprised just over 2% of emissions in 2023 (25,448 mt CO_2e).

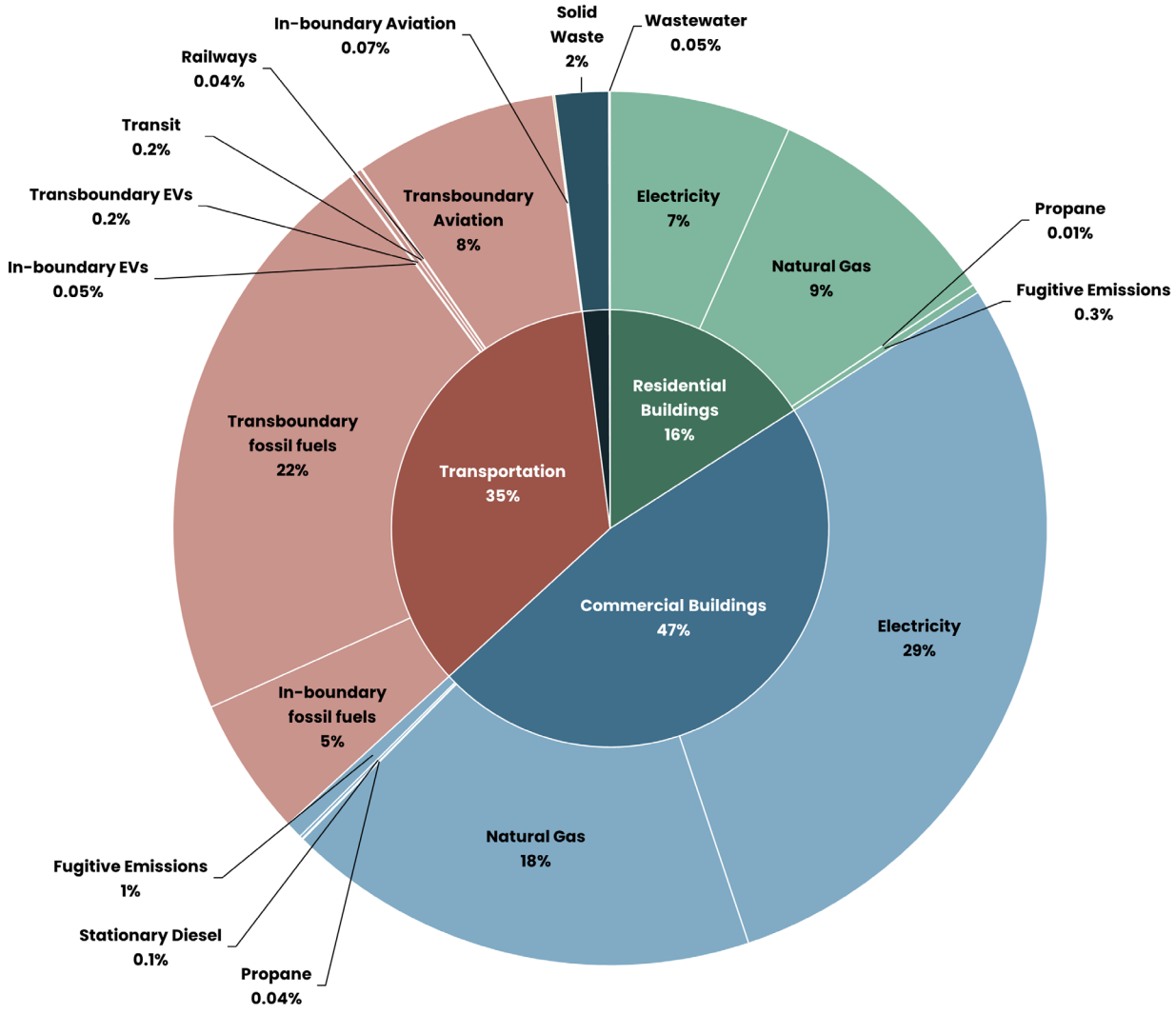

Figure 3. Summary of emissions by sector and source for the City of Boulder in 2023.

Emissions by Source

The ranking of sources by quantity of emissions remains the same in 2023 as it was in 2022. The emission sources from largest to smallest are as follows: electricity (36% or 447,572 mt CO_2e), transportation fuels (35% or 436,725 mt CO_2e), stationary fuels (27% or 345,533 mt CO2e), solid waste (2% or 24,856 mt CO_2e), and wastewater (0.05% or 592 mt CO_2e). See Figure 4. As compared to 2022, the share of stationary fuel increased from 25% to 27%, while the share of electricity emissions dropped from 38% to 36% and transportation fuels remained at 35%.

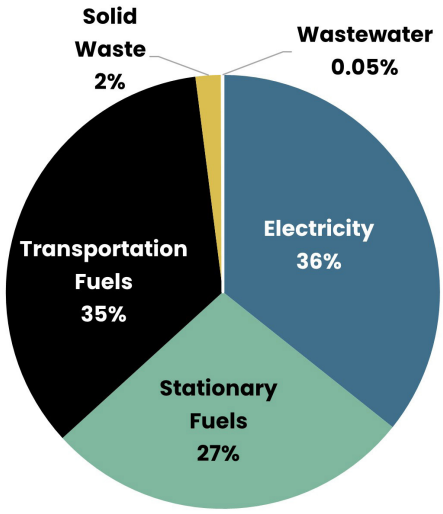

Figure 4. Emissions by source including transboundary transportation emissions (mt CO_2e).

IS BOULDER ON TRACK TO MEET NEW TARGETS?

The city of Boulder's current emission reduction targets are:

- Reduce emissions 70% from 2018 levels by 2030.
- Become a net-zero city by 2035.
- Become a carbon positive city by 2040.

To reach the target of a 70% reduction by 2030, Boulder's emissions need to be reduced by an average of 7% (of the 2023 total) per year (See Figure 5). Since the 2018 baseline, Boulder's emissions have reduced on average 5% per year, meaning the emissions reductions from now until 2030 need to nearly double to meet the goal. While this may appear daunting, several market forces will likely accelerate Boulder's progress in the coming years. Electricity emissions will continue to drop as Colorado's remaining coal plants are retired, with the last operating plant set for retirement by the end of 2030. Boulder's electricity provide, Xcel Energy, is on a trajectory to exceed an 80% reduction in system-wide grid emissions by 2030 as compared to their 2005 baseline and continues to support the city in developing strategies to close the gap towards Boulder's 100% emissions-free electricity goal.

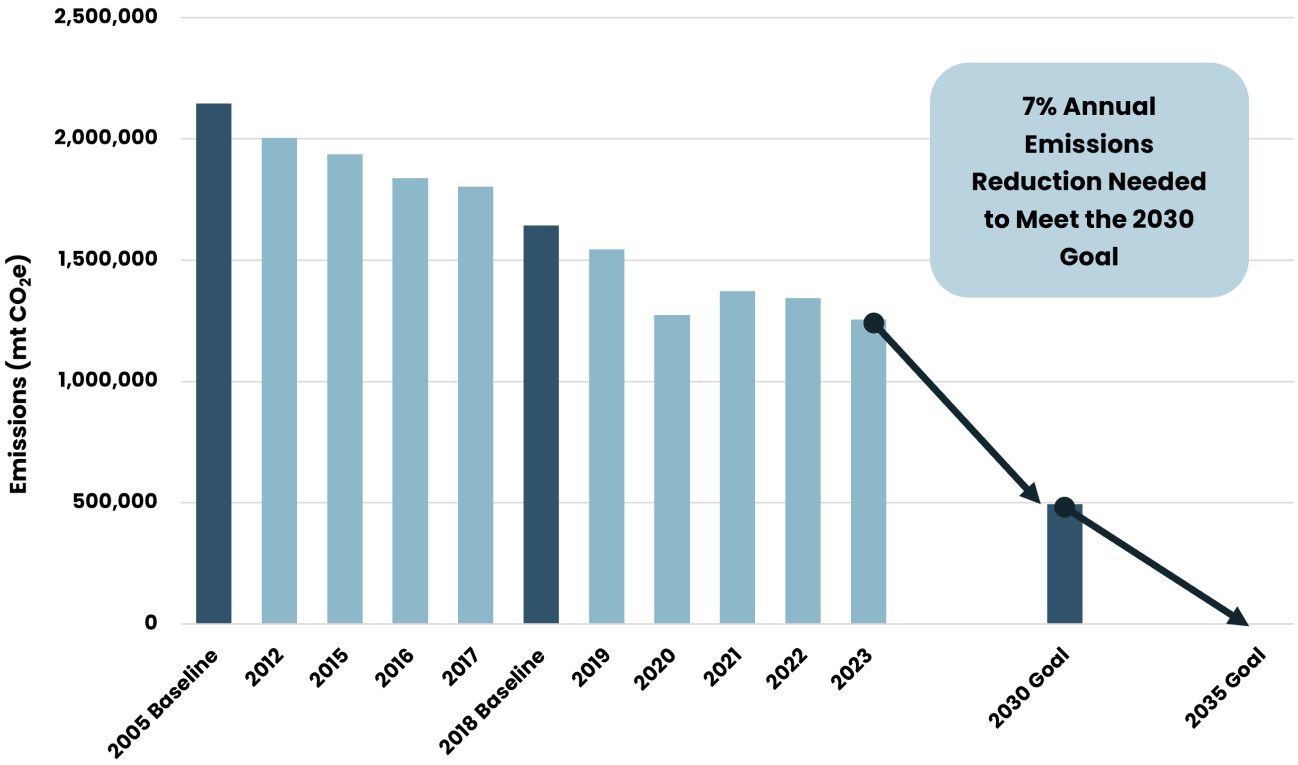

Figure 5. Historical emissions from 2005 – 2023 and in comparison to Boulder's 2030 and 2035 emissions reduction targets. Annual emissions reductions of approximately 7% are needed in order to achieve the 2030 target.

Investments approaching $1 billion will be made in regional building decarbonization over the next five years, enabled by federal grants and utility incentives. This includes Boulder's partnership with the Denver Regional Council of Governments (DRCOG) on the Climate Pollution Reduction Grant.[5] Electric vehicle adoption continues to accelerate as more models are now entering the market. Through their Energy Partnership Agreement, Boulder and Xcel Energy have outlined strategies and priorities that, if fully implemented, could reduce overall emissions 68% below 2018 levels by 2030 (2% below the 2030 target).[6] Additionally, efforts are also underway to address the composting limitations that underlie Boulder's setback in solid waste emissions.

