2017 Bozeman Community Greenhouse Gas Emissions Report

CITY OF BOZEMAN | NOVEMBER 27, 2017

The City of Bozeman is committed to taking meaningful action on climate change. The Bozeman community greenhouse gas emissions inventory analyzes local greenhouse gas emissions from energy use in our vehicles, homes and businesses, solid waste, and water. This inventory helps guide the implementation of our Community Climate Action Plan and measures progress towards our goal of reducing greenhouse gas emissions 10 percent below 2008 levels by 2025.

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A message from **Mayor Carson Taylor**

The City of Bozeman has been committed to do its part to reduce its carbon emissions since 2006, when our Mayor signed on to the Mayors Climate Protection Agreement. Despite the best efforts of many, including our community, the situation is becoming critical because of the federal roll back of environmentally protective regulations. Ignoring science and our responsibility to all humanity is worse than bad policy. Thus in this country the responsibility will rest on local governmental entities, such as ours, to provide more leadership in the struggle against climate change caused by human-made carbon emissions.

The great thing about our City is that most of us are ready to meet the challenge of reducing our personal and community carbon emissions. The Bozeman Solar Project with Northwestern Energy and Montana State University, the City's LEED buildings and investments in energy efficiency, individual commitments as expressed through the residential Energy Smackdown and the commercial Bozeman Energy Project are promising--as long as we are able to expand those projects. More education and more consciousness about our role in climate change will also build an understanding that will drive more of us to demand more clean energy and clean transportation from the private sector, including utilities and auto manufacturers. This will, in turn, create actions necessary for a long-term impact.

I am heartened by the results of the 2017 Greenhouse Gas Emissions Inventory Report. We need to recognize that most of the improvement is due to the acquisition of hydropower by NorthWestern Energy. This means that there is more work to do as we bring solar energy to our houses, invest in our community buildings to make them more energy efficient, and demand more clean energy and green design from the business community. We can be proud of our accomplishments, but only if that pride compels us toward more significant actions and goals.

Your Mayor,

Carson Taylor

Carson Taylor

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ACKNOWLEDGMENTS

Energy

Richard Edwards, Heather Bellamy (NorthWestern Energy)

Transportation

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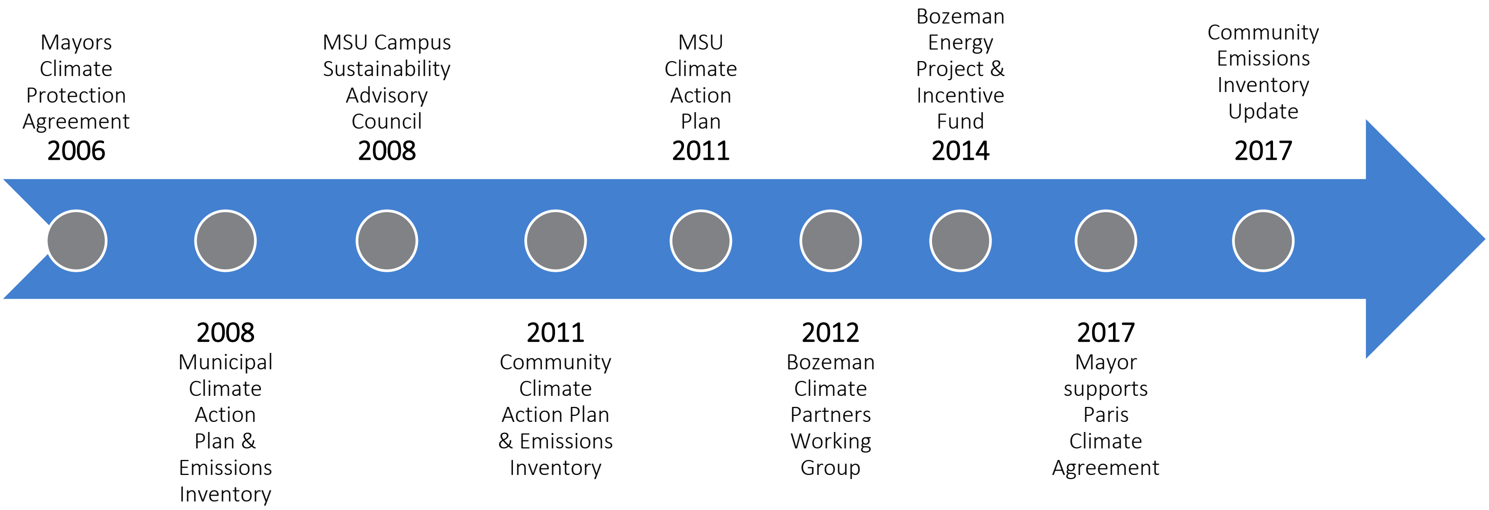
Bozeman's Climate Action Timeline



II. INTRODUCTION

Bozeman's vision for a sustainable environment, as described in the 2017 Strategic Plan, is to cultivate a strong environmental ethic, protecting our clean air, water, open spaces and climate, while promoting environmentally sustainable businesses and lifestyles.

For the City of Bozeman, sustainability means making better use of resources, such as water, energy and waste, and designing neighborhoods to be more walkable and bikeable. Sustainability also means investing in the future by opening doors for clean-energy technology, innovation, and jobs.

Bozeman's 2011 Climate Action Plan created a framework of recommended actions to help Bozeman achieve its goal of reducing greenhouse gas (GHG) emissions 10 percent below 2008 levels by 2025. A comprehensive GHG emissions inventory report allows us to track progress towards this goal, defines the contribution of emissions from each source, and guides future action under the Climate Action Plan.

Over the past decade, the City of Bozeman and Montana State University, along with other businesses, non-profits, and individuals in the community, have taken steps to be part of the solution to climate change. Through these efforts, and with help from our partners at NorthWestern Energy, the Bozeman community has reduced greenhouse gas emissions to 2008 levels, regardless of rapid population and economic growth. Census data released in 2016 ranks Bozeman number one in the nation for micropolitan area population growth. During the period from 2008 to 2016, Bozeman's population increased 27 percent. While we should celebrate that we have limited the growth of emissions, we know that without additional innovation we can expect emissions to increase well above our goal. Climate change and growth are both a challenge and an opportunity. The vision for a sustainable environment described by our community in the 2017 Strategic Plan is a call for transformative change towards low- and no-carbon solutions. This greenhouse gas emissions inventory provides a roadmap for future planning. We invite the community to join us in identifying a sustainable path forward as we prepare to develop an updated Climate Action and Adaptation Plan in 2019.

Climate Change Impacts in Bozeman

There is widespread consensus among the scientific community that human activities are negatively impacting the Earth's climate through increased greenhouse gas emissions, causing adverse health, social, economic and ecological effects.

In November 2017, scientists from 13 federal agencies released the fourth National Climate Assessment, which finds that global annual average air temperature has increased 2˚F since 1901, with the last three years being the warmest on record and 16 of the 17 warmest years occurring since 2000. Large forest fires in the western United States have increased since the 1980s and are projected to continue to increase. Annual trends toward earlier spring snowmelt and reduced snow pack are already affecting water resources and agriculture in the western United States.

The report concludes that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extant of observational evidence.[1]

The 2017 Montana Climate Assessment indicates that Montana's annual average temperatures have risen across the state between 1950 and 2015 by 2.0 to 3.0˚F, with the greatest warming in spring. By mid-century, Montana temperatures are projected to increase by approximately 4.5 to 6.0˚F depending on the amount of greenhouse gases we emit in the coming decades. Summer precipitation is expected to decline and extreme heat days will increase by 5 to 35 additional days by mid-century.[2]

Bozeman's adopted 2017 Drought Management Plan identifies that Bozeman is extremely vulnerable to drought in part due to the increased potential impacts from climate change. The plan forecasts that warming in the region and longer dry spells could result in earlier melting of the snowpack and increased evapotranspiration. This could results in a shift in peak stream runoff to early spring or late winter, away from mid to late summer when water demand is greatest and further amplifying the risk of forest fire. Bozeman's water supply is heavily dependent upon snowpack, which has decreased since approximately 1980.[3]

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[1] USGCRP. 2017: **Climate Science Special Report: Fourth National Climate Assessment, Volume I** [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp, doi:10.7930/J0J964J6

[2] Whitlock, C, Cross W, Maxwell B, Silverman N, Wade AA. 2017. Executive Summary. In: Whitlock C, Cross W, Maxwell B, Silverman N, Wade AA. 2017. 2017 Montana Climate Assessment. Bozeman and Missoula MT: Montana State University and University of Montana, Montana Institute on Ecosystems. 318 p. doi:10.15788/m2ww8w

[3] Pederson, G.T. 2011. The unusual nature of recent snowpack declines in the North American Cordillera, Science, 333(6040), 332-335, doi:10.1126/science

III. EXECUTIVE SUMMARY

The 2016 City of Bozeman Community Greenhouse Gas (GHG) inventory is Bozeman's second comprehensive inventory of community emissions. The original baseline inventory was completed in 2008. This updated report includes inventories for the calendar years 2008, 2012, and 2016. Due to extensive changes in inventory protocols, as well as changes in the quality and types of data available, we recalculated the 2008 baseline year to ensure accurate comparisons over time. We defined the emissions inventory boundary based upon Bozeman's 2016 city limits.

