City of Bozeman 2024 Community Greenhouse Gas Emissions Inventory

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INTRODUCTION

Since 2008, the City of Bozeman has tracked community-wide greenhouse gas (GHG) emissions, and beginning in 2016, has conducted bi-annual GHG inventories following the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). These inventories, developed with ongoing guidance from the International Council for Local Environmental Initiatives (ICLEI), have enabled Bozeman to identify key emission sources, observe trends, and understand the drivers of change across four main sectors: building energy use (stationary energy), transportation, waste, and industrial processes.

Using 2008 as a baseline year, Bozeman adopted its Climate Plan in 2020, setting bold targets including a 26% reduction in emissions by 2025, achieving 100% clean electricity by 2030, and reaching carbon neutrality by 2050. As the city continues to grow, these bi-annual inventories play a crucial role in tracking progress, identifying opportunities for emissions reductions, and guiding local and individual climate action.

The GHG inventory captures emissions within Bozeman's city limits, serving as the geographic boundary for assessing the scope of emissions by both source and activity (Figure 1).

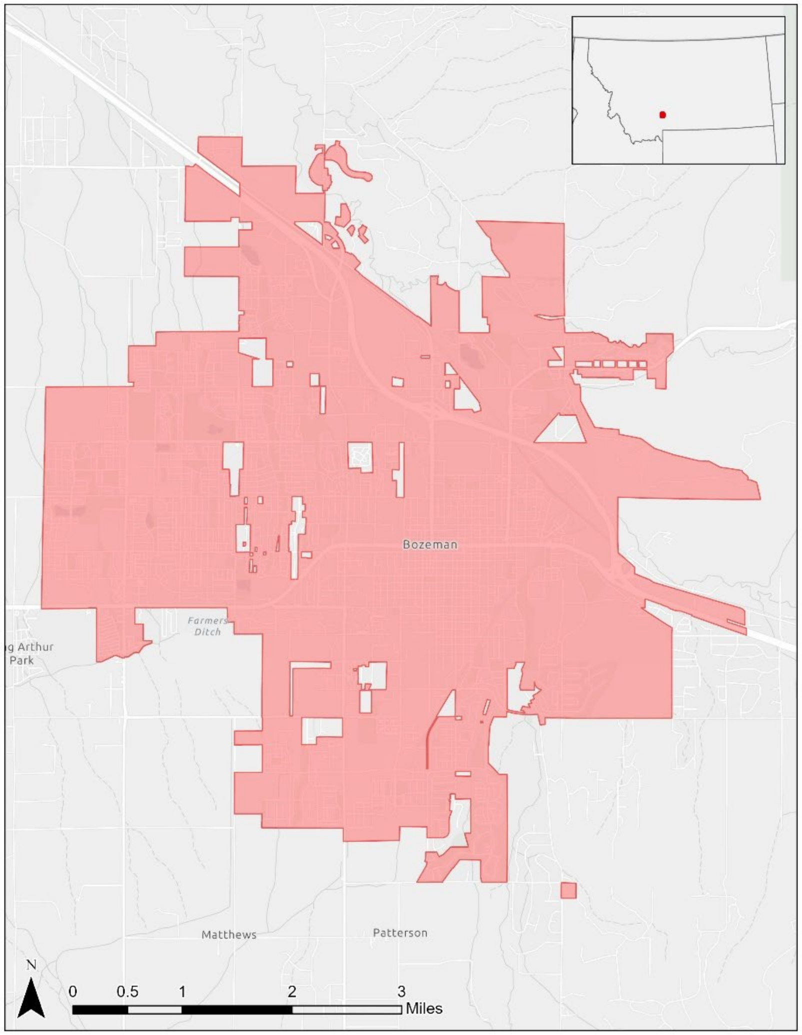

Figure 1. 2024 Bozeman City Limits.

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OVERVIEW OF EMISSIONS

In 2024, Bozeman's greenhouse gas (GHG) emissions totaled 705,542 metric tons of carbon dioxide equivalent (mt CO_2e), encompassing all emissions generated within the city from building energy use (stationary energy), transportation, and waste.

Stationary energy was the largest emissions source, contributing 50% of the total. Within that category, commercial and industrial buildings accounted for 28%, while residential buildings made up 22%. Transportation was the second-largest source, responsible for 38% of total emissions. Waste and wastewater processes contributed 11% of total emissions. The remaining 1% of total emissions are from other industrial processes as well as indirect upstream and downstream emissions, generally defined as Scope 3 emissions. For more on emissions by Scope see Figure 5 on page 5.

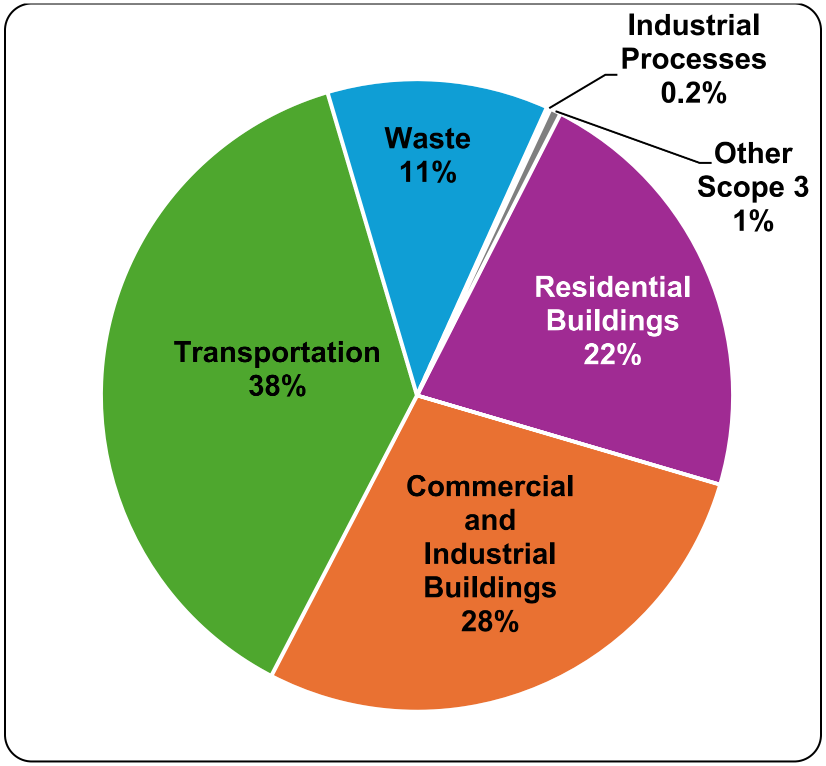

Figure 2. 2024 Greenhouse gas emissions by sector.

Bozeman's total greenhouse gas (GHG) emissions in 2024 rose 3% from 2022 and are 35% higher relative to the 2008 baseline. On a per capita basis, emissions increased slightly by 0.6% from 2022 but have declined by 16% since 2008. A key driver of the rise in overall emissions is Bozeman's rapid population growth, which has increased by 61% between 2008 and 2024. Although population growth has slowed slightly from the average 4% annual increase of the last decade to 3% between 2022 and 2024, the community is still managing the effects of growth, which have exceeded the emissions forecast from the 2020 Climate Plan. See Figure 3.