5 See: https://engage.drcog.org/cprg.
6 See: https://bouldercolorado.gov/media/11217/download?inline.

KEY TRENDS DRIVING EMISSIONS IN 2023

Now past the fluctuations of the COVID-19 pandemic, emissions are showing a steady decrease over time. The inventory showed a decrease of 7% (89,093 mt CO_2e) between 2022 and 2023 and a reduction of 24% (389,153 mt CO_2e) from the 2018 baseline (Figure 6).

As Boulder seeks to track progress towards its goals, it is important to understand short-term influences on emissions and how those influences may alter previously persistent trends. The COVID-19 pandemic caused a significant short-term reduction in emissions, as seen in Boulder's 2020 inventory. What its sustained influences will be on transportation, buildings, consumption, and waste are still unknown. As seen in 2022, and again in 2023, benefits realized through a rise in hybrid and remote work have been offset by increases in single-occupant vehicle travel and longer commutes. Similarly, food delivery and takeout models that were critical for sustaining food service and groceries during the pandemic have become a now-expected convenience that contributes to increased solid waste and transportation emissions. While Boulder's 2023 emissions are likely now indicative of the post-pandemic new normal, 2024 will likely again see another shift due to the effects of inflation. While these global health and economic influences complicate community GHG analysis, persistent trends in emissions reduction are still evident.

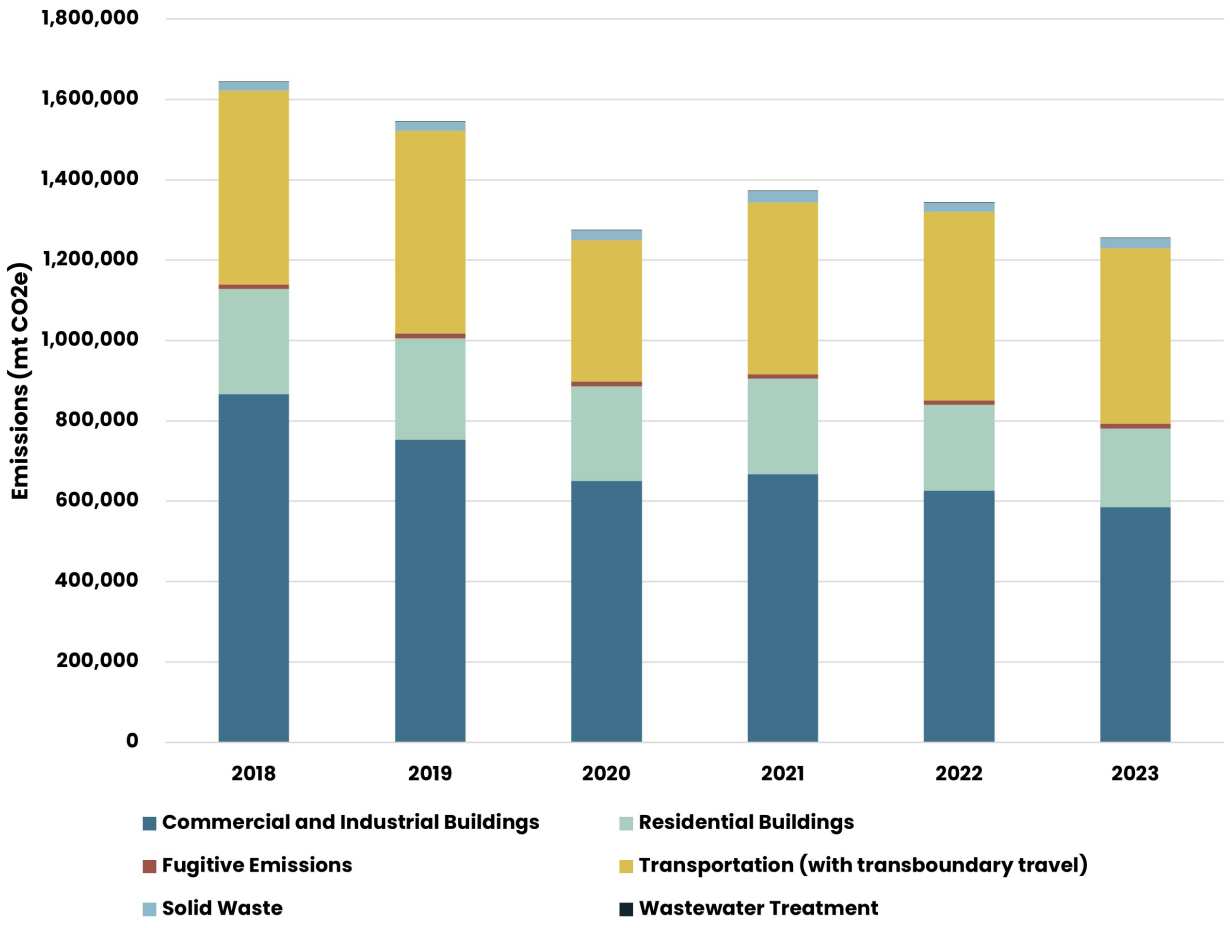

Figure 6. Emissions by sector by year since the 2018 baseline (mt CO_2e).

What's Driving Changes in Emissions Since 2018

Since the baseline year of 2018, several factors have been at play in reducing emissions in the City of Boulder (Table 2). Some of these factors include:

- **Xcel Energy's decreasing electricity emissions:** Xcel Energy's electricity emission factor has decreased 53% since 2005 due to increased renewable energy resources on the electric grid and reduced reliance on coal. The emissions factor has decreased 23% since 2018 and decreased 5% since 2022. State policy requires Xcel Energy to reduce their emissions 80% by 2030 and provide 100% emissions-free electricity by 2050.[7] Current projections suggest Xcel Energy will achieve an 85% or more reduction by 2030 and could realize near-zero emissions as early as 2040.
- **Increase in the number of housing units and commercial square footage:** While the city has limited growth boundary and infill opportunity, redevelopment has led to an increase in both the number of housing units and the total amount of commercial square footage in the city since 2018.
- **Increase in local renewable energy generation:** According to Xcel Energy's community energy reports, there has been a 237% increase in enrollment in Xcel's renewable energy programs as well as installations of rooftop solar systems in Boulder since 2018. In 2023, the city met its 2030 target of 100 MW of local generation. Local renewables can help reduce the community's emissions from the building energy sector.
- **Increase in adoption of electric vehicles and buses:** Since 2018, Boulder has seen substantial growth in the adoption of electric vehicles. At the start of 2018, there were 863 registered electric vehicles; by the end of 2023, there were 6,125 registered electric vehicles in the city. That is a 610% increase in registrations in a short period of time. The city also partners with Via Mobility to operate the HOP bus route and aims to electrify the HOP fleet, with 3 buses already electrified and 7 on order (representing 63% of their fleet) and the goal to have an entirely electric fleet by 2030.
- **Shifts in transportation patterns:** Transportation emissions from fossil fuel vehicles within Boulder's boundaries (in-boundary) have decreased 43% since 2018 and 10% since 2021. In contrast, transboundary emissions increased 16% since 2018 and increased 13% since 2021. In-line with these data, in-boundary vehicle miles traveled (VMT) have decreased in recent years while transboundary VMT have increased. This is largely due to an increasing workforce (with 11% more service area jobs since 2018) and increasing commute distances (with an increase in non-resident employees). Contributing to this trend are limitations in regional transit options and increasing housing unaffordability in Boulder and surrounding communities.

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7 See: https://leg.colorado.gov/bills/hb19-1261.

Table 2. Emissions trends by sector and source in 2018 and 2023.

Emission Source	2018 Emissions (mt CO_2e)	2023 Emissions (mt CO_2e)	Change between 2018-2023
Building Energy			
Electricity	799,836	447,572	-44%
Natural Gas	338,024	343,505	2%
Propane	N/A	572	N/A
Diesel	1,136	1,456	28%
Transportation			
On-Road Fossil Transportation (In boundary)	104,579	64,260	-39%
On-Road Transit (Diesel Buses)	5,132	2,310	-55%
Electric Vehicles and Buses	246	677	175%
Transboundary On-Road	272,105	273,645	1%
Railways	96	564	488%
Transboundary Aviation	100,405	94,412	-6%
In-Boundary Aviation	852	858	1%
Waste & Wastewater			
Solid Waste	18,233	23,050	26%
Composting	3,083	1,806	-41%
Wastewater	704	592	-16%
Total	**1,644,430**	**1,255,278**	**-24%**

Putting it into Context

Normalized metrics[8] help identify broader trends over time and compare Boulder to other communities. From 2018 to 2023, most metrics showed a decrease, except for EV registrations and waste per resident. Many metrics also decreased between 2022 and 2023, while some increased, including waste per resident, residential natural gas use per housing unit, and in-boundary travel per resident. Year over year values might fluctuate for a variety of reasons, so analyzing the overarching trends over time is helpful for understanding how climate actions are impacting the city's GHG emissions (Table 3).

8 Normalized metrics are intensity ratios that can be used in GHG emissions accounting to scale the net generated emissions by business metrics or other financial or community indicators, such as emissions per person or emissions per job.

Table 3. Normalized Metrics.

Emission Metrics[9]	2018 Baseline	2022	2023	Change Since 2018
Total emissions per person (mt CO_2e/resident)	15.1	12.4	11.6	-23.1%
Total emissions per Gross Domestic Product (GDP) (mt CO_2e / $)	0.00007	.00004	0.000035	-49.6%
Residential electricity per housing unit (kWh/housing unit)	5,230	5,390	5,207	-0.4%
Residential natural gas use per housing unit (therms/ housing unit)	460	453	454	-1.4%
Commercial & Industrial electricity use per building floor space (kWh/sqft)	23.0	18.7	17.3	-24.6%
Commercial & Industrial natural gas per building floor space (dekatherm/sqft)	0.088	0.086	0.086	-2.3%
In-boundary travel per person (VMT/resident)	2,209	1,368	1,487	-32.7%
% of registered vehicles that are electric	1.45%	4.86%	7.43%	412%
Landfill tons per person (tons/resident)	0.79	0.78	0.83	5.1%

Heating and cooling degree days are another metric that can be used to provide context around emissions trends. A heating degree day is a measure of how cold a day is compared to a median temperature, usually 65F, while a cooling degree day measures how warm a day is compared to a median temperature. These metrics can help understand if the climate is warming or cooling and how that may impact energy use. For example, a particularly cold winter will lead to a spike in heating degree days and an increase in energy used to heat homes and buildings, most likely from natural gas. If a summer is particularly hot, a spike in cooling degree days would be expected and the energy used to cool homes and businesses would also spike, most often from electricity.

