Missoula County Operations Greenhouse Gas Emissions Inventory Report and Analysis, 2016

A Baseline Inventory to Guide Future Climate Action Goals for Missoula County Operations

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Cover photo by Michelle Gustafson, courtesy of Five Valleys Land Trust

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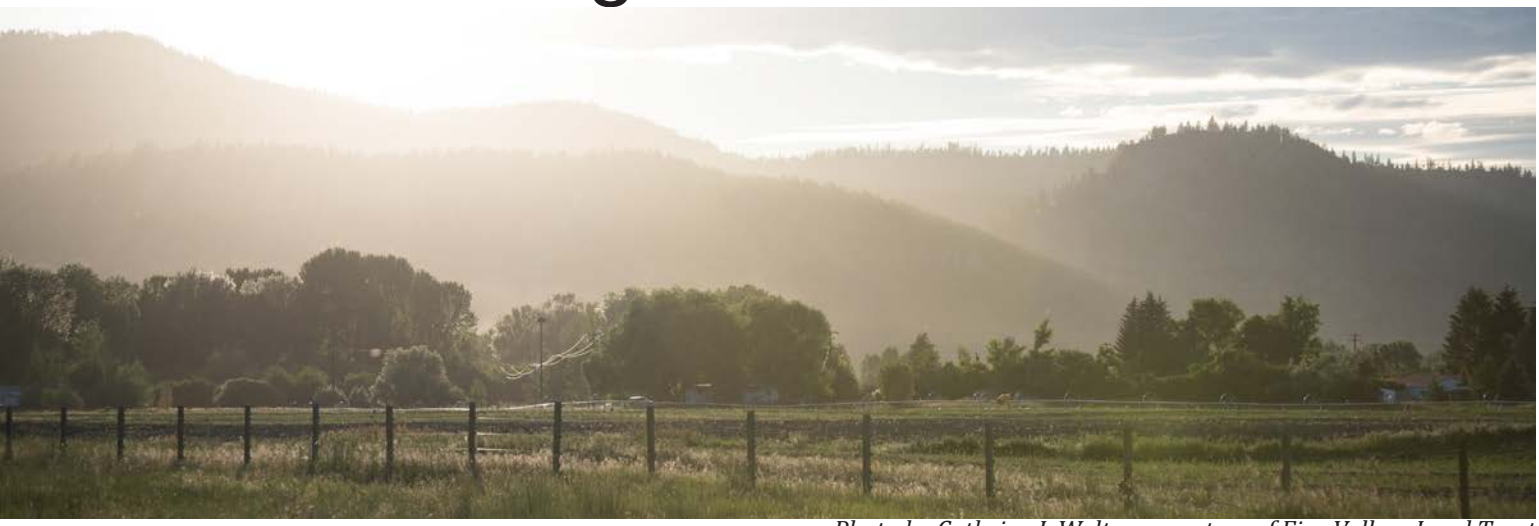

Photo by Cathrine L Walters, courtesy of Five Valleys Land Trust

I would like to express my heartfelt appreciation to several people who have helped develop Missoula County's first Greenhouse Gas Emissions Inventory, as well as this Report and Analysis. I sincerely thank Missoula County's Board of County Commissioners, Jean Curtiss, Nicole "Cola" Rowley, and David Strohmaier for committing to local climate action. Their leadership in sustainability is expressed through the adoption of several internal policies and plans with community resiliency in mind, participating in community solar programs, and encouraging sustainable development. Their guidance has allowed Missoula County to move forward with climate action.

My genuine gratitude is extended to the Director of the Missoula County Community and Planning Services Department, Pat O'Herren, the Assistant Director of Community and Planning Services, Karen Hughes, and the Director of the Missoula City-County Health Department, Ellen Leahy, for committing staff time and resources to make this huge step in climate action and resiliency possible. I attribute the generation of the Greenhouse Gas Emissions Inventory, the Report, and the subsequent Climate Action and Resiliency Plan to their staunch dedication to local climate solutions and unyielding enthusiasm for community health and happiness.

I am also most grateful for the work and commitment of Missoula County's Greenhouse Gas Emissions Inventory Technical Advisory Group, the members of which are undoubtedly some of the most devoted, brilliant, and passionate people in the Missoula community:

- **Jennifer Bernosky,** Account Manager, Republic Services
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- **Nicole Rowley**, Missoula County Commissioner
- **Robin Saha**, Associate Professor of Environmental Studies, University of Montana
- **Allison Seils**, former Financial Controller, Missoula County Financial Services
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I also thank the 199 anonymous Missoula County employees who participated in the Employee Commute Survey. Your voluntary participation has helped the County make great strides in climate action and community resiliency. I furthermore would like to recognize all of the County employees who assisted me in gathering the necessary data to complete the Emissions Inventory, their assistance has made the Emissions Inventory and Report a success:

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- **Eric Seitz**, Purchasing and Supply Technician, Missoula County Central Services
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I owe the accomplishments of the Greenhouse Gas Emissions Inventory to all of the people who have helped me during the project’s process. Thank you all, and I am eager to see what Missoula County achieves in the face of climate change.

Preface

This Greenhouse Gas Emissions Inventory Report and Analysis represents Missoula County's ongoing commitment to addressing climate change and building resiliency in our communities. Although inventories cannot account for all of the complexities associated with climate change, I'm confident that the information presented in this report will allow the County to make the most informed decisions possible regarding emission reduction targets and climate action and resiliency planning. Missoula County has continuously enhanced sustainability efforts, including supporting solar energy use and incorporating policies to reduce County waste and to encourage green building practices. This report is a crucial step as a sustainability advocate and leader. The Greenhouse Gas Emissions Inventory Report and Analysis is essential to protecting the health, well-being, and economic vitality of those who live, work and recreate in Missoula County.

Nicole Rowley, Missoula County Commissioner

Executive Summary

Photo source: destinationmissoula.org

PROJECT BACKGROUND:

Missoula County is joining local and global efforts to address climate change by taking the first step in developing this baseline greenhouse gas emissions inventory. Several entities in Montana have made a commitment to combat climate change through developing similar municipal-operation emission inventories. Those entities include: The state of Montana[1], the City of Bozeman[2], the City of Helena[3], the City of Missoula[4], the University of Montana[5], Montana State University[6], and now Missoula County. There have also been community-wide emissions inventories in Bozeman[7], Helena[8], and Missoula[9]. Missoula County is the first County in Montana to conduct a greenhouse gas emissions inventory for their operations. This baseline inventory will allow the County to know where its operations' emissions are coming from, realize how much control the County has over their emissions, identify attainable reduction targets, and ultimately build a more resilient community through climate action planning.

Goal 4 of Missoula County's Growth Policy states:

Reduce Missoula County's contribution to climate change while promoting resiliency and adapting to its impact on the natural environment and communities.

Missoula County's Growth Policy, adopted June 2016, states a commitment to reducing their contribution to climate change, and the first step to reaching that goal is evaluating how much they are contributing to climate change, in the form of pollutants.

Ultimately, the Greenhouse Gas Emissions Inventory and Report lays the groundwork that is fundamental to the development of Missoula County's Climate Action and Resiliency Plan (anticipated 2018). Now that the County knows where their emissions come from, and how much control they have over those emissions, they can set practical reduction targets that are specific to County operations; moreover, there are distinct ways in which climate change affects the community, and therefore the Climate Action and Resiliency Plan should reflect those conditions and opportunities unique to the community.

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1 https://deq.mt.gov/Portals/112/Energy/ClimateChange/Documents/GreenhouseGasInventory.pdf
2 https://www.bozeman.net/home/showdocument?id=3140
3 http://aeromt.org/PDFs/ClimateChangeTaskForce.pdf (Appendix G)
4 https://www.ci.missoula.mt.us/DocumentCenter/Home/View/5610
5 http://www.umt.edu/sustainability/documents/greenhouseinventory.pdf
6 http://www.montana.edu/sustainability/projectsandinitiatives/Climate%20Action%20Plan%20w%20Appendices2011.pdf
7 https://dev7.visioninternet.com/BozemanMT6/home/showdocument?id=3130
8 http://aeromt.org/PDFs/repower2010/Diana_Maneta_Community_GHG_Inventory_4_8_10.pdf
9 http://www.missoulacurrent.com/wp-content/uploads/2017/04/3.2017_missoulaemissionsinventory.pdf

Although climate change may appear to directly impact the environment through consequences such as less snow and more wildfires, it actually permeates other aspects of the Montanan lifestyle on a much deeper level. Figure 1 below, Linkages Between Impacts of Climate Change, aims to illustrate some of the inherent relationships between climate change, the environment, public health, our economy, and agriculture. The figure does not aim to be a comprehensive account of all implications associated with climate change; to include all effects of climate change in the figure below would be both impractical and confusing.

For instance, climate change affects the economic security of Montana's number one industry, agriculture, in various different ways. Rising concentrations of greenhouse gases in the Earth's atmosphere increase average long-term temperatures and affect precipitation patterns. These changes in weather and climate impact Montana's environment in profound ways, such as increasing wildfire potential and increasing the growth rate of crops. An increase in wildfire clearly increases the amount of areas burned, including crop fields, which could deplete vegetation for both human and livestock consumption. Moreover, increasing a crop's growth rate actually decreases their ability to uptake nitrogen from the soil, which is an incredibly important process for a plant to develop a rich nutrient profile.

These impacts, on the surface level, are conventionally thought of as a strictly "environmental" problems; however, when evaluating their true, long-term impacts, it is clear that higher concentrations of greenhouse gases lead to a slough of interconnected conditions.

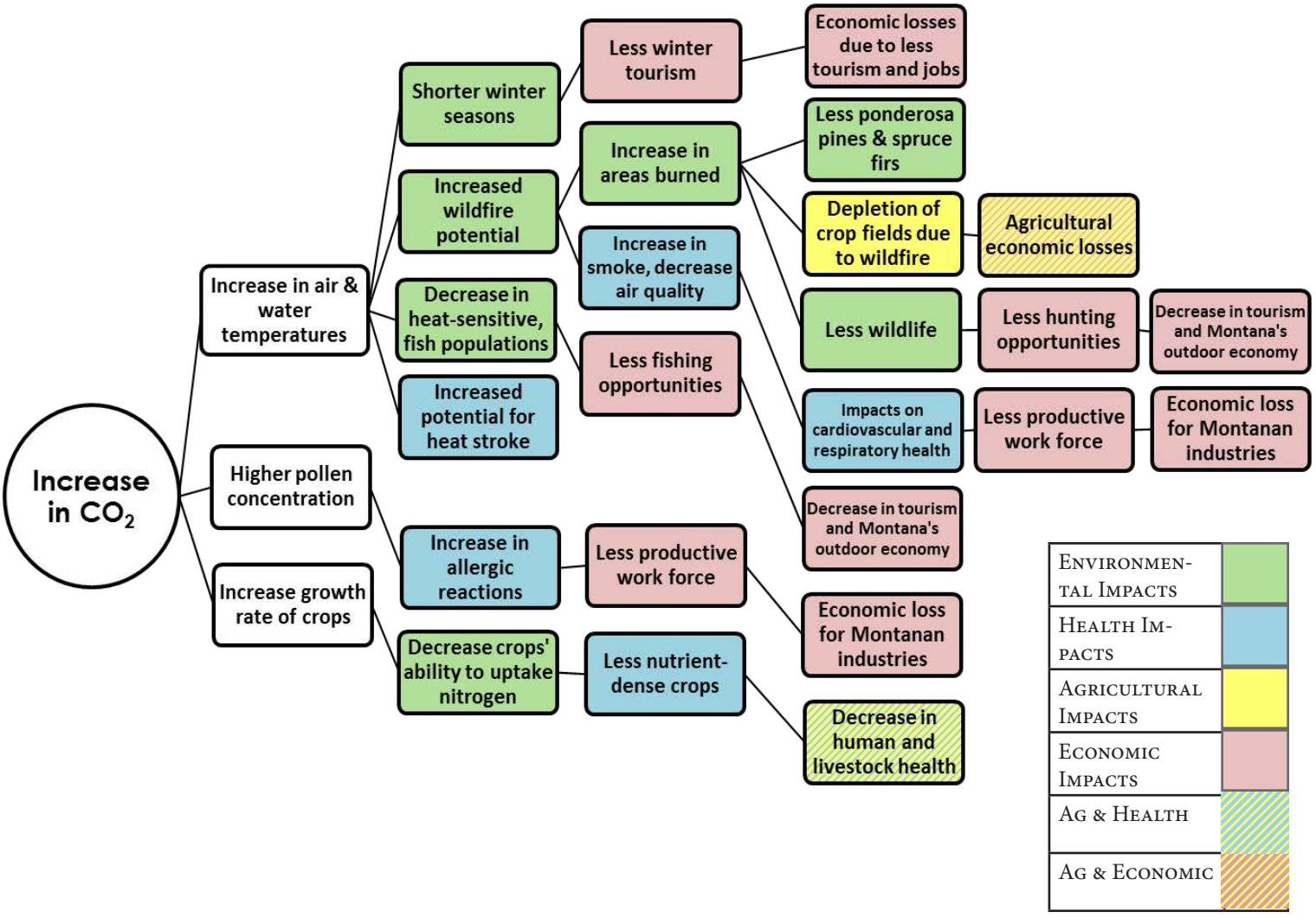

Fig. 1: Linkages between impacts of climate change

PROJECT GOALS:

- Know where Missoula County operations' pollutants are coming from
- Know how much control the County has over their emissions
- Establish a baseline inventory to reference our future progress
- Establish a system for conducting future inventories
- Fortify culture of sustainability in community
- Identify climate action objectives

PROJECT PROCESS:

1. Establish the scope of the inventory: Missoula County operations
2. Collect activity-use data from all activities within the boundary that produce GHG emissions
3. Organize activity-use data into spreadsheets from all sectors being evaluated (buildings and facilities, vehicle fleet, employee commute, water and wastewater treatment facilities, and streetlights and traffic signals)
4. Plug activity use data into relevant calculators provided by ClearPath, an inventory program developed by ICLEI- Local Governments for Sustainability. [1]

CLIMATE CHANGE QUICK FACTS:

- Montana is expected to see a 4-5 degree temperature increase by 2055, with as much as a 6.5 degree increase in the winter
- Cutthroat trout habitat in Montana is expected to decline 58% by 2080 due to increased water temperatures and competition with invasive species
- Acreage burned in Montana is expected to increase 200-500% by 2055
- Winter sport days are expected to decline by 1/3 by 2050
- Montana's outdoor economy could see a loss of 11,000 jobs and $281 million in labor earnings by 2050

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1 This is where the appropriate emission factors are applied, the GHGs being measured are converted into carbon dioxide equivalent (CO_2e), and an emission output for that activity is produced. An emission factor is a value that represents how many emissions are produced from a single activity at a given rate. They are determined by a community's context in the U.S. and their specific energy-mix for their region. Details on emission factors can be found on page 20. CO_2e is the variable that represents all GHGs being measured by an inventory. In the County's case, that is methane, nitrous oxide, and carbon dioxide. Details on how to calculate CO_2e can be found on page 21.

PROJECT FINDINGS AND CONCLUSIONS:

In 2016, Missoula County operations emitted a total of 6,810 metric tons of CO_2e ($MtCO_2e$), or 14,982,000 pounds of CO_2e, which is the weight of about 3,745 medium-sized cars. The municipal sectors included in this inventory are:

- **Buildings & Facilities:** 2,690 $MtCO_2e$
- **Vehicle Fleet:** 2,066 $MtCO_2e$
- **Employee Commute:** 1,411 $MtCO_2e$
- **Water & Wastewater Treatment Facilities:** 642 $MtCO_2e$
- **Streetlights & Traffic Signals:** 0.26 $MtCO_2e$

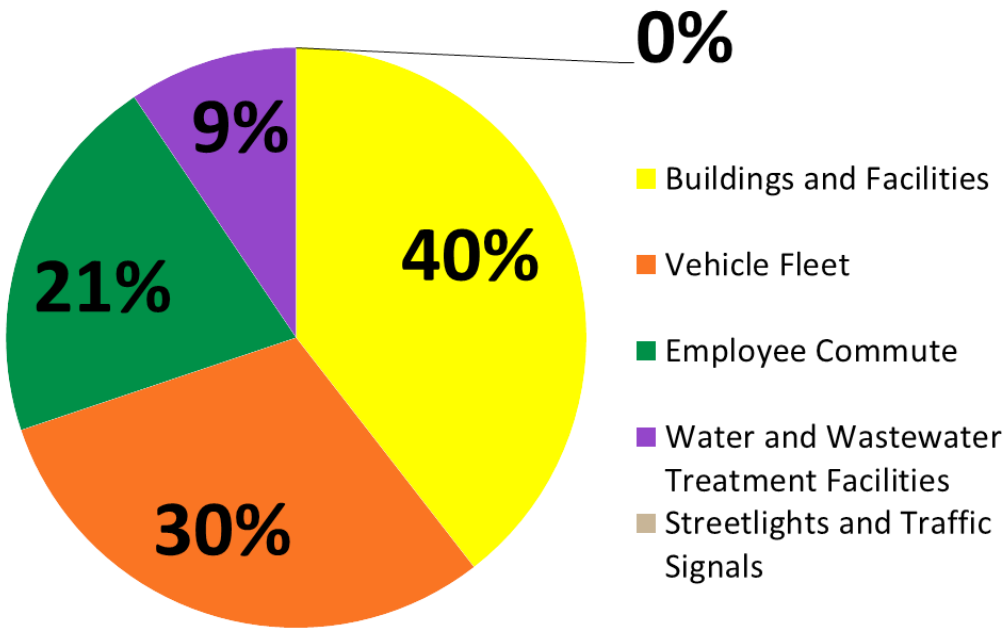


Fig. 2: Percentages of emission contribution by sector; 0% refers to streetlights & traffic signals

If you imagine a cube that stands about 30 feet tall, and fill it with greenhouse gases, that cube would weigh approximately one metric ton. Now, try to imagine 6,810 of those cubes; that's how much greenhouse gas Missoula County operations emitted in 2016. If you arranged all of those cubes in one line, they would stretch 39 miles- about the distance between Missoula and Stevensville.

In order to generate 6,810 $MtCO_2e$, you would need to produce approximately 272,400 pounds of beef, or about 326,880 pounds of pork, or around 973,830 pounds of poultry, as illustrated in Fig. 4 below. You would also have to drive around 17,025,000 miles in a medium-sized car to produce the equivalent of County emissions in 2016.

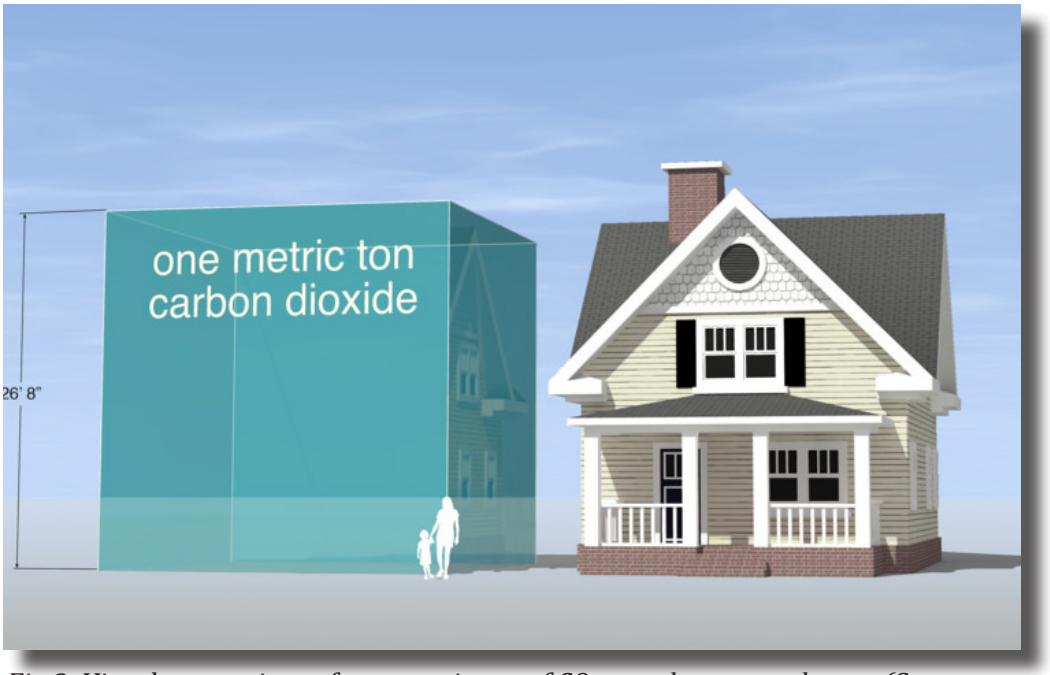


Fig 3: Visual comparison of one metric ton of CO_2 to a three-story house. (Source: realworldvisuals.com)

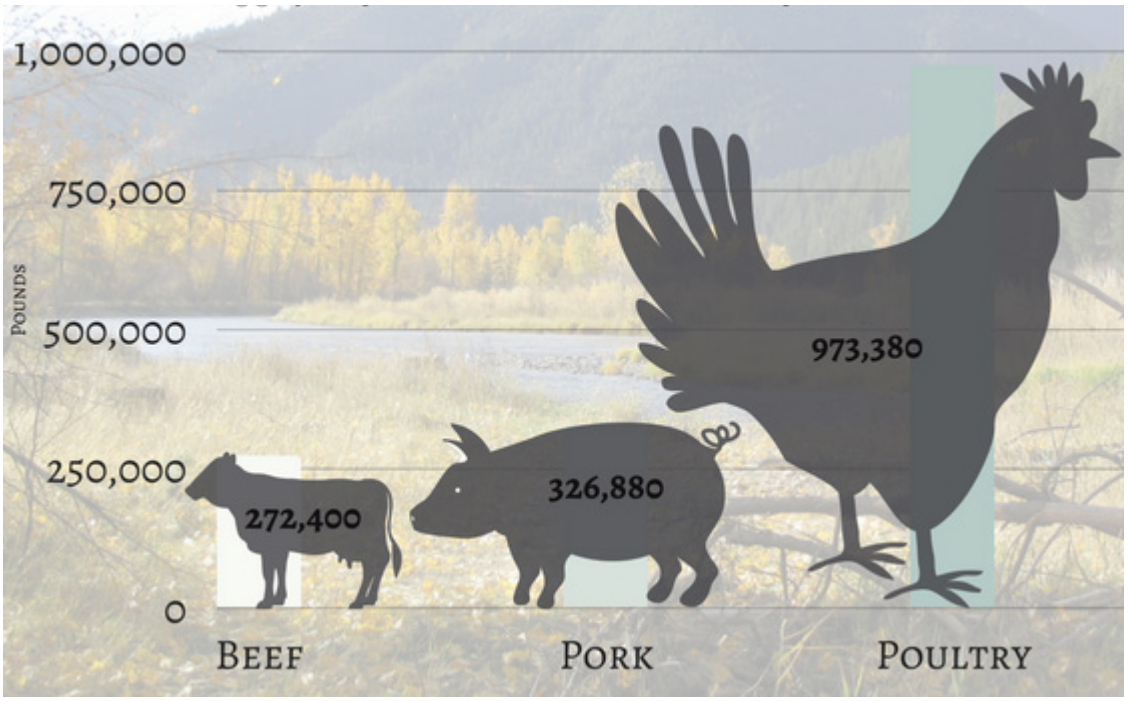


Fig. 4: 6,810 $MtCO_2e$ is the amount of greenhouse gas emitted from producing approximately 272,400 pounds of beef, about 326,880 pounds of pork, or around 973,830 pounds of poultry. (Graphic by Katie Klietz, Missoula County Communications Coordinator).

