# CITY OF BOULDER COMMUNITY-WIDE GREENHOUSE GAS EMISSIONS SUMMARY REPORT

CALENDAR YEAR 2022

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), N~~ʉ~~m~~ʉ~~n~~ʉʉ~~ (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.*

Dear Friends and Partners,

Boulder, like many cities across the country, conducts regular GHG emissions inventories to measure the scope and scale of our climate pollution and to help identify opportunities for the greatest impact. 2022's inventory is a wealth of storylines and areas for inquiry, from our community's reemergence from the COVID-19 pandemic to the urgent need to dramatically reduce use of fossil fuels.

Take the COVID-19 story. As restrictions eased and economic activity picked back up, emissions were expected to bounce back, and we saw this in our 2021 emissions report. The rebound was not a total surprise as GHG emission trends are rising across most cities. With that backdrop, we are proud to report that in 2022, Boulder's community-wide GHG emissions have decreased 2% from 2021 and were 18% below the 2018 baseline.

Despite this seemingly positive step in reducing emissions, we must view this year's inventory as a stark reminder of the significant work ahead. Fossil fuel extraction and consumption is still the single-largest contributor to climate change, while we continue to see an increasing number of days of extreme heat, harmful air pollution and environmental degradation—all of which disproportionately impact Boulder's lower income residents and communities of color. We must not accept these disparities as something we are powerless to address.

Another storyline emerging is the more hopeful climate situation in the U.S. The year 2022 marked unprecedented investments in an equitable clean energy economy, ensuring a just transition away from fossil fuels and building healthy, climate-resilient communities. Locally, we're moving forward with policies to reduce emissions from commercial buildings and to help low-to-middle- income residents transition from natural gas to heat pumps. We're also embracing transportation policies that prioritize transit and the electrification of vehicles that move people, goods, and services throughout our city.

We know the road ahead is long, but we're ready to come together to center community, scale what works, and take advantage of new federal, state, and local funding to reduce emissions and adapt to current climate impacts. Thank you for your support.

Sincerely,

Jonathan Koehn

Director of Climate Initiatives, City of Boulder

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# Glossary of Terms

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

### Biogenic emissions ($CO_{2(b)}$)

Emissions produced by living organisms or biological processes, but not fossilized or from fossil sources.

### 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 of the greenhouse gas 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 a year). A CBEI is a way to tally up a comprehensive emissions 'footprint' of a community.

### 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 arises 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 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] For more information see: https://ghgprotocol.org/sites/default/files/standards/GPC_Full_MASTER_RW_v7.pdf.
[2] See: https://bouldercolorado.gov/guide/circular-boulder.

**Global Warming Potential**

A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of $CO_2$.

**GPC**

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

**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.

**Waste Characterization/Composition**

Is the result of a study solid waste composition study, using survey data and a systematic approach to analyze the waste stream and determine the waste source (paper, wood, textiles, garden waste, etc.).

**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.

# INTRODUCTION

The City of Boulder has contracted with Lotus Engineering and Sustainability LLC (Lotus) since 2016 to complete annual GHG emissions (GHG) inventories. Analyzing the results of each years' inventories helps the city track their progress towards GHG emission reduction goals and learn more about their emissions footprint. 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.

The results contained herein are for the calendar year 2022—a year which saw activity return to levels near those that were seen before the onset of the COVID-19 pandemic. As seen in the inventory results, many trends which began during the pandemic have been durable and continue to alter data trends. Although the pandemic has been winding down for two years now, it will be years before a full picture of its effects and impacts is fully formed. Making meaningful comparisons of emissions data over time is integral in assuring our GHG report is credible, transparent, and useful. This report focuses on 2018 as the reference point in the past 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 next steps regarding climate work and sustainability goals. Tracking emissions across the several different sectors, including buildings, transportation, and waste, helps the city develop specific strategies and programs that target specific emission sources. However, the community's economy is continually growing. With this growth comes more concern over growing GHG emissions, or an opportunity to further reduce per-capita emissions with smart growth planning.

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 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 continue to be 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 therefore 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.

# EXECUTIVE SUMMARY

## Boulder's Climate Targets

Since the early 2000s, the City of Boulder has been involved in meaningful climate action and GHG reduction work. The city signed on to the Kyoto protocol in 2002 and adopted its first carbon reduction goals in 2006. In the years since, Boulder has continued to adapt its climate action goals in accordance with IPCC guidance and new scientific findings regarding GHG reduction.

Most recently, the city joined ICLEI's 150 Race to Zero Campaign in 2021, accompanying other cities in adopting ambitious emissions reduction goals. Boulder updated its current Climate Action Plan in 2021 to incorporate these new mitigation targets, which are as follows:

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

To reach these targets, Boulder has adopted additional targets, including reaching 100% renewable energy by 2030 and becoming a zero-waste city by 2025. Other climate work is underway in regard to energy, materials, transportation, land use, natural climate solutions, and finances. Keeping up with these ambitious targets is vital.

Colorado residents are still recovering from the floods of 2013 and the Marshall Fire of 2021. Intensified rainstorms and extensive drought are well-evidenced consequences of climate change—climate work is more important now than ever as these events become more frequent. At the same time, as temperatures increase across the globe, including here in Boulder, the most vulnerable community members are facing a greater heat burden. Extreme heat kills more Americans than any other weather event; however, not everyone's risk is the same. These occurrences highlight the significance of creating resiliency strategies that help communities adapt to climate change disruptions and its resulting inequities.

Meeting these goals and targets presents significant challenges. As the community established new normal activity levels, GHG emissions have rebounded. Emissions dropped drastically in 2020—mostly because driving and flying came to an abrupt halt—and began rebounding in 2021. Now in 2022, communities continue their efforts to reduce emissions while emission-generating activities rebound towards 2019 levels. While hybrid working conditions have remained popular, more people are returning to in-office work and are commuting once again. Navigating these unique dynamics and tracking how day-to-day life has been altered are both important considerations for climate work.

***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.*

**In 2022, Boulder's community-wide emissions decreased 2% from 2021 and were 18% below the 2018 baseline. Boulder has continued to reduce emissions since the adoption of its first Climate Action Plan in 2005. See Figure 1 for more.**

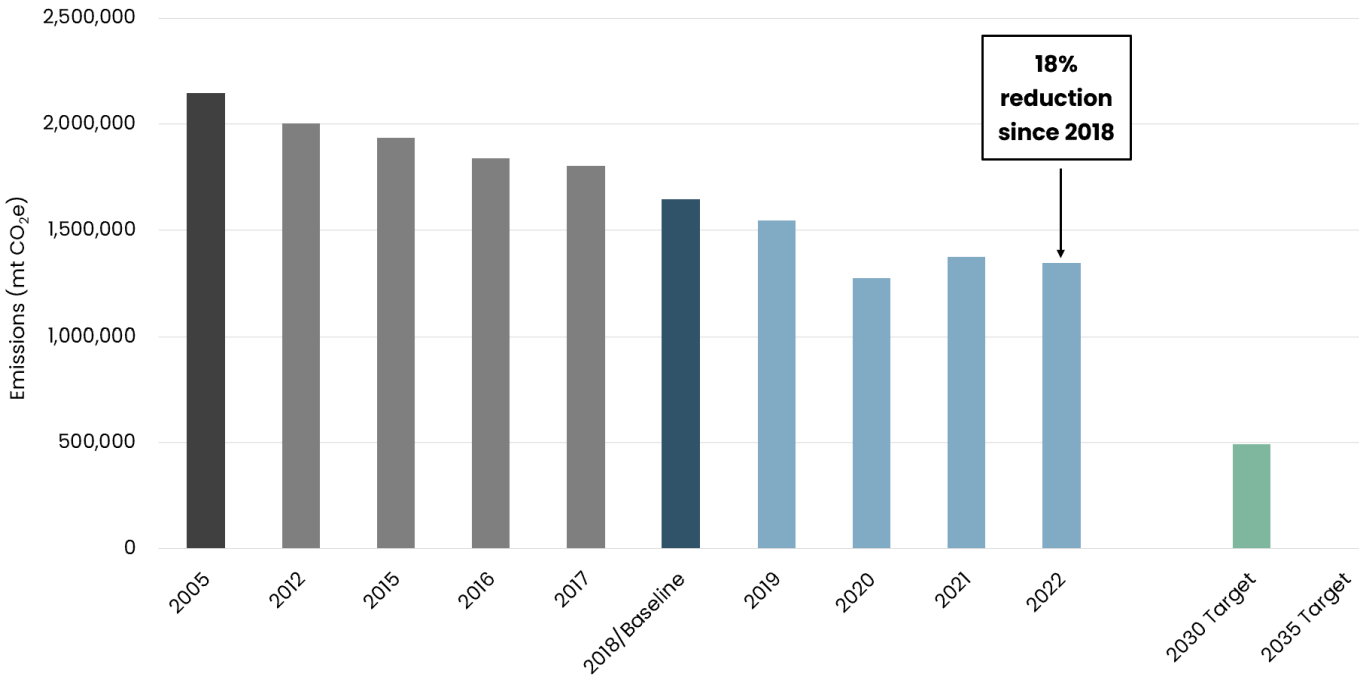


*Figure 1. Total Community GHG Emissions.*

## Emissions Snapshot

In 2022, the biggest contributors to emissions come from:

- Building electricity use (38%)
- Building natural gas use (25%)
- On-road transportation fuels (29%)
- Aviation fuels (7%)

**Boulder's community-wide emissions totaled 1,344,371 mt $CO_2e$ in 2022.**

Figure 2 provides an overview of total emissions including transboundary travel, broken out by sector and source. Additional details can be found in the *Current Emissions Snapshot* section.

