ClimateNav | CITY OF BLOOMINGTON

City of Bloomington, IN

2023 Community-Wide and Municipal Operations Greenhouse Gas Inventory

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Letter from the Assistant Director of Sustainability

I am pleased to present the City of Bloomington's 2023 Community-Wide and Municipal Operations Greenhouse Gas Inventory Report.

We completed the report in collaboration with ClimateNav, a public-benefit startup dedicated to helping local governments tackle climate change and improve sustainability within communities. The inventories were drafted in accordance with international standards, such as the *Global Protocol for Community-Scale Emissions*, to allow for the most rigorous accounting of our carbon footprint as possible.

Greenhouse gas inventories play an important role in helping climate-conscious cities like Bloomington understand the sources of emissions within our community, as well as to assess the impacts of local, state, and federal policy in mitigating those emissions over time. They also provide valuable insights that help us allocate resources more effectively, argue persuasively when applying for federal and state grants, and develop more targeted strategies for improving sustainability.

This report marks a significant milestone in our ongoing commitment to environmental stewardship and climate action as a city. For the first time, we have included a dedicated Municipal Operations Inventory alongside our Community-Wide Inventory, providing a new level of transparency and accountability in accounting for our City's carbon footprint. We've also provided an interactive version of the inventory on our Climate Action Dashboard, available at https://bloomington.climatenavhub.com, to enhance public engagement with the inventory.

Moving forward, we've established a streamlined process for updating both the community-wide and municipal operations inventories on an annual basis. This commitment to annual reporting places Bloomington among a select group of cities nationwide at the forefront of local climate action.

I encourage everyone to review this report thoroughly and join us in our ongoing work to combat climate change and promote sustainability within our community. Your engagement and support are vital as we strive to create a more resilient and environmentally responsible Bloomington for future generations.

Shawn Miya
Assistant Director of Sustainability
City of Bloomington, Indiana

Introduction

An overview of the GHG inventory process and the relevant protocols and methodologies used in this report.

Background

Local governments are emerging as critical players in the global fight against climate change. Greenhouse gas inventories serve as their most powerful data-driven tool for understanding emission sources and charting a path toward net-zero emissions for the entire community.

Climate Change: A Global Challenge with Local Impacts

Climate change, driven primarily by human activities that release greenhouse gases (GHGs) into the atmosphere, represents one of the most pressing challenges facing the world today. As global temperatures rise, communities worldwide are experiencing more frequent and severe weather events, shifting precipitation patterns, rising sea levels, and disruptions to local ecosystems. These changes have far-reaching consequences for public health, economic stability, and social equity.

In Bloomington, as in many cities across the United States, the effects of climate change are already being felt. Increased flooding risks, more intense heat waves, and changes in local biodiversity are just a few examples of how global climate shifts are manifesting at the local level. Understanding and addressing these impacts is crucial for ensuring the long-term resilience and prosperity of the City.

The Rising Role of Local Governments in Climate Action

While climate change is a global issue, local governments are increasingly recognized as key players in both efforts to mitigate existing emissions and adapt to the changing climate. Cities and towns are often on the front lines of climate impacts and are uniquely positioned to implement targeted solutions that address their community's specific vulnerabilities and mitigation opportunities.

Local governments can influence a significant portion of a community's greenhouse gas emissions through policies and programs related to land use, transportation, building codes, and waste management. They also have the ability to lead by example, implementing sustainable practices in their own operations and inspiring action from residents and businesses.

Moreover, local governments are often more agile than larger governmental bodies, allowing them to experiment with innovative approaches and respond quickly to emerging challenges. By taking decisive action on climate change, cities like Bloomington can not only contribute to global efforts but also create more livable, sustainable, and economically vibrant communities for their residents.

Greenhouse Gas Inventories: A Foundation for Climate Action

A greenhouse gas (GHG) inventory is a comprehensive accounting of the GHG emissions produced by a specific entity—in this case, the City of Bloomington—over a given period. The inventory serves as a crucial tool for understanding a city's contribution to climate change and identifying opportunities for emission reductions.

By quantifying emissions from various sectors such as building energy, transportation, and waste management, a GHG inventory provides a baseline against which future progress can be measured. This data-driven approach enables city leaders to:

1. Set informed and achievable emission reduction targets
2. Develop targeted climate action plans and policies
3. Prioritize investments in low-carbon infrastructure and programs
4. Track progress over time and adjust strategies as needed
5. Engage stakeholders with clear, quantifiable information

For Bloomington, this inventory represents a commitment to transparency and actionable climate leadership. It provides a foundation for evidence-based decision-making and helps ensure that the city's climate efforts are focused on the areas of greatest impact.

Two Complementary Approaches to Inventorying Local Emissions

This report encompasses two distinct but related GHG inventories: a community-wide inventory and a municipal operations inventory. Each provides valuable insights into different aspects of Bloomington's emissions profile.

Community-Wide Inventory

The community-wide inventory, conducted according to the *Global Protocol for Community-Scale (GPC) Emissions*, offers a comprehensive view of all GHG emissions within the City's geographic boundaries. This includes emissions from residential and commercial energy use, transportation, industrial processes, and waste management. By capturing the full scope of emissions associated with city-wide activities, this inventory helps identify broad trends and opportunities for community-wide climate action.

Municipal Operations Inventory

The municipal operations inventory, following ICLEI's *Local Government Operations (LGO) Protocol*, focuses specifically on emissions from the City of Bloomington’s own governmental activities. This includes emissions from City-owned buildings, vehicle fleets, streetlights, water treatment facilities, and other municipal operations. While typically a smaller portion of a city's overall emissions, this inventory is crucial for demonstrating leadership and identifying opportunities for the local government to "walk the talk" on climate action.

Together, these two inventories provide a comprehensive picture of Bloomington's GHG emissions, enabling the City to develop holistic strategies that address both community-wide and government-specific emission sources. By undertaking both inventories, Bloomington demonstrates its commitment to thorough and transparent climate action planning.

In the following sections, the specific methodologies, findings, and implications of both the 2023 community-wide and municipal operations inventories are discussed in detail.

About the City

Incorporated Name
City of Bloomington

County of Incorporation
Monroe County, IN

Year of Incorporation
1818

Population
78,840

Land Area
23.43 mi^2

A Brief History

Established in 1818, Bloomington has a rich history that spans over two centuries. Originally settled by pioneers from Kentucky, Tennessee, the Carolinas, and Virginia, the City was named for its abundance of blooming wildflowers. Over time, Bloomington evolved from a frontier settlement reliant on farming, limestone quarrying, and furniture manufacturing to become a vibrant, progressive community known for its cultural diversity, educational institutions, and commitment to sustainability.

Today, Bloomington is home to Indiana University, founded in 1820, which has played a significant role in shaping the City's character. The presence of the University has contributed to Bloomington's reputation as a center for education, research, and innovation, attracting a diverse population and fostering a culture of intellectual curiosity and civic engagement.

A Leader in Local Climate Action

Bloomington has emerged as a leader in municipal climate action, demonstrating a commitment to addressing global environmental challenges at the local level. In April 2021, the Bloomington City Council unanimously passed Resolution 21-08, formally adopting the City of Bloomington Climate Action Plan (CAP). This comprehensive plan set ambitious targets for reducing greenhouse gas emissions within the community:

- Aiming for a 25% reduction below 2018 levels by 2030
- Setting a target for carbon neutrality by 2050

What sets Bloomington apart is not just the adoption of these goals, but the City's dedication to regular assessment and transparency to help meet them. Unlike many municipalities that conduct greenhouse gas inventories every few years, Bloomington has committed to annual inventories. This frequent data collection and analysis allows for more responsive policy-making and demonstrates the City's serious approach to climate action.

Funding the Local Climate Transition

Bloomington's commitment to climate action is further evidenced by its innovative approach to funding sustainability initiatives. The City has established a dedicated budget for climate action, funded by a portion of the Economic Development Local Income Tax (ED-LIT). This allocated funding stream of $2 million annually is a rarity among U.S. cities and positions Bloomington as a pioneer in sustainable urban development.

The Economic and Sustainable Development (ESD) Department is responsible for spearheading the City's climate initiatives and managing sustainability-related programs. ESD’s staff and a small number of programs are funded by the City’s General Fund, while the majority of the City’s high-impact sustainability programs are funded by the aforementioned climate action budget.

Engaging the Community

Bloomington recognizes that effective climate action requires community-wide engagement and transparency. To this end, the City has developed a comprehensive Climate Action Dashboard, accessible at bloomington.climatenavhub.com. This interactive tool allows residents, businesses, and other stakeholders to:

- Explore the details of the Climate Action Plan
- Track the City's progress towards its emissions reduction goals
- Learn about current sustainability initiatives
- Find ways to get involved in local climate action programs
- Learn about how to reduce your individual carbon footprint and identify relevant financial rebates and incentives

The Dashboard has already been updated to include the emissions data presented in this inventory report. Residents are encouraged to visit the Dashboard to explore an interactive version of the inventory and learn about Bloomington’s different sustainability initiatives. Additionally, the Dashboard provides an extensive list of actions that individual residents can take to reduce their own carbon footprints, along with funding and educational resources to help guide action.

Inventory Methodology

Community-Wide Inventory Protocol

Global Protocol for Community-Scale Greenhouse Gas Inventories (v1.1)

Community-Wide Reporting Level

BASIC+

Municipal Operations Inventory Protocol

Local Government Operations Protocol (v1.1)

Inventory Boundaries

Official Municipal Boundaries

Reporting Year

2023

Community-Wide Inventory Methodology

Bloomington's community-wide GHG inventory adheres to the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)*. Developed by ICLEI - Local Governments for Sustainability, the World Resources Institute, and C40 Cities Climate Leadership Group, the GPC is the most widely used international accounting and reporting standard for cities.