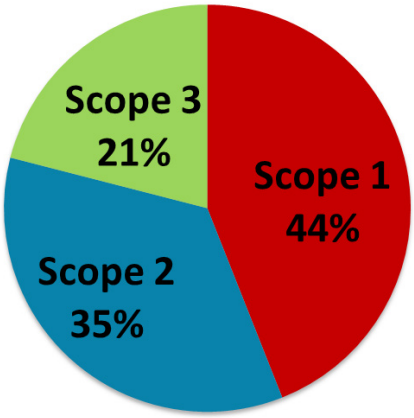


Fig. 5: Percentages of emission contribution by scope.

Results by Scope

Scope 1[1] emissions account for 44% of the inventory, and refers to on-site fossil fuel combustion. These are the emissions that Missoula County has the most control over, such as how much fuel they use in their vehicle fleets and how much natural gas or propane they use to heat their facilities.

Scope 2 emissions make up 35% of the total emission output, and refers to emissions generated from electricity use. Although the County cannot control how much energy is generated at a power-plant, they can control how much energy they consume, thereby decreasing overall demand of energy production.

Scope 3 emissions account for 21% of the inventory, which strictly refers to County employee commute to and from work within County operations. These are the emissions that the County has the least amount of control over; however, these emissions are an important portion to consider when making reduction decisions, because they make up a substantial portion of the total emission output from County operations.

The emissions that will be a primary target for County reduction efforts are therefore Scope 1 emissions. Sectors that fall into this category include vehicle fleet (69% of Scope 1 emissions), buildings and facilities (23% of Scope 1 emissions), and water and wastewater treatment facilities (8% of Scope 1 emissions). Final emission reduction decisions made in these sectors will be included in Missoula County's Climate Action and Resiliency Plan, but examples of actions to be taken could be to enforce the procurement of vehicles with a higher fuel economy, limit unnecessary use of County operated vehicles, and increase the insulation of County buildings and facilities to decrease heat demand.

Context

While comparisons with other similar communities would give the illusion of context for the results of the County's Emissions Inventory, it would largely be a distraction from the purpose of the Emissions Inventory Report and the comparisons themselves would be impractical. There are vast differences between different inventories, such as geographic area, population size, types and extent of services provided by local agencies, and inconsistencies between inventory years, that make comparing them for the sake of context incredibly difficult. No conclusions could be derived from comparing the County's operations with the City's, nor with Bozeman, Helena, etc. The most important deduction from this Report is that it provides a baseline for future inventories, and therefore the important comparison to be made is across time for the same operation, not across communities. However, for those who are strictly curious, a few such comparisons have been included in Appendix A.

Table 1 illustrates data from the Missoula community-wide[2] emissions inventory, developed by Climate Smart Missoula for 2014,[3] as well as data from the City's operations emissions inventory from 2015, and the County's operations emissions inventory from 2016. This table is not included in this report for comparison purposes, rather to demonstrate the collaboration and consistency of climate action across community and government entities throughout the county and community of Missoula.

1 "Scopes" are the standard method of defining different types of emissions. They allow us to 1) know where our energy is coming from, and 2) recognize how much control we have over certain emissions. Details on Scopes can be found on page 18.

2 "Community-wide" inventories measure the emissions generated from residential, commercial, industrial, and transportation sectors, as opposed to emissions from government operations.

3 http://www.missoulacurrent.com/wp-content/uploads/2017/04/3.2017_missoulaemissionsinventory.pdf

Table 1: Emissions data from Climate Smart Missoula, the City of Missoula, and Missoula County

INVENTORY	EMISSIONS IN $MtCO_2e$
Missoula County, 2016	6,810
City of Missoula, 2015	7,722
Community of Missoula, 2014	913,250

Table 2: Emissions by sector from City of Missoula, 2015 and Missoula County, 2016 inventories

SECTOR	CITY OF MISSOULA ($MtCO_2e$)	MISSOULA COUNTY ($MtCO_2e$)
Buildings & Facilities	2,394	2,690
Vehicle Fleet	1,622	2,066
Employee Commute	695	1,411
Water & Wastewater Treatment Facilities	2,239	642
Streetlights & Traffic Signals	772	0.26

Missoula County has joined the City of Missoula and Climate Smart Missoula in creating a baseline inventory to measure their future approaches to climate action and inform strategies identified in Missoula County's Climate Action and Resiliency Plan, anticipated 2018. While this may be the first established greenhouse gas emissions inventory for County operations, the County administration and employees of Missoula County have demonstrated efforts to create a sustainable government through internal policies, plans, and practices, outlined in Missoula County's Sustainability Assessment.[1]

Fig. 6: Highlights from Missoula County's Sustainability Assessment

1 View the full Sustainability Assessment in Appendix B.

General recommendations

The purpose of this Inventory Report and Analysis is to document the findings of the County's baseline Greenhouse Gas Emissions Inventory and explain what the results could mean for future County operations, provide context for those results in regards to the greater Missoula community, and clarify what the County intends to do with the information offered by the baseline inventory. Moreover, the objective of this Report is not to make conclusions on how the County should operate in the future, but rather to guide decisions for forthcoming operational efforts. The final proposals for impending County policies and plans will be included in the County's Climate Action and Resiliency Plan, but based off inventory results there are some general recommendations to be considered moving forward with climate action and resiliency planning:

1. Create a climate action policy advisory group
2. Utilize climate action planning and forecasting tools through ClearPath
3. Dedicate resources and staff time to sustain climate action planning and implementation
4. Increase incentives for alternative methods of commute for County employees
5. Collaborate with communities to identify issues and take advantage of opportunities to become more resilient in the face of a changing climate
6. Expand and encourage renewable energy initiatives throughout County
7. Strengthen and create partnerships with community members, businesses, non-profits, and other relevant entities to address issues associated with climate change, such as impacts on the economy, the environment, and increases in potential hazards (i.e. wildfire, floods, droughts, etc.)
8. Include energy conservation, sustainability, and alternative commuting methods as topics for County employee training, orientations, and educational events

Conclusions

The Greenhouse Gas Emissions Inventory for Missoula County operations estimated a baseline amount of 6,810 metric tons of greenhouse gases in 2016. Due to upgrades in calculation protocols and technology, this baseline is subject to change in the future. The baseline inventory informs focus-areas and sectors for emission reduction and mitigation opportunities, which will be further examined and defined in Missoula County's Climate Action and Resiliency plan, anticipated 2018. The most valuable aspect of the baseline inventory is the information it provides for future climate action strategies; without a baseline to reference our efforts to, there would be no way to gauge the County's progress in climate action.

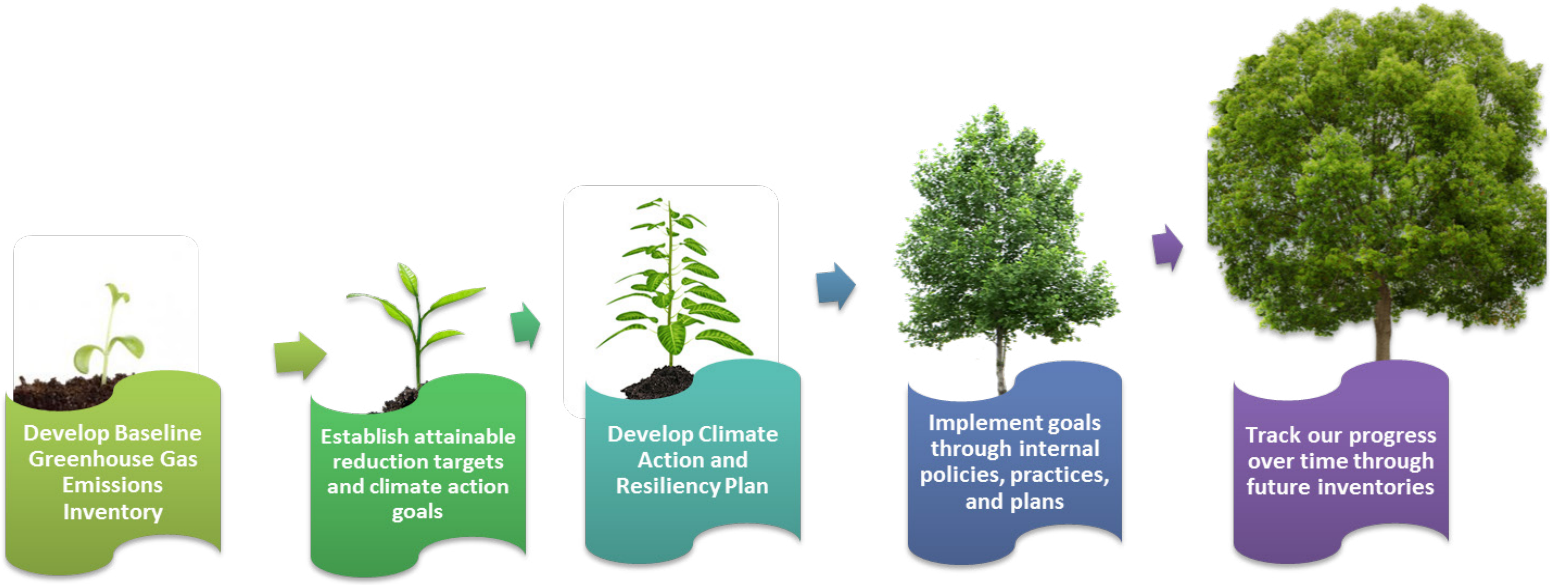


Fig. 7: Linear progression of County goals moving forward with climate action

While the County's total emissions are not particularly alarming, the County will continue to move forward in combating climate change by reducing County generated emissions and encouraging sustainable operations without reduction in services for residents.

Operational sustainability and County efforts to confront climate change will have profound benefits for government efficiency, including reducing energy costs through decreasing electricity and fuel demand, but those decisions go far beyond Missoula County operations. Through developing this report and using the data to develop a strategic plan for climate action and mitigation techniques, the County is affirming its reputation as a leader and advocate of sustainability, which will in-turn influence residents of the County to commit to climate action initiatives as well. The primary motive for Missoula County to reduce its impact on climate change is to cultivate resiliency in the surrounding community; thereby protecting the things that are valued most by County residents: open spaces, the local economy, clean air and water, public health, and ultimately the unique quality of life exclusive to Missoula County, Montana.

I. Introduction

PURPOSE OF INVENTORY

The objective of this GHG emissions inventory is to measure how much Missoula County operations are contributing to climate change and develop a baseline estimation of the County's emission output, in an effort to understand where the County's emissions are coming from and how they can be reduced. In June 2016, the Board of County Commissioners (BCC) adopted the County's updated Growth Policy. Goal 4 of that document aims to "Reduce Missoula County's contribution to climate change while promoting resiliency and adapting to its impact on the natural environment and communities." Explicitly stated as an action item for this objective is to develop the County's baseline GHG emissions inventory. The County cannot hope to reduce emissions without first understanding where those emissions are coming from, and how much they are emitting. Missoula County plans to use the data compiled in this report to monitor emissions over time, as well as set reduction targets and climate action goals to be outlined in Missoula County Climate Action and Resiliency Plan, anticipated in 2018.

In order to uphold Missoula County's responsibility to protect public health and safety of those who live, work, and visit here, the County is dedicated to taking action to protect the local environment from the consequences associated with climate change. Missoula County has the potential to decrease their contribution of GHG emissions into the atmosphere, mitigate the effects that climate change is already having in the community, promote adaptation techniques, and build resiliency among residents. Climate change poses very real concerns that threaten almost every aspect of society. A healthy, resilient community comprises a thriving local economy, healthy residents, and clean air and water, all of which depend upon the protection of environmental resources and cultural values.

Missoula County has already taken great strides in operational sustainability, such as through internal County policies, participation in community solar initiatives, incorporating climate change into development regulations and plans, and installing high-efficiency appliances in appropriate facilities.[1] Conducting a GHG emissions inventory is a vital preliminary step to developing a strategic plan to combat climate change. Furthermore, the GHG Emissions Inventory provides opportunities to explore initiatives the County might pursue to improve resiliency for rural communities facing climate change impacts. Although decreasing the County's contribution to climate change may have a limited impact on global climate fluctuation, the County's efforts to reduce their emissions will improve resiliency and protect quality of life throughout Missoula County.

1 See Missoula County's Sustainability Assessment in Appendix B

GREENHOUSE GASES

Greenhouse gases (GHGs) are gases that absorb radiation from the sun and trap heat in the Earth's atmosphere, creating a greenhouse effect. The more GHGs in the atmosphere, the more heat is trapped, which results in increased global temperatures ("global warming") and climate change. GHGs are released as a byproduct of combustion of fossil fuels, such as coal, natural gas, and petroleum based fuels (gasoline and diesel). We combust fossil fuels to power our everyday activities like lighting our homes or driving our cars. When a fossil fuel is combusted, both steam and GHGs are produced. The GHGs are released into the atmosphere, while the steam is used to spin a turbine and generate electricity, for example.

Global Warming Potential

Some GHGs are more effective at heating the atmosphere than others. The Intergovernmental Panel on Climate Change (IPCC) assigned each GHG a Global Warming Potential (GWP) numerical value that represents the gas's efficacy at trapping heat.

Table 3: Global Warming Potential

Greenhouse Gas	Global Warming Potential
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310

The GWP of a GHG is relative to the warming potential of carbon dioxide, the value of which is set to 1. For example, one metric ton of methane is 21 times more effective at heating the atmosphere than one metric ton of carbon dioxide. It would therefore take 21 metric tons of carbon dioxide to trap as much heat as one metric ton of methane.

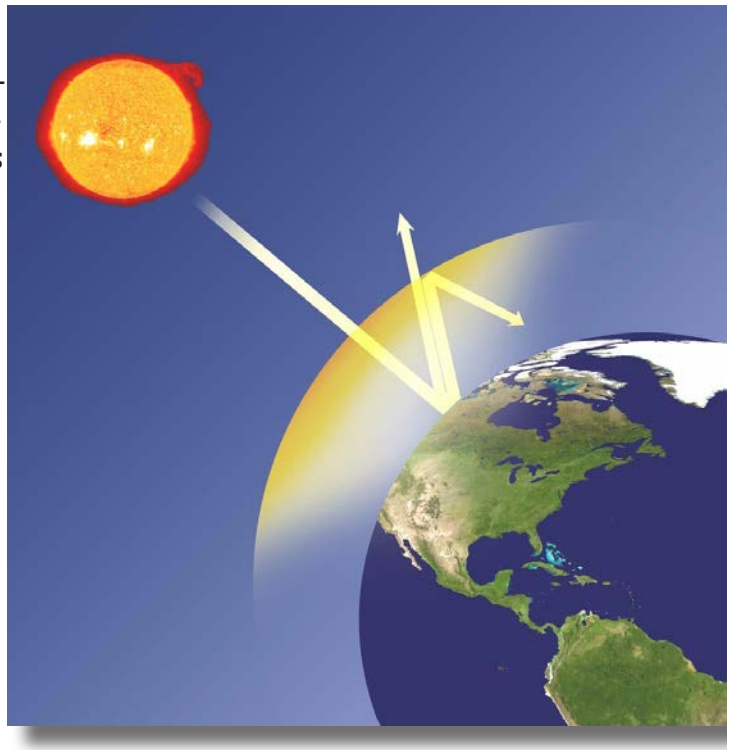


Fig 8: The Sun's radiation penetrates the Earth's atmosphere and warms the surface; some heat escapes the atmosphere, but an increasing amount is reflected back onto the Earth due to GHGs (Source: http://schroederillustration.com).

$MtCO_2e$

The GHGs measured in this inventory include methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). All of the GHGs in this inventory are measured in metric tons (Mt). A metric ton is a universal unit of measurement typically used to measure GHGs, and is equal to about 2,200 pounds. Imagine a cube that stands 30 feet tall, about the height of a three-story house. If that cube was filled with GHGs, it would weigh approximately one metric ton. To put this concept into context further, one metric ton of CO_2 is produced to meet the monthly energy demand for the average American household.

For the sake of simplification, instead of counting three different emissions values for every single thing included in the inventory (CH_4, CO_2, and N_2O), the gases are converted into one number that reflects their GWP with respect to carbon dioxide (Table 3). This number is referred to as CO_2 equivalent (CO_2e). Steps for calculating $MtCO_2e$ can be found in Chapter II: Methodology.

Weather vs. Climate

Weather refers to the short-term condition of the atmosphere, such as temperature, precipitation, and wind patterns, while climate refers to the average behavior of the atmosphere (i.e. the average weather conditions) over a long period of time. Therefore, the term "climate change" refers to a change in the average long-term weather behavior.

The Earth's climate is regulated by the aforementioned greenhouse effect, a system operated by the fragile balance of naturally-occurring gases (GHGs). While this system occurs on its own (without human intervention) and makes life on Earth possible, human activities (i.e. burning fossil fuels) have led to an increase in the concentration of GHGs, which intensifies the greenhouse effect. Due to the increased concentration of GHGs directly as a result of anthropogenic activities, the Earth's atmosphere is warming and changing more rapidly than it would have otherwise.

Storm clouds and a rainbow in Missoula, MT. (Source: http://elevation.maplogs.com)

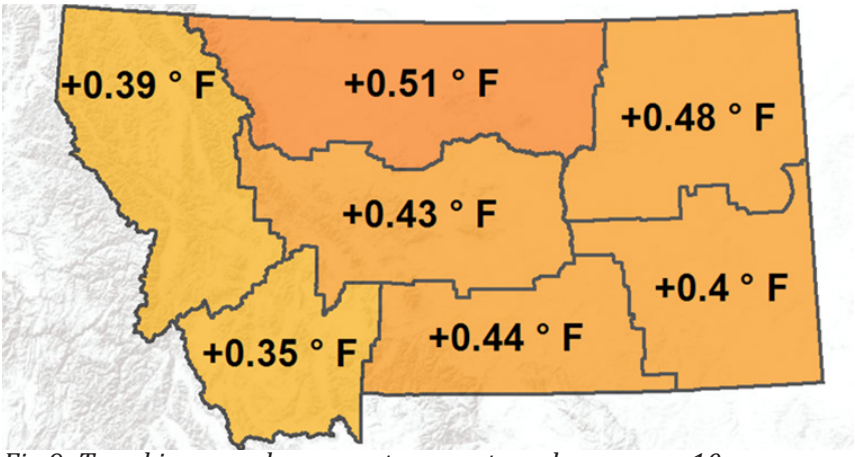


Fig 9: Trend in annual average temperature degrees per 10 years, 1950-2015 (Source: Montana Climate Assessment 2017)

How Climate Change is Affecting Our Community

Missoula is no stranger to the repercussions of climate change. When discussing climate change on a global scale, the most common concerns include rising sea levels, increasing air temperatures, and changes in precipitation. Although our county is safe from rising sea levels (unlike coastal states, such as California and North Carolina), we experience a unique variety of environmental stresses because of global climate fluctuation. In a business-as-usual (BAU) scenario (if the world continued to produce GHGs at the same rate as we are now) Montana is expected to see a 4-5 degree increase in temperature by 2055, with as much as a 6.5 degree temperature increase in winter in particular (Power, 2015). This temperature increase means dramatic changes in snow melt hydrology: less snow, increased rate of snow melt, and less runoff into streams, whose ecosystems depend upon snow runoff.

Precipitation patterns are more difficult to predict than temperature, as short-term data sets include a substantial amount of variability. Despite the challenges associated with predicting future precipitation patterns in Montana, it is expected that there will be less precipitation in the summer months. Moreover, it is conclusive that higher temperatures will lead to an increased rate of evaporation in rivers and reservoirs (Carlson, 2010).

Increased temperatures coupled with a decrease in summer precipitation in Montana will expectedly lead to longer summer droughts and shorter winters, which could be devastating to local ecosystems, recreational activities, our economic security, public health, and Montanan culture.

The purpose of this section is to address why climate change is a concern in our community, and hopes to answer why this inventory and report have been created. However, climate change research is ongoing, and verdicts are continuously being established and clarified. This section does not aim to be a comprehensive or conclusive report on the impacts of climate change in Missoula; rather, it aims simply to illuminate how climate change could impact our community.

FORESTS: A lack of moisture and high temperatures in the summer months will undoubtedly lead to increased wildfire potential. In fact, forest managers estimate that acreage burned in Montana will increase 200-500 percent, depending on location by 2055. High summer temperatures combined with little moisture will also increase disease and beetle kill, leading to an even further decline in native trees and shrubbery. Forests currently populated by Ponderosa pines and Douglas firs will shift primarily to Montane spruce-fir[1], while grasslands will convert to sage and other scrubs (Power, 2015).

RIVERS AND STREAMS: Snow melt in recent years has not only increased in rate, but has also begun melting at earlier times of the year. Native fishery populations are in decline as a direct result of temperature increase. Increased stream temperatures, as well as decreased water levels due to less snow and therefore less runoff, greatly alter the delicate fishery ecosystems in Missoula. Many native Montanan fish populations need connected waterways to spawn, feed, and otherwise survive, and with increasing stream temperatures, native fish populations are limited to sections of streams that remain cold enough to live in. Increased stream temperatures means an altered timeline for fish hatchings, which is what our native fish populations depend on for food. Moreover, local fish populations will experience an increase in competition with invasive species that are better suited for warmer water temperatures (Wenger et al., 2011). The habitat of cutthroat trout, Montana's state fish, has already shrunk by more than 85%, with two subspecies having gone extinct; it is expected the cutthroat trout will experience an additional 58% decline in what is left of their habitat by 2080 (Wenger et al., 2011).