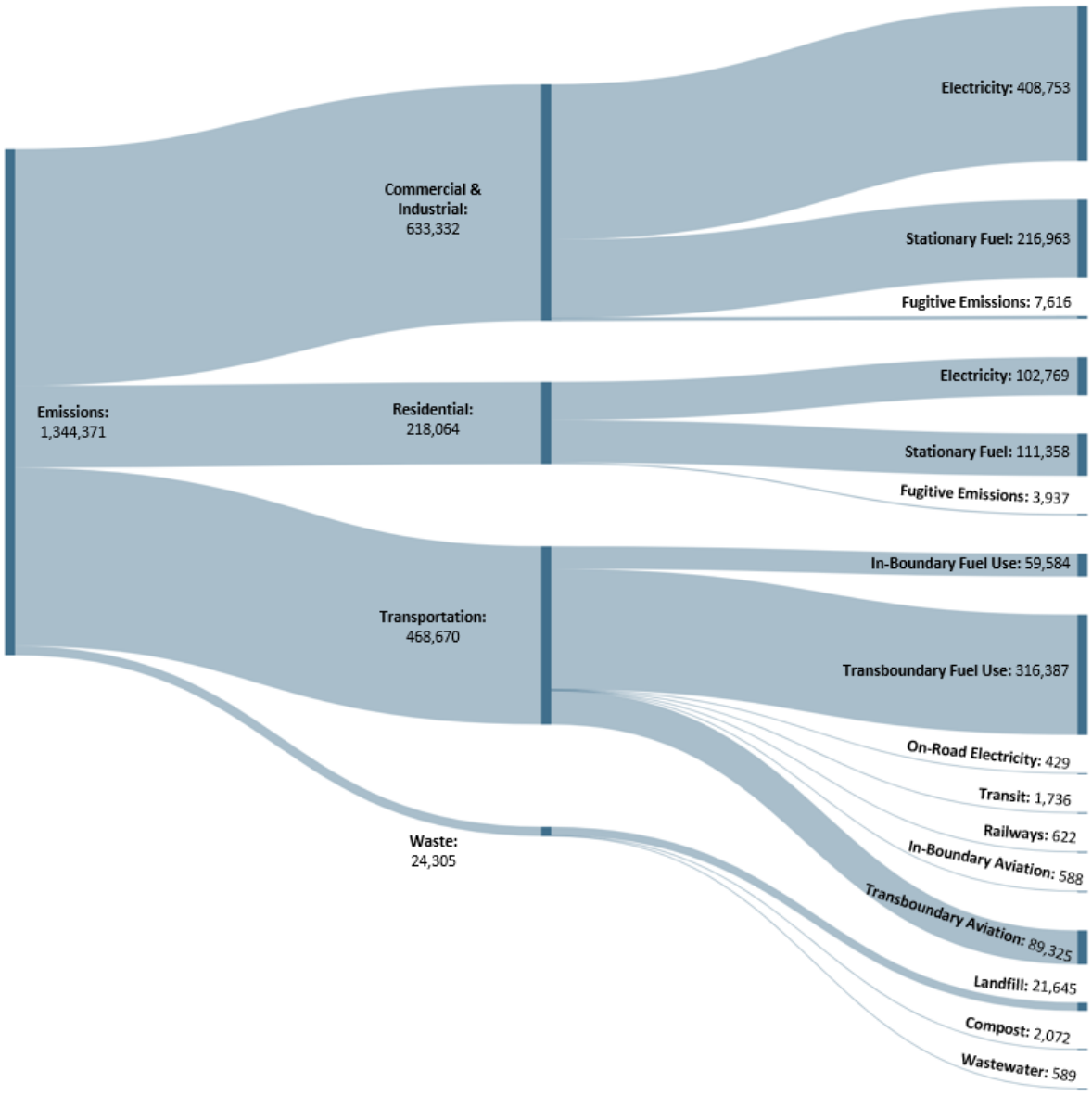


*Figure 2. Snapshot of Boulder's 2021 GHG Emissions (mt $CO_2e$).*

## Emissions Changes from 2021-2022

The overall drop in community emissions was driven primarily by the cleaning of the grid. There was also a modest drop in emissions from stationary energy usage in residential, commercial, and industrial buildings. Working against the overall trend was the transportation sector, which saw a modest increase.

- Transportation (up 10%).
- Wastewater Treatment (up 3%).
- Residential Buildings (down 10%.
- Commercial & Industrial Buildings (down 6%).
- Solid Waste (down 19%).

## Key Takeaways from the 2022 Inventory

Some key takeaways from the 2022 greenhouse gas emissions inventory include:

- Emissions decreased slightly from 2021 levels (down 2%) and are still moderately below 2018 levels (down 18%).
- Compared to the prior baseline (2005), emissions have decreased by 37%.
- Boulder's largest emissions sources in 2022 were electricity use, natural gas use, on-road transportation, and aviation; this breakdown was the same in 2021.

In alignment with previous years, the city's largest emissions source is electricity. Thanks to the advocacy of Boulder and many others, Xcel Energy's aggressive emission reduction goals—if met—will help lower these emissions. Colorado House Bill 19-1261 requires the power sector to reduce its emissions 80% from 2005 levels by 2030. As of publication of this report, Xcel Energy is proposing an electricity generation portfolio that would reduce emissions even further. The city's additional goals to electrify transportation and eliminate natural gas building appliances will shift community energy consumption to electricity use, and hence, increase electricity emissions in coming years, making continued focus on reducing electricity emissions critical.

# METHODOLOGY

Boulder's 2022 GHG Inventory used the same protocol as previous community inventories: the Global Protocol for Community-Scale Greenhouse Emission Inventories (GPC).[3] The GPC protocol provides a robust framework for accounting and reporting citywide 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.[4] By completing a GPC-compliant inventory, Boulder can report emissions to the Carbon Disclosure Project (CDP),[5] which outwardly demonstrates Boulder's climate change commitments to a global audience. The following report reviews how the 2022 inventory was completed, 2022 GHG emissions sources, and trends in emissions.

## Changes to the Methodology and Available Data in 2022

### 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-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.

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[3] For more information see: https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities.
[4] For more information see: https://www.globalcovenantofmayors.org/.
[5] For more information see: https://www.cdp.net/en/info/about-us.

### 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.

## Other Data Sources and Methodology

### 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 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.

### 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.

### 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. 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, emissions can be calculated. 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 Wastewater Treatment Plant. The plant tracks data on annual wastewater treatment processes, such as denitrification and anaerobic digestion. Emissions from wastewater treatment are calculated using this data.

## Other Emissions Inventories

### Consumption Based Emissions Inventory

Boulder is in the process of conducting its first consumption-based emissions inventory (CBEI). This will be a calculation of the greenhouse gas emissions associated with producing, transporting, using, and disposing of products and services consumed by the City of Boulder.

The main purpose of a CBEI is to gain understanding into where "embedded" emissions generated outside Boulder's boundaries constitute a significant portion of the carbon footprint of the community. By conducting a CBEI, the City of Boulder hopes to gain insights about where local consumption gives rise to emissions outside a city's borders, and suggest additional opportunities for reducing emissions.

# CURRENT EMISSIONS SNAPSHOT

**In 2022, Boulder's community GHG emissions totaled 1,344,371 mt $CO_2e$, which is an 18% reduction from 2018 baseline year emissions. This total includes emissions from transboundary transportation (flights out of Denver International Airport (DEN) attributable to Boulder residents and transboundary vehicle trips). Of these emissions, 938,659 mt $CO_2e$ were generated within Boulder's city limits, which is a 39% reduction from 2018 levels.**

## Emissions Snapshot

### Emissions by Sector

At 47% of total emissions (633,332 mt $CO_2e$), the commercial and industrial building energy use sector made up the largest share of Boulder's emissions, followed by transportation emissions at 35% (468,670 mt $CO_2e$) and residential building energy use emissions at 16% (218,064 mt $CO_2e$). The remaining 2% of emissions were generated from solid waste (23,716 mt $CO_2e$) and wastewater treatment (589 mt $CO_2e$). See Figure 3.

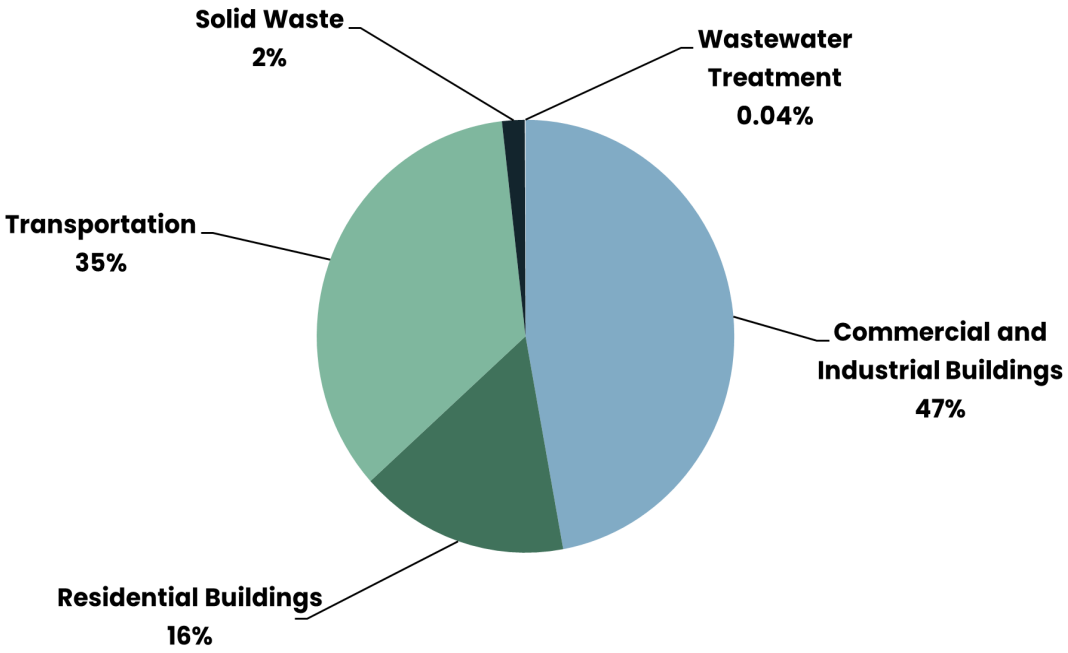


*Figure 3. Emissions by sector including transboundary transportation emissions (mt $CO_2e$).*

### Emissions by Source

Boulder's emission sources in 2022 from largest to smallest were as follows: electricity (38% or 511,951 mt $CO_2e$), transportation fuels (35% or 468,241 mt $CO_2e$), stationary fuels (25% or 339,873 mt $CO_2e$), solid waste (2% or 23,716 mt $CO_2e$), and wastewater (0.04% or 589 mt $CO_2e$). See Figure 4.

