MADISON, WISCONSIN

2018 & 2022 Inventory of Government Operations Greenhouse Gas Emissions

Prepared For:

Madison, Wisconsin

Produced By:

ICLEI – Local Governments for Sustainability USA
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Abbreviations

CARB	California Air Resources Board
CCAR	California Climate Action Registry
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
CH4	Methane
GHG	Greenhouse Gas
GWP	Global Warming Potential
ICLEI	International Council for Local Environmental Initiatives/Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
LGO	Local Government Operations
kWh	Kilowatt-Hour
MT	Metric Tons
MMBtu	One Million British Thermal Units
N2O	Nitrous Oxide
SBT	Science-Based Target
scf	Standard Cubic Foot
VMT	Vehicle Miles Traveled
WICCI	Wisconsin Initiative on Climate Change Impacts

Definitions

Net-zero	Greenhouse gas emissions equal removals from the atmosphere

Letter from the Mayor

I am pleased to share the results of the latest greenhouse gas inventory for our government operations. The City of Madison is committed to doing our part to reduce greenhouse gas emissions and avoid the worst impacts of climate change.

This report not only marks a milestone in our commitment to sustainability but also provides a path to making our community more environmentally sustainable and resilient for current and future Madisonians. At the heart of this inventory lies a crucial understanding: to effectively address climate change, we must first measure our impact. By tracking our greenhouse gas emissions, we gain invaluable insights into the sources of our carbon footprint, allowing us to develop targeted strategies and policies to mitigate our environmental impact.

This inventory and the emissions reductions it shows are more than just a collection of numbers – they are a testament to the dedication and hard work of the City, community leaders, local businesses, and everyone who calls Madison home. It reflects the collective work of countless individuals who have embraced the challenge of building a more sustainable Madison. One of the key benefits of greenhouse gas inventories is their ability to hold us accountable. By documenting our emissions and progress towards reduction goals, we ensure that our actions are not just goals but tangible steps towards a cleaner, healthier environment.

As you review this greenhouse gas inventory, I ask that you remember that numbers from 2022 are likely influenced by the later effects of the COVID-19 pandemic. Nevertheless, we have achieved tangible, encouraging results. Let us use this inventory as a springboard for further action, inspiring us to continue our efforts to tackle climate change and build a more resilient community.

Sincerely,

Mayor Satya Rhodes-Conway

Executive Summary

The City of Madison is committed to doing our part to reduce greenhouse gas emissions and avoid the worst impacts of climate change. Madison has set the ambitious goal of reaching 100% renewable energy and net zero carbon emissions for city operations by 2030 and community-wide by 2050. Having already reduced local government operations emissions from 96,137 metric tons carbon dioxide equivalent (MT CO2e) in 2018 to 89,650 MT CO2e in 2022, we are making significant strides toward achieving that target. This is a reduction of 6,487 MT CO2e over four years (-6.7%).

In addition to establishing these goals, the City is also investing in a wide range of initiatives (air quality, extreme heat, flooding, and other impacts including climate-related hazards) to build our community's resilience to climate change:

- Installing a network air quality monitors across the city
- Collaborating with the University of Wisconsin-Madison to map extreme heat and urban heat islands
- Developing strategies to cool the city and keep residents safe during extreme heat
- Updating the stormwater ordinance, embarking on detailed watershed studies, and upgrading stormwater infrastructure

Despite our efforts to respond to the effects of climate change, these initiatives will not solve the main driver of it: greenhouse gas emissions. Maintaining an updated inventory of their sources and outputs is critical to developing effective strategies and tracking progress toward cutting greenhouse gas emissions across the various city sectors. This report provides estimates of greenhouse gas emissions resulting from activities in Madison as a whole in 2018 and 2022.

Three greenhouse gases are included in this inventory: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). Many of the charts in this report represent emissions in "carbon dioxide equivalent" (CO2e) values.

