

CITY OF
MISSOULA

MISSOULA, MONTANA

2019 Community
Greenhouse Gas Inventory

February 2022



Missoula, MT is home to many passionate citizens who are dedicated to protecting the land, air, and water in which they live, work, and recreate. They are committed to preserving natural resources and creating a healthy and resilient community for future generations to enjoy.

Missoula is not immune to the effects of climate change, as can be witnessed by increasingly dry, hot, and wildfire-smoke-filled summers, and decreasing snowpack in the winter. It is imperative that the Missoula community do its part to mitigate greenhouse gas emissions that contribute to our changing climate and build a resilient city that can handle the current and future climate change effects that threaten our health and safety.

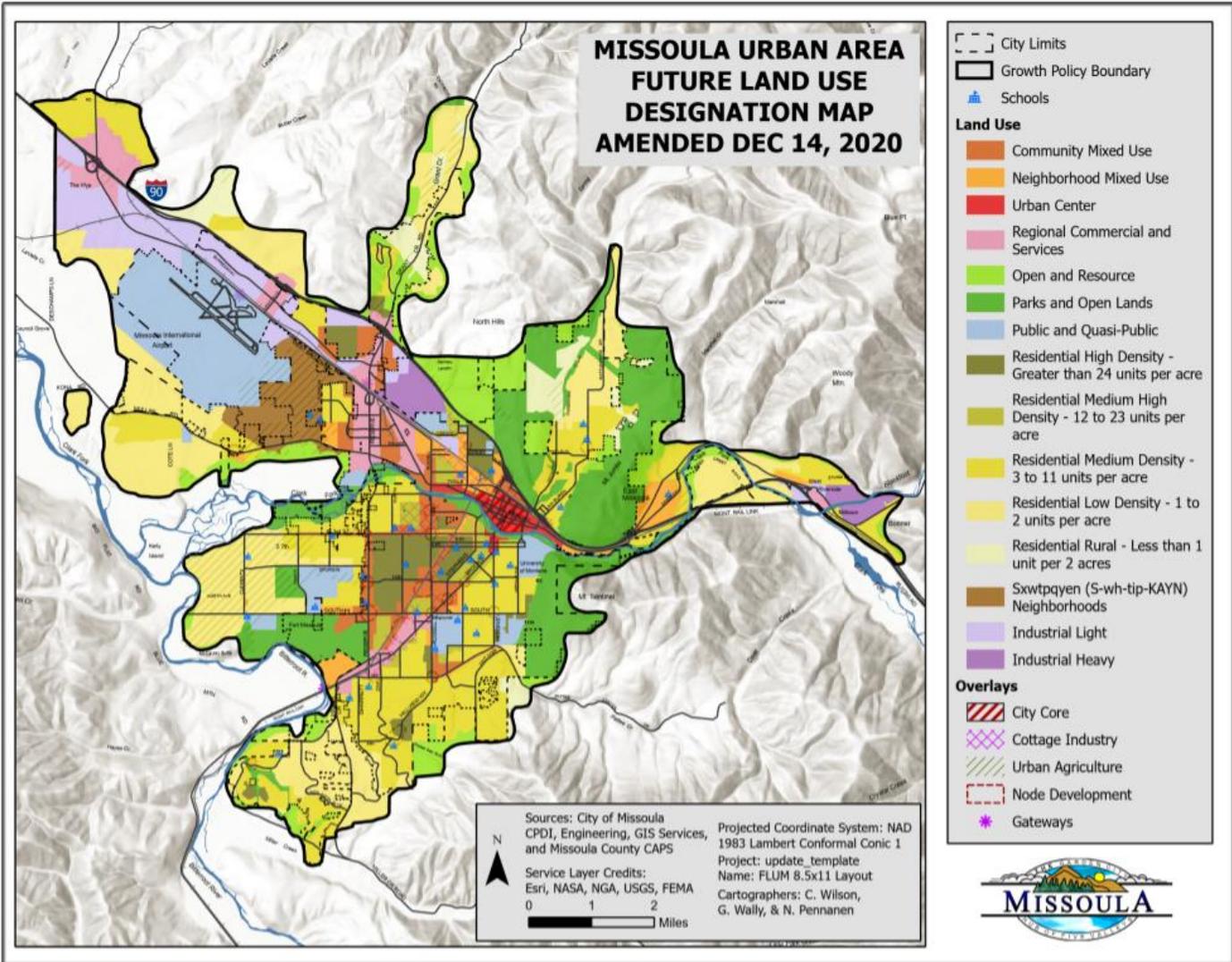
To better understand the progress our community has made, and the areas in which more action is needed, the City of Missoula, with support from its partners, conducts periodic community greenhouse gas (GHG) emissions inventories. This report represents Missoula's Community GHG Emissions Inventory from the calendar year 2019 and serves to provide insight and guidance on the City's adopted goals of clean electricity, carbon neutrality, and zero waste. This inventory is a tool used by city staff and community partners to understand where to direct efforts in the important fight against climate change in order to build a more resilient Missoula.

The City of Missoula, together with our community partners, businesses, residents, and visitors can all work together to reduce our environmental impact and ensure a healthy, sustainable future. The data provided here helps to support that mission.



Inventory Boundary

This inventory uses the Our Missoula City Growth Policy boundary, as seen below, which expands beyond Missoula city limits. The use of this boundary accounts for the growth and development of the Missoula urban community.



Urban Growth Area Population Estimation Methodology:

Our 2019 population was projected backward from the 2020 population estimate, which was determined from the aggregation of reported 2020 decennial census populations of all census blocks within the urban growth area boundary. For this report we assumed a 1.5% population growth rate, as cited in the Our Missoula, City Growth Policy 2035.

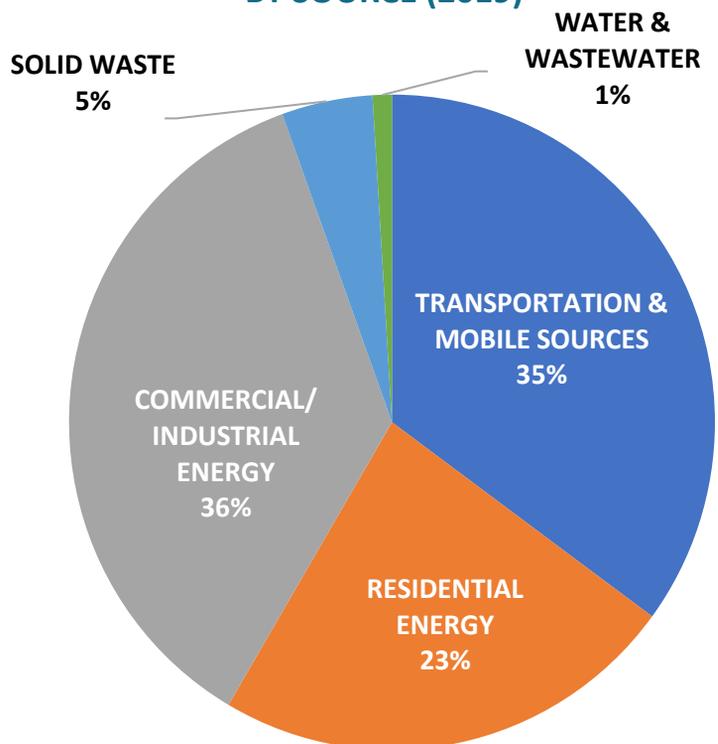
About the Inventory

The Missoula Community Greenhouse Gas Inventory was prepared in accordance with the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions using ICLEI’s ClearPath Emissions Management Tool. Inventory data was gathered for the 2019 calendar year from utilities and other local sources. The inventory spans seven emissions source categories as shown below. As a community-scale inventory, it accounts for Missoula’s resident, employee, and visitor activities within or originating from the Missoula Growth Policy boundary.