Key Features of the GPC Protocol

1. **Comprehensive Scope:** The GPC requires cities to account for emissions from key sectors within their geographical boundaries, including:
    - Stationary Energy (i.e., energy used to power buildings, fixed infrastructure, and other parts of the City's built environment)
    - Transportation
    - Waste
    - Industrial Processes and Product Use (IPPU)
    - Agriculture, Forestry, and Other Land Use (AFOLU)
2. **Emissions Scopes:** The GPC categorizes emissions into three scopes:
    - Scope 1: Direct emissions from sources within the city boundary
    - Scope 2: Indirect emissions from grid-supplied electricity, heat, steam, and cooling consumed within the city boundary
    - Scope 3: Other indirect emissions that occur outside the city boundary as a result of activities taking place within the city boundary
3. **Flexible Reporting Levels:** The GPC offers two reporting levels:
    - BASIC: Covers scope 1 and scope 2 emissions from stationary energy and transportation, as well as scope 1 and scope 3 emissions from waste.
    - BASIC+: Includes BASIC sources plus more complex scope 1 and scope 3 emissions.
4. **Standardized Reporting:** The GPC provides a standardized format for reporting emissions, facilitating comparison between cities and tracking progress over time.

By following the GPC, Bloomington ensures that its community-wide inventory is comprehensive, internationally recognized, and comparable with analyses conducted in other cities worldwide.

Municipal Operations Inventory Methodology

For its municipal operations inventory, Bloomington utilizes the *Local Government Operations (LGO) Protocol*. This protocol, developed by ICLEI - Local Governments for Sustainability USA, provides a standardized approach for local governments to quantify and report GHG emissions resulting from their operations.

Key Features of the LGO Protocol

1. **Focus on Government Control:** The LGO Protocol specifically addresses emissions from sources that local governments own or control, such as:
    - Buildings and other facilities
    - Streetlights and traffic signals
    - Vehicle fleet
    - Water delivery and treatment facilities
    - Wastewater treatment plants
    - Solid waste operations
    - Urban forestry

2. **Operational and Financial Control Approaches:** The protocol allows for reporting based on either operational control (activities the government operates) or financial control (activities the government funds).

3. **Detailed Guidance:** The LGO Protocol provides specific methodologies for calculating emissions from various municipal activities, ensuring consistency and accuracy.

4. **Integration with Community-Wide Inventories:** While focused on government operations, the LGO Protocol is designed to be compatible with community-wide inventories, allowing cities to understand how their operations contribute to overall community emissions.

5. **Policy Relevance:** By isolating government operations, the LGO Protocol helps cities identify opportunities for emissions reductions in their own activities, supporting lead-by-example initiatives.

How the Inventory Data Was Collected

The data collection process for the greenhouse gas inventory was designed to be comprehensive, methodical, and tailored to the City's specific context. The process began by identifying all required and recommended emissions sources using the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)* for the community-wide inventory and the *Local Government Operations (LGO) Protocol* for the municipal operations inventory. For each emissions source, the most appropriate in-boundary data provider was determined, such as the local electric utility for grid-supplied electricity data or municipal waste management services provider for waste data.

A crucial step in the process was building strong relationships with key personnel within these organizations, primarily engaging with their sustainability, procurement, and data analytics teams. These relationships were instrumental in facilitating pulling the requisite data for the inventories, as well as understanding the different assumptions and constraints associated with each organization’s provided datasets.

However, limitations with data providers’ ability to query and transform the data exactly as required by the inventory protocols is a common occurrence. ClimateNav worked with each data provider to obtain the highest quality data possible within the data providers’ system constraints and carefully documented the parameters used in internal queries to ensure replicability in future years. Where exact data wasn't available, a proxy was identified to use as an alternative data source instead. In cases where a suitable proxy couldn't be identified, this was clearly notated in the inventory, with a detailed explanation for why the data was unavailable.

The ClimateNav Approach

ClimateNav is a public-benefit startup committed to tackling climate change and improving sustainability within local communities. Founded in 2020 by former public servants, the ClimateNav Team has direct experience working in and with local government and deeply understands the challenges and constraints faced by them. Our mission is to build tools and technology to help local governments and public agencies reduce their emissions and create more sustainable communities in a data-driven and equitable way.

We've spoken with hundreds of municipal leaders over the years, and we've seen firsthand many of the challenges faced by local government staff trying to utilize and update local greenhouse gas inventories. To this end, we've developed a unique approach to provide a more cost-effective and useful way to approach the GHG inventory process. We detail this approach and its benefits below.

Ensuring Consistency and Actionability

While standardized protocols like the GPC and LGO provide a framework for compiling greenhouse gas inventories, the field of emissions accounting still faces significant challenges in achieving true year-over-year comparability. ClimateNav addresses these challenges through an innovative, three-pronged approach that sets a new standard for consistency, accuracy, and policy relevance in conducting GHG inventories.

A persistent issue in the field of GHG accounting is the lack of consistency between inventories, even when they follow the same protocols. Different consultants often employ varying technical approaches to estimate emissions within each sector, leading to discrepancies that can obscure real trends in emissions data. This inconsistency can make it difficult for cities to accurately track their progress and make informed policy decisions.

To address these challenges and provide Bloomington with a truly robust and actionable inventory, ClimateNav has implemented a three-fold approach:

1. **Back-Casting for Consistency:** ClimateNav doesn't just start with the current year's data. Instead, we apply our specific technical approach to estimating emissions retroactively to prior inventory years. This back-casting ensures that all numbers, regardless of the year, are calculated using the same methodology. The result is a dataset that allows for genuine year-over-year comparisons, revealing true trends in a city's emissions profile.
2. **Streamlined Annual Process:** Recognizing the importance of regular, consistent data collection, ClimateNav has developed proprietary technology that streamlines the inventory calculation process. This system is designed to be repeatable on an annual basis, allowing Bloomington to maintain its commitment to yearly inventories without an overwhelming administrative burden.

   Moreover, ClimateNav works to build deep relationships with data providers, integrating as closely as possible with their systems. This approach not only ensures data consistency but also improves the efficiency and accuracy of data collection over time.
3. **Transparent Documentation:** ClimateNav places a strong emphasis on documenting every technical detail of the inventory process. This level of transparency serves two crucial purposes:

   - It allows the City of Bloomington and other interested stakeholders to fully understand the methodology behind their inventory, fostering trust in the results.
   - It enables the City or other consultants to replicate the analysis in the future, ensuring continuity even if there are changes in who conducts the inventory or the underlying data provider's own staff.

A Pragmatic Approach to Data Gaps

Another significant challenge in constructing GHG inventories is dealing with missing or incomplete data. ClimateNav addresses this issue with a pragmatic approach focused on maximizing the policy relevance of the final report.

When exact data is unavailable, we carefully select proxies that align with the City's policy needs and control. For instance, in the case of Bloomington's municipal fleet, perfect annual mileage data for every vehicle was not available. Instead of using a broad estimate that might not reflect the City's actual operations and could not realistically reflect actual emissions changes year-over-year, ClimateNav opted to track the percentage of electric vehicles versus traditional combustion engines in the fleet.

This choice was made because:

1. The City has limited control over the total miles driven due to relatively inflexible operational needs.

2. The City arguably has more direct influence over vehicle purchasing policies and can work towards increasing the proportion of EVs in its fleet.

By focusing on choosing a proxy metric which the City can actually directly influence, the inventory becomes a practical tool for policy-making rather than just a compliance exercise founded on inaccurate estimations and assumptions. Pragmatic decisions like this were made throughout the inventory process, allowing Bloomington to set targeted and actionable goals and measure progress on them using the annual inventory report.

Independent Review Process

The greenhouse gas inventory presented in this report underwent a comprehensive independent review conducted by Dr. Valère Lambert, Principal Investigator at the University of California, Santa Cruz. The third-party verification process strengthened the reliability and credibility of the inventory findings through a systematic evaluation of three key components:

- **Data Verification:** The review process began with a thorough examination of all underlying data used in emissions calculations. This included cross-referencing raw data inputs against original source documentation from third-party providers to verify accurate transcription and proper data handling throughout the inventory development process.
- **Methodological Assessment:** A detailed evaluation of the methodological framework employed in this inventory was conducted. This assessment examined the application of global emissions protocols, verified the appropriateness of emissions factors and calculation methodologies, and scrutinized key assumptions.
- **Technical Validation:** The final component of the review focused on technical accuracy, encompassing a detailed examination of all quantitative analyses and their visual representations. This included verification of calculation procedures, validation of the code used to generate data visualizations, and confirmation that all graphs and figures accurately represent the underlying data.

Community-Wide Inventory

A comprehensive inventory of greenhouse gas emissions generated by all activities taking place within the City's geographic boundaries.

Overview

Introduction

A community-wide greenhouse gas (GHG) inventory is a comprehensive accounting of GHG emissions produced within a defined geographic boundary over a specified time period. For the City of Bloomington, this inventory encompasses all GHG emissions occurring within the city limits during the 2023 calendar year.

There are several motivators for why a local government conducts a community-wide greenhouse gas inventory:

- They establish a baseline understanding of emission sources and quantities.
- They enable tracking of emissions trends over time.
- They inform the development of targeted climate action plans and policies.
- They allow for benchmarking and comparison with other communities.

Inventory Methodology

This inventory was completed using the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)*, which is the most widely used international accounting and reporting standard for cities. The GPC provides a robust, transparent and globally-accepted framework for consistently identifying, calculating and reporting city-wide GHG emissions.

