City of Boulder
Community Greenhouse Gas Emissions Inventory

2016 UPDATE

November 2017

With data analysis and reporting from

lotus
engineering & sustainability

Contents

Figures and Tables

I. Introduction

Each year, the City of Boulder completes an annual greenhouse gas (GHG) inventory to (a) assess our community's contribution to global climate change, (b) track progress against our Climate Commitment goals, and (c) inform the design of policies and programs aimed at reducing GHG emissions, minimizing impacts and potentially halting or reversing current trends.

Boulder's GHG inventory provides an analysis of emissions created by the activities of Boulder residents, businesses, institutions and industries. By comparing inventories over time, Boulder can track the success of existing and future climate change-related policies and programs. These comparisons create a dynamic feedback loop to inform and shape future improvement strategies. Tracking annual GHG emissions also allows the city to provide regular updates to the community and measure progress towards goals, via the citywide dashboard Boulder Measures.

Key Changes and Achievements in 2016

- **Reduced Overall Emissions:** The city achieved a 13 percent emissions reduction from the 2005 baseline, even with a growing population and economy. Emissions per capita and per economic growth realized much greater reductions.
- **Lower On-Road Emissions**: Vehicle miles traveled have decreased 14 percent per resident since 2005.
- **Progress Towards Zero Waste Goals:** Diversion from landfill increased 136 percent from 2005 to 2016. Between 2015 and 2016, multifamily waste diversion increased 131 percent.
- **Wastewater Treatment Facility (WWTF) Successes:** In 2016, the city's WWTF boasted both the lowest energy usage since 2007 and the best nitrogen removal performance in the facility's history, capturing substantial emission reductions since 2005.
- **Improved Tracking:** Boulder streamlined its annual emissions reporting to follow the BASIC level reporting categories of the *Global Protocol for Community-Scale GHG Emissions (GPC)*, allowing Boulder to better compare its progress and emissions trends over time to other cities around the world.

Informing Local Policy

Annual GHG inventory results help to inform local policy and program design. The results also help to guide department workplans to achieve Boulder's Climate Commitment goals.[1] The GHG inventory findings described in this report have informed the following:

- **Transition to Clean Electricity**: Because electricity accounts for half of the city's emissions, city policy decisions and program design must prioritize efforts to add renewables to the electricity grid as soon as possible, through both municipalization of the electric utility and increasing the amount of local

[1] Program design and policy implications for Climate Commitment action areas not reflected in the GHG inventory, such as water conservation and resource use, will be addressed in Climate Commitment progress updates accessible at: https://bouldercolorado.gov/climate

renewable generation in the community. This includes allocating more EnergySmart rebate dollars to local solar development and implementing a local solar strategy.

- **Promote Electrification**: Because electricity can be generated from clean renewable sources, city programs and policies must encourage the transition to electricity from fossil fuels with no viable renewable alternatives (natural gas and petroleum). This transition entails encouraging the adoption of electric space and water heating systems through pilots, financial incentives, education and outreach. The city must also continue to encourage electric vehicle adoption; an electric vehicle strategy is currently under development.
- **Advance Building Codes and Requirements:** Because energy use in buildings accounts for nearly three-quarters of the community emissions footprint, Boulder's building codes must continue to set high-efficiency standards for new construction and major renovations, including incorporating performance-based codes. Continued emphasis on prescriptive policies such as the Building Performance Program and SmartRegs, and voluntary programs, such as EnergySmart, is important to capture efficiency upgrades in existing buildings and incent high-efficiency equipment.
- **Support Large Energy Consumers**: Commercial and industrial buildings account for over half of the community's total GHG emissions; the largest energy users include the University of Colorado Boulder and Boulder's large industrial businesses. The city's Climate Action Plan (CAP) tax budget does not have sufficient resources to provide significant commercial and industrial rebates due to the scale of their energy use; however, the city will prioritize partnership and collaborative efforts to assist in commercial and industrial emission reduction efforts.
- **Reduce Vehicle-Miles Traveled (VMT):** Because most of the transportation sector emissions are tied to on-road VMT, programs and policies, including the Transportation Master Plan updates, should continue to prioritize VMT reduction efforts and alternative transportation options to reduce total VMT.
- **Improve Waste Management.** Because landfill tonnage has increased, largely due to construction and demolition activities, city programs and policies will improve enforcement of residential construction waste requirements and will investigate new commercial construction waste requirements to ensure this waste is managed and tracked properly.

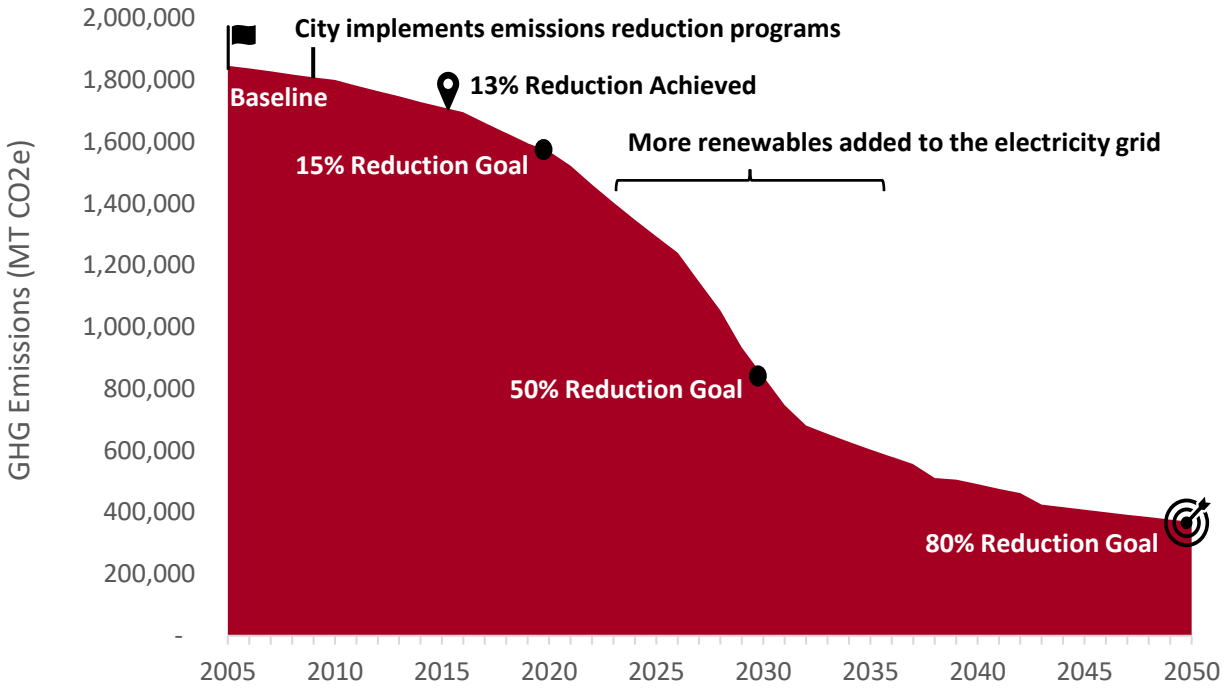
I. Community Progress

The City of Boulder has long understood the importance of local climate action. For the Boulder community, climate action is about resilience and transformation: the need to adapt to the climate changes that are already in motion, as well as reduce the emissions-heavy activities that drive future climate change.

Boulder's Climate Commitment provides a framework to rapidly transition from fossil fuels to a clean energy economy and lifestyle through innovative strategies, products and services that dramatically reduce GHG emissions, enhance our community's resilience and support a vital and equitable economy. Our goal is to reduce our community GHG emissions by at least 80 percent below 2005 levels by 2050 (Figure 1).

In 2016, Boulder achieved a 13 percent emissions reduction from its 2005 baseline, continuing progress toward its climate commitment goals.

Figure 1. Boulder GHG Emissions Reduction Goals



Since 2005, Boulder has seen a 10 percent increase in population, a 56 percent increase in retail sales and a 49 percent increase in overall Gross Domestic Product (GDP).[2] Although growth contributes to local economic vitality, it makes the task of achieving significant reductions in energy use and GHG emissions more challenging.

Fortunately, Boulder is reducing overall GHG emissions even as the economy and population grows. Overall, 2016 emissions decreased by 13 percent since the baseline year, but when normalized by community indicators, the reductions are even more dramatic, as shown in Table 1.