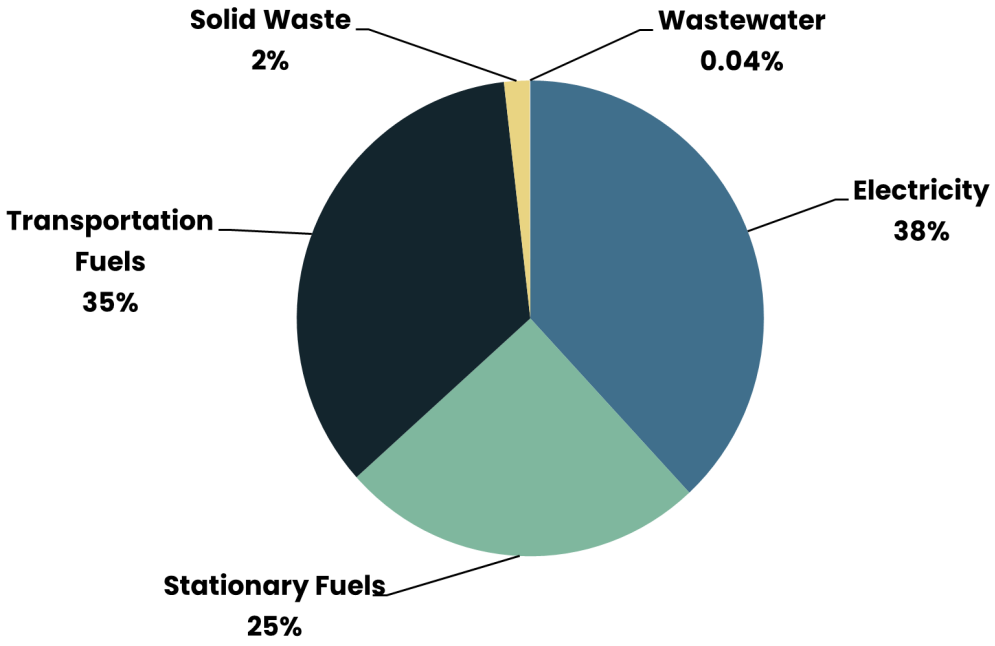


*Figure 4. Emissions by source including transboundary transportation emissions (mt $CO_2e$).*

## IS BOULDER ON TRACK TO MEET NEW TARGETS?

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

- Reduce emissions 70% by 2030 (against a 2018 baseline)
- 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 9% (of the 2022 total) per year. Figure 5 shows that emissions have reduced by 18% between 2018 and 2022, which is an average of approximately 4.5% per year. The city's emissions in 2022, while not decreasing significantly from 2021 levels, were still lower than pre-pandemic levels in 2019. While this seems hopeful, the increase in emissions in 2021 combined with the small decrease in 2022 slowed progress towards emissions reduction goals.

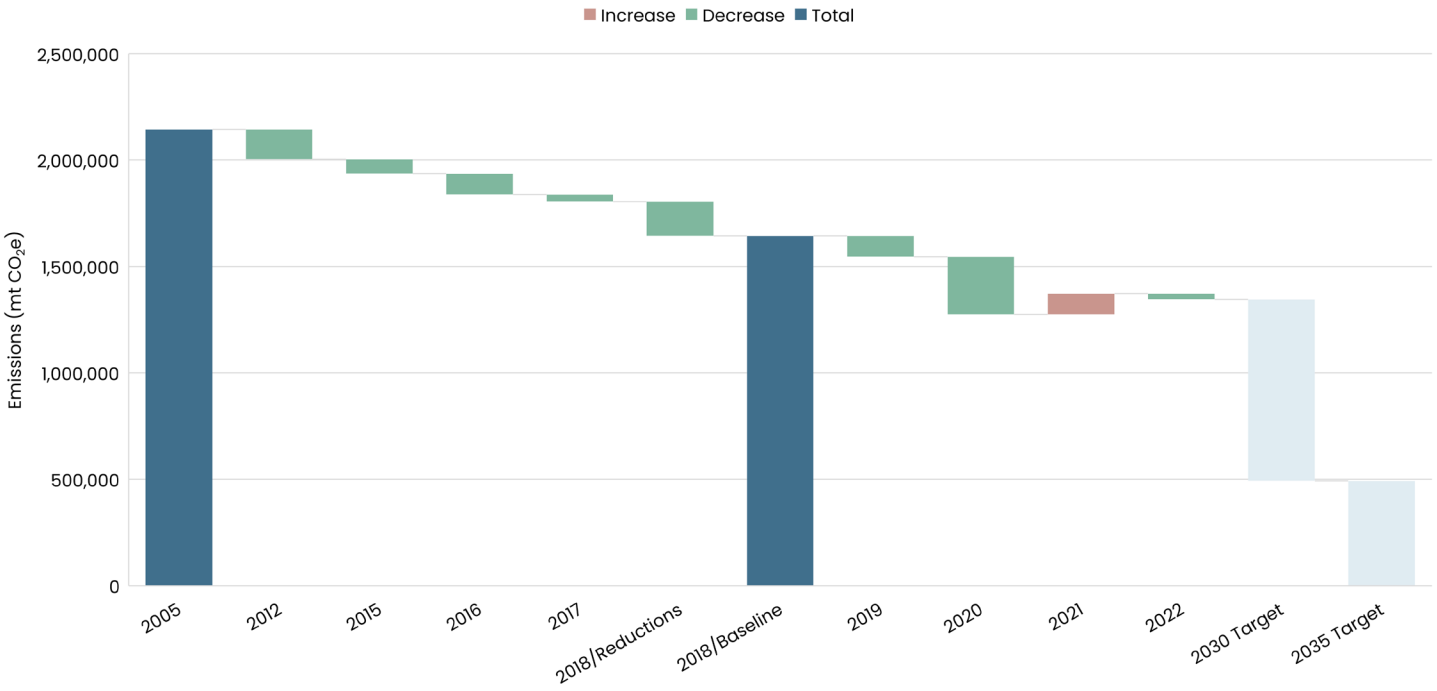


*Figure 5. Tracking emissions reductions since 2005 and 2018 (new baseline).*

Boulder has a high adoption rate for electric vehicles (EVs) when compared to other municipalities in the state. Xcel Energy's requirement to reduce emissions from the electricity it provides 80% by 2030 will also help the city lower its emissions, especially in regard to building electricity use and electricity use from EVs. Following the passage of the Inflation Reduction Act and the Infrastructure Investment and Jobs Act, more incentives are becoming available at the city-, state-, and utility-level to help reduce the upfront costs of renewable energy, heat pump, and EVs. Focusing on ways to reduce emissions now—not only in the future—is vital to meeting the city's 2030 and 2035 targets.[6]

# KEY TRENDS DRIVING EMISSIONS IN 2022

**In contrast to the increase in community emissions between 2020 and 2021, this past year, 2022, saw emissions decrease once again. The inventory showed a decrease of 2% (28,353 mt $CO_2e$) between 2021 and 2022 and a reduction of 18% (300,060 mt $CO_2e$) from the 2018 baseline.**

## Changes in Emissions

The decrease in 2022 emissions over 2021 was driven by a reduction in building energy usage and a cleaner electricity grid. Despite decreases in stationary energy usage, transportation emissions increased—especially transboundary travel. Trends are detailed below.

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[6] 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.

## Changes in Emissions

The decrease in 2022 emissions over 2021 was driven by a reduction in building energy usage and a cleaner electricity grid. Despite decreases in stationary energy usage, transportation emissions increased—especially transboundary travel. Trends are detailed below.

- **Building electricity usage and emissions:** Commercial and residential electricity usage and emissions have both declined since 2021. Residential electricity usage decreased 12% from 2021, with emissions decreasing 16%. Commercial electricity usage decreased 3% from 2021 and emissions decreased 8%. Energy efficiency measures drive residential emissions reductions and will continue to play a role in reducing emissions in years to come. Also, Xcel's cleaning of the grid will make up for the difference between reduced usage and reduced emissions.
- **Building natural gas usage and emissions:** Between 2018 and 2022, commercial natural gas emissions and usage increased 2% and residential natural gas usage and emissions increased 0.4%. Between 2021 and 2022, commercial and residential natural gas emissions and usage both decreased 1%. Electrification, especially of commercial and residential heating systems, has the potential to reduce natural gas usage, and therefore emissions, over time.
- **Cleaner electricity:** Xcel Energy's electricity emission factor has decreased 47% since 2005 due to increased renewable energy resources on the electric grid and reduced reliance on coal. The emissions factor has decreased 19% since 2018 and decreased 4% since 2021. Due to the requirements of House Bill 19-1261, Xcel Energy must reduce their emissions 80% by 2030.[7]
- **Transportation emissions:** In-boundary transportation emissions from fossil fuel vehicles have decreased 43% since 2018 and have decreased 10% since 2021. Transboundary emissions have increased 16% since 2018 and have 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. Electric vehicle adoption rates are also increasing. This will play a major role in reducing transportation emissions as electricity gets cleaner in the years to come.

## Increases in Emissions/Activity since 2018 Baseline

While most emission sources have decreased, four sources have increased since 2018.

### Transboundary On-Road Vehicles

Emissions from transboundary travel increased 16% from 2018 to 2022 (up 44,282 mt $CO_2e$) to their highest level since 2018. The increase can be attributed to several factors: RTD's service hours have declined since the pandemic and have yet to fully recover, transboundary VMT overall is increasing, and the population is growing in the Front Range.[8]

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[7] See: https://leg.colorado.gov/bills/hb19-1261.
[8] See: https://www.cpr.org/2021/08/12/census-colorado-population-growth-front-range/.

## Stationary Diesel

In this iteration of the inventory, the city discovered that there is an inconsistency in how the state reports stationary diesel use at CU Boulder and how the University reports diesel use. Therefore, this iteration of the inventory utilized diesel reported by CU. As a result, while stationary diesel emissions increased 12% between 2018 and 2022 (up 99 mt $CO_2e$), they comprised a minor part, or 0.1%, of Boulder's stationary energy sector and total 2022 emissions.

## Railways

Railway emissions more than doubled between 2018 and 2022, increasing by 526 mt $CO_2e$ between the two years. The EPA now tracks emissions data from railway activity, as opposed to fuel usage data. The previous methods likely resulted in an underestimation of railway activity emissions, so the methodology update played a part in the emissions increase. Similar to stationary diesel emissions, railway emissions comprise a small part of Boulder's total 2022 emissions, making up 0.05% of all emissions.

## On-Road Electric Vehicles

Emissions produced by electricity use from electric vehicles and buses driving in Boulder increased 74% between 2018 and 2022. In this case, an increase means that EV adoption is growing in the community, likely lowering emissions from fossil fuels in vehicles. Currently, Boulder has one of the highest EV adoption rates in the state, with nearly 5% of registered vehicles being electric vehicles.

## Normalized Metrics

Normalized metrics[9] are another way to analyze emission changes. Looking at several normalized metrics between 2018 and 2022, all values decreased between the two years with the exception of EV registration data. Per capita emissions, electricity use per person, natural gas use per housing unit, in-boundary VMT per resident, and landfilled waste per resident all decreased between the two years. Generally, this means that Boulder residents are using less energy, producing less waste, as well as driving less. However, Boulder's population declined from 2021 levels, which could be responsible for some of the downward trends. Natural gas usage per square foot for commercial and industrial entities decreased, which points to the commercial sector using less energy as well. Despite the economic rebound following the pandemic, emissions per GDP have decreased over the last few years—GDP is growing, and emissions are decreasing. Lastly, there was a significant increase in the percentage of registered vehicles that are electric. Had this not been the case, transportation-related emissions might have been substantially higher based on VMT.