Results in Brief

The estimated population in the City of Missoula urban boundary in 2019 was approximately **92,650**. The population collectively produced 1,129,011 Metric Tons of CO₂ equivalent (CO₂e). When we factor carbon sequestration by Missoula’s urban forests, the overall 2019 emission are **1,118,208 Metric Tons of CO₂e**. This equates to roughly **12.1 Metric Tons of CO₂e per capita**. Of the seven emission sources gathered, commercial/industrial energy, transportation, and residential energy make up 94% of the total emissions.

MISSOULA’S COMMUNITY GHG EMISSIONS BY SOURCE (2019)



- TRANSPORTATION & MOBILE SOURCES
- RESIDENTIAL ENERGY
- COMMERCIAL ENERGY
- INDUSTRIAL ENERGY
- SOLID WASTE
- WATER & WASTEWATER
- AGRICULTURE & URBAN FORESTRY



COMMERCIAL/INDUSTRIAL ENERGY

Commercial/Industrial Energy contributed to the largest portion, 36%, of greenhouse gas emissions. Of these emissions, 70% is emitted as a result of electricity use and 30% as a result of natural gas use.

Commercial/Industrial electric service accounts for 68% of all community electricity (6,000+ customers).

Commercial/Industrial natural gas service accounts for 48% of all community natural gas use (3,600+ customers).

GRID ELECTRICITY & STATIONARY COMBUSTION AT A GLANCE

406,703 METRIC TONS OF CO₂e
Released into the atmosphere from this emissions source

This is equal to:



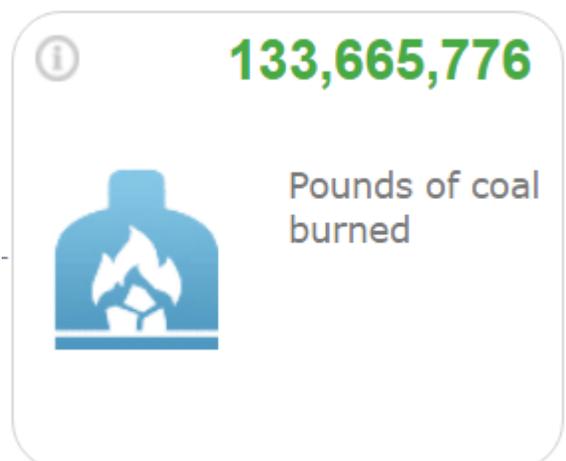
88,450 passenger vehicles driven in one year



2,243 railcars' worth of coal burned

Electricity Emissions Equivalency:

Natural Gas Emissions Equivalency:





TRANSPORTATION & MOBILE SOURCES

Transportation and Mobile Sources contributed the second largest portion, 35%, of greenhouse gas emissions. Of these emissions, 84% came from tailpipe emissions measured by Vehicle Miles Traveled (VMT), 15% came from airport operations measured by airplane gasoline and other metrics provided by the Missoula Montana Airport, and 1% came from Montana Rail Link operations.

MOBILE EMISSIONS AT A GLANCE

AVERAGE OF 1.8 MILLION DAILY VMT
From trips within Missoula's urban boundary

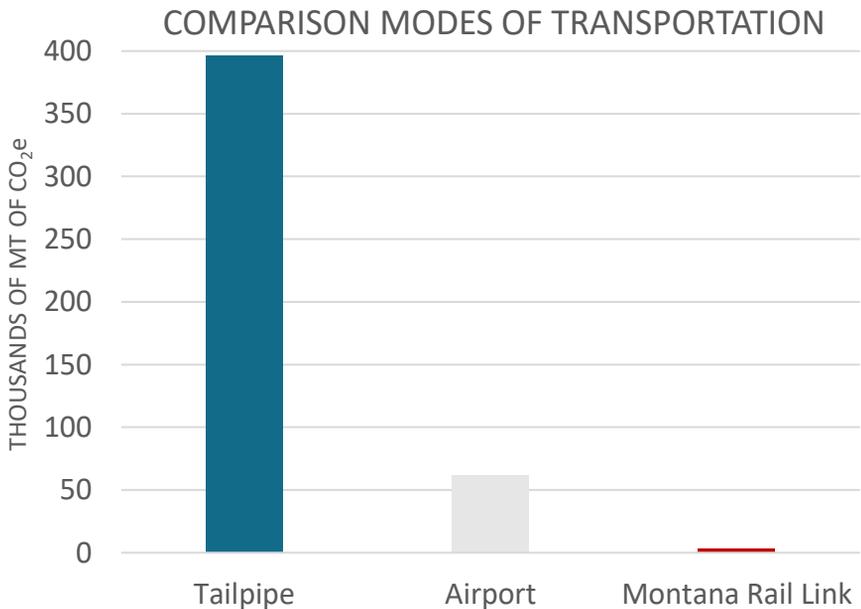
39,919 ANNUAL TRIPS
Made by air traffic from Missoula Airport

396,217 METRIC TONS OF CO₂e
Released into the atmosphere from this emissions source

The carbon emitted from this source is equal to:



2,186 railcars' worth of coal burned





RESIDENTIAL ENERGY

Residential Energy contributed to 23% of total emissions. Of these emissions, 50.43% is emitted as a result of electricity use and 49.57% as a result of natural gas use.

Residential electric service accounts for 31% of all community electricity (38,800+ customers).

Residential natural gas accounts for 52% of all community natural gas use (31,100+ customers).