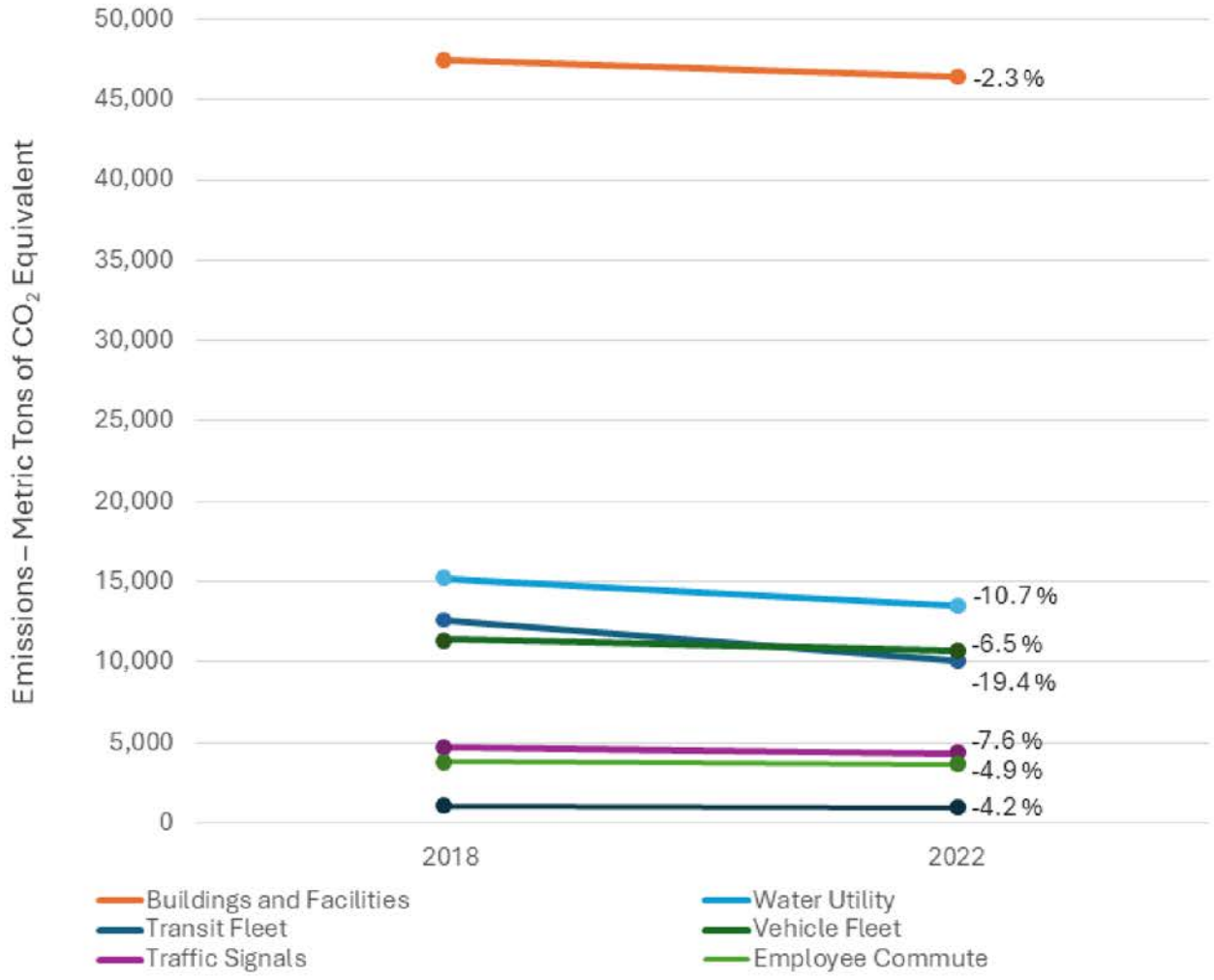
100 Block of State Street during Maxwell Street Days

Key Findings

Figure 1 shows Government Operations emissions by sector for 2018 and 2022. The largest contributor in 2022 is Buildings & Facilities (52%). The next largest contributors are Water Utility Facilities (15%), Vehicle Fleet (12%), and Transit Fleet (11%). Actions to reduce emissions in all of these sectors will be a key part of a climate action plan. Streetlights & Traffic Signals (5%), Employee Commute (4%), Process & Fugitive Emissions, & Solid Waste Facilities (<0.1%) were responsible for the remaining emissions.

The Inventory Results section of this report provides a detailed profile of emissions sources within Madison; information that is key to guiding local reduction efforts. These data will also provide a baseline against which the city will be able to compare future performance and demonstrate progress in reducing emissions.

Figure 1: Government Operations Emissions Trends (2018 to 2022)



Introduction to Climate Change

Naturally occurring gases dispersed in the atmosphere determine the Earth's climate by trapping solar radiation. This phenomenon is known as the greenhouse effect. Overwhelming evidence shows that human activities are increasing the concentration of greenhouse gases (GHGs) and changing the global climate. The most significant contributor is burning fossil fuels for transportation, electricity generation and other purposes, which introduces large amounts of carbon dioxide and other greenhouse gases into the atmosphere.

Collectively, these gases intensify the natural greenhouse effect, causing global average surface and lower atmospheric temperatures to rise across the globe, threatening the safety, quality of life, and economic prosperity of communities. Although the natural greenhouse effect is needed to keep the earth warm, a human-enhanced greenhouse effect with the rapid accumulation of GHGs in the atmosphere leads to too much heat and radiation being trapped. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report confirms that human activities have unequivocally caused an increase in carbon emissions and other GHGs in the atmosphere [1]. Many regions are already experiencing the consequences of global climate change, and Madison is no exception.

East Washington Avenue on June 28th, 2023 during the worst of the Canadian wildfire air-quality impacts

[1] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [MassonDelmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

We are already feeling the impacts of climate change in Madison, especially increased heat and rainfall. The climate of the Midwest has continuously warmed since the first half of the 20th century, and annual precipitation has increased alongside it. Recent decades were Wisconsin's warmest and wettest on record. Wisconsin's annual average temperature has risen by 3 degrees Fahrenheit since the 1950's and is likely to increase an additional 2 - 8 degrees Fahrenheit by 2050 according to climate projections from the Wisconsin Initiative on Climate Change Impacts (WICCI). By 2050, extreme heat days over 90 degrees Fahrenheit will likely triple, and the number of hot nights when the temperature does not drop below 70 degrees Fahrenheit will likely quadruple. With the higher temperatures comes a number of risks to the health of our residents, including heat waves, flooding, and poor air quality. Some populations are especially at risk, such as those with preexisting cardiovascular and respiratory conditions and the elderly.

Our region has also seen frequent changes associated with the shifting temperature and climate patterns. Summer months with fewer warm days and extreme fluctuations in dry and wet periods have resulted in unpredictable weather patterns. This warming trend is bringing increases in the frequency of extreme storms and heavy rainfall events, leading to flooding and high winds that put our communities at risk. By the end of the century, these storms will probably be nearly twice as frequent throughout Wisconsin [2]. Throughout the Midwest, and in Madison, roads, wastewater facilities, bridges, and energy systems need upgrades to offset the increased risk of failure brought about by more frequent and intense storms. The existing quality of most Midwestern infrastructure currently ranges from C to D+, emphasizing their susceptibility to increased stressors associated with climate impacts [3]. The failure of these systems would not only be costly, but dangerous as well, cutting us from access to vital goods and services.