[9] 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 1. Normalized metrics.*

| Emission Metrics | 2018 Baseline | 2022 | Change since 2018 |
|---|---|---|---|
| Total emissions per capita ($mtCO_2e$/resident) | 15.1 | 12.4 | -17.8% |
| Total emissions per Gross Domestic Product (GDP) ($mtCO_2e$ / $) | 0.00007 | 0.00004 | -42.1% |
| Residential electricity per person (kWh/Person) | 2,226 | 2,098 | -5.7% |
| Residential natural gas use per housing unit (therms/housing unit) | 460 | 453 | -1.5% |
| C&I natural gas per building floor space (dekatherm/sqft) | 0.088 | 0.086 | -2.8% |
| In-boundary VMT per capita (VMT/resident) | 2,209 | 1,368 | -38.1% |
| % of Registered Vehicles that are Electric | 1.45% | 4.86% | 235% |
| Landfill tons per capita (tons/resident) | 0.79 | 0.78 | -1% |

# STATIONARY ENERGY

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

Overall, commercial electricity use (48%) comprises the largest percentage of total stationary energy emissions. The next greatest source of emissions is commercial natural gas use (25%) followed by residential natural gas use (13%) and residential electricity use (12%). Fugitive emissions (from natural gas transmission leakage), commercial stationary diesel, commercial propane, and residential propane make up the remaining 2% of stationary energy emissions.

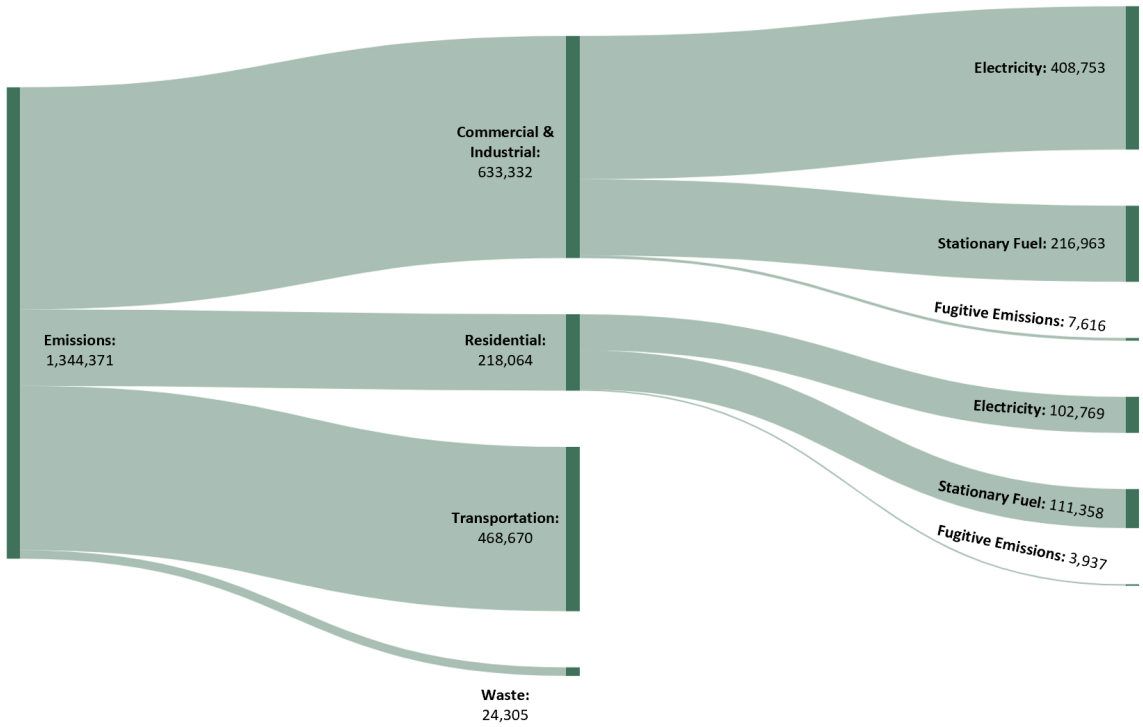


*Figure 6. Stationary energy sector breakdown (mt $CO_2e$).*

## Stationary Energy Trends

**From 2021 to 2022, emissions from building electricity decreased 10%, while emissions from natural gas decreased 3%. Other than a slight increase in 2021, electricity emissions have decreased every year since the 2018 baseline. Natural gas and stationary diesel emissions have fluctuated each year since 2018.**

The consistent reduction in electricity emissions can be attributed to:

- **Reduction in electricity usage:** Residential electricity usage has decreased 6% since the 2018 baseline and decreased 12% between 2021 and 2022. Commercial electricity usage has decreased 14% since the 2018 baseline and decreased 3% between 2021 and 2022. Reductions in electricity usage can occur for several reasons, including energy efficiency upgrades like new windows and insulation and behavior changes like unplugging unused appliances. Over time, electric use per person may increase as buildings and transportation become electrified, however, local solar adoption, along with cleaner electricity on the grid, can help to lower total emissions.
- **Cleaner electricity:** Colorado's electricity grid has continued to become cleaner since 2005. Xcel Energy has been required by Colorado's Renewable Energy Standard[10] and the state's Clean Air Clean Jobs Act[11] to reduce its operational emissions and include more renewable energy sources in its provided energy. In addition, House Bill 1261, which

[10] For more information, see: https://www.xcelenergy.com/staticfiles/xe/Corporate/CRR2013/environment/renewable-energy.html.
[11] For more information, see: https://www.xcelenergy.com/environment/system_improvements/colorado_clean_air_clean_jobs.

was passed in 2019, requires GHG emission reductions across all sectors, including electricity generation. Xcel Energy's Clean Energy Plan tracks progress towards their goal of 80% reduction in electricity generation emissions by 2030.[12] According to Xcel Energy, the emission factor for electricity has decreased 4% since 2021, 19% since 2018, and 47% since 2005. See Figure 7 below. Because commercial and residential electricity use decreased between 2021-2022, emissions were reduced even more when including the 4% decrease in Xcel's electric emissions factor.

- **More local renewable energy generation:** The city of Boulder has a goal to generate at least 100MW of renewable energy locally by 2030. As of 2022, Boulder has approximately 79MW of local renewable energy generation through on-site solar installations and solar gardens. This indicates great adoption of rooftop solar and renewable programs offered by Xcel Energy. Local generation is factored into Xcel's annual electricity emissions factor—increasing local generation helps Xcel and Boulder reach emission reduction goals.

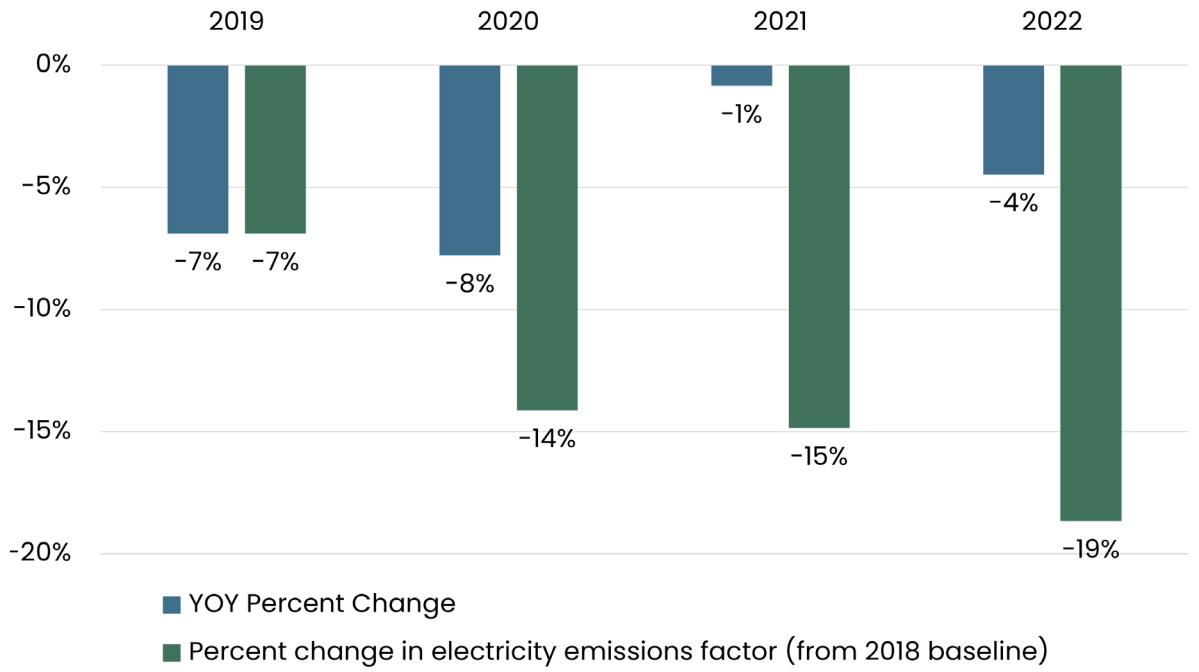


*Figure 7. Change in electricity emission factors since 2018.*

## Other Stationary Energy Trends

The proportion between commercial electricity and commercial natural gas emissions has begun to even out between 2018 and 2022. In the residential sector, natural gas now comprises a higher percentage of emissions than electricity (Figure 8). This emphasizes the need to convert homes and businesses from natural gas heating to electric heat pumps.

Natural gas consumption has decreased by 3% since the 2018 baseline. Residential and commercial propane emissions were included for the first time in 2021; propane emissions decreased 10% between 2021 and 2022.

[12] For more information see https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO%20Recent%20Filings/Colorado%20Energy%20Plan%202120.pdf.