The 2011 Community Climate Action Plan reduction goal:

1) Reduce emissions to 10 metric tons of CO_2e per capita by 2020
2) Reduce emissions to 10 percent below 2008 levels by 2025 to 472,000 metric tons CO_2e

The inventory adheres to the Global Protocol for Community-Scale Emissions and the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas (GHG) emissions. The City of Bozeman Sustainability Office collected data related to energy, transportation, solid waste, water, wastewater, and emissions rates. We calculated our carbon emissions using the ICLEI ClearPath platform, which includes calculators for inventories, forecasts, and planning.

Bozeman Solar Project Pilot, NorthWestern Energy's 385kW solar PV array at the City of Bozeman Water Reclamation Facility. Photo: Orion Thornton

Bozeman's overall community emissions totaled 522,405 metric tons of carbon dioxide equivalent (MT CO_2e) in 2016. Since the baseline year of 2008, total community emissions have decreased 0.3 percent, despite considerable population and economic growth. Our emissions increased from 2008 to 2012, but have since declined by 5 percent, as summarized in Table 1. After normalizing for various growth factors, a trend towards improved efficiency emerged. Based on 2016 census data, Bozeman had 45,250 people and 18,293 households, resulting in per capita emissions of 11.5 MT CO_2e per person. Since 2012, per capita emissions have decreased by 21 percent and energy use per job has decreased by 9 percent.

Table 1. Overall Bozeman Community Greenhouse Gas Emissions Trend

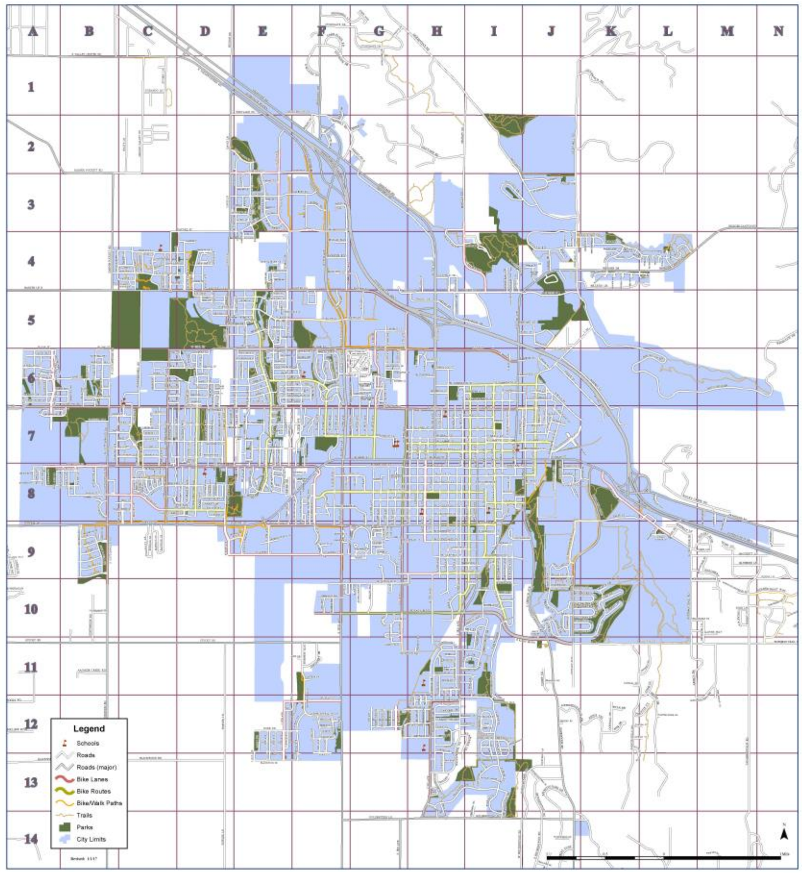
	2008	2012	2016	Reduction Since 2008	Reduction Since 2012
Total GHG Emissions	523,826	552,117	522,405	-0.3%	-5.4%

IV. METHODOLOGY

Boundary Definition

Our boundary is based upon the 2016 City of Bozeman city limits. Recognizing that this area will grow and change over time with new annexations, it best represents our political area of influence. In the future, we may consider revising this boundary to reflect a Metropolitan Planning Organization (MPO) boundary.

The original 2008 emissions inventory gas and electricity data were, by necessity, based upon NorthWestern Energy's town code boundary, which extended from Bear Canyon to the east to Black Bull to the west; Springhill in the North and Hyalite Canyon to the south. In the current inventory, NorthWestern Energy was able to use GIS data and customer billing information to extract and summarize accurate electricity and natural gas usage data to reflect the City of Bozeman boundaries.



2016 City of Bozeman City Limits

Protocol Adherence

This inventory is compliant with the Global Protocol for Community-Scale Emissions (GPC), which is the most current and applicable standard available for establishing community-wide greenhouse gas emissions and provides consistency in reporting for cities around the world. City staff will work with CDP (formerly known as the Carbon Disclosure Project), an organization that works with local governments and corporations to measure and disclose greenhouse gas emissions.

For this report, greenhouse gas (GHG) emissions were totaled by calculating emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from data on energy use and waste generation. CH_4 and N_2O were converted to CO_2 equivalent (CO_2e) global warming potential (GWP) units using the converstion equations developed by the Intergovernmental Panel on Climate Change (IPCC). We used the IPCC 5th Assessment's GWP 100-year values for greenhouse gas emissions. The total units of CO_2e then represent the sum total of all greenhouse gases multiplied by their corresponding GWP factor. All gases are reported in the standard GHG units of metric tons CO_2e. The protocol does not calculate hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), or sulfur hexafluoride (SF_6).

Data Collection

Data for this inventory was collected by the City of Bozeman Sustainability Office from a variety of community partners, including NorthWestern Energy, Montana Department of Transportation, Montana Department of Environmental Quality, Bozeman-Yellowstone International Airport, Republic Waste Services, Gallatin Solid Waste Management District, and several City of Bozeman departments.

Electricity and natural gas data were provided by NorthWestern Energy for the calendar years 2012 and 2016. Utility data for the new inventory boundary was not available for 2008. Given this limitation, we enlisted a sustainability engineering firm, the Brendle Group, to draw on their experience with greenhouse gas emissions inventories to estimate residential and commercial gas and electricity use. They estimated electricity use from 2008 based upon energy use per household and energy use per business in 2012 multiplied by the number of households and businesses in 2008. The American Community Survey was used to estimate the number of households and businesses in each year. We estimated natural gas use in a similar manner. They first estimated the number of natural gas customers according to the percentage of total households and businesses that were natural gas customers in 2012. They then applied the energy use per household and business from 2012 to the number of estimated customers in 2008. A memo detailing this methodology is included in Appendix A. Emissions data from 2008 should be regarded with caution, but it serves as a reasonable proxy for our baseline emissions.

The remaining sectors from the 2008 inventory, including transportation and solid waste, use data from the original 2008 inventory; the data was then recalculated using the current protocol to ensure more accurate comparisons between the inventory years of 2012 and 2016.

Population and household data is from the US Census and American Community Survey, as detailed in Table 2.

Table 2. Population and household data.

Year	Population	Households
2008	35,538	14,676
2012	37,619	17,100
2016	45,250	18,293

Emissions Platform

This inventory used ICLEI USA ClearPath, an advanced web application for energy and emissions management for governments and communities. ClearPath offers a comprehensive approach to measuring and monitoring community emissions, while offering technical support and training on the application and protocol. We enlisted ICLEI USA to complete a technical review of our inventory to ensure accuracy.

Scope

City staff collected data according to the primary sector categories of transportation, residential energy use, commercial energy use, solid waste, water and wastewater. Other categories that were added to the updated inventories include: process and fugitive emissions from natural gas, transmission and distribution loss from electricity, aviation fuel, off-road vehicles, residential propane and wood stoves, and landfill methane emissions.

The Global Protocol for Community-Scale Greenhouse Gas Emissions Inventory (GPC) also requires reporting of emissions by "scope". Scope 1 refers to emissions produced within the city limits. This includes local combustion of all fossil fuels such as gasoline, diesel, natural gas, propane and any other fuel. Methane produced from landfill waste and wastewater treatment are also included in Scope 1. Scope 2 emissions include greenhouse gas emissions that occur as a consequence of using grid-supplied electricity, but the emissions occur outside city limits. Scope 3 emissions refers to all other greenhouse gas emissions that occur outside of the city resulting from activities that take place within city limits. Some examples of Scope 3 emissions include employee commute, business travel, and production of goods used or consumed within the city. Airport travel and landfilled waste are examples of Scope 3 emissions sources that are included in this inventory. The 2011 Community Climate Action Plan recognized that the airport was an inextricable part of Bozeman's economy and recommended including Bozeman's proportional share of the air travel occurring at the Bozeman-Yellowstone International Airport in future inventories. Including air travel is also recommended in the GPC protocol. These scope distinctions help to avoid double counting between communities and to clarify where emissions are generated.