Yahara River looking Northwest

[2] Wisconsin Initiative on Climate Change Impacts. 2021. Wisconsin's Changing Climate - Impacts and solutions for a warmer climate. Retrieved from https://wicci.wisc.edu/2021-assessment-report/.
[3] U.S. Global Change Research Program. 2023. National Climate Assessment – Ch 24: Midwest. Retrieved from https://nca2023.globalchange.gov/chapter/24/.

With these challenges ahead of us, your government has used the incredible support for climate action in Madison to achieve numerous successes over this past year. In March 2023 the Common Council approved new ordinance to create the Building Energy Savings Program to slash commercial emissions. By October, the City added the 100th electric vehicle to its fleet, making it the largest in the state. In June, Metro Transit used a $38 million Federal Transit Administration grant to purchase sixteen all-electric buses and modernize the bus maintenance facility with charging equipment and solar roofs. In addition to these actions, city facilities saw solar installed throughout the year, increasing the city's energy consumption from renewable sources to 74%. At the start of the year, the City of Madison Transit Oriented Development Overlay Zoning District to encourage compact, pedestrian-friendly development along future bus rapid transit lines and areas in the city of high-frequency local transit service. April saw the City complete the first round of the Efficiency Navigator Program, which helped upgrade 88 rental units in the Northside and Southwest side of Madison, cutting both energy costs and emissions. The Engineering Division's GreenPower Program also welcomed its largest ever class of trainees in October, enabling participants to prepare for employment opportunities in solar and electrical industries ahead of a 2024 filled with projects. MadiSUN continued an additional year in March, providing Mt. Zion Baptist Church with grant funding to install rooftop solar [4]. These are just a handful of successes we achieved together, and we must continue to build upon this momentum in the following year to protect our community and planet.

Ice fishers on Monona Bay

[4] City of Madison Mayor's Office. 2024. 14 Sustainability Wins from 2023. Retrieved from https://www.cityofmadison.com/mayor/blog/2024-01-16/14-sustainability-wins-from-2023

Greenhouse Gas Inventory as a Step Toward Carbon Neutrality

Facing the climate crisis requires the concerted efforts of local governments and everyone close to the communities directly dealing with the impacts of climate change.

Cities, towns and counties are well placed to define coherent and inclusive plans and strategies for adaptation, resilience and mitigation. Existing targets and plans need to be reviewed to bring in the necessary level of ambition and outline how to achieve net-zero emissions by 2050 at the latest. Creating a roadmap for climate neutrality requires Madison to identify priority sectors for action, while considering climate justice, inclusiveness, local job creation and other benefits of sustainable development.

To complete this inventory, Madison contracted ICLEI - Local Governments for Sustainability (ICLEI), which provides authoritative direction for greenhouse gas emissions accounting and defines climate neutrality as follows:

> The targeted reduction of greenhouse gas (GHG) emissions and GHG avoidance in government operations and across the community in all sectors to an absolute net-zero emission level at the latest by 2050. In parallel to this, it is critical to adapt to climate change and enhance climate resilience across all sectors, in all systems and processes.

To achieve ambitious emissions reduction and move toward climate neutrality, Madison has set a goal of net-zero local government operations emissions by 2030 and should act rapidly following a holistic and integrated approach. Climate action is an opportunity for our community to experience a wide range of co-benefits, such as creating societal and economic opportunities, reducing poverty and inequality, and improving the health of people and nature.

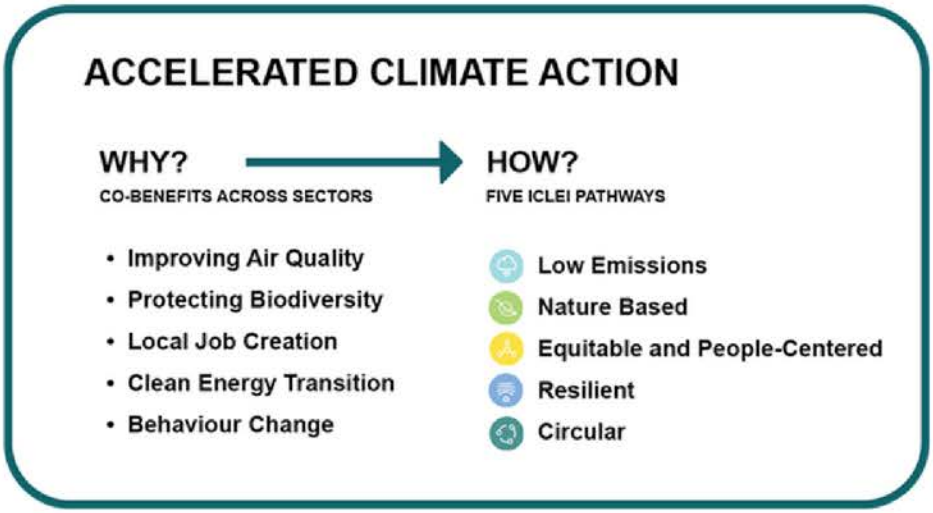


Figure 2: Co-benefits and ICLEI Pathways to Accelerated Climate Action

ICLEI Green Climate Cities Framework

For this inventory, ICLEI's process for quantifying Madison's emissions is informed by its Green Climate Cities Framework for integrated climate action. The City follows the stepwise approach shown below in Figure 3, which involves collecting and analyzing climate data, action, implementation, leadership, and collaboration—always with an equity lens.