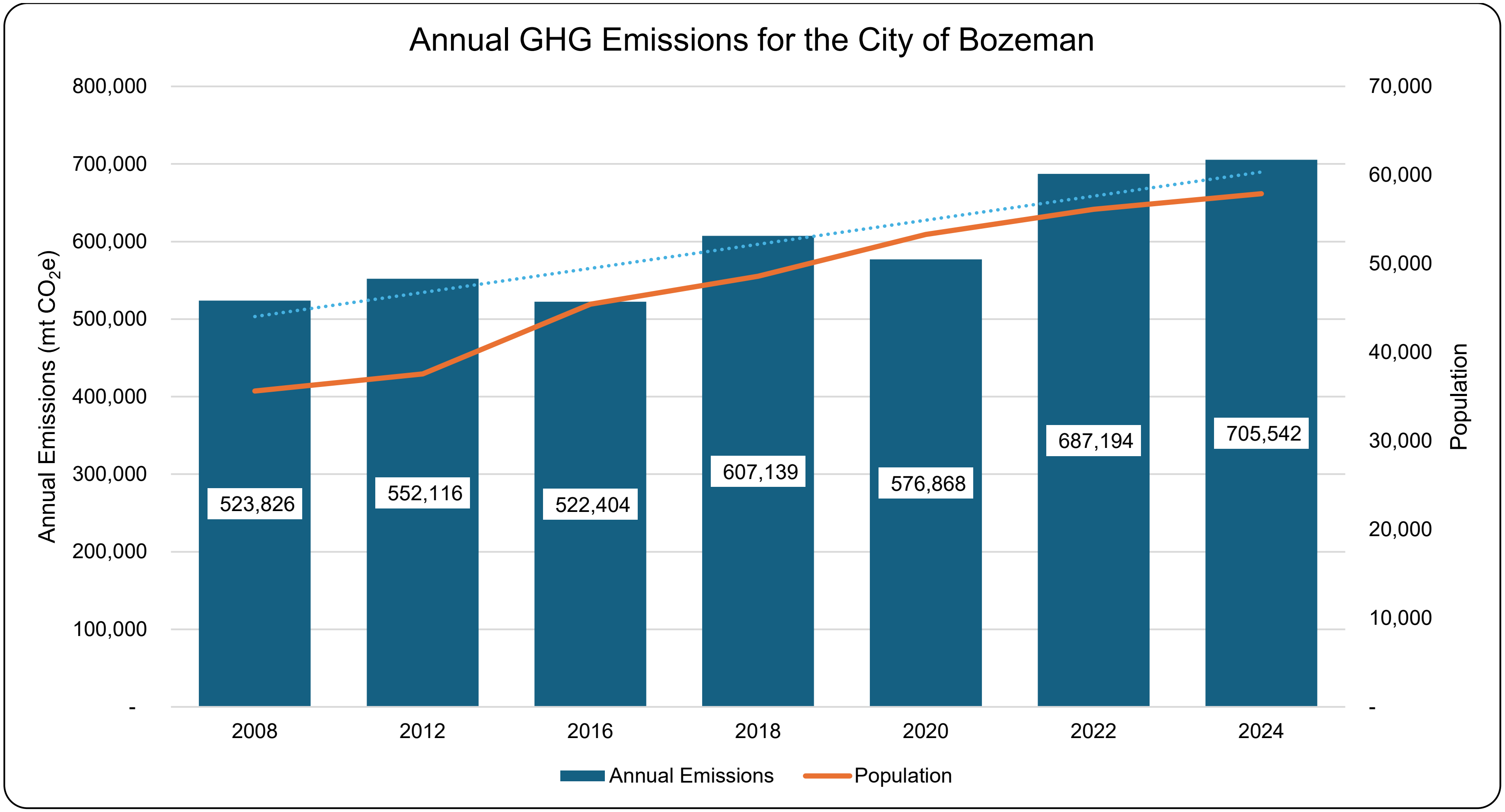

Figure 3. Annual Greenhouse Gas emissions for the City of Bozeman.

While Bozeman's population continues to grow, surpassing the projections used to set goals in the 2020 Climate Plan, per capita emissions have decreased. This decline suggests that collective and individual actions have mitigated the growth of greenhouse gas emissions.

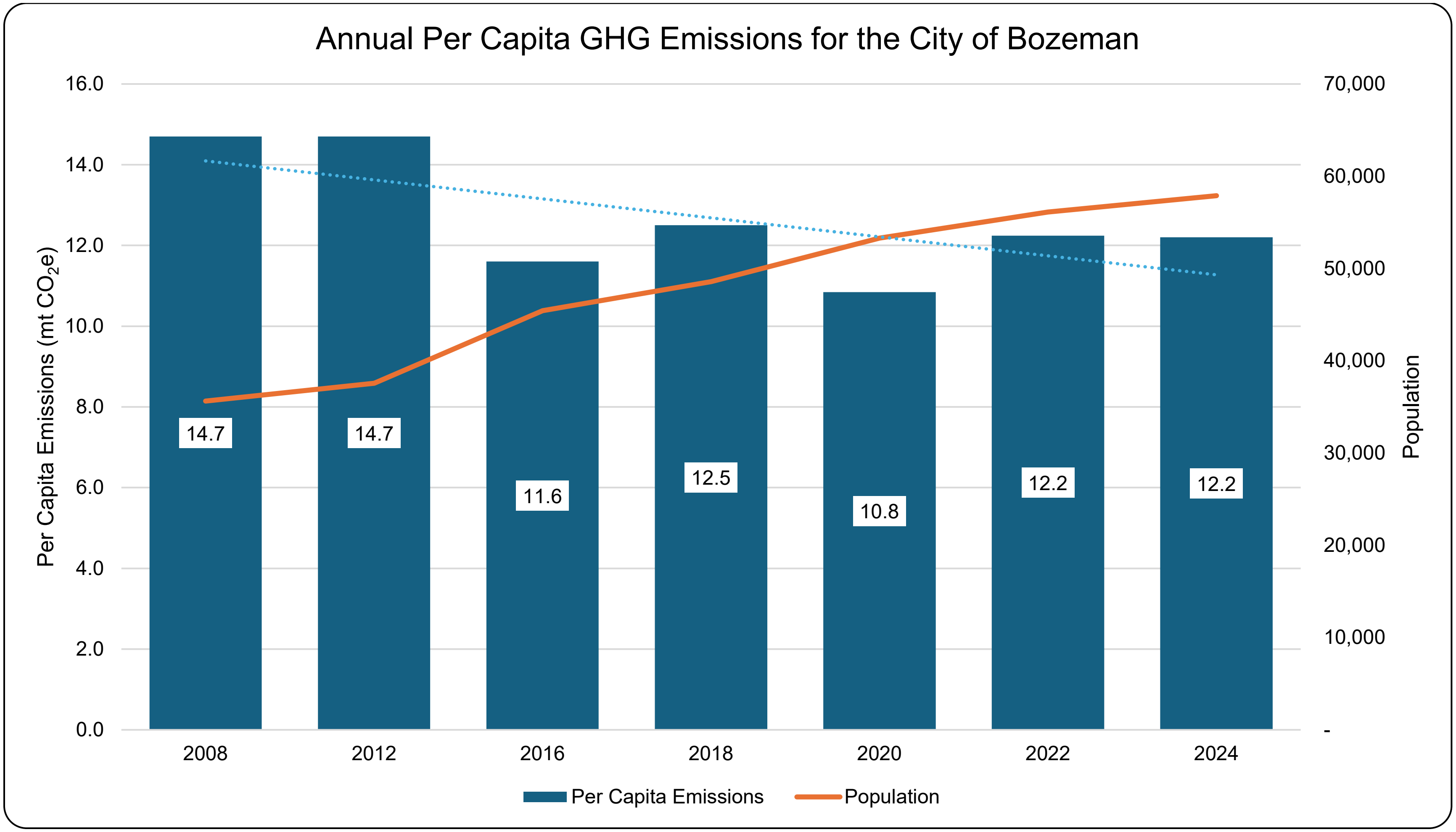

Figure 4. Annual per capita greenhouse gas emissions for the City of Bozeman.

EMISSIONS BY SCOPE

Greenhouse gas emissions are categorized by sector, scope, and source. When assessing emissions by scope, each source is evaluated based on where the emissions are released in relation to the city boundary.

Scope 1 emissions originate within the city limits and include direct sources such as natural gas consumption, vehicle use, and local waste processing.

Scope 2 emissions result from the use of grid-supplied electricity that is produced outside the city and consumed within it.

Scope 3 emissions occur outside the city boundary but are driven by activities within Bozeman, such as the disposal of waste in external landfills.

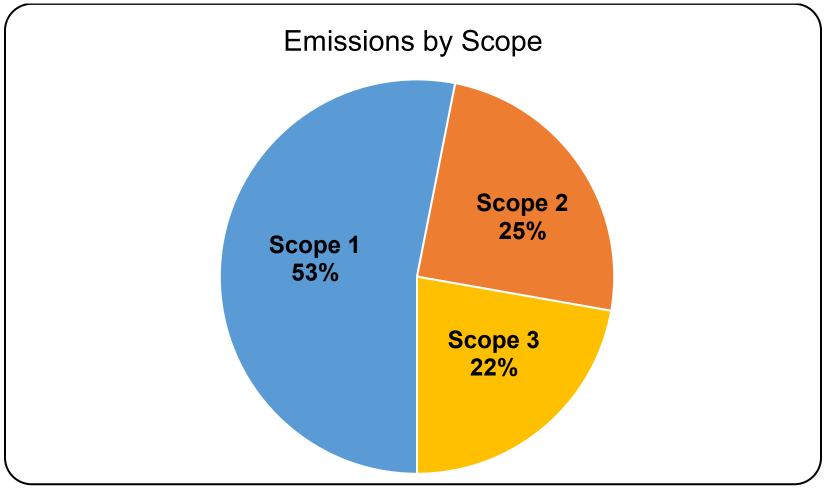

Figure 5. 2024 Greenhouse gas emissions by scope.