Emissions Factors

The emissions factors, or rates, from our electricity associated with commercial and residential buildings were calculated using NorthWestern Energy's emissions factor for carbon dioxide (CO_2) per megawatt hour of electricity generated. This factor was available for 2016 and 2012; however, it was not available for 2008. Using the utilities' unique emissions factor provides for the most accurate estimate of the carbon intensity of the electricity we consume in Bozeman. Furthermore, our emissions inventory will better reflect any changes in the carbon intensity of the energy that our utility procures or purchases on the open market in the future. Other greenhouse gas emissions factors for methane (CH_4) and nitrous oxide (N_2O) were estimated using the EPA eGrid Pacific Northwest geographic emissions factors. Our original 2008 emissions inventory used the EPA eGrid factor for the entire inventory. This emissions factor reflects a large volume of hydroelectricity in Oregon and Washington. Use of this factor underestimated past emissions and current emissions. The recalculated 2008 inventory used the NorthWestern Energy 2012 emissions factor as a more reasonable approximation of the carbon intensity of our electricity in Montana. For transportation and waste, EPA emissions factors were used. All emissions factors are detailed in Appendix B.

Bozeman Public Library is LEED Silver Certified and is equipped with a 16.7kW solar PV array.

V. RESULTS

The majority of Bozeman's GHG emissions come from energy use, in the form of buildings, vehicles, and air travel. Consistent with the 2008 baseline emissions inventory, residential and commercial building energy use were the largest contributors to Bozeman's emissions in 2016. Together, these sectors comprised 53 percent of the overall emissions. Transportation emissions have increased 41 percent since 2008 and now contribute 42 percent of the overall emissions, as shown in Figure 1. Table 3 details greenhouse gas emissions by sector and year and Table 4 provides this information on a per capita basis. In the last five years, emissions declined by 5 percent while population and our workforce grew by 20 and 22 percent, respectively. We observed efficiency improvements and an overall reduction in the residential and commercial sectors.

Figure 1. Bozeman community greenhouse gas (GHG) emissions by sector.

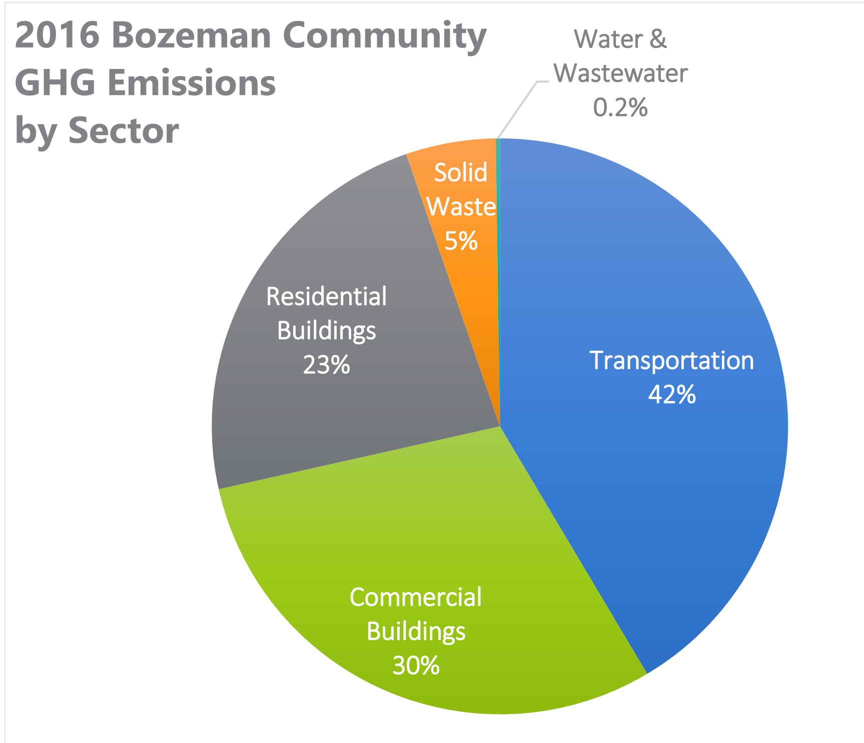
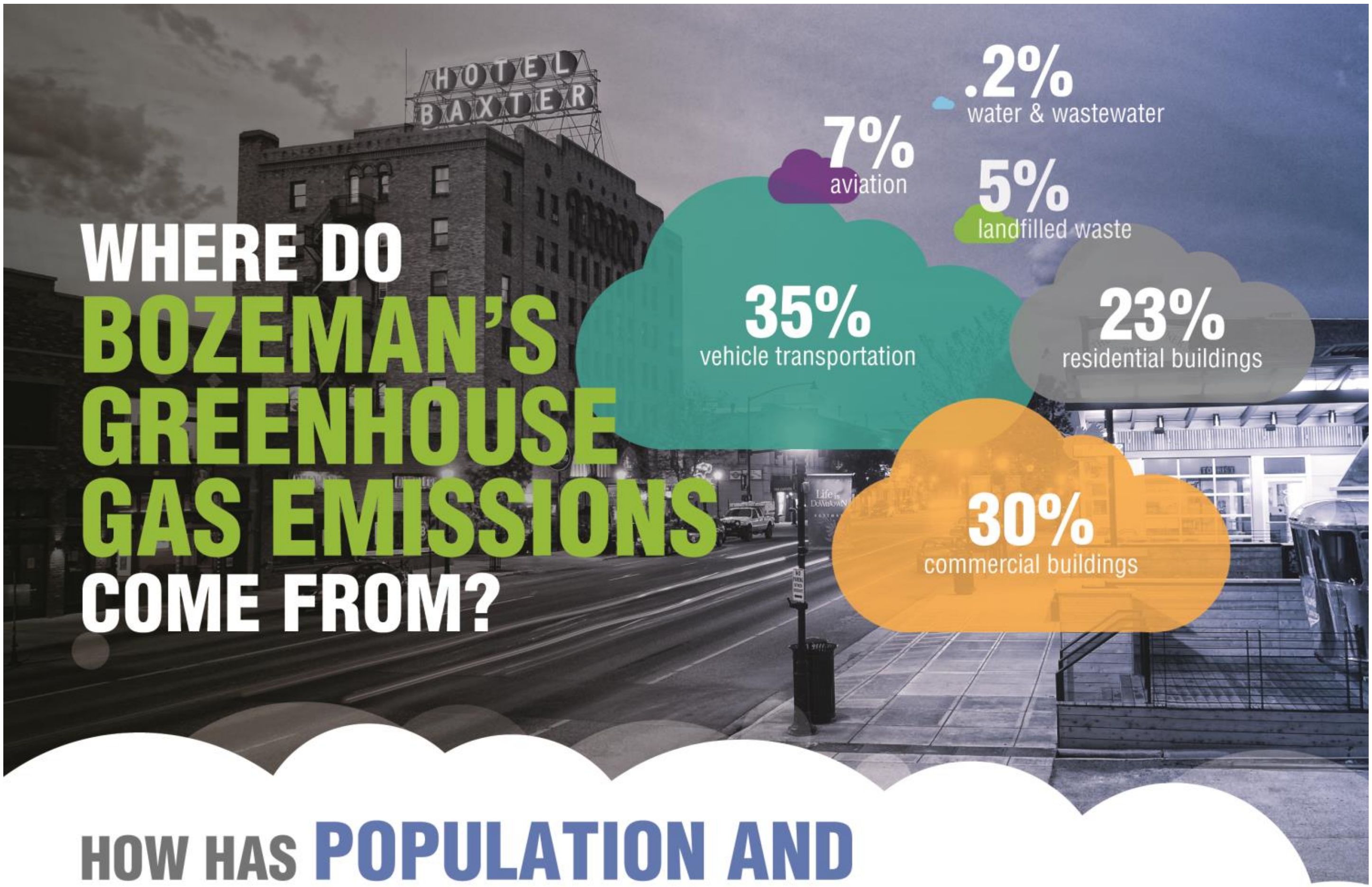


Table 3. Total emissions (metric tons CO_2 equivalent) by sector and inventory year.