Emissions Scopes and Reporting Levels

The GPC categorizes emissions into three "scopes":

SCOPE 1

Direct emissions from sources within the city boundary (e.g., fuel combustion in buildings, vehicles)

Example: Emissions from natural gas combustion in homes

SCOPE 2

Indirect emissions from grid-supplied electricity, heat, steam and cooling consumed within the city boundary

Example: Emissions from electricity produced at a coal-fired power plant outside of the City's boundaries but used within the City to power homes

SCOPE 3

All other indirect emissions that occur outside the city boundary as a result of activities taking place within the city

Example: Emissions from the disposal of waste generated inside of the City but landfilled elsewhere

The GPC offers two levels of reporting: BASIC and BASIC+. This inventory was conducted at the more comprehensive BASIC+ level, aiming to include as many emission sources as possible for a complete picture of Bloomington's carbon footprint.

Prior GHG Inventories

The City of Bloomington has commissioned a number of greenhouse gas inventories prior to 2023 as well. Prior to this report, the most recently conducted GHG inventory was based on calendar years 2019-2022 and can be found on the City's website here. Before that, a 2018 GHG inventory was also conducted and is available here.

A Word of Caution When Comparing With Prior Inventories

While these prior reports provide valuable insights into the City's emissions at a specific point in time, it is important to exercise caution when comparing data between different inventories.

Different consultants often use varying methodologies when calculating GHG inventories, which can make year-over-year comparisons challenging. Even when the same consultant is conducting the analysis across multiple years, discrepancies can arise due to differences in how data providers generate and deliver information. For example, internal data query processes within a utility or government agency may change, resulting in variances in the numbers reported from one year to the next, even if the emissions activities themselves haven't shifted significantly.

To address this issue, ClimateNav has taken a more comprehensive and innovative approach in compiling Bloomington's 2023 GHG inventory. In addition to calculating emissions for 2023, ClimateNav requested data for prior years wherever possible to create a more consistent, year-over-year emissions trend. This reduces the likelihood of methodological inconsistencies and ensures a higher level of accuracy across the datasets.

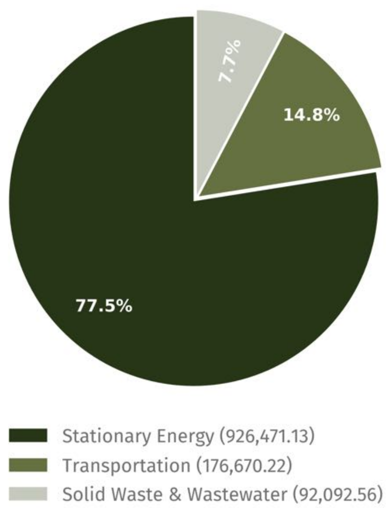
The good news is that ClimateNav's methodology, as described in the introduction to this report, is designed to overcome the common challenges of data inconsistency and comparison across years. Looking forward, ClimateNav will continue to support future community-wide inventories with a streamlined process that maximizes the comparability and reliability of the data, ensuring Bloomington can better track its progress in reducing emissions.

Overall Trends

A Breakdown of Community-Wide Emissions

The City of Bloomington is estimated to have contributed 1,195,233.91 in metric tons of CO_2e emissions in the calendar year of 2023. As shown in the pie chart below, 77.5% of these emissions came from the Stationary Energy sector, followed by 14.8% in the Transportation sector and 7.7% for Solid Waste & Wastewater.

Community-Wide Emissions, by Sector (2023)



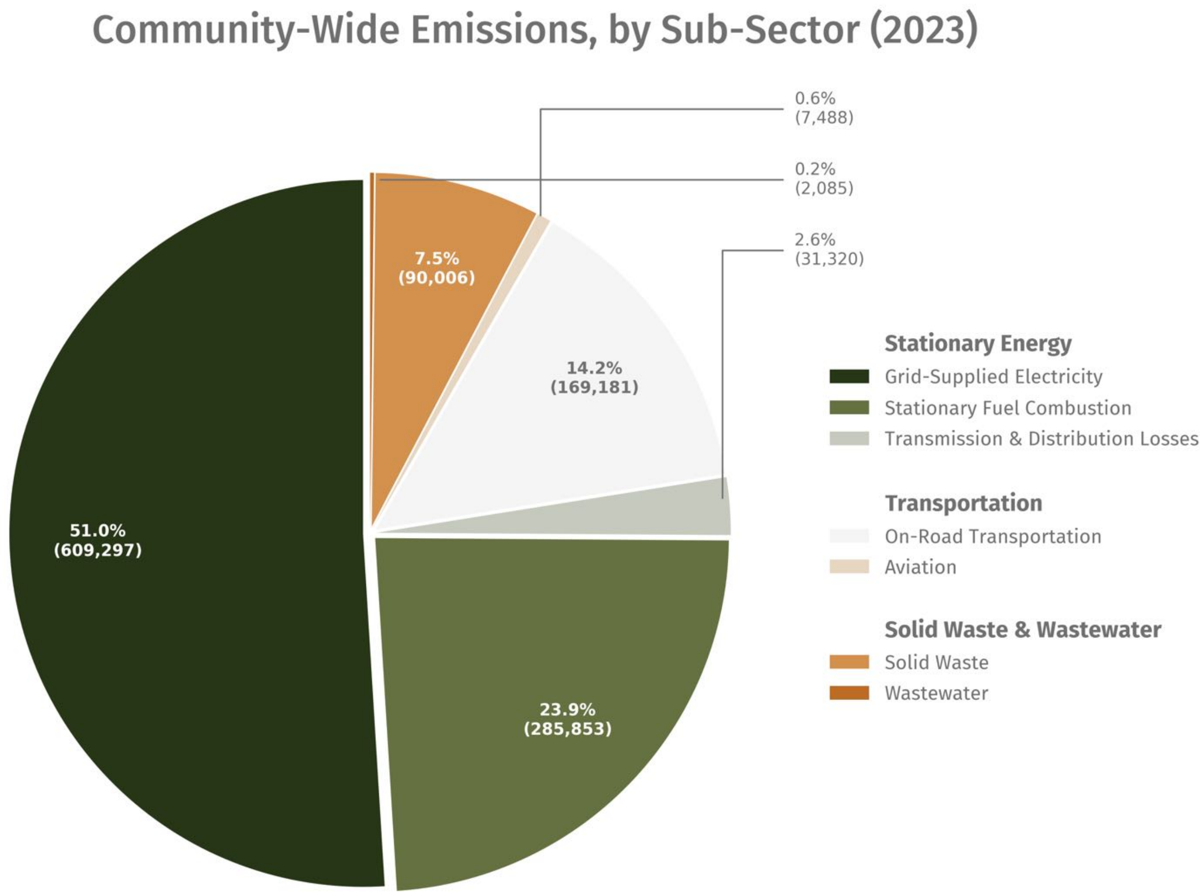
Emissions from each sector can be further segmented by their constituent sub-sectors which describe the different types of emission sources within each sector.

The following are some high-level observations about the breakdown of emissions on a sub-sector level for the community-wide inventory:

- **Just over half (51.0%) of the emissions can be attributed to the consumption of grid-supplied electricity by Duke Energy, followed by 23.9% for stationary fuel combustion through CenterPoint Energy.** Indiana, as a state, has a relatively lower amount of renewable energy generation powering the grid than many other states as a result of both state policy and geographical considerations. Accordingly, the EPA estimates that Indiana's grid produces 22.7% more emissions than the national average, which partially explains why grid-supplied electricity is such a major contributor to Bloomington's emissions.
- **On-road transportation dwarfs the aviation sub-sector within transportation sector overall, resulting in 14.2% of total community-wide emissions in contrast to just 0.6% for aviation.** This is likely a function of the Monroe County Airport being a relatively smaller airport, and Indianapolis International Airport—which serves significantly more flight routes—being within just under an hour's drive from the city limits.
- **Solid waste and wastewater make up less than 10% of overall emissions, specifically 7.5% and 0.2% respectively.** Solid waste is a more challenging sub-sector to decarbonize than others. Decarbonization requires one of three main approaches: reducing the total volume of waste disposed, installing methane capture systems in landfills, or diverting waste entirely through reprocessing facilities. Each of these options is costly to implement and rarely generates a net surplus of savings to

distribute throughout the value chain. This is unlike grid-supplied electricity, where new solar power plants can simultaneously reduce consumer costs and yield profits for developers.

A pie chart of community-wide emissions broken out by each sub-sector is included below.