In 2024, Scope 1 emissions accounted for 53% of Bozeman's total greenhouse gas emissions, totaling 374,686 metric tons of CO_2e. The primary contributor was on-road vehicle activity, followed by natural gas use in both commercial and residential buildings.

Scope 2 emissions represented 25% of total emissions, or 174,018 metric tons of CO_2e. These emissions stem primarily from the consumption of grid-supplied electricity in commercial and residential buildings, with a fraction associated with charging electric vehicles.

Scope 3 emissions made up the remaining 22% (156,838 metric tons of CO_2e). Approximately half of these emissions were from aviation, while the other half resulted from sources such as waste and wastewater treatment, the transport of waste beyond city limits, and transmission and distribution (T&D) losses from electricity delivery.

Transmission and Distribution Losses

Transmission and distribution (T&D) losses refer to the portion of electricity lost during the process of delivering power from generation to end-users. NorthWestern Energy estimates a T&D loss rate of 6.27%, which equates to 25,274,794 kilowatt-hours lost while supplying electricity to Bozeman. These losses resulted in 11,593 metric tons of CO_2e emissions, accounting for approximately 2% of the city's total greenhouse gas emissions.

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EMISSIONS BY SECTOR & SOURCE

Bozeman's community-scale greenhouse gas inventory is organized into four main sectors, each encompassing a range of emission sources: stationary energy, transportation, waste and waste processes, and industrial processes.

- Stationary energy includes emissions from electricity and natural gas use in commercial and residential buildings, as well as propane and diesel combustion and transmission and distribution (T&D) losses.

- Transportation includes emissions from on-road and off-road gasoline and diesel use, aviation, public transit, electric vehicle charging, and associated T&D losses.

- Waste and waste processes account for emissions from the collection, transport, and treatment of waste, along with methane released from decomposing organic materials in landfills.

- Industrial processes consist primarily of emissions from refrigerant leaks in heating, ventilation, and air conditioning (HVAC) systems.

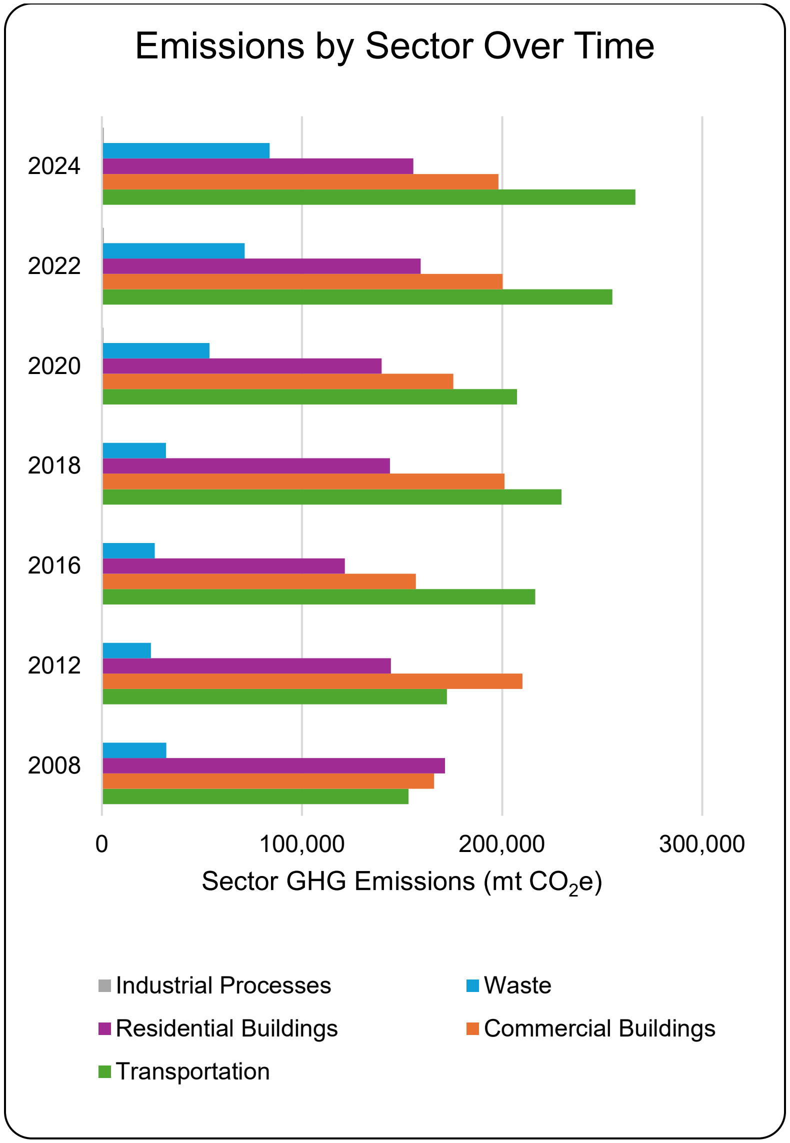


Figure 6. Annual greenhouse gas emissions by sector.

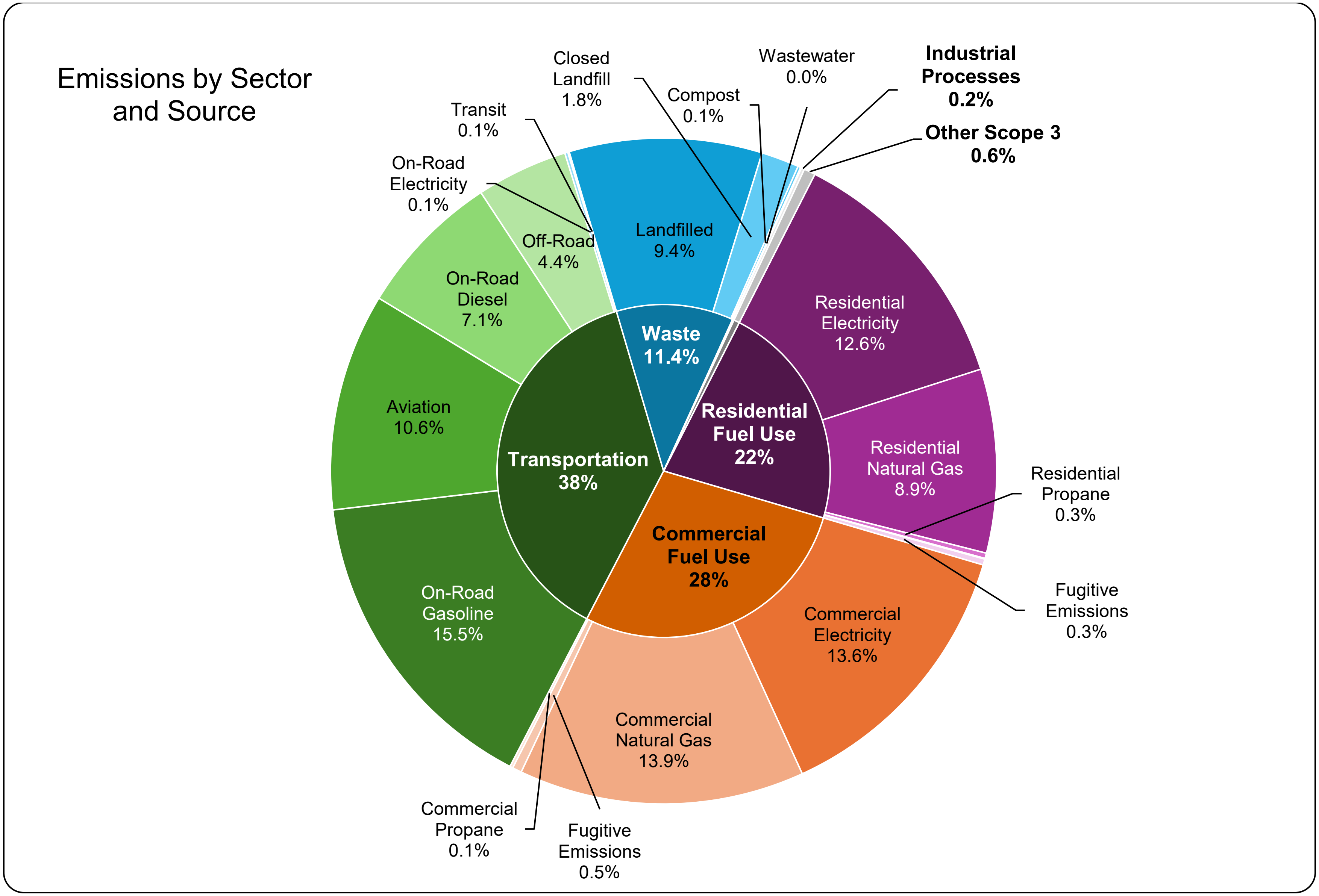


Figure 7. 2024 Greenhouse gas emissions by sector and source.