	2008	2012	2016	Change since 2008	Change since 2012
Transportation	153,211	172,391	216,608	41%	26%
Commercial	166,005	210,082	156,894	-5%	-25%
Residential	171,457	144,384	121,344	-29%	-16%
Landfilled waste	32,232	24,502	26,354	-18%	8%
Water & Wastewater	921	757	1,204	31%	59%
Total	523,826	552,116	522,404	0%	-5%

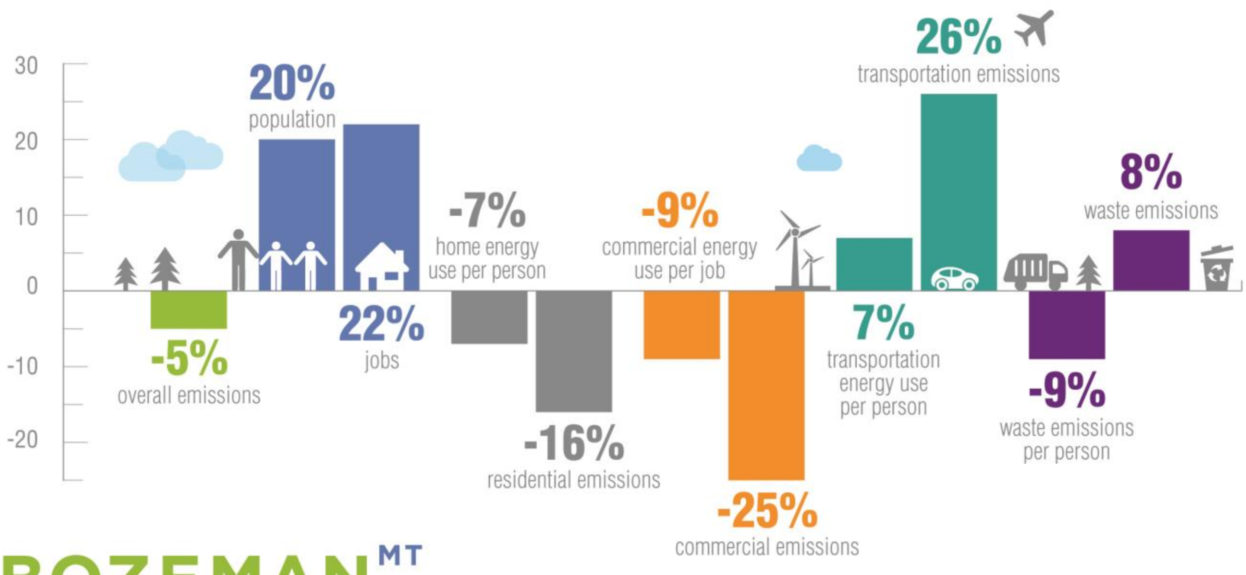
Table 4. Per capita emissions (metric tons CO_2 equivalent) by sector and year.

	2008	2012	2016	Change since 2008	Change since 2012
Transportation	4.3	4.6	4.8	11%	4%
Commercial	4.7	5.6	3.5	-26%	-38%
Residential	4.8	3.8	2.7	-44%	-30%
Landfilled waste	0.9	0.7	0.6	-36%	-11%
Water & wastewater	0.0	0.0	0.0	3%	32%
Total	14.7	14.7	11.5	-22%	-21%



HOW HAS POPULATION AND ECONOMIC GROWTH AFFECTED BOZEMAN'S EMISSIONS?

Since 2012, Bozeman has seen growth in population, commercial activity, and tourism. Despite these demographic trends, greenhouse gas emissions have decreased overall.



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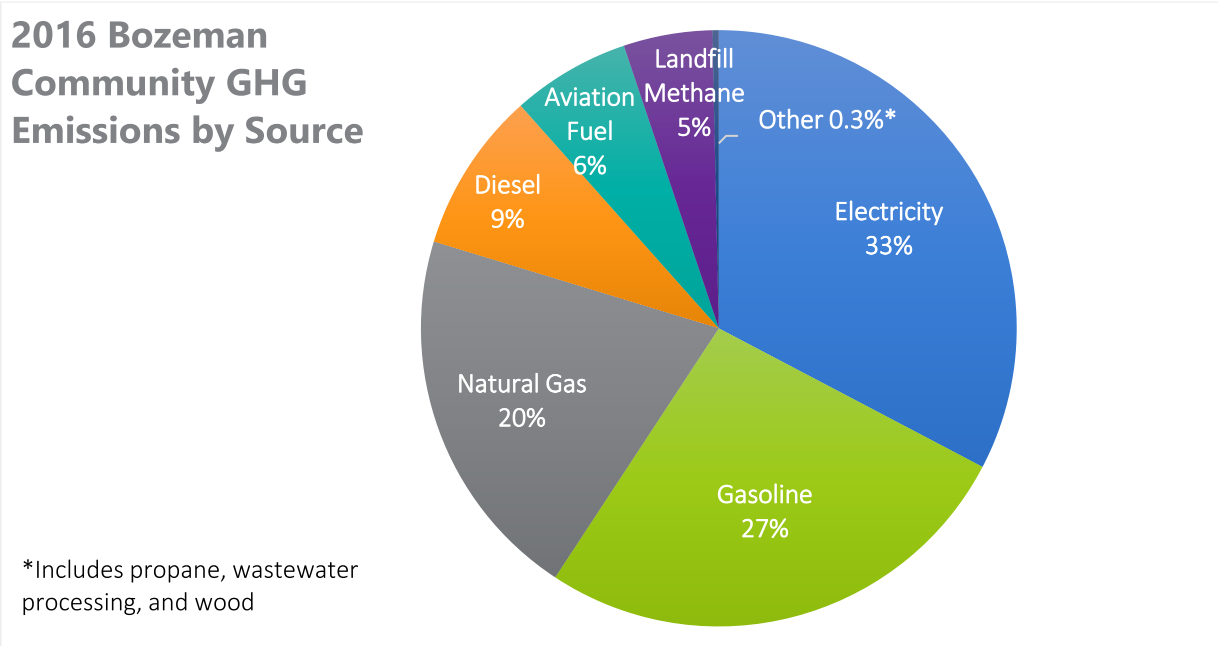
Another way to view our greenhouse gas emissions is by source. The leading sources contributing to greenhouse gas emissions in Bozeman are electricity, natural gas, gasoline, diesel, aviation fuel, and landfill methane. The 2016 inventory, shown in Figure 3, indicates electricity is the largest contributing source, representing 33 percent of emissions. This is followed by gasoline used for transportation; and natural gas used in buildings.

Figure 3. 2016 Bozeman community greenhouse gas (GHG) emissions by source.



The 2016 emissions sector and source results are similar to our first community inventory; however, electricity emissions have declined and transportation fuel emissions have increased since 2012, as detailed in Figure 4.

Figure 4. Bozeman community greenhouse gas (GHG) emissions sources by year.

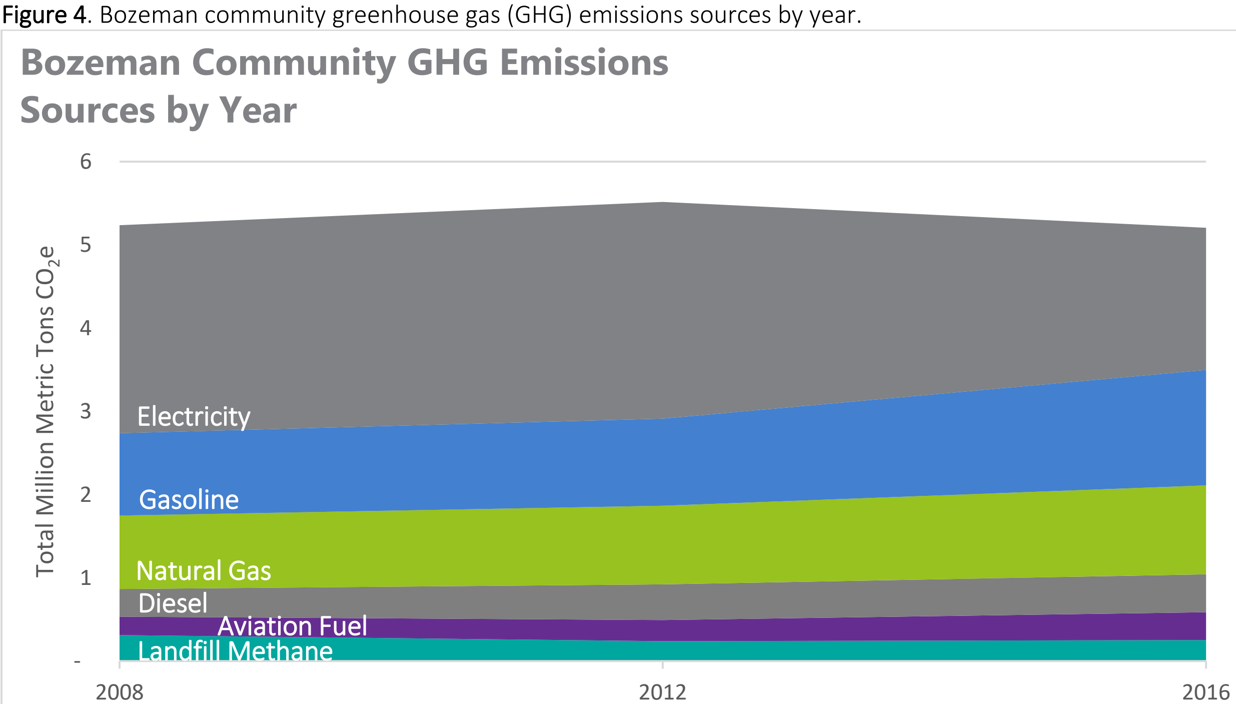


Table 4. Total emissions (metric tons CO_2 equivalent) by source and year.