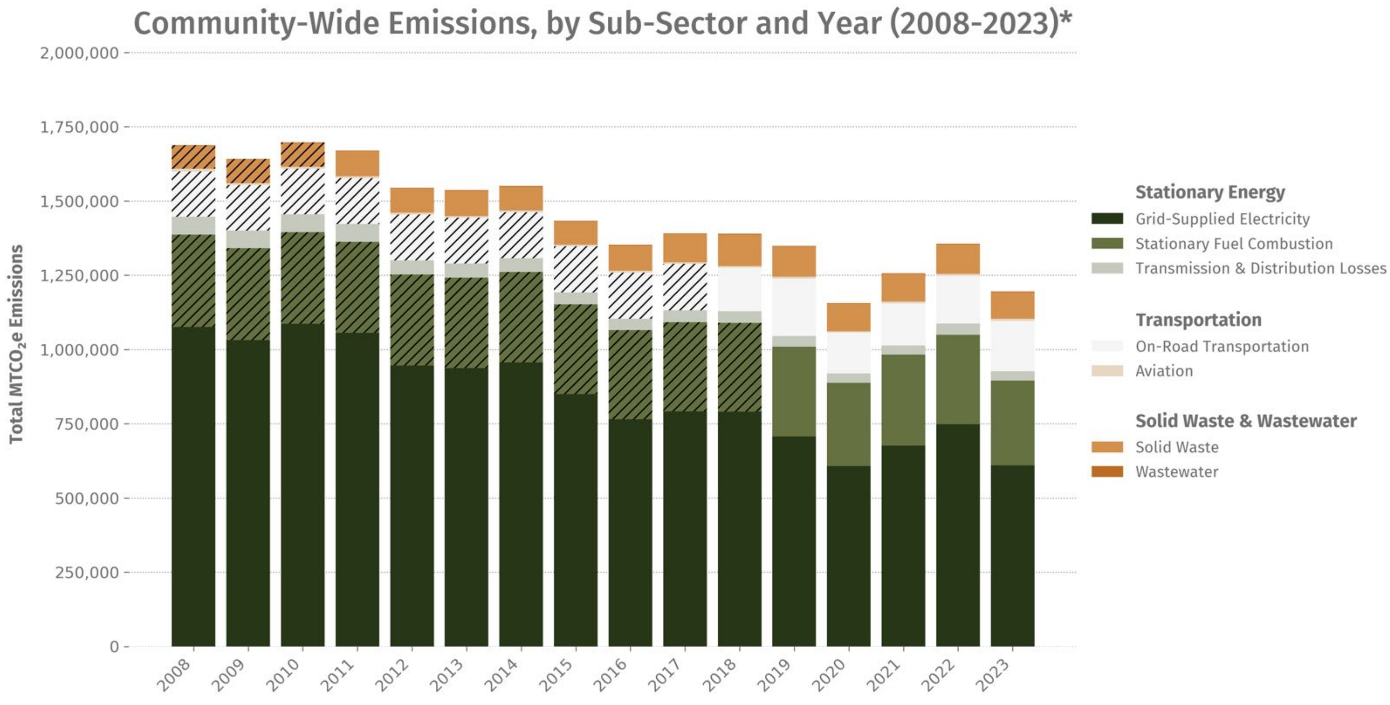
Understanding Historical Emissions

A useful exercise—and indeed a primary motivation for updating a greenhouse gas inventory—is to compare the emissions year-over-year to understand trends, as well as to ascertain the impact of federal, state, and local regulations in mitigating emissions over time.

As was mentioned in the Introduction to this report, a number of data limitations and methodological challenges make comparing emissions year-over-year quite difficult. Fortunately, these challenges will be resolved in future years due to the methodology developed and employed by ClimateNav in calculating emissions, starting with this 2023 inventory. This will make future year-over-year comparisons highly accurate and useful in driving consequential policy decisions.

However, in the meantime, an estimate of historical emissions can be calculated by interpolating trends in the existing data that is available. In practice, this means if data from 2008-2017 is unavailable but 2018-2023 data is, those prior years can be estimated based on the trendlines present in the available data.

This interpolation process was conducted and the resulting graph is provided below. Please note that this is a rough estimation given the data limitations and should not be taken as exact emissions numbers for each historical year.



*Cross-hatched bars indicate the data was unavailable for that year and instead imputed.

The above graph demonstrates a few trends in Bloomington's community-wide inventory over the years:

- **Grid-supplied electricity remains the primary driver of emissions within the City, by far, for every year inventoried.** However, the total amount of emissions from grid-supplied electricity decreased in absolute terms since 2008. This is validated by the EPA's estimations that the state of Indiana's electric grid has reduced in carbon intensity by approximately 35.5% between the years of 2007 and 2023.
- **Stationary fuel combustion and on-road transportation are the top two and three sources of community-wide emissions, respectively, historically.** Unlike grid-supplied electricity, these two emissions drivers have not reduced much in absolute terms. This is consistent with the fact that reducing emissions from these two sub-sectors is much more difficult than doing so in the grid-supplied electricity sub-sector. Emissions can be reduced on either the supply side (i.e., through the electrification of vehicles or buildings that rely on fossil fuels) or demand side (e.g., increasing the usage of public transit or reducing the amount of heating used in buildings during the winter). Both of these pose significant challenges in that supply-side solutions are incredibly capital-intensive and demand-side solutions require significant behavioral change—illustrating the challenge that lies ahead for Bloomington in reducing emissions from these two sub-sectors.[1]
- **Emissions from the solid waste sub-sector have actually increased slightly since 2008.** This is despite the fact that Bloomington's population, according to the US Census, has remained relatively constant over that same time period. The EPA reports that per capita municipal solid waste generation has increased relatively consistently since 1960, so Bloomington's increase in this sub-sector's emissions is not unique and reflects a broader national trend.

The rest of this chapter goes into depth in analyzing emissions from each sub-sector and exploring the different drivers of Bloomington's community-wide emissions in 2023 and years prior.

[1] Absolute emissions from grid-supplied electricity are much easier to decrease on both the supply and demand side. On the supply side, renewable energy is easier to implement in the electric grid because it can be financed and integrated centrally. Utility companies can build renewable plants that serve millions simultaneously, while reducing stationary fuel combustion requires consumers to make capital expenditures individually. For example, millions of consumers with gas stoves must individually switch to electric cooktops, or homeowners with gas heating must adopt alternative systems, like geothermal heating—each of which requires significant upfront investment and may not be accessible to all.

On the demand side, stationary fuel combustion uses (like home heating with natural gas) are still less elastic than electricity uses, because homes must be heated during winter months, making reductions more difficult. Similar challenges in both supply and demand explain why emissions from the on-road transportation sub-sector have also not significantly decreased in Bloomington over the past decade, compared to the significant progress made in reducing emissions from grid-supplied electricity.

Progress Toward Emissions Reduction Targets

Overview of Emissions Reduction Targets

The City of Bloomington formally adopted its Climate Action Plan in April 2021 by a unanimous vote. The Plan established two specific emissions reduction targets to help guide the City's efforts to reduce its emissions and contribution toward global warming:

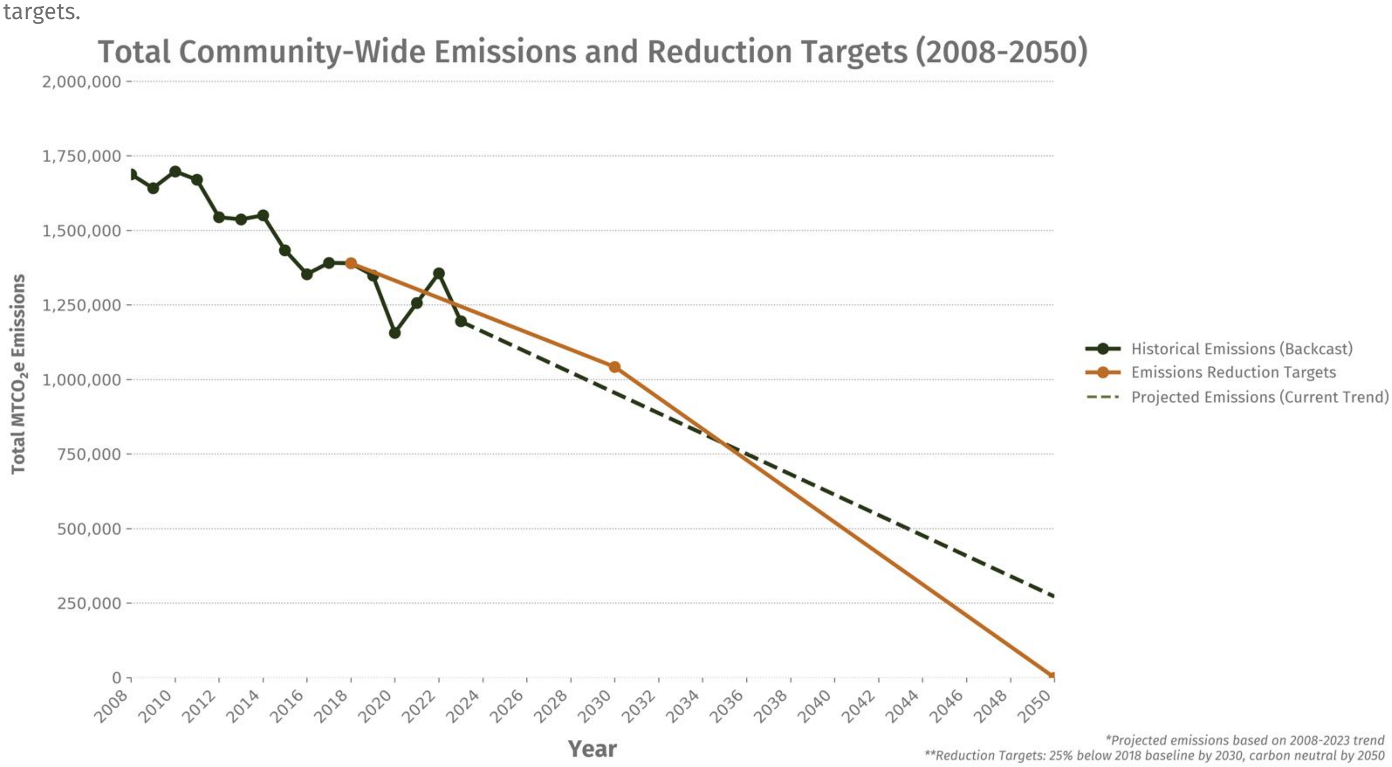
1. To reduce community-wide greenhouse gas emissions by 25% below the 2018 baseline by 2030
2. To reduce community-wide greenhouse gas emissions by 100% below the 2018 baseline by 2050 (i.e., carbon neutrality)

The **2018 official baseline** was determined to be 1,290,493 $MTCO_2e$ in the 2021 Climate Action Plan formally adopted by Council. However, as mentioned previously, this 2023 community-wide inventory was conducted using an updated methodology based on the latest climate science. Therefore, a "backcast" which estimates what the inventory would be in prior years results in a **2018 adjusted baseline** of 1,364,956 $MTCO_2e$.