GRID ELECTRICITY & STATIONARY COMBUSTION AT A GLANCE

263,700 METRIC TONS OF CO₂e
Released into the atmosphere from this emissions source

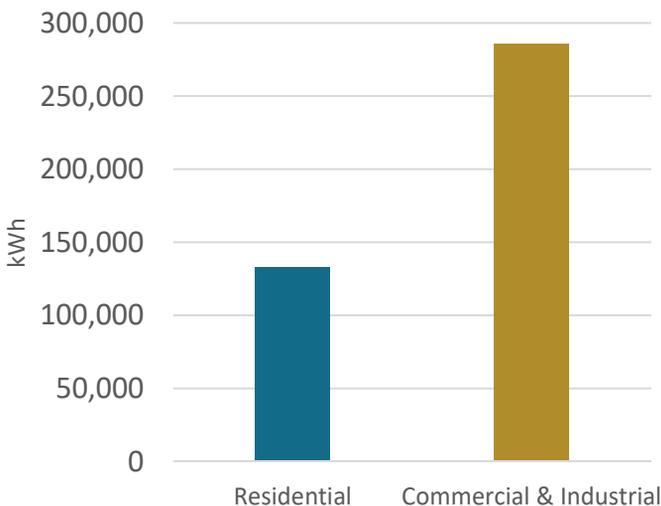
This is equal to:

57,349 passenger vehicles driven in one year

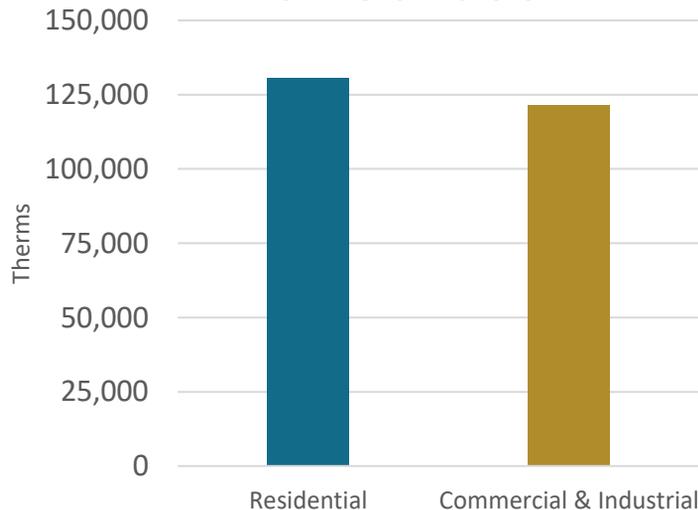
1,455 railcars' worth of coal burned



ELECTRICITY BY SECTOR



NATURAL GAS BY SECTOR





SOLID WASTE

Solid waste generated within the City’s urban boundary accounts for roughly 5% of the citywide GHG emissions in 2019. This metric accounts only for the emissions associated with materials breaking down in the landfill and does not account for the global impact of the materials that we purchase, consume, and discard. Cascadia Consulting Group conducted a Baseline Waste Composition Study for the City of Missoula in 2019. The graph below represents amount of material going to the landfill, and potential for recovery through recycling and composting.

WASTE GENERATION AT A GLANCE

96,840 TONS OF SOLID WASTE
Generated within Missoula’s urban boundary

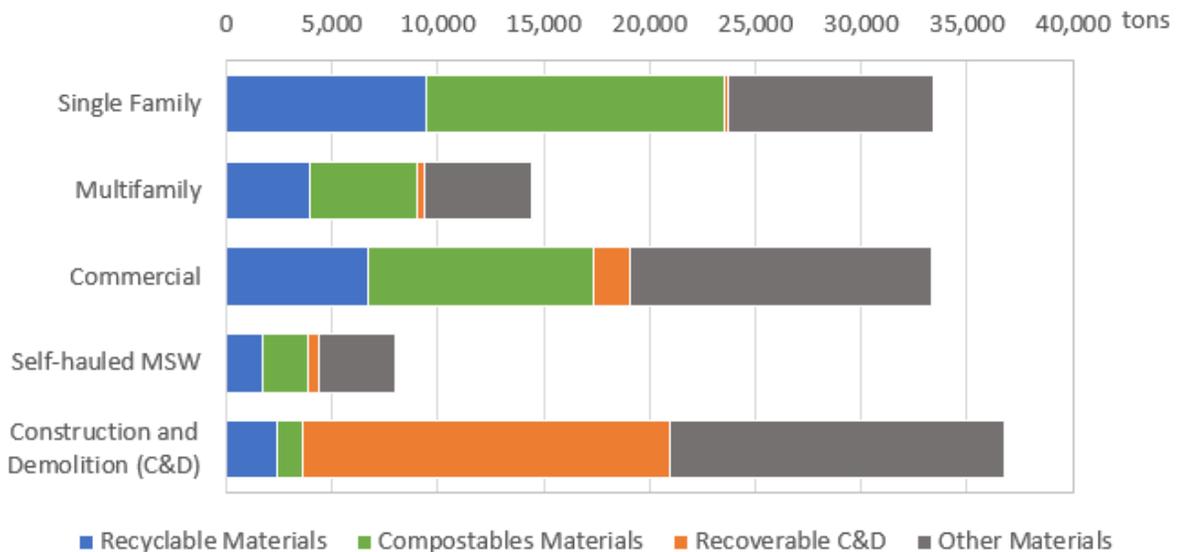
52,090 TONS OF SOLID WASTE
Collected by hauler designated routes

66,482 METRIC TONS OF CO₂e
Released into the atmosphere from this emissions source

This is equal to:



14,458 passenger vehicles driven in one year





WATER & WASTEWATER

Water delivery and wastewater treatment accounted for roughly 1% of Missoula's annual GHG emissions in 2019.

Missoula receives its sole source of water from the Missoula Valley Aquifer, and the associated emissions are the result of electricity used by pump stations to transfer water to the treatment facility and ultimately to the end user, as well as methane produced from the Wastewater Treatment Plant.

The Water & Wastewater Treatment Plant processed 7.83 million gallons of wastewater in 2019. A portion of the treated effluent flows into the Hybrid Poplar trees (1.83 million gallons), bio-solids are treated for composting, and biogas is used to heat and power operations.

WATER & WASTEWATER AT A GLANCE

OVER 73,700 MISSOULA RESIDENTS
Are served by Missoula Water

10,903 METRIC TONS OF CO₂e
Released into the atmosphere from this emissions source

This is equal to:



2,371 passenger vehicles
driven in one year





AGRICULTURE & URBAN FORESTRY

Of the reported sectors within the greenhouse gas emissions inventory, agriculture and urban forestry provides a unique lens. Agriculture activities can release greenhouse gases, but the plants, trees, and shrubs that grow in urban areas are a source of carbon sequestration – the long-term storage of carbon in plants, soils, and water bodies.

The 82 acres of urban forest within Missoula's city limits sequesters roughly 1% of citywide greenhouse gas emissions. The annual net reduction from carbon sequestration was calculated using data from the City of Missoula Urban Growth Policy and ICLEI's Land Emissions and Removals Navigator (LEARN) tool.

AGRICULTURE AND URBAN FORESTRY AT A GLANCE

82 ACRES

Of urban tree canopy in Missoula city limits

OVER 40,000 ACRES

Make up the City's total land base

10,802 METRIC TONS OF CO₂e

Sequestered from the atmosphere from this emissions source

This is equal to:



keeping 2,371 passenger vehicles off the road for one year

How do other cities compare?