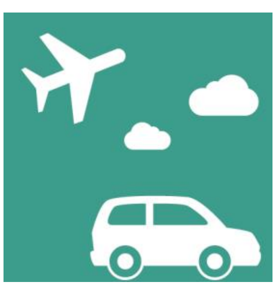
Sector	2008	2012	2016	Change since 2008	Change since 2012
Electricity	249,849	260,241	170,816	-32%	-34%
Gasoline	98,887	104,796	138,735	40%	32%
Natural Gas	88,260	94,450	106,804	21%	13%
Diesel	33,169	42,828	45,550	37%	6%
Aviation Fuel	22,198	25,364	33,524	51%	32%
Landfill Methane	31,190	23,906	25,154	-19%	5%
Other	273	532	1,822	567%	242%
Total	523,826	552,117	522,405	0%	-5%

Table 5. Per Capita Emissions (metric tons CO_2 equivalent) by source and year.

Sector	2008	2012	2016	Change since 2008	Change since 2012
Electricity	7	7	4	-46%	-45%
Gasoline	3	3	3	10%	10%
Natural Gas	2	3	2	-5%	-6%
Diesel	1	1	1	8%	-12%
Aviation Fuel	1	1	1	19%	10%
Landfill Methane	1	1	1	-37%	-13%
Other	0	0	0	424%	185%
Total	14.7	14.7	11.5	-22%	-21%

Bozeman strives to be a climate leader by promoting energy efficiency and clean energy with city programs that help reduce emissions in key areas, such as electricity use. The most significant emissions reductions occurred after our utility, NorthWestern Energy, transitioned a large share of their coal-based electricity to hydroelectricity in 2014. In 2016, NorthWestern Energy's delivered electricity portfolio was 36 percent hydro and 18 percent wind. Approximately 54 percent of the total company-owned generation and contracted electric supply was low-carbon.

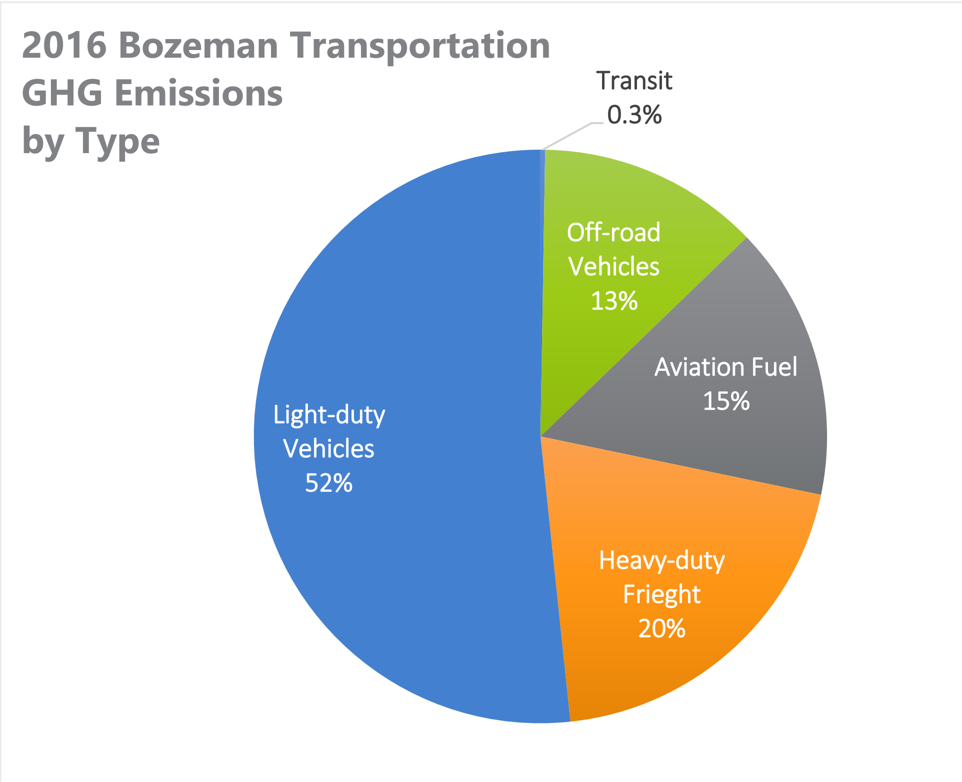
Transportation



Transportation emissions are estimated using Vehicle Miles Traveled (VMT) in Bozeman, calculated annually by the Montana Department of Transportation (DOT). Traffic counts and vehicle type surveys on a variety of street types are collected and a computer model is used to generate the total estimated miles traveled on all streets and highways within the City of Bozeman. Vehicle class data for Bozeman, statewide Montana registration data, and national fuel economy estimates also contribute to the calculation.

We calculated aviation emissions based on fuel use at the Bozeman-Yellowstone International Airport. According the Global Protocol for Community-Scale Emissions, a percentage of the airport's emissions should be included in our community inventory. This percentage is based on the airport's estimate of locally originating flights from Bozeman. Off-road vehicle emissions are estimated using statewide Montana data on off-road vehicle fuel consumption. We assign a portion of these emissions to Bozeman based on population. Emissions from public transit were estimated and represent a small share of overall transportation emissions. Figure 5 details the percent share of each of these contributing sources.

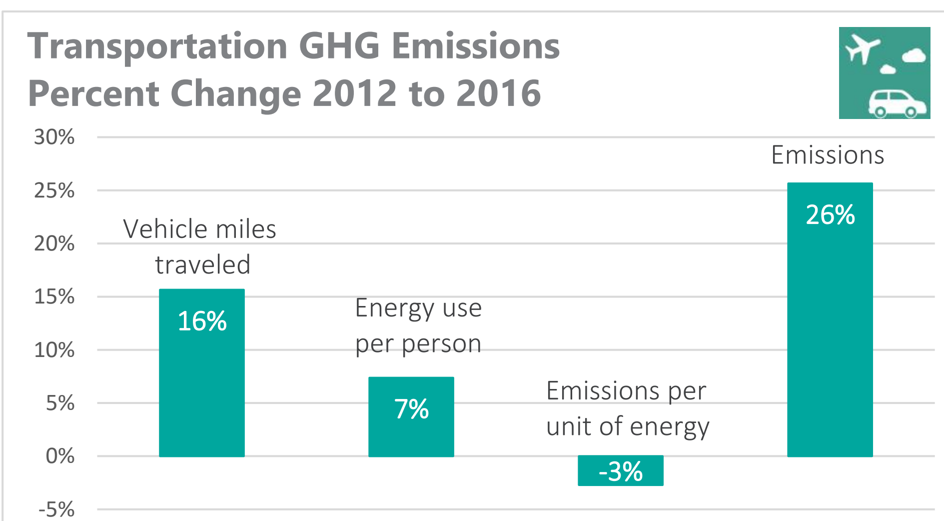
Figure 5. 2016 Bozeman transportation greenhouse gas (GHG) emissions by type.



The transportation sector accounts for 42 percent of total emissions and contributed 216,608 MT CO_2e in 2016. Since 2012, overall transportation emissions climbed 26 percent. This increase outpaces city population growth and reflects Bozeman's role as a regional economic hub in a growing county where there is a daily influx of employees and consumers. Over half of transportation emissions come from light-duty gas and diesel vehicles. Aviation emissions now contribute 15 percent of transportation emissions. The Bozeman-Yellowstone International Airport has grown to become the busiest airport in Montana, while Bozeman is only the fourth largest city.

Figure 6 details the growth of Vehicle Miles Traveled and energy use per person since 2012, which again suggests regional growth. Transportation emissions per unit of energy declined slightly with improved vehicle emissions standards. Growth of transportation emissions can be limited by reducing vehicle miles traveled through infill development, biking, walking, carpooling, and public transit; and by transitioning to less carbon-intensive vehicle technologies, such as electric vehicles.

Figure 6. Transportation greenhouse gas (GHG) emissions and efficiency percent changes from 2012 to 2016.