9 It should be noted that multifamily electricity and natural gas use is classified by Xcel Energy as Commercial energy use rather than residential energy use.

As shown in Figure 7, despite some year-to-year variation, heating degree days have decreased 19% since 2018 while cooling degree days have increased by 56% since 2018. This matches meteorological data that suggests the past few years have been the hottest on record. Therefore, the need for energy to heat homes and buildings in Boulder would be expected to decrease into the future, while energy used to cool homes and buildings would be expected to increase.

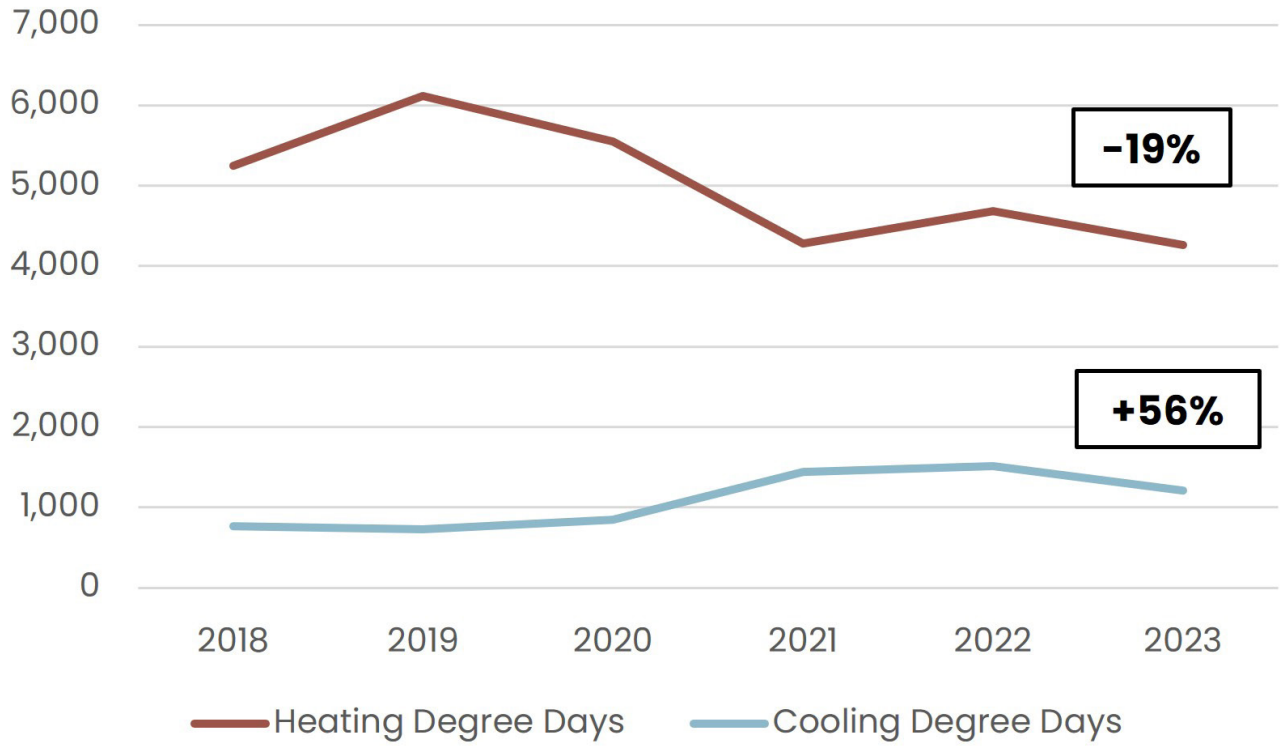

Figure 7. Changes in the number of heating and cooling degree days in the City of Boulder from 2018-2023.

BUILDING ENERGY

Building energy use made up 63% of Boulder's 2023 emissions inventory, similar to 2022. This sector remains the biggest driver of emissions, and an important focus for emission reduction strategies.

The largest source of building energy emissions is commercial and industrial electricity use at 46%, followed by commercial natural gas use at 28%. This is a continuation of the trend seen in recent years, as commercial energy use has historically been higher than residential. Residential natural gas use is next at 14%, followed by residential electricity use at 11%. Smaller sources of emissions from propane, stationary diesel use, and fugitive emissions total the remaining 1% of emissions. See Figure 8.

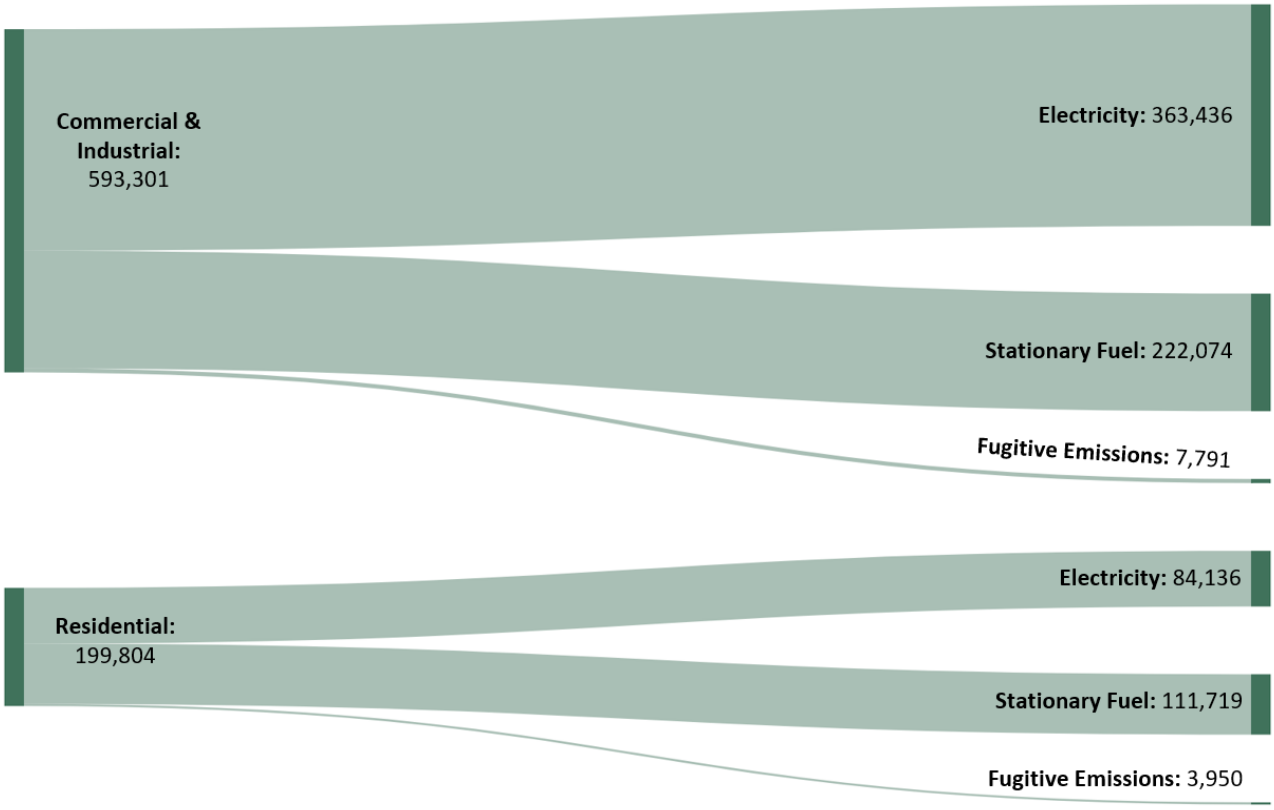

Figure 8. Building energy sector breakdown (mt CO_2e).

Building Energy Trends

The largest single contributor to the drop in emissions from building energy use over time is declining electricity emissions. Between 2022 and 2023, building electricity use emissions decreased by 13% and have decreased 44% since 2018. In contrast, building natural gas use emissions increased 2% from 2022 to 2023, and have similarly increased 2% from 2018. Emissions from other building fuel use increased slightly in 2023 from 2022 and has largely fluctuated over time. See Figure 9.

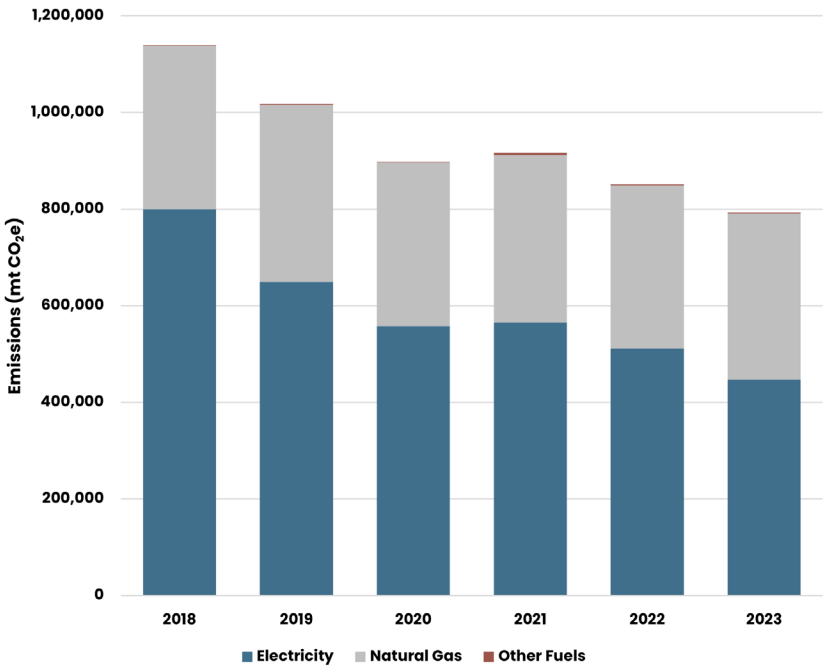

Figure 9. Emissions from building electricity use, natural gas use, and other fuel use from 2018-2023 (mt CO_2e).