City of Missoula, MT - 2019

- Population: 92,650
- 1,118,208 MT of CO₂e
- 12.1 MT of CO₂e/capita

City of Bozeman, MT - 2017

- Population: 45,250
- 522,404 MT of CO₂e
- 11.5 MT of CO₂e/capita

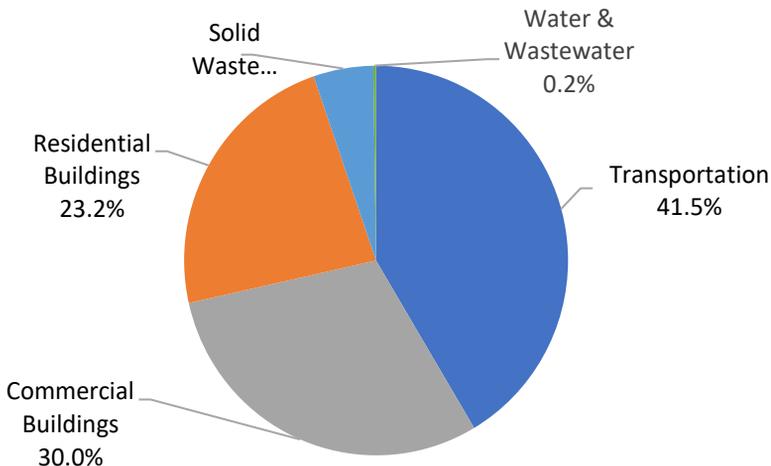
City of Boulder, CO - 2019

- Population: 106,392
- 1,446,276 MT of CO₂e
- 13.6 MT of CO₂e/capita

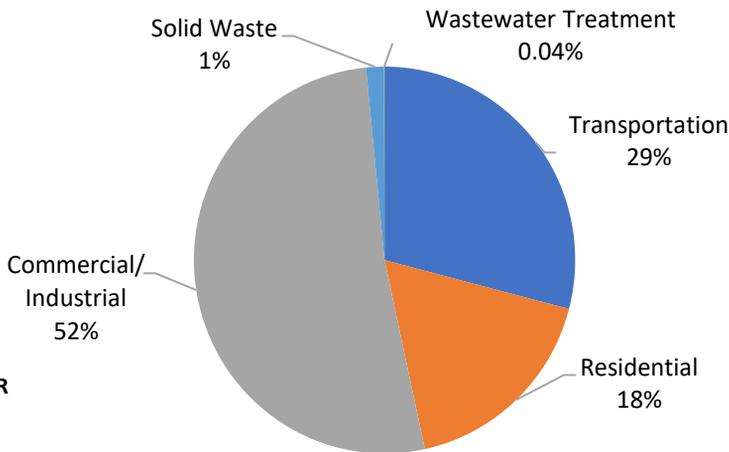
City of Boise, ID- 2019

- Population: 226,115
- 2,527,671 MMT of CO₂e
- 11.2 MT of CO₂e/capita

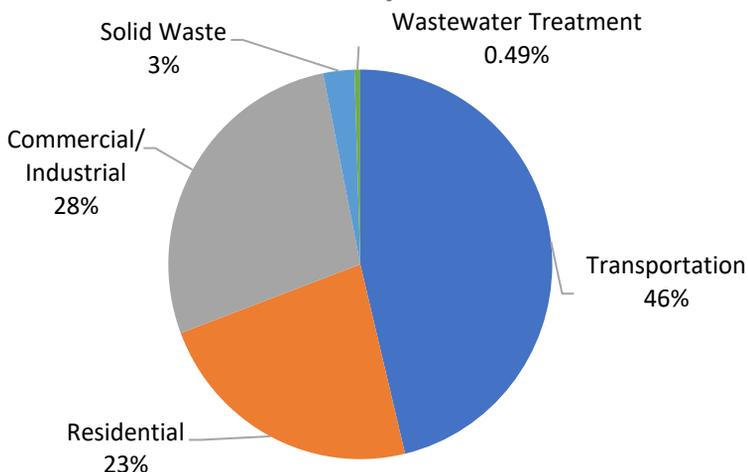
Bozeman Community GHG Emissions



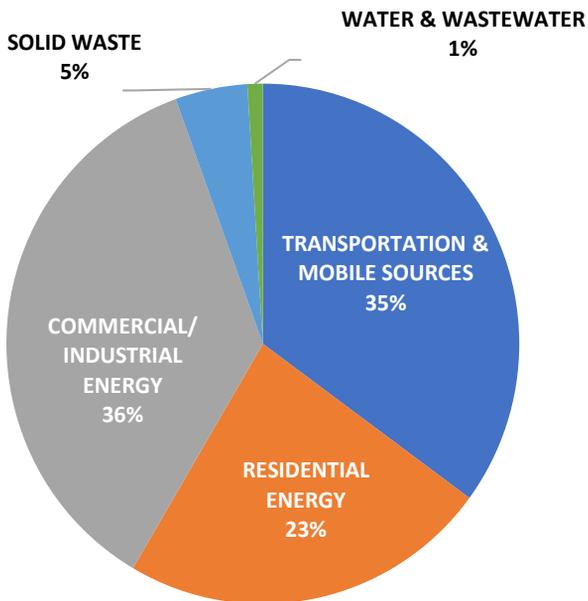
Boulder, CO Community GHG Emissions



Boise, ID Community GHG Emissions



MISSOULA COMMUNITY GHG EMISSIONS



Current Projects and Programs Aimed at Reducing the Missoula Community's Carbon Footprint

The City of Missoula and its many community partner, including Missoula County, Climate Smart Missoula, University of Montana, local businesses, nonprofits, and individuals have significantly contributed to the projects and programs listed below as well as creating additional goals and efforts throughout the Missoula community. These collective and collaborative efforts contribute to our community's overarching climate goals and help in the important fight against the climate emergency that our community faces.

Energy and Buildings

- In April 2019, the Missoula County Commissioners and the Missoula City Council adopted a joint resolution that establishes a goal of 100% clean electricity for the Missoula urban area by 2030. In June 2020, the City of Missoula, Missoula County, and NorthWestern Energy entered into a Memorandum of Understanding to cooperate in support of the 100% clean electricity goal. The city and county are also partnering on statewide efforts with Bozeman and Helena, both of which have established 100% clean electricity goals for their own communities.
- The Missoula Climate Smart Action Plan, developed in 2015, includes a goal of carbon neutrality for the Missoula urban area by 2050.
- The Building(s) for the Future program, a partnership between Climate Smart Missoula, the City of Missoula and Missoula County, launched in 2020, is designed to significantly reduce energy use in the built environment.
- The *Electrify Missoula* campaign looks to transition Missoula's buildings from natural gas to clean electricity, to reduce indoor air pollution as well as carbon emissions.

Energy and Buildings Cont.

- Both the City and County have achieved SolSmart Silver recognition for reducing barriers to rooftop solar through zoning, permitting, and related processes.
- The Solar-Ease program aims to make rooftop solar as easy as possible for Missoula residents.