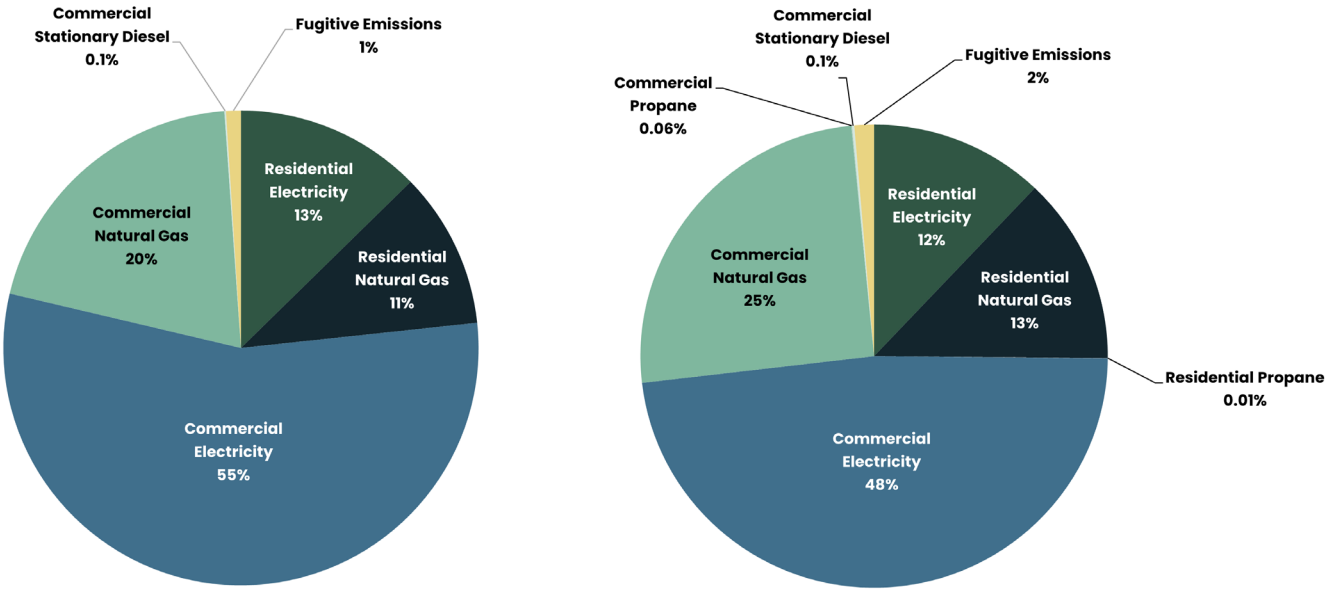


*Figure 8. Stationary energy emissions breakdown in 2018 (left) and 2022 (right) (mt $CO_2e$).*

## Action Plan

Strategies such as reducing energy emissions through shifting energy generation from fossil fuels to renewables, electrifying transportation and making buildings more efficient, have long been central to the city's strategies to mitigate the climate crisis. In recent years, Boulder's work on systems change in the energy sector has focused significantly on clean energy sources. Electricity generation has consistently comprised more than half of Boulder's emissions, making it a key target for climate action. Between 2010 and 2020, the city combined policy action at the state level with pursuing local control of electricity through municipalization.

On Nov. 3, 2020, the community voted to enter a new franchise with Xcel Energy, with a core goal of the relationship to achieve the community's goal of emissions-free electricity by 2030. The city also continues its policy advocacy to accelerate progress towards emissions-free electricity statewide. 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. Strategies also recognize the substantial progress made in eliminating electricity-sourced emissions, not just locally, but statewide, and the foundation this creates for accelerating the move away from natural gas and transportation fuels.

At a high level, this systems-change work in the energy sector is focused on:

- **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 mobility:** maximizing vehicle electrification and providing greater access for community to be able to utilize clean, affordable transportation across various platforms.
- **Clean energy sources:** ensuring a 100% emissions-free electricity supply, providing affordable access to solar and storage.

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 a clean, affordable, and resilient energy transition.

*Table 2. Objectives, targets, and progress measures for the Stationary Energy sector.*

| Objectives | Targets |
|---|---|
| Ensure equitable and affordable access to energy. | 100% of our community members will have unburdened access to basic heating, cooling, and energy needs by 2035. |
| Establish a safe, healthy, and resilient fossil-fuel-free energy system. | Our energy system will deliver 100% renewable electricity by 2030 and strive to meet the resiliency and reliability needs of the community. |
| Transform existing building stock to mitigate their environmental impacts and ensure they provide affordable, healthy, and resilient spaces for their occupants. | Our existing building stock will promote health and wellbeing of occupants and have zero operational emissions by 2040. |
| Ensure all newly constructed buildings have the lowest possible carbon footprint and provide affordable, healthy, and resilient spaces for their occupants. | Achieve zero operational emissions in all new buildings with a 40% reduction in embodied carbon by 2031. |

# TRANSPORTATION

Transportation emissions made up 35% of Boulder's 2022 emissions inventory. These emissions fall into two categories: in-boundary and transboundary (sometimes called cross-boundary). In-boundary transportation emissions include all emissions that happen within Boulder's city limits. This includes trips that start and end in Boulder, as well as the portion of miles that occur within the city boundary for trips that originate or end outside the boundary. Transboundary transportation emissions include emissions from miles that occur outside the city boundary, but that are induced by Boulder residents (commuting out of the city and/or taking a flight from DEN) or commuters coming into Boulder.

Figure 9 shows the breakdown of transportation emissions.

Emissions from transboundary transportation (86% of total transportation emissions) include:

- Transboundary on-road transportation: emissions from 50% of vehicle miles traveled that occur outside Boulder's boundary where the city is the origin or destination of the trip (66% of total transportation emissions).
- Transboundary aviation: emissions from flights out of DEN (19% of total transportation emissions) that are attributable to the city based on total origin-destination passengers (excludes connecting flights) and the ratio of Boulder's population to the Boulder-Denver Metropolitan Area population.

Emissions from in-boundary transportation (14% of total transportation emissions) include:

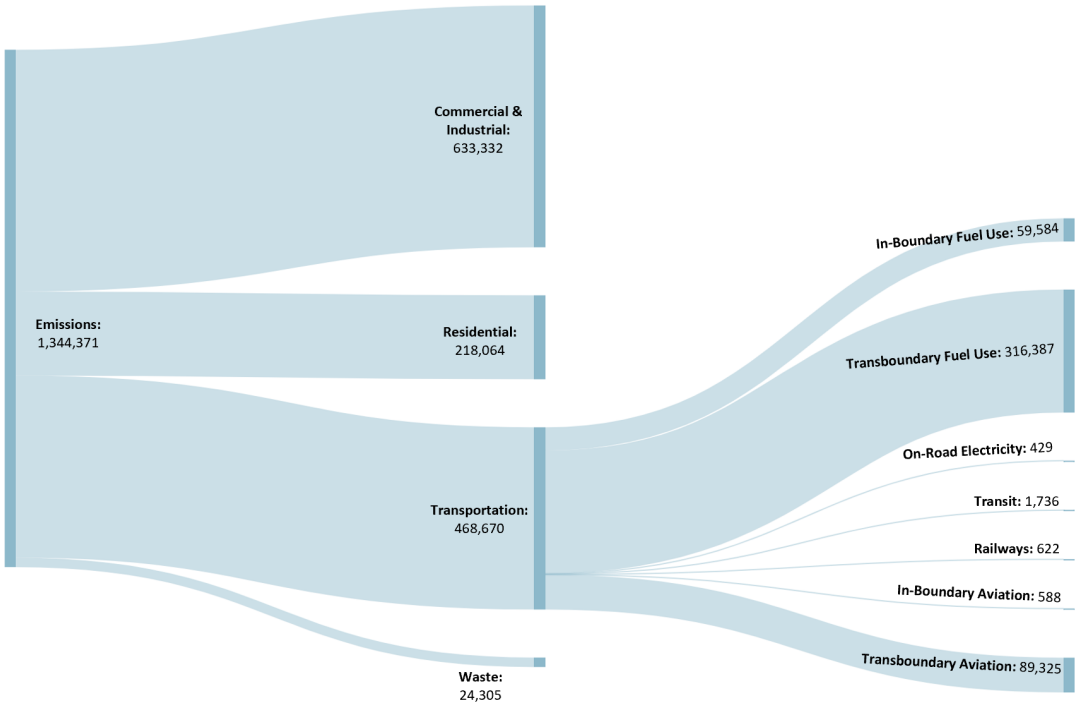


*Figure 9. Transportation sector emissions breakdown (mt $CO_2e$).*

- In-boundary on-road transportation: emissions from all vehicles traveling within Boulder's boundaries (13.1% of total transportation emissions), which includes miles for trips that start and end within Boulder. This also includes transit activities occurring within Boulder. See Figure 11 for breakout of miles by type.
- In-boundary railways (1.1% of total transportation emissions).
- In-boundary aviation - flights activity at Boulder Municipal Airport (0.12% of total transportation emissions).

## Transportation Trends

**Boulder's transportation emissions increased 10% from 2021 levels but remain below 2018 levels. In-boundary and transboundary transportation emissions went in opposite directions in 2022 compared to 2021, decreasing 4% and increasing 16% respectively.**