Table 1. Normalized 2016 Emission Metrics

Metrics	2005 (Baseline)	2016	Percent Change
GHG Emissions Per Capita	19 MT CO2e per person	15 MT CO2e per person	21% decrease
Emissions per Tax Dollar [3]	0.017 MT CO2e per $	0.008 MT CO2e per $	49% decrease
Emissions per GDP	0.00012 MT CO2e per $	0.00007 MT CO2e per $	39% decrease
Residential Emissions per Housing Unit	7.5 MT CO2e per housing unit	5.4 MT CO2e per housing unit	27% decrease
Commercial & Industrial Emissions per Employee	20 MT CO2e per FTE	17 MT CO2e per FTE	15% decrease

How Boulder Compares

Boulder is not alone in its commitment to emissions reductions. Cities around the country and the world are leading the way with aggressive climate and energy goals and there are many success stories. The United Nations Environment Programme[4] estimates that cities produce 60 percent to 80 percent of all GHG emissions, making cities a critical participant and partner in the sustainability movement.[5]

To truly understand a city's emissions impact and to assess progress, most cities track the metric of emissions generated per capita (Figure 2). This metric shows an average citizen's impact. While Boulder's per capita emissions (15 MT CO2e per capita) are in line with many other cities, there is still significant opportunity for Boulder to further reduce emissions and lead the way to achieving substantial reductions.

[2] Boulder's GDP is a measurement of the monetary value of goods and services produced in the city and is therefore a measure of productivity and economic health of the community.

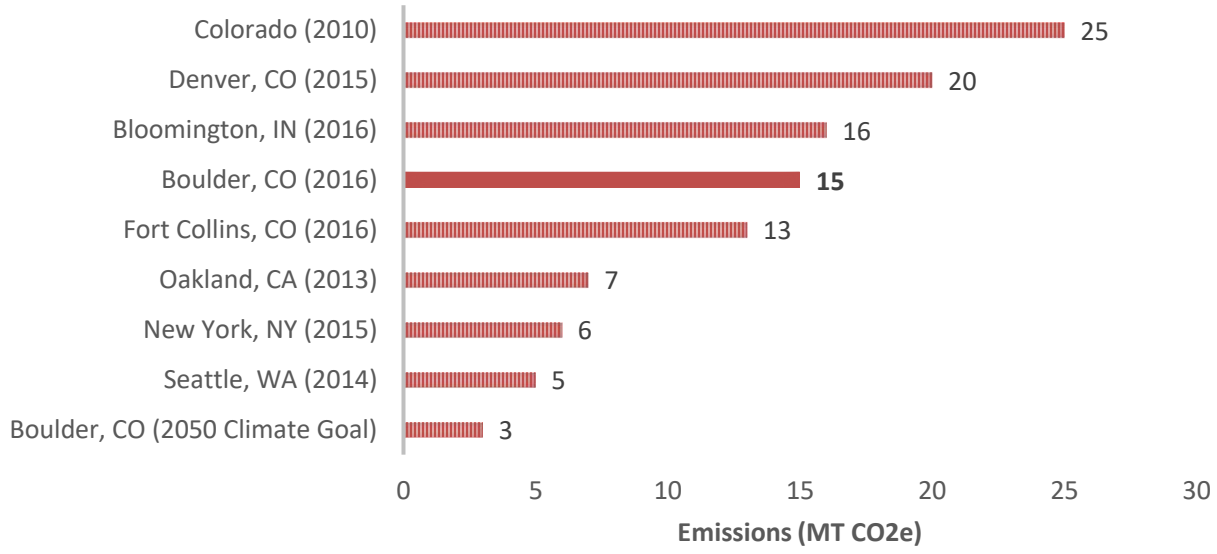
[1] Number of Housing Units was replaced as number of households as a community indicator in 2016 as it is a better metric for tracking normalized emissions.

[3] Collected tax includes sales and use tax, property tax, and other tax.

[4] For more information see: http://www.unep.org/SBCI/pdfs/Cities_and_Buildings-UNEP_DTIE_Initiatives_and_projects_hd.pdf.

[5] For more information on the role of cities and climate change see Lotus' blog, *The Power of Municipalities:* http://www.lotussustainability.com/blog/2015/8/11/the-power-of-municipalities.

Figure 2. Per Capita Emissions Comparison[6]



Organizations such as the Global Covenant of Mayors for Climate & Energy, C40 Cities, Urban Sustainability Directors Network, ICLEI - Local Governments for Sustainability, and CDP Cities (all of which Boulder is a member) allow cities to share progress and lessons learned, establish partnerships, share best practices and collaborate to achieve climate goals.

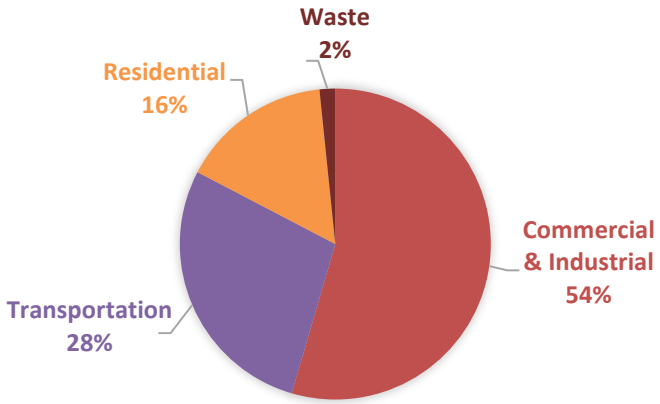
[6] City and County of Denver Climate Action Plan 2015. Accessed Nov. 2017 from: https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/Climate1/CAP%20-%20FINAL%20WEB.pdf
2016 Community Greenhouse Gas Emissions Inventory. Accessed Nov. 2017 from: https://bloomington.in.gov/sites/default/files/2017-08/2016%20Bloomington%20ghg%20inventory-final.pdf
Fort Collins 2016 Community Carbon Inventory. Accessed Nov. 2017 from: https://www.fcgov.com/climateaction/pdf/2016-community-carbon-inventory-update.pdf
City of Oakland 2016 Greenhouse Gas Emissions Inventory Report (2013 Data Year). Accessed Nov. 2017 from: http://www2.oaklandnet.com/oakca1/groups/pwa/documents/report/oak059097.pdf
Inventory of New York City Greenhouse Gas Emissions in 2015. Accessed Nov. 2017 from: http://www.dec.ny.gov/docs/administration_pdf/nycghg.pdf
Colorado Greenhouse Gas Inventory—2014 Update Including Projections to 2020 & 2030. Accessed Nov. 2017 from: https://www.colorado.gov/pacific/sites/default/files/AP-COGHGInventory2014Update.pdf

II. 2016 Boulder Carbon Footprint

In 2016, the Boulder community generated 1.59 million metric tons of greenhouse gas emissions in carbon dioxide equivalent (MT CO2e).[7] This is a 13 percent reduction from the 2005 baseline of 1.85 million MT CO2e.

Commercial and industrial buildings were the largest contributor, generating over half of Boulder's emissions in 2016 (Figure 3). The transportation sector contributed nearly a third of emissions.

Figure 3. Boulder's 2016 Emissions by Sector (%)



Building energy consumption was the community's largest emissions generator in 2016, representing 70 percent of Boulder's carbon footprint.

To reduce building energy use, the City of Boulder's energy programs help residents, businesses and property owners reduce energy consumption through behavior change, efficiency upgrades, equipment incentives, innovative solutions, advising and resources.

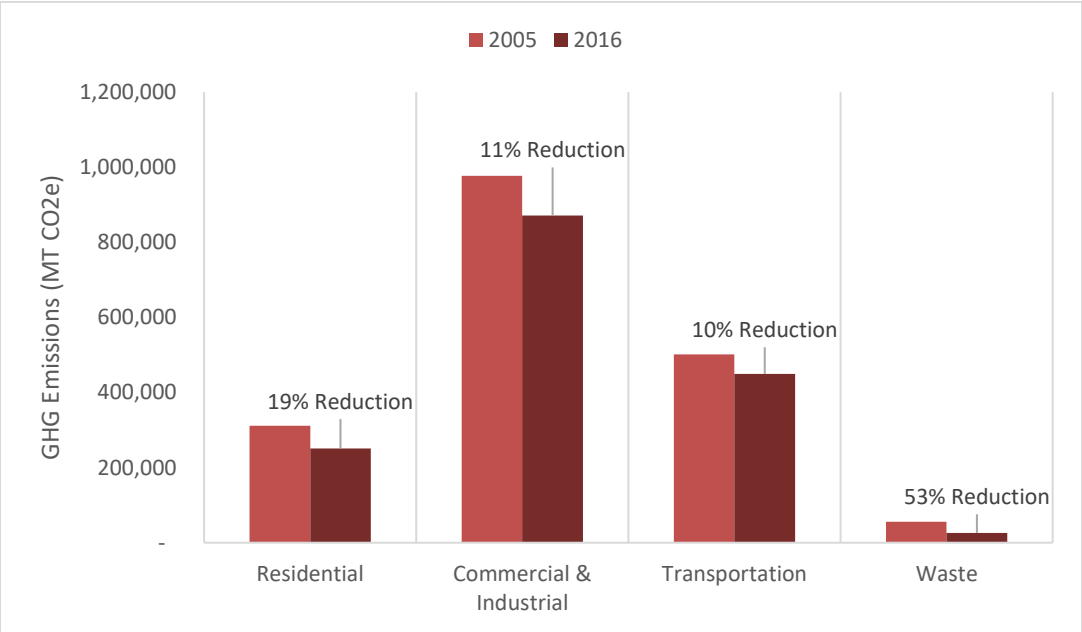
EnergySmart | *SmartRegs* | *Building Performance Program* | *Boulder Energy Challenge*

Boulder's energy programs have achieved impressive results[8] in partnership with Boulder County and Partners for a Clean Environment (PACE). Success is evident in the sector emissions comparison to the 2005 baseline (Figure 4).