Transportation

- Missoula's Long Range Transportation Plan, called Missoula Connect, was adopted in 2021 and includes the following goals to reduce vehicle miles traveled:
 - Reduce drive-alone commute share to 34% by 2045
 - Reduce drive-alone commute trips by 20,000 by 2045
 - Triple bike and walk shares and quadruple transit share by 2045
 - Achieve a small increase in carpool and work from home
- The Missoula Urban Transportation District (Mountain Line) has incorporated several electric buses into its fleet and has established a goal of zero-tailpipe emissions by 2035.

Zero Waste

- In 2016, the City of Missoula purchased the local compost facility, which is supported by local haulers, nonprofits, and individuals who bring their material for composting.
- The City commissioned a waste composition study in 2020 to look at municipal and community waste in order to identify specific materials and sectors that can contribute to diverting waste from the landfill.

Zero Waste Cont.

- The City is working with local partners to increase local zero waste infrastructure opportunities to recycle and compost, as well as build local end markets and zero waste businesses.
- Home ReSource continues its education program to recruit and train school-age zero waste ambassadors and hosts a Zero Waste Missoula community group.

Carbon Neutrality in City Operations

- In 2018, the Wastewater Treatment Plant installed a cogeneration unit to generate electricity and thermal energy from the biogas that is produced during plant processes. This system produces over 24% of the plant's electricity, and almost all of the plant's heat.
- The City is currently under contract with McKinstry to complete an Energy Performance Contract to identify and implement opportunities for energy conservation and renewable energy efforts throughout existing city buildings and facilities.
- City Parks and Recreation Department is currently piloting a pesticide-free program in public parks, which has many co-benefits including creating healthier soil that can sequester more carbon.
- In 2021, the City of Missoula began offering a telecommuting option for city employees which will help reduce carbon emissions from commuting.

While it is essential for the Missoula community to reduce its carbon footprint to address the climate crisis, the fact is that our climate is already changing. Hotter, drier summers and warmer, wetter winters mean more spring flooding, more summer drought, longer wildfire seasons, and more wildfire smoke. The Climate Ready Missoula Plan, adopted by the City of Missoula and Missoula County in May 2020, identifies a broad range of strategies that are needed to protect the Missoula community's health and safety, our economy, and our ecosystems in the face of these changes.

Conclusion

This inventory is to inform you of our current climate state and our ongoing work to achieve our established goals to address climate change. If you want to learn more about our adopted goals, what is currently in progress, and how to get involved, please refer to these dedicated pages:

- [100% Clean Electricity](#)
- [Carbon Neutrality](#)
- [Zero by Fifty](#)
- [Resiliency](#)

Missoula Community GHG Comparison Report

A comparison between the prior and current inventories was not included in this report, as there were many differences in the data that could not be reconciled. To address these discrepancies, an inventory comparison was conducted by ICLEI USA. The following pages describe how each of the reporting sectors varied and likely reasons why these discrepancies occurred. Our next Community GHG Emissions Inventory will be completed in Spring of 2023, which will include data from calendar year 2022, and will provide a more concise comparison with the 2019 inventory.

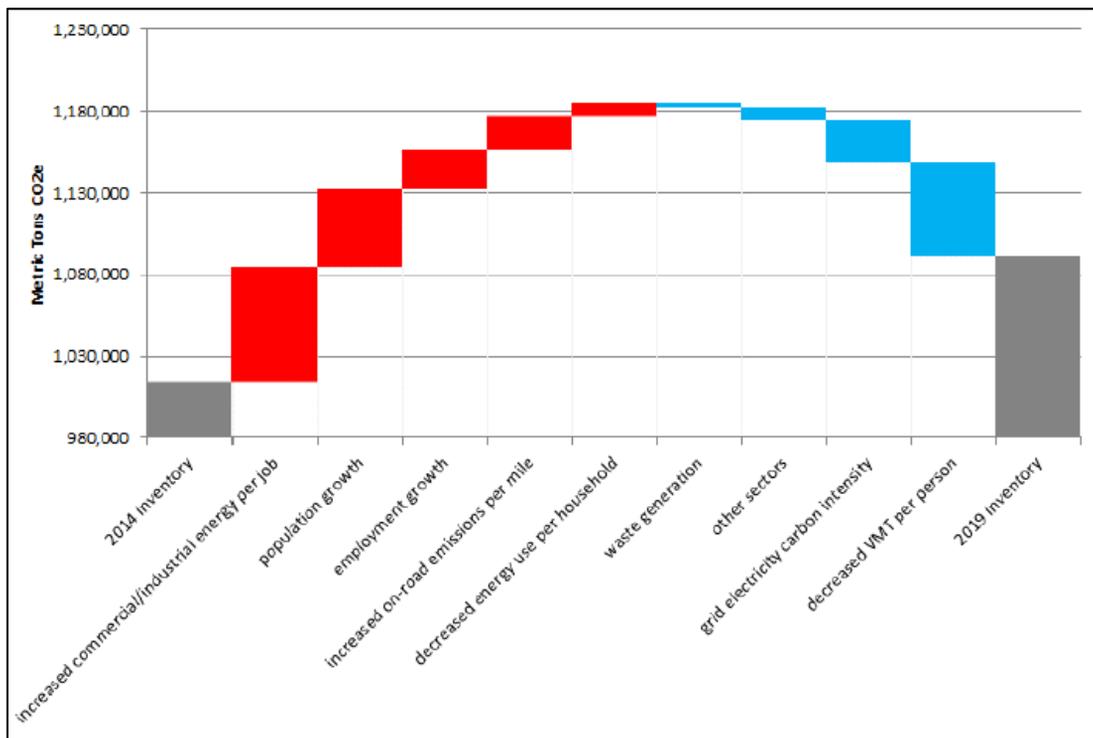
Missoula, MT Comparison of GHG Inventory Results (2014 and 2019) 15

Completed by Eli Yewdall, ICLEI USA, Oct 15, 2021

Upon comparison, City of Missoula staff noted some major differences between the 2014 and 2019 greenhouse gas inventory results. In order to verify the data, and understand these discrepancies, the City contracted with ICLEI USA to review current results and provide some additional context into major differences. Please note that some of the metrics provided in the following report may differ slightly from final inventory report numbers, as data has been updated as a result of the feedback below.

Summary

This is an analysis of changes in community-wide GHG emissions for Missoula, MT between 2014 and 2019. This analysis is based on inventory data in the ClearPath tool, using the inventories names 'Community Inventory 2019' and 'Missoula Community Carbon Emissions Inventory - W&WW Data Separated & Factor Sets Adj' for 2014. Overall emissions¹ increased by 77,795 metric tons of carbon dioxide equivalent (MTCO₂e), or 7.7% over the period. The largest contributor to increasing emissions is an increase in commercial/industrial energy use (see further discussion below), followed by population growth. Increases were partially offset by decreases, with decreased vehicle miles per person and cleaner sources of electricity being the largest. Changes by sector or major factor are described below, in order of the absolute value of the associated emissions change.