Decreasing Electricity Emissions

The overall reduction in building electricity use emissions since 2018 stem from:

- **Reduction in electricity usage:** Since 2018, electricity used in residential homes has decreased by 19% while commercial electricity usage has decreased 20% since 2018. Boulder's aggressive energy codes ensure that as new buildings are constructed and older ones remodeled, the building stock becomes increasingly efficient. Improvements are also promoted through other regulations and voluntary program participation. While buildings will continue to become more efficient, it is expected that future inventories will show electricity use increasing due to electrification of buildings and transportation. Increases in electricity use and associated emissions would be offset by the much larger emissions reductions from decreasing natural gas and transportation fuel use. The emissions impact of rising electricity use will also decline as the electricity grid continues to become cleaner. See Figure 10.

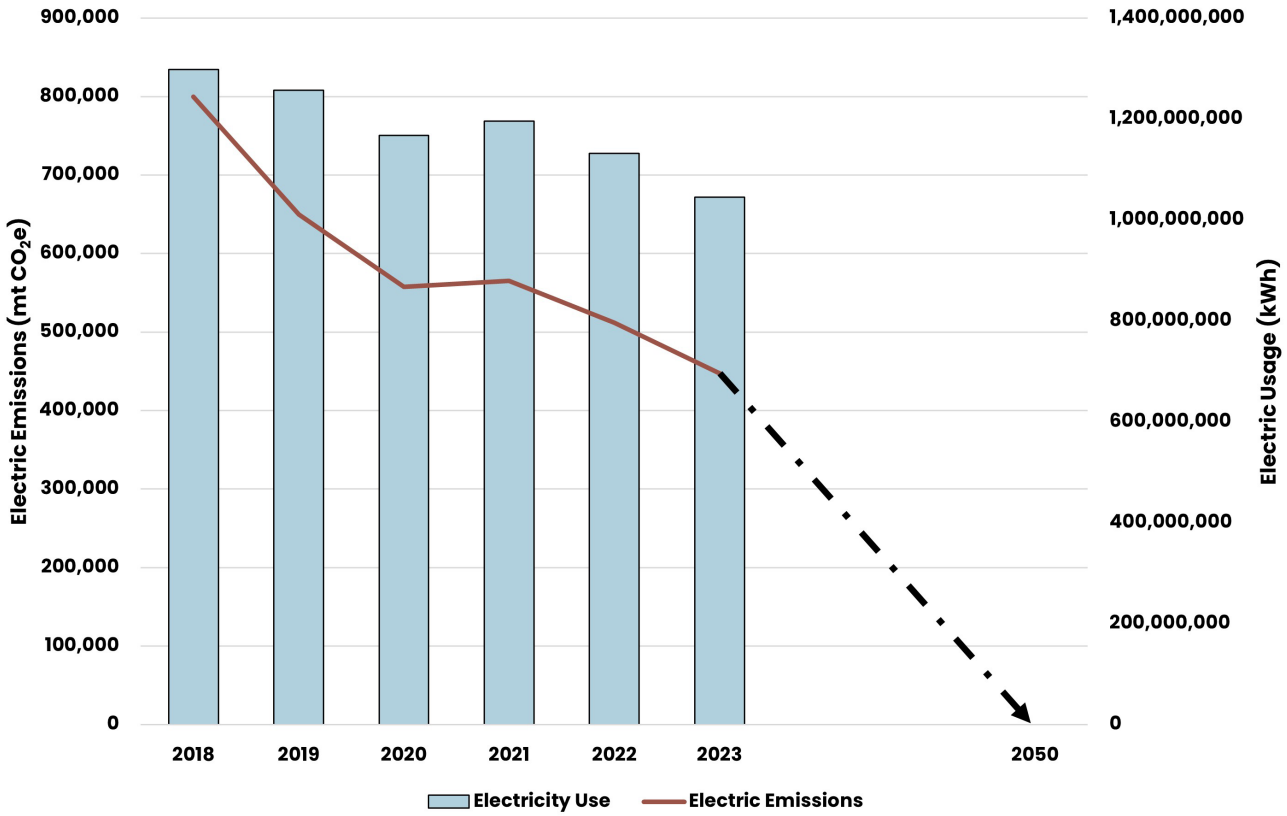

Figure 10. Comparison of past electricity usage and emissions from 2018-2023, with projected electricity emissions out to 2050.

» **Cleaner electricity:** The electricity grid in Colorado is continually adding renewable energy sources, as well as benefiting from the accelerated retirement of coal plants. Xcel Energy has been required by Colorado's Renewable Energy Standard[10] and the state's Clean Air Clean Jobs Act[11] to add more renewable energy resources to the grid and to reduce the company's greenhouse gas emissions. State legislation adopted in 2019 requires investor-owned utilities, like Xcel Energy, to reduce electricity generation emissions 80% compared to 2005 levels by 2030 and be carbon-free by 2050.[12] The utility reports its electricity emissions factor annually and has seen steady annual reductions, including an overall reduction since 2018 of 23%. See Figure 11 below. By 2030, Xcel Energy's electricity emissions factor is forecasted to decline 75% from 2018 levels.

10 See: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/2022-25%20RES%20Plan%20Notice.pdf.
11 See: https://www.xcelenergy.com/environment/system_improvements/colorado_clean_air_clean_jobs.
12 See: https://leg.colorado.gov/bills/HB19-1261.

» **More local renewable energy generation:** The city's 2016 Climate Action Plan (the "Climate Commitment") set a goal to generate at least 100MW of renewable energy locally by 2030, which was achieved in 2023. The 2023-2025 Partnership Agreement between the City of Boulder and Xcel Energy revised the target to 145 MW of local generation and storage by 2030.

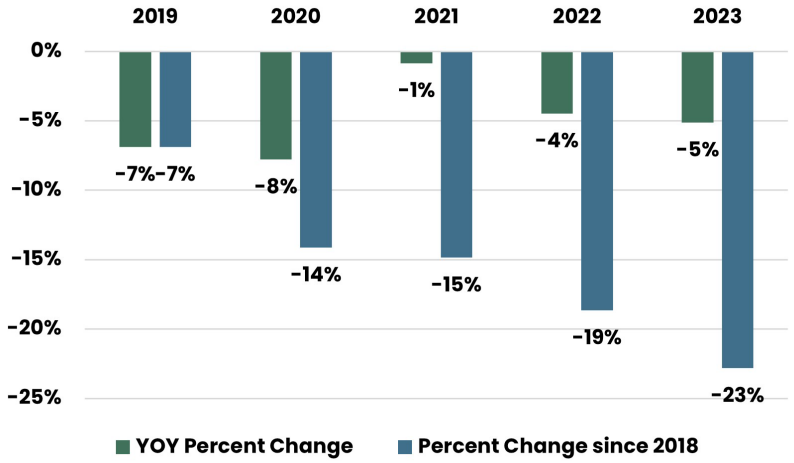

Figure 11. Change in Xcel Energy electricity emission factors since 2018.

Increasing Natural Gas Emissions

As Boulder's electricity is getting cleaner and electricity use has been declining, natural gas usage is making up a greater share of building energy emissions, as shown in Figure 12. In the commercial sector, natural gas emissions increased from 20% to 28% since 2018—commercial building area increased 7% and GDP increased 41% during the same period. Similar trends are occurring in the residential sector, where natural gas emissions increased from 11% to 14% since 2018. Since emissions from natural gas now make up a larger proportion of building energy emissions than electricity use, this emphasizes the need to convert homes and businesses from natural gas heating to electric heat pumps. Other stationary energy sources (e.g., diesel, propane) make up a minimal proportion of emissions but are still important to consider phasing out to help reduce emissions.

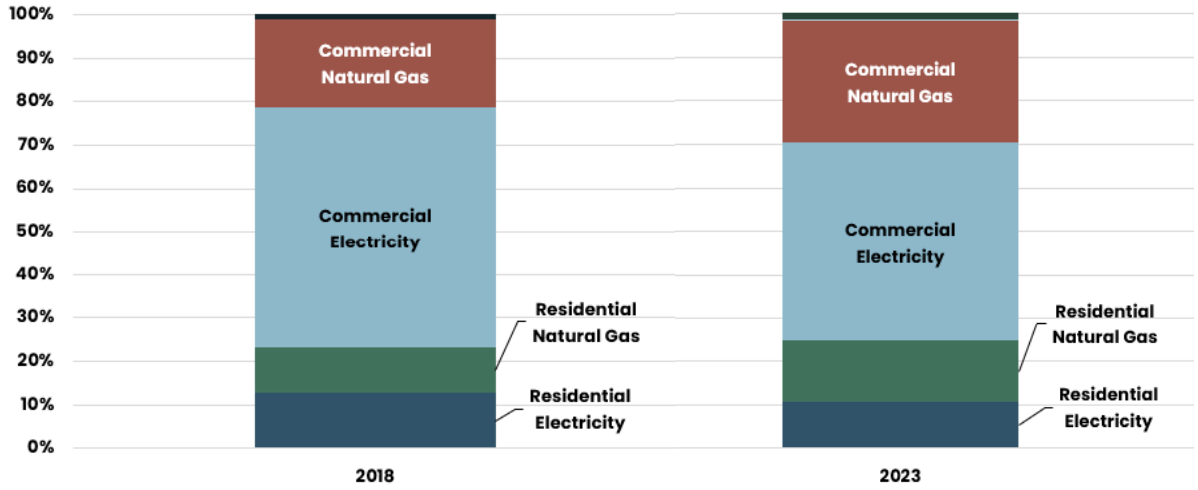

Figure 12. Stationary energy emissions breakdown in 2018 (left) and 2023 (right) (mt CO_2e). Included in the top bar are emissions from propane, stationary diesel, and fugitive natural gas emissions.

Priorities for Action

Strategies for reducing energy emissions through shifting energy generation from fossil fuels to renewables and making buildings more efficient have long been central to the city's plan to mitigate the climate crisis. In recent years, Boulder's work on systems change in the energy sector has focused significantly on achieving a cleaner electricity grid. Electricity generation has consistently comprised more than half of Boulder's emissions, making the sector a key target for climate action. In 2020, the city entered a new franchise with Xcel Energy, with a core goal of achieving emissions-free electricity by 2030. Additionally, the city focuses beyond just achieving an emissions-free electricity supply, ensuring that energy affordability, resilience, and reliability become cornerstones to the transition to a clean energy system.