[7] Boulder's community GHG inventory tracking excludes the optional Scope 3 emission source from Denver International Airport. Including optional Scope 3 emissions from Denver International Airport, the Boulder community generated 1.76 million MT CO2e in 2016, resulting in a 9 percent overall reduction in GHG emissions. For more information see **Air Travel** in Section II, Transportation.

[8] For detailed energy reduction achievements, please see program progress reports at: https://bouldercolorado.gov/climate/climate-sustainability-division

Figure 4. Emissions Comparison by Sector

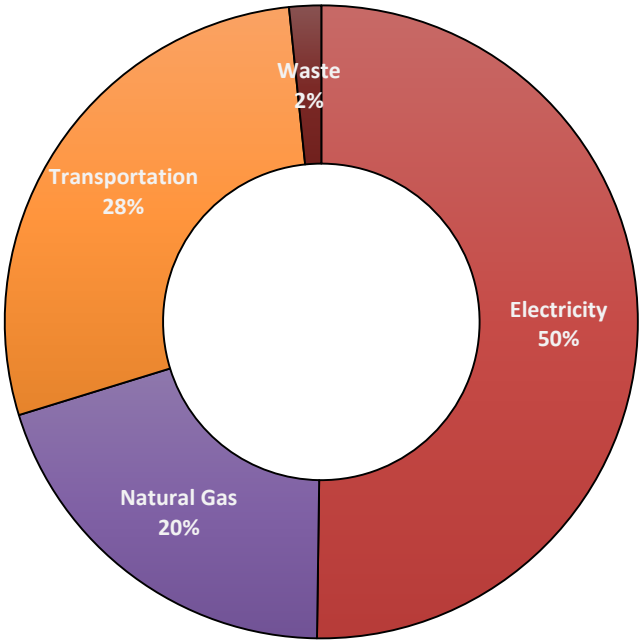


Though significant emissions reduction progress has been made in the community--reductions have been achieved in each sector--Boulder still has work to do in tackling our emissions' sources.

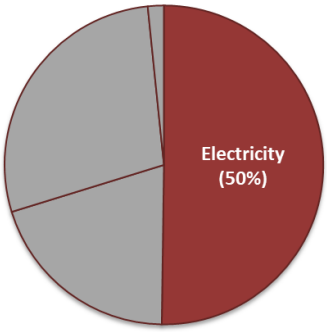
Emissions Sources

Fossil fuels were the largest source of Boulder emissions in 2016, with 98 percent of Boulder's emissions coming from electricity, natural gas and transportation fuel consumption (Figure 5).

Figure 5. Boulder's 2016 Emissions by Source (%)



Electricity

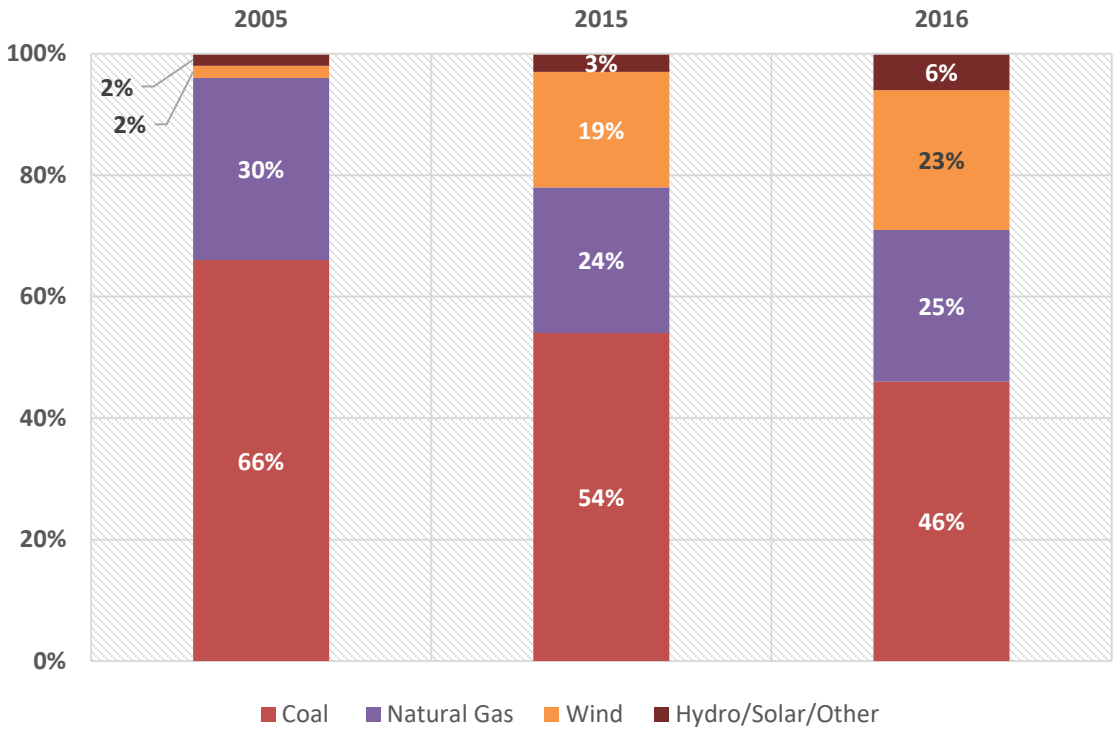


Emissions from electricity consumption account for 50 percent of Boulder's emissions footprint. These emissions are generated by the combustion of fossil fuels and therefore are dependent on the fuel mix that powers the electricity grid. Boulder's electricity is produced largely from emissions-generating combustion of coal and natural gas.

However, the electricity grid mix has incorporated an increasing amount of renewable energy since 2005 (Figure 6). Based on data from Boulder's current electricity provider, Xcel Energy, its electricity emission factors for CO_2 improved over 34 percent from 2005 to 2016 for the Colorado region.[9]

[9] Xcel Energy. **Energy and Carbon Emissions Reporting 2016 Summary**. Accessed Nov. 2017 from: https://www.xcelenergy.com/staticfiles/xe-responsive/Environment/Carbon/Carbon-Reduction-2016-Energy-and-Carbon-Summary.pdf

Figure 6. Xcel Energy Colorado Electricity Grid Fuel Mix



Because the electricity generation mix has such an influence over the emissions generated from electricity consumption, the City of Boulder's Climate Commitment has set a goal to rapidly transition to an energy system and economy that is powered 100 percent by renewable clean electricity, with 50 percent or more of that produced locally. Efforts to form its own municipal electric utility (municipalization) is the city's primary strategy to achieving this goal. Visit the Energy Future webpage to learn more about this effort. In addition to pursuing municipalization, the city has developed many programs and policies to encourage the development of local solar installations within the community.

Solar in Boulder

The city has supported the installation of nearly 20 Megawatts (MW) of local solar generation in the community. This support includes a tool to understand solar potential and programs to encourage installation, such as solar grants and rebates and a solar bulk purchasing program in partnership with Boulder County.

These efforts, along with changes to the permitting processes to reduce soft costs and code updates to require new buildings to be solar-ready, have led to Boulder's certification as a Platinum Solar Friendly and Gold SolSmart Community. Staff is completing a comprehensive strategy and action plan to meet long-term local renewable energy generation goals, the bulk of which are solar energy related.

Electricity Trends

Emissions from electricity have decreased 21 percent despite a nearly 12 percent increase in overall electricity consumption in the city. This trend is the result of an increased percentage of renewables powering the grid, which offsets the increases in consumption. It also underscores the importance of achieving 100 percent renewable electricity as soon as possible.