Table 1. 2024 Greenhouse gas emissions by sector, source, and scope.

Stationary Energy			
Fuel Usage	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Commercial and Industrial Natural Gas	97,822	1	14%
Commercial and Industrial Propane	1,048	1	0.1%
Residential Propane	1,824	1	0.3%
Residential Natural Gas	62,912	1	9%
Residential Wood	249	1	0.04%
Electricity	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Commercial and Industrial Grid-Supplied Electricity	90,015	2	13%
Residential Grid-Supplied Electricity	83,013	2	12%
Commercial and Industrial T&D Losses	6,031	3	1%
Residential T&D Losses	5,562	3	1%
Fugitive Emissions	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Commercial and Industrial	3,180	1	0.5%
Residential	2,045	1	0.3%
Total Stationary Energy	**353,699**		

Transportation			
On-Road Vehicles	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Emissions from fuel combustion on-road transportation occurring in the city	159,287	1	22.6%
Emissions from grid-supplied energy consumed in the city for on-road transportation	989	2	0.1%
EVs T&D Losses	66	3	0.0%
Off-Road	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Off-road fuel use	31,343.1	1	4.4%
Transit	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Transit activities within the city (buses)	501	1	0.1%
Aviation	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Transboundary aviation	74,466	3	10.6%
Total Transportation	**266,653**		

Waste			
Community Solid Waste	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Landfilled waste treated outside the City	65,988	3	9.4%
Composted waste treated inside the City	162	1	0.0%
Composted waste treated outside the City	802	3	0.1%
Emissions from closed landfill	12,933	1	1.8%
Wastewater Treatment and Discharge	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Wastewater Generated and Treated in City	313	1	0.0%
Total Waste	**80,198**		

Industrial Processes and Product Use			
Refrigerant Leakage	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Emissions from leaked refrigerants in the City	1,068	1	0.2%
Total Refrigerants	**1,068**		

Other Scope 3			
Other Scope 3	**GHG Emissions (mt CO_2e)**	**Scope**	**Percentage of Total**
Emissions from transport, collection, and processing of waste	3,923	3	0.6%
Total Other Scope 3	**3,923**		

STATIONARY ENERGY

In 2024, stationary energy remained Bozeman's largest source of greenhouse gas emissions, contributing 50% of total community-wide emissions, equal to 353,699 metric tons of CO_2e. This reflects a 2% decrease from 2022 levels.

The stationary energy sector includes emissions from electricity and natural gas use in buildings, along with other fuel sources such as propane, wood, and transmission and distribution (T&D) losses. Fugitive emissions from natural gas sourcing, transportation, and leakage are also included in this sector.

Electricity use, including T&D losses, accounted for 52% of stationary energy emissions (184,621 mt CO_2e), while natural gas use, including fugitive emissions, made up 47% (165,958 mt CO_2e). The remaining 1% (3,120 mt CO_2e) resulted from commercial and residential propane use as well as residential heating with wood.

Commercial and industrial buildings were responsible for 56% of stationary energy emissions (198,095 mt CO_2e), representing 28% of Bozeman's total emissions.

Residential buildings contributed the remaining 44% (155,604 mt CO_2e), or 22% of total emissions. Emissions from both building types saw modest reductions from 2022, 1% for commercial and 2% for residential.

Following the lifting of COVID-19 restrictions in 2022, an increase in commercial energy use was anticipated due to the return of activity in offices and educational institutions. Likewise, population growth contributed to higher residential energy demand between 2020 and 2022. However, the slight decline in emissions from 2022 to 2024 suggests that both commercial and residential energy use have stabilized.

Between 2022 and 2024, Bozeman added 54 commercial businesses and issued 595 certificates of occupancy for new residences. The overall observed reduction in energy emissions over this period indicates improvements in building efficiencies.

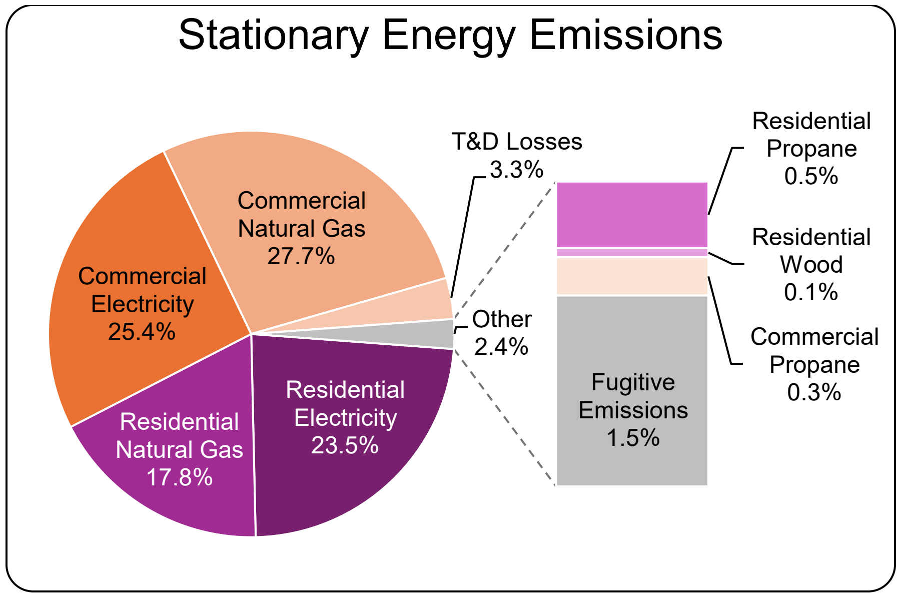


Figure 8. Stationary energy emissions.

TRANSPORTATION

The transportation sector is Bozeman's second-largest source of greenhouse gas emissions, accounting for 38% of total emissions in 2024, or 266,653 metric tons of CO_2e, an overall 5% increase from 2022.

On-road vehicles remain the primary source of transportation emissions. Gasoline-powered vehicles contributed 41% of the sector's total emissions (109,368 mt CO_2e), while diesel vehicles accounted for 19% (49,919 mt CO_2e). Public transit emissions were minimal at 0.2% (501 mt CO_2e), and electric vehicles, including associated T&D losses, made up 0.4% (1,055 mt CO_2e).

Aviation contributed 28% of total transportation emissions (71,830 mt CO_2e), marking a 4% increase from 2022. Aviation emissions rose significantly between 2020 and 2022 as post-pandemic travel resumed but have since stabilized.

Off-road sources made up the remaining 12% of transportation emissions (31,343 mt CO_2e). These include fuel use from agricultural equipment, private aviation (such as medical helicopters and aerial surveys), boats, construction and industrial machinery, lawn and garden tools, and recreational vehicles like snowmobiles and ATVs.

In total, Bozeman residents drove 341,284,544 miles in 2024, an 8% increase from 2022, based on vehicle miles traveled (VMT) estimates from the Montana Department of Transportation, which are derived from road mileage and vehicle count models.

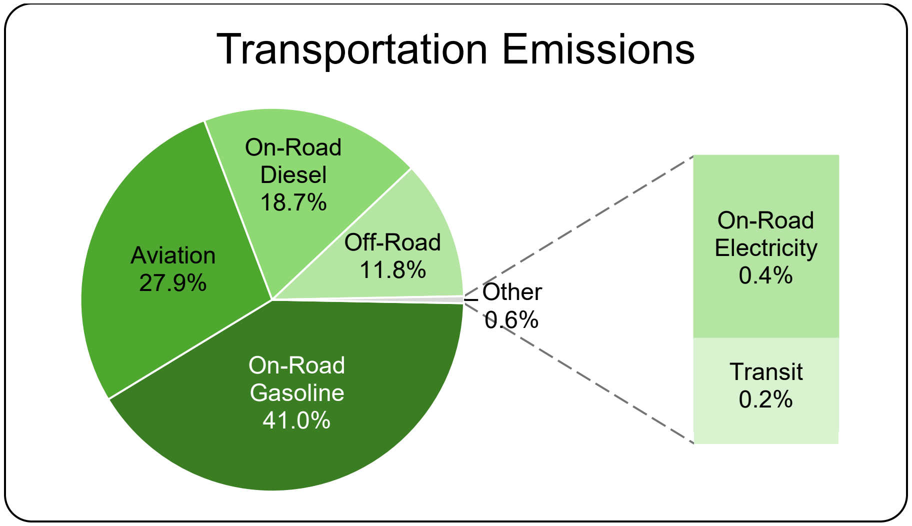


Figure 9. Transportation emissions.