¹ The 2019 inventory introduces CO₂ removals by urban trees in Missoula; as something new to the 2019 inventory these are not looked at in this analysis.

The data provided by the utility shows a 27% decrease in commercial electricity usage, while industrial electricity use increased by almost a factor of seven, which was due to a change in classification used by the utility. Natural gas shows a similar pattern of large decrease in commercial usage with very large increase in industrial usage, again indicating a change in classification. For this reason, commercial and industrial usage are combined in the contribution analysis. The combined total of commercial and industrial electricity use increased by about 21%, while combined commercial and industrial natural gas usage increased by 28%. The total number of jobs in Missoula increased by only 6.8%, meaning energy intensity per job increased. If production increased in a small number of energy intensive industries, that could explain the overall change; more detailed data on particular industries and production would be needed to confirm this.

Staff response: The difference represented in this sector is primarily due to internal accounting changes with the primary energy utility to capture more key accounts, while identifying an increased intensity per job.

Population Growth

The City of Missoula's population increased 8.2% from 2014 to 2019, and the number of occupied housing units increased by 10.4%. Population growth and number of housing units drive emissions from transportation and residential energy, respectively.

Transportation

The vehicle mile data for the 2014 and 2019 come from two different data sources. 2014 data is from Missoula's MPO, while 2019 data is from Google Environmental Insights Explorer (EIE). EIE data is not available prior to 2018.

The VMT per person for 2019 is about 10% lower than for 2014, but this does not necessarily represent an actual decrease because of the change in data source. EIE data does show a 3% decrease in total VMT from 2018 (the first year available) to 2019; it is unclear whether this represents a temporary change or a longer-term trend. EIE shows 2020 transportation emissions down 18% from 2019, but 2020 is an atypical year nationwide because of pandemic restrictions. EIE data for 2021 will likely be available in the first half of 2022 and will provide a better indicator of long-term trend.

The emissions per mile are slightly higher in 2019 because of changes to the assumed breakdown of passenger cars vs light trucks.

Staff response: The decrease in this sector is due to different reporting sources between the 2014 and 2019 inventories. After further research, the Google EIE default boundary was city limits, rather than the Growth Policy Boundary (used for this inventory). MPO data was gathered and updated to represent the correct boundary.

Consistent with national trends, electricity generation supplying Missoula became cleaner over the period. Emissions factors used are from NorthWestern Energy, and emissions per kWh decreased by about 6%.

Residential Energy Use

The data shows a small increase in natural gas usage per household, and a small decrease in electricity usage per household. In addition, census data shows a shift by about 4% of households from natural gas to electricity for heating (this would be expected to cause increased electricity per household and decreased natural gas use per household). It suggests that households that continued using natural gas for heating increased usage by more than the average, and that a larger decrease in electricity use across all households was partly offset by increased usage at those that switched fuels.

Accounting for the emissions factors for natural gas and electricity, the net effect is a small decrease in emissions per household because of changes in per household energy usage.

Staff response: The decrease in emissions in this sector appears to directly correlate to changes in energy use between inventory years. Future inventories will help determine if this will be a continued trend.

Solid Waste

The inventory data show a decrease in the total tons of waste generated by over 50% from 2014 to 2019. To have this much decrease in five years seems unlikely; rather it is likely there was some change in data source or methodology.

In addition, the waste composition data applied in the two inventories is different. The 2014 inventories applies EPA default composition to all waste while the 2019 inventory separates construction and demolition waste; however, C&D waste emissions are calculated using a composition profile that assumes high percentages of food waste and paper which are not typically found in C&D waste - this results in a higher emissions per ton for 2019 waste compared to 2014.

Emissions from the in-boundary Missoula Landfill, which also decreased by about 23%, are included in the 'other sectors' section of the contribution analysis.

Staff response: The decrease in this sector is explained by different reporting methods and capabilities by the hauler between the 2014 and 2019 inventories. With further refinement of data collection, the next inventory will provide a more accurate picture of waste generation for the City of Missoula.

ACKNOWLEDGMENTS

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APPENDIX

A. Emissions Scopes

An organization's carbon footprint has three components for purposes of developing a GHG inventory:

Organization: Scopes (1-3), as seen below, are used in the context of reporting on GHG emissions associated with individual organizational entities (e.g., the operations of a business or local government).

SCOPE 1:

Scope 1 emissions are direct greenhouse (GHG) emission that occur from sources that are controlled or owned by an organization (e.g., emissions associated with fuel combustion in boilers, furnaces, vehicles).

SCOPE 2:

Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling.

SCOPE 3:

Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain. Examples include transportation and distribution, business travel, employee commuting, use of sold goods, etc.

Community: The Community Protocol does not use scopes as a framework for categorizing emissions in community inventories because the organization-related definitions of scopes do not translate to the community scale in a manner that is applicable, clear and valuable.

APPENDIX

B. Grid Electricity Factor Set*

Community Inventory - 2019

Greenhouse Gas	2019
CO2 lbs/MWh	1058.22
CH4 lbs/GWh	68
N2O lbs/GWh	10

* NorthWestern Energy provided a 2018 Environment, Social and Governance (ESG) factors data sheet. CO₂e was provided as 0.48MT/MWh and was converted to 1058.22lbs/MWh. CH₄ was not included in the ESG, which is not typically calculated by utilities. This value was used from the eGRID 2019 NWPP regional data (0.068lbs/MWh) and converted (x1000) to 68lbs/GWh (see below's eGRID 2019 NWPP regional data). NO_x, instead of N₂O was provided on the ESG, thus the eGRID 2019 NWPP N₂O value was used (0.010lbs/MWh) and converted (x1000) to 10lbs/GWh (see below's eGRID 2019 NWPP regional data).

C. Missoula Electric Cooperative Factor Set**

Missoula Electric Cooperative - Community 2019

Greenhouse Gas	2019
CO2 lbs/MWh	34.65
CH4 lbs/GWh	68
N2O lbs/GWh	10

** Missoula Electric Cooperative provided CO₂e emissions data, supplied by Bonneville Power Administration. CO₂ was calculated as 34.65lbs/MWh. CH₄'s value was used from the eGRID 2019 NWPP regional data (0.068lbs/MWh) and converted (x1000) to 68 lbs/GWh (see below's eGRID 2019 NWPP regional data). N₂O's value, was used from the eGRID 2019 NWPP regional data (0.010lbs/MWh) and converted (x1000) to 10lbs/GWh (see below's eGRID 2019 NWPP regional data).