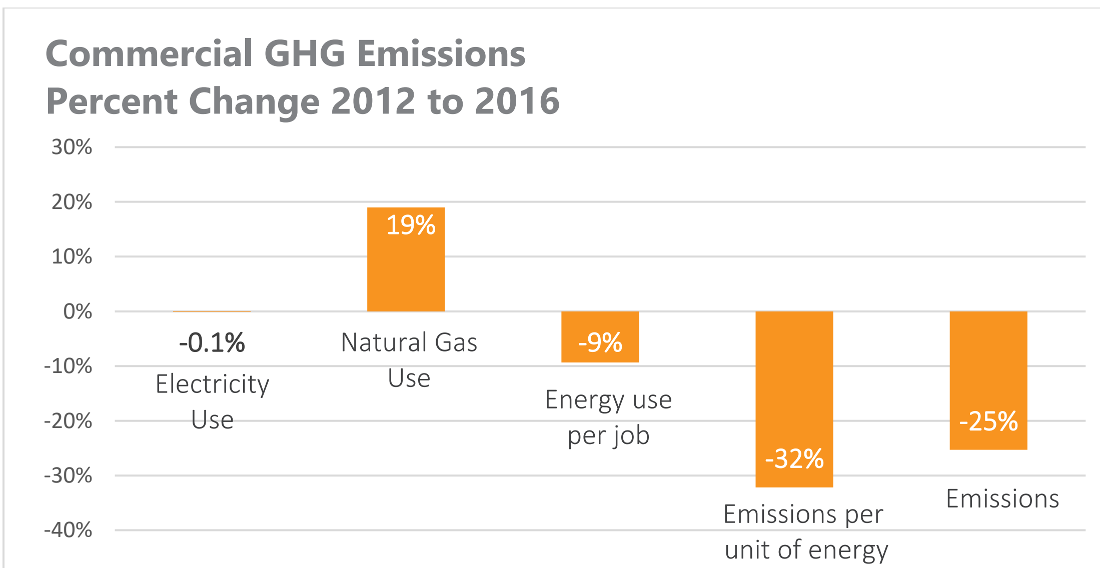


Commercial Buildings

Emissions from the commercial sector include CO_2e emissions from electricity and natural gas used by businesses within the City of Bozeman, including Montana State University. Commercial building greenhouse gas emissions totaled 156,894 MT CO_2e in 2016 and declined by 25 percent since 2012. Electricity use declined slightly, which is likely an indicator of improved lighting efficiency with widespread adoption of commercial applications of LED technology. Natural gas use, however, increased due to new construction in the commercial sector and low natural gas prices. Energy use per job decreased, which suggests improved energy efficiency. This efficiency gain is likely related to the statewide adoption of the 2012 International Energy Conservation Code (2012 IECC) that became effective in November 2014. The 2012 IECC is estimated to improve commercial and residential energy efficiency by 10 to 15 percent over the previous energy code. Greenhouse gas emissions per unit of energy declined by 32 percent as a direct result of the transition from coal to wind and hydroelectricity in our grid-supplied electricity. Figure 7. details these commercial trends.

Emissions in this sector can be reduced through energy efficiency upgrades to existing buildings, high performance energy standards for new buildings, on-site distributed renewable energy generation, and low-carbon grid-supplied electricity.

Figure 7. Commercial greenhouse gas emissions (GHG) and efficiency percent changes from 2012 to 2016.



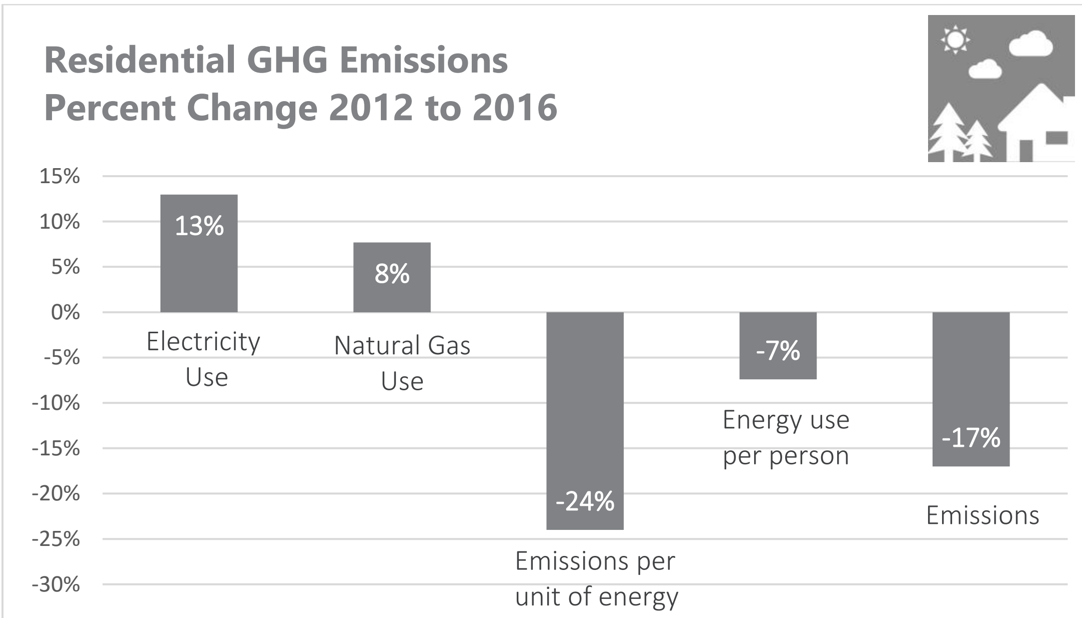
Residential Buildings

Emissions from the residential sector include CO_2e emissions from electricity, natural gas, propane, and wood used in residential homes, condominiums, and apartments within the City of Bozeman. Residential greenhouse gas emissions totaled 121,344 MT CO_2e and represents 23 percent of emissions. This sector declined by 17 percent since 2012. Electricity and natural gas use increased since 2012, but at a slower rate than population growth. In fact, energy use per person declined by 7 percent. Similar to the commercial sector, this is likely the result of the 2012 International Energy Conservation Code. Residential adoption of LED technology has been slower than that of commercial buildings, which may explain why electricity use did not decline. Emissions per unit of energy decreased by 24 percent due to the reduced carbon intensity of the grid-supplied electricity.

The residential reduction is smaller than the commercial reduction primarily because commercial businesses use a larger proportion of electricity relative to natural gas.

Similar to commercial buildings, energy efficiency upgrades to existing homes, high-performance energy standards for new homes, on-site distributed renewable energy, and low-carbon grid supplied electricity sources will reduce greenhouse gas emissions in the building sector.

Figure 8. Residential greenhouse gas emissions (GHG) and efficiency percent changes from 2012 to 2016.



Landfilled Waste

Landfilled waste emissions account for 5 percent of Bozeman's emissions and totaled 26,354 MT CO_2e in 2016, increasing by 8 percent since 2012. Tons of waste landfilled in 2016 increased by 26 percent since 2012. Both construction waste and municipal solid waste helped drive this increase. On a per capita basis, emissions declined by 9 percent.

Waste from the City of Bozeman goes to the Logan Landfill, which accepts waste from several counties. Calculations were made to account only for the percentage of waste generated by the City of Bozeman population. Methane from the landfill is currently vented at the Logan Landfill. Conditions are dry and cold in Logan, thus the facility does not generate enough methane to require flaring at this time. This sector includes historic emissions from the closed Story Landfill where methane is captured, flared, and converted to CO_2 before it is emitted into the atmosphere. Transportation emissions from shipping waste out-of-boundary to the Logan Landfill and equipment emissions involved with handling the waste at the landfill were also included in this sector.

Methane is the primary greenhouse gas emission associated with landfilled waste. Methane is generated when organic material decomposes in anaerobic conditions. Diverting organic material from the landfill and composting is the primary means of reducing waste related emissions. The City of Bozeman and the Gallatin Solid Waste Management District both compost yard waste and a variety of other organic materials. Generally, recycling helps reduce greenhouse gas emissions by reducing the use of raw materials, but also by diverting waste and extending the life of landfill cells.

Figure 8. Landfilled waste greenhouse gas emissions (GHG) and efficiency percent changes from 2012 to 2016.

Water and Wastewater

Emissions associated with the community water treatment, conveyance, and wastewater treatment processes contribute approximately 0.2 percent of total emissions. Greenhouse gas emissions are produced from the electricity and natural gas used in the treatment process. In addition, there is a small amount of methane and nitrous oxide emissions associated with the treatment process. While emissions in this sector have increased since 2008 with the intensification of water and wastewater treatment processes, it remains a relatively small contributor under the current system. Relative to other communities, we benefit by having a water source in close proximity to Bozeman and a largely gravity fed water distribution system.

VI. EMISSIONS FORECAST

Using the ClearPath tool, we can project a variety of future scenarios given a range of potential emissions reductions and increases, including a "business as usual" scenario to forecast our emissions in the year 2025. This helps us determine if we are on track to meet our emissions reduction goal of 10 percent below 2008 levels by 2025. While there are few certainties in regards to future policy scenarios at the local, state, or federal level that might influence emissions, we can likely assume continued population growth. Since our baseline year of 2008, Bozeman's population grew by 27 percent. Assuming the same rate of annual growth, we projected two scenarios. Figure 9 displays Bozeman's "business as usual" potential emissions increase based on the recalculated 2008 baseline through 2025. This indicates that Bozeman's emissions may have climbed to over 1.1 Million MT of CO_2e, well beyond our target of 472,000 MT of CO_2e. Bozeman would likely be on this growth curve today without the transition to a lower carbon grid-electricity portfolio.