Transportation – Aviation

While Bozeman does not have an airport within its city limits, the Bozeman-Yellowstone International Airport (BZN), located just a few miles from downtown, functions as the primary air travel hub for the community. Although emissions associated with air travel that occurs outside the City's boundary are considered optional reporting through the GPC, the Bozeman-Yellowstone International Airport is an integral part of the City of Bozeman's economic function and is included in the greenhouse gas emissions inventory to more accurately describe overall community emissions. Because the associated emissions occur outside city boundaries, they are categorized as Scope 3 emissions. Following ICLEI guidance, these emissions are estimated based on the proportion of airport passengers who originate their travel in Bozeman, which serves as a proxy for the community's share of jet fuel and aviation gasoline consumption. In 2024, BZN served 2,642,707 total passengers, with 38% (approximately 1 million passengers) originating their travel from the airport. This activity is estimated to have required 7,621,179 gallons of jet fuel and aviation gasoline, resulting in 74,466 metric tons of CO_2e emissions. These aviation-related emissions accounted for 11% of Bozeman's total greenhouse gas emissions in 2024.

Aviation emissions are a notable feature of Bozeman's 2024 greenhouse gas inventory due to their significant rate of increase following the COVID-19 pandemic. Prior to 2020, air travel at the Bozeman-Yellowstone International Airport was growing steadily, in line with national trends. During pandemic-related travel restriction air travel declined sharply, dropping 58% nationwide and 43% at BZN.

Between 2020 and 2024, domestic air travel in the U.S. gradually rebounded to near pre-pandemic levels. In contrast, BZN experienced a much faster recovery, with passenger volumes surpassing pre-pandemic levels by 68% (see Figure 10). Although these numbers reflect total air traffic at BZN and are not solely attributable to Bozeman residents, the rapid increase in regional air travel has a significant impact on the community's overall emissions.

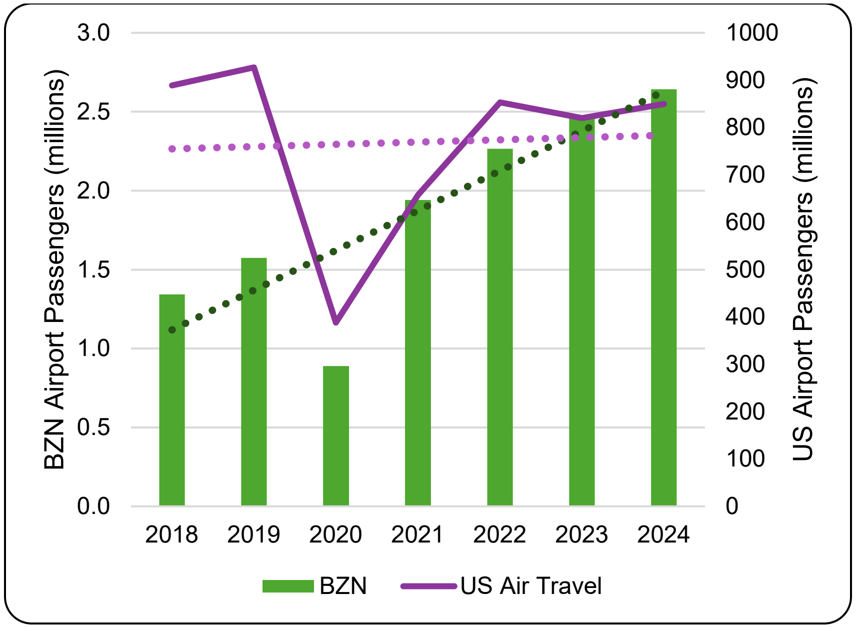


Figure 10. Air travel at BZN and domestic US airports - ***US Dept. of Transportation – Bureau of Transportation Statistics***

WASTE & WASTEWATER

In 2024, waste and wastewater processes accounted for 11% of Bozeman's total greenhouse gas emissions, totaling 80,198 metric tons of CO_2e, an 18% increase from 2022.

Ninety-seven percent of Bozeman's waste is collected and transported to the Logan Landfill and includes both solid waste and compostable materials. Solid waste refers to materials that are not recycled or composted, most of which are categorized as municipal solid waste (MSW), such as food scraps, non-recyclable paper, and plastics. Solid waste also includes other discarded items such as tires, electronic waste, and construction debris. In 2024, MSW made up approximately 70% of the city's landfilled waste, with a total of 62,835 tons, representing a 23% increase from the 50,894 tons recorded in 2022. Notably, organic materials such as paper and food scraps sent to landfills have a higher global warming potential than if they were composted or recycled.

Solid waste emissions totaled 53,888 metric tons of CO_2e, 82% of all waste-related emissions, and rose by 22% from 2022. The second-largest contributor to emissions within this sector is the closed Story Mill Landfill in Bozeman, which continues to emit methane from previously landfilled organic material. Although the methane is captured, flared, and converted to carbon dioxide before release, it still accounts for 16% of waste-related emissions (12,933 mt CO_2e).

Wastewater treatment added a relatively small portion—0.4%—of waste sector emissions (313 mt CO_2e), which is largely dependent on wastewater volume and organic concentration. A small share of Bozeman's waste, including food scraps and other green waste, is composted locally. In 2024, composted materials contributed 1% of waste-related emissions (965 mt CO_2e).

Altogether, Bozeman generated 100,929 tons of discarded material in 2024. The community diverted 10,448 tons through composting and 2,078 tons through recycling, avoiding an estimated 10,776 metric tons of CO_2e emissions.

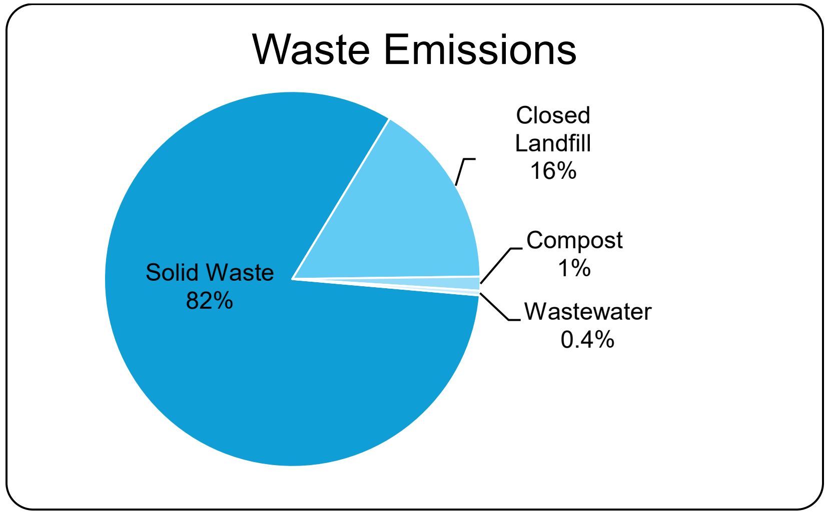


Figure 11. Waste emissions.

INDUSTRIAL PROCESSES & OTHER SCOPE 3 EMISSIONS

In 2024, industrial processes and other Scope 3 emissions contributed a combined 0.7% of Bozeman's total greenhouse gas emissions, totaling 4,991 metric tons of CO_2e.

Industrial product use primarily refers to emissions from refrigerant leaks in commercial building HVAC systems. These are estimated based on the assumption that 25% of Bozeman's commercial building space is refrigerated, with a refrigerant leakage rate of 5%, following the methodology outlined by the Intergovernmental Panel on Climate Change (IPCC). Refrigerant leaks accounted for 0.2% of Bozeman's total emissions (1,068 mt CO_2e).

Other Scope 3 emissions not captured elsewhere in the inventory stem from the transportation of solid waste to the Logan Landfill, located outside the city limits. This waste transport activity contributed 0.6% of total emissions (3,923 mt CO_2e).

DRIVERS OF GREENHOUSE GAS EMISSIONS

The greenhouse gas emissions inventory provides insights into the sources and sectors of emissions, and trends over time. The 2024 GHG inventory offers a clearer view of what recalibrated emissions may look like for the Bozeman community following the exceptional circumstances of the COVID-19 pandemic and the notable drop in emissions seen in 2020. To complement the GHG inventory, the ICLEI Contribution Analysis tool offers valuable insights into the key sources behind changes in emissions between inventory years.

From 2022 to 2024, overall emissions rose by 3%, a much smaller increase compared to the 19% jump observed between 2020 and 2022. The Waste sector saw the largest increase, rising from 71,311 to 83,808 metric tons of CO_2e, an 18% increase. While Bozeman's growing population continues to be a significant factor in emissions growth, the second largest contributor in this analysis, the rise in waste emissions, outpaced population growth, suggesting an increase in waste generated per person.

Other contributors to rising emissions include an increase in vehicle miles traveled per person, growth in employment, and shifts in the electricity and heating fuel mix.