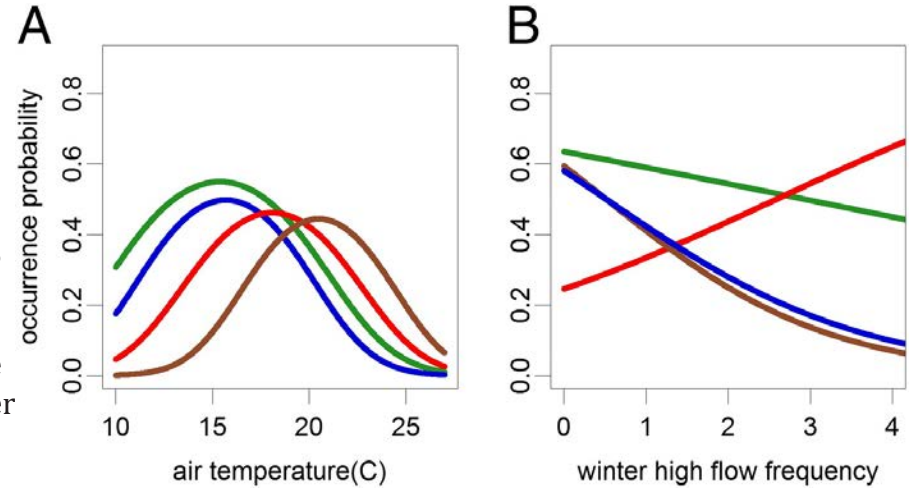
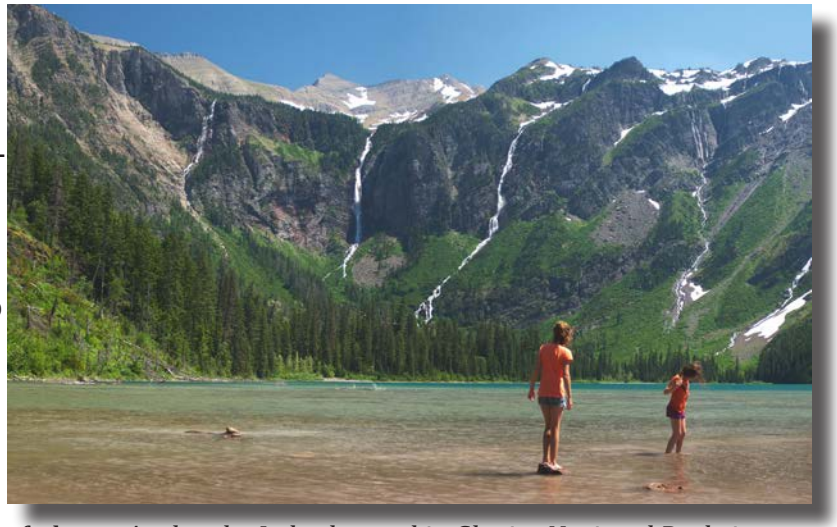


Fig 10: Occurrence probability of trout species with consideration to air temperature (A) and winter high flow frequency (B). Green: cutthroat trout. Red: rainbow trout. Blue: brook trout. Brown: brown trout. (Source: PNAS, Wenger et al. 2011)



Avalanche Lake, located in Glacier National Park, is a popular spot for visitors. (Source: National Geographic)

TOURISM: The second largest industry in Montana is tourism, behind only agriculture. Tourists visit Montana because of the wide array of outdoor recreational activities that Montana is known for, such as hunting, fishing, hiking, and

1 Montane spruce-firs are expected to increase significantly in the mountainous landscapes of Montana in a hotter, drier climate scenario (6 degree C increase and 90% less moisture in the summer), while Subalpine spruce-firs are expected to decrease. In a flat landscape in the same climate scenario, both Subalpine and Montane spruce-firs are predicted to increase.

winter sports. All of these activities are jeopardized because of climate change. An estimated 3.1 million people visit Missoula County annually, spending around $310 million, according to the Missoula Economic Partnership (Grunke, 2017). This money most obviously helps support our local economy through supporting local businesses, contributing about $22 million in taxes, and supporting 3,200 jobs (Erickson, 2014).

Increasing temperatures in Missoula will affect wildlife and hunting seasons, which is another reason why people visit this area. Wildlife will stay in the high country for longer periods of time during the year, both because they seek cooler temperatures, and they will not be forced into lower elevations due to snowfall. This could considerably shorten the hunting season, due to lack of available wildlife; it will also become more difficult for hunters to track, locate, and transport game (Power, 2015). Lack of wildlife and decreasing fish populations could lead to a decline in tourism for Missoula County, an industry of which we depend on for economic security, and therefore our quality of life.

Winter precipitation will come more as rain than as snow. The elevation at which snow pack will be found will continue to rise as temperatures do, which could affect the location of current base ski areas, forcing them to reassess their infrastructure and hours of operation, in some seasons not operating at all. Less snow will therefore lead to a decline in the amount of people visiting Montana to ski, snowshoe, snowmobile, and take advantage of other winter recreational opportunities. By 2050, winter activity days could decrease by about a third, which will lead to the loss of 1,500 winter sport jobs and about $37 million in labor earnings. (Power, 2015).

A recent report commissioned by the Montana Wildlife Federation and prepared by Power Consulting Inc. claims that Montana's outdoor economy could experience a total loss of 11,000 jobs and $281 million in labor earnings by 2050 if we continue emitting GHGs at a BAU rate (Power, 2015). This includes the four sectors that are crucial to Montana's thriving outdoor economy: national park visits, hunting, angling, and winter sports.

Source: The Prairie Star

AGRICULTURE:

Agriculture may be the largest economic industry in Montana, but perhaps even more noteworthy is its iconic place in Montana's history, and its foundational influence on Montanan cultural values. Climate change therefore not only threatens the economic benefits of agriculture, but also the very culture and lifestyle that many Montanans take pride in.

There are some misconceptions when discussing climate change and its impacts on agriculture. One in particular is the belief that increasing temperatures will lead to a longer growing seasons and increased crop yields, thereby making climate change a perceived benefit to farmers. While an increase in atmospheric carbon dioxide may cause plants to grow faster (as CO_2 is a vital component of a plant's photosynthesis process), their increased growth rate limits their ability to intake nitrogen from the soil, which is essential to a plant's ability to produce nutrient-rich food (Feng et al., 2015); this affects crops that are produced both for human and livestock consumption.

A decrease in summer precipitation and therefore ground moisture, coupled with the increase in CO_2, leads to fast-growing and dry plants, which is the ideal fuel for wildfire. There are immense implications of wildfire on crop and livestock fields, potentially causing the depletion of crops due to burnt fields.

According to a report commissioned by the Mon-

tana Farmers Union and prepared by Power Consulting Inc., in a BAU scenario, by 2050 cattle raising to experience a 20% decline in production, equating to about 12,167 jobs lost and $364 million in labor earnings. Crop production is expected to experience a 25% decline, equating to 12,457 jobs lost and $372 million in labor earnings (Power, 2016).

Wildfire smoke billows from Lolo National Forest during the Sunrise Fire of 2017. (Source: KULR8)

PUBLIC HEALTH: Climate change will also have serious impacts on individual health, ranging from physical ailments to mental wellbeing. Increased occurrences of wildfire, for instance, will amplify particulate matter in the atmosphere and cause potentially detrimental effects on human cardiovascular and respiratory systems. Moreover, with any increase in temperature comes an increase risk of heat stroke, and even death.

In general, diseases and bacteria thrive in higher temperatures. For this reason, the Missoula City-County Health Department (MCCHD) predicts that Montana will experience a surge in water and airborne diseases, including salmonellosis, campylobacteriosis, cholera, and cryptosporidiosis (*Missoula City- County Health Department Climate Change Adaptation Plan*, 2017).

Amplified CO_2 levels and higher temperatures could pose serious threats to individuals with seasonal allergies. With a higher concentration of pollen and a longer pollen season, those who have allergies (and those who will develop allergies) will likely have to take more days off work to recuperate; moreover, due to all of the increased stress on individual health due to consequences associated with climate change, employees will work less and take more time off to recover, resulting in a less productive workforce and less economic gain for Montanan industries.

CLIMATE MIGRANTS: Due to Missoula's geographic location and topography, we are fortunate to not experience many of the negative consequences of climate change as severely as other communities. In particular, communities located in the Southern and Midwestern U.S. (Fig. 11) are expected to observe a higher and more rapid increase in average temperatures, and it is predicted that people located in those areas will migrate to more comfortable locations, such as Missoula County. Furthermore, as rising sea levels begin to consume the infrastructure along coastal communities, many people along the coasts will seek refuge in inland communities.

The Pacific Northwest, including Missoula, will likely be a popular area to relocate to due to stresses from climate change. A growing population in Missoula County will necessitate reassessment of development and infrastructure plans, such as planning and zoning for future growth, transportation and road systems, and increased capacity for our water and wastewater treatment facilities.

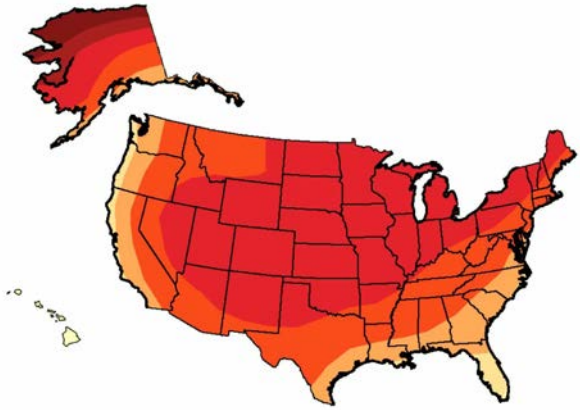


Fig 11: Higher average temperatures are predicted for areas in dark red- primarily the mid and south west. (Source: National Climate Assessment)

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II. Methodology

Steps taken to create inventory:

1. Collect activity-use data from appropriate entities (utility companies, departments)
2. Organize data into spreadsheets
3. Input data from spreadsheets into relevant emissions calculators provided by ClearPath, an emission inventory program developed by ICLEI, Local Governments for Sustainability

Missoula County's GHG Emissions Inventory exclusively measures emission outputs confined within Missoula County operations and facilities for the calendar year 2016. The sectors that comprise this inventory include: buildings and facilities, vehicle fleet, employee commute, water and wastewater treatment facilities, and streetlights and traffic signals. Any department, building, facility, vehicle fleet, or entities otherwise operated by Missoula County administration or employees were included in this inventory.

The reporting period for this inventory spans the entirety of the calendar year 2016 (January 1st, 2016 to December 31st, 2016). The report relies upon the most accurate and up-to-date data available while using calculators created for the purpose of measuring emission out puts from government operations.

Why ICLEI's ClearPath?

The first step in creating a GHG emissions inventory is to explore possible inventory programs and tools. The County evaluated tools that could be used to store, process, and track emissions data over time, and more thoroughly examined two viable programs: the EPA's Local Inventory Tool and ClearPath, developed by ICLEI- Local Governments for Sustainability.

The Local Inventory Tool was developed by the Environmental Protection Agency (EPA) as an interactive spreadsheet, designed for local governments to evaluate their operation's GHG emissions. This tool would allow the user to input data for several sectors, including transportation, waste management, and water management. The EPA also provides many external resources to help the user understand how to use the tool and related protocols. Although the tool itself is free to use, additional staff time and costs needed to be considered, as the tool does not include internal emission factor protocols and calculation tools, thereby making it more difficult and time-consuming for the user to calculate emission output.

ClearPath, developed by ICLEI, is an extensive cloud-based software package that provides users with detailed protocols, modules, and exceptional technical assistance. Unlike the Local Inventory Tool, ClearPath is programmed to complete emission calculations for the user. Additionally, ClearPath includes a few different modules (Planning, Forecasting, and Monitoring) that allow for further data analysis and interpretation; the County plans to use these modules when developing the Climate Action and Resiliency Plan. Both the City of Missoula and Climate Smart Missoula have used ClearPath as their primary inventory tool for City operation emissions and community-wide emissions, and have endorsed ClearPath as the best tool for emissions accounting. Moreover, having emission data uniformity, and consistently in one program across the City, County, and community allows for better communication between such entities, as well as more efficient planning and collaboration. The primary drawback for this program was the annual cost, which is covered under the County's membership in ICLEI. However, there is an expected savings in staff time needed for each assessment as compared with the Local Inventory Tool.

After selecting the program that was better suited to fit the needs of the County's emissions inventory, the findings were compiled in a memo. You can view the memo in its entirety in Appendix C.

The different scopes and sectors are associated with a different color throughout the report.

KEY:

Scope 1
Scope 2
Scope 3

Buildings & Facilities
Vehicle Fleet
Employee Commute
Water & Wastewater Treatment Facilities
Streetlights & Traffic Signals

SCOPE

This Emissions Inventory was created in accordance with the Local Government Operations Protocol (LGOP), version 1.1 provided by ICLEI. To allow for consistency and transparency across inventories when accounting for direct and indirect emissions, the LGOP follows the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) GHG Protocol Corporate Standard when categorizing emissions into different scopes.

Table 4: Classifying County operations into Scopes

	DEFINITION	MC OPERATIONS ACTIVITIES
Scope 1	All direct emissions from on-site fossil fuel combustion	- Mobile fuel combustion from petroleum-based fuel (i.e. gasoline and diesel) in County vehicle fleets - Natural gas and propane use to heat facilities - Fugitive emissions from water and wastewater treatment facilities
Scope 2	Indirect emissions from energy generated in one location, but used in a different location	- Electricity use in buildings, facilities, and traffic signals
Scope 3	Indirect emissions that occur outside of the inventory boundary, but are a result of activities within the boundary	- Fuel consumption from Missoula County employee commutes

Why are emissions categorized into different "scopes"?

Classifying emissions into scopes is the standard way of defining different types of emissions, this both helps us understand where emissions are coming from and how much control the County has over those types of emissions. For example, there is more control over emissions that are categorized as Scope 1 than Scope 3 emissions, as the County can directly control how much fuel is used in vehicles, whereas they cannot regulate how employees commute to work. Knowing how much control the County has over emissions is crucial when setting emission-reduction targets.

Table 5: Variables and data source for each sector

Sector	Variables Used	Data Source
Buildings & Facilities	- Kilowatt hour usage - Type of fuel used for stationary fuel combustion (i.e. natural gas or propane) - Amount of fuel used (gallons of propane or thermal units of natural gas)	Utility invoices gathered from either MC's Financial Services Dept or by individual departments
Streetlights & Traffic Signals	- Kilowatt hour usage	Utility invoices gathered from either MC's Financial Services Dept or the Public Works Department
Vehicle Fleet	- Type of fuel used in vehicles (diesel or gasoline) - Number of vehicles in fleet - Type of vehicles in fleet, including year and model - Annual fuel use in gallons - Total 2016 mileage for each vehicle	Invoices from departments. Often departments kept records of vehicle types within their fleets, as well as the odometer reading for each vehicle, which allowed for extrapolation of the appropriate data (mileage for each vehicle)
Employee Commute	- Type of fuel used in employee vehicles (diesel or gasoline) - Number of employees that drive to work - Number of employees that take the bus to work - Type of vehicle used (if employee drives), including year and model - Total number of MC employees	Data extrapolated from a voluntary County Employee Commute Survey with a 24% response rate
Water & Wastewater Treatment Facilities	- Amount of water processed in millions of gallons of water per day (MGD) - Utilization of nitrification, denitrification, neither, or both - Utilization of anaerobic or aerobic processes - Kilowatt hour usage - Use of septic systems, wastewater treatment lagoons, neither, or both	Most information related to water and wastewater treatment facilities was collected from the facility's respective operator. Kilowatt hour usage was provided in the form of invoices from each month, from either MC's Financial Services Dept or the Public Works Department

What is an emissions factor?

An emissions factor is a value that represents how much a certain activity outputs emissions at a specific rate. Emissions factors help us calculate the total amount of emissions outputted by each sector. For example, in order to calculate total GHG emissions originating from buildings and facilities, we would need to know how much GHG is produced from one hour of electricity use, or from one gallon of natural gas.

Emissions factors are determined by the geographic location of where energy is produced, as illustrated by Fig. 12, the eGRID map below. Missoula County falls within the NWPP subregion. The energy mix for NWPP is shown in Fig. 13 (right).

Fig. 13: NWPP eGRID region energy mix

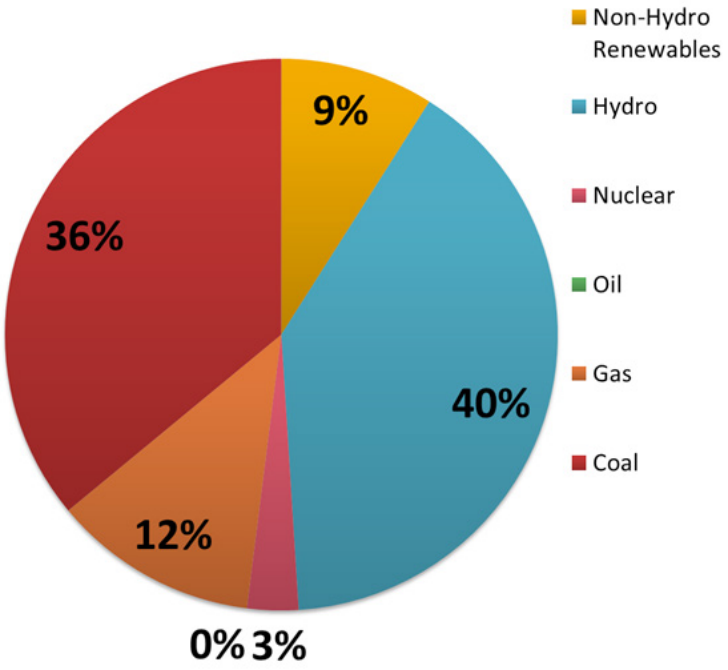
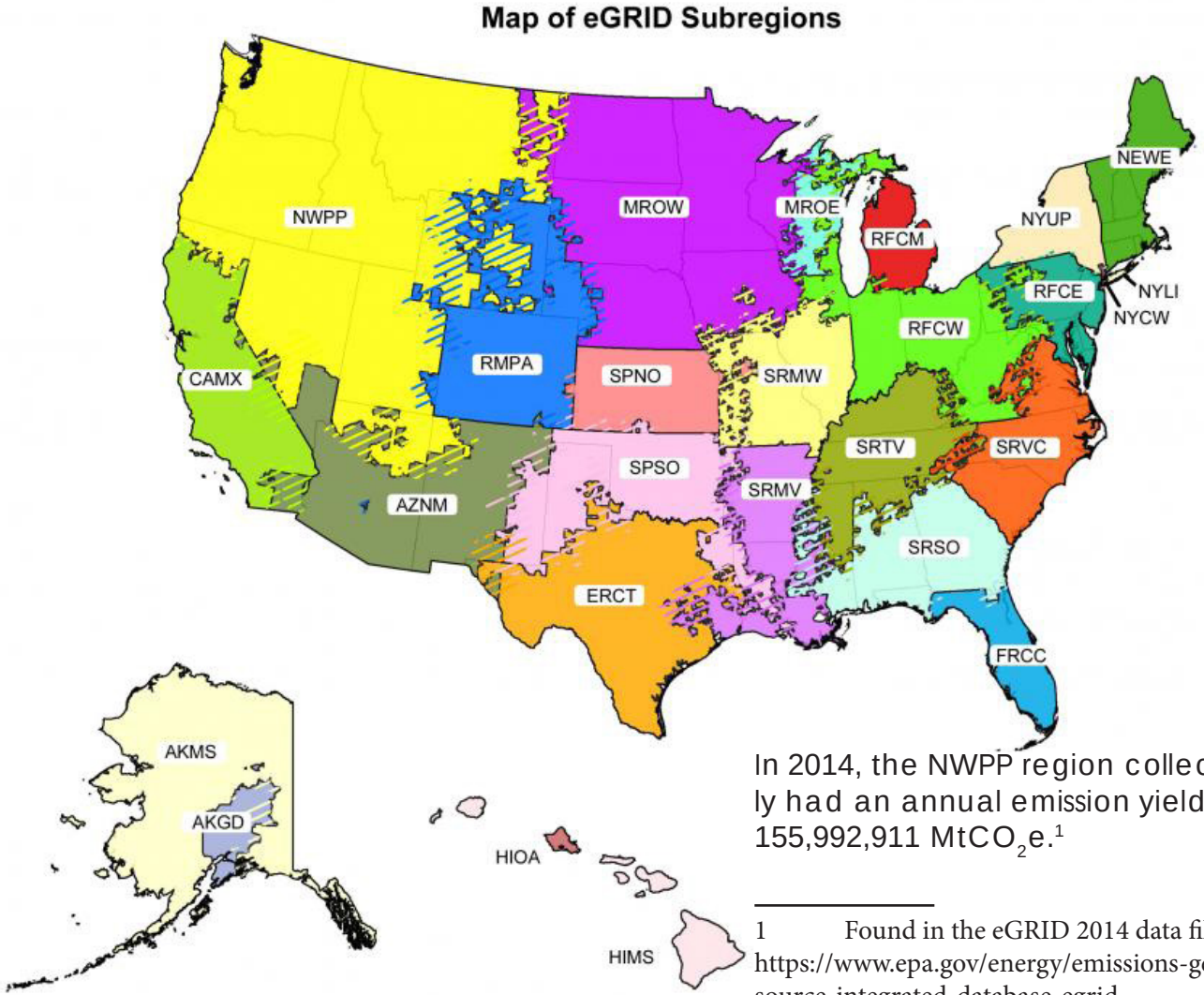


Fig. 12: Emissions and Generation Resource Integrated Database (eGRID) map



In 2014, the NWPP region collectively had an annual emission yield of 155,992,911 $MtCO_2e$.[1]

1 Found in the eGRID 2014 data file, here: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

Steps for Calculating $MtCO_2e$:

1. Calculate the metric tons emitted for each GHG being measured in the inventory (CO_2, CH_4, N_2O):

- Measure activity data for every activity that emits GHGs (electricity use, thermal usage, miles traveled, etc.)
- Multiply the activity data by it's respective emissions factor for each GHG and each activity to give you the metric tons released from each activity
- Add together each activity's metric tons of GHG, separate based on type of GHG being measured (one sum for CO_2, one sum for CH_4, and one sum for N_2O)

2. Now that you have the metric tons released for each GHG being measured, multiply each sum from the first step by its respective GWP (Table 4):

- $MtCO_2$ x 1
- $MtCH_4$ x 21
- MtN_2O x 310

3. Add the products from step 2 together to calculate total metric tons of CO_2 equivalent ($MtCO_2e$)

Technical Advisory Group

Data and calculations were reported to Missoula County's Greenhouse Gas Emissions Inventory Technical Advisory Group (TAG) for revision and accuracy before being formally included in the inventory. The TAG comprises community members that have used ICLEI's ClearPath, are technologically savvy, were able to help the County gather and interpret the appropriate data, or otherwise have experience developing a GHG emissions inventory.