To effectively address the remaining emissions gap, Boulder must prioritize transitioning away from natural gas in buildings. Strategies should include:

- **High-performance, emissions-free, healthy buildings:** Developing innovative financing solutions for efficiency and electrification that will provide increased affordability and access for residents with lower incomes, ensuring use of low carbon building materials in construction, enhancing workforce and market development for affordable HVAC retrofits and new builds, determining the optimal placement, and pairing of local generation and storage to optimize resilience and demand management.
- **Clean energy sources:** Continuing work with Xcel Energy to ensure a 100% emissions-free electricity supply and to provide affordable access to local solar and storage.

TRANSPORTATION

In 2023, emissions from the transportation sector, including emissions from transboundary transportation, totaled 35% of the city's GHG emissions. This report considers Boulder's emissions with transboundary travel. Transboundary emissions include emissions from travel that occur outside the city boundary, but that are the result of actions taken by Boulder residents or commuters coming into Boulder. In-boundary emissions occur fully (start to finish) within Boulder's city limits. See Figure 13 for a breakdown of emissions in the transportation sector.

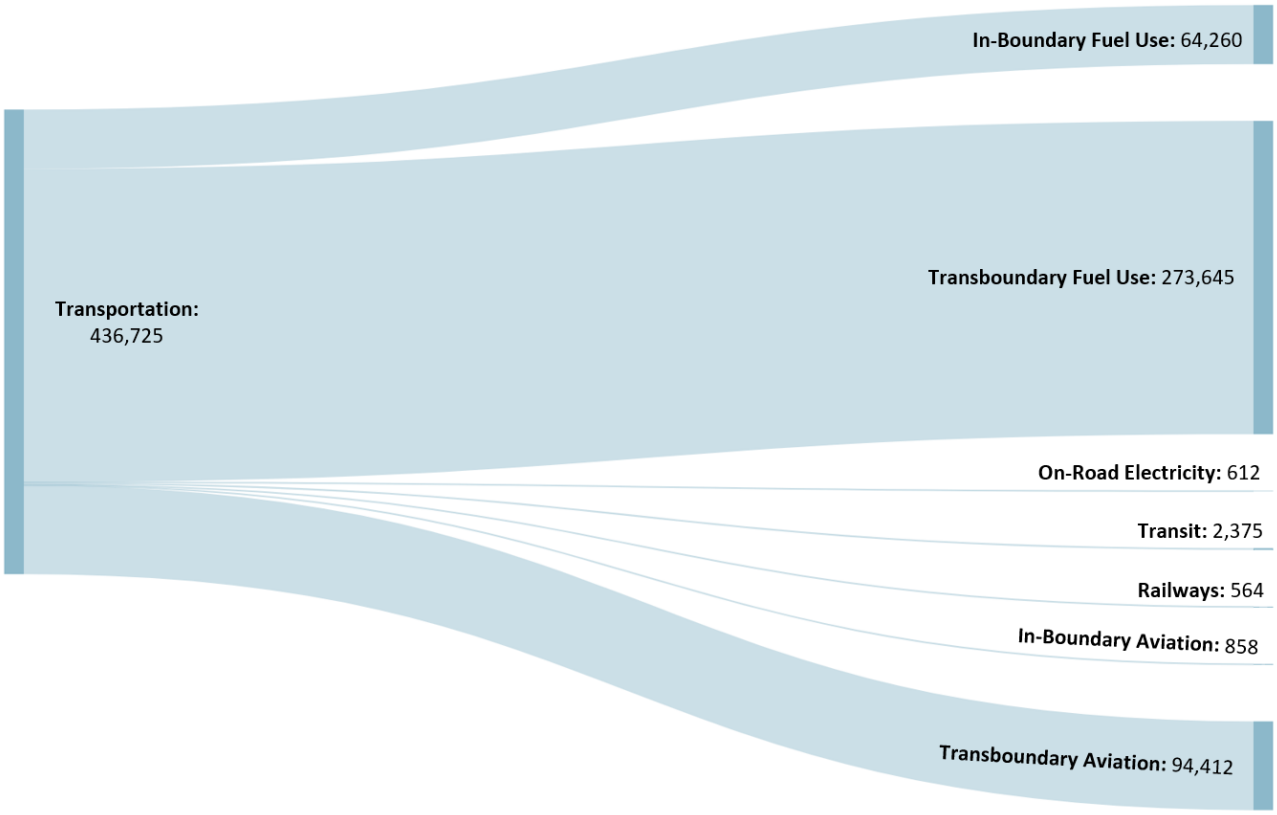

Figure 13. Transportation sector emissions breakdown (mt CO_2e).

Emissions from transboundary transportation (84% of total transportation emissions) include:

- Transboundary on-road transportation: Emissions from trips that occur outside Boulder's boundary (using 50% of the vehicle miles traveled) where the city is the start or end of the trip (62.7% of total transportation emissions).
- Transboundary aviation: Emissions from flights out of DEN (21.6% of total transportation emissions) that are attributable to the city based on the city's share of passengers.

Emissions from in-boundary transportation (16% of total transportation emissions) include:

- In-boundary on-road transportation: Emissions from all vehicle trips that start and end within Boulder's boundaries (15.4% of total transportation emissions). This also

includes transit activities occurring within Boulder. See Figure 15 for breakout of miles by type.

» In-boundary railways: Emissions from freight rail fuel use (0.1% of total transportation emissions).

» In-boundary aviation: Emissions from flight activity at Boulder Municipal Airport (0.2% of total transportation emissions).

Transportation Trends

Transportation emissions in Boulder decreased by 7% in 2023 compared to 2022, and by 10% from 2018 levels (Figure 14). In-boundary emissions are lower than in 2018, though increased slightly in 2023 from 2022. On the other hand, transboundary emissions decreased both year over year and since 2018.

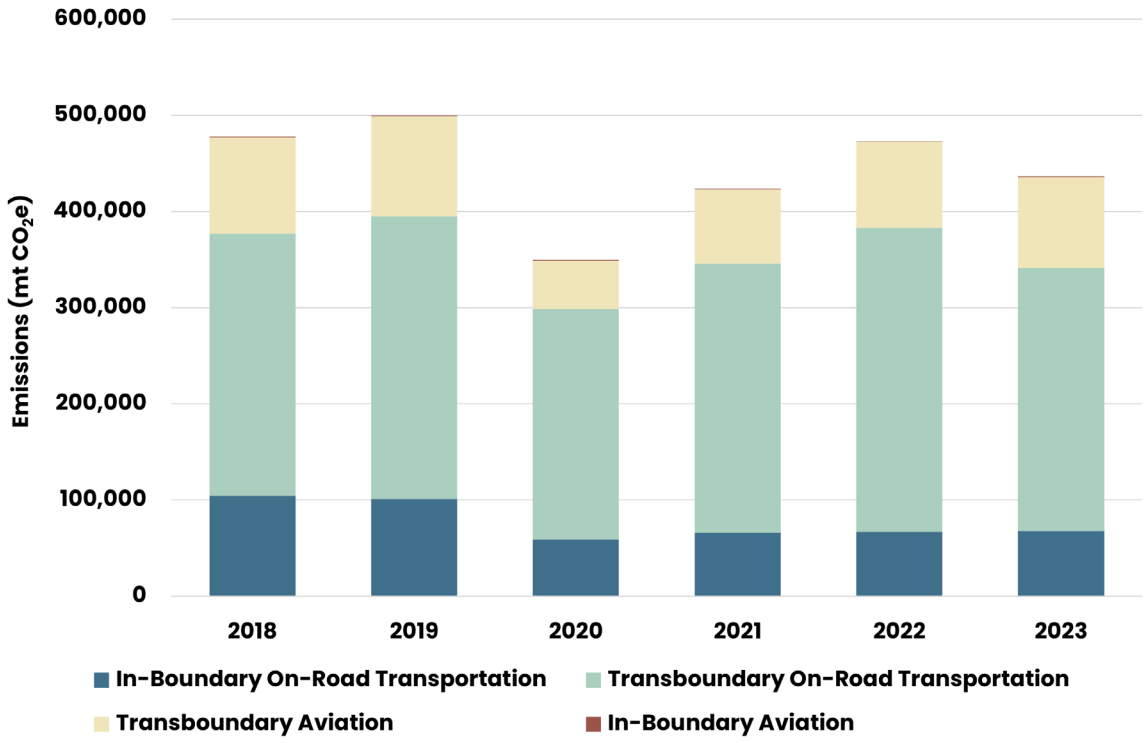

Figure 14. Change in transportation emissions since 2018.

The recent changes in transportation emissions can be seen in the following trends:

» **Vehicle trips return to pre-pandemic levels:** As Figure 15 conveys, total VMT increased more than 10% between 2018 and 2019, then dropped dramatically in 2020 due to the pandemic. VMT increased in 2021 and again in 2022 but decreased slightly in 2023, and total VMT in 2023 is nearly equal to the VMT total in 2018.

» **Shift in employee commuting:** Many offices are now back to in person or hybrid work schedules. Recent trends show a pronounced difference in travel behavior between Boulder resident- and non-resident employees. Based on the most recent community survey, for work trips, Boulder residents drive alone less (53% of resident

employees) and use more multimodal options (23% of resident employees), while 80% of non-resident employees drive alone and only 2% take the bus, bike, or walk to work. Boulder resident-employee commutes are generally shorter, while non-resident commutes are increasing—48.6% reported a commute distance of 11-20 miles and 29.3% reported a commute distance of more than 20 miles.[13]

» **In-boundary vs. transboundary transportation shift:** Since 2018, both in-boundary and transboundary emissions have decreased. Since 2022, there has been a slight increase (2%) in in-boundary transportation emissions and decrease (9%) in transboundary transportation emissions. The growth in electric vehicle usage has contributed to the overall decrease in emissions. Though transboundary on-road VMT is higher than it was in 2018 (Figure 15), a larger portion of that VMT is from EVs, causing the total emissions in 2023 to be nearly identical to the emissions in 2018. The overall decrease in in-boundary VMT as compared to 2018 could be showing a mode shift in residents taking alternative forms of transportation, like transit, electric scooters, or walking/biking, rather than taking trips in a single occupant vehicle.