In this analysis, the City's emissions targets will be evaluated against the adjusted baseline as it provides a more consistent and accurate picture of the City's progress toward achieving its emissions reduction goals.

Overall Emissions Reduction Targets

The chart below provides a visual overview of the City's progress toward achieving its overall, community-wide emissions reduction targets.



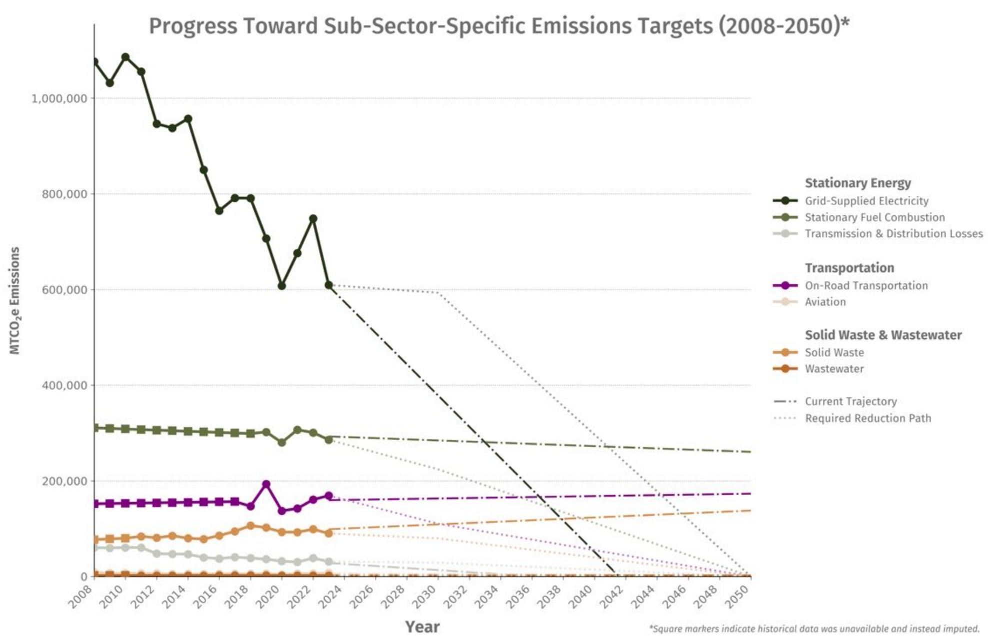
Here are some observations based on the chart and the City's current emissions reduction targets:

- **The City is on track—and even ahead of schedule—to meet its 2030 emissions target.** The 2030 goal is to reduce community-wide emissions by 25% of the 2018 baseline. The orange line in the graph above shows the trendline necessary to meet both the 2030 and 2050 emission reduction targets. The dotted black line extrapolates the City's current emissions and forecasts what they may look like between 2024 and 2050 based on historical emissions data as far back as 2008. As shown on the graph, the projected emissions trendline is below the emissions reduction target trendline through 2030 which demonstrates that the City is on track to meet its 2030 target, assuming emissions continue to decrease at the same average pace as they have since 2008.
- **The City is not currently on track to meet its 2050 carbon neutrality goal.** The projected emissions trendline crosses the emissions reduction target trendline around the year 2035 and then remains above the latter line through 2050. This suggests that the City will need to increase the magnitude of its emissions reductions to remain on pace with the 2050 target.
- **The City will need to increase its rate of annual emissions reductions by 29.6% to achieve its 2050 carbon neutrality goal.** Currently, the projected emissions trendline shows the City is reducing its community-wide emissions by about 34,168 $MTCO_2e$ per year. However, the City will actually need to reduce its overall emissions by 44,268 $MTCO_2e$ annually if it wants to achieve carbon neutrality by 2050—a 29.6% increase in its rate of annual emissions reductions.

Overall, the City is on track to meet its 2030 emissions reduction target and needs to make a modest increase in its rate of annual emissions reductions to achieve carbon neutrality by 2050. The majority of climate action plans, including the City of Bloomington's, are written with the assumption that a combination of future federal/state policy and technological advances will drive down community-wide emissions by a substantial degree on their own. Therefore, the projected emissions trendline shown in the graph above is likely overly conservative and much of the 29.6% increase in reductions needed may be accounted for by future policy and technological developments.

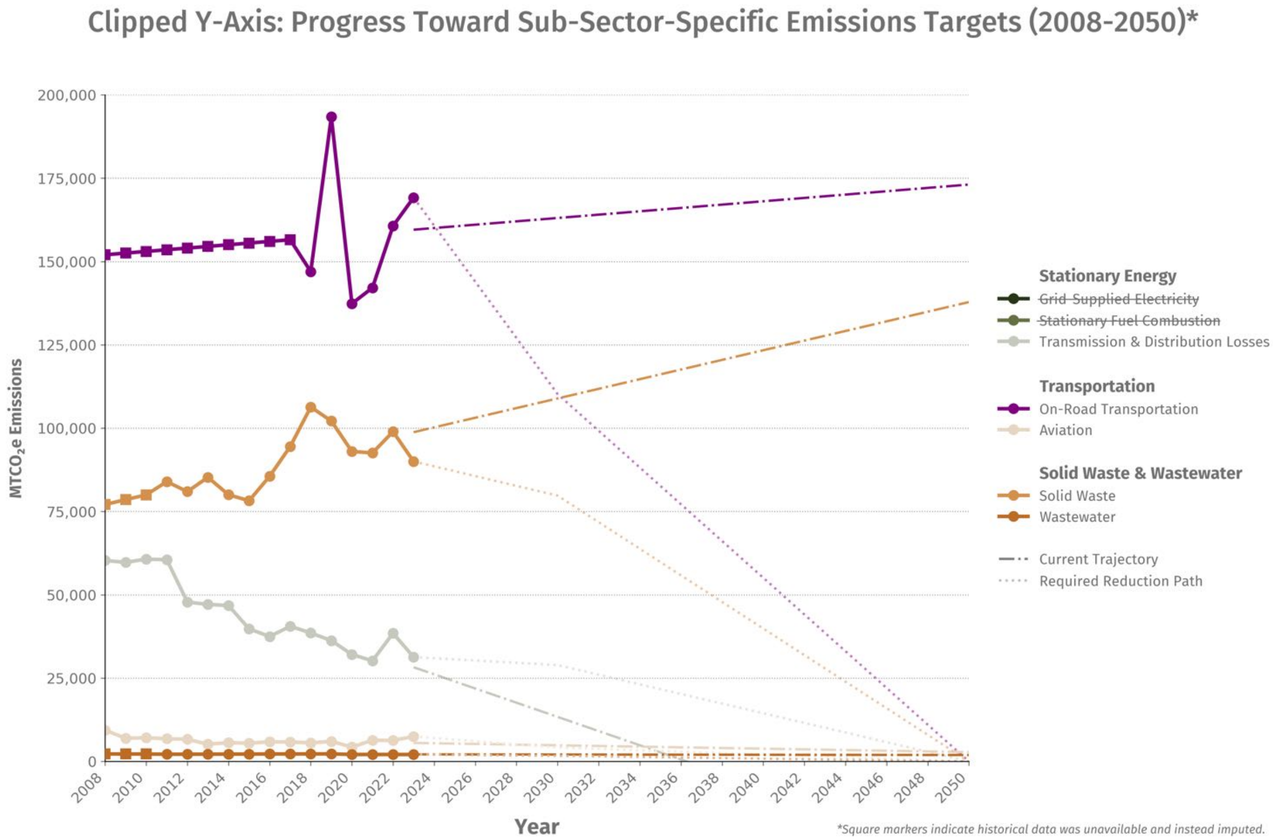
Sub-Sector Emissions Reduction Targets

The chart below provides an overview of progress toward the emissions reduction targets on a sub-sector-specific basis. Historical data (sometimes imputed via a backcast) is provided for the years 2008 through 2023. The data is then extrapolated out to 2050 on the basis of the current emissions trajectory and a contrasting line showing the required reduction path to meet the reduction targets is also shown.[2]



[2] Forecasts shown are based on historical trends and may not reflect future conditions. For example, Duke Energy recently extended the lifespan of coal plants due to increased regional power demand (Institute for Energy Research, 2024), indicating that historical grid decarbonization trends may not continue at the same rate. Similar shifts in other sectors could alter actual reduction paths from those shown.

Because of the above graph's scale, smaller values can be difficult to see when showing the full range, so the graph below focuses on displaying emissions only between 0 and 200,000 $MTCO_2e$ to better highlight the trends of lower-emitting sectors. As a result, the graph below excludes the Grid-Supplied Electricity and Stationary Fuel Combustion sub-sectors (as indicated with a strikethrough in the legend) but provides a better view of the other sub-sectors such as Aviation and Wastewater.



Here are some observations based on a sub-sector analysis of the City's emissions targets:

- **The City is ahead of schedule in meeting its grid-supplied electricity reduction targets but behind in the stationary fuel combustion sub-sector.** Duke Energy, the City's primary electric utility provider, has increasingly moved toward renewables in recent years which has resulted in significant decarbonization in this sub-sector. Grid-supplied electricity is expected to reach carbon neutrality by 2041, whereas stationary fuel combustion is not on track to meet either of the City's 2030 or 2050 emissions targets.
- **On-road transportation remains a significant source of emissions and is not on track to meet either of the City's reduction targets.** Decarbonizing the on-road transportation sub-sector requires electrification of vehicles which is both expensive and still in the early stages in the US. The City is not on track to meet either of the 2030 or 2050 reduction targets and will need to significantly increase the electrification of its residents' vehicles to reach the targets.
- **Solid waste, the fourth largest source of emissions in the City, is also not on track to meet either of the City's reduction targets.** While a smaller share of emissions than the top three sub-sectors, the gap between the current trajectory and required reduction path is much larger than for the top three sub-sectors. This suggests that the City must significantly increase its rate of emissions reduction in the solid waste sub-sector to achieve carbon neutrality in this area and points to the inherent challenges in decarbonizing this sub-sector which have made the existing rate of progress lower than in other areas.