For more information on TAG, check out Missoula County's Community Resiliency Webpage.

Table 6: Emission factor used based on activity data

Activity	Emission Factor Used[1]
Electricity use	eGRID2012 Grid Electricity
Stationary fuel combustion	ClearPath default
Mobile fuel combustion for vehicle years 1980-1995	1980-1995 Model Vehicles
Mobile fuel combustion for vehicle years 1996-2017	1996-2017 Model Vehicles
Nitrification/ denitrification process in water and wastewater treatment plants (WWTP)	ClearPath default
Anaerobic/ aerobic process in WWTP	ClearPath default

1 Find emission factor variables in Appendix E.

III. Uncertainties

A GHG emissions inventory inherently includes mathematical and scientific uncertainties, both in data aggregation and calculations. All GHG emissions inventories rely upon the foundational elements of emissions factors and global warming potential values of different greenhouse gases, both of which, while representing the most accurate information possible, do intrinsically have inevitable scientific ambiguities. For example, calculating $MtCO_2e$ for employee commutes did not include the use of a CO_2 monitor on vehicles, but rather was calculated based on behavioral assumptions. Furthermore, this was the first GHG emissions inventory calculated for Missoula County operations, and it was therefore difficult to gather relevant data with there being no previous system in place for such an inventory. Further uncertainties exist in each sector of the inventory, involving the practice of data collection and calculation, which is explained in detail below (table 7).

Despite the uncertainties associated with creating a GHG emissions inventory, the results presented in this report are reliable for making emission- reduction decisions, setting reduction targets, and identifying other relevant climate action goals. With consideration to the above disclaimers, Missoula County is confident that the information presented in this report is reliable and as accurate as possible.

Table 7: Uncertainties associated with each sector

Buildings & Facilities	Kilowatt hour and thermal usage data was extrapolated from monthly utility bills from each department, which gave precise data for how much electricity and fuel was being used by a facility. In a few cases, a department purchased fuel whole-sale, (ex: propane tanks) and data for how much fuel was actually used from that whole-sale purchase was unrecorded or otherwise unavailable. For this reason, the amount of fuel purchased throughout the year was used as an input for emission output calculations, and might not reflect the true amount of fuel combusted.
Vehicle Fleet	There are over 30 vehicle fleets under Missoula County operations, with over 600 vehicles and pieces of equipment total across those fleets. The sheer volume of vehicles and machinery to account for made it difficult to gather all of the data necessary to calculate emissions outputs. Moreover, since this is the first emissions inventory conducted for County operations, there was no system in place that made it easy to find all of the data necessary for this sector. In many cases, a list of vehicles for a department's fleet would be provided, but the odometer and fuel usage data would be found elsewhere. For this reason, some vehicle mileage and fuel usage data was unaccounted for, either because the vehicle was simply not used in 2016, or the data was never recorded. If fuel consumption data is available, the amount of vehicle miles traveled (VMT) is not necessary for calculating emissions from a given fleet. However, the VMT could be significant information when determining reduction targets and forecasting emissions from vehicle fleets. Therefore, the County found it necessary to calculate VMT when possible. The Public Works fleet included machinery that used an hours-used meter as opposed to a conventional odometer, which meant it was necessary to convert "hours used" into mileage. This conversion required estimations of how many miles a piece of equipment would have gone if used for X amount of hours. For example, if a fork lift was used for 90 hours, that amount of time needs to be converted into miles. If we estimate that a forklift travels at 3 MPH, then the mileage for the forklift is 270 miles. Some estimations for equipment hours-to-miles conversions may not be entirely accurate, and it is surmised that the VMT calculated for this sector are fairly conservative.

Employee Commute	Although accounting emissions for this sector is optional according to the LGOP, the County ultimately decided to include this section in the inventory for the sake of developing the most accurate representation of their operation's emissions yield. The emissions calculated in the Employee Commute sector are the most unreliable. Data for this sector were extrapolated from an Employee Commute Survey, distributed to every County employee* via email. This survey was not mandatory, and the County received a 24% response rate. Therefore, in order to scale-up the results from the survey to reflect total County employees, estimations and assumptions were made that may not reflect the actual commuting behaviors of employees. Furthermore, it is suspected that the 199 out of about 847 employees who participated in the Employee Commute Survey are those who likely partake in methods of travel alternative to single-passenger vehicle commuting. Consequently, it is speculated that the emissions calculated in this sector are an underestimate of the reality. **The survey was not distributed to the Sheriff's Department, as the County sheriff officers use their work vehicle as their personal commute vehicle, and therefore their mileage and fuel usage was already accounted for in the vehicle fleet portion of the inventory. They were not included in this sector to avoid double-counting.*
Water & Wastewater Treatment Facilities	There are many calculation assumptions made in this sector. In order to calculate emissions from the County's water and wastewater treatment plants (WWTP), the population served by each facility is required. There is a standard equation given by the Montana Department of Environmental Quality to estimate the population: Number of homes served by WWTP multiplied by 2.5 (this number represents the average number of people living in a Missoula County dwelling, based off recent census data). Since this number represents the average number of people in a home, the emissions calculations could be over or underestimated. ClearPath also assumes other fundamental values required for accurate WWTP emission yields, such as the "BOD_5 load" which refers to the quantity of biodegradable organic matter contained in water. If a WWTP does not know their BOD_5 load, ClearPath assumes a generation rate of 0.09 kg/person/day, and a removal rate of 32.5%. Because there are so many foundational calculation assumptions applied in this sector, the emissions output may overestimate or underestimate the true amount of emissions from the County's WWTP.
Streetlights & Traffic Signals	Kilowatt hour usage was the only variable needed to calculate the emissions outputs from County operated streetlights and traffic signals. The County's Public Works Department oversees five traffic signals, referred to as "flashers" for school crossings. The Public Works Department also owns some path lights, which are included as part of several different facilities. At the beginning of this inventory, it was unclear whether or not those path lights should be included as part of this sector, or as part of the "Buildings or Facilities" sector. Ultimately, the County opted to include path lights in the emissions calculations for their respective building, as they were viewed as part of that facility's total emissions output, rather than an individual emitter.

IV. Results

Missoula County operations emitted 6,810 $MtCO_2e$ in 2016

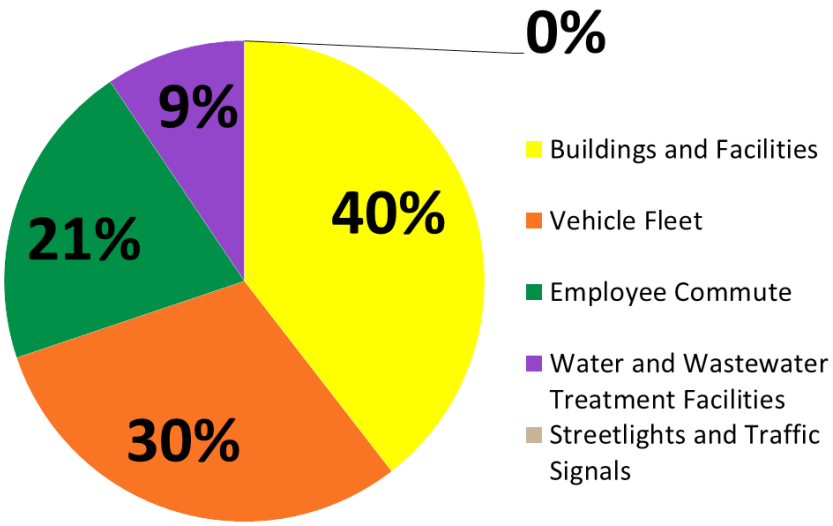


Fig. 14: Total emissions by sector

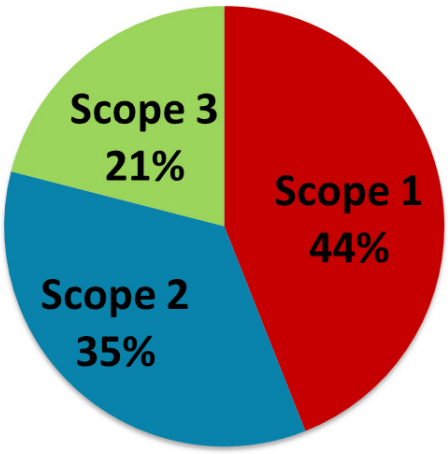


Fig 15: Total emissions by scope

SCOPE 1:
- *Use of petroleum-based fuel in vehicle fleets, 69%*
- *Use of natural gas or propane for heating buildings and facilities, 23%*
- *Fugitive emissions from WWTP, 8%*

SCOPE 2:
- *Electricity use in buildings, 83%*
- *Electricity use in WWTP, 17%*
- *Electricity use from streetlights, <1%*

SCOPE 3:
- *Employee commute, 100%*

The majority of emissions from Missoula County operations are categorized as Scope 1- referring to on-site combustion of fossil fuels, such as the use of petroleum-based fuel in vehicle fleets (i.e. gasoline and diesel), as well as fuel used to heat buildings (petroleum and natural gas). The County has the most control over these emissions, because the emissions are generated on-site, and they will therefore be a priority target when making reduction decisions.

However, the County also has a fair amount of influence over emissions categorized as Scope 2: emissions generated from electricity use. While they cannot directly control how much power is generated from a power plant, they can control the energy demand from County operations.

Employee commute comprises the entirety of Scope 3 emissions; although this Scope is the smallest section of emissions, employee commute alone makes up 21% of the total emissions, which is substantial as a single sector. The County has the least amount of control over this Scope, as they cannot force employees to commute a certain way, but they already participate in Transportation Demand Management organizations, which can influence employee behavior through incentives.

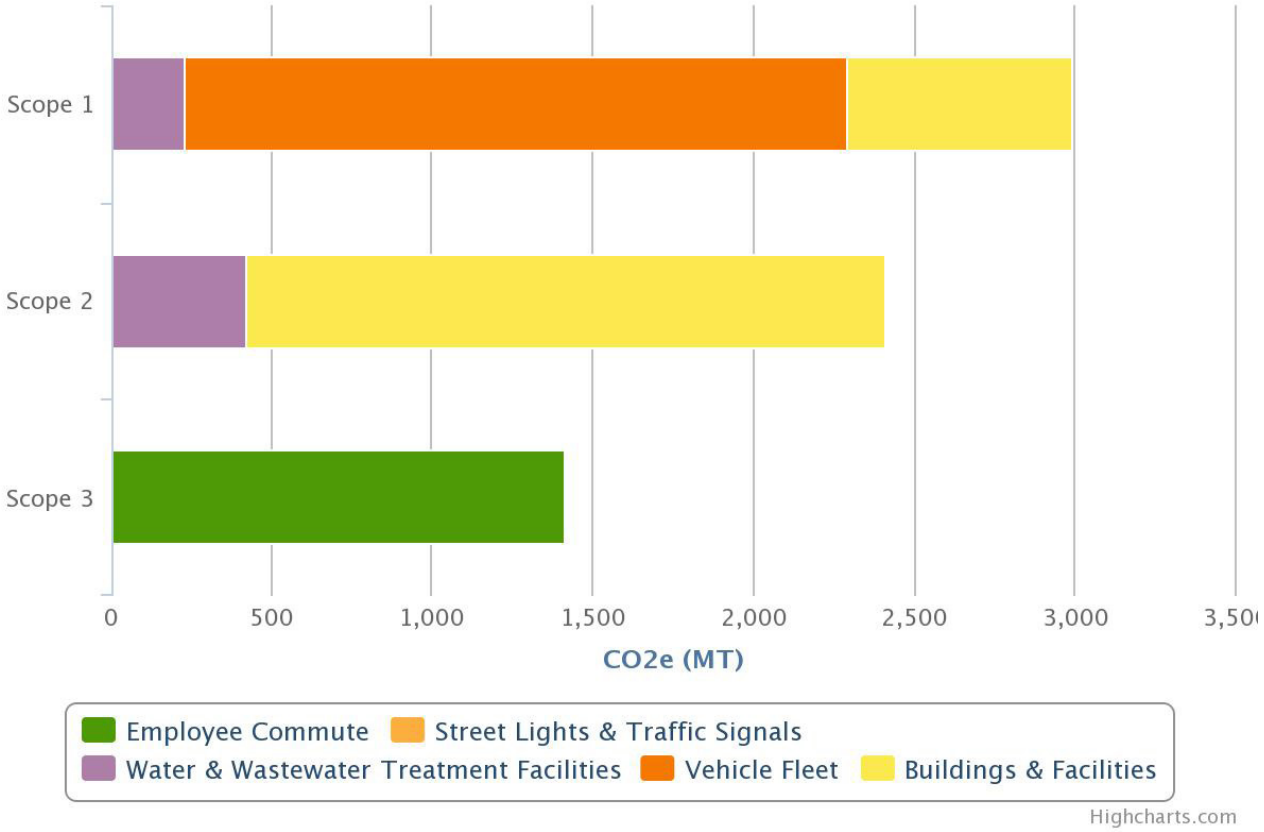


Fig. 16: This bar chart illustrates which sectors contributed to which scopes

The 2016 Greenhouse Gas Emissions Inventory establishes the baseline emission yield for Missoula County operations, which will allow the County to make data-driven climate action decisions. The baseline allows the County to identify focus-areas for energy efficiency and conservation, as well as other circumstantial sustainability initiatives. The following section breaks-down the total inventory results by County sector.

Buildings & Facilities: 2,690 $MtCO_2e$

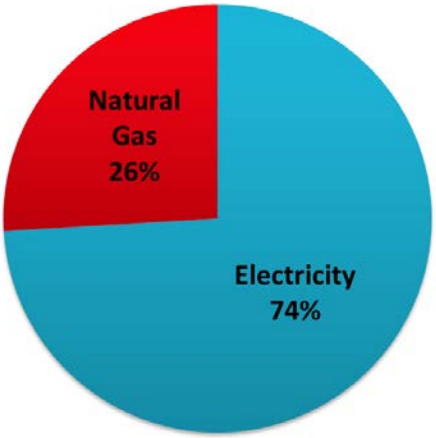


Fig. 17: Heating buildings (Scope 1)= 26%. Electricity use in buildings (Scope 2)= 74%

Missoula County Detention Center. (Source: missoulacounty.us)

Natural gas and propane use to heat County buildings and facilities account for 26% of emissions for this sector. These are the emissions that the County has the most control over. They can limit their emissions output in this sector most effectively by reevaluating the amount of heat necessary to warm County facilities, installing more insulation in buildings and facilities to limit heat-loss, incorporating programmable thermostats to release heat intermittently, and retrofitting buildings with high-efficiency (HE) heating, ventilation and cooling (HVAC) systems and appliances.[1]

Scope 2, or electricity, accounts for 74% of emissions from this sector. Although the County has less direct control over these types of emissions, it is still important to reduce them, since they account for such a large portion of this sector. Reducing energy demand, and therefore energy-generation and subsequent emission output, can be fairly simple to achieve: the County could enforce the use of light emitting diode (LED) lighting in all County operated facilities. LEDs use 75% less energy and last 25 times longer than incandescent lights (https://www.nrdc.org/sites/default/files/lightbulbguide.pdf). Additionally, new buildings could be oriented to utilize passive solar energy.

While installing HE equipment and maximizing energy conservation through building design are substantial methods of reducing energy demand, the most effective method of energy conservation is through behavioral change. Energy conservation needs to be perceived as a doable task for County employees, which can be achieved through educational opportunities and incentive programs. For example, tasks such as turning off the lights, computer monitors, copiers, and other office machinery, or using sweaters and blankets instead of space-heaters may seem menial, but can make a huge impact in reducing energy demand if enough people participate. The County could encourage these behaviors through additional incentive programs, such as interdepartmental competitions to reduce energy demand. Departments could be categorized by size or occupancy, with there being a winner for each category. Whichever departments use the least amount of electricity during one month would be the winner, and would be offered some sort of prize for their efforts. This is just one example of how the County could incentivize energy conservation.

1 The County's Facilities Department has already made numerous adjustments to several County operated buildings by installing HE HVAC systems and lighting fixtures. A list of these upgrades can be found in Missoula County's Sustainability Assessment in Appendix B.

Fig. 18 below illustrates the top five emitters out of 56 buildings and facilities within Missoula County operations. The Detention Center, at 926 $MtCO_2e$, has the largest emissions output within County operations, which comes as no surprise; it's a large facility, housing hundreds of people (inmates), and it operates 24 hours a day, seven days a week. It is followed by the Courthouse, the Public Library (which has extended business hours), Partnership Health Center (PHC) main clinic, and the Missoula City-County Health Department (MCCHD).

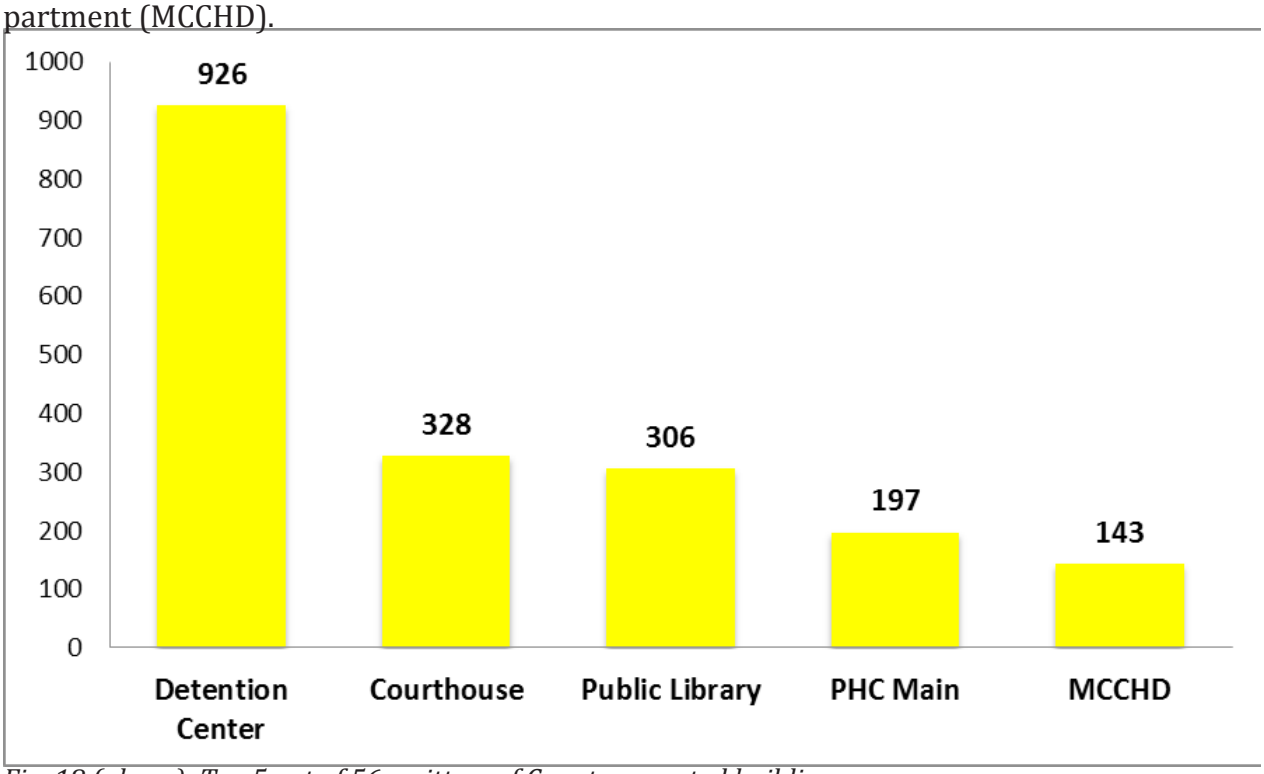
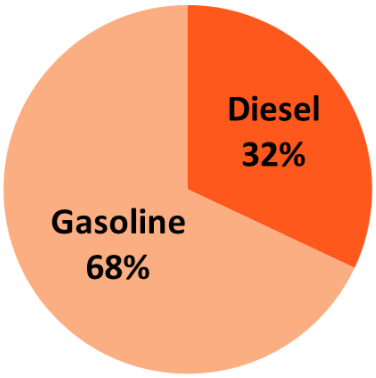


Fig. 18 (above): Top 5 out of 56 emitters of County operated buildings

Vehicle Fleet: 2,066 $MtCO_2e$ = 221,499 Gallons of Fuel



Missoula County operates 35 vehicle fleets and more than 600 vehicles. In 2016, those vehicles consumed 221,499 gallons of petroleum-based fuel, with 70,339 gallons being diesel and 151,160 being gasoline.

This sector is entirely comprised of Scope 1 emissions, which means emissions from vehicle fleet will be a high-priority reduction target in future climate action decisions. The County could significantly reduce emissions from this sector by encouraging departments to purchase more hybrid vehicles or vehicles with a more efficient fuel economy, or by limiting unnecessary mileage using work vehicles.

Fig. 19: Type of fuel used by vehicle fleets within County operations

The Sheriff Department's fleet produced the most emissions in this sector at 754 $MtCO_2e$. This inventory accounts for 85 vehicles within the Sheriff Department, and is the fleet with the highest number of vehicles accounted for in this inventory, so their spot as the top emitter comes as no surprise. However, efforts to reduce emissions specific to the Sheriff Department may prove difficult due to the performance needs and constant use of County sheriff vehicles.