APPENDIX

D. WECC Northwest (NWPP) eGRID 2019 Factor Set

Greenhouse Gas	2019
CO2 lbs/MWh	715.241
CH4 lbs/GWh	68
N2O lbs/GWh	10

E. Waste Characterization Factor Set

Community 2019 – Waste

Resource	%
Mixed MSW	48.6
Food Scraps	24.1
Dimensional Lumber	8.3
Corrugated Cardboard	4.4
Grass	3.6
Office Paper	3.2
Magazines/Third Class Mail	3.2
Leaves	1.8
Branches	1.8
Newspaper	1

APPENDIX

E. Waste Characterization Factor Set Cont.

Community 2019 – C&D Waste

Resource	%
Mixed MSW	0
Newspaper	0
Office Paper	0
Corrugated Cardboard	0
Magazines / Third Class Mail	0
Food Scraps	0
Grass	0
Leaves	0
Branches	0
Dimensional Lumber	47.2

Note: Changed factor set for C&D waste to one with 47.2% dimensional lumber (based on Cascadia report), and 0% on the remaining factor set categories. Other than lumber, the components of C&D waste typically do not break down in a landfill to produce emissions.

APPENDIX

F. Transportation Factor

2019 US National Defaults (updated 2021)

Gas Passenger Vehicle Fuel Economy (MPG)	24.37713
Gas Passenger Vehicle g CH ₄ /mi	0.0183
Gas Passenger Vehicle g N ₂ O/mi	0.0083
Gas Light Truck Fuel Economy (MPG)	17.86788
Gas Light Truck g CH ₄ /mi	0.0193
Gas Light Truck g N ₂ O/mi	0.0148
Gas Heavy Truck Fuel Economy (MPG)	5.371652
Gas Heavy Truck g CH ₄ /mi	0.0785
Gas Heavy Truck g N ₂ O/mi	0.0633
Gas Transit Bus Fuel Economy (MPG)	17.86788
Gas Transit Bus g CH ₄ /mi	0.0193
Gas Transit Bus g N ₂ O/mi	0.0148
Gas Para Transit Bus Fuel Economy (MPG)	17.86788
Gas Para Transit Bus g CH ₄ /mi	0.0193
Gas Para Transit Bus g N ₂ O/mi	0.0148
Gas Motorcycle Fuel Economy (MPG)	24.37713
Gas Motorcycle g CH ₄ /mi	0.0183
Gas Motorcycle g N ₂ O/mi	0.0083
Electric Vehicle Fuel Economy	0.0000

APPENDIX

F. Transportation Factor Cont.

2019 US National Defaults (updated 2021)

Diesel Passenger Vehicle Fuel Economy (MPG)	24.37713
Diesel Passenger Vehicle g CH ₄ /mi	0.0005
Diesel Passenger Vehicle g N ₂ O/mi	0.001
Diesel Light Truck Fuel Economy (MPG)	17.86788
Diesel Light Truck g CH ₄ /mi	0.001
Diesel Light Truck g N ₂ O/mi	0.0015
Diesel Heavy Truck Fuel Economy (MPG)	6.392468
Diesel Heavy Truck g CH ₄ /mi	0.0051
Diesel Heavy Truck g N ₂ O/mi	0.0048
Diesel Transit Bus Fuel Economy (MPG)	17.86788
Diesel Transit Bus g CH ₄ /mi	0.001
Diesel Transit Bus g N ₂ O/mi	0.0015
Diesel Para Transit Bus Fuel Economy (MPG)	17.86788
Diesel Para Transit Bus g CH ₄ /mi	0.001
Diesel Para Transit Bus g N ₂ O/mi	0.0015
Diesel Motorcycle Fuel Economy (MPG)	24.37713
Diesel Motorcycle g CH ₄ /mi	0.0005
Diesel Motorcycle g N ₂ O/mi	0.001

APPENDIX

G. Resource Mixes

eGRID 2019 NWPP Region

Resource	% of Mix
Hydro	42.34
Coal	22.98
Gas	19.86
Wind	7.98
Nuclear	3.14
Solar	1.42
Biomass	1.16
Geothermal	0.59
Other Fossil	0.22
Oil	0.19
Other Unknown	0.12

APPENDIX

G. Resource Mixes Cont.

2019 Missoula Electric Cooperative

Resource	% of Mix
Large Hydroelectric	82.32%
Nuclear	11.46%
Other	5.39%
Small Hydroelectric	0.84%

2019 NorthWestern Energy

Resource	% of Mix
Hydroelectric	42.36%
Coal	24.85%
Wind	15.83%
Petroleum Coke	6.80%
Natural Gas	5.13%
Waste Coal	5.03%

APPENDIX

H. Sector Data 2019

Overall Totals

Sectors	MT of CO ₂ e	Percentage of Sector Total
Transportation & Mobile Sources	396,216.758	35.43%
Residential Energy	263,700.32	23.58%
Commercial Energy	222,257.80	19.88%
Industrial Energy	184,515.50	16.50%
Solid Waste	51,417.75	4.60%
Water & Wastewater	10,902.87	0.98%
Agriculture & Urban Forestry	-10,802.50	-0.97%

NOTE: The 2014 Community Greenhouse Gas Emissions Inventory factor sets were readjusted to match the same data source for NorthWestern Energy, Missoula Electric Cooperative, and transportation US national defaults, for their respective reporting year.

APPENDIX

H. Sector Data Cont.

Residential Energy

Inventory Record	MT of CO ₂ e	Percentage of Sector Total
NorthWestern Energy Residential Electricity	132,353	50.19%
NorthWestern Residential Natural Gas	130,540	49.50%
Missoula Electric Cooperative Residential Electricity	538.04	0.20%
NorthWestern Landlord/Tenant Residential Electricity	103.76	0.04%
NorthWestern Energy Landlord/Tenant Residential Natural Gas	165.52	0.06%

Commercial Energy

Inventory Record	MT of CO ₂ e	Percentage of Sector Total
NorthWestern Commercial Electricity	143,969	64.78%
NorthWestern Commercial Natural Gas	77,600	34.91%
Missoula Electric Cooperative Commercial Electricity	289.47	0.13%
NorthWestern Energy Internal Natural Gas	218.29	0.10%
NorthWestern Energy Internal Electricity	184.04	0.08%

APPENDIX

H. Sector Data Cont.

Industrial Energy

Inventory Record	MT of CO₂e	Percentage of Sector Total
NorthWestern Energy Industrial Electricity	141,016	76.43%
NorthWestern Industrial Natural Gas	43,485	23.57%
Missoula Electric Cooperative Industrial Electricity	14.496	0.01%

Transportation & Mobile Sources

Inventory Record	MT of CO₂e	Percentage of Sector Total
Missoula Metropolitan Planning Organization (MPO): Gas	240,167	60.615%
Missoula Metropolitan Planning Organization (MPO): Diesel	91,313	23.046%
Airport: Domestic Passenger – Jet Fuel	42,557	10.741%
Airport: Freight – Jet Fuel	18,239	4.603%
Montana Rail Link: Line-Haul	1,728.9	0.436%
Montana Rail Link: Switchyard	1,356.6	0.342%
Airport: Domestic Passenger – Aviation Gasoline	479.39	0.121%
Airport: Freight – Aviation Gasoline	205.45	0.052%
Airport: Construction	132.81	0.034%
Airport: Large Utility	23.267	0.006%
Airport: Small Utility	14.341	0.004%