The Framework is organized into Analyze, Act, and Accelerate phases for communities pursuing integrated climate action. The Framework incorporates greenhouse gas emissions reductions, climate adaptation actions, and equitable, inclusive decision-making. While Madison's inventory has Science-Based Targets [5] and falls under Step C- Analyze and set a baseline, the City has reached Step F - Implement and monitor through additional efforts beyond the scope of this project.

Over 600 U.S. communities have followed this basic Framework, previously known as ICLEI's Five Milestones for Emissions Management, and today, it is represented through the streamlined Analyze-Act-Accelerate model shown below.

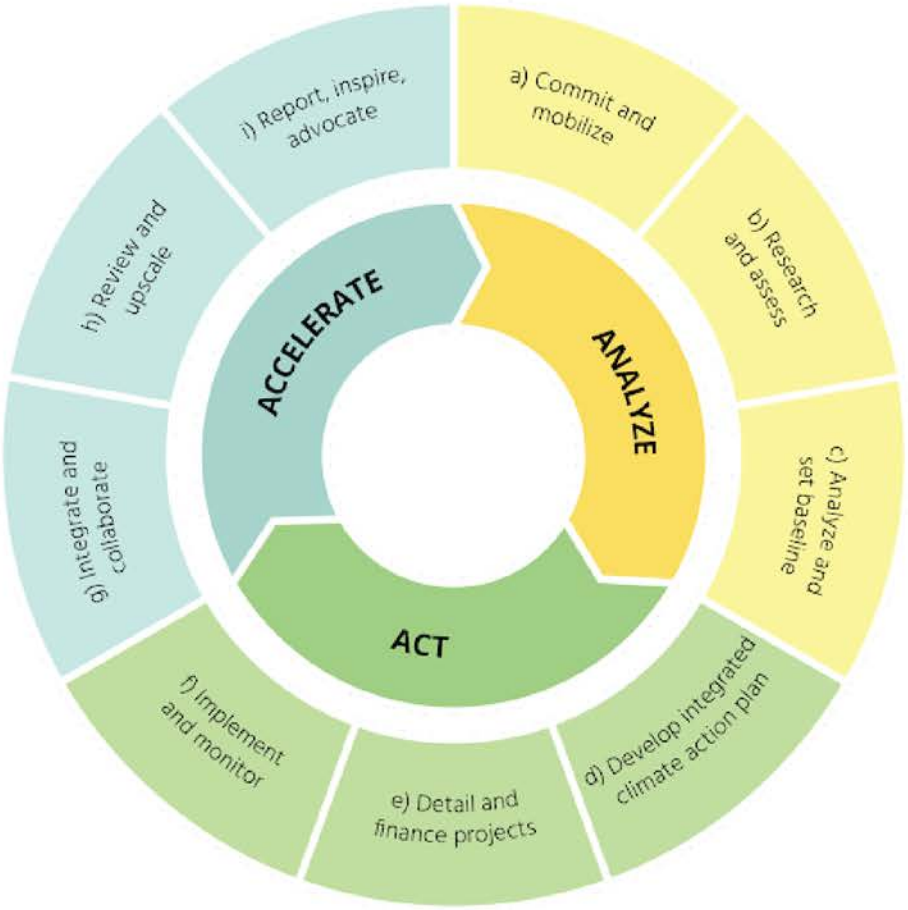


Figure 3: ICLEI Green Climate Cities Framework

[5] Science-Based Targets are calculated climate goals, in line with the latest climate science, that represent your community's fair share of the ambition necessary to meet the Paris Agreement commitment of keeping warming below 1.5°C. To achieve this goal, the Intergovernmental Panel on Climate Change (IPCC) states that we must reduce global emissions by 50% by 2030 and achieve climate neutrality by 2050. Equitably reducing global emissions by 50% requires that high-emitting, wealthy nations reduce their emissions by more than 50%.

Inventory Methodology

Understanding a Greenhouse Gas Emissions Inventory

The first step toward achieving tangible greenhouse gas (GHG} emission reductions requires identifying baseline emissions levels and sources and activities generating emissions in the community. This report presents emissions from the Madison community as a whole. The government operations inventory is mostly a subset of the community inventory, as shown in Figure 4. For example, data on commercial energy use by the community includes energy consumed by municipal buildings, and community vehicle-miles-traveled estimates include miles driven by municipal fleet vehicles.

Figure 4: Relationship of Community and Government Operations Inventories

As local governments continue to join the climate protection movement, the need for a standardized approach to quantify GHG emissions has proven essential. This inventory uses the approach and methods provided by the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (Community Protocol) and the Local Government Operations Protocol for Accounting and Reporting Greenhouse Gas Emissions (LGO Protocol), both of which are discussed further on the following page.

See Table 1 for the carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) Global Warming Potentials (GWPs) from the IPCC 5th Assessment Report [6].

Table 1: Global Warming Potential Values (IPCC, 2014)

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO2)	1
Methane (CH4)	28
Nitrous Oxide (N2O)	265

[6] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Local Government Operations (LGO) Protocol

In 2010, ICLEI, the California Air Resources Board (CARB), and the California Climate Action Registry (CCAR) released Version 1.1 of the LGO Protocol [7]. The LGO Protocol serves as the national standard for quantifying and reporting greenhouse emissions from local government operations. The purpose of the LGO Protocol is to provide the principles, approach, methodology, and procedures needed to develop a local government operations greenhouse gas emissions inventory.

The following activities are included in the LGO inventory:

- Energy and natural gas consumption from buildings & facilities and streetlights & traffic signals
- Steam and district heating
- Government owned/operated landfills
- Energy consumption in the supply of potable water
- On-road transportation from vehicle fleet, transit fleet, and employee commute
- Process & fugitive emissions from natural gas distribution

Quantifying Greenhouse Gas Emissions

Sources and Activities

Communities contribute to greenhouse gas emissions in many ways. Two central categorizations of emissions are used in the community inventory: 1) GHG emissions that are produced by "sources" located within the community boundary, and 2) GHG emissions produced as a consequence of community "activities."