The Road Department (76 vehicles), Road: Seeley (20 vehicles), and Building Inspection (4 vehicles) [1] are fleets operated under the Public Works Department. Both Road Departments contain heavy-duty machin-

1 In most cases, there are more vehicles within the fleets accounted for in this inventory, but weren't included due to lack of available data; we assume this is because those unaccounted for vehicles were simply unused during 2016.

ery and equipment, and therefore contain the most vehicles with relatively low fuel economies accounted for in this inventory. It could be difficult to reduce emissions from these fleets as well, given that the type of work fulfilled by these fleets can only be done using the type of machinery within them.

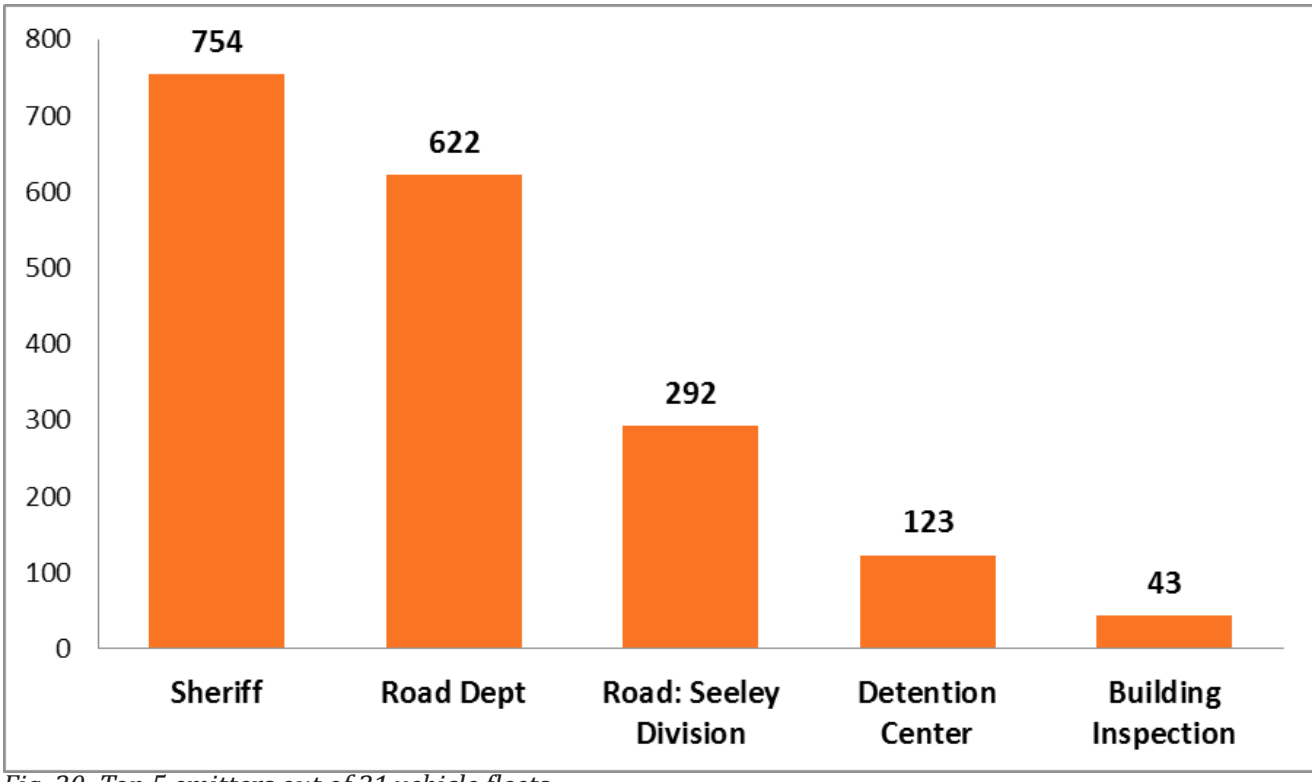


Fig. 20: Top 5 emitters out of 31 vehicle fleets

Employee Commute: 1,411 $MtCO_2e$

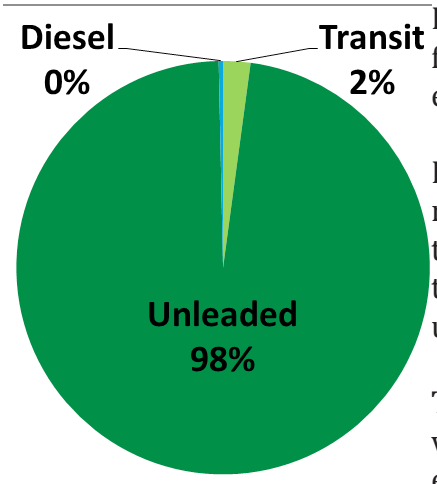


Fig. 21: Percentage of fuel use from employee commute

Emissions generated from Missoula County employee commute to and from work in 2016 amounted to 1,411 $MtCO_2e$, which is 21% of the total emissions output for Missoula County operations.

Employees who use unleaded gasoline in their personal vehicles to commute to and from work accounted for 98% of emissions in this sector, with the remaining 2% of emissions coming from employees who commute to and from work via transit. However, of the 98% of employees who use unleaded gasoline, about 10% carpool to and/or from work.

There were employees who reported to have used diesel in their personal vehicles, but the amount was imperceptible given the large scale of County employees (which, at the time of this inventory, was 847 employees).

Of the employees who participated in the survey, around 2% bike in colder months and around 10% in warmer months, while about 5% walk in colder months and around 4% in warmer months.

Although the emissions from this sector are generated from mobile-fuel combustion (Scope 1), ultimately the emissions are generated as a result of employee behavior; something Missoula County operations has little control over. Therefore, this sector is classified as Scope 3.

While the County has the least control over this sector in terms of reducing emissions, it is still important

to consider for their future climate action goals, as it accounts for a substantial portion of the total emissions outputs from County operations. The County could continue to use and expand incentive programs to encourage alternative methods of travel, such as participating in Missoula in Motion's Commuter Challenge.[1] The County could also consider building more bike shelters and parking, offer informational sessions that elucidate the health benefits of biking and walking, or provide resources for employees who live outside of city limits, such as additional bus routes and methods of coordinating carpooling between employees.[2]

Employee commute data was extrapolated from a County-wide Employee Commute Survey. The County can utilize the comments from the Employee Commute Survey to address current concerns associated with alternative commuting methods, and provide appropriate support to employees that want it.

Fig. 21 below is a chart that illustrates the responses to "Why do you choose to drive to work alone?" from the Employee Commute Survey.[3] The most popular reasons why employees choose to drive alone to work include needing a car for errands before and/or after work, child-related obligations, having irregular work hours, and taking less time than other methods such as bike, walking, or using public transit. The purpose of this question is to develop incentives or programs that appeal to the majority of County employees. For example, because so many employees feel that they have child-related obligations that prohibit them from biking, walking, or taking the bus, the County could offer a daycare service for children that is close in proximity to an employee's office, making it easier for that employee to carpool or take the bus.

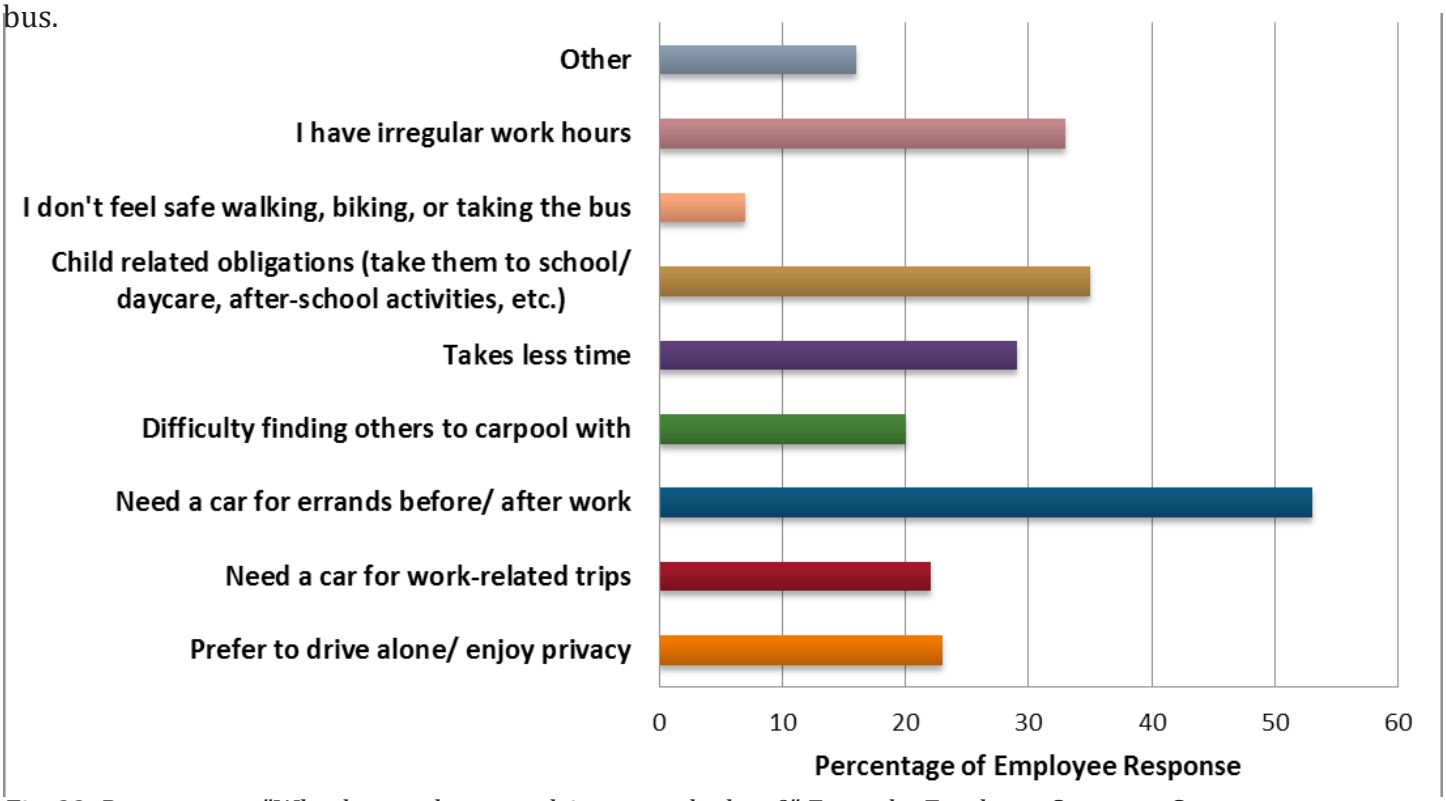


Fig. 22: Responses to "Why do you choose to drive to work alone?" From the Employee Commute Survey

1 Several departments within County operations do participate and support the Commuter Challenge.
2 Missoula in Motion's Way to Go! Missoula tool is a helpful resource to coordinate carpooling between employees.
3 See the Employee Commute Survey in Appendix D.

Comments from the Employee Commute Survey that provide further perspective on employee behavior:

- "I have to drive my daughter to daycare all the way across town. During the summer my husband is off due to being a teacher and try to ride my bike part of the time then."
- "I would like to take the bus, but there are no bus lines that run to the Miller Creek/ Linda Vista areas. It would be great if efforts were made to serve this area with a bus line. There are thousands of households up there that could utilize it."
- "I have multiple off-site meetings most days of the week. That prohibits many alternative forms of transportation because of time inefficiency. I also carry equipment when I travel to off-site meetings and presentations."
- "My commute via city bus is over 45 minutes from my neighborhood. If I drive it takes less than 10."
- "There is not enough room to walk safely or I would... Also the bus times do not correspond to the times I need for work, otherwise I would use it most days."
- "Immediate availability needed, frequent on-call status."

The Mountain Line bus system. (Source: The Missoulian)

Suggestions from County employees, taken from the Employee Commute Survey:

- " The IRS code allows for an employee-financed commuter benefit in which an employee designates a portion of salary before taxes (pretax income) to pay for qualified transit, bicycle maintenance costs, vanpooling, or parking expenses (up to the IRS allowable monthly maximum). This is an employee benefit that would cost the County $0 (similar to flex accounts for health care costs)."
- "Even though I drive alone frequently, I do also bike. I aspire to take the bus. I value limiting emissions. Maybe there are other incentives to encourage bus riding, ride sharing?"
- " We need a covered, secure bike area at the detention facility."
- " If the County was able to host a daycare for employees, it would make it a lot easier to use alternative methods of transportation."

People biking along the River Trail in Missoula. (Source: The Missoulian)

Water & Wastewater Treatment Facilities: 642 $MtCO_2e$

The amount of emissions produced by the four County-operated WWTP corresponds to the population served by those WWTP. The Lolo water system, serving around 2,800 people, produced about 396 $MtCO_2e$ in 2016, while the Sunset West water system serves only 98 people and produced only 22 $MtCO_2e$.

Population served by each WWTP was not the only variable that determined the amount of emissions generated at each facility. As show in Fig. 24, all four County- operated WWTP use electricity, three use septic tank systems, one discharges waste into rivers and/or estuaries, and none of them use nitrification or denitrification as a wastewater treatment process (the lack of this process releases emissions, which is show in dark red in Fig. 24).

It is unlikely that County-operated WWTP will be a priority focus for emission reduction, since WWTP only accounted for 9% of the total emission output for County operations. However, it will be important to evaluate the capacity of these facilities as Missoula County continues to grow, and certain wastewater treatment procedures may want to be considered to limit the emissions that come with increased capacity.

Fig. 23: Emissions generated from each County operated WWTP

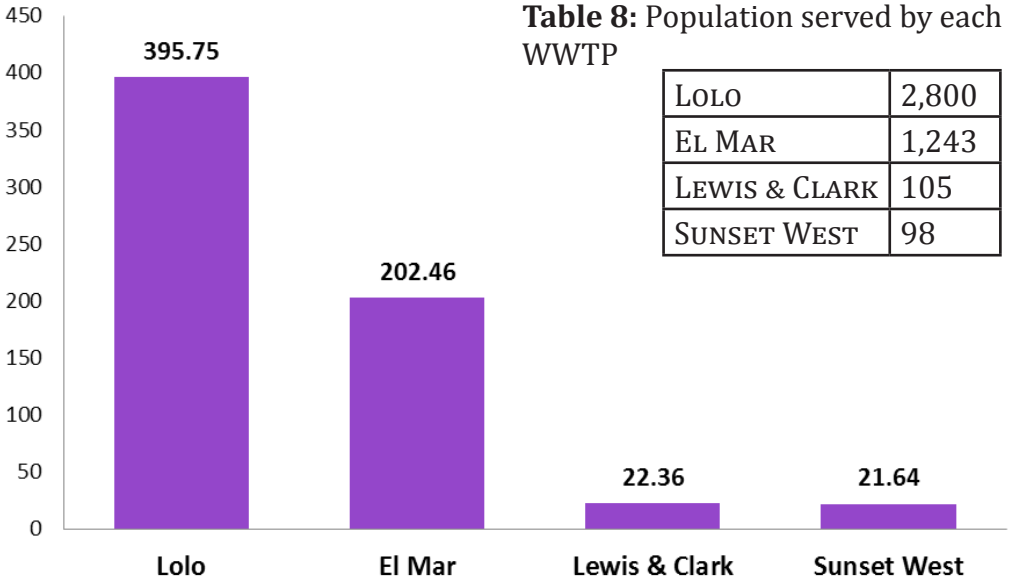


Table 8: Population served by each WWTP

Lolo	2,800
El Mar	1,243
Lewis & Clark	105
Sunset West	98

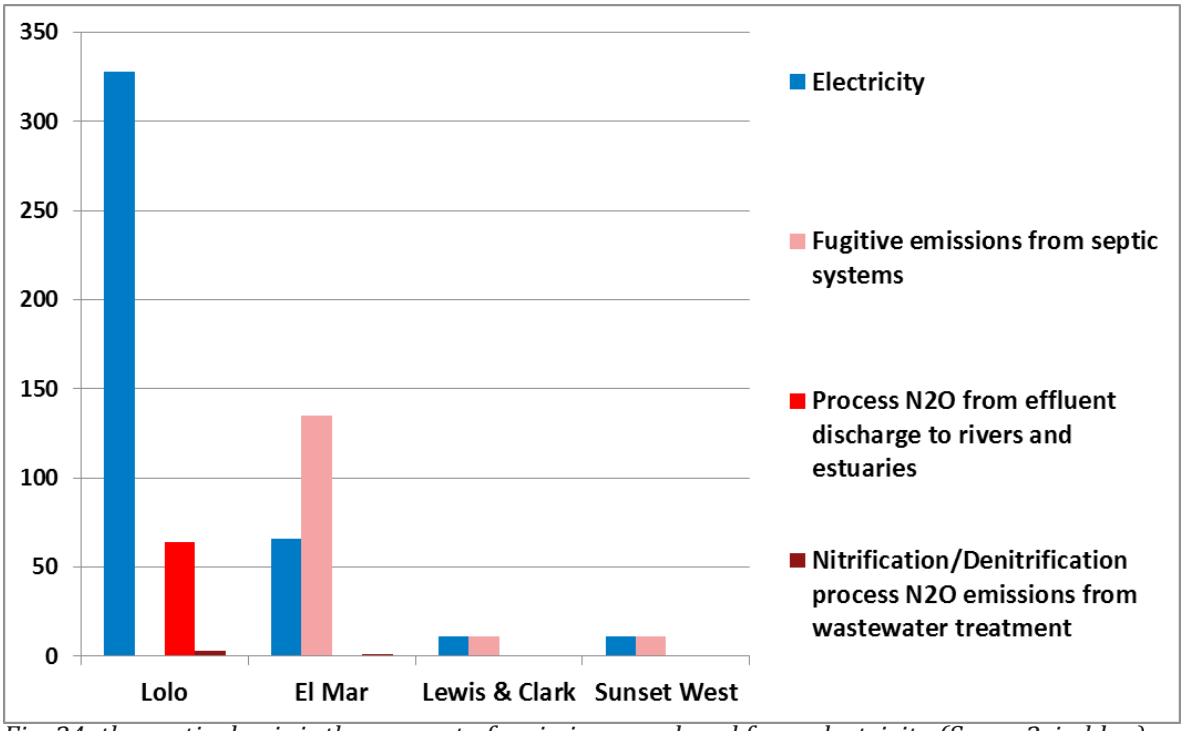


Fig. 24: the vertical axis is the amount of emissions produced from electricity (Scope 2, in blue) and different methods of wastewater treatment (Scope 1, in red).

V. Conclusions

Recommendations for Future Inventories:

- Unless the County acquires more streetlights and traffic signals, it is suggested that this sector is omitted from future inventories. As a general rule for GHG emission inventories, if a sector is less than 5% of the total emission output, it should be considered for removal. In the County's inventory, streetlights and traffic signals accounted for a total of 0.26 MtCO2e, which is less than 1% of the total emission output.
- It is recommended that the County implement a consistent, organized, and centralized record-keeping system, where utility and fuel invoices and mileage reports could be stored for future inventories and monitoring.
- Vehicles and equipment should be separated in future inventories, for the sake of reflection and monitoring.
- Create a new transportation factor set that is for vehicles years 2010-2017, instead of 1996-2017. This would generate three factor sets for vehicles: 1980-1995, 1996-2009, and 2010-2017.
- All of the NorthWestern Energy utility accounts should be supervised by one appointed employee; this can be easily achieved by adding all of the County-operated utility accounts to the same energy account on NorthWestern Energy's website. Doing this will make it easier to access invoices within a certain time-frame.

General Recommendations for County Operations:

The purpose of this Inventory Report and Analysis is to document the findings of the County's baseline GHG Emissions Inventory and explain what the results could mean for future County operations, provide context for those results in regards to the greater Missoula community, and what the County intends to do with the information offered by the baseline inventory. Most importantly, it allows the County to monitor their progress in reducing greenhouse gases over time. Moreover, the objective of this Report is not to make conclusions on how the County should operate in the future, but rather to guide decisions for forthcoming operational efforts. The final proposals for impending County policies and plans will be included in the County's Climate Action and Resiliency Plan, but based off inventory results there are some general recommendations to be considered moving forward with climate action and resiliency planning:

1. Create a climate action and policy advisory group

This group should guide the County in making final decisions regarding internal policies, plans, and practices. It will be comprised of community members who have experience with climate action planning and can provide insight to the most appropriate decisions to be made in the realms of sustainability with regard to the specific context of Missoula County operations. It is suggested that some or all of the members in County's current Greenhouse Gas Emissions Inventory Technical Advisory group be transitioned into this new policy-oriented committee.

2. Utilize climate action planning and forecasting tools

As a member of ICLEI, the County has access to forecasting, planning, and monitoring tools provided by ClearPath. In an effort to analyze the data provided in by the Emissions Inventory and make informed decisions regarding the cost benefits of certain climate actions and expected emission-reduction outcomes, utilizing these modules is recommended.

3. Dedicate resources to sustain climate action planning and implementation

Missoula County has recently decided to enhance their current staff by hiring an Energy Conservation and

Sustainability Coordinator. Increasing capacity to work toward the County's climate action and resiliency goals is crucial for long-term progression and achievement of goals.

4. Increase incentives for alternative methods of commute

Employee commute accounted for a substantial portion of the total emissions output for County operations, and expanding incentives that encourage employees to utilize different commuting methods, such as walking, biking, or taking the bus, is an important step to consider in reducing the County's contribution to climate change.

5. Collaborate with communities to identify issues and take advantage of opportunities to become more resilient in the face of a changing climate

By hosting presentations, forums, distributing surveys, or conducting listening sessions on energy conservation, energy independence, waste reduction, etc. the County can educate the public on the effects of climate change (such as drought and water concerns or wildfire potential) and how individuals can make a difference.

6. Expand and encourage renewable energy initiatives throughout County

Missoula County has made numerous commitments to solar energy, including investing in MEC's Community Solar Project and applying to become a SolSmart designated community.[1] By making efforts to explore other ways to expand renewable energy throughout the community, the County can reduce both County and community generated emissions, as well as provide additional opportunities for use of renewable energy resources.

7. Strengthen and create partnerships with community members, businesses, non-profits, and other relevant entities to address issues associated with climate change, such as impacts on the economy, the environment, and increases in potential hazards (i.e. wildfire, floods, droughts, etc.)

Through networking and forming meaningful partnerships throughout the Missoula community, the County will continue to cultivate a culture of sustainability and climate action advocacy, as well as develop local solutions to climate change.