Residential Electricity Trends since 2005 Baseline

- ***The residential sector consumed less electricity in 2016 and overall sector emissions decreased.***
  - 1.5 percent total decrease in kilowatt (kWh) consumption
  - 11 percent decrease in kWh consumption per household
  - 28 percent emissions reduction overall for residential sector

The decrease in per household electricity consumption demonstrates that Boulder residents are using less electricity to perform the same tasks, while total residential electricity consumption remains relatively flat due to population increases.

Commercial and Industrial (C&I) Electricity Trends since 2005 Baseline

- ***The C&I sector consumed more electricity in 2016, but realized a reduction in consumption per dollar produced and a reduction in overall sector emissions.***
  - 15 percent total increase in kWh consumption
  - 7 percent increase in kWh consumption per full-time employee
  - 23 percent decrease in kWh consumption per GDP
  - 19 percent emissions reduction overall for C&I sector

This overall decrease in C&I emissions shows that, while the sector is using more electricity due to a growing economy, the improved electricity grid emissions factor results in lower emissions overall, further demonstrating the importance of a clean electricity grid. While the sector increased overall electricity consumption, the amount of electricity consumed per dollar produced has decreased, showing efficiency improvements in production.

The overall increase in electricity consumption in the C&I sector can be attributed to several causes.

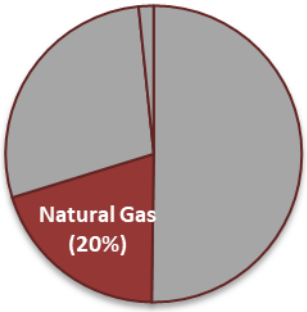
1. **Economic Growth**: Jobs, C&I floor space and GDP have increased since 2005.
2. **Operation of the University of Colorado-Boulder's Cogeneration Facility**: In 2004, the university began to phase out the operation of its cogeneration facility. Taking the cogeneration system offline resulted in a corresponding drop in natural gas consumption and a significant increase in the amount of grid electricity consumed.[10]
3. **Increased Plug Loads and Space Density**: The rapid proliferation of electronic devices had also led to increased electricity use in the C&I sector. Plug loads are among the fastest-growing drivers of energy consumption in C&I buildings. While C&I office buildings are starting to make more efficient use of space, they are also seeing higher energy use per square foot and operating at longer hours.
4. **Development of Energy-Intensive Industry and Facilities**: Beyond typical economic growth, new, highly energy-intensive facilities in Boulder have come online since 2005. These include the addition of large new data centers[11] and the legalization of medical and recreational marijuana facilities.

Marijuana Electricity Use

The marijuana sector contributes just over 2 percent of total 2016 electricity consumption and just under 3 percent of C&I electricity consumption.

Natural Gas

Emissions from natural gas account for 20 percent of Boulder's emissions footprint. These emissions are generated by the combustion of natural gas, largely for heating buildings and water.



Natural Gas Trends

Emissions from natural gas have increased 17 percent despite a 4 percent reduction in overall natural gas consumption. While this seems counterintuitive, explanations are provided below.

[10] Since shutting down its aging cogeneration system, the university designed and built a new $91 million campus utility system. Although CU Boulder and the city expect that this new system will reduce total emissions for the campus in tandem with other efforts at CU, the system is not yet online, and these reductions will not be evident for several inventories.

[11] While most new data centers have been constructed to be extremely energy efficient, data centers are energy intensive by nature and this still represents a large new electric load.

Residential Natural Gas Trends since 2005 Baseline

- ***The residential sector consumed less natural gas and realized an emissions reduction in 2016.***
  - 4 percent total decrease in dekatherm (Dth) consumption
  - 14 percent decrease in Dth consumption per household
  - 4 percent emissions reduction overall for residential sector

The need for heating, as measured by Heating Degree Days[12], has decreased by 5 percent since 2005. This trend suggests that the residential sector saw a decrease in natural gas consumption commensurate with the weather – residents needed to heat their homes less frequently compared to the baseline year. The reduction in natural gas use per household also indicates that residents are implementing energy efficiency measures and/or engaging in fuel switching efforts – replacing natural gas heating equipment with electric heating and cooling systems such as heat pumps.

Boulder's Electrification Pilot
(Roadmap to Renewable Living)

Boulder and its Carbon Neutral Cities Alliance (CNCA) partners New York, Washington D.C. and Burlington, VT., were awarded $200,000 to support work with the major air source heating and cooling companies to jointly develop programs that can support home owners in replacing their fossil fuel-based appliances with high-efficiency, renewable energy-ready heat pumps.

Currently, most homes in Boulder and in many other cities are dependent on non-renewable natural gas, propane and heating oil for heat, and many do not have summer cooling. Boulder is developing a pilot which offers an opportunity for a large climate impact by creating strategies to rapidly accelerate the adoption of electric heating and cooling systems. As the grid's emissions factor improves, the climate impact of this program grows. Boulder will launch the Roadmap to Renewable Living pilot for residents in early 2018.

C&I Natural Gas Trends since 2005 Baseline

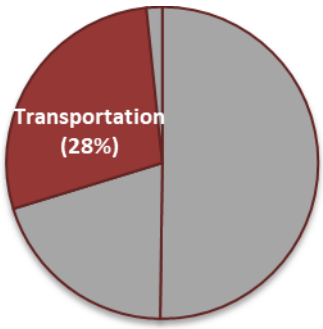
- ***The C&I sector consumed less natural gas in 2016, with significant reductions per production metrics; however, emissions increased for the sector due to carbon intensity changes.***
  - 4 percent total decrease in Dth consumption
  - 11 percent decrease in Dth consumption per full-time employee
  - 36 percent decrease in Dth consumption per GDP
  - 24 percent overall emissions increase for C&I sector

[12] A Heating Degree Day (HDD) is roughly proportional to the energy used for heating a building. They are calculated by taking the difference between the average daily temperature and the balance point temperature. The balance point temperature is the average daily outside temperature at which a building maintains a comfortable indoor temperature without heating or cooling. When the average daily temperature is below the balance point temperature the result is heating degree days (i.e., the building must be heated to maintain the balance point temperature). HDD were taken from: http://www.weatherdatadepot.com/ using at 65-degree Fahrenheit balance point.

The above metrics may seem counterintuitive, because despite the decrease in consumption, the overall sector emissions for natural gas increased from 2005. This increase is largely due to the changes in operation of the University of Colorado cogeneration facility. In the baseline year, nearly half of the cogeneration facility's natural gas consumption transferred to electricity generation, rather than thermal use – effectively lowering the community's overall emissions factor for natural gas. In 2016, with the university's facility no longer operating fulltime, all natural gas consumed by the university was for thermal use and therefore raised this emissions factor. Should the university facility operate regularly again in the future, we can once again anticipate lower natural gas emissions associated with the university's consumption, and a better correlation to the 2005 baseline metrics.

Transportation

Emissions from transportation, the second largest contributing sector, are responsible for 28 percent of Boulder's emissions footprint. Transportation emissions are largely generated from the combustion of vehicle fuel, mainly gasoline and diesel, to power on-road travel within the Boulder Valley. A small portion of these emissions are also generated from fuel consumption by other transportation, including railways and air travel from the Boulder municipal airport.



Transportation Trends

Emissions from transportation have decreased 10 percent since the 2005 baseline. This decrease is largely due to a reduction in vehicle-miles-traveled (VMT)[13] within the Boulder Valley since the baseline year.

On-road Travel Trends since 2005 Baseline

- ***On-road VMT and emissions decreased in 2016***
  - 5 percent decrease in total on-road travel VMT
  - 14 percent decrease in VMT per person
  - 12 percent decrease in VMT per job
  - 10 percent emissions reduction from on-road travel

Reductions in VMT are mainly due to behavior change – residents and employees are increasing their use of alternative transportation options, such as public transit and bicycling, instead of single occupant vehicle use. These changes are encouraged and supported by Boulder's Transportation Master Plan and GO Boulder[14] efforts to expand and improve the city's multi-modal infrastructure and support programs such as the EcoPass and parking management. Further, citizens are electing to purchase more efficient, electric vehicles and the city's support and incentives for electric vehicles, as well as the transition of the city fleet to cleaner fuels, has contributed to the overall sector emissions reductions in the community.

[13] VMT is estimated by a combination of regional modeling conducted by the Denver Regional Council of Governments, counting number of cars entering Boulder at key locations and at intersections by the City of Boulder Transportation Division and regular travel behavior surveys of residents and employees.