Table 2: Source vs. Activity for Greenhouse Gas Emissions (GHG)

Source	Activity
Any physical process inside the jurisdictional boundary that releases GHG emissions into the atmosphere.	The use of energy, materials, and/or services by members of the community that result in the creation of GHG emissions.

Activities within a community include, but are not limited to: heating of homes, driving cars, and throwing away trash. Sources are where the emissions from those activities occur, which may or may not be the same place the activity occurs. When you drive your car, the source is the car's tailpipe. Similarly, when a gas furnace in your home runs, the source is the exhaust vent of the furnace. On the other hand, when you throw away trash the source is at the landfill the trash is sent to. When you flip a switch and use electricity, the source is the power plant where the electricity is generated. Because landfills and power plants are usually located outside the community, careful inclusion of both sources and activities provides a fuller picture of community emissions.

[7] ICLEI. 2008. Local Government Operations Protocol for Accounting and Reporting Greenhouse Gas Emissions. Retrieved from http://www.icleiusa.org/programs/climate/ghg-protocol/ghg-protocol

Base Year

The inventory process requires the selection of a base year with which to compare current emissions. Madison's LGO greenhouse gas emissions inventory utilizes 2018 as its baseline year as it provides a recent year for which the necessary data are available.

Quantification Methods

GHG emissions can be quantified in two ways:

- Measurement-based methodologies refer to the direct measurement of GHG emissions (from a monitoring system) emitted from a flue of a power plant, wastewater treatment plant, landfill, or industrial facility.
- Calculation-based methodologies calculate emissions using activity data and emission factors. To calculate emissions accordingly, the basic equation below is used:

Activity Data x Emission Factor = Emissions

Most emissions sources in this inventory are quantified using calculation-based methodologies. Activity data refer to the relevant measurement of energy use or other GHG-generating processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Please see the appendices for a detailed listing of the activity data used in composing this inventory.

Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data (e.g. lbs CO2/kWh of electricity). For this inventory, calculations were made using ICLEI's ClearPath Climate Planner tool [8].

Members of the Forestry Section of the Streets Division planting a tree on South Pinckney Street

[8] ICLEI's ClearPath Climate Planner tool is the leading online software for completing greenhouse gas inventories, forecasts, climate action plans, and monitoring at community-wide or government-operations scales. The software allows for local governments to track direct and indirect emissions from energy, transportation, waste, consumption, and forests and trees. Emissions are entered under the guidance of different protocol options, including the U.S. Community Protocol, Global Protocol for Community-scale Greenhouse Gas Inventories, or Local Government Operations Protocols.

Government Operations Emissions Inventories Results

The total Government operations emissions for the 2018 and 2022 inventories are shown in Table 3 and Figures 5 and 6.

Table 3: 2018 and 2022 Government Operations Emissions Inventories

Sector	Fuel or Source	2018 Usage	2022 Usage	Usage Unit	2018 Emissions (MT CO2e)	2022 Emissions (MT CO2e)	% Change (MT CO2e)
Buildings & Facilities	Grid Electricity - City (Residential) - MG&E	480	96	kWh	0.35736	0.064445	-129.29%
	Grid Electricity - City (Commercial) - MG&E	20,756,653	27,421,263	kWh	15,453	18,408	19.12%
	Grid Electricity - Institutional - Alliant	27,534,431	27,450,821	kWh	19,813	14,475	-26.94%
	Grid Electricity - City-owned Building - Alliant	1,221,275	1,301,615	kWh	879	686	-21.96%
	Natural Gas - City (Residential) - MG&E	109	80	Therms	1	0.42549	-57.45%
	Natural Gas - City (Commercial) - MG&E	972,738	974,531	Therms	5,174	5,183	0.17%
	Steam - City County Building	16,684	9,865	Pounds	4,058	4,206	3.65%

Table 3: 2018 and 2022 Government Operations Emissions Inventories (Continued)

Sector	Fuel or Source	2018 Usage	2022 Usage	Usage Unit	2018 Emissions (MT CO2e)	2022 Emissions (MT CO2e)	% Change (MT CO2e)
Buildings & Facilities	Steam - Monona Terrace	8,610	8,064	Pounds	2,094	3,438	64.18%
Buildings & Facilities Total					**47,472**	**46,396**	**-2.27%**
Street Lights & Traffic Signals	Grid Electricity - MG&E	6,243,066	6,384,827	kWh	4,648	4,286	-7.79%
	Grid Electricity - Alliant	65,631	97,198	kWh	47	51	8.51%
Street Lights & Traffic Signals Total					**4,695**	**4,337**	**-7.63%**
Vehicle Fleet	On Road - Gasoline	190,762	302,304	Gallons	1,685	2,655	57.57%
	On Road - Diesel	441,979	388,861	Gallons	4,513	3,970	-12.03%
	On Road - Propane	168		Gallons	1		
	On Road - Biodiesel		57,124	Gallons		0	
	On Road - Ethanol		449	Gallons		4	
	On Road - Electric		40,812	kWh		22	
	Off Road - Gasoline	1,681	8,872	Gallons	15	79	426.67%
	Off Road - Diesel	77,657	118,247	Gallons	793	1,207	52.21%
	Off Road - Propane	857	9,198	Gallons	5	51	920.00%
	Biodiesel - B2	143,566		Gallons	1,436		
	Biodiesel - B5	82,014	91,592	Gallons	795	888	11.70%