The above chart shows that gains in the decarbonization of grid-supplied electricity are driving the majority of overall, community-wide emissions reductions. Historically, this has been the largest source of emissions for most communities, so it's promising to see such significant progress in this area. However, decarbonizing the other sub-sectors will be crucial if the City wants to remain on track to meet its future reduction targets.

Stationary Energy

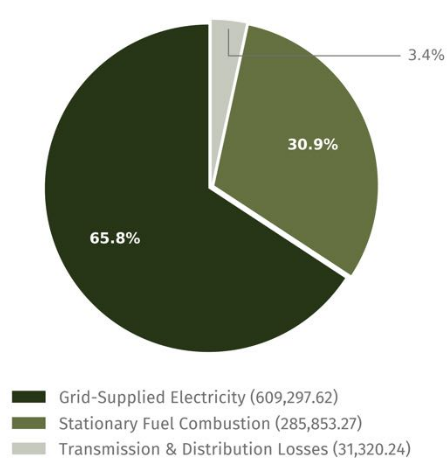
Overall Emissions from Stationary Energy

Emissions from the Stationary Energy sector represent 77.5% of Bloomington's total overall emissions—meaning it is the largest source of emissions in the City. Stationary Energy refers broadly to emissions from energy used to power residential, commercial, and industrial buildings, as well as other facilities that consume energy for heating, cooling, lighting, and powering appliances and machinery. These emissions primarily stem from the combustion of fossil fuels, such as natural gas and coal, as well as electricity generated from non-renewable sources.

Overall emissions from this sector, by year, are shown in the chart to the right and the table below. Note that emissions from this sector are broadly split into three different sub-sectors:

- **Grid-Supplied Electricity:** Emissions from the combustion of fossil fuels to generate electricity and transmit it via the power grid for use in powering buildings, facilities, and machinery. For example, Duke Energy generates a significant portion of Bloomington's electricity using coal-fired power plants.
- **Transmission and Distribution:** Emissions resulting from energy losses that occur during the transmission and distribution of electricity from power plants to end users. These losses are mainly due to resistance in power lines and equipment inefficiencies.
- **Stationary Fuel Combustion:** Emissions generated directly from burning fossil fuels such as natural gas, propane, or oil on-site in homes, businesses, or industrial facilities for heating, cooking, or other energy needs.

Stationary Energy Emissions, by Sub-Sector (2023)



As shown in the pie chart on the right, the majority of Bloomington's emissions are due to grid-supplied electricity which is the case for most urbanized cities in the United States. This is followed by Stationary Fuel Combustion which makes up around a third of stationary energy emissions. Transmission and distribution losses constitute a relatively much smaller share of overall emissions but are still significant enough to merit their inclusion in the inventory.

Actual data values for the Stationary Energy sector are shown below. Note that historical data from 2008-2018 are missing for the Stationary Fuel Consmption sub-sector because they were unable to be provided by the City's stationary fuel utility, CenterPoint Energy.

Stationary Energy Emissions, by Sub-Sector and Year ($MTCO_2e$)

Year	Grid-Supplied Electricity	Stationary Fuel Consumption	Transmission & Distribution Losses from Grid-Supplied Electricity
2008	1,076,318	-	60,300.99
2009	1,031,594	-	59,735.98
2010	1,086,305	-	60,698.31
2011	1,055,410	-	60,525.46

2012	946,256	-	47,828.14
2013	937,576	-	47,114.23
2014	956,841	-	46,781.31
2015	850,042	-	39,797.33
2016	764,492	-	37,478.39
2017	791,230	-	40,553.00
2018	790,861	-	38,560.76
2019	706,566	302,169.33	36,256.30
2020	607,556	280,189.14	32,097.95
2021	676,060	306,742.98	30,192.95
2022	748,433	300,858.33	38,472.32
2023	609,298	285,853.27	31,320.24

Grid-Supplied Electricity and Transmission & Distribution Losses

Grid-supplied electricity is the sub-sector which refers to emissions generated in supplying electricity to power buildings, facilities, and machinery within the inventory boundaries. Closely related to this sub-sector are emissions resulting from energy lost in the transmission and distribution (T&D) of that electricity to its end destination.

T&D losses are an inevitable result of energy dissipating as heat when electricity travels through power lines and transformers, causing inefficiencies in the electric grid. These losses mean that for every kilowatt-hour of energy consumed within Bloomington, some additional percentage of energy had to be generated to compensate for the lost energy during transmission. As a result, the actual emissions associated with electricity use in the City are slightly higher than the amount of electricity consumed would suggest, due to these grid inefficiencies. Those emissions are accounted for as "T&D Losses" within the greenhouse gas inventory.

The methodology for calculating these emissions is as follows:

1. **Gather Raw Data:** Total annual energy consumption in kilowatt-hours (kWh) for each year and category (residential, commercial, industrial, etc.) is collected. For the City of Bloomington, this data was obtained from the local utility, Duke Energy.
2. **Calculate Emissions:** The EPA's eGRID emissions factors are used to calculate total emissions for Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). eGRID provides region-specific emissions factors that reflect the energy mix (e.g., coal, natural gas, renewable energy) used to generate the electricity consumed in Bloomington.
3. **Convert to Metric Tons:** The emissions calculated in pounds (lbs) for each greenhouse gas are converted to metric tons, as metric tons are the standard unit used in greenhouse gas reporting.
4. **Convert to CO_2 Equivalents:** The metric tons of each gas are converted to metric tons of CO_2 equivalent ($MTCO_2e$). This step accounts for the global warming potential (GWP) of each gas, where methane (CH_4) and nitrous oxide (N_2O) have a higher GWP than carbon dioxide (CO_2).
5. **Aggregate Emissions:** The $MTCO_2e$ values for each greenhouse gas are summed to obtain the total standardized emissions by year and category. This aggregated data provides a comprehensive view of Bloomington's grid-supplied electricity emissions and helps identify trends over time.

A breakdown of emissions from the grid-supplied electricity sub-sector is shown in the table below.

Grid-Supplied Electricity Emissions, by Category and Year ($MTCO_2e$)				
Year	Residential	Commercial	Industrial	Government
2023	228,776	174,595	80,108	125,819

Next, emissions from transmission and distribution losses were calculated for each category described above to provide a better picture of total emissions stemming from the consumption of grid-supplied electricity within the City. The following methodology was applied:

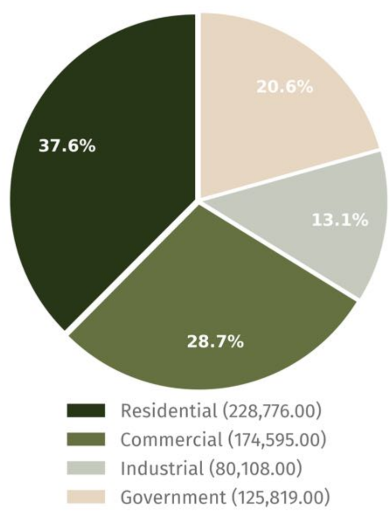
1. **Calculate the T&D Loss Rate:** Table 10 from the Energy Information Administration's (EIA) *State Electricity Profile for Indiana* was used, which was only updated through 2022 at the time of inventory compilation. Using the Energy Information Administration (EIA)'s preferred formula, the estimated rate for T&D losses was calculated by dividing the estimated losses by the result of total disposition minus direct use. Since data for 2023 was unavailable, the loss rate from 2022 was imputed.
2. **Apply the Loss Rate:** After determining the T&D loss rate, it was applied to each category of $MTCO_2e$ emissions for grid-supplied electricity. This allowed for the calculation of the proportional increase in emissions due to energy lost during transmission and distribution, which occurs upstream of actual stationary energy consumption within the inventory boundaries.

Transmission & Distribution Losses Emissions, by Category and Year ($MTCO_2e$)

Year	Residential	Commercial	Industrial	Government
2023	11,759.95	8,974.84	4,117.86	6,467.58

As you can see in the chart to the right, the majority of emissions from the Grid-Supplied Electricity sub-sector are from the residential category, accounting for 37.6% of total emissions. This category includes electricity used in homes for heating, cooling, lighting, appliances, and electronic devices. Close behind is the the commercial category, contributing 28.7% of emissions. This category encompasses electricity use by businesses, offices, retail spaces, and service providers. Common uses include lighting, HVAC systems, computers, and machinery required for operations.