Figure 9. Bozeman's greenhouse gas emissions in the baseline year of 2008 projected through 2025.

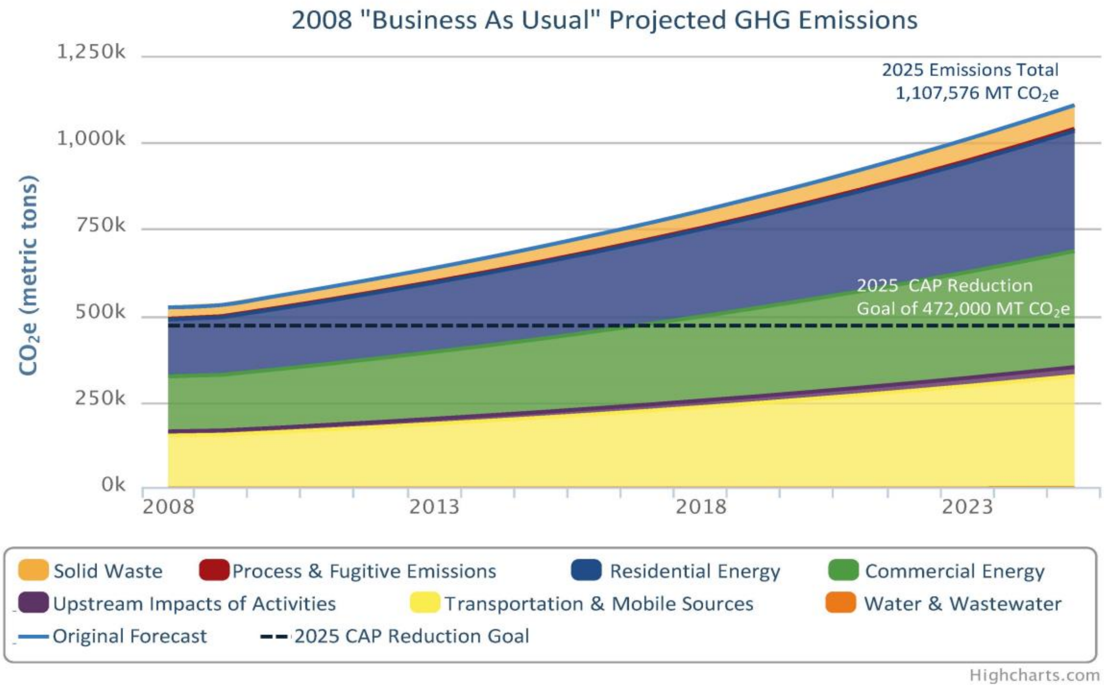
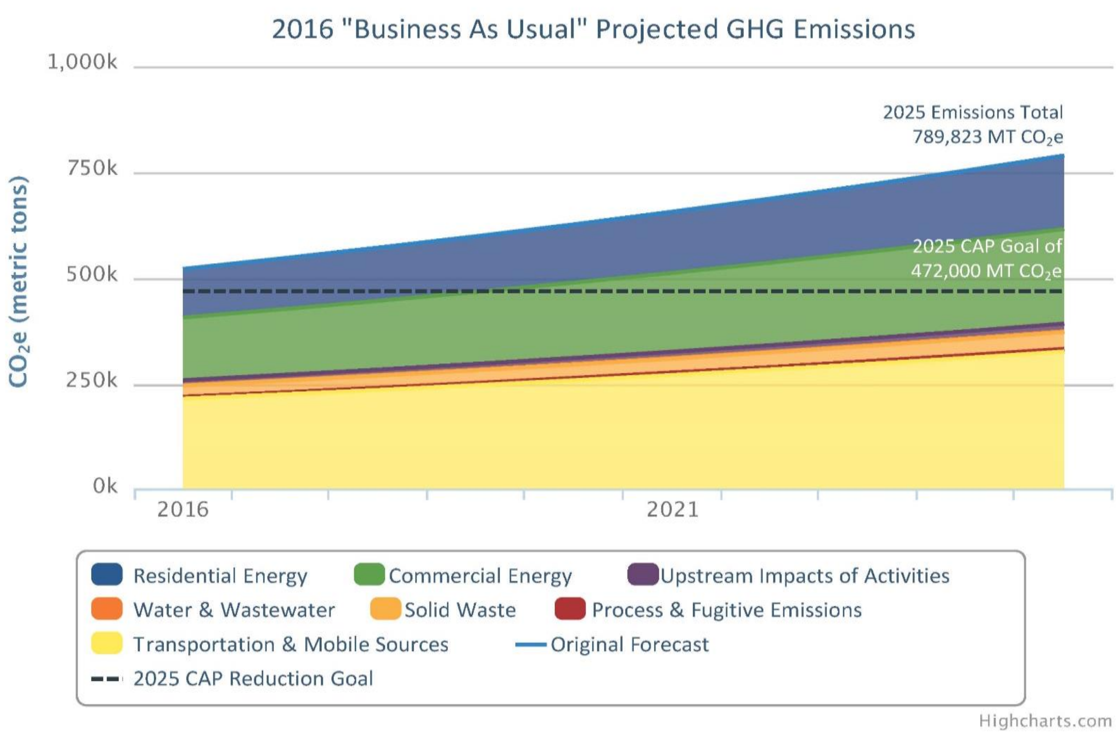


Figure 10 provides another "business as usual" forecast based on our 2016 greenhouse gas emissions levels using the same estimate of annual growth. This forecast brings us much closer to our 2025 emission reduction goal, but it indicates that continued population growth will increase our emissions to 790,000 MT CO_2e and we will not reach our reduction goal. This suggests that additional effort is required to reach our target reduction goal of 472,000 MT CO_2e.

Figure 10. Bozeman's greenhouse gas emissions in the year 2016 projected through 2025.



VII. CONCLUSION

Several decades of climate research has concluded that human activities are changing our climate. The impact of climate change within Montana was summarized in the 2017 Montana Climate Assessment. Projected effects of climate change in Montana include increased average temperatures, more extreme heat days, reduced snowpack, increased spring precipitation, extended summer drought, increased risk of forest fire, and secondary effects to the economy, ecosystem, and human health. The reduction of greenhouse gas emissions (GHG) is a serious and pressing matter since the U.S. is one of the largest historic emitters of greenhouse gas emissions and is one of the largest emitters per capita and for total emissions in the world, averaging about 20 metric tons (MT) of GHG per capita per year. Annual worldwide average emissions are 4 MT per capita and Bozeman residents fall around 11.5 MT per capita.

The City of Bozeman estimates the community's baseline 2008 greenhouse gas emissions to be 523,826 MT CO_2e. Total greenhouse gas emissions were 522,405 MT CO_2e in 2016. During this 8-year period, emissions declined in residential and commercial buildings, but increased in the transportation and waste sectors. NorthWestern Energy's transition to wind and hydroelectricity is driving the reduction in emissions for Bozeman. Bozeman's 2008 baseline per capita emissions were 14.7 MT of GHG per year and declined to 11.5 MT of GHG per year in 2016, bringing us closer to our interim 2020 goal of reducing per capita emissions to 10 MT of GHG per year. Assuming growth continues at the current rate, our emissions will exceed our 2025 goal of 472,000 MT CO_2e. Further steps can be taken to reduce emissions, which can have positive effects on the local and global environment and economy.

Recommended Next Steps

With direct control over only a small fraction of the community's greenhouse gas emissions, cooperative partnership will be needed to make significant inroads to reduce greenhouse gas (GHG) emissions. Continued collaboration with NorthWestern Energy, Montana State University, the Bozeman School District, the building industry, residents, and local businesses will help us achieve our goals.

The results of our emissions inventory suggest that there is a need to focus on transportation and the building sectors. Moving forward, we will pursue new initiatives in this area, including advancing plans and policies related to electric vehicle (EV) charging infrastructure and EV cars, bike share and car share, and by supporting Transportation Demand Management programs and transit options. In the commercial and residential building sectors, we will focus on marketing of existing programs, pursuing building energy code related opportunities, and encouraging the advancement of renewable energy policies.

This emissions inventory report will be used to help identify and prioritize specific actions in the near-term and will be a resource for future planning initiatives. In 2018, we will develop our first Climate Vulnerability Assessment to help us better prepare for our changing climate. In 2019, we will use the Vulnerability Assessment, alongside a community stakeholder group, to develop our first Climate Action and Adaptation Plan. During this process, the community and City Commission will have an opportunity to examine alternative reduction strategies, evaluate our established 2025 emissions reduction goals, and consider a long-term target emissions reduction goal.