8. *Include energy conservation, sustainability, and alternative commuting methods as topics for County employee training, orientations, and educational events*

Employee training opportunities and orientations should include suggestions for how to create a sustainable office-space, how to conserve energy, waste reduction, resources for utilizing alternative commuting methods, etc.

1 See Missoula County's Sustainability Assessment in Appendix B.

Appendix A: Comparisons

Comparisons with Similar Communities

Table 9 illustrates a comparison between total emissions from Missoula County operations and the City of Missoula operations for their baseline inventory years. Population within a government operation boundary correlates with the amount of emissions from that operation, as the population determines the types of services necessary and how large those services need to be to meet the demand of the population. The table below compares the Missoula County government, serving a population of 116,130 in 2016, and the City of Missoula government, serving a population of 68,169 in 2008.

City of Missoula residents are served by both City and County governments, although the majority of services provided to them, such as water and wastewater treatment plants (WWTP), are managed by the City government. The City of Missoula's emissions in 2008 are higher than the emissions from Missoula County, with the difference largely being from two sectors: WWTP and streetlights and traffic signals. Why is this, if the County's population is larger? Although the City of Missoula's population is included within the County's inventory boundary, the residents of the City are serviced by streetlights and WWTP provided by the City government. The County government's WWTP serve approximately 4,246 people[1], versus the 68,169 people living in the City of Missoula in 2008. The emissions from the City's WWTP and streetlights reflect the capacity of those facilities needed to meet a larger population demand.

Table 9: Comparison of baseline GHG Emission Inventories for Missoula County operations in 2016 and City of Missoula operations in 2008

SECTOR	**$MtCO_2e$**	**$MtCO_2e$**
Buildings & Facilities	2,690	2,776
Vehicle Fleet	2,066	1,707
Employee Commute	1,411	771
Water & Wastewater Treatment Facilities	642	2,739
Streetlights & Traffic Signals	0.26	873
TOTAL	**6,810**	**8,866**
	Missoula County, 2016	City of Missoula, 2008

Table 10: Comparisons of Missoula County to Cities of Bozeman and Helena

OPERATION	**YEAR**	**POPULATION**	**$MtCO_2e$**
Missoula County	**2016**	**116,130**	**6,810**
City of Bozeman	2006	36,668	7,136
City of Helena	2007	28,844	8,769

Table 11 provides further data comparisons to Missoula County's Greenhouse Gas Emissions Inventory. The following communities were chosen due to similarities in population and size. Please keep in mind the amount of incorporated cities and towns and the population served by those incorporated communities; as explained above, emissions are affected by the amount of services provided by an operation which is influenced by the size of the population served.

1 This is the sum of the populations served by each County- operated WWTP, on page 31.

Table 11: Comparisons of Missoula County operations to similar communities

OPERATION	YEAR	POPULATION	$MtCO_2e$	NOTES
Missoula County, MT	**2016**	**116,130**	**6,810**	One incorporated city with total population of 72,364
City of Flagstaff, AZ[1]	2010	66,149	51,176	
Boulder County, CO[2]	2012	305,548	12,717	Ten incorporated cities and towns with total population of 271,716
Orange County, NC[3]	2005	121,991	38,864	Three incorporated cities and towns with total population of 72,708
City of San Luis Obispo, CA[4]	2005	43,964	6,580	

Population size is far from the only factor that influences emission output for a government operation. This section focuses on population size for the sake of comparison and simplification. These comparisons should be contextualized with the understanding that there are a multitude of complexities that affect emissions for different communities and governing bodies- population size, area of the inventory boundary, how that particular government or community operates in terms of which services are provided and in what quantity, inconsistent activities such as construction that occurred during the inventory year, etc.

1 http://www.flagstaff.az.gov/DocumentCenter/Home/View/13996
2 https://assets.bouldercounty.org/wp-content/uploads/2017/03/greenhouse-gas-inventory-2006.pdf (Pg. 44)
3 http://www.orangecountync.gov/document_center/DEAPR/Orange_County_GHG_Inventory_Final.pdf (Pg. 30)
4 http://www.ca-ilg.org/sites/main/files/file-attachments/ghginventory.pdf (Pg. 31)

Missoula County Sustainability Assessment

Introduction:

Sustainability, in general terms, refers to an entity's ability to develop and operate in a way that "meets the needs of the present generation without compromising the needs of future generations." For the purposes of this assessment, Missoula County refines that definition to emphasize the County's efforts made in the realms of energy use, decreasing greenhouse gas emissions, waste reduction, and otherwise advocating for environmentally-friendly processes and development.

This assessment hopes to create an awareness of the significance of environmentally-conscious decisions of local governing authorities, thereby increasing interest and involvement in sustainable practices throughout communities. This sustainability assessment furthermore anticipates clarifying how decision and policy-makers consider the goals of environmental sustainability. The focus of this assessment is on county operations and facilities; however, information about the County's role in efforts that affect sustainability for the county as a whole are also highlighted.

Purpose:

I. Assess sustainability efforts made by Missoula County in recent years

II. Evaluate efficacy of policies and practices within Missoula County facilities and operations

III. Create a document that can be used in concert with information gained through the greenhouse gas emissions inventory, research, and community input to develop a climate action plan that guides future sustainability efforts for Missoula County facilities and operations

Internal County Policies

For the purpose of facilitating meaningful change in Missoula County, an evaluation of internal County policies is crucial in order to move forward both as a government operation and as an influential force in our community. While Missoula County has accomplished a considerable amount in the realm of sustainable policies, it should be noted that there are certain limitations; i.e. a policy is only as effective as its implementation and enforcement.

1. **Waste Reduction and Recycling Policy** (Policy No. 2012-04, November 13, 2012)

    - Reduces the amount of waste generated by County operations
    - Expands the life of a product by reuse
    - Focuses on recycling all appropriate material, disposing waste only when necessary, and encouraging the purchase of recycled products

Implementation Notes: While many departments demonstrate autonomy when implementing recycling procedures, there is no County-wide system that enforces the Waste Reduction and Recycling Policy. Several departments- the Health Department, for example- have individuals that volunteer to transport appropriate materials to the recycling center. Missoula County's Energy Corps member is currently working on enlisting recycling services for Community and Planning Services, the City-County Health Department, and Partnership Health east building, which we hope can be used as an implementation model for other County departments and facilities.

2. **Green Building Policy** (Resolution 2010-070, June 10, 2010)

- Developed by the County's Green Government Committee
- Aims to "achieve the highest, most cost-effective environmental performance possible over the life of County projects"
- Encourages the use of green building practices in design, construction, and operation of County facilities
- Promotes Leadership in Energy and Environmental Design (LEED)* certification when designing, remodeling, and operating County facilities
- Establishes the Green Building Team
- Goals of implementing this policy include the creation of local jobs as well as improving employee health and productivity

Implementation Notes: While all design and construction proposals are required to comply with the goals of the Green Building Policy, each department is responsible for incorporating this policy internally, as well as pursuing green building training opportunities. The Courthouse is an example of a County facility that is currently being remodeled to seek the minimum LEED certification level. It should also be noted that the Green Building Team no longer exists.

**LEED is a third-party certification program that is recognized as the national standard for developing high-performance, sustainable structures. LEED comprises a rating system that establishes silver, gold, and platinum levels, ranking efficiency of energy and water, indoor environmental quality, and sustainability.*

3. **Motor Pool Vehicle Procurement Policy** (Policy No. 2007-04, September 20, 2007)
    - Ensures that County vehicles are environmentally sustainable, specifically considering fuel economy and emissions

Implementation Notes: The County's motorpool includes a 2009 Toyota Prius with a fuel economy of 46 MPG and a 2012 Toyota Prius with a fuel economy of 48 MPG, while the average fuel economy of the motorpool is 24.4 MPG (36 vehicles). The Water Quality District fleet (three vehicles) includes a 2003 Honda Civic Hybrid with a fuel economy of 41 MPG and an overall fuel economy average of 27 MPG. There are several other fleets within County operations, but no others that have vehicles with outstanding fuel economy such as hybrid vehicles.

4. **Disposal of County Surplus Property Policy** (Policy No. 2011-02, May 31, 2011)
    - Aims to establish procedures for the discarding of surplus county real and personal property
    - Controls waste and misuse of County property
    - Advises disposal of surplus property should minimize environmental impacts
    - Encourages departments to utilize opportunities for reduce-reuse-recycle
    - Primary goal of this policy is to obtain the maximum use from a piece of property and to recover any residual value at the time of disposal

Implementation Notes: Departments are permitted to apply additional requirements so long as they are equal to or more restrictive than the standards established by this policy. Department heads are held responsible for forming procedures to demonstrate compliance. It is difficult to find data on the efficacy of this policy, and how well it is being implemented.

Plans

In addition to official County policies, Missoula County has also incorporated sustainability and environmental-action into many of their updated plans and procedures for continued operation.

1. **Addition of Climate Change Provisions in** County's Growth Policy

    - Ch. 2, Goal 4: Reduce Missoula County's contribution to climate change while promoting resiliency and adapting to its impact on the natural environment and the community

Objectives	Actions
4.1 Reduce Missoula County's contribution to climate change	4.1.1 Use green building principles and consider energy efficiency and waste reduction when siting, upgrading, and constructing public facilities. 4.1.2 Adopt a green-building incentive program for qualifying private sector development projects focusing on siting, energy efficiency, waste reduction and other measures 4.1.3 Encourage alternative energy development and use in county facilities and land use plans and policies. 4.1.4 Work with Mountain Line, MRTMA and/or other transportation providers to expand service to rural areas and/or promote ridesharing. 4.1.5 Ensure land use plans and regulations accommodate home-based businesses where appropriate to reduce vehicle miles traveled. 4.1.6 Develop county policy to reduce energy use and waste generation at the county level and encourage recycling efforts. Find and use renewable energy sources where possible.

4.2 Develop and implement strategies to adapt to climate change	4.2.1 Convene a working group to investigate the current level of greenhouse gas emissions generated from County facilities and develop a climate change monitoring, mitigation, and adaptation plan for Missoula County or participate in other local working groups
4.3 Encourage legislative action on alternative energy	4.3.1 Support the continuation of tax breaks for alternative energy 4.3.2 Lobby for tax breaks for community solar

- **Implementation Notes:** Missoula County Board of County Commissioners, Missoula City-County Health Department, and Missoula County Community and Planning Services each committed resources to allow the County to host its first Energy Corps member to help implement climate action initiatives outlined in the 2016 Missoula County Growth Policy. Work by the Energy Corps member includes:

- Creating the County's baseline Greenhouse Gas Emissions Inventory for County facilities and operations

- Identifying recent and current sustainability policies, practices, plans, and initiatives as outlined in the Sustainability Assessment

- Researching climate action planning models for the County

- Researching how to develop an ongoing sustainability program

  Implementing recycling for a cluster of departments and developing a model for other departments to eventually adopt

2.

2012 Energy Conservation Code

- Adopted as part of the County Building Code, as required under the State Building Code

  i. New construction of buildings in the County must meet certain energy-efficiency qualifications:

  ii. At least 75% of permanent light fixtures must have high-efficiency bulbs (CFLS & LEDS)

  iii. Insulation and air-sealing requirements: Blower Door Test (measurement of building air tightness)

  iv. Testing of heating system ductwork is required

- Programmable thermostats on forced air (furnaces)

  i. Tax credits & incentives:

  ii. Homebuyers are eligible for a state tax credit of up to $500 per individual when they purchase or build a home "above" the energy code or improve the efficiency of their existing home

  iii. $1,500 tax credit for utilizing geothermal systems

  iv. $500 tax credit for wind and solar systems

  $500 for qualified wood and pellet stoves

3.

Incorporating Climate Change Impacts in Emergency Management (projects underway)

- Acknowledging climate change as a formidable force throughout the Emergency Management Operations' (EMO) pre-disaster mitigation plan (PDM)

  - PDM identifies mitigation strategies for hazards that the County is more susceptible to due to climate change*, such as:

  - Increased wildfire potential

  - Increased flooding

  - Unpredictable and severe weather conditions

- Increased droughts

The Pre-Disaster Mitigation Plan was approved by the MT DES, FEMA Region 8, and was adopted by both City and County May 2017

**These hazards exist regardless of climate change, but are exacerbated as a result of climate change*

4.

Community Wildfire Protection Plan (Project underway)

- Provides a plan for improving adaptability of communities and the county in the face of increasing wildfire activity due in part to climate change.
- Includes a wildfire risk assessment
- Guides how to create resilient landscapes and fire adapted communities in regards to defensible space, protecting key community assets, public outreach and education and land use planning
- Provides information about improving response and suppression capabilities
- Includes an action plan

5.

Land Use Strategy (LUS) (Project underway)

- As an amendment to the Missoula County Growth Policy, the LUS is a plan for how to guide growth towards existing communities and activity areas in the county, avoid risks such as flooding and wildfire, and protect key resources.
- The county land use map, as part of the Growth Policy, is being updated over the next couple of years, starting with the urban area
- Mapping in rural areas is planned to start in 2019 or 2020
- The updated land use map will identify areas for growth and protection in the county. Land use mapping will be developed using community input guided by adopted County policies that encourage sustainable growth and development, such as encouraging growth in and around existing communities and avoiding additional development in hazardous areas.

  The LUS update will take consideration of sustainability and environmental health in order to achieve resiliency, for structures, communities and the landscape, and will avoid development on environmentally sensitive areas such as wetlands and floodplains

6.

Transportation Planning

i. Activate Missoula 2045- adopted 2017, developed by the Missoula Metropolitan Planning Organization, which covers the City of Missoula and portions of the County in the urban areas and areas surrounding the City:

ii. Long range transportation plan that “provides a blueprint for creating an accessible and connected transportation system over the next 30 years.”

iii. Strategic plan to invest in and otherwise support regional transportation objectives. Activate Missoula intends to coordinate with the various transportation partners on their projects and goals in order to prioritize the needs of the community in urban areas

iv. Incorporates all conventional methods of transportation, i.e. walking, biking, driving, rail, freight, air, and using transit

1. Sets goals for reducing vehicle miles traveled and improving access to transportation alternatives, specific goals include:

2. Maintain our existing transportation system

3. Improve the efficiency, performance, and connectivity of a balanced transportation system

4. Maximize the cost-effectiveness of transportation

5. Promote consistency between land use and transportation plans to enhance mobility and accessibility

6. Provide safe and secure transportation

7. Promote economic vitality

8. Protect the environment

v. Promote community health and social equity through the transportation system

vi. Matches community needs and available funding

- Expects to support County and City's Growth Policy updates; using transportation systems to help implement plans within growth policies

i. Missoula Active Transportation Plan (MATP)- adopted 2011, covers the City of Missoula and the surrounding urban ares:

ii. Lays out the community's vision for the bike and pedestrian components of the larger, multi-modal transportation system

Recommends new policies and designs and provides a list of proposed projects from which the MPO can draw in prioritizing federal aid transportation funding for bike and pedestrian infrastructure.

Challenges: In general, when considering sustainability in transportation plans, it is difficult to overcome the public's perceived safety of "alternative" transportation methods (i.e. biking, walking). There are also perceived time commitments that come with the walking or biking; many people believe they are unable to accommodate their schedules with the time it takes to walk, bike, or take the bus. Providing incentives that compete with free parking is also challenging, as free parking encourages the use of personal vehicles and not buses, biking, walking, etc. Moreover, advocating for sustainable transportation requires substantial staff time, and if support is not top-down, it is unlikely to succeed. A large portion of Missoula County residents live outside of City limits, and currently do not have convenient access to trails, sidewalks, or other means of connection to the City that allow for biking, walking, or use of public transportation for work within the City.

7.

Consideration of Sustainability Provisions in Development Regulations

- Zoning regulations, in general, structure an appropriate setting for sustainable development. Subdivision regulations could be implemented perfectly, but if a location is inappropriate for development, the protocols are completely invalidated.

- There are certain protocols present in zoning regulations that aim to protect riparian areas, floodplains, and other ecologically significant areas. These principles, by defending natural areas, promote environmental security, and therefore sustainability.

  Protocols in subdivision regulations for Missoula County also address planning procedures

and adaptation or mitigation techniques for natural disasters; threats that are heightened as a direct result of climate change.

I.

- Planning for floods:

- New developments, such as roads, utilities, or other subdivision related developments are prohibited in a floodplain.

- Major subdivisions (six lots or more) that include land defined as a floodplain must not develop on that land.

- Flood hazard areas are deemed appropriate for use of common areas, open spaces, and agricultural areas.

  These regulations meet, and in some cases exceed, FEMA standards, and enhance the integrity of natural river systems and their inevitable migration over time.

II.

- Planning for wildfire:

- Proposed subdivisions located in the Wildland Urban Interface (WUI), or subdivisions that score a moderate or higher score on the Fire Hazard Assessment, are of particular risk of wildfire.

- Information produced by the wildfire risk assessment and the Community Wildfire Protection Plan (item 4) in conjunction with the predictive housing development model will aid in planning of safe and appropriate land development intended to reduce wildfire risk.

- County land use planners, firefighters, and other land management agencies are collaborating to improve growth management and wildfire risk reduction in the WUI.

  Through improved land use planning and helping communities reduce their exposure to wildfire dangers, Missoula County is actively addressing climate change impacts.

- June 2015: the BCC adopted 3.2.2.11 Solar Orientation into the subdivision regulations: Streets in residential subdivisions should, where possible, be aligned to within 30 degrees of an east-west axis to support solar panel utilization

- As part of the future update of the Missoula County Zoning Regulations, staff with examine opportunities to incorporate sustainability provisions.

Future updates to the Missoula County Subdivision Regulations may also incorporate additional sustainability provisions

Challenges: Generally, Missoula County residents prefer a non-regulatory approach to addressing issues within the community. However, sometimes regulations are necessary to confront these issues. As the County moves through its zoning update, the County should take advantage of opportunities to incorporate sustainability provisions into the regulations. Similarly, there are also opportunities to better address sustainability in the Missoula County Subdivision Regulations, which may be pursued in the future.

8.

Health Department's Plan to Address Climate Change as a Public Health Issue

i. The US Global Climate Research Program has identified the following as the key threats to public health, as a direct result of climate change:

ii. Increases in heat illness and deaths related to extreme heat

iii. Changes in temperature extremes will affect air quality

iv. Mental health problems will increase due to increases in extreme weather conditions

v. Increases in diseases that are transmitted by food, water, and insects

vi. Increases in allergy-related health risks due to pollen production as a result of rising temperatures, including respiratory conditions such as chronic obstructive pulmonary disease and asthma

- Children, the elderly, and those of low socioeconomic status will be most vulnerable to health risks associated with climate change
- The Missoula City-County Health Department has formed an internal Climate Change Committee and is working on a Climate Change Adaptation Plan that outlines how MCCHD will respond to health issues resulting from climate change
- Primary issues discussed in the plan include extreme heat, disease patterns, water quality, food, air quality, and mental illness

The MCCHD's plan will also identify methods and resources for mitigation, specific to Missoula County. For example, the plan will include a list of indoor cool-air locations as previously identified by Climate Smart Missoula, with the intention of public distribution

Practices

Aside from official policies and plans, Missoula County departments have also demonstrated a commitment to being sustainable and to the environment through their own autonomous practices. While this assessment primarily focuses on the administrative operations of Missoula County, this section also lists practices that may be more community-oriented.

1. Sustainable Sites Initiative (SITES) Certification of Fort Missoula Regional Park (FMRP)

- FMRP aims to be SITES certified by 2018. Phase I of FMRP opened on April 29, 2017. Construction efforts continue on Phase II toward and anticipated 2018 completion
- SITES is a sustainability-focused framework that certifies landscapes that reduce water consumption, filter and reduce storm water runoff, provide wildlife habitat, reduce energy consumption, improve air quality, promote a healthy lifestyle, and increase outdoor recreation opportunities
    - SITES provides performance measures, allowing support of unique site-specific conditions, such as:
    - Rehabilitation of soil conditions by planting native flora and vegetation
    - Site design, construction, and management that limits generation of waste
- Landscape development focusing on reducing greenhouse gas emissions and preserving natural resources
    - The FMRP project team used sustainable building practices and locally sourced material throughout the project to:
    - Protect and maintain culturally and historic places
    - Support physical activity, mental restoration, and social connection

- Reduce energy consumption (i.e. LED lighting fixtures on the 5-plex sports field complex)

- Reduce greenhouse gas emissions

Challenges: The project is early in the SITES certification process. An initial challenge was accumulating project history required for SITES certification, as the planning process of FMRP has a 20-year history. Another challenge has been ensuring that the project intent to improve soil condition satisfies the 12 inch minimum depth of topsoil suggested for SITES certification. Due to the nature and location of FMRP, a 6 inch consistent depth of topsoil is uncommon. As a result of project scale and cost to meet minimum soil depths, the project team focused on the intent by restoring the site to meet and exceed pre-developed soils conditions that will withstand the indented use and purpose of the site.

2. LEED Certification of Courthouse

- Courthouse renovation and the LEED certification process began in 2011 and had an expected completion date of September 2016. We are currently in Phase V of the project, which focuses on the parking lot and surrounding landscaping

- The Courthouse renovation is expected to meet the minimum amount of credits (we currently have 33) to reach the first level of LEED certification, simply called LEED Certified (40 points). However, project developers are hopeful to reach 50 credits, earning a Silver designation. Following Silver is Gold at 60-79 points, and Platinum at 80+ points.

    i. There are specific prerequisites that a building must meet in order to meet minimum certification requirements:

    ii. Construction Activity Pollution Prevention (attempted)

    iii. 20% Water Use Reduction (awarded)

    iv. Fundamental Commissioning of the Building Energy System (attempted)

    v. Minimum Energy Performance (awarded)

    vi. Fundamental Refrigerant Management (awarded)

    vii. Storage and Collection of Recyclables (attempted)

    viii. Minimum Indoor Air Quality Performance (awarded)

- Environmental Tobacco Smoke Control (awarded)

    i. In addition to the awarded prerequisites listed above, the Courthouse has also been awarded for several other credits:

    ii. Development Density and Community Connectivity

    iii. Public Transportation Access

    iv. Bicycle Storage

    v. Low-Emitting and Fuel Efficient Vehicles

    vi. Parking Capacity

    vii. Maximize Open Space

    viii. Water Use Reduction

    ix. Optimize Energy Performance

x. Enhanced Refrigerant Management

xi. Radon Mitigation

Exemplary Performance- Maximize Open Space

Challenges: The main challenge has been navigating the complexities of the building itself; due to the historical nature of the Courthouse, it was difficult to renovate whilst still preserving its historical features. The "easiest" LEED Certification project would be a newly constructed building, as opposed to a renovation. Additionally, employees were still present in the Courthouse during the renovation, and thus proved difficult to coordinate employee schedules with the expectations of renovation completion.