[14] Since 1989, GO Boulder has been working to create an innovative and balanced transportation system to sustain the quality of life valued by Boulder residents, employees and visitors. GO Boulder creates and promotes "Great Options" for transportation to increase the travel choices available to our community. https://bouldercolorado.gov/goboulder

Integrating Transportation & Sustainability

Among several sustainability objectives, the city's Transportation Master Plan (TMP) aims to reduce VMT in the Boulder Valley, increase alternative transportation options, and encourage electric vehicle (EV) adoption.

Success to date in reducing VMT has depended on improving travel options, providing incentives and reducing the subsidies to auto travel like free parking. Further, the city will operate over 40 publicly-available EV charging stations by the end of 2017.

See the 2016 Transportation Report on Progress for more information.

Other Transportation Trends since 2005 Baseline

- ***Air travel and railway emissions increased in 2016; however, these sources make up less than 1 percent of total transportation sector emissions.***
  - 10 percent increase in Boulder Municipal Airport travel emissions due to more flights
  - Railway emissions were not calculated in the 2005 baseline, but have been incorporated into the current inventory in line with protocol guidance

Air Travel

The air travel accounted for in Boulder's GHG inventory is from the Boulder Municipal Airport, which is located within Boulder's city boundaries. While Denver International Airport (DIA) serves Boulder residents, it is located outside of Boulder city boundaries, and therefore outside of the community GHG inventory boundaries. Per the GPC, the emissions associated with Boulder residents traveling through DIA are considered Scope 3 emissions that are optional to report under BASIC level reporting.[15] City staff have historically calculated these Scope 3 emissions, and continue to do so for tracking purposes. However, these Scope 3 emissions are tracked separately and not incorporated into the GHG inventory emissions totals. This method of tracking ensures the city is reporting emissions consistent with protocol requirements and therefore enables the city to better compare its carbon footprint to other cities, while focusing tracking efforts on the GPC-required Scope 1 and Scope 2 emissions sources over which the city has more control. Table 2 displays the Scope 3 emissions trends from DIA air travel by Boulder residents.

Table 2. Optional Scope 3 Emissions Trends from DIA Air Travel[16]

	2005	2016	Percent Change
Scope 3 Emissions (MT CO2e) from DIA Air Travel	87,600	163,600	87% increase

[15] See Appendix A: **GPC-Compliant Inventories** for more information on GPC BASIC level reporting requirements.

[16] Optional Scope 3 air travel emissions are not included in the overall Boulder emissions inventory of 1.59 million MT CO2e or its 13 percent reduction. Including optional Scope 3 emissions from Denver International Airport, the Boulder community generated 1.76 million MT CO2e in 2016, resulting in a 9 percent overall reduction in GHG emissions.

Waste

Emissions from waste account for 2 percent of the community's carbon footprint. The waste sector incorporates both emissions from municipal solid waste and wastewater. Emissions from municipal solid waste are generated by decomposition of landfilled and composted materials. Emissions from wastewater are generated from effluent discharge and flared digester gas.

Waste Trends

Overall waste emissions decreased by 53 percent between 2005 and 2016. This sector decrease was achieved due to emissions reductions from both municipal solid waste and wastewater treatment.

Municipal Solid Waste Trends since 2005 Baseline

- ***Emissions from municipal solid waste decreased and landfill diversion rates increased in 2016.***
  - 30 percent increase in total tons landfilled
  - 4 percent increase in residential waste landfilled
  - 58 percent decrease in landfill waste emissions

Despite the increase in landfill tonnage, there was a significant reduction in emissions attributable to municipal solid waste in 2016. This discrepancy is primarily due to changes in the methodology and emission factors for waste between 2005 and 2016. The standard waste emission factors used today[17] are more accurate, as they are based on the material composition of the municipal solid waste and account for landfill operations (e.g., whether the landfills use methane gas recovery).

The overall increase in landfill tonnage can be attributed to:

1. **Community Growth.** Population, jobs and GDP have increased since 2005.
2. **Development**. Construction and demolition (C&D) projects in the community fluctuate over time and result in inconsistent waste trends. Further, C&D waste materials like concrete and steel are very heavy and increase landfill tonnage, but are less carbon intensive compared to lighter materials like organic waste when evaluating emissions impacts.
3. **Improved Tracking**. Composting was not tracked and included in the baseline inventory. However, since 2005, the city has improved compost data tracking and now incorporates those emissions into the inventory. Composting represented 26 percent of solid waste emissions in 2016 and composting efforts continue to grow annually.

[17] The emissions factors used are sourced from ICLEI's *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions*, in compliance with GPC requirements. *More information is available at: http://icleiusa.org/ghg-protocols/*

A Zero Waste Future

The City of Boulder's goal is to, by 2025, divert 85 percent of our waste from the landfill by either reusing or recycling waste into new materials.

On June 16, 2015, City Council adopted a Universal Zero Waste Ordinance (Boulder Revised Code Title 6, Chapter 3 and Title 6, Chapter 12) to expand recycling and composting to all Boulder property owners, businesses and public places.
Learn more from www.zerowasteboulder.com

The City of Boulder is tackling its waste streams through its Zero Waste efforts, which are evident when analyzing the community waste streams and diversion rates.

- ***The diversion rate from landfill to composting and recycling increased in 2016.***
  - The total diversion rate increased from 27 percent in 2005 to 40 percent in 2016
  - Residential diversion increased from 37 percent in 2005 to 43 percent in 2016
  - C&I diversion increased from 20 percent in 2005 to 38 percent in 2016

Though single-family landfill tonnage has increased since 2005, the tons of waste landfilled have decreased 9 percent since the adoption of the Universal Zero Waste Ordinance in 2015. Further, the composting and recycling diversion rates have also seen a marked increase since these efforts began, with the multifamily waste stream diversion rates increasing from 21 percent to 33 percent in just the past year. Much of this change will be reflected in the next GHG emissions inventory.

Wastewater Treatment Trends since 2005 Baseline

- ***Effluent discharge and emissions from wastewater treatment decreased in 2016 while capturing the best nitrogen removal performance in the facility's history.***
  - 76 percent decrease of nitrogen effluent discharge (kg) per day
  - 55 percent reduction in wastewater emissions

Though responsible for only three percent of waste sector emissions, emissions from wastewater treatment processes have achieved significant reductions since 2005. The emissions associated with the effluent discharge of the wastewater treatment facility (WWTF) are impacted by the amount of nitrogen discharged by the community and by the performance of the treatment processes associated with nitrogen removal.

In 2016, the WWTF boasted both the lowest energy usage since 2007 and the best nitrogen removal performance in the facility's history. Prior to 2006, around 1,000 MT CO_2e per year were associated with effluent nitrogen discharge. The $45M Liquid Stream Upgrades Project that occurred between 2005 and 2008 incorporated an activated sludge biological nutrient removal system capable of roughly 50 percent nitrogen removal. This upgrade was motivated by new discharge permit limits for ammonia and nitrate. This upgrade resulted in a reduction in emissions associated with effluent nitrogen discharge of 300 MT CO_2e.

Further progress from the $5M Nitrogen Upgrades Project that began in 2015 is evident in 2016 effluent nitrogen performance, and nitrogen removal performance will improve even more in 2017 and 2018.

Awarding Action

In 2017 the WWTF received the Partner of the Year award from the Colorado Industrial Energy Challenge for its energy reductions.