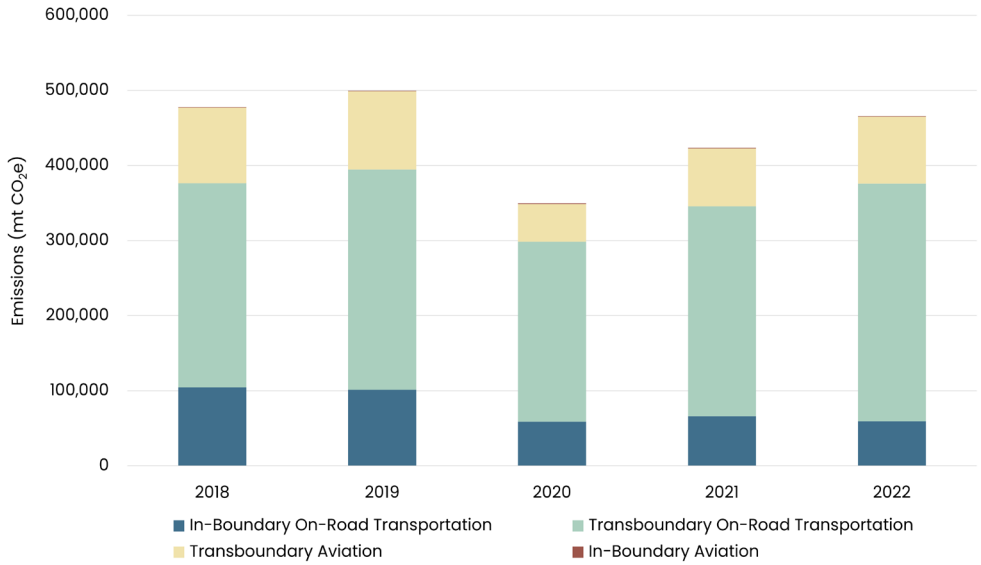


*Figure 10. Change in transportation emissions since 2018.*

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

- **VMT nearing return to level seen pre-pandemic:** As Figure 11 conveys below, total vehicle miles traveled (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 and is now nearing the level seen in 2019. More people have returned to driving single-occupancy vehicles (SOVs)—this pandemic trend has remained durable. As indicated by the latest Boulder Valley Employee Survey[13] (BVES Report), between 2017 and 2022, the percentage of commuters driving SOVs has increased from 63.8% to 70.2%. Transit use dropped from 5.6% to 2.5% between the same years. Using SOVs over multimodal options increases VMT. Commute distances also changed between 2017 and 2022. The percentage of employees that work in Boulder who commute zero to two miles has dropped from 19.9% to 11.7%, whereas the percentage of employees who commute over 20 miles has increased from 16.9% to 19.7%. This mode shift is vital to note because it highlights the importance of targeting transboundary vehicle trips by non-resident employees and visitors in sustainability strategy development.
- **Shift in employee commuting:** More workers returned to working in person in 2022. There is currently a pronounced difference in travel behavior between Boulder resident- and non-resident employees. For work trips, Boulder residents drive alone less and use a variety of multimodal options. According to the BVES Report, non-resident employees primarily drive alone to work and their one-way trip distance to work continues to increase. The BVES Report also showed that 53% of Boulder residents who work in the city drive alone, compared to 80% of non-resident employees. In contrast, only 2% of non-resident employees bus, bike, or walk to work, compared to 23% of resident employees doing the same. Looking at Boulder resident-employees, 31.8% reported a commute distance of zero to two miles and 53.2% reported a commute distance of three to five miles. For non-residents, 48.6% reported a commute distance of 11-20 miles and 29.3% reported a commute distance of more than 20 miles.
- **In-boundary vs. transboundary transportation shift:** Figure 10 above shows the change in transportation emissions since 2018. Emissions from in-boundary transportation (including transit and railways) are lower compared to 2018, and emissions from transboundary on-road transportation are higher compared to 2018. Between 2021 and 2022, in-boundary transportation emissions have decreased 4% and transboundary transportation emissions have increased 14%. It is important to understand the differences not only in mode types but also in commuting distances between resident and non-resident Boulder workers. According to the BVES Report, employees who are Boulder residents commute, on average, 3.9 miles. Non-residents, however, commute an average of 18.3 miles. In addition, non-residents comprise a large percentage of the workforce—approximately 60%. Boulder residents are more apt to take alternative forms of transportation (e.g., transit, biking) and are driving shorter distances, while non-residents are driving alone more often and longer distances, which is likely playing into the difference between in-boundary and transboundary transportation trends. Additionally, in 2022, nearly 37% of all trips, for work and other purposes, were done using alternative forms of transportation, compared to 27% in 2017. This is another contributor to the reduction in in-boundary VMT and emissions.

[13] See: https://bouldercolorado.gov/media/4807/download?inline.

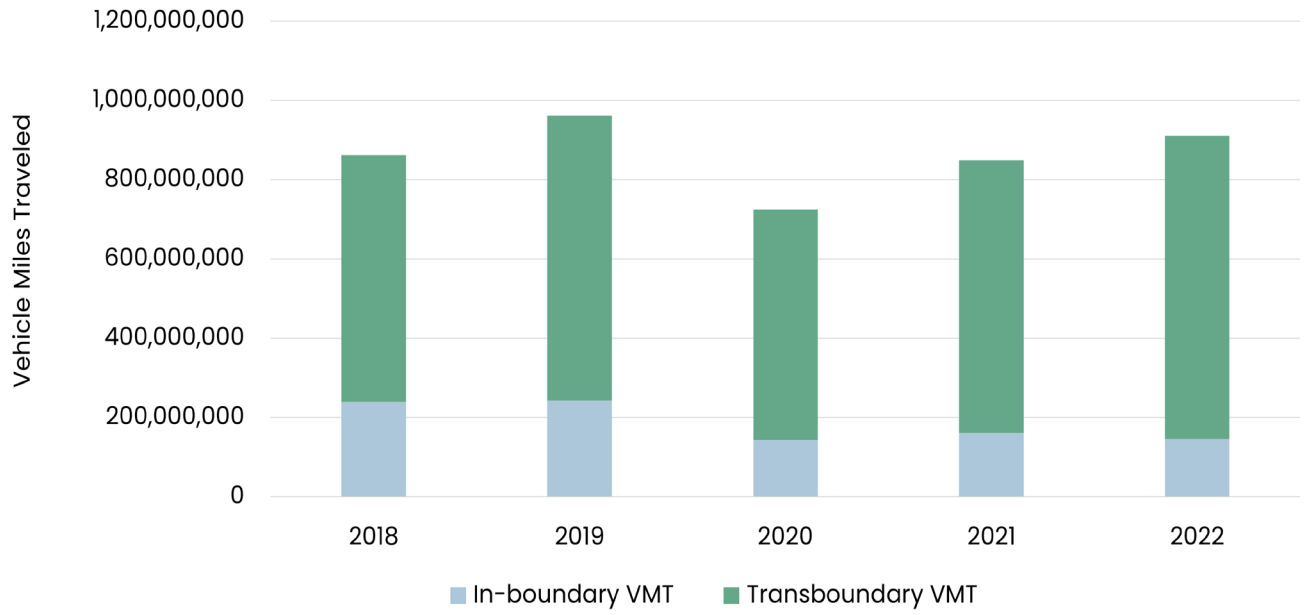


*Figure 11. In-boundary and transboundary VMT between 2018-2022.*

Other transportation trends include:

- **Rebound in aviation travel:** Looking at the aviation sector, gallons of jet fuel increased 15% between 2021 and 2022 but have decreased 12% since 2018. Gallons of aviation gas decreased 26% between 2021 and 2022 and have also fallen 12% 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.
- **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. As more efficient vehicles are driven the amount of fuel used per mile (MPG) has decreased. More states are also adopting California's Clean Car Standards, like Colorado, which will lead to the production of more fuel-efficient vehicles. This will in turn lead to fuel and emissions reductions.
- **Railway emissions:** Railway emissions increased 96% between 2021 and 2022 and increased 548% between 2018 and 2022. This is due primarily to the updated methodology from the EPA for calculating railway activity emissions. Despite this large increase, railway emissions continue to make up very little of Boulder's total emissions.
- **Increase in electric vehicles:** The community saw 1,195 additional EV registrations in 2022, the highest the city has ever seen in a single year. The total number of EVs in Boulder has risen from 1,417 in 2018 to 4,404 in 2022. The city's EV adoption rate (percent of total vehicle registrations that are EVs) has also jumped from 3.5% in 2021 to 4.9% in 2022. See Figure 12. This is optimistic—not only are Boulder residents purchasing more EVs, but this trend may continue with rebates now available at the state, federal, and

[14] See: https://ijet.aero/ijet-blog/different-types-aviation-fuel-jet-fuel#:~:text=AVGAS%2C%20or%20aviation%20gasoline%2C%20is,the%20thrust%20of%20expelled%20air.
[15] See: https://www.epa.gov/automotive-trends/highlights-automotive-trends-report.

utility level. In addition, if the same number of miles driven by EVs in Boulder in 2022 had instead been driven by average gasoline-powered passenger vehicles, an additional 4,691 mt $CO_2e$ would have been emitted.

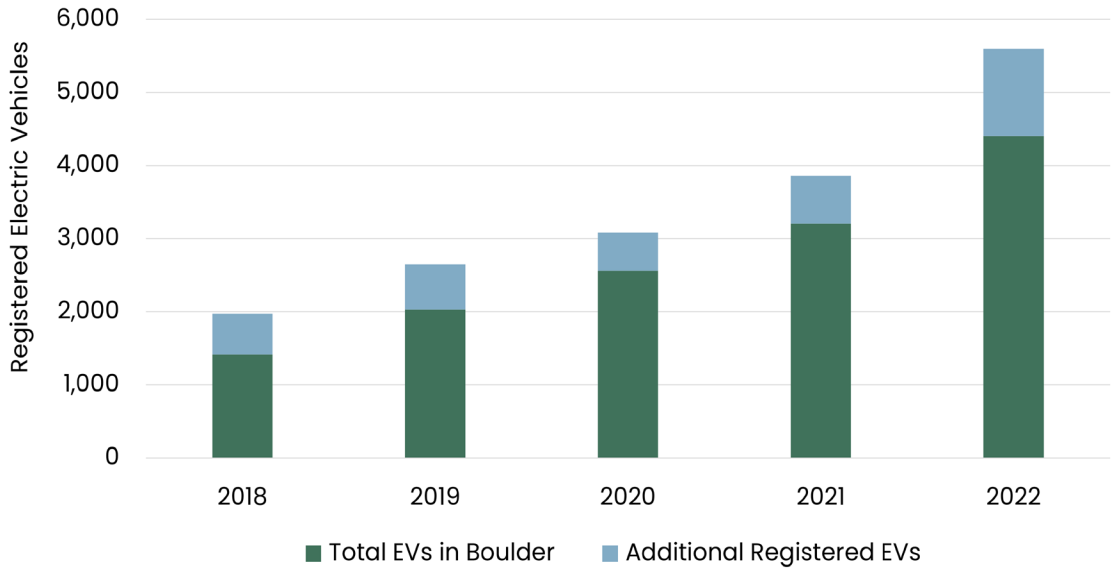


*Figure 12. Trends in EVs over time.*

## Action Plan

The comprehensive overview of Boulder's transportation policies, plans and actions going forward can be found in the 2019 Transportation Master Plan (TMP) and the 2020 TMP Progress Report. 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:

- **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 changing non-resident employee travel behavior by providing regional travel options that can compete against the personal vehicle in terms of travel time and cost.
- **VMT Reduction:**
  - **Multimodal Transportation Investments:** Continue investing in multimodal infrastructure and programs outlined in Boulder's TMP to achieve SOV vehicle trip and GHG reduction goals as well as broader community sustainability goals.
  - **Vision Zero:** The city has adopted a Vision Zero policy that aims at eliminating serious and fatal traffic crashes and updated its Vision Zero Action Plan to continue implementation of safety improvements in the areas of engineering, enforcement, education, and evaluation. Safer travel conditions can increase the number of transit, biking and walking trips and shift trips away from motor vehicles on the city's Core Arterial Network.

- **Micromobility Program:** Expand electric bikeshare program and the pilot e-scooter programs. Micromobility trips can replace vehicle trips for many trips around the city and provides 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 EcoPass or Parking Cash-Out. As a model employer, the city will continue to provide commute benefits and telework options to city employees.

- **Electrification strategy:** Continue to coordinate the multi-departmental working group on EV and alternative fuels strategy development with a community goal of 30% EV adoption by 2030. This includes pursuing funding opportunities for public charging infrastructure, developing low-income access opportunities, pairing EV charging with solar and electrifying RTD, city, BVSD and CU bus fleets. While RTD provides most of the transit service to and within Boulder, the city contracts with Via Mobility, the city's paratransit provider, to operate the HOP service. The city's aims to electrify the HOP fleet, with 3 buses already electrified and 7 more on order, with the goal to have an entirely electric fleet by 2030.
- **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 better manage access to the curb for Transportation Network Companies, like Uber or Lyft, and freight deliveries, and rethink use of public right-of-way to increase multimodal access.

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 the city's collaborative climate transportation work.

*Table 3. Objectives, targets, and progress measures for the Transportation sector.*

| Objectives | Targets |
|---|---|
| Provide clean mobility solutions that meet community needs. | All Boulder residents will have access to clean mobility options by 2035. |
| | 30% vehicle miles travelled in Boulder will be electric by 2030. |

## WASTE AND WASTEWATER

Waste (solid waste and compost) and wastewater emissions comprise a small part of Boulder's total emissions, making up 2% and 0.04%, respectively. 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.