APPENDIX

H. Sector Data Cont.

Solid Waste

Inventory Record	MT of CO₂e	Percentage of Sector Total
Missoula Landfill EPA Facility Emissions	31,704	61.66%
Republic Services Landfill – Minus City of Missoula Operations	16,055	31.22%
Self-Haul	2,475.60	4.81%
C&D Waste	1,129.50	2.20%
Republic Services Landfill – City of Missoula Operations	53.65	0.10%

Water & Wastewater

Inventory Record	MT of CO₂e	Percentage of Sector Total
Water Dept Lifts & Pumps	7,587.4	69.59%
WWTP Ops Energy Use	2502.1	22.95%
WWTP Lifts & Pumps	284.77	2.61%
Septic Systems	261.22	2.40%
Water Dept Ops	233.92	2.15%
WWTP Flared Biogas	27.214	0.25%
RSID El Mar – within community boundary	3.1689	0.03%
WWTP Cogen	1.8439	0.02%
WWTP Boiler Biogas	1.237	0.01%

APPENDIX

H. Sector Data Cont.

Agriculture & Urban Forestry

Inventory Record	MT of CO ₂ e	Percentage of Sector Total
Trees Outside of Forest – City of Missoula	-5680.5	-52.59%
Undisturbed Forest	-5651	-52.31%
Non-Forest to Forest	-23	-0.21%
Harvest Wood Products	249	2.31%
Forest Disturbances	148	1.37%
Forest to Settlement	139	1.29%
Forest to Wetland	16	0.15%

I. Photo Credits, Sector Icons & Resource Links

- Carbon equivalencies provided by: <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>
 - Passenger vehicles are defined as 2-axle 4-tire vehicles, including passenger cars, vans, pickup trucks, and sport/utility vehicles. In 2018, the weighted average combined fuel economy of cars and light trucks was 22.5 miles per gallon (FHWA 2020). The average vehicle miles traveled (VMT) in 2018 was 11,556 miles per year (FHWA 2020).
 - Carbon dioxide emissions per ton of coal were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12). The amount of coal in an average railcar was assumed to be 100.19 short tons, or 90.89 metric tons.
- Clark Fork River (title page)
 - <https://www.britannica.com/topic/University-of-Montana>

APPENDIX

I. Photo Credits, Sector Icons & Resource Links

- Mount Sentinel (pg. 1)
 - <https://jetsettingfools.com/things-to-do-in-missoula-montana/>
- Missoula Growth Policy & Map (pg. 2)
 - <https://www.ci.missoula.mt.us/1748/Our-Missoula-Growth-Policy>
- US Census Bureau – 2014 & 2019 Data (pg. 3)
 - <https://data.census.gov/cedsci/table?g=1600000US3050200&tid=ACSDP5Y2014.DP05>
 - <https://www.census.gov/quickfacts/fact/table/missoulacitymontana,US#>
- Mobile Emissions Icon (pg. 3-4, 6-9)
 - https://www.freepik.com/free-icon/stacked-travelling-cars-frontal-view_787920.htm
- Commercial Energy Icon (pg. 3-4)
 - https://www.flaticon.com/free-icon/buildings_665312?term=building&page=1&position=49&page=1&position=49&related_id=665312&origin=tag
- Industrial Energy Icon (pg. 3-4)
 - <https://icon-library.com/icon/factory-icon-transparent-23.html>
- Residential Energy Icon (pg. 3, 6)
 - <https://icon-library.com/icon/house-icon-vector-free-download-10.html>
- Solid Waste Icon (pg. 3, 7)
 - <https://icons8.com/icon/1942/trash>
- Water & Wastewater Icon (pg. 3, 8)
 - <https://icon-library.com/icon/water-icon-png-19.html>

APPENDIX

I. Photo Credits, Sector Icons & Resource Links Cont.

- Agriculture/Urban Forestry Icon (pg. 3, 9)
 - <https://icon-library.com/icon/icon-forest-0.html>
- Commercial/Industrial Energy Photo (pg. 4)
 - https://missoulacurrent.com/wp-content/uploads/2018/06/MREA_parkingGarage.jpg
- Transportation & Mobile Sources Photo (pg. 5)
 - <https://bloximages.chicago2.vip.townnews.com/missoulian.com/content/tncms/assets/v3/editorial/4/9a/49af9aba-06b6-519e-acfd-8bf6ddaf74b4/600f67797d473.image.jpg?crop=1719%2C967%2C0%2C119&resize=1120%2C630&order=crop%2Cresize>
- Coal Railcar Icon (pg. 4-6)
 - <https://www.dreamstime.com/coal-train-car-black-icon-white-background-image184724342>
- Residential Energy Photo (pg. 6)
 - <https://destinationmissoula.org/images/headers/about-missoula.jpg>
- EPA Energy/Carbon Sequestration Equivalencies (pg. 4-9)
 - <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>
- Solid Waste Photo (pg. 7)
 - <https://bloximages.chicago2.vip.townnews.com/mtstandard.com/content/tncms/assets/v3/editorial/7/79/77923b10-de65-11e2-812a-001a4bcf887a/51caeea722681.preview-699.jpg?crop=699%2C393%2C0%2C93&resize=1200%2C675&order=crop%2Cresize>
- Baseline Waste Composition Study (pg. 7)
 - <https://www.ci.missoula.mt.us/DocumentCenter/View/55981/Missoula-Baseline-Waste-Composition-Report-2021-PDF>

APPENDIX

I. Photo Credits, Sector Icons & Resource Links Cont.

- Water & Wastewater Photo (pg. 8)
 - <https://www.pncc.govt.nz/media/3131147/missoula.jpg?crop=0,0.15345321866041178,0,0.0021370862653114411&cropmode=percentage&width=1920&height=1080&rnd=131986901730000000&mode=crop¢er=0.5,0.5>
- Water & Wastewater Treatment Plant (pg. 8)
 - <https://www.google.com/maps/@46.8798399,-114.0416101,370m/data=!3m1!1e3>
- Agriculture/Urban Forestry Photo (pg. 9)
 - <https://www.ci.missoula.mt.us/ImageRepository/Document?documentID=46600>
- ICLEI's LEARN TOOL (pg. 9)
 - <https://icleiusa.org/LEARN/>
- Missoula's Urban Forest (pg. 9)
 - <https://images.squarespace-cdn.com/content/v1/5ac3b249c3c16a6e17d243b1/1530573518411-375K38SZ2M4E4IA86CCK/Gerald+St+copy.jpg?format=1000w>
- 2019 City of Boulder, CO Community Greenhouse Gas Emissions Report (pg. 10)
 - <https://bouldercolorado.gov/media/4884/download?inline>
- 2017 Bozeman Community Greenhouse Gas Emissions Report (pg. 10)
 - <https://www.bozeman.net/home/showdocument?id=5418>
- 2019 City of Boise, ID Community Greenhouse Gas Emissions Report (pg. 10)
 - <https://www.cityofboise.org/programs/climate-action/research-and-data/>