III. Next Steps

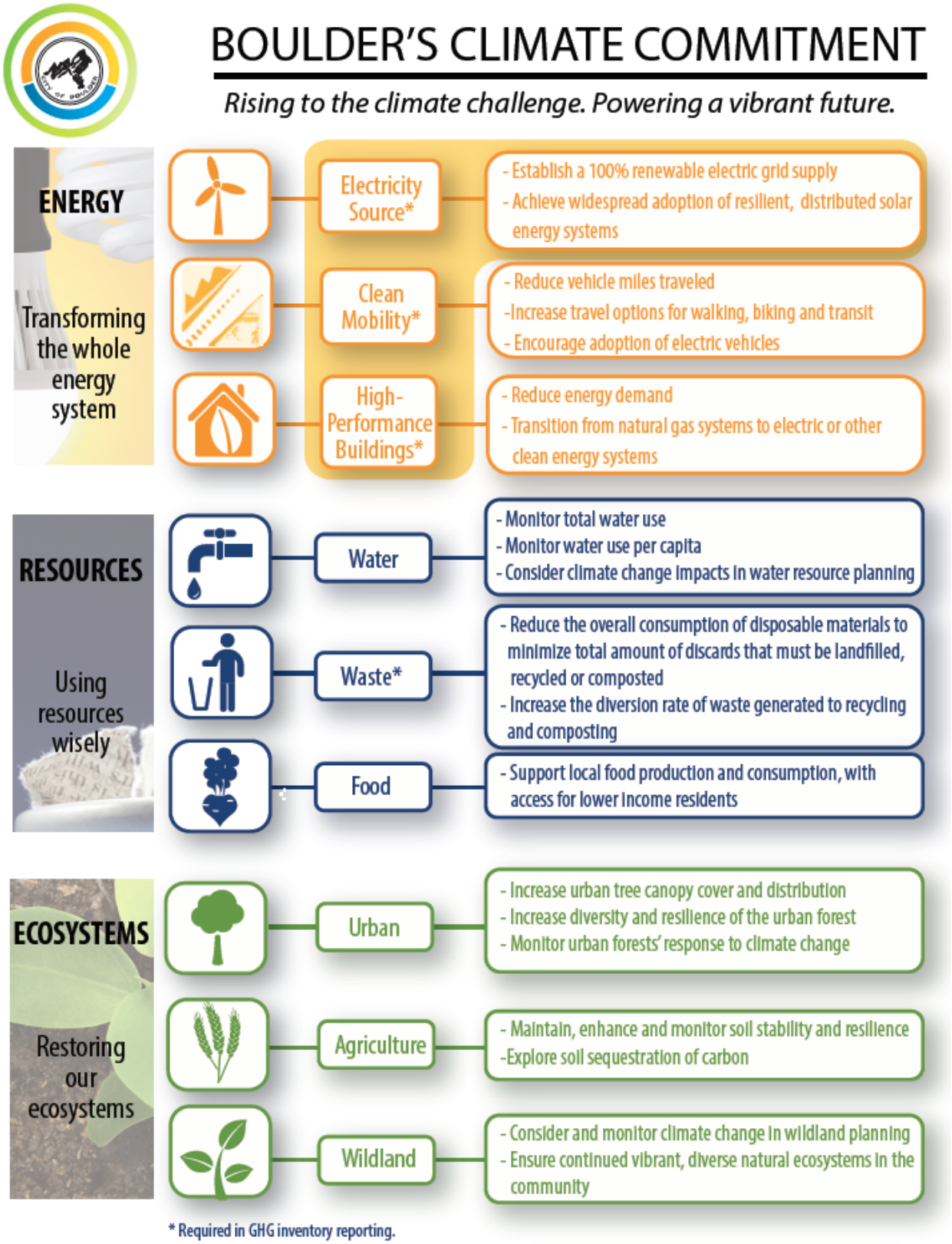
Boulder has long understood the importance of local climate action. Boulder's residents and businesses were among the first in the country to implement a Climate Action Plan Tax (see Appendix B: Climate Action Plan (CAP) Tax Budget)[18] to support a host of other energy efficiency and conservation programs (see Table 3. Current Action Areas). Programs including EnergySmart, SmartRegs and the Building Performance Ordinance are being replicated elsewhere as they begin to achieve the full benefits of their implementation locally. Other programs, like a local Energy Impact Offset Fund and changing the City of Boulder's energy supply from fossil fuels to renewable sources through the possible creation of a municipal electric utility, are still taking shape.

In December 2016, City Council unanimously approved the adoption of Boulder's Climate Commitment goal to reduce community GHG emissions by 80 percent below 2005 levels by 2050. To achieve this goal, Boulder's Climate Commitment focuses on the following action areas: energy, resources, and ecosystems. While the Climate Commitment focuses on a multitude of strategies in these areas, from energy sources to urban wildlands to local food production, the action areas focused on energy and waste are those that directly address GHG emissions generation and are required to be reported under GHG inventory best practices. Therefore, the annual GHG inventory serves as a vital component of the Climate Commitment for tracking program success and, most importantly, the city's progress towards its overall climate goals.

The graphic below shows the high-level strategies in place for these Climate Commitment action areas and identifies which are also reported in the GHG inventory: electricity source, clean mobility, high-performance buildings, and waste.

[18] The CAP Tax first passed in 2007 and was the nation's first voter-approved tax dedicated to addressing climate change. The CAP tax is levied on city residents and businesses and is based on the amount of electricity they consume.

Figure 7. Boulder's Climate Commitment



The city's action plan to address emissions includes a set of aggressive, city-funded programs and services which are largely funded by the CAP Tax (**Appendix B**: provides further information on how these funds are allocated). The programs and services outlined in Table 3 are designed to reduce local greenhouse gas emissions and mitigate climate change].

Table 3. Current Action Areas

Climate-Energy Action Areas (2018-2019)
Buildings
• **Building Performance Program:** Continue implementation and building owner support for the city's energy reporting and energy efficiency requirements on C&I buildings (larger than 20,000 sf). • **SmartRegs:** Implementation of strategies to achieve 100 percent compliance with the city's rental housing efficiency requirements by the end of 2018. • **Natural Gas Replacement:** Launch city-county collaborative implementation of pilot project in residential natural gas appliance replacement program. • **Voluntary Energy Efficiency:** Continue to support Boulder County's Partners for a Clean Environment (PACE) advising services and program implementation, including EnergySmart. • **Clean Energy Finance:** Work with Boulder County to expand utilization of the Colorado Commercial Property Assessed Clean Energy (C-PACE)[19] financing program. • **Electricity Offset for Marijuana Facilities:** Achieve 100 percent compliance with the city's requirement for marijuana facilities to offset their electricity usage with renewable energy**.** • **Net Zero Energy Codes:** Every three years, update energy codes to ensure the city is on pathway to the goal of net zero energy codes for all new buildings by 2031. • **City Facilities:** Continue to retrofit city buildings to reduce emissions, including major redevelopment efforts such as the Alpine-Balsam site, which will demonstrate accelerated energy efficiency and renewable energy adoption.
Electricity Source Change
• **Renewable Grid Electricity**: Either by forming a municipal electric utility, working with the incumbent utility, or promoting legislative and regulatory changes, work to ensure that 100 percent of grid electricity that serves in-city customers comes from renewable energy by 2030. • **Solar/Local Generation Strategy**: Implement community solar strategy designed to achieve the renewable energy targets adopted in the Climate Commitment (50 MW by 2020). This strategy includes both city facility solar development and community solar adoption. • **Energy Resilience:** Complete implementation of the Department of Energy's Energy Resilience grant and implementation of resilient energy systems at three critical community service centers.
Mobility
• **Multi-Modal Transportation Options**: Continue work with Transportation Division/GO Boulder to implement multimodal action items from Boulder's Transportation Master Plan (TMP) to achieve GHG reduction goals as well as broader community sustainability goals.

[19] For more information see: http://copace.com/

- **Develop Electric Vehicle (EV) Strategy**: Develop strategy to achieve Climate Commitment emission reduction targets related to EVs.
    - **Electric Vehicle Adoption**: Continue to coordinate the multi-departmental working group on EV and alternative fuels strategy development. Finalize multi-department EV adoption strategy and action plan. Continue to work on accessibility of EV charging.
    - **Electrification of Transit**: Expand cross departmental collaboration and continue working with Via and RTD to explore adoption of transit fleet vehicle electrification options.
- **Emerging Transportation Technologies**: Work with Transportation Division/GO Boulder to research and evaluate emerging mobility options including mobility on demand, expanded ride share systems, connected/automated vehicles and new heavy transport options (e.g. renewable natural gas or diesel fleet vehicles).
- **Employee Commute**: Demonstrate city leadership in continuing to advance additional low emission commute options for city employees (e.g. EV adoption, electric van pool, telework, etc.) and offer incentive programs to encourage the use of transportation options.

Waste

- **Zero Waste Resolution and Zero Waste Strategic Plan:** Continue implementation strategies to achieve 85 percent waste diversion by the year 2025.
- **Universal Zero Waste Ordinance:** Continue to refine the implementation systems and compliance support for the city's recycling and composting expansion requirements on homeowners, property managers and businesses.
- **Public Place Recycling and Composting:** Continued transition of city-owned public space waste receptacles to include zero waste services.
- **Food Waste Reduction:** Increase awareness of food waste and encourage edible food recovery programs.

Cross Cutting Initiatives

- **Carbon Tax Research:** Begin to investigate future carbon taxes that would discourage the use of natural gas and petroleum, as the city transitions to clean renewable electricity.
- **Energy Impact Offset Fund (EIOF)**[20]: Manage the newly created fund that collects required energy offset payments from the licensed marijuana facility owners, which will be used to develop local renewable energy projects in the future.
- **Program Tracking and Reporting**: Continue city organization and community wide emissions tracking and reporting, as well as program level tracking and reporting. Work to integrate into the city dashboard and centralized data management systems.
- **Climate Action Plan Strategy Development:** Develop the Climate Action Plan to achieve the recently adopted Climate Commitment goals. This 5-year action plan should include strategies for key areas (electricity source change, high performance buildings, clean mobility, resource use, and ecosystems).