Table 3: 2018 and 2022 Government Operations Emissions Inventories (Continued)

Sector	Fuel or Source	2018 Usage	2022 Usage	Usage Unit	2018 Emissions (MT CO2e)	2022 Emissions (MT CO2e)	% Change (MT CO2e)
Vehicle Fleet	Biodiesel - B11	238,629		Gallons	2,655		
	Biodiesel - B20		220,019	Gallons		3,970	
	Biodiesel - B100		12,692	Gallons		0	
Vehicle Fleet Total					**11,411**	**10,673**	**-6.47%**
Transit Fleet	Diesel - Metro Transit	1,227,847	989,509	Gallons	12,539	10,105	-19.41%
Transit Fleet Total					**12,539**	**10,105**	**-19.41%**
Employee Commute	Gasoline	8,721,510	7,925,533	Miles	3,727	3,393	-8.96%
	Diesel	64,273	290,521	Miles	104	254	144.23%
	Electric		69,989	Miles		12	
	Public Transit - Bus	436,166	158,222	Passenger Miles/Year	25	9	-64.00%
Employee Commute Total					**3,856**	**3,668**	**-4.88%**
Solid Waste Facilities	CH4 - Demetral Landfill (Closed)	7	7	Pounds	0.00000085960	0.00000085960	0.00%
	CH4 - Sycamore Landfill (Closed)	0.0003	0.0003	Pounds	0.00000386112	0.00000386112	0.00%
	CH4 - Mineral Point Landfill (Closed)	0.0001	0.0001	Pounds	0.000001036	0.000001036	0.00%
	CH4 - Olin Landfill (Closed)	0.00008	0.00008	Pounds	0.0000016856	0.0000016856	0.00%

Table 3: 2018 and 2022 Government Operations Emissions Inventories (Continued)

Sector	Fuel or Source	2018 Usage	2022 Usage	Usage Unit	2018 Emissions (MT CO2e)	2022 Emissions (MT CO2e)	% Change (MT CO2e)
Solid Waste Facilities	CH4 - Greentree Landfill (Closed)	0.0003	0.0003	Pounds	0.0000035084	0.0000035084	0.00%
Solid Waste Facilities Total					**0**	**0**	**0.00%**
Water & Wastewater Facilities	Grid Electricity - Madison Water Utility - Alliant	2,237,410	2,136,584	kWh	1,610	1,127	-30.00%
	Grid Electricity - Madison Water Utility - MG&E	17,655,672	17,762,259	kWh	13,145	11,924	-9.29%
	Natural Gas - Madison Water Utility - MG&E	70,152	80,427	Therms	373	428	14.75%
Water & Wastewater Facilities Total					**15,128**	**13,479**	**-10.90%**
Process & Fugitive Emissions Total	Fugitive Emissions from Natural Gas Distribution - MG&E	1,042,999	1,055,038	Therms	181	183	1.10%
	Hydrofluorocarbon & Refrigerant Emissions - R-410a	0.41206031862	0.401347601	Metric Tons	711	692	-2.67%
	Hydrofluorocarbon & Refrigerant Emissions - R-134a	0.0281227	0.0281227	Metric Tons	37	37	0.00%

Table 3: 2018 and 2022 Government Operations Emissions Inventory (Continued)

Sector	Fuel or Source	2018 Usage	2022 Usage	Usage Unit	2018 Emissions (MT CO2e)	2022 Emissions (MT CO2e)	% Change (MT CO2e)
Process & Fugitive Emissions Total	Hydrofluorocarbon & Refrigerant Emissions - R-22	0.0606594746306	0.0456909264206	Metric Tons	107	80	-25.23%
Process & Fugitive Emissions Total					**1,036**	**992**	**-4.25%**
Total Government Operations Emissions					**96,137**	**89,650**	**-6.75%**

*Blank cells are a result of variability in the format of available data by sector and fuel or source type.

Figure 5 shows the distribution of Government Operations emissions by sector. Buildings & Facilities are the largest contributor, then Water & Wastewater Treatment Facilities, & Transit/Vehicle Fleet.

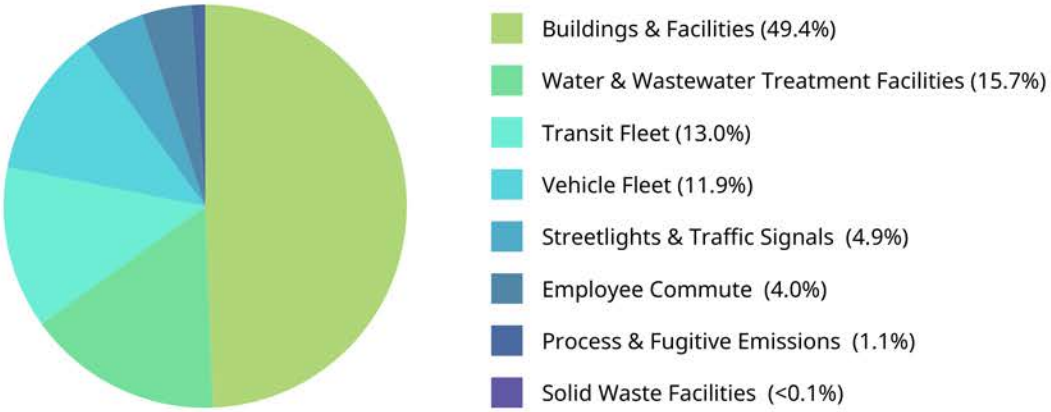


Figure 5: 2018 Government Operations Emissions by Sector

Figure 6: 2022 Government Operations Emissions by Sector

Next Steps

The inventory should be used to focus and prioritize actions to reduce emissions. Based on the inventory results, the following areas have the greatest potential for emissions reduction:

- Energy
  - Transition to renewable power for city facilities
- Transportation
  - Electrify Bus Rapid Transit
  - Expand electric vehicle charging

Completion of another GHG inventory in two to five years is recommended to assess progress resulting from any actions implemented, and Madison plans to do so every four. The detailed methodology section of this report, as well as notes and attached data files in the ClearPath Climate Planner tool provided to the Madison, will be helpful to complete a future inventory consistent with this one.