3.

Public Outreach and Education of Pollution and Water Quality

- Missoula County's Water Quality District has held a household hazardous waste collection event (Haz Waste Days) every year since 1993. Plans for a permanent collection facility are currently underway.
- At the Haz Waste Days event, residents of Missoula County are able to drop off their hazardous materials (oil-based paints, paint thinners, degreasers, gasoline, fertilizer, used motor oil, etc.) at no charge. Residents are also able to drop off pesticides, herbicides, and other toxic products for a small fee. The materials are then disposed of in an appropriate way- a collaboration with Home ReSource to allow reuse of usable products from Haz Waste Days is likely in the future.
- Haz Waste Days not only increases public safety through education, but also promotes environmentally-healthy behaviors. Ultimately, Haz Waste Days embodies a fundamental goal of the WQD, as outlined in their website: "Public education on prevention of water pollution."
- The WQD also initiated the website riversmartmt.org, which includes a multitude of educational information and resources that elucidate on the importance of native plants for healthy riparian areas and streams. Water quality is dependent upon the native plants that reside along the banks, as plants filter out pollutants, stabilize banks, and support wildlife, all of which contribute to a healthy river and riparian ecosystem.
- In addition to online resources, the WQD will periodically publish newspaper, radio, and TV advertisements about pollution and waste reduction for protection of riparian areas.

The WQD furthermore educates the public by working with schools and community groups to perform storm drain stenciling around Missoula, as well as presenting school programs about water quality to all grade levels, including at the University of Montana.

4.

Encouraging a More Sustainable Commute

- Missoula County contributed to MUTD/Mountain Line's Zero Fare Program that started in 2015 as part of a three-year pilot project. Ridership has increased by 38% just in the first 12 months of the program
- Missoula County provides funding to help support Missoula Ravalli Transportation Management Association (MRTMA) and Missoula in Motion (MIM), which helps address travel demand management and provide options for employee commutes, including those that extend beyond Mountain Line's service area
- The County's Parks, Trails, and Open Lands (PTOL) program has also established a number of transportation and recreation trails throughout the county. PTOL has partnered with City Parks and Recreation, the Montana Department of Transportation, and the Metropolitan Planning

Organization (MPO) on developing additional trails that can be used for recreation and transportation within the urban area

- For instance, the Montana Department of Transportation was instrumental in the development of the Missoula to Lolo (M2L) pathway, and the PTOL program works closely with them on implementing shared-use paths as part of roadway reconstruction projects

The M2L trail is a seven mile, multi-use pathway that stretches from Missoula to Lolo. The trail is part of a larger, 45 mile trail system known as the Bitterroot Trail. The M2L trail was identified as a necessity by City and County planners over 20 years ago, and was completed in June 2016.

Challenges: While the public continues to increase demand for trails, there are limited resources to meet these expectations, especially considering construction and maintenance of the proposed trails. Additionally, the three-year pilot project for Mountain Line's Zero Fare Program comes to an end this year; concerns on how to continue funding this program are pertinent at this time.

5.

Habitat Certification of County Parks

In collaboration with the National Wildlife Federation (NWF), the County has designated five different conservation parks as a Certified Wildlife Habitat, otherwise known as NWF's Garden for Wildlife program

i. Tom Green Memorial Park (located along Rattlesnake Creek)

ii. Ravenwood Park (located in the Linda Vista area)

iii. Lions/Clearwater Park (Seeley Lake)

iv. Riverside Park (Lolo)

v. Hellgate Park (Turah/Clinton area)

- **More information on these parks can be found here:** http://gis.missoulacounty.us/CAPS/ParksAndTrails/
- The Garden for Wildlife program promotes healthy and sustainable gardening techniques that encourage the restoration of natural habitats and support wildlife
- In order to have areas certified as Wildlife Habitat, it must meet the minimum "components of habitat" as defined by the NWF:

Food Sources (3 minimum)	Seeds, berries, nectar, nuts, fruits, sap, pollen, foliage/twigs, supplemental feeders (butterfly, squirrel, suet, hummingbird, seed, etc.)
Water Sources (1 minimum)	Bird bath, shallow dish, lake, stream/river, seasonal pool, ocean, spring, rain garden, butterfly puddling areas, water garden/pond
Places for Cover (2 minimum)	Wooded area, bramble patch, ground cover, rock pile/wall, cave, roosting box, dense shrubs/thicket, evergreens, brush/log pile, burrow, meadow/prairie, water garden/pond

Places to Raise Young (2 minimum)	Mature trees, meadow/prairie, nesting box, wetland, host plants for caterpillars, dead trees/snags, dense shrubs/thicket, water garden/pond, burrow, cave
Sustainable Gardening Practices (2 minimum)	Limit water use, collect rain water, plant buffer around bodies of water, xeriscape, drip or soaker hose for irrigation, use of mulch or ground cover to retain soil moisture and limit erosion, reduce or eliminate lawn, practice integrated pest management, remove invasive species, keep cats indoors, use native plants, eliminate chemical pesticides and fertilizers, create compost pile

6. Commitment to Renewable Energy through Community-Oriented Programs

- Investment in Missoula Electric Cooperative's Community Solar Program (MEC Solar):
    - Program helps community members overcome obstacles of taking advantage of solar energy by installing photovoltaic (PV) arrays within their service area as an effort to supplement community residents' energy usage
    - County initially invested in 10 solar panels during Phase I of the program in Lolo
    - County further invested in 49 panels during Phase II in Frenchtown
    - Together, both investments offset the County's annual electricity usage from MEC by 5%
- County's goal to achieve at least a Bronze* designation through the SolSmart program:
    - SolSmart is a program aimed at reducing soft costs** of solar energy
    - Increase opportunities to develop and use solar energy
    - Make it faster, easier, and more affordable for County residents and businesses to install and utilize solar energy systems
    - These efforts aim to increase the efficiency of local processes related to solar development, which may save time and money
- The County also provided support for legislative items that advocated for the use of renewable energy, particularly bills that supported net metering of solar energy systems. The County furthermore adamantly opposed items that discriminated against the advancement of renewable energy use in Montana.

**In order to attain a Bronze designation, a community must meet the program pre-requisites: point requirements in the two foundational categories- Permitting and Planning, Zoning and Development Regulations. These pre-requisites require communities to create a permit checklist online and conduct a review of existing barriers in the zoning code. Once a community meets these pre-requisites, an additional 20 points must be earned in all categories (for a total of 60 points).*

***Solar soft costs include the non-hardware (i.e. PV panels) costs of installing solar energy systems. These costs include expenditures associated with planning and zoning, permitting and inspection, financing, customer acquisition, and installation labor.*

Challenges: The decision to participate in the SolSmart program was very recent, as we just sent our letter

of support in February. Montana Renewable Energy Association will be the advisor for this program. We have yet to fully discuss our potential role in the program or expectations with MREA.

7. Upgrades to Lighting, Heating, Cooling, and Ventilation Systems

A. Courthouse

i. Renovation seeking LEED Certification

ii. Four Arco high-efficiency boilers replacing two old steam boilers, saving 27% in thermal usage from natural gas

iii. Heat-recovery system that recovers ~ 75% of heated air used to preheat air entering the courthouse

iv. During remodel of Courthouse Annex- upgrades to all air handling units to more efficient systems that incorporate a heat recovery system

v. Upgraded old heat pumps in the Courthouse and Annex for more efficient models

vi. Upgraded from T-12 to T-8*, to the current LED light fixtures, saving 37% in kWh usage

B. Health Department

i. Upgraded to more efficient hot water boiler

ii. Upgraded from T-12 to T-8 light fixtures

iii. Replaced old non-insulated doors on existing roof top HVAC unit with new insulated doors to help keep the air warm in the winter and cool in the summer

iv. Upgraded HVAC motor with a more efficient motor

C. Grants Department

i. Upgraded heating units to more efficient models during remodel of building

ii. Light fixtures upgraded to T-8

D. Detention Center

i. Two Arco boilers added to be used when the primary boilers produce too much heat- i.e. the new boilers utilized during spring/summer months

ii. Upgraded light fixtures from T-8 to LEDs, saving 37% in kWh usage

iii. Warehouse & shop designed for high-efficiency heating systems

iv. Warehouse & shop designed with sky lights to save kWh usage

v. Upgraded to T-5 light fixtures in warehouse

E. Partnership Health, east

i. Installed two high-efficiency boilers, saving 20% in thermal usage from old models

F. Partnership Health, west

i. Replaced old boilers with high-efficiency models

ii. Installed high-efficiency heating units

iii. Upgraded light fixtures to T-8

G. Partnership Health, Lowell School

i. Building designed using high-efficiency furnaces

ii. T-8 light fixtures

H. Records Management

i. Upgraded heating systems to higher-efficiency

ii. Upgraded light fixtures to T-8

**Note regarding florescent tube light fixtures: T-12= low efficiency, T-8= higher efficiency, T-5= most efficient*

Challenges: The departments within Missoula County are all, generally speaking, independent from each other and tend to operate autonomously. For this reason, it is difficult to gather data regarding lighting, heating, and other building upgrades. Facilities Management keeps track of upgrades that they supervise; however, there does not seem to be an all-inclusive list of all energy-related upgrades for every County facility.

Conclusion

In many instances, as outlined in this document, Missoula County has embraced operational sustainability. The County has retrofitted buildings to have LED lighting and high-efficiency boilers and HVAC systems, purchased incredibly fuel-efficient vehicles into the County motor pool, advocated for renewable energy use where appropriate, encouraged environmental conservation and stewardship, etc. All of these sustainability efforts made by the County help to protect residents' livelihoods and provide economic security.

While efforts were made to make this list as comprehensive and inclusive as possible, there may be policies, plans, or practices within County operations that were unaccounted for in this document. The County plans to update the Sustainability Assessment as often as necessary to keep the information contained in this document up-to-date and accurate.

Appendix C: Inventory Tool Memo

MISSOULA COUNTY COMMUNITY AND PLANNING SERVICES

200 W. BROADWAY

MISSOULA, MONTANA 59802-4292

PHONE: (406) 258-4657 FAX: (406) 258-3920

To: Patrick O'Herren & Karen Hughes
From: Erika Barnett
Date: 11/14/2016

Re: Preferred tool for Missoula County Greenhouse Gas Emissions Assessment

Missoula County is experiencing some of the unfortunate effects of climate change. This includes not just rising temperatures, but increased wildfire potential, declining snowpack, and greater stress on ecological systems, just to name a few. However, we have the opportunity to come together as a community to prepare for an uncertain future. As the Energy Corps member for Missoula County, it is my responsibility to work with other county staff to create our first greenhouse gas (GHG) assessment for county facilities and operations, which is the key initial step to combating climate change. The county can use this baseline GHG emissions inventory to track GHG emissions, and make more environmentally-conscious decisions regarding county operations. This assessment can also help the County to develop a Climate Action Plan that includes setting realistic goals for a more sustainable future.

The first step in conducting a GHG emissions inventory is to select the most appropriate inventory tool to store, process, and track emissions data over time. I have completed fairly extensive research on a number of different programs, and have more thoroughly examined two viable options: the EPA's Local Inventory Tool and ICLEI's ClearPath. Below is a brief description followed by an outline of benefits and drawbacks for each tool.

Local Inventory Tool was developed by the Environmental Protection Agency as an interactive spreadsheet, which allows local governments to evaluate their operation's GHG emissions.

- Benefits – This inexpensive tool is available online and it allows the user to input data for several sectors, including transportation, residential, commercial, waste management, and water management. The EPA also provides many external resources to help the user understand how to use the tool and related protocols.
- Drawbacks – This tool does not include internal emission-factor protocols and calculation tools, which are required for conversion of raw data into data that can be used in the tool. Due to this omission, there is a higher staff cost in the time it takes to complete each assessment and there are greater chances for error each time an assessment is completed, especially if this is assigned to different staff over time. In addition this tool does not include more complex data-analysis modules.
    - For example, in order to calculate emissions from stationary combustion sites, I would need the necessary data (what fuel is being used and how often), and then I would need to figure out the CO2 emission factor for each fuel type (bituminous coal, residual fuel oil, diesel, liquefied petroleum gas, or natural gas). I would also potentially need to use the following equation to convert fuel purchase and storage data into estimates of fuel use:
        - TOTAL ANNUAL FUEL CONSUMPTION= ANNUAL FUEL PURCHASES- ANNUAL FUEL SALES + FUEL STOCK AT BEGINNING OF YEAR- FUEL STOCK AT END OF YEAR

As you can imagine, using the emissions factors conversion equations as well as fuel usage equations can be very time consuming.

- Costs- Free for the tool. However, this does not include the additional staff costs required for each assessment.

ClearPath was developed by ICLEI (formally known as International Council for Local Environmental Initiatives) as an extensive cloud-based software package that provides users with detailed protocols, modules, and exceptional technical assistance.

- Benefits-In addition to the benefits provided by the EPA's Local Inventory Tool, ClearPath is pre-programmed to complete emissions calculations for the user. There are a few different modules (i.e. Planning, Forecasting, and Monitoring), which allow for further data analysis and would be incredibly useful now or in the future, as the County develops and updates a future Climate Action Plan. Both the City of Missoula and Climate Smart Missoula endorse ClearPath as the best program to use for emissions accounting, and also use ClearPath as their primary emissions-data program. Having emission data uniformity, and consistently in one program, across the City, County, and community would allow for a better communication between such entities, as well as more efficient planning and collaboration. By using the same tool as the City and Climate Smart Missoula, these entities would likely prove to be helpful resources should I need help developing the emissions inventory.
- Drawbacks- The program comes with an annual cost, which covered under County membership in ICLEI USA – Local Governments for Sustainability. In addition, there have been several residents over the years who have raised concerns about ICLEI.
- Cost - Approximately $1,750 annually. However, there is an expected savings in staff time needed for each assessment as compared with the EPA tool due to the preprogrammed protocols and superior technical assistance provided by ClearPath.

Conclusion and Recommendation

I have familiarized myself with both programs and, having read both the EPA's and ICLEI's user guides for their respective inventory tools, can say with confidence that ClearPath is the superior choice.

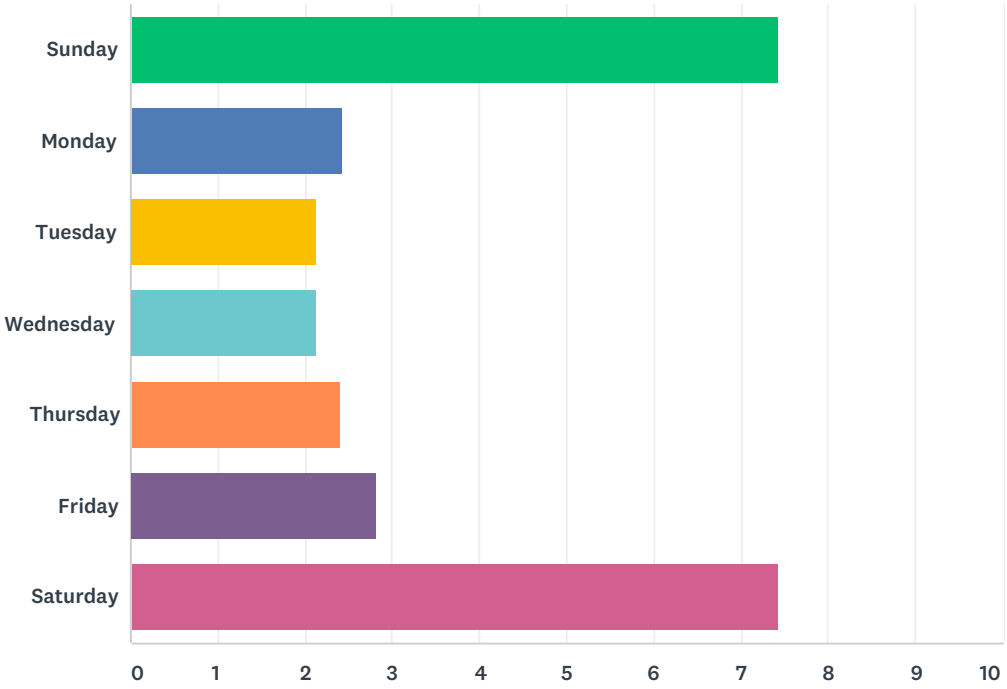
Either tool may technically work, but based on my research I am fairly certain that using the EPA's tool will take more time and effort in creating a baseline emissions inventory than ICLEI's ClearPath and that there is a higher chance of error with each assessment due to differences in how information processed and input into each assessment.

Ultimately, I believe that the ClearPath program will benefit Missoula County the most, not just for completing the initial emissions assessment, but because we are able to more accurately track data over time and because I expect more advanced modules will be useful in developing the subsequent Climate Action Plan.

Appendix D: Employee Commute Survey

Q1 In a typical week during colder months (autumn/winter), how do you travel to work?

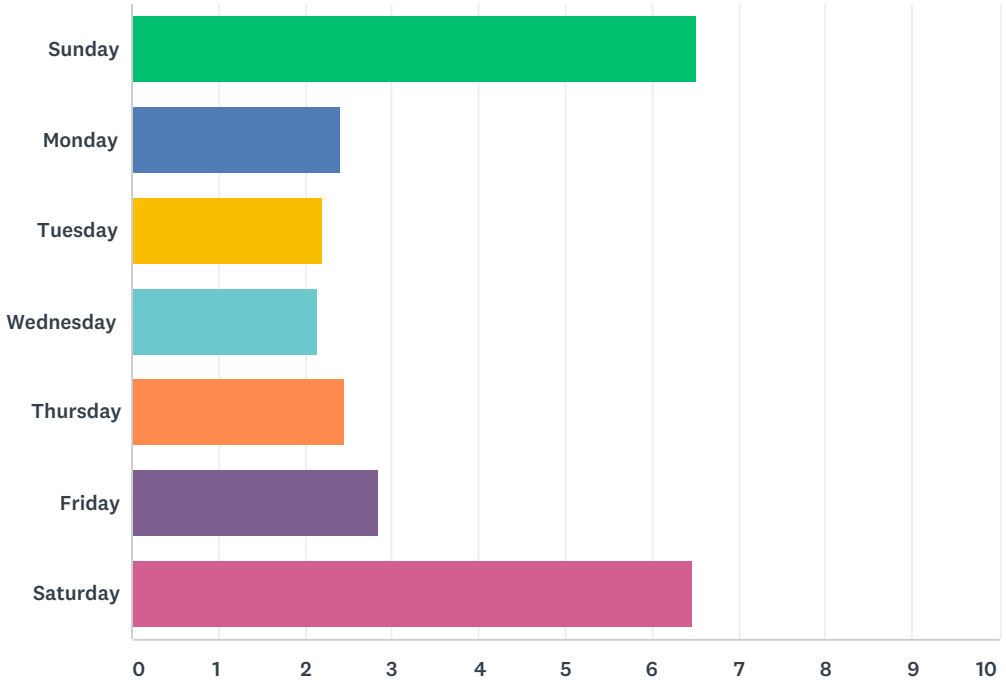
Answered: 199 Skipped: 0



	DRIVE ALONE	CARPOOL (2-7 PEOPLE)	VANPOOL (8+ PEOPLE)	BUS	BIKE	WALK	WORK FROM HOME	DAY OFF	TOTAL	WEIGHTED AVERAGE
Sunday	7.54% 15	0.50% 1	0.00% 0	0.00% 0	0.50% 1	0.00% 0	0.50% 1	90.95% 181	199	7.42
Monday	60.30% 120	12.06% 24	0.00% 0	10.55% 21	2.51% 5	6.53% 13	0.50% 1	7.54% 15	199	2.42
Tuesday	63.32% 126	12.56% 25	0.00% 0	11.56% 23	2.51% 5	6.53% 13	0.50% 1	3.02% 6	199	2.14
Wednesday	64.82% 129	11.56% 23	0.00% 0	10.05% 20	2.51% 5	7.54% 15	0.50% 1	3.02% 6	199	2.14
Thursday	61.31% 122	10.05% 20	0.00% 0	12.06% 24	2.01% 4	7.04% 14	1.01% 2	6.53% 13	199	2.41
Friday	54.77% 109	11.06% 22	0.00% 0	12.06% 24	2.51% 5	5.53% 11	1.51% 3	12.56% 25	199	2.82
Saturday	7.54% 15	0.50% 1	0.00% 0	0.00% 0	0.50% 1	0.00% 0	0.50% 1	90.95% 181	199	7.42

Q2 In a typical week during warmer months (spring/summer), how do you travel to work?