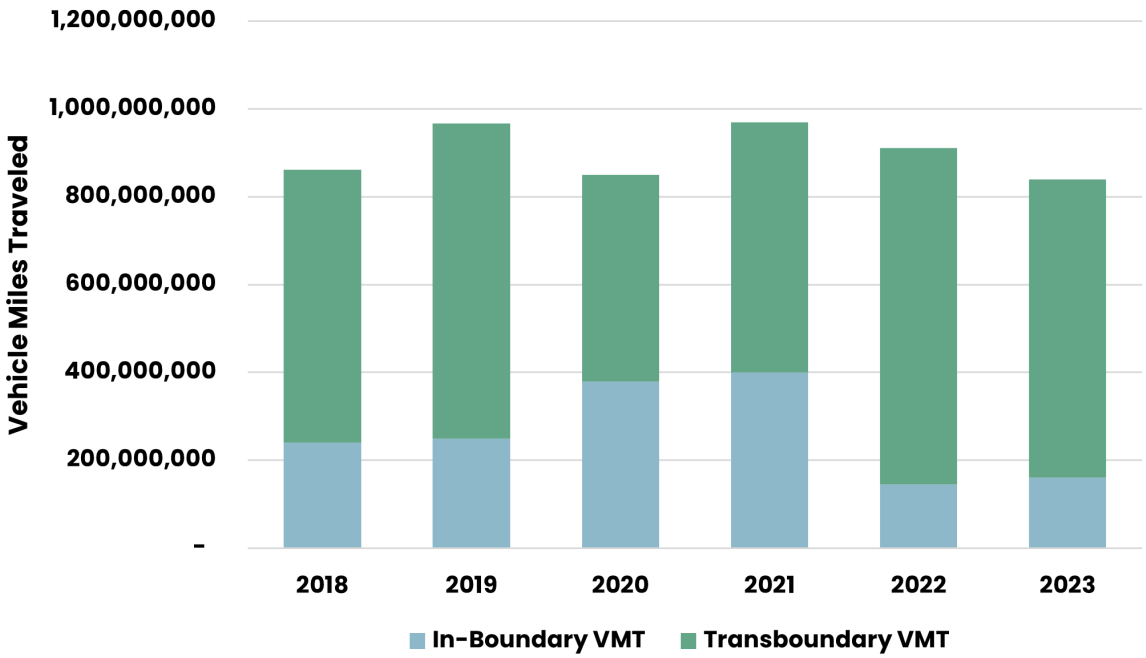

Figure 15. In-boundary and transboundary VMT from 2018-2023.

» **Rebound in aviation travel:** Jet fuel usage increased 5% between 2022 and 2023 but is still down 8% since 2018. Aviation gas usage increased 44% between 2022 and 2023 and has also increased 27% since 2018. Jet fuel is used in airplanes with turbine engine jets (commercial airliners) while aviation gas is used in airplanes using propellers or piston-engines.[14] For commercial airliners, this trend is consistent with the easing of the pandemic; fuel usage has generally decreased since 2018 but is returning to pre-pandemic levels. For smaller airplanes, fuel usage has not bounced back yet.

13 See: https://bouldercolorado.gov/media/4807/download?inline.
14 See: https://airplaneacademy.com/the-differences-between-avgas-jet-fuel-auto-fuel-and-diesel/.

» **Increase in fuel efficiency:** According to the EPA, fuel efficiency standards have increased 32% since 2004.[15] Higher fuel efficiencies mean less fuel used per mile. Colorado's adoption of California's Clean Car Standards should lead to the production and sale of more fuel-efficient vehicles and, in turn, lead to fuel and emissions reductions.

» **Increase in electric vehicles:** The community saw 1,721 additional EV registrations in 2023, the most in a single year for the third straight year. The total number of EVs in Boulder has risen from 1,417 in 2018 to 6,125 in 2023. The city's EV adoption rate (percent of total vehicle registrations that are EVs) has also jumped from 1.45% in 2018 to 7.43% in 2023. See Figure 16. Boulder County now has the second-highest EV adoption rate in the state, slightly behind Pitkin County.[16] Continuing to increase the proportion of vehicles as electric vehicles will help Boulder to reduce its emissions from the transportation sector.

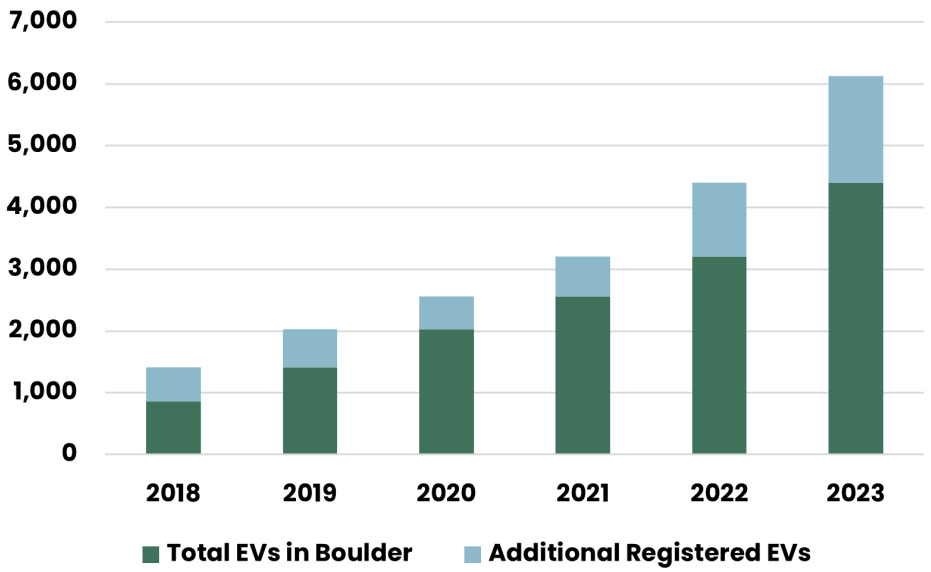

Figure 16. Total and additional annual registered electric vehicles in the City of Boulder, 2018-2023.

Priorities for Action

The comprehensive overview of Boulder's transportation policies, plans, and actions going forward can be found in the 2019 Transportation Master Plan[17] (TMP) and the 2020 TMP Progress Report.[18] The report details the city's efforts to address transportation emissions (with a target of reducing transportation emissions 50% by 2030 against a 2005 baseline) through a set of aggressive, city-funded programs and services. Residents and businesses in Boulder can also help the city reach the goals in the TMP by reducing their own vehicle miles traveled and using carbon-free modes of transportation more frequently. Regarding emissions reductions, transportation-related efforts include:

15 See: https://www.epa.gov/automotive-trends/highlights-automotive-trends-report.
16 See: https://bigpivots.com/top-counties-for-ev-sales-per-1000-residents/.
17 See: https://bouldercolorado.gov/media/1045/download?inline=.
18 See: https://bouldercolorado.gov/media/1047/download?inline.

» **Increase EV adoption and access to charging:** Work toward achieving the community goal of 30% EV adoption by 2030. Pursue funding opportunities for public charging infrastructure, expanding home charging access beyond single-family homes, developing low-income access opportunities, pairing EV charging with solar, and electrifying RTD, city, BVSD and CU bus fleets.

» **Reducing single-occupancy vehicle trips, particularly from non-resident commuters:** Transit improvements are a key strategy in reducing long-term emissions, while also creating a more livable, healthy community. Strategies include:

- **Regional Multimodal Investments and Coordination:** Continue to coordinate with regional partners on multimodal corridor investments including bus rapid transit (BRT) service and regional bikeways. Regional BRT investments are critical to addressing non-resident employee commuting by providing regional travel options that can compete against personal vehicles in travel time and cost.
- **Local Multimodal Transportation Investments:** Continue investing in multimodal infrastructure and programs outlined in Boulder's 2019 Transportation Master Plan (TMP).
- **Vision Zero:** Continue to implement the strategies and recommendations in the Vision Zero Action Plan. Safer travel conditions can increase the number of transit, biking and walking trips and shift trips away from motor vehicles.
- **Micromobility Program:** Expand electric bikeshare and shared e-scooter programs, which can replace vehicle trips for many trips around the city and provide a critical first and final mile solution for transit users.
- **Transportation Demand Management (TDM):** Continue to work with local employers and Boulder Transportation Connections to implement TDM programs that provide employee commute benefits such as the RTD EcoPass or Parking Cash-Out programs. As a model employer, the city will continue to provide commute benefits and telework options to city employees.

» **Explore emerging transportation policies and technologies:** Research and evaluate emerging mobility options including expanded micromobility programs, rideshare systems, connected/automated vehicles, and new heavy transport options (e.g., renewable natural gas or diesel fleet vehicles). Develop policies on more effective curbside management to improve access to the curb, and rethink use of public right-of-way to increase multimodal access.

WASTE AND WASTEWATER

Waste (solid waste and compost) and wastewater emissions in 2023 were 2% and 0.05%, respectively, of overall emissions (Figure 17). These emissions only include treatment of the waste and do not include "embodied emissions," or emissions associated with the production of goods that are later disposed in the landfill; these emissions are capture in Boulder's Consumption-Based Emissions Inventory.[19]