Two members of Madison's Fleet Division inspecting City vehicles

Conclusion

This inventory marks the completion of Step C of the ICLEI GreenClimateCities Framework, though additional steps by the City of Madison place its progress at Step F - Implement and monitor. The next step is to build upon the existing Madison initiatives with a more robust climate action plan that identifies specific quantified strategies that can cumulatively meet that target.

The Intergovernmental Panel on Climate Change (IPCC) states that to meet the Paris Agreement commitment of keeping warming below 1.5°C we must reduce global emissions by 50% by 2030 and reach climate neutrality by 2050. Equitably reducing global emissions by 50% requires that high-emitting, wealthy nations reduce their emissions by more than 50%. More than ever, it is imperative that countries, regions, and local governments set targets that are ambitious enough to slash carbon emissions between now and mid-century. In line with global efforts, the City of Madison's 2050 Science-Based Targets are 100% net-zero carbon emissions for local government operations [9].

Science-Based Targets (SBTs) are calculated climate goals, in line with the latest climate science, that represent a community's fair share of the global ambition necessary to meet the Paris Agreement commitment [10]. Community education, involvement, and partnerships will be instrumental to achieve a science-based target. Using its 2005 baseline, the City of Madison calculated its 2030 local government operations emissions goal, and is maintaining that same target with addition of the newer inventories. ICLEI generally encourages cities to adopt or use existing 2030 SBTs.

Science-Based Targets are climate goals in line with the latest climate science. They represent the city's fair share of the ambition necessary to meet the Paris Agreement commitment to keep warming below 1.5°C.

In addition, Madison will continue to track key energy use and emissions indicators on an on-going basis. It is recommended that communities update their inventories regularly, especially as plans are implemented to ensure measurement and verification of impacts. Regular inventories also allow for "rolling averages" to provide insight into sustained changes and can help reduce the change of an anomalous year being incorrectly interpreted. This inventory shows that buildings & facilities, water & wastewater treatment facilities, and government-owned fleet patterns will be particularly important to focus on. Through these efforts and others, Madison can achieve environmental, economic, and social benefits beyond reducing emissions.

Solar lighting along the Campus Drive bicycle path

[9] City of Madison Sustainability & Resilience. 2024. Climate. Retrieved from https://www.cityofmadison.com/sustainability/climate
[10] "Science Based Climate Targets: A Guide for Cities." Science Based Targets Network, November 4, 2021. https://sciencebasedtargetsnetwork.org/.

Appendix: Methodology Details

Energy

Table 4: Energy Data Sources

Activity	Data Source	Data Gaps/Assumptions
Electricity Consumption	Madison Gas & Electric	Energy use tagged with "city" was considered municipal
	Alliant Energy	N/A
Natural Gas Consumption	Madison Gas & Electric	Energy use tagged with "city" was considered municipal
Steam Consumption	DOA Capitol Complex	Boiler efficiency assumed to be 100% to match Net Thermal MMBtu with Reports MMBtu/Sales

Table 5: MG&E + MROE Emissions Factors for Electricity Consumption

Year	CO2 (lbs./MWh)	CH4 (lbs./GWh)	N2O (lbs./GWh)
2018	1630	169	25
2021 (Proxy for 2022)	1470	148	22

Table 6: Alliant Energy (Wisconsin Power & Light) Emissions Factors for Electricity Consumption

Year	CO2 (lbs./MWh)	CH4 (lbs./GWh)	N2O (lbs./GWh)
2018	1580	40	20
2022	1159	30	10

Transportation

Table 7: Transportation Data Sources

Activity	Data Source	Data Gaps/Assumptions
On Road Vehicle Fleet	City of Madison	Fuel use estimated to output activity data for some records via hours of operation
Off Road Vehicle Fleet	City of Madison	Fuel use estimated to output activity data for some records via hours of operation; Vehicles using biodiesel not provided - marked "small utility" by default
Transit Fleet	Metro Transit	Assumed all fuel use attributed to transit buses as Metro Transit only ran 40' buses
Employee Commute	City of Madison	Ratio of respondents using gasoline passenger vehicles, diesel passenger vehicles, and public transit applied to entire employee population

For vehicle transportation, it is necessary to apply average miles per gallon and emissions factors for CH4 and N2O to each vehicle type. The factors used are shown in Table 8.