Answered: 199 Skipped: 0



	DRIVE ALONE	CARPOOL (2-7 PEOPLE)	VANPOOL (8+ PEOPLE)	BUS	BIKE	WALK	WORK FROM HOME	DAY OFF	TOTAL	WEIGHTED AVERAGE
Sunday	7.04% 14	0.50% 1	0.00% 0	0.00% 0	1.01% 2	0.50% 1	0.50% 1	90.45% 180	199	6.51
Monday	54.77% 109	11.06% 22	0.00% 0	6.53% 13	14.57% 29	6.03% 12	0.50% 1	6.53% 13	199	2.40
Tuesday	57.79% 115	11.56% 23	0.00% 0	7.04% 14	15.08% 30	5.03% 10	0.50% 1	3.02% 6	199	2.19
Wednesday	59.80% 119	10.55% 21	0.00% 0	7.54% 15	14.07% 28	4.52% 9	0.50% 1	3.02% 6	199	2.14
Thursday	54.27% 108	10.55% 21	0.00% 0	9.55% 19	11.56% 23	6.03% 12	1.01% 2	7.04% 14	199	2.45
Friday	48.24% 96	10.05% 20	0.00% 0	8.54% 17	12.06% 24	6.03% 12	1.51% 3	13.57% 27	199	2.85
Saturday	7.54% 15	1.01% 2	0.00% 0	0.00% 0	0.50% 1	0.50% 1	0.50% 1	89.95% 179	199	6.47

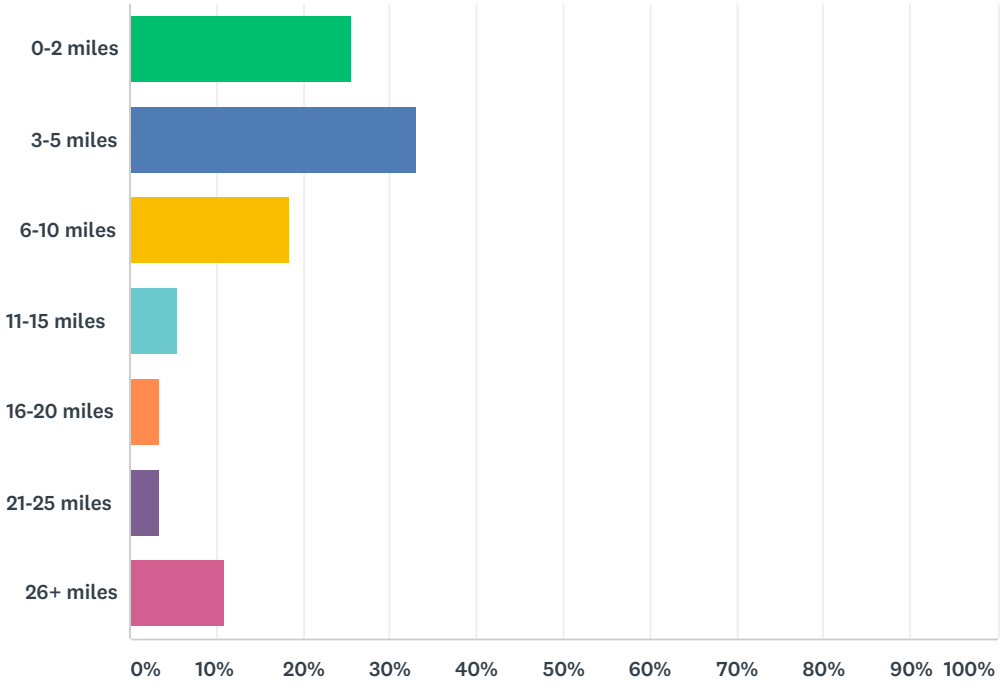
Q3 If you selected drive alone, carpool, vanpool, or bus for any of the above questions, please continue the survey. If you do not drive, carpool, vanpool, or take the bus, you have completed the survey and may scroll to the bottom of the page to submit. Please add any additional comments here.

Answered: 11 Skipped: 188

Q4 How many miles is your typical commute to work (individual trip, not

roundtrip)? Bus riders: after you answer this question, you have completed the survey and may submit.

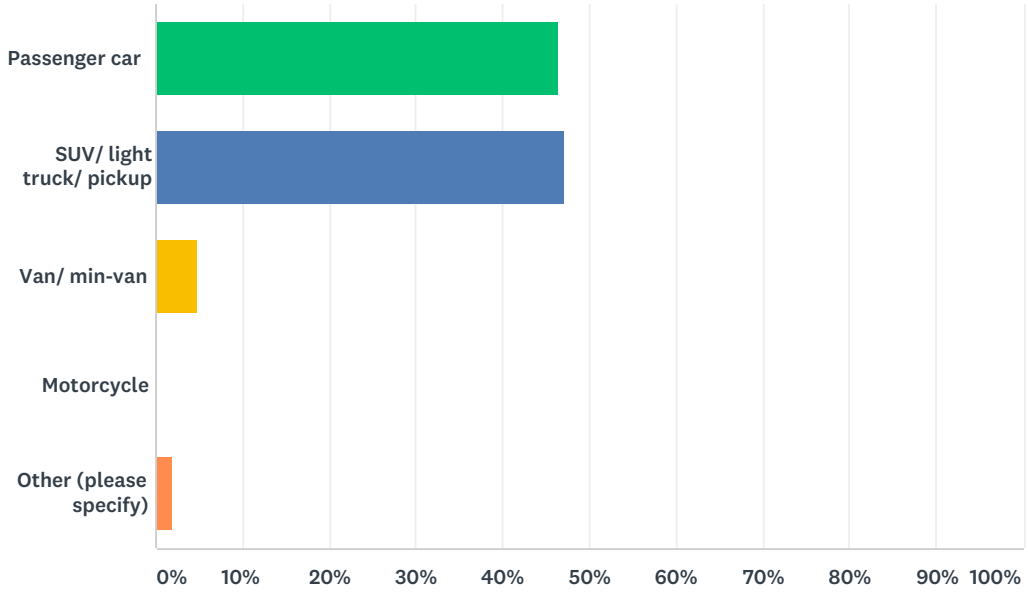
Answered: 184 Skipped: 15



ANSWER CHOICES	RESPONSES	
0-2 miles	25.54%	47
3-5 miles	33.15%	61
6-10 miles	18.48%	34
11-15 miles	5.43%	10
16-20 miles	3.26%	6
21-25 miles	3.26%	6
26+ miles	10.87%	20
TOTAL		184

Q5 What type of vehicle is used when you drive, carpool, or vanpool to work?

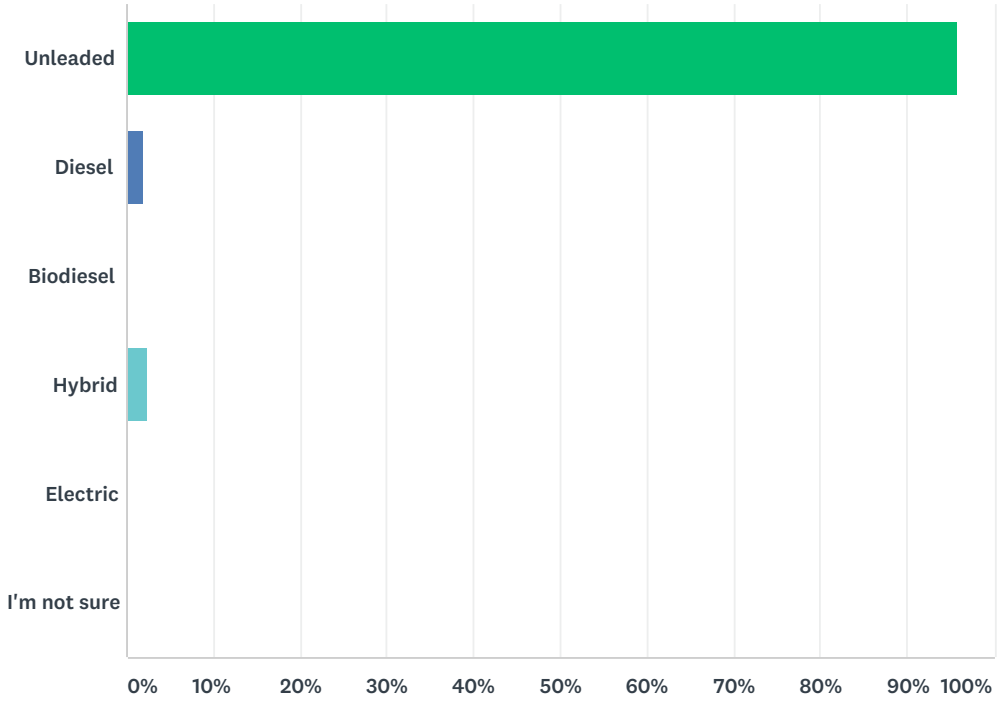
Answered: 166 Skipped: 33



ANSWER CHOICES	RESPONSES	
Passenger car	46.39%	77
SUV/ light truck/ pickup	46.99%	78
Van/ min-van	4.82%	8
Motorcycle	0.00%	0
Other (please specify)	1.81%	3
TOTAL		166

Q6 What type of fuel is used in this vehicle?

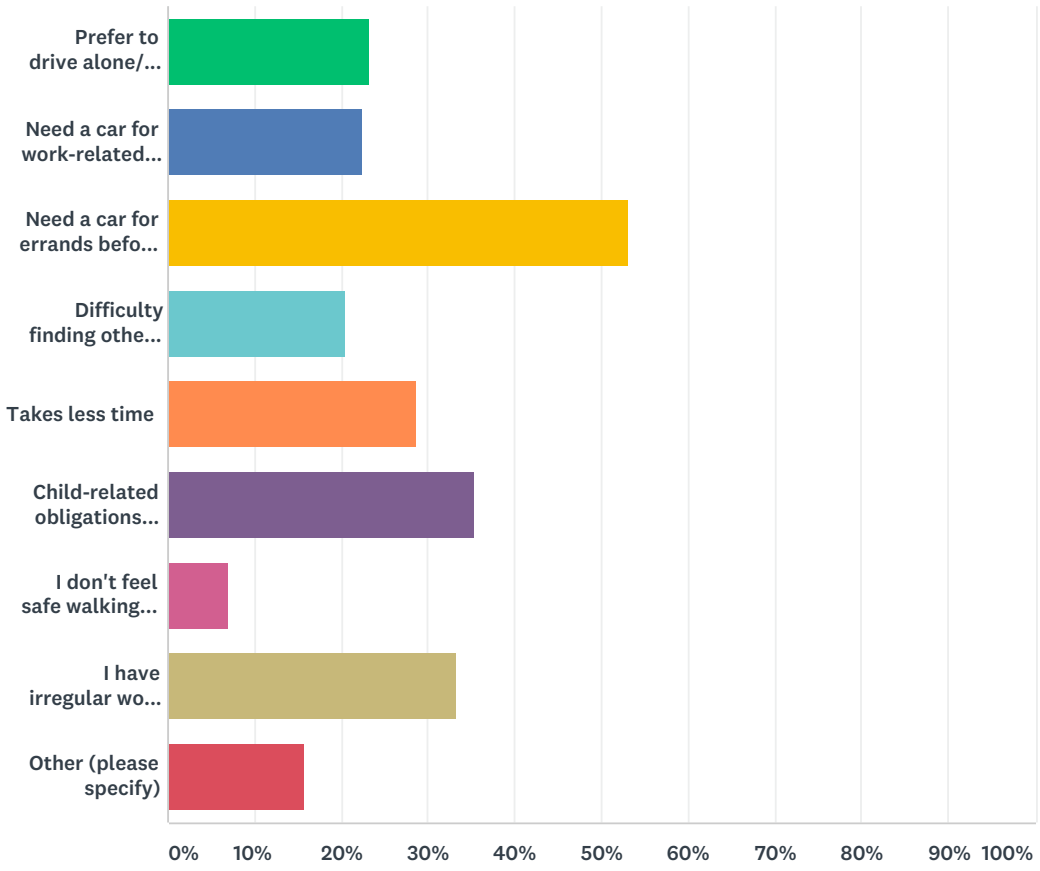
Answered: 167 Skipped: 32



ANSWER CHOICES	RESPONSES	
Unleaded	95.81%	160
Diesel	1.80%	3
Biodiesel	0.00%	0
Hybrid	2.40%	4
Electric	0.00%	0
I'm not sure	0.00%	0
TOTAL		167

Q7 If you drive alone to work, what are your reasons? (Select all that apply.)

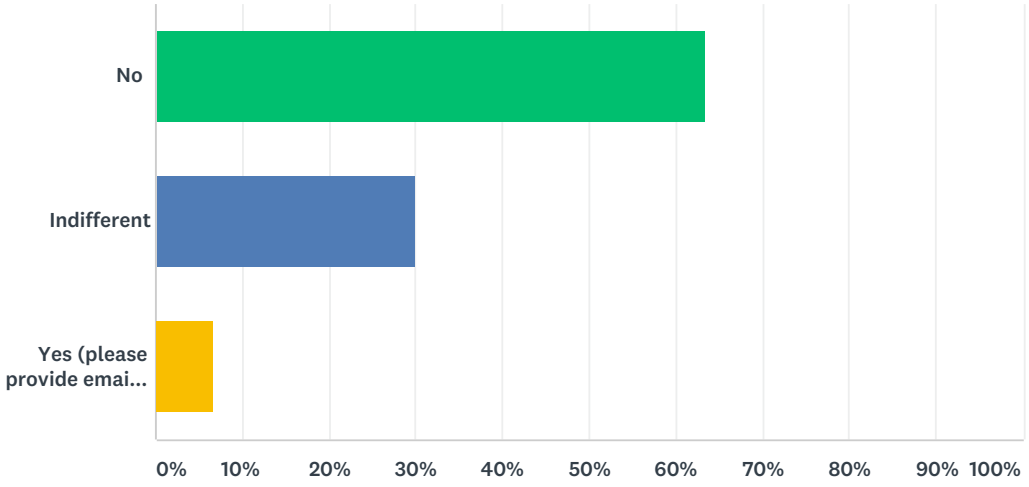
Answered: 147 Skipped: 52



ANSWER CHOICES	RESPONSES	
Prefer to drive alone/ enjoy privacy	23.13%	34
Need a car for work-related trips	22.45%	33
Need a car for errands before/ after work	53.06%	78
Difficulty finding others to carpool with	20.41%	30
Takes less time	28.57%	42
Child-related obligations (take them to school/daycare, after-school activities, etc.)	35.37%	52
I don't feel safe walking, biking, taking the bus, etc.	6.80%	10
I have irregular work hours	33.33%	49
Other (please specify)	15.65%	23
Total Respondents: 147		

Q8 Are you interested in learning more about commuting options?

Answered: 164 Skipped: 35



ANSWER CHOICES	RESPONSES	
No	63.41%	104
Indifferent	29.88%	49
Yes (please provide email address)	6.71%	11
TOTAL		164

Q9 Thank you for your participation! Any other comments that you would like to add, regarding your commute?

Answered: 35 Skipped: 164

Appendix E: Emission Factors

eGRID2012 Grid Electricity Factor Sets

GHG/Rate	Value
CO_2 lbs/MWh	665.75
CH_4 lbs/GWh	12.60
N_2O lbs/GWh	10.38

Source: https://www.epa.gov/sites/production/files/2015-10/documents/egrid2012_summarytables_0.pdf

Transportation Factor Sets

Vehicle Type, GHG/Rate	1980-1995 Model Vehicles	1996-2017 Model Vehicles
Gas passenger vehicle fuel economy	20.3	22.2
Gas passenger vehicle g CH_4/mi	0.0757	0.0316
Gas passenger vehicle g N_2O/mi	0.0580	0.0177
Gas light truck fuel economy	16.7	17.2
Gas light truck g CH_4/mi	0.1152	0.0274
Gas light truck g N_2O/mi	0.0796	0.0356
Gas heavy truck fuel economy	5.6	6.5
Gas heavy truck g CH_4/mi	0.3799	0.0552
Gas heavy truck g N_2O/mi	0.0795	0.0948
Diesel passenger vehicle fuel economy	17	25
Diesel passenger vehicle g CH_4/mi	0.0005	0.0005
Diesel passenger vehicle g N_2O/mi	0.0010	0.0010
Diesel light truck fuel economy	7	13.4
Diesel light truck g CH_4/mi	0.0009	0.0010
Diesel light truck g N_2O/mi	0.0014	0.0015
Diesel heavy truck fuel economy	5.6	6.5
Diesel heavy truck g CH_4/mi	0.0051	0.0051
Diesel heavy truck g N_2O/mi	0.0048	0.0048

Source:
Gasoline data-- Passenger and light truck fuel economy calculated by finding the average between 1980-1995 vehicles' MPG from here: https://s3.amazonaws.com/ClearPath-ICLEI/User+Guides/ClearPath+Inventory+Module+User+Guide.pdf. MPG found in table 2, page 12.

CH4 and N2O emission factors found here: https://www.epa.gov/sites/production/files/2016-03/documents/mobileemissions_3_2016.pdf

Found average MPG for heavy duty trucks here: https://www.eia.gov/totalenergy/data/annual/showtext.php?t=pTB0208

1. Calculating N_2O emissions from centralized wastewater treatment facilities without nitrification/ de-nitrification processes:

Annual N_2O emissions ($MtCO_2e$)= ((P_{total} x $F_{ind-com}$) x EF w/o nit/denit x 10^{-6}) x GWP

P_{total}= population that is served by the centralized WWTP adjusted for industrial discharge, if applicable (user input)
$F_{ind-com}$= factor for industrial and commercial co-discharge waste into the sewer system (1.25)
EF w/o nit/denit= emission factor for a WWTP without nitrification/ denitrification [g N2O/person/year] (3.2)
10^{-6}= conversion from g to metric ton
GWP= global warming potential (310).

2. Calculating N_2O emissions from effluent discharge into rivers and estuaries:

Population x Industrial-commercial multiplier x (N load/person -N uptake x BOD_5 load/person) x EF x 365.25 x .001 x (44kg N2O/kgN) x (1-Fraction N removed in nitrification/denitrification)

N load/person = .026 kg N/person/day
BOD_5 load/person =.09 kg BOD_5/person/day
In both cases, EF=.005 kg N released as N_2O/kg N in sewage

3. Calculating fugitive CH4 emissions from septic systems:

Annual CH_4 emissions ($MtCO_2e$)= (P x BOD_5 load x Bo x MCF_{septic} x 365.25 x 10^{-3}) x GWP

P= population served by septic systems (user input)
BOD_5 load= amount of BOD5 produced per person per day (0.090)
Bo= maximum CH_4 - producing capacity for domestic wastewater (0.6)
MCF_{septic}= CH_4 correction factor for septic systems (0.5)
365.25= conversion factor (day/year)
10^{-3}= conversion from kg to metric tons
GWP= global warming potential (21)

Source: Local Government Operations Protocol, ver. 1.1 (https://www.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf)

Table G.1. U.S Default Factors for Calculating Carbon Dioxide Emissions from Fossil Fuel Combustion[40]

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / Short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Short ton**
Anthracite	25.09	28.24	1	103.54	2597.82
Bituminous	24.93	25.47	1	93.40	2328.46
Subbituminous	17.25	26.46	1	97.02	1673.60
Lignite	14.21	26.28	1	96.36	1369.28
Coke	24.80	27.83	1	102.04	2530.59
Mixed Electric Utility/electric power	19.73	25.74	1	94.38	1862.12
Unspecified Residential/Com*	22.05	26.00	1	95.33	2102.03
Mixed commercial sector	21.39	25.98	1	95.26	2037.61
Mixed industrial coking	26.28	25.54	1	93.65	2461.12
Miked industrial sector	22.35	25.61	1	93.91	2098.89
Natural Gas	**Btu/scf**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO2/scf**
Pipeline (US weighted average)	1028	14.47	1	53.02	0.0545
Greater than 1000 btu	>1000	14.47	1	53.06	Varies
975 to 1000	975-1,000	14.73*	1	54.01*	Varies
1000 to 1025	1,000 – 1,025	14.43	1	52.91*	Varies
1025-1035	1025-1035	14.45	1	52.98*	Varies
1025 to 1050	1,025 – 1,050	14.47*	1	53.06*	Varies
1050 to 1075	1,050 – 1,075	14.58*	1	53.46*	Varies
1075 to 1100	1,075 – 1,100	14.65*	1	53.72*	Varies
Greater than 1100	> 1,110	14.92*	1	54.71*	Varies
Fossil Fuel-derived Fuels (gaseous)	**MMBtu/scf**	**kg C / MMBtu**		**g CO2/MMBtu**	**g CO2/short ton**
Acetylene***	0.00147	n/a	1	0.0716	n/a
Fossil Fuel-derived Fuels (solid)	**MMBtu/short ton**	**kg C / MMBtu**		**kg CO2/mmBtu**	**kg CO2/short ton**
Municipal Solid Waste	9.95	24.74	1	90.7	902.47
Tires	26.87	23.45	1	85.97	2310.01
Fossil Fuel-derived Fuels (gaseous)	**MMBtu/scf**	**kg C / MMBtu**		**kg CO2/MMBtu**	**kg CO2 / scf**
Blast Furnace Gas	0.000092	n/a	1	274.32	0.0252
Coke Oven Gas	0.000599	n/a	1	46.85	0.0281

[40] CCAR's General Reporting Protocol Version 3.1 (January 2009) and CARROT contain different default CO_2 emission factors than presented here. CCAR members are allowed to use either the emission factors presented here or those found in the GRP/CARROT. If members use the default emission factors from the Local Government Operations Protocol, CCAR asks that this be documented in CARROT.

Table G.1. U.S Default Factors for Calculating Carbon Dioxide Emissions from Fossil Fuel Combustion Continued

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Petroleum Products	**MMBtu / gallon**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Distillate Fuel Oil No. 1	0.139	19.98	1	73.25	10.18
Distillate Fuel Oil No. 2	0.138	20.17	1	73.96	10.21
Distillate Fuel Oil No. 4	0.146	20.47	1	75.04	10.96
Residual Fuel No. 5	0.140	19.89	1	72.93	10.21
Residual Fuel No. 6	0.150	20.48	1	75.10	11.27
Still Gas	0.143	18.20	1	66.72	9.54
Kerosene	0.135	20.51	1	75.20	10.15
LPG	0.092	17.18	1	62.98	5.79
Propane	0.091	16.76	1	61.46	5.59
Ethane	0.096	17.08	1	62.64	6.01
Propylene	0.091	17.99	1	65.95	6.00
Ethylene	0.100	18.39	1	67.43	6.74
Isobutane	0.097	17.70	1	64.91	6.30
Isobutylene	0.103	18.47	1	67.74	6.98
Butane	0.101	17.77	1	65.15	6.58
Butylene	0.103	18.47	1	67.73	6.98
Naphtha (<401d F)	0.125	18.55	1	68.02	8.50
Natural Gasoline	0.110	18.23	1	66.83	7.35
Other oil (>401 d F)	0.139	20.79	1	76.22	10.59
Pentanes Plus	0.110	19.10	1	70.02	7.70
Petrochemical Feedstocks	0.129	19.36	1	70.97	9.16
Petroleum Coke	0.143	27.93	1	102.41	14.64
Special Naphtha	0.125	19.73	1	72.34	9.04
Unfinished Oils	0.139	20.32	1	74.49	10.35
Heavy Gas Oils	0.148	20.43	1	74.92	11.09
Lubricants	0.144	20.26	1	74.27	10.69
Motor Gasoline	0.125	19.15	1	70.22	8.78
Aviation Gasoline	0.120	18.89	1	69.25	8.31
Kerosene Type Jet Fuel	0.135	19.70	1	72.22	9.75
Asphalt and Road Oil	0.158	20.55	1	75.36	11.91
Crude Oil	0.138	20.32	1	74.49	10.28
Waxes*	0.132	19.81	1	72.64	9.58