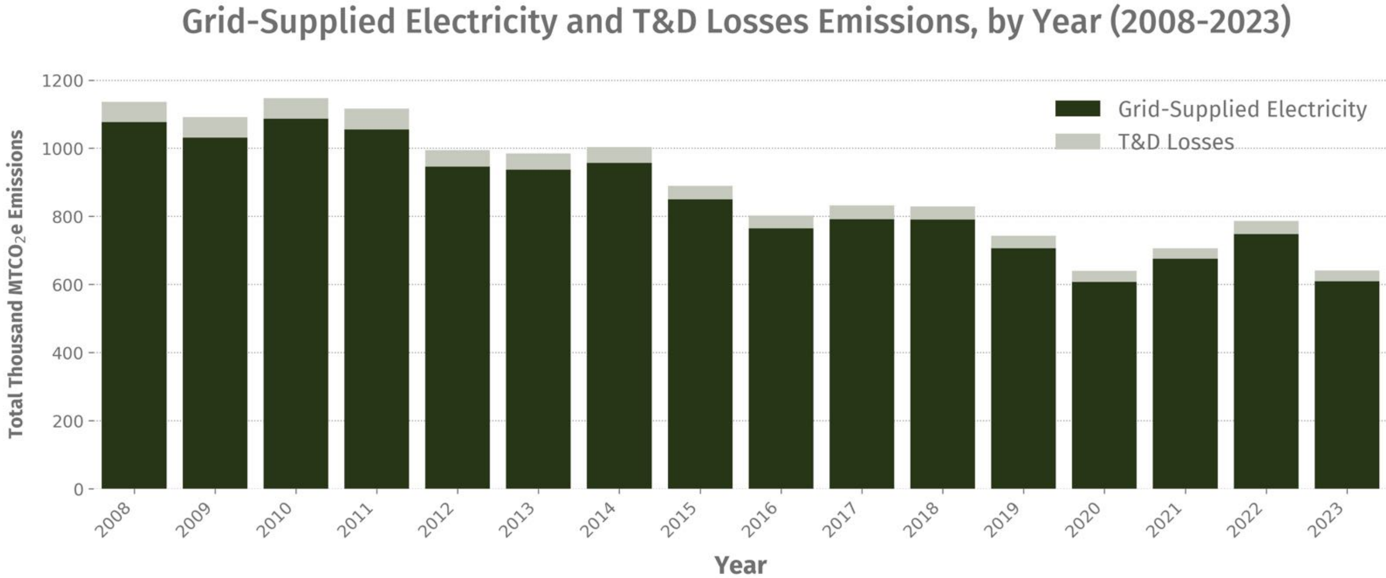
Grid-Supplied Electricity Emissions, by Category (2023)



The government category represents 20.6% of emissions. This includes public buildings, schools, and other government facilities that consume electricity for essential services such as lighting, public infrastructure, and administration. Note that the government category refers to all levels of government (federal, state, and local) and not just emissions from the City of Bloomington's operations.

Lastly, the industrial category accounts for 13.1%, reflecting electricity consumption by factories, warehouses, and manufacturing plants. This category typically includes energy-intensive operations such as production machinery, industrial lighting, and facility maintenance systems. As expected, this is the smallest category of grid-supplied electricity emissions in the City, which makes sense given that Bloomington is not a major location for industrial facilities or mass production.

Another useful way to analyze emissions from this sector is to look at the historical trends of how emissions have changed over the years due to these two sub-sectors. As you can see in the chart below, total emissions from both grid-supplied electricity and T&D losses have decreased steadily over the years.



From 2008 to around 2013, emissions remained relatively high and stable. However, starting in 2014, there has been a gradual decline in emissions from grid-supplied electricity. This decrease is largely attributed to Duke Energy's adoption of renewable and low-carbon sources of energy, such as wind and solar. While the shift to cleaner energy has played a primary role in reducing emissions, improvements in energy efficiency, such as more efficient appliances and lighting, have also contributed as a smaller but still important secondary driver.

T&D losses, represented by the lighter section at the top of each bar, follow the same pattern, with a slight decline in recent years, proportional to the overall reduction in grid-supplied electricity emissions. Since T&D losses are directly proportional to emissions from grid-supplied electricity, the two are tightly correlated and it's expected that ther trendlines follow one another closely.

Stationary Fuel Combustion

The other major contributor to stationary energy emissions is the Stationary Fuel Combustion sub-sector. This sub-sector primarily consists of emissions from the combustion of fuels used on-site, with the majority of emissions coming from the combustion of natural gas. Natural gas is commonly used in heating, cooking, and for various uses in residential, commercial, and industrial buildings.

A table showing a breakdown of emissions from this sub-sector, using data provided by CenterPoint Energy, is included below[3]:

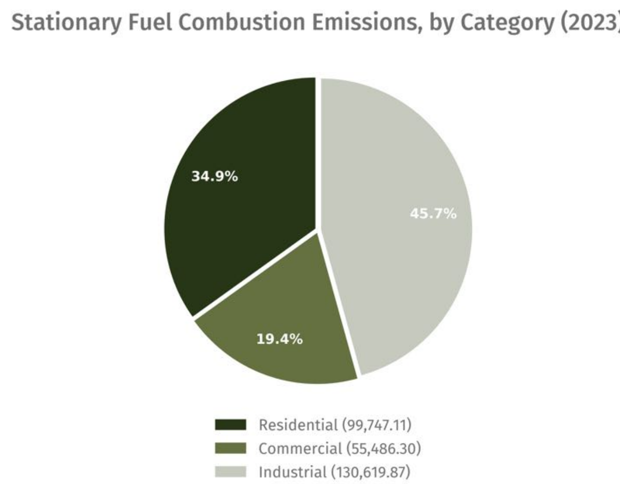
Stationary Fuel Combustion Emissions, by Category and Year ($MTCO_2e$)

Year	Residential	Commercial	Industrial
2019	115,060.24	63,113.41	123,995.68
2020	103,930.55	54,939.47	121,319.12
2021	113,369.82	62,914.79	130,458.36
2022	110,190.20	60,101.13	130,567.00

[3] CenterPoint Energy uses a different set of categories than Duke Energy, choosing to consolidate the Government category with the Commercial category. This means stationary fuel emissions cannot be compared directly with grid-supplied electricity emissions on a category-by-category basis.

2023	99,747.11	55,486.30	130,619.87

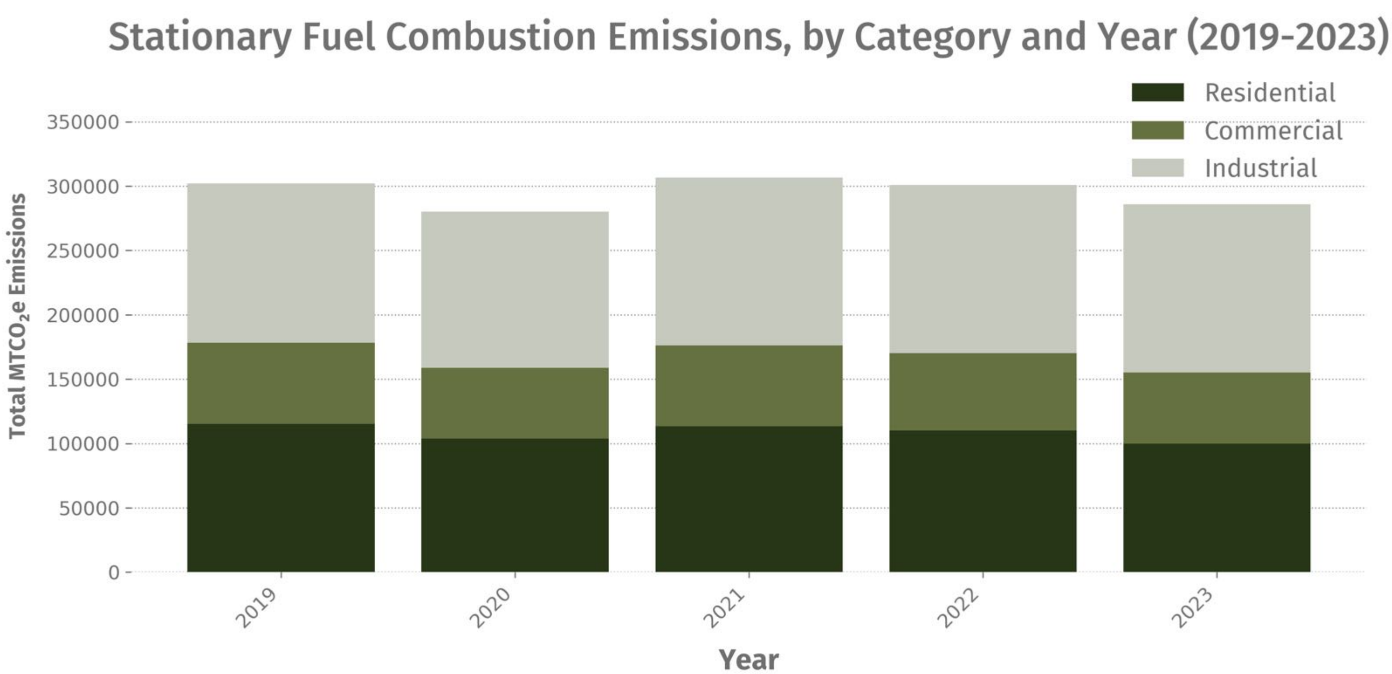
The pie chart of stationary fuel combustion emissions for 2023 (shown to the right) demonstrates that the largest share comes from the industrial category, accounting for 45.7%. This reflects the heavy reliance of industrial facilities on natural gas for powering machinery, heating, and other industrial processes.



The residential category contributes 34.9% of emissions, which includes emissions from natural gas use in homes for heating, cooking, and water heating.

The commercial category makes up 19.4% of emissions. This includes emissions from natural gas used in businesses, office buildings, and other commercial operations for similar needs such as heating, water heating, and cooking.

A stacked bar chart which visualizes historical emissions from 2019-2023 for the stationary fuel combustion sub-sector is included below. The relative ratio of emissions contributed by each category is fairly constant year-over-year, suggesting that the customer base which consumes stationary fuel within the City of Bloomington has not changed significantly over the past four years.