Table 8: 2018 MPG and Emissions Factors by Vehicle Type

Fuel	Vehicle Type	MPG	CH4 (g/mile)	N2O (g/mile)
2018				
Gasoline	Passenger car	24.37713	0.0186	0.0093
	Light truck	17.86788	0.0201	0.0167
	Heavy truck	5.365653	0.086	0.0664
	Motorcycle	24.37713	0.0186	0.0093
Diesel	Passenger car	24.37713	0.0005	0.001
	Light truck	17.86788	0.001	0.0015
	Heavy truck	6.307708	0.0051	0.0048

Table 9: 2021 MPG and Emissions Factors by Vehicle Type (Proxy for 2022)

Fuel	Vehicle Type	MPG	CH4 (g/mile)	N2O (g/mile)
2021 (Proxy for 2022)				
Gasoline	Passenger car	25.3	0.0084	0.0069
	Light truck	18.2	0.0117	0.0087
	Heavy truck	5.383557	0.0719	0.0611
	Motorcycle	44	0.0084	0.0069
Diesel	Passenger car	25.3	0.0005	0.001
	Light truck	18.2	0.001	0.0015
	Heavy truck	6.561615	0.0051	0.0048

Potable Water

Table 10: Potable Water Data Sources

Activity	Data Source	Data Gaps/Assumptions
Energy Used in the Supply of Potable Water	Madison Gas & Electric; Alliant Energy	Separated from buildings & facilities energy consumption

Solid Waste

Table 11: Solid Waste Data Sources

Activity	Data Source	Data Gaps/Assumptions
Government Owned/Operated Landfills	City of Madison Engineering Division	Government only owns/operates closed landfills

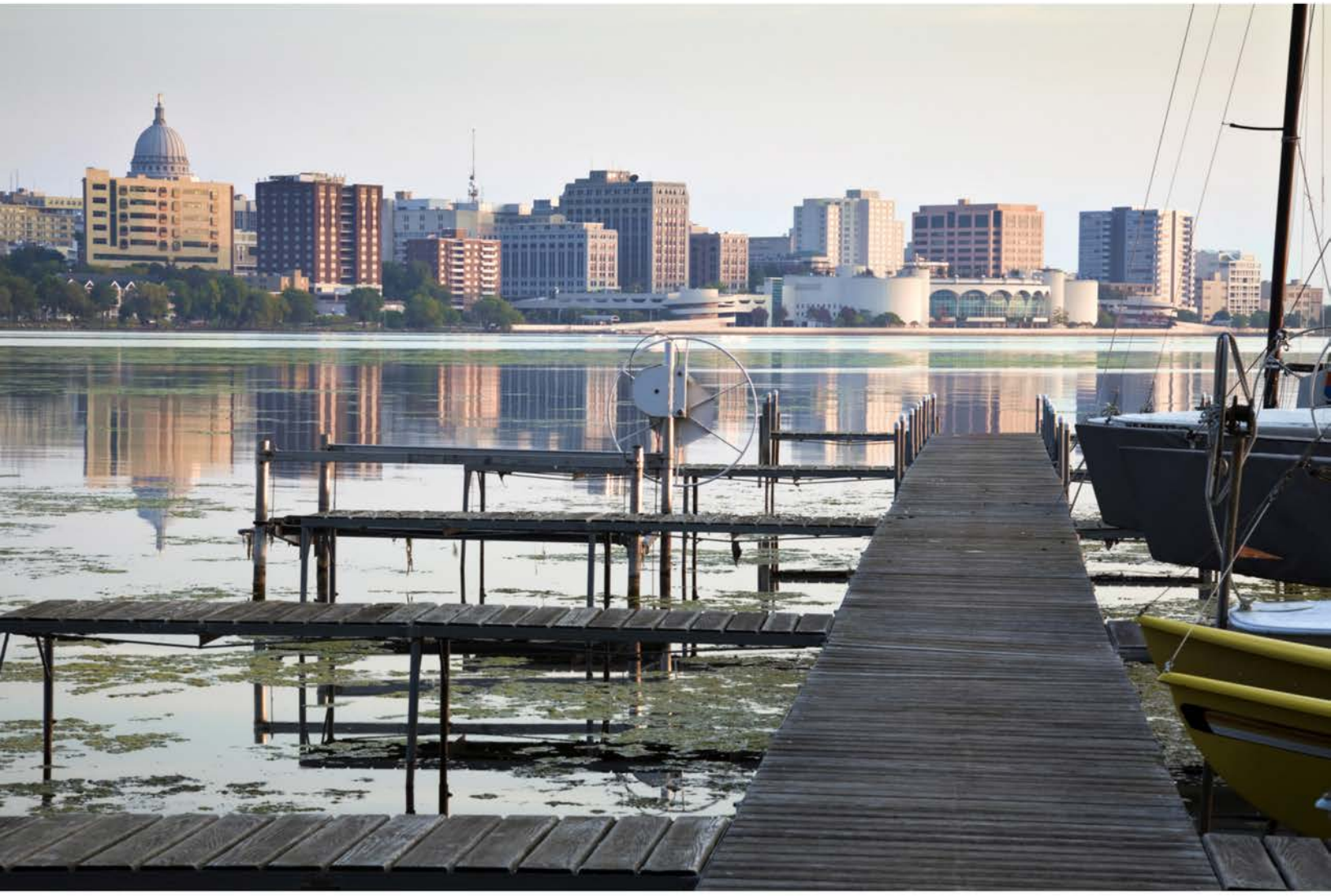
Fugitive Emissions

Table 12: Fugitive Emissions Data Sources

Activity	Data Source	Data Gaps/Assumptions
Fugitive Emissions from Natural Gas Distribution	Madison Gas & Electric	ClearPath defaults used for leakage rate, gas density, and gas composition
Hydrofluorocarbon & Refrigerant Emissions	City of Madion	N/A

Inventory Calculations

The 2018 & 2022 inventories were calculated following the US Community Protocol and ICLEI's ClearPath Climate Planner software. As discussed in Inventory Methodology, the IPCC 5th Assessment was used for global warming potential (GWP) values to convert methane and nitrous oxide to CO2 equivalent units. ClearPath Climate Planner's inventory calculators allow for input of the sector activity (i.e. kWh or VMT) and emission factor to calculate the final carbon dioxide equivalent (CO2e) emissions.



View of downtown Madison from Monona Bay