VIII. APPENDIX

A. Estimate of 2008 Gas & Electricity Utility Use

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Bozeman, MT 2008 GHG Inventory Estimate

Introduction

This memo provides the results of a brief exercise to estimate the 2008 GHG electricity and natural gas emissions based on 2012 and 2016 inventories, to align with policy goals. The approach was based on a phone call with Natalie Meyer, Sustainability Program Manager on September 20, 2017. The electricity and natural gas emissions in the 2008 GHG inventory presented in the 2011 CAP are estimated from use data based on the town code which covers a much larger area than the town boundaries. The town boundaries were used to estimate the 2008 transportation emissions as well as all emissions in the 2012 and 2016 inventories. This boundary discrepancy was due to limitations in available data from the local utilities at the time the 2008 inventory was compiled. Outlined below is the approach taken to estimate the electricity and natural gas use from residents and businesses within the town boundaries in 2008.

Note: Data used in this analysis were provided by Natalie Meyer, the Sustainability Program Manager at the City of Bozeman from two different sources.

1. 2012 and 2016 reported community emissions were downloaded from ClearPath on 10/5/17
2. 2008 natural gas and electricity use data were provided by email on 10/4/17 (Community CAP 2011_NEWdata.pdf)

Electricity

- Summary of the electricity data provided is shown below.

	Provided		
Electricity Use	2016	2012	CAP 2008*
Residential (MMBtu)	431,908	382,338	714,766
MMBtu per Household	22	22	31
MMBtu per Person	10	10	
Commercial (MMBtu)	659,077	660,082	1,028,329
MMBtu per Establishment	183	193	207
Number of Households	19,453	17,138	23,325
Population	45,250	37,619	
Number of commercial establishments	3,610	3,419	4,961
*Electricity data reported in 2011 CAP based on town code boundary			

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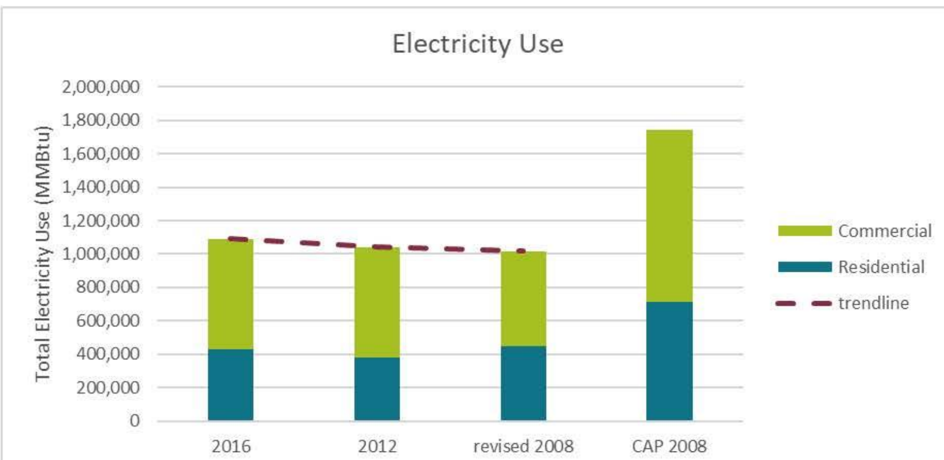
- Checked American Community Survey (ACS) info for number of households within city limits of Bozeman[1]

	2012	2008
ACS # of households	17,100	14,676

- Since the 2012 number matched up well with the number of households reported with the 2012 electricity data, used the 2008 value to estimate the electricity use within the city of limits of Bozeman in 2008, under the same boundaries as for the 2012 and 2016 inventories (# households x use per household) – see below
    - Residential: 455,000 MMBtu (133,353,000 kWh)
- The same process was used to scale commercial use by using the number of businesses from the census data[2] to get the estimate listed below.

	2012	2008
Census: # of businesses	3039	2736

    - Commercial: 566,000 MMBtu (165,885,000 kWh)
- Revised data line up well with what would be expected with trend between 2012 and 2016 – see graph below



Natural Gas Use

Did not address any other heating use (wood, propane etc.) since very small portion of the inventory.

- Used same method described above to try and estimate the number of customers within city limits. The number of households listed as natural gas customers in 2012 is about 83% of the

[1] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_15_5YR_B25001&prodType=table
[2] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

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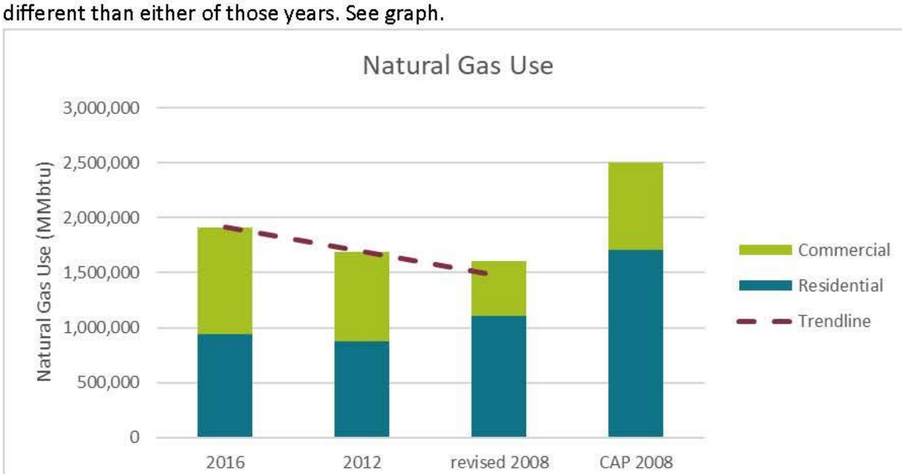
total number of households within city limits on the ACS survey at that time. It was assumed that 83% of the households within city limits were on natural gas in 2008 as well, so the estimated residential natural gas customers totaled 12,205.

- The same process was used to scale commercial customers where 70% of businesses within city limits were natural gas customers in 2012, and that resulted in an estimated 1,911 commercial natural gas customers in 2008.
- The estimated customer counts and the energy use by household and business from 2008 data shown in the table below were used to estimate total natural gas use.

	Provided		
	2016	2012	CAP 2008
Residential MMBTU	943,022	875,706	1,707,117
MMBtu per Household	59	62	90
MMBtu per Person	21	23	
Commercial	972,665	817,150	795,030
MMBtu per Business	428	385	264

- Estimated natural gas use for 2008
  - Residential: 1,098,000 MMBtu
  - Commercial: 504,500 MMBtu
- The overall natural gas use is only slightly higher than what might be expected based on the trends from 2012 to 2016, but the break out between commercial and residential is significantly different than either of those years. See graph.



GHG Emissions

The 2012 and 2016 electricity emissions estimates use emissions factors from Northwestern Energy. The emissions factor used for the CAP 2008 inventory was not provided, but in the 2012 inventory the electricity emissions factor used was 790 lbs. CO_2e/MWh as compared to the eGrid factor for that year of 669 lbs. CO_2e/MWh. The following analysis shows the total 2008 GHG emissions using the newly back casted electric and gas numbers using both the utility provided electricity emissions factor from the

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2012 inventory and the 2007 eGrid emissions factor[3] for NWPP (the northwest sector). If the city knows that the electricity generation makeup was similar in 2008 and 2012, then the 2012 emissions factor could be used. Otherwise the eGrid factor should be used.

2008 Energy Emissions	2012 emissions factor	2007 eGrid factor
Natural Gas	85,500 MT CO_2e	85,500 MT CO_2e
Electricity	106,800 MT CO_2e	116,700 MT CO_2e
Total	192,300 MT CO_2e	202,200 MT CO_2e

Uncertainty

The revised energy use for both electricity and natural gas are within the range expected based on the 2012 and 2016 data. There is more uncertainty inherent in the natural gas use since there are other heating fuel types and the proportion of businesses and residences using natural gas needs to be estimated as well as the use per customer. While we feel reasonably certain that these estimates could be used as a baseline for reporting goal progress within the community, additional accuracy and/or certainty could be obtained through the following approaches.

- Additional data sources could be used to estimate the number of businesses and households within city limits (economic development department, city manager, cities LEAP)
- Census or other data containing heating fuel type for Bozeman could be used to refine the estimate of the number of businesses and households that are natural gas customers.
- The total energy use and customer count could be gathered for additional years where available (ex: 2010 or 2014) to create more data points to increase the certainty of trendlines.
- Weather normalization could be used to adjust the natural gas use estimate.

[3] There was an eGrid emissions factor published in 2007 and 2009, so the 2007 would be most applicable to the 2008 inventory.

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B. Emissions Factors

Greenhouse Gas	2008	2012	2016
CO_2 lbs/MWH	1745	1745	1086
CH_4 lbs/GWH	12.6	12.6	97.807
N_20 lbs/GWH	10.38	10.38	14.224