On the other hand, several factors helped offset these increases. Milder winters have led to reduced use of heating fuels, lessening the emissions intensity of stationary energy. Commercial and residential energy use has declined, further moderating emissions from that sector. And by composting organic materials as opposed to landfilling, waste emissions were reduced.

Additional factors contributing to emissions reductions include improvements in vehicle fuel efficiency, and a decrease in methane emissions from the closed Story Mill Landfill.

Table 2. Contribution Analysis factors.

Contribution	Emissions (mt CO_2e)
Waste Generation	21,870
Population	10,667
VMT	8,744
Growth in Employment	7,269
Electricity & Heating Fuels Mix	5,861
Other	4,031
Vehicle Efficiency	-2,703
Commercial Energy	-4,212
Residential Energy	-9,137
Compost	-10,205
Warmer Winter	-12,712

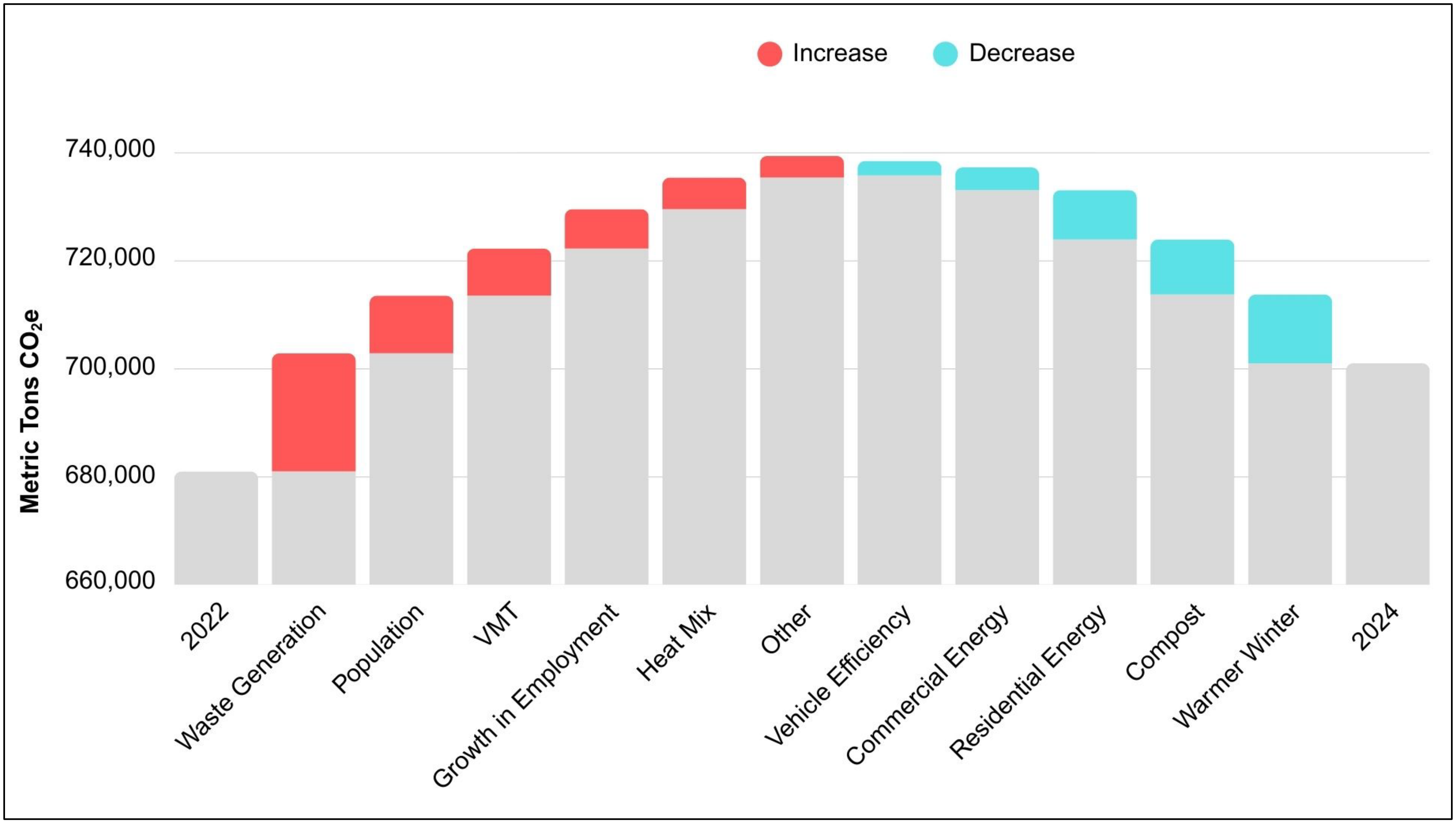


Figure 12. ICLEI Contribution Analysis.

URBAN TREE CANOPY ANALYSIS

In addition to the greenhouse gas emissions inventory, the City of Bozeman conducted an urban tree canopy analysis by using Summer 2024 aerial imagery and 2023 LiDAR (Light Detection and Ranging) to create a high-resolution landcover dataset. The results allow for the quantification of urban tree canopy within Bozeman City limits and the calculation of two key estimates: carbon stock, the total carbon stored in trees and plants, and carbon sequestration, the process by which trees absorb carbon through photosynthesis and store it in biomass and soils.

In 2024, the City of Bozeman, including county inholdings, encompassed 14,706 acres, with an estimated 1,238 acres of urban tree canopy. Based on carbon removal rates for Montana's urban areas and carbon storage estimates for Gallatin County, Bozeman's urban forest is estimated to store 61,019 metric tons of carbon and has the potential to remove 3,380 metric tons of CO_2 per year, equal to roughly 0.5% of the city's total greenhouse gas emissions.

The 2024 urban tree canopy analysis establishes a baseline for calculating the City's net balance of tree canopy carbon emissions and removals, known as carbon flux. To calculate net GHG emissions and removals from urban forests as defined by the IPCC gain-loss method, multiple years of tree canopy coverage data is required. Future GHG emission inventories will incorporate the calculation of carbon flux.

While measuring carbon storage and sequestration provides valuable insight it does not quantify other direct or indirect benefits of ecosystem services provided by the urban forest, such as air pollutant removal, stormwater filtration, and shade that mitigates urban heat and reduces building cooling demand.

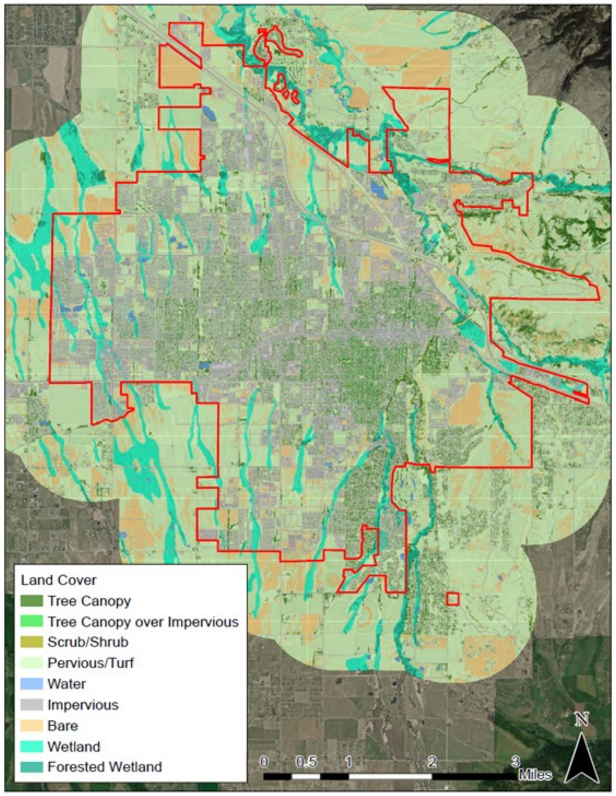


Figure 13. 2024 Urban Tree Canopy Analysis Landcover Dataset

PER CAPITA EMISSIONS

Between 2022 and 2024, Bozeman's per capita greenhouse gas emissions remained steady at 12.2 metric tons of CO_2e per person, and remains 16% lower than the 2008 baseline year. During this same period, Bozeman's population more than doubled. The continued decline in emissions per person since 2008 indicates that the city's rapid population growth has not led to a proportional rise in total greenhouse gas emissions. Bozeman's per capita emissions are 14% below the national average, though still more than two and a half times higher than the global average.

Table 3. Local, national, and international per capita emissions.