[20] In 2017 the city created the EIOF for licensed marijuana businesses to participate in for compliance with the 100 percent electricity offset requirement. Previously, these businesses were offsetting their consumption through external programs. The EIOF enables the city to collect these offset payments and use this money to fund development of local renewable energy projects within the community.

- **Climate Commitment Community Engagement**: Continue community engagement around development of a coordinated climate action strategy and implementation plan with special focus in 2018 on the Ecosystems area.
- **Boulder Energy Challenge (BEC):** Track progress of the second round of the BEC, to provide funding to support the development and commercialization of innovative GHG emission reducing technologies and strategies in Boulder.

Ready to Engage?

Residents, businesses, property owners and institutions can all help Boulder achieve its emissions goals!

Things you can do to contribute and help keep Boulder on track with its emissions goals:

- Capture energy efficiency opportunities in your homes and businesses
- Electrify your homes and vehicles
- Take advantage of solar grants and rebates
- Reduce your waste and take advantage of our community recycling and composting resources
- Use alternative transportation to get around town
- Take fewer flights and opt for teleconferencing

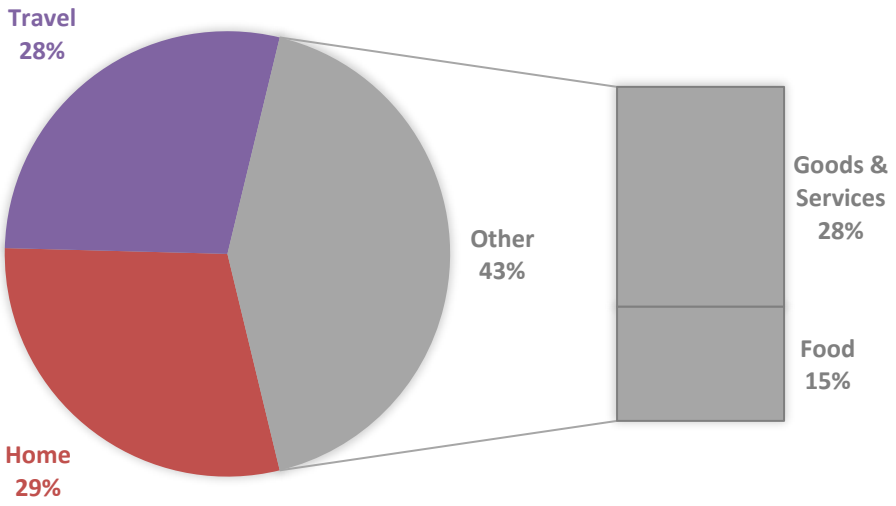
Boulder follows best practice protocols for calculating community GHG emissions.[21] These protocols look largely at city boundaries and the activities generating emissions within them. However, they do not account for other emissions-generating activities we know exist, such as emissions from imported food and emissions from goods and services. In fact, we estimate these protocols only cover just over half of an individual household's emissions footprint compared to what a full lifecycle methodology may capture.

According to resources from the Berkeley Institute of the Environment [22], an average household in Boulder County has a lifecycle emissions footprint of just over 48 MT CO2e per year. Just over half of that average household's emissions would be accounted for in the community GHG inventory based on protocol methodology – emissions associated with energy consumption in the home and travel. The remaining 43 percent of the household footprint is not accounted for in the community GHG inventory (Figure 8).

[21] See **Appendix A: Methodology Background** for more information on GPC BASIC level reporting requirements.

[22] Christopher M. Jones and Daniel M. Kammen, Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities. Supporting Materials. Environ. Sci. Technol., 2011, 45 (9), pp 4088–4095. Accessed Nov 2017 from: http://www.coolcalifornia.org/calculator-documentation

Figure 8. Average Boulder County Household Emissions Footprint (*For Illustrative Purposes Only*)[23]



Even if it's not captured in our community GHG inventory tracking, the city encourages everyone to do what they can to lessen our overall impact on the climate. Actions may include:

- Making eco-conscience purchases
- Eating a plant rich diet (i.e. limiting red meat consumption)
- Sourcing local goods and services

Residents can calculate their own emissions footprint at: http://www.coolcalifornia.org/calculator-households-individuals.

Want to learn more? Check out Boulder's community climate action portal here: http://boulder.earth/

[23] Calculated using average household data for Boulder County from http://www.coolcalifornia.org/calculator-households-individuals.

Appendix A: Methodology Background

Practicing Accountability and Leadership

Boulder has long understood the importance of local climate action. Boulder's residents and businesses were among the first in the country to support and participate in programs like the Climate Action Plan Tax (CAP Tax) and a host of other energy efficiency and conservation programs. Some of these, including EnergySmart, SmartRegs and the Building Performance Ordinance, are being replicated in other cities as they begin to achieve the full benefits of their implementation locally. Other programs, like a local carbon offset fund and electric utility municipalization, are still taking shape.

In 2015, the City of Boulder committed to the global Compact of Mayors (Compact), a worldwide effort to highlight the leadership of cities in addressing climate change and demonstrate the collective impact of city efforts. One of the requirements of the Compact is the completion of a GHG inventory that complies with the *Global Protocol for Community-Scale GHG Emissions* (GPC). Boulder's 2016 GHG inventory is GPC-compliant and fulfills the inventory requirement Boulder has committed to under the Compact.

Inventory Methodology

The GPC is the official protocol specified by the Compact of Mayors. It defines what emissions must be reported and how. Following the City of Boulder's commitment to the Compact in 2015, Boulder began calculating inventories to meet the Compact's GPC-compliant requirements. The annual Boulder community inventory also draws on methods from ICLEI-Local Governments for Sustainability's (ICLEI) *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions*, which provides more detailed methodology specific to U.S. communities.

As part of its Climate Commitment, Boulder selected the 2005 inventory as the GHG baseline to which all future inventories are compared. Please refer to the July 30, 2015 council memo[24] reference about why this was chosen as the baseline year.

Previous Inventory Methodologies

Boulder developed annual inventories from 2005 through 2010 using the Greenhouse Gas Protocol Initiative's *GHG Protocol Corporate Standard*. Results from the 2010 inventory were published in a comprehensive report titled *Community Guide to Boulder's Climate Action Plan, 2010/2011 Progress Report*[25]. From 2011 to 2014, Boulder had limited access to energy consumption data for the community and was unable to complete annual GHG inventories. However, in 2015 Boulder could calculate a 2012 GHG inventory using ICLEI's *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version 1.0*, from October 2012.

Following successful lobbying efforts with other Colorado communities to the Colorado Public Utilities Commission to require regulated utilities to provide cities with an annual Community Energy Report containing data necessary for a GHG inventory, Boulder has been able to complete annual inventories

[24] See the July 30, 2015 council memo to understand why 2005 was chosen as the baseline year (https://documents.bouldercolorado.gov/weblink/ElectronicFile.aspx?docid=129619&dbid=0)

[25] Results from the 2010 inventory are not included in the analysis presented in this report.

beginning 2015 using the Community Energy Report from Xcel Energy. With annual data now accessible and the need to develop all future inventories using the GPC-compliant methodology, Boulder elected to also revise the 2012 inventory to be consistent with the GPC methodology.

GPC-Compliant Inventories

The GPC protocol was released in 2014 and provides a transparent GHG accounting methodology for reporting community GHG emissions, and unlike many other protocols, provides a consistent structure that will enable better comparisons among different cities.[26]

There are two reporting levels for the community framework:

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

Based on available data, Boulder has chosen the BASIC reporting level, which is consistent with many other cities to date. To ensure consistency emissions reporting, previous annual inventories have been adjusted to report all emissions in the required BASIC emission scopes and categories. The categories required to be reported under the BASIC reporting level are:

1. **Scope 1:** GHG emissions from sources located within the city boundaries, including:
    a. Energy and transportation fuel combustion.
    b. Fugitive emissions.
    c. Solid waste treated within the city.
    d. Wastewater treated within the city.
2. **Scope 2:** GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
3. **Scope 3**: GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundaries, including:
    a. Solid waste treated outside the city.
    b. Wastewater treated outside the city.

Electricity and natural gas emission factors are sourced from Xcel Energy's *City of Boulder's Annual Community Report*.[27] All other emission factors are based on ICLEI's *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version* 1.0, July 2013 and ICLEI's *Local Government Operations Protocol*.

Annual activity data is provided by the sources listed in Table 4.