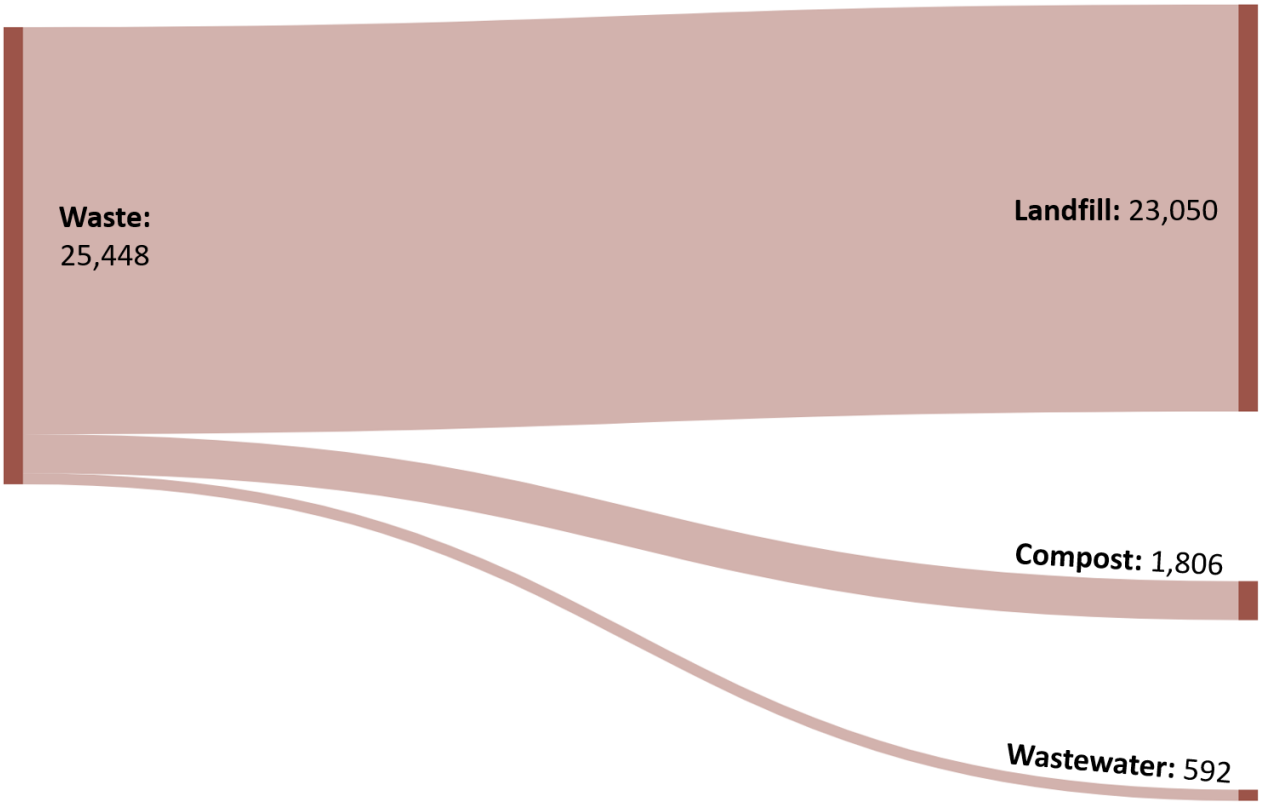

Figure 17. Waste sector breakdown (mt CO_2e).

Waste and Wastewater Trends

Landfilled waste emissions are trending up since 2018 (up 26%) and are up from 2022 (up 6%). Compost emissions have steadily decreased since 2018 (down 41%) and decreased from 2022 (down 13%), which means composting is decreasing and more compostable materials are likely ending up in the landfill. Emissions from wastewater have also fluctuated every year, though they have leveled off since 2021, with an overall decrease of 16% since 2018. See Figure 18.

19 See: https://bouldercolorado.gov/media/13343/download?inline.

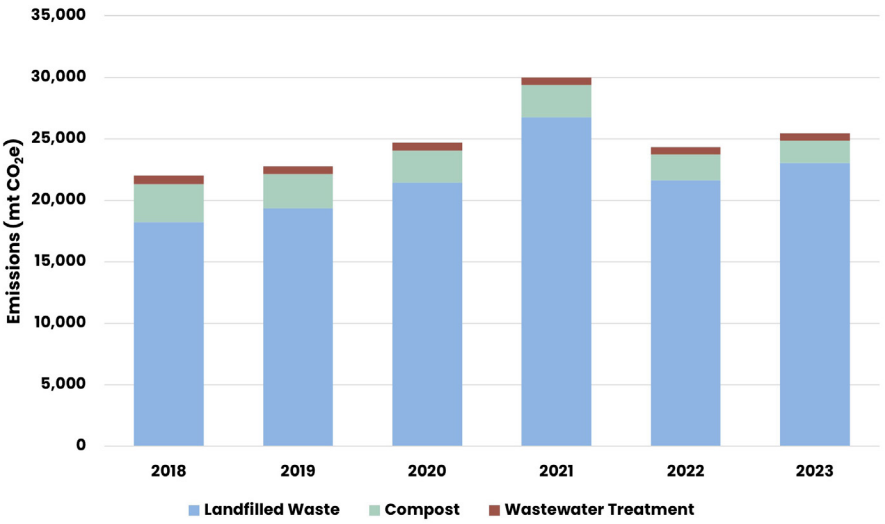

Figure 18. Landfilled waste, compost, and wastewater treatment emissions from 2018-2023 (mt CO_2e).

Waste and wastewater trends can be attributed to:

- **Increasing waste generation:** In 2022, there were challenges collecting data from the waste haulers required to report to the city through the ReTrac system. These issues were not encountered in 2023, therefore year over year waste tonnage has increased (reflecting better data accuracy). Since 2018, waste tonnage has increased 5%. This could be due to a variety of factors, like new and redevelopment of buildings, contamination of the recycling and compost streams, and changes in population and/or visitation. The slight increase in landfilled waste since 2018 is illustrated in Figure 19.

- **Reduced composting rates:** Composting tonnages and therefore emissions have been falling since 2018. This decline in composted waste is shown in Figure 19. Although compost does release methane, it diverts organic matter from the landfill, creates fewer emissions than landfilling, and increases soil health and water retention. Reduced compost tonnage means increased landfilled tonnage and emissions. In 2023, A1 Organics introduced new restrictions on items accepted at their compost facilities, making it important to track trends in waste and composting tonnages going forward to see the impacts of those restrictions.

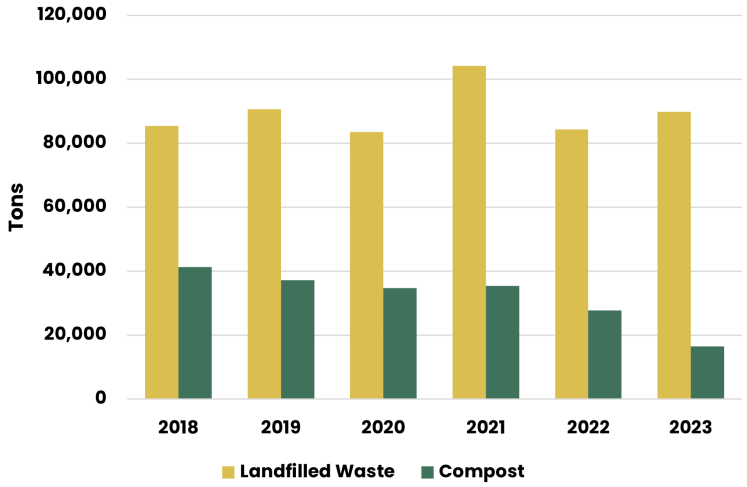

Figure 19. Annual change in waste and compost tonnage 2018-2023.

- **Wastewater:** Emissions from the wastewater treatment plant have declined 16% since 2018 and have remained level since 2021. Wastewater treatment emissions are a function of several inputs: population, treatment plant processes (such as nitrification and flaring of digester gas), and quantity of wastewater treated. These emissions do not include energy use at the treatment plant, which are captured in Building Energy. Population and quantity of wastewater treated are inherently linked, therefore fluctuations in population over time have impacted the city's wastewater treatment emissions over time.

Priorities for Action

Boulder's focus is transitioning beyond traditional zero waste goals of diverting waste for recycling to a more comprehensive approach to change the system of consumption and keep materials in circulation as long as possible. As a first step, the city produced the Circular Boulder analysis and roadmap, which examined the current level of circularity in Boulder throughout the local materials economy, and completed a Consumption-Based Emissions Inventory to assess impacts of household-level consumption.[20]

To address remaining emissions from the waste-sector, strategies should focus on addressing consumption and material reuse, including:

» **Reduce consumption of consumer goods:** Reduce consumption-based emissions through lower carbon choices (local, etc.), minimizing single use plastics, maximizing reuse and repair opportunities, promoting sharing platforms over direct ownership, and supporting market development for recyclables.

» **Enhance circularity in the built environment:** Promote adoption of low-carbon construction materials, design buildings for sustainable deconstruction, maximize reuse of building materials during deconstruction, and support market development for building material diversion.

» **Increase reuse of organics materials:** Increase the circularity of the local organics economy by minimizing food waste, maximizing the production of clean compost, and exploring innovative methods such as biochar production to regenerate natural systems within our community.

With the commitment to new overarching emission mitigation goals for the community, Boulder also established a set of new objectives, targets, and short-term progress measures (next one to five years) which are detailed below to track progress towards our transition to a circular materials economy.

20 See: https://bouldercolorado.gov/media/13343/download?inline.

NATURE-BASED CLIMATE SOLUTIONS

The city's 2016 Climate Commitment introduced a new focus on the role of ecosystems in climate action. In 2017, the city and Boulder County initiated their first respective carbon sequestration initiatives, both on agricultural holdings. Land plays an important role with regard to climate change. Well-managed ecosystems can act as a sponge, absorbing both carbon and water from the atmosphere, while also fostering community resilience through enhancing the ability of ecosystems to absorb and buffer extreme conditions and disruptive climate change. At the same time, these carbon sinks and water cycling capabilities are at risk of depletion from disturbances such as forest and grassland degradation and desertification, wildfire and drought, and urban sprawl.

Forests and Trees Outside Forests

The city has been working to quantify the GHG impacts of its lands and ecological processes. One of the first areas it has done so is through its forestry work, on both urban and natural lands. In 2021, the city participated in ICLEI's cohort to calculate the total GHG emissions, removals (i.e., sequestration or sinking potential), and carbon storage (i.e., sink) from land use and land use changes in the city's forest lands—both natural forests managed through Open Space and Mountain Parks (OSMP), and urban forests. The objective was to begin integrating the results of these assessments into the city's annual inventory process.

The results of this 2021 analysis indicated that the total amount of carbon stored in Boulder's forests and trees within the city boundary are approximately 350,000 metric tons as of the latest period of analysis (2016-2019), with the large majority (69%) stored in urban tree canopy and the remaining 31% stored in forests. When including the entire 40,000+ acres of open space and park lands within the boundary of analysis, the amount of carbon stored is about 2.3 million metric tons, with the vast majority (75%) located within forested lands (Figure 20). A subsequent analysis of carbon sinks and carbon cycling on the city's open space and park lands further concluded that there is a total carbon sink of approximately 2.7 million metric tons.

Figure 20. Total carbon stored in Boulder's forests and trees outside forests (urban trees).

In addition to calculating the total carbon stock held within Boulder's trees and forests, the analysis calculated annual emissions and removals (sequestration) that both the forests and larger ecological systems absorb annually. When summing the total emissions produced by trees that were lost or damaged, primarily through wildfire, with the amount of carbon removed from the atmosphere from existing and new trees, a net annual GHG change figure was calculated, with negative values representing removals and positive values representing emissions.