Per Capita Emissions (mt CO_2e)				
	2008	2020	2022	2024
Bozeman	14.7	10.8	12.2	12.2
National	18.8	13.5	14.4	14.3
International	4.7	4.5	4.7	4.7

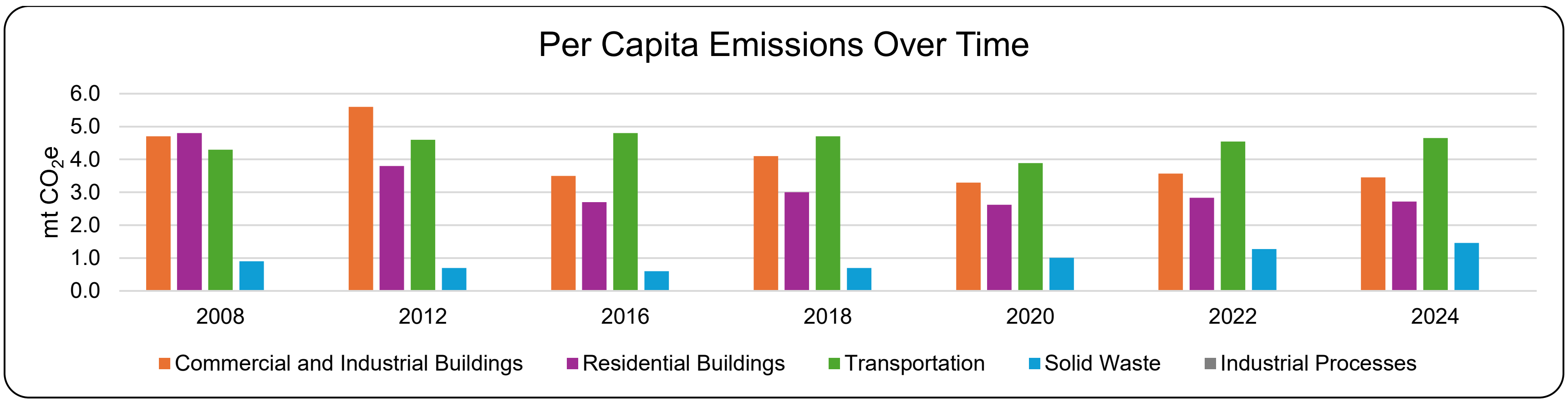


Figure 14. Per capita emissions over time by sector.

BOZEMAN CLIMATE PLAN GOALS

With the adoption of the 2020 Climate Plan, Bozeman set ambitious emissions and energy targets, including a 26% reduction from 2008 levels by 2025, 100% net clean electricity by 2030, and carbon neutrality by 2050. The emissions targets align with the 2015 Paris Climate Agreement and the United States' original targets to reduce greenhouse gas emissions and adapt to the impacts of climate change. Parties to the Paris Climate Agreement have Nationally Determined Contributions that are essential to limiting the average global temperature rise to well below 2°C (3.6°F) above pre-industrial levels, while also pursuing efforts to limit the temperature increase to 1.5°C (2.7°F). Meeting this target does not avoid extreme, global warming effects, but serves as an agreed aspirational target to avoid the more extreme and irreversible climate effects expected with 2°C (3.6°F) of warming. Bozeman's climate targets were adopted in solidarity with the commitment to limit human-driven warming to 1.5°C, representing meaningful yet daunting benchmarks in a rapidly growing community.

Figure 14 provides a trend line of Bozeman's actual GHG inventories dating back to the benchmark year of 2008. The Climate Plan reduction pathway to carbon neutrality is represented on the green line. The 2024 greenhouse gas emissions inventory indicates that current emissions are 35% above the 2008 benchmark. Notably, the 2008 benchmark inventory year excluded Scope 3 aviation emissions. Aviation emissions were previously a minor source of emissions but contributed 10.6% of total emissions in 2024. A correction of the baseline year and subsequent projections relative to our climate goals will be evaluated in future inventories.

Prior inventories have included a business-as-usual (BAU) projection that was developed in 2019. Since the adoption of the Climate Plan, population growth and economic activity have surpassed the assumptions used to develop the BAU projection. The projection also includes assumptions of incremental efficiency gains under federal policies and economic trends, suggesting the BAU projection requires a review and update.

Overall, the trend line suggests the need for significant and impactful solutions to bend the emissions growth curve. Progress towards Bozeman's climate goals is achievable and relevant. Every tenth of a degree of warming avoided protects human health and well-being in the Bozeman community and beyond. Improvements to per capita emissions demonstrate that individuals can pursue a lower-carbon lifestyle in thriving, resilient, connected cities that support more efficient buildings and infrastructure. Progress towards our goals will require further prioritization and implementation of the Climate Plan, coupled with supportive state and federal climate policy comprised of consumer incentives, technology investments, and regulatory oversight.