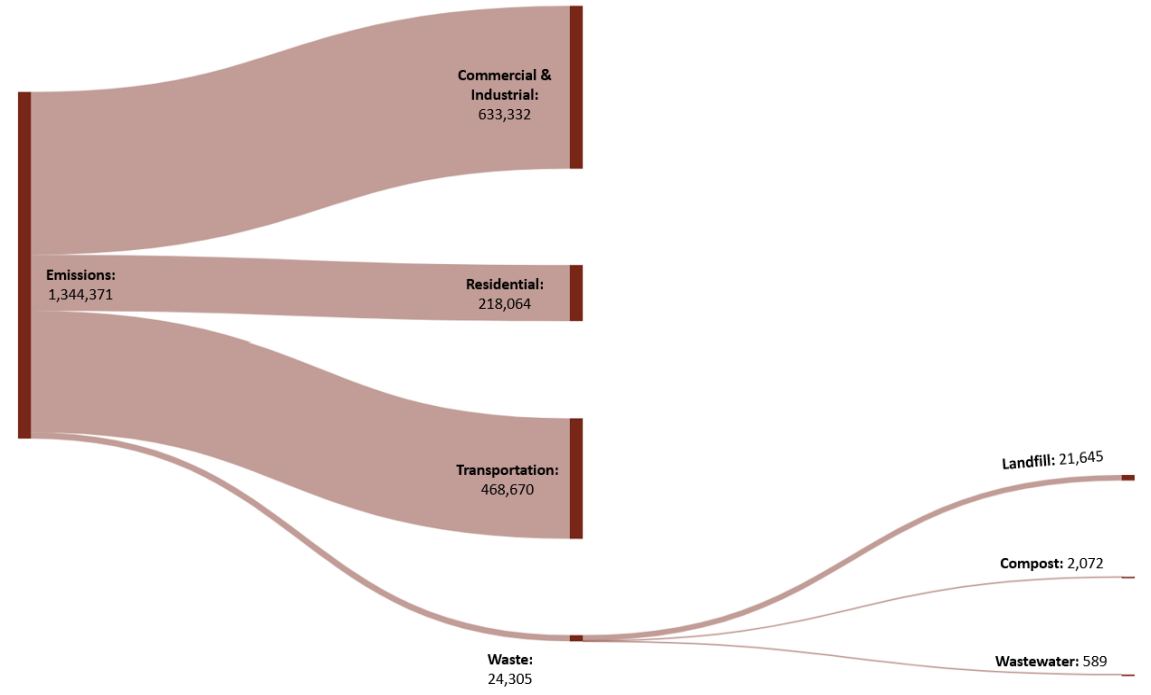


*Figure 13. Waste sector breakdown (mt $CO_2e$).*

## Waste and Wastewater Trends

**Landfilled waste emissions have increased 19% since the 2018 baseline. Emissions from compost have fluctuated each year since the 2018 baseline, with an overall decrease since 2018 (down 33%). Emissions from wastewater have also fluctuated every year with an overall decrease of 16% since 2018.**

Waste and wastewater trends can be attributed to:

- **Waste:** Tons of landfilled waste decreased in 2022 with a total decrease of 1% since 2018. Data collection challenges led to a probable underestimate of waste tonnage and emissions in 2022. Waste tonnage remained fairly consistent from 2018 to 2022 with the exception of a spike in 2021. This spike could be due to population growth, construction, and an increase in single-use items due to the pandemic.
- **Composting emissions:** Composting tonnages and therefore emissions have been falling since 2018. Although compost does release methane, it prevents organic matter from ending up in the landfill. Reduced compost tonnage means increased landfilled tonnage and emissions; composting food and yard waste creates fewer emissions than landfilling. Additionally, compost helps to increase soil health and water retention (amongst other benefits).

Figure 14 highlights waste and compost tonnages every year from 2018 to 2022. Waste tonnages have fluctuated over the years while compost tonnages have steadily decreased. In 2023, A1 Organics introduced new restrictions on items that will be accepted at their compost facilities. It will be important to track trends in waste and composting tonnages going forward to see the impacts of those restrictions.

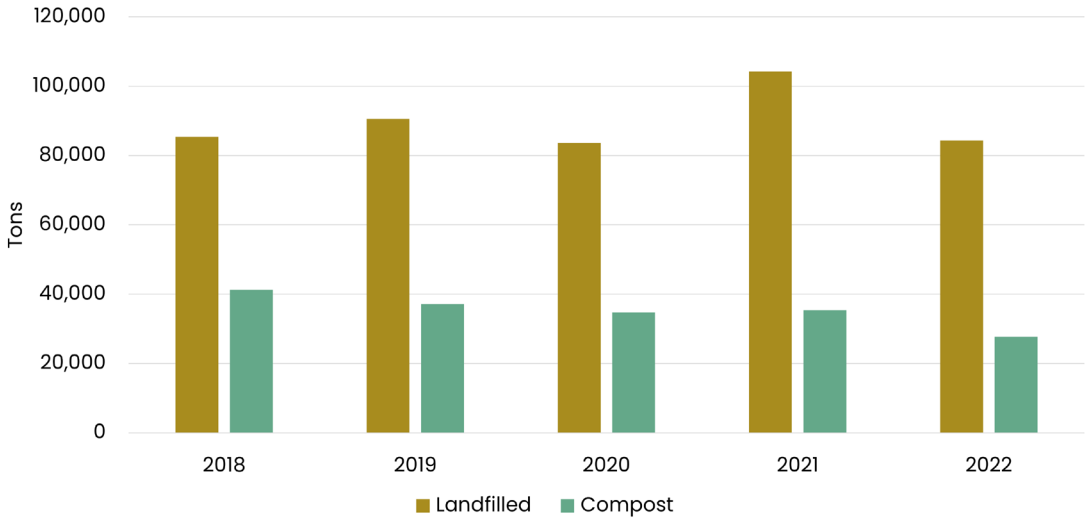


*Figure 14. Annual change in waste and compost tonnage 2018-2022.*

- **Wastewater:** Emissions from the wastewater treatment plant have declined 16% since 2018 and have increased 3% 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. 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 (Figure 15).

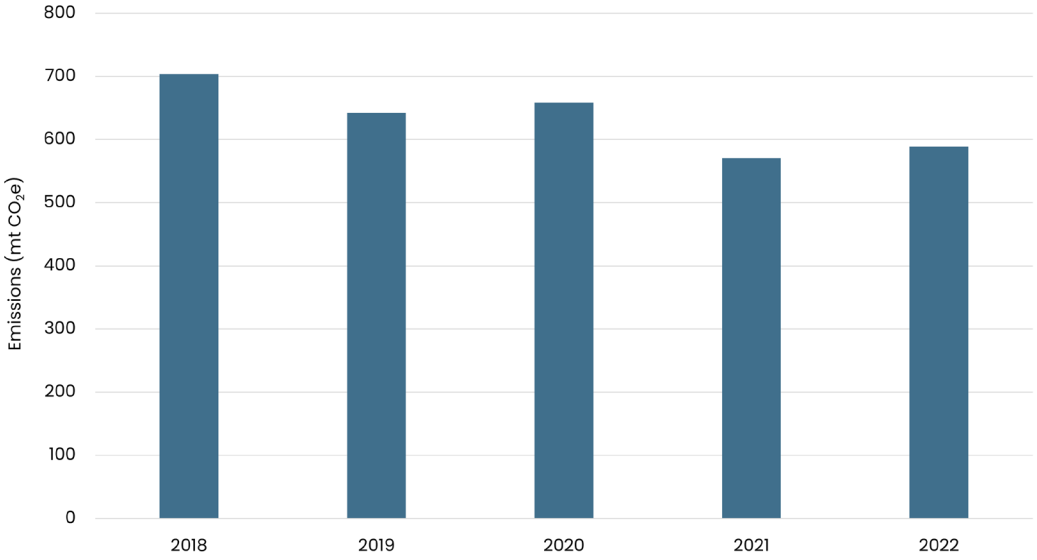


*Figure 15. Trends in wastewater treatment GHG emissions (2018-2022).*

## Action Plan

Boulder's work is transitioning beyond traditional zero waste goals of diverting waste for recycling to a broader set of actions that change the system of consumption and keep materials in circulation as long as possible. As a first step, the city, via consulting firm Metabolic, produced the Circular Boulder analysis and roadmap. Metabolic examined the current level of circularity in Boulder by performing an in-depth Material Flow Analysis. They also identified hotspots and opportunities that exist throughout the local materials economy and summarized the impacts

of some of those hotspots. This innovative work is informing the development of Boulder's strategic plan for a circular materials economy, the next evolution of reducing waste.

At a high level, this circular economy systems-change work is focused on:

- **Consumer goods:** reducing consumption-based emissions through lower carbon choices (local, etc.), minimizing single use plastics, maximizing reuse and repair through clinics and stores, promoting sharing platforms over direct ownership, and supporting market development for recyclables.
- **Built environment:** understanding the opportunity for and promoting adoption of low-carbon construction materials, maximizing reuse of building materials and designing buildings for reuse in deconstruction, supporting market development for construction waste diversion.
- **Organics materials:** increasing 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.

*Table 4. Objectives, target, and progress measures for the Waste sector.*

| Objectives | Targets |
|---|---|
| Minimize waste production per capita and maximize diversion from landfills. | Become a zero-waste city by 2025. |
| Reduce the carbon footprint of production cycles we have the greatest ability to affect | Reduce community consumption-based emissions 50% by 2030 against a 2018 baseline. |
| Employ circular principals in building construction and demolition. | By 2025, host educational and outreach sessions with large actors in our region on implementing low carbon procurement strategies and policies. |
| Make the repair reuse and remanufacture of components and materials easier and more accessible. | Materials and products are designed to last with the ability to recycle, reuse, repair, or remanufacture at the end of product life by 2030. |
| | Increase participation in sharing platforms 30% over a 2020 baseline to foster equitable access to goods and services over ownership by 2030. |

| Objectives | Targets |
|---|---|
| Establish an economic basis for circular entrepreneurship and innovation. | Create a closed loop system that reduces fire risk in our community, converts biomass to biochar, and generates clean energy to fuel buildings by 2030. |
| | Foster community and entrepreneurial partnerships and platforms to promote repair and reuse by 2030. |

# NATURE-BASED CLIMATE SOLUTIONS

In the city's 2016 Climate Action Plan (the "Climate Commitment") the city established a new action area focusing on the role of ecosystems in climate action. In the following year, 2017, the city and Boulder County both initiated their first carbon sequestration initiatives, both on agricultural holdings. Land plays an important role with regards to climate change: it can act as a sponge and absorb carbon from the atmosphere, or it can contribute to the climate crisis through forest and grassland destruction and the increased expansion of cities. The city has been working to quantify the impacts of its lands.