Beyond Forests and Trees

Currently, there are no established protocols for capturing carbon sequestration benefits in land management other than forests that can be directly integrated into the city's overall carbon management inventory. The city has explored the potential of working with other organizations in the development of such an inventory. However, as subsequent analysis described below has indicated, the overall annual additional carbon sequestered through city managed lands does not justify the considerable time and expense necessary to develop and maintain such an inventory process annually.

Carbon Sequestration Across all Land Types

Looking beyond just trees and forests, the city recently completed an analysis of the carbon absorption and holding capacity across all city properties lands to assess carbon stored by other land cover types, such as in grasslands, wetlands, biomass, and soils. The total carbon stored across the 36,466 acres of land managed by the city was estimated at 2,768,600 mt CO_2e. Using a cost of carbon of $140 to $380 per mt CO_2e, if all the carbon stored across these lands were released to the atmosphere, it could result in $387 million to $1.05 billion in damages, emphasizing the importance of preserving this existing carbon stock.

City properties do also sequester an additional amount of carbon each year. However, this level of sequestration can vary widely depending on both the availability of water—the driving factor determining carbon cycling—and the level of forest fire. The report found that in some years over the past decade, the prevalence of wildfire has resulted in the city lands being a net producer of carbon emissions. On years not heavily impacted by fire, sequestration rates were projected to range from 8,000 mt CO_2e/year up to 20,000 mt CO_2e, with an average likely to be around 12,905 mt CO_2e of carbon per year. While the carbon stock of OSMP land is large, it cannot reasonably be used to offset annual emissions.

Alternative Ecosystem-Based Approaches

- **Biochar:** Boulder is starting to explore the production and application of biochar within the city's forest systems. Biochar, a form of charcoal-like solid carbon produced by heating organic materials in a low-oxygen environment, locks carbon into a stable form that can be used as a soil amendment and persist in soils for centuries.

- **Wood burial:** The city has also analyzed the effectiveness of wood burial strategies for carbon sequestration. This approach has recently been getting significant attention because of its relative simplicity. However, a study contracted by the city

suggests that there are numerous challenges to such an approach—the carbon intensity of removal and transportation of materials, the difficulty and high costs of maintaining burial sites for 5-10 decades; the potential impact to forests in doing large scale biomass removals—that make such an approach questionable. which implies harvesting large volumes of vegetative biomass and burying them in the ground in order to avoid their oxidation and contribution to carbon dioxide release.

Emissions Snapshot

Annual removals from Boulder's forests and urban trees, including OSMP lands, represent about 2% of the community's annual GHG emissions.

Boulder has not established a regular cadence for updating annual carbon removals from forests and urban trees, and forest cover does not change significantly year-to-year. Therefore, estimated GHG removals from 2021 are detailed below in Table 4. The City of Boulder is not currently factoring these removals into our annual GHG inventory. Overall, while the water-limited ecosystems of the Boulder area do not support large scale annual sequestration of carbon, the carbon already sequestered in the landscapes in and around Boulder is a vital source of ecological function and stability that should be protected wherever possible. Maintaining and expanding the forest in Boulder is an important action that the city can take towards building the city's resilience and simultaneously reducing community wide GHG emissions.

Table 4. Estimated GHG removals of forests and urban trees.

Land Use Sequestration: City Only	Emissions (mt CO_2e)	
	2005	2021
Forests Remaining Forests	(1,073)	(1,041)
Forests Converted to Other Lands & Disturbances	748	641
Other Lands Converted to Forests	(6)	(2)
Sequestration from Urban Trees	(8,795)	(8,898)
Emissions from Urban Trees (due to tree loss)	2,688	58
Total Net GHG Removals	**(6,403)**	**(9,243)**

Land Use Sequestration: City + OSMP Lands	Emissions (mt CO_2e)	
	2005	2021
Forests Remaining Forests	(16,685)	(16,542)
Forests Converted to Other Lands & Disturbances	11,759	16,745
Other Lands Converted to Forests	(20)	(14)
Sequestration from Urban Trees	(21,055)	(20,962)
Emissions from Urban Trees (due to tree loss)	995	0
Total Net GHG Removals	**(26,001)**	**(20,773)**

Priorities for Action

Building on the city's legacy as a leader in open space and environmental protection, the city is advancing and mainstreaming ecosystems as a core focus area for climate action, both in its ability to reduce overall emissions and enhance community resilience. Key priorities for action include:

- **Maintaining and Expanding Urban Forests:** Protect existing forests and trees to prevent conversion to other land uses, and plant additional trees, thereby enhancing carbon sequestration while also providing cooling benefits.
- **Connected Landscapes:** Analyze, design, and implement a broader landscape network, both within Boulder and regionally, that can serve as critical habitat and carbon-rich vegetative systems, providing cooling and carbon sequestration benefits and supporting water management objectives.
- **Green Jobs:** Work in collaboration with Boulder County and the State to support the growth of green jobs and training programs. A robust workforce is critical for effectively maintaining Boulder's natural resources.

CONCLUSION

Each year continues to be warmer than the last. According to the National Oceanic and Atmospheric Administration, the warmest year globally in the modern recordkeeping era was 2023. It was more than 2˚F warmer in 2023 than when records were started in 1850.[21] This warming is leading to negative impacts on the climate, which are being felt in Boulder now. Heat waves, droughts, wildfires, and increasing bad air quality days are happening across the Front Range and remain a threat to people's health, homes, and livelihoods. Boulder set ambitious GHG emissions reduction targets, and the city has committed to taking action to reduce emissions from its municipal operations as well as community-wide. Continuing to track emissions annually helps the city know whether they are on track to meet their goals and if stronger action needs to be taken. While substantial progress has been made to achieve its 2030 and 2035 emission reduction goals, the city will need to accelerate its efforts.

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21 See: https://www.climate.gov/news-features/featured-images/2023-was-warmest-year-modern-temperature-record.

APPENDIX A - METHODOLOGY

Boulder's 2023 GHG Inventory used the same protocol as previous community inventories: the Global Protocol for Community-Scale Greenhouse Emission Inventories (GPC).[22] The GPC protocol provides a robust framework for accounting and reporting community-wide GHG emissions. This protocol is required for cities committed to the Global Covenant of Mayors for Climate & Energy. Boulder signed onto this covenant in 2015.[23] By completing a GPC-compliant inventory, Boulder can report emissions to the Carbon Disclosure Project (CDP),[24] which outwardly demonstrates Boulder's climate change commitments to a global audience. The following report reviews how the 2023 inventory was completed, 2023 GHG emissions sources, and trends in emissions.

Global Warming Potentials

The IPCC releases global warming potential values with each new release of its Assessment Reports. The latest Assessment Report, AR6, was released in August of 2021. The 2021 and 2022 community GHG emissions inventories both use the most up-to-date global warming potentials for CH_4, N_2O, and HFCs.

Utility Emissions

Electricity and natural gas in Boulder are provided by Xcel Energy. Xcel Energy releases annual Community Energy Reports for the communities it serves, which detail the amount of electricity and natural gas used within a community's boundaries. Xcel also provides an annual emissions factor for its electricity and natural gas supply, which is verified externally by the Climate Registry.

Stationary Diesel

The Colorado Department of Public Health and the Environment (CDPHE) collects data on diesel used in industrial boilers and generators. CDPHE provided this data for entities in Boulder. Also included is stationary diesel use for the University of Colorado Boulder (CU); usage data is provided separately by CU.

Propane

Beginning in 2021, Boulder received data on propane consumption by residential and commercial users from a major provider in the community. These data were added to the inventory, but no other data were reported and no data from previous years exist to determine a baseline. This source will be included in all future inventories so it will be possible to study trends.

Vehicle Miles Traveled (VMT)

As previously reported, Boulder changed its VMT methodology in 2021, for the 2020 emissions inventory, to leverage more accurate cell phone data. This new cell phone data source was used again in 2022 and will continue to be used for future inventories. In this year's iteration of the inventory, a small methodology fix was made to divide and allocate in-

22 See: https://ghgprotocol.org/ghg-protocol-cities.
23 See: https://www.globalcovenantofmayors.org/.
24 See: https://www.cdp.net/en/info/about-us.

boundary and transboundary VMT more accurately and in alignment with the GPC protocol. Previously, the transboundary VMT assigned to Boulder was overcounted, so this update decreased VMT emissions for the city. Inventories from 2018 to 2021 were updated to reflect this change.

Transit

RTD operates several bus routes within the city. Additionally, the city owns and operates the HOP route, which has recently added electric buses to the fleet. Emissions from transit are a combination of the electricity used by the HOP buses, fuel used by fossil fuel powered HOP buses, and the fuel used by RTD's buses.

Jet Fuel

Boulder Municipal Airport still provides data on fuel used by planes at the airport. For the 2022 inventory, Lotus updated the methodology for calculating attributable transboundary emissions from Denver International Airport (DEN) to align with methods in use by Boulder County and other Front Range communities. Transboundary aviation emissions from DEN are now calculated by scaling down fuel consumption using the origin/destination-connecting passenger split reported by DEN. In 2022, 59% of DEN's passengers were origin/destination passengers, so 59% of DEN fuel use data were assumed to be attributable to communities in the Denver-Boulder Metropolitan Area. Fuel usage data were then scaled down to the City of Boulder using the population of the metropolitan area compared to the city's population. Previous inventories dating back to 2018 were updated using this new methodology to ensure consistency and comparability.

Railways

The United States Environmental Protection Agency (EPA) tracks fuel use data for all freight trains in the US. Instead of only tracking fuel data, the EPA now reports emissions generated by trains at the county-level. For the 2022 inventory, county-level railway activity emissions were scaled down to the city level using the proportion of railroad miles in Boulder County compared to the city of Boulder.

Waste

Boulder requires waste haulers to report data on waste, recycling, and compost collected within city boundaries. This data is tracked through a system called ReTRAC. Emissions can be calculated based on total tonnage of waste landfilled, the most recent Boulder County Waste Characterization (2019), and emission factors from the EPA's Waste Reduction and Materials tool. It is important to note that due to challenges with data collection from waste haulers in the community, the inventory does not capture the full magnitude of Boulder's 2022 waste emissions; the reported 2022 waste data is likely an underestimate.

Wastewater

The city owns and operates the 75th Street Water Resource Recovery Facility. The plant tracks data on annual wastewater treatment processes, such as denitrification and anaerobic digestion. Emissions from wastewater treatment are calculated using this data.