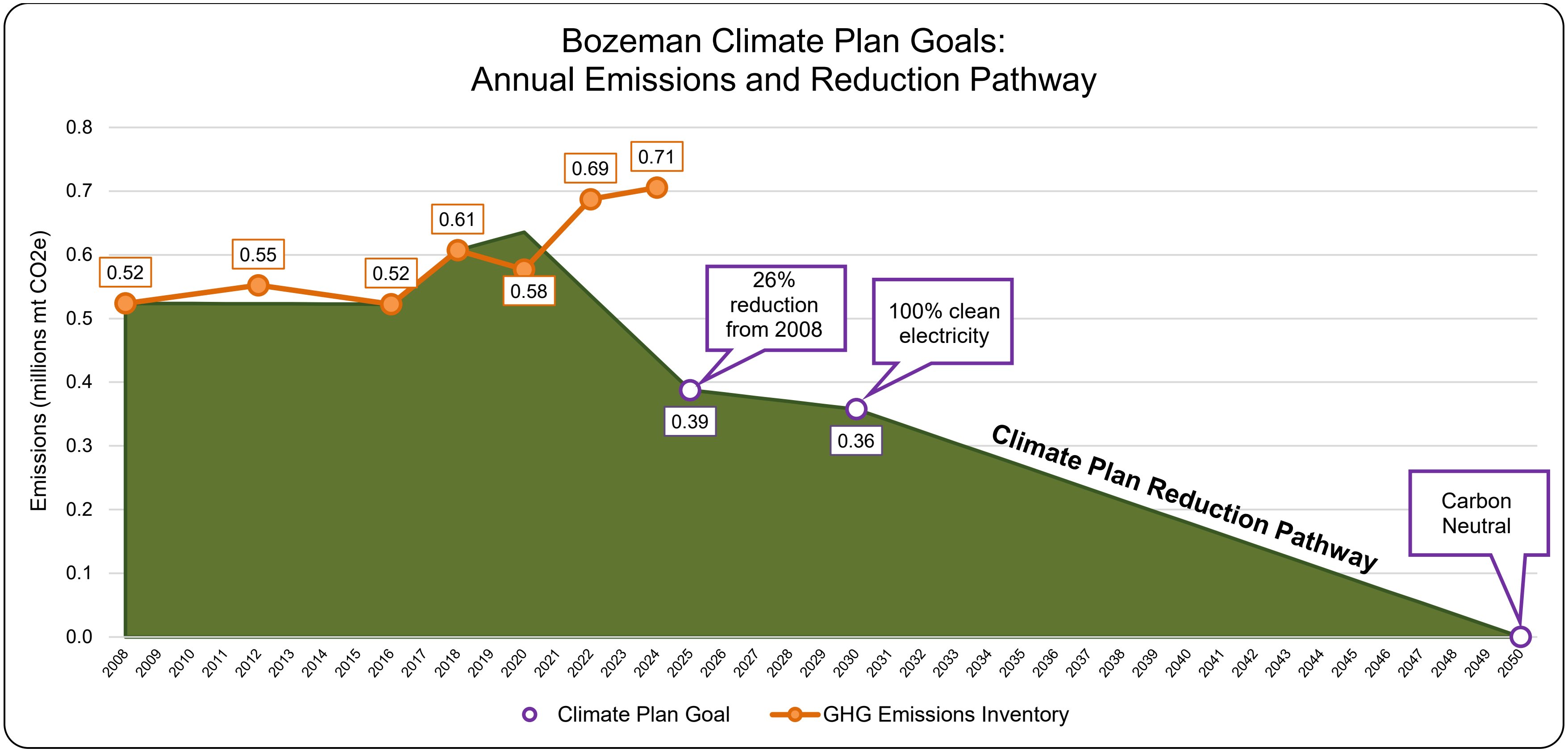


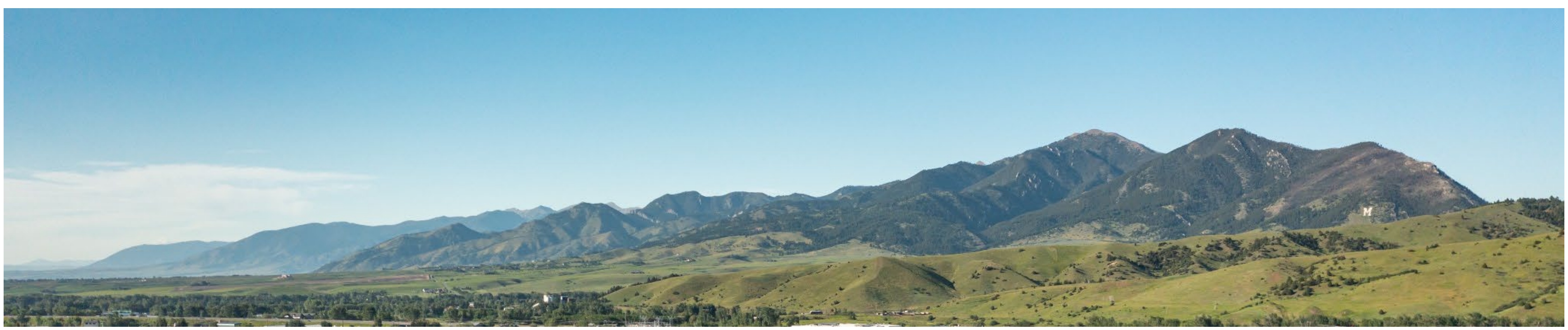
Figure 15. Bozeman Climate Plan Goals: Annual Emissions & Reduction Pathway

SUMMARY

Bozeman's 2024 greenhouse gas emissions inventory offers a clearer understanding of community-scale emissions following the impacts of the COVID-19 pandemic, outsized population growth, and increased tourism throughout the mountain west. While some sectors saw a rise in emissions, others showed stabilization or even reductions. Having a broader perspective of emissions for the City of Bozeman allows for the reevaluation and prioritization of the solutions and actions that will bring the community closer to achieving the goals established in the 2020 Climate Plan.

Overall, both emissions and population increased 3% from 2022 to 2024, this marginal decrease in population growth from years past when Bozeman, experiencing a population boom, saw emissions growth across all sectors. From the previous inventory year of 2022 to current, sector emissions have begun to stabilize. Both commercial and residential energy use decreased slightly, indicating reduced energy use in homes and workplaces, as well as the construction of more efficient buildings. The most significant increase in emissions was observed in the Waste sector, in both total and per capita measures, highlighting an area the city and community can prioritize for emissions reduction opportunities.

Accelerating the implementation of the solutions and actions outlined in the 2020 Climate Plan will bring Bozeman closer to achieving its community climate goals for 2025, 2030, and 2050. Ongoing monitoring of community-wide greenhouse gas emissions provides valuable insight into where policy, collaboration, and individual efforts can strengthen progress toward these goals.



APPENDIX A: DATA SOURCES

Emissions Source	Data Source	Were Emissions Estimated or Calculated?
Building Electricity Use	NorthWestern Energy	Calculated
Building Natural Gas Use	NorthWestern Energy	Calculated
Building Propane Use	US Census ACS House heating Fuel Survey data, Bozeman commercial square footage data, CBECS data, and US EIA unit conversions	Estimated
Building Wood Use	US Census ACS House heating Fuel Survey data	Estimated
Fugitive Emissions from Natural Gas Leakage	GPC Protocol default leakage rate	Calculated
Transmission & Distribution Losses	NorthWestern Energy loss rate	Calculated
Vehicle Miles Traveled	City of Bozeman and MT DOT	Calculated
Vehicle Registrations	EPA State Inventory Tool Mobile Combustion Module	Calculated
Electric Vehicle Registrations	Atlas EV Dashboard	Calculated
EV Transmission & Distribution Losses	NorthWestern Energy loss rate	Calculated
Transit Fuel Use	Human Resources Development Council	Calculated
Aviation Fuel Use	Bozeman/Yellowstone International Airport	Calculated
Waste and compost tonnage	Gallatin County Solid Waste, City of Bozeman	Calculated
Closed landfill emissions	Estimated emissions depreciation rate via ICLEI	Estimated
Waste transport, collection, and processing emissions	GPC Protocol methodology	Calculated
Wastewater	City of Bozeman	Calculated
Refrigerant Leaks	Commercial square footage and IPCC methodology	Estimated
NorthWestern Energy Electric Emissions Factor	NorthWestern Energy	N/A

APPENDIX B: EMISSIONS FACTORS

Stationary Energy Emission Factors—Electricity & Natural Gas				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Electricity	CO_2	0.457	mt CO_2/MWh	Northwestern Energy's EEI-ESG Template 2023
	CH_4	0.00003	mt CH_4/MWh	EPA's eGrid 2023
	N_2O	0.000004	mt N_2O/MWh	
Natural Gas	CO_2	0.0053	mt CO_2/therm	2013 ICLEI US Community Protocol: Appendix C
	CH_4	0.0000005	mt CH_4/therm	
	N_2O	0.00000001	mt N_2O/therm	
Propane	CO_2	0.00559	mt CO_2/gal	
	CH_4	0.000001	mt CH_4/gal	
	N_2O	0.0000001	mt N_2O/gal	
Wood	CO_2	93.8	kg/MMBTU	
	CH_4	0.316	kg/MMBTU	
	N_2O	0.0042	kg/MMBTU	

Transportation Emission Factors—Ethanol, Gasoline, and Diesel				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Gasoline	CO_2	0.00878	mt CO_2/gal	EPA Estimates
	CH_4	Varies by vehicle	g/mile	
	N_2O			
Diesel	CO_2	0.01	mt CO_2/gal	
	CH_4	Varies by vehicle	g/mile	
	N_2O			
Ethanol	CO_2	0.006	mt CO_2/gal	
	CH_4	Varies by vehicle	g/mile	
	N_2O			

Off-road Emissions Factors				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Agriculture	CO_2	0.00878	mt CO_2/gal	EPA Estimates
	CH_4	6.26	g CH_4/mile	
	N_2O	1.05	g N_2O/mile	
Aviation	CO_2	0.00878	mt CO_2/gal	
	CH_4	3.88	g CH_4/mile	
	N_2O	2.13	g N_2O/mile	
Boating	CO_2	0.00878	mt CO_2/gal	
	CH_4	3.41	g CH_4/mile	
	N_2O	0.05	g N_2O/mile	
Commercial Industrial	CO_2	0.00878	mt CO_2/gal	
	CH_4	6.13	g CH_4/mile	
	N_2O	0.97	g N_2O/mile	

Off-road Emissions Factors				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Construction	CO_2	0.00878	mt CO_2/gal	EPA Estimates
	CH_4	7.57	g CH_4/mile	
	N_2O	1.01	g N_2O/mile	
Lawn & Garden	CO_2	0.00878	mt CO_2/gal	
	CH_4	6.53	g CH_4/mile	
	N_2O	0.92	g N_2O/mile	
Recreation	CO_2	0.00878	mt CO_2/gal	
	CH_4	4.29	g CH_4/mile	
	N_2O	1.21	g N_2O/mile	
Miscellaneous	CO_2	0.00878	mt CO_2/gal	
	CH_4	5.44	g CH_4/mile	
	N_2O	1.05	g N_2O/mile	
Transit Emission Factors				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Diesel	CO_2	0.01021	mt CO_2/gal	EPA Estimates
	CH_4	0.0095	g CH_4/mile	
	N_2O	0.0431	g N_2O/mile	

Aviation Emission Factors				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Jet fuel	CO_2	9.75	Kg CO2/gal	Per guidance from ICLEI on emissions factors used in the ClearPath tool.
	CH_4	0.41	g CH4/gal	
	N_2O	0.08	g N2O/gal	
Aviation Gasoline	CO_2	8.31	kg CO2/gal	
	CH_4	0.36	g CH4/gal	
	N_2O	0.07	g N2O/gal	

Waste Emission Factors				
Emission Source	**GHG**	**Value**	**Unit**	**Source**
Municipal Solid Waste	CH_4	Varies by waste type	mt CH_4/ ton waste	2013 ICLEI US Community Protocol, Appendix E
Recycled Waste	CH_4	Varies by waste type	mt CH_4/ ton waste	
	N_2O		mt N_2O/ wet short ton waste	
Green Waste	CH_4	0.0036	mt CH_4/ ton waste	EPA Waste Reduction Model (WARM) Documentation
	N_2O	0.00004	mt N_2O/ ton waste	
Food Waste	CH_4	0.00251	mt CH_4/ ton waste	
	N_2O	0.00004	mt N_2O/ ton waste	
Wastewater	CH_4	Varies by treatment	Varies	2013 ICLEI US Community Protocol, Appendix F
	N_2O			