One of the first areas in which the climate benefits of natural climate solutions are being quantified is urban forestry. In 2021, the city participated in the piloting of a new ICLEI protocol--Appendix J to the U.S. Community Protocol. This appendix on Forests and "Trees outside Forests", establishes guidance for communities to integrate such sequestration and emission values of city managed/influenced forests into their inventories.

Currently there are not established protocols for capturing carbon sequestration benefits in land management other than forests. The city is working with a broad consortium of organizations to develop these protocols. This would enable the city to start capturing the soil-based sequestration efforts it is engaged in along with other potential natural climate solutions. These efforts and their developments will be reported on in subsequent reports. This report will focus solely on forests as the only area in which there are currently established and accepted quantification methods of nature-based sequestration actions.

## Forests and Trees Outside Forests

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 and its Open Space and Mountain Parks (OSMP) lands, with the aim of integrating the results into the city's annual inventory process.

The results show that the total amount of carbon stored in Boulder's forests and trees within the city boundary are ~350,000 metric tons as of the latest period of analysis (2016-2019), with the large majority (69%) stored in urban tree canopy with the remaining 31% stored in forest. When including the city's OSMP lands within the boundary of analysis, the amount of carbon stored is ~2.3 million metric tons, with the vast majority (75%) within forested lands (Figure 16).

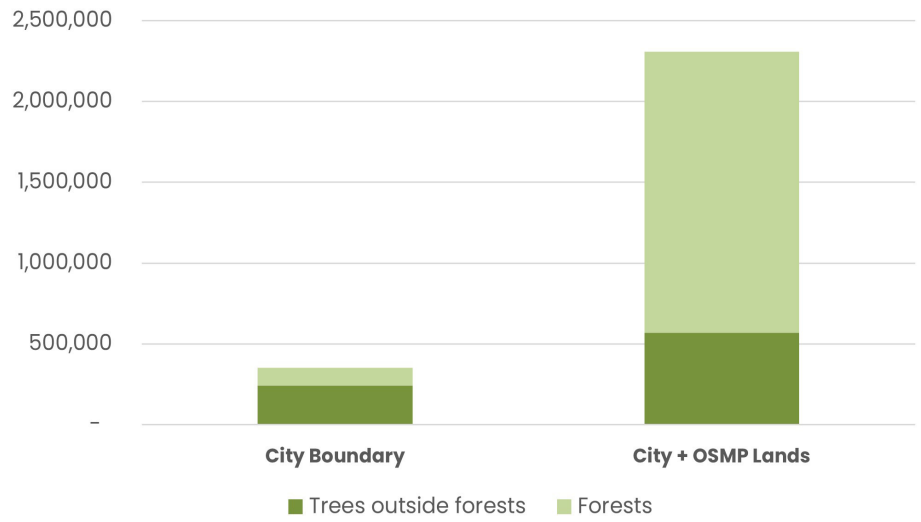


*Figure 16. Total Carbon Stored in Boulder's Forests and Trees Outside Forests in 2020 (Urban Trees).*

In addition to calculating the total carbon stock held within Boulder's trees and forests, the Appendix J analysis provided guidance on calculating the annual emissions and removals (sequestration) that those trees and forests yield. When summing the total emissions produced by trees that were lost or damaged 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**. For more details on the Forest and Trees Outside of Forests analysis, refer to the 2021 Community Greenhouse Gas Emissions Inventory Report.

## Emissions Snapshot

Boulder has not established a regular cadence for updating annual carbon removals from forests and urban trees. Therefore, estimates from 2021 were used to estimate total net emissions from emissions and removals. A full analysis of the carbon absorption and holding capacity of city open space lands is due to be completed at the end of 2023.

When using 2021 removals estimates, total net emissions including transboundary transportation and emissions removals in Boulder in 2022 are 1,323,698 mt $CO_2e$ (Table 5). Annual removals from Boulder's forests and urban trees, including OSMP lands, represent about 2% of the community's annual GHG emissions. Maintaining and expanding the forest in Boulder is an important action that the city can take, and it will also be critical for building the city's resilience and reducing community wide GHG emissions simultaneously.

*Table 5. GHG emissions including annual carbon emissions and removals of forests and urban trees in the annual GHG inventory.*

| Emission Type by Sector | Emissions ($mtCO_2e$) | | |
|---|---|---|---|
| | 2005 | 2021 | 2022 |
| Commercial and Industrial Buildings | 977,220 | 675,579 | 633,332 |
| Residential Buildings | 311,427 | 240,727 | 218,064 |
| Transportation (with transboundary aviation) | 801,206 | 426,452 | 468,670 |

| Emission Type by Sector | Emissions ($mtCO_2e$) | | |
|---|---|---|---|
| | 2005 | 2021 | 2022 |
| Transportation (without transboundary aviation) | 320,257 | 69,937 | 62,958 |
| Solid Waste | 53,840 | 29,396 | 23,716 |
| Wastewater Treatment | 1,800 | 571 | 589 |
| **Total Gross Emissions (with transboundary emissions)** | **2,145,493** | **1,372,724** | **1,344,371** |

| Land Use Sequestration: City Only | Emissions ($mtCO_2e$) | | |
|---|---|---|---|
| | 2005 | 2021 | 2022 |
| Forests Remaining Forests | (1,073) | (1,041) | (1,041) |
| Forests Converted to Other Lands & Disturbances | 748 | 641 | 641 |
| Other Lands Converted to Forests | (6) | (2) | (2) |
| Sequestration from Urban Trees | (8,795) | (8,898) | (8,898) |
| Emissions from Urban Trees | 2,688 | 58 | 58 |
| **Total Net GHG Removals** | **(6,403)** | **(9,243)** | **(9,243)** |
| **Total (Net) GHG Emissions without transboundary emissions and removals** | **1,658,141** | **1,006,967** | **929,416** |

| Land Use Sequestration: City + OSMP Lands | Emissions (mt $CO_2e$) | | |
|---|---|---|---|
| | 2005 | 2021 | 2022 |
| Forests Remaining Forests | (16,685) | (16,542) | (16,542) |
| Forests Converted to Other Lands & Disturbances | 11,759 | 16,611 | 16,611 |
| Other Lands Converted to Forests | (20) | (14) | (14) |
| Sequestration from Urban Trees | (21,055) | (20,962) | (20,962) |
| Emissions from Urban Trees | 995 | 10 | 10 |
| **Total Net GHG Removals** | **(26,001)** | **(20,773)** | **(20,773)** |
| **Total (Net) GHG Emissions with transboundary emissions and removals** | **2,119,492** | **1,351,951** | **1,323,698** |

## Action Plan

Building on the city's legacy as a leader in open space and environmental protection, the city's climate action program has also been a leader in advancing and mainstreaming ecosystems as a core focus area for climate action. Over the next three to five years, Boulder's major actions will take place in the following areas:

- **Urban Forests for Life** — A multi-year campaign will be initiated to mobilize both public and private sector entities to plant over 10,000 trees in the Boulder area.
- **Cool Landscapes** – This initiative has both urban and working lands components.

- **Cool Corridors (urban)** – Design and implement a network of corridors throughout the city that can act as both critical habitat and carbon-rich vegetative networks that support urban cooling and other green infrastructure benefits. This initiative will also integrate aspects of the "Absorbent Landscapes" focus area through exploring ways to increase the capture and utilization of rainwater resources in urban landscape hydration.
- **Cool and Absorbent Landscapes (working lands)** – Analyze the larger working land network owned by the city to assess the potential of using vegetative and water management systems to support both cooling and storm water management objectives.

- **Center for Regenerative Solutions –** Building on the four years of development work that has taken place in collaboration with the Urban Sustainability Directors Network (USDN) the city will expand efforts to support adoption and development of similar urban nature-based solutions in communities across the Country. This work is being designed to intersect mitigation, adaptation/resilience, and equity objectives.
- **Green Jobs**– Working in collaboration with Boulder County and the State, support the development of a range of green jobs including organic landscape maintenance, urban forestry and tree care, and land regeneration contract and work opportunities through collaboration with a wide range of related governmental and non-governmental organizations. placement of State and Federally supported CCC crews in support of actions developed in the initiatives outlined above.

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 1-5 years) which are detailed below to track progress towards the city's nature-based climate solutions work:

*Table 6. Objectives, target, and progress measures for the Natural Climate Solutions.*

| Objectives | Targets |
|---|---|
| Foster community resilience through carbon enhanced ecosystems. | Reach 25% tree canopy by 2035, targeting growth of canopy cover in areas of greatest need. |
| | Increase water absorption capacity by 25% in high flood risk areas by 2030. |
| | Create connected "cool corridors" across 10% of urban land area by 2030. |
| | Develop landscape cooling/absorption zones in 25% of the peri-urban areas surrounding the city by 2030. |
| | Reduce fire hazards in urban-wildland interface and other high fire risk zones by 50% by 2030. |
| Increase natural carbon sequestration within and beyond our boundaries. | Remove 40,000 tons of $CO_2$ annually by 2030 through forest, urban tree, and soil landscape restoration. |

| Objectives | Targets |
|---|---|
| Design actions to maximize equitable ecosystem benefits. | Achieve tree planting capable of achieving 30% canopy cover in 100% of high vulnerability neighborhoods by 2030. |
| Support the growth of economic sectors that sustain critical ecosystem services. | Support Climate Conservation Corps establishment in Boulder/Boulder County. |
| | Strive to ensure 40% of new employment comprises equity-based green sector jobs. |
| Advance the field of natural climate solutions beyond Boulder. | Develop globally accessible tools for carbon management and optimal ecosystem services planning by 2025. |

# CONCLUSION

In July 2019, the Boulder City Council declared a climate emergency, recognizing the accelerating rate and intensifying effects of climate change.[16] Many of these effects are already visible in Boulder city limits. The floods in 2013 and the devastating Marshall Fire exemplify climate change's real-time threat to the natural environment, public health, city infrastructure, and peoples' livelihoods. Measuring the community's GHG emissions helps Boulder track progress on its climate goals and by reducing emissions the city works towards reducing climate change's negative effects. As seen throughout this report, Boulder's community wide emissions in 2022 show a continued decrease overall and several other notable trends. From clear impacts of Xcel Energy's work greening the grid to a clear increase in electric vehicle adoption, Boulder has lots of new data to support continued climate action work. While emissions continue to decrease, the rate of decrease must accelerate if Boulder is to achieve its 2030 goals.

[16] See: https://boulder.novusagenda.com/agendapublic/AttachmentViewer.ashx?AttachmentID=2197&ItemID=2074.