[26] For more information see: http://www.ghgprotocol.org/city-accounting.
[27] Note: The 2016 GHG inventory used the activity data published by Xcel Energy in the 2016 Community Energy Report for Boulder as of September 2017. These numbers may be subject to change on the Xcel Energy website depending on how frequently Xcel Energy re-calculates and publishes the reports on the website: https://www.xcelenergy.com/working_with_us/municipalities/community_energy_reports

Table 4. Activity Data Sources

Activity Data	Data Source
Electricity	Xcel Energy's Annual Community Report
Natural Gas	Xcel Energy's Annual Community Report
On-road transportation	City of Boulder staff and Southwest Energy Efficiency Project (SWEEP)
Public transit	RTD and City of Boulder staff
Railways	Denver Regional Council of Governments (DRCOG) and Colorado Department of Transportation (CDOT) staff
Aviation	Boulder Municipal Airport staff
Solid waste	City of Boulder staff
Wastewater treatment	Boulder Wastewater Treatment Facility staff
Renewable energy	Xcel Energy's Annual Community Report

Xcel Energy includes industrial energy data with the commercial and institutional sector, therefore this sector is reported as combined. Boulder can expect to receive this data each year in updated Xcel Energy Community Energy reports.

Differences Between Inventory Methodologies

Calculation methodologies between the different protocols follow the same logic: Emissions are a product of emission factors and activity data. Although many themes stay consistent between protocols, different protocols may use different emission factors, lump emissions together differently and require different emission sources.

Today, emission factors from the most current version of ICLEI's *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* and ICLEI's *Local Government Operations Protocol* are the most widely used and accepted. Most of these factors stay relatively constant over time, except for electricity emission factors that are sourced directly from Xcel Energy.

Most of the factors between all three inventory years are similar with a few notable exceptions, as shown in Table 5.

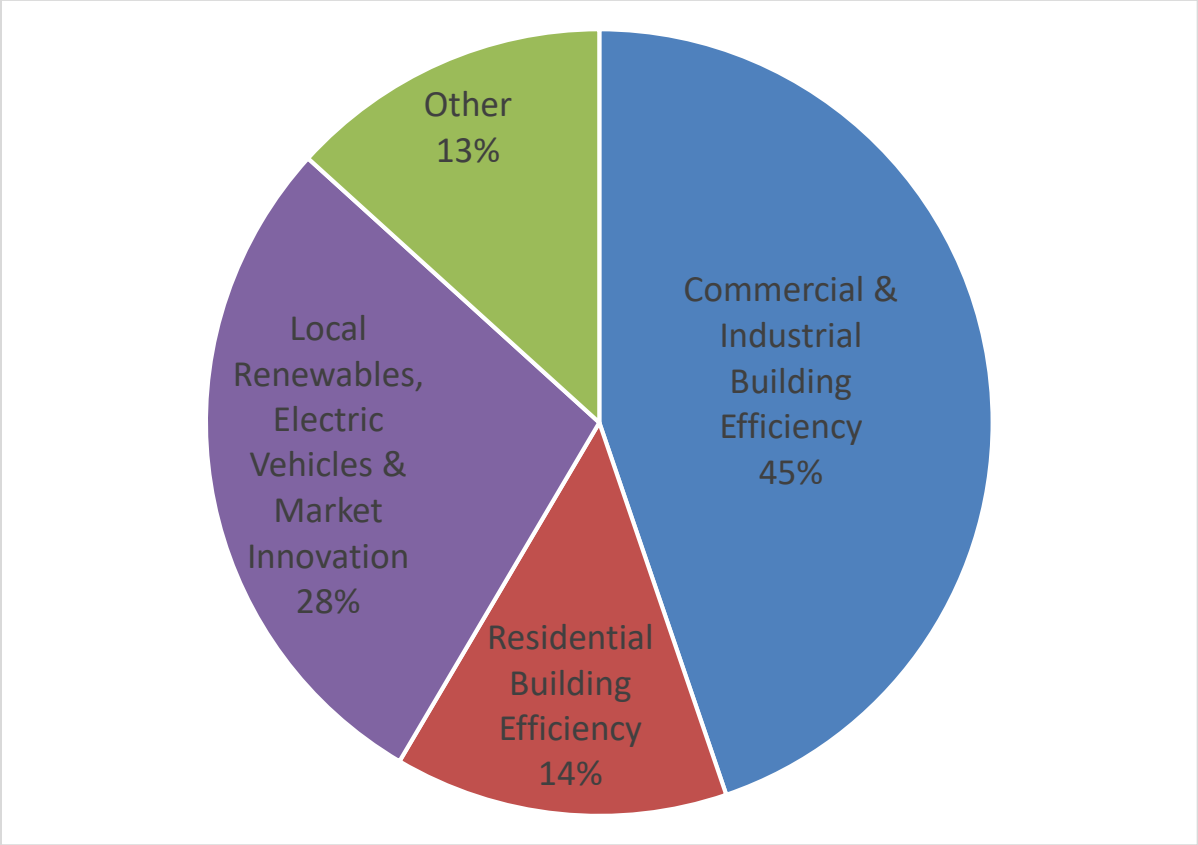
Table 5. Activity Data Source Differences

Data Source	2005	Current Inventories
Electricity emission factor source	EPA's eGRID	Xcel Energy
Vehicle type distribution source	Colorado Department of Public Health and Environment Air Pollution Control Division	SWEEP
Waste types	Landfilled waste	Landfilled and composted waste
Waste characterization source	Not required	Boulder County's 2010 Waste Characterization Study

Appendix B: Climate Action Plan (CAP) Tax Budget

The 2018 budget for the CAP tax allocates programmatic funds to energy and climate initiatives by the approximate percentages council agreed to in 2012 and has further supported in numerous meetings.[28] The annual estimated CAP tax revenue for 2018 is approximately $1.75 million, and will be allocated as follows:

Figure 9. 2018 CAP Tax Allocation



C&I Building Efficiency

- **EnergySmart and Partners for a Clean Environment (PACE):** In partnership with Boulder County, these programs provide rebates and one-on-one energy advising services to businesses.
- **Building Performance Ordinance:** Requirements for all large (> 20,000 ft2) commercial and industrial buildings to rate and report their energy usage and perform cost effective efficiency actions over time.
- **Marijuana Energy Requirements:** Continued tracking and enforcement of the requirements for marijuana business to offset 100 percent of their electricity consumption with renewable energy. Development of a new Energy Impact Offset Fund to use the offset payments to develop local renewable projects.

[28] For more information see: https://www-static.bouldercolorado.gov/docs/energy-programs-options-and-conclusions-report-by-brendle-group-1-201305081148.pdf?_ga=1.22105467.1533547097.1463426273

Residential Demand Side Management

- **SmartRegs:** Requirements for energy efficiency (equivalent to the 2000 International Energy Conservation Code) in rental housing units, which account for over half of the Boulder's housing stock. In 2018, most of these program costs are being covered by the city's general fund, due to CAP Tax revenue shortages.
- **Residential EnergySmart**: provides homeowners with energy advising services and rebates.
- **Residential Electrification Pilot**: Boulder has initiated a collaborative effort with 20 U.S. cities and major heat pump manufacturers to accelerate the transition from natural gas furnaces and water heaters to electric heat pumps that can be powered by renewables. This effort has been funded by hundreds of thousands of dollars in external grant funding, and the four leading cities - New York, Burlington, DC and Boulder - will receive some dedicated funding for 2018 pilot projects. Boulder's pilot project, partially funded by CAP Tax, will provide homeowners with a comprehensive Roadmap to Renewable Living that displays financing strategies for bundling efficiency, electrification and rooftop solar photovoltaic (PV) system.

Local Renewables, Electric Vehicles and Market Innovation

- **Local solar programs:** Our programs include providing grants for low income residents and non-profits, as well as solar rebates (through EnergySmart) and a solar bulk purchasing program in partnership with Boulder County. Staff is now working on a comprehensive strategy and action plan to meet long-term goals.
- **Electric vehicle programs:** CAP Tax funds have gone towards subsidizing electric vehicle charging stations and developing a long-term electric vehicle strategy.
- **Boulder Energy Challenge (BEC):** BEC was launched in June 2014 to support the development and commercialization of innovative emission-reducing technologies and strategies in Boulder. In that initial launch, the BEC funded all six finalist projects, totaling $337,500. The program was relaunched in 2017, and the challenge funded four projects, with $157,600 in total funding.

Other

- Administrative and overhead costs
- External communications and outreach to the community and other key stakeholders
- Program tracking and evaluation (including annual GHG Inventories)
- Memberships in professional organizations, regional/national/international coalitions, etc.