The methodology for calculating emissions from stationary fuel combustion is as follows:

1. **Gather Raw Data:** Data for total annual natural gas consumption in therms was retrieved from CenterPoint Energy. Due to limitations in CenterPoint's internal database systems, the data could not be perfectly segmented into the exact categories required by the *Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC).*

2. **Calculate Emissions:** Using the EPA's annually-released Emissions Factors Hub spreadsheet, emissions factors for the combustion of natural gas were applied to the consumption data to calculate total CO_2, CH_4, and N_2O emissions in pounds (lbs) for each category.
3. **Convert Emissions to Metric Tons:** The calculated emissions in pounds were then converted to metric tons, which is the standard unit for reporting greenhouse gas emissions.
4. **Convert to CO_2 Equivalents:** The metric tons for each greenhouse gas were converted to their respective metric tons of CO_2 equivalent ($MTCO_2e$) using their global warming potential (GWP). This ensures that the emissions reflect the different warming impacts of methane and nitrous oxide compared to carbon dioxide.
5. **Aggregate Emissions:** Finally, all the $MTCO_2e$ values for each category and year were aggregated to calculate the overall standardized emissions for stationary fuel combustion. This aggregation provides a complete emissions profile by category, allowing for year-to-year comparisons and overall trends.

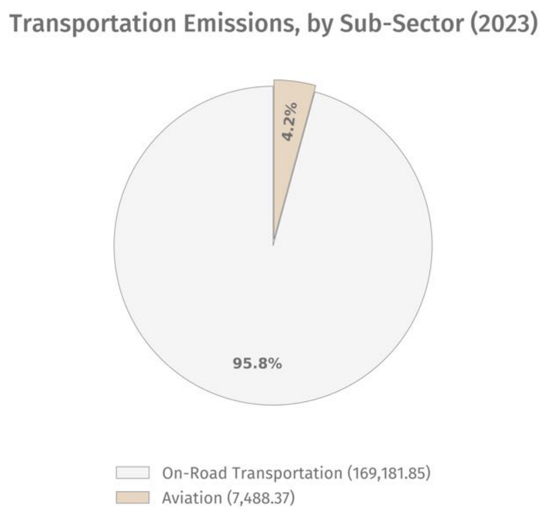
Transportation

Overall Emissions from Transportation

Emissions from the Transportation sector represent 14.8% of Bloomington's total overall emissions—making it the second largest source of emissions in the City. Transportation refers broadly to emissions generated from powering mobile vehicles that provide transportation throughout the City, including passenger, commercial, and government vehicles.

A breakdown of emissions from this sector are included in the pie chart to the right. Note that Bloomington's transportation-related emissions are primarily split into the following two sub-sectors:

- **On-Road Transportation:** Emissions from passenger and commercial cars, trucks, buses, and other motorized vehicles that use public roadways.
- **Aviation:** Emissions from air travel and local airport operations, including fuel combustion from aircrafts departing from Bloomington.



There are other types of transportation-related emissions as well, including off-road transportation (such as construction equipment and agricultural vehicles), railways, and water transport. However, due to a lack of available data, emissions from these other sub-sectors have not been included in this inventory. However, the vast majority of emissions for this sector are accounted for by on-road transportation, so the exclusion of these other sub-sectors does not prevent this inventory from providing an accurate, overall view of transportation-related emissions.

As shown in the pie chart on the right, the vast majority of Bloomington's emissions are due to on-road transportation, which is as expected. Aviation still makes up over 4% of emissions, and note that this only accounts for the refueling of airplanes within the inventory boundaries and not for other types of aviation-related emissions such as in-boundary helicopter flights.

The table below includes the raw data for emissions for each of these sub-sectors, by year, in terms of metric tons of CO_2e.

Transportation Emissions, by Sub-Sector and Year ($MTCO_2e$)

Year	On-Road Transportation	Aviation
2018	146,970.9703	5,587.11
2019	193,418.6754	6,023.56
2020	137,353.4733	4,316.89
2021	142,128.1253	6,364.06
2022	160,662.1199	6,308.72
2023	169,181.8490	7,488.37

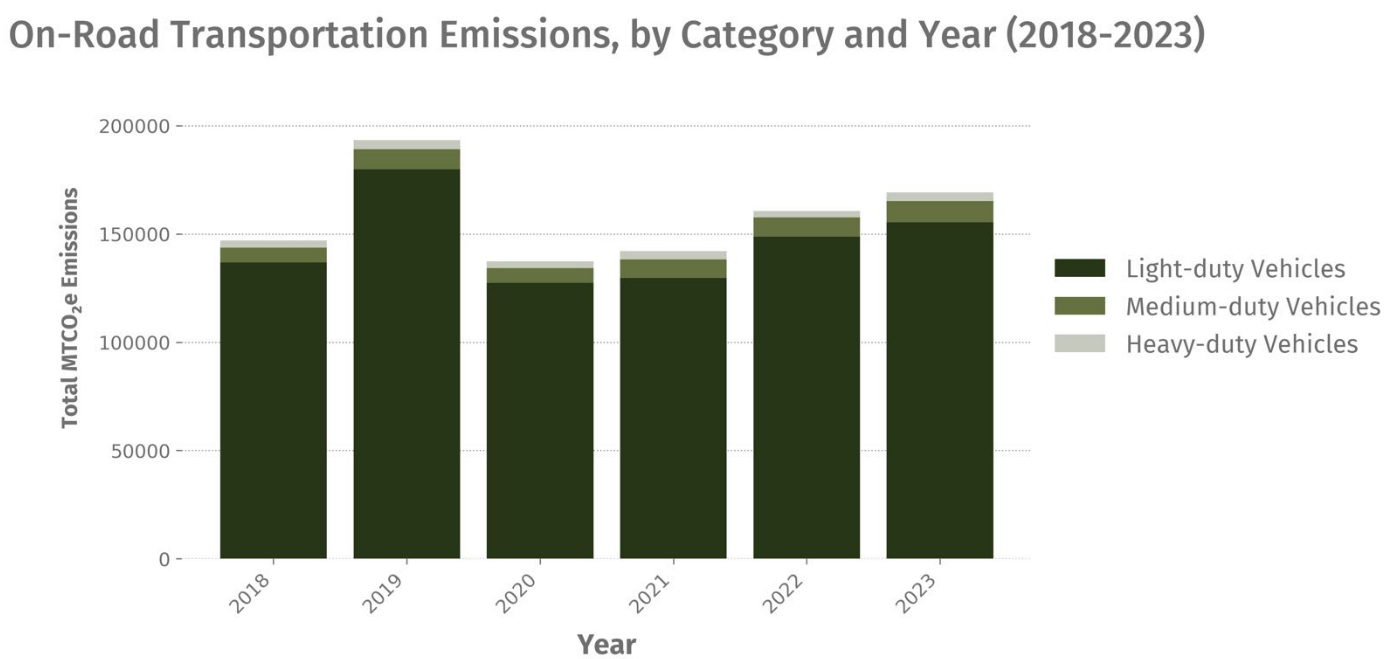
On-Road Transportation

On-Road Transportation is a sub-sector which refers to emissions from the use of vehicles on public roadways. It includes both passenger and commercial vehicles. The standard way to determine emissions from this sub-sector is to base emissions estimates on the number of vehicles miles traveled (VMT) within the inventory boundary. VMT is a standard statistic provided by the Indiana Department of Motor Vehicles and is based on precision readings from embedded scales and other sensors in roadways, so it's directly tied to actual daily traffic that the roadways experience throughout the year.

Note that emissions from on-road transportation can be split into three different vehicle classes:

- **Light-Duty:** Vehicles typically weighing less than 8,500 pounds, including most passenger cars and small trucks.
- **Medium-Duty:** Vehicles weighing between 8,500 and 26,000 pounds, often used for commercial purposes like delivery trucks and larger vans.
- **Heavy-Duty:** Vehicles weighing more than 26,000 pounds, commonly used for freight transport, such as buses, large trucks, and tractor-trailers.

The graph below shows emissions from this sub-sector segmented by the aforementioned vehicle classes:



As shown above, the majority of emissions from this sub-sector are the result of the activities of light-duty vehicles. These emissions estimates are based on **in-boundary movement**, meaning they account for emissions from vehicles while they are inside of Bloomington's city boundaries. If a vehicle's trip originates in Bloomington, spends 2.5 miles traveling within the City, and then exits onto a highway outside of the City and drives for many miles more, just 2.5 miles worth of emissions would be accounted for based on the GPC's carbon accounting standards.

Given this methodological choice, it makes sense that light-duty vehicles make up the bulk of Bloomington's emissions since this accounts for the bulk of vehicles in the City, making their daily commute or completing other trips within the City's boundaries.

Note that emissions from electric vehicles were excluded from this analysis because they do not involve the mobile combustion of fuels but instead rely upon electricity for vehicle charging. As a result, those associated emissions have been excluded in the graph above and are instead accounted for in the grid-supplied electricity sub-sector, a part of the stationary energy sector.

A table which breaks down the emissions data by vehicle class is included below:

On-Road Transportation Emissions, by Category and Year ($MTCO_2e$)			
Year	Light-Duty	Medium-Duty	Heavy-Duty
2018	136,807.5938	6,791.1841	3,372.1925
2019	179,822.3745	9,368.4990	4,227.8020
2020	127,376.5412	6,896.0095	3,080.9225
2021	129,713.7616	8,506.3736	3,907.9901
2022	148,694.1622	8,970.8801	2,997.0777
2023	155,355.9231	9,864.8781	3,961.0478

The full methodology for calculating emissions from this sector is included below:

1. **Gather Raw Data:** Data for estimating on-road transportation emissions within the City boundaries was sourced from two key data providers. The Indiana Department of Transportation (INDOT) provided traffic statistics for estimating vehicle miles traveled (VMT) starting from 2018. Additionally, the Bureau of Motor Vehicles (INBMV) offered a county-level vehicle registration dataset, which was filtered to include Diesel, Electric, Flexible, Gas, Electric & Diesel Hybrid, and Electric & Gas Hybrid vehicles. This dataset was further broken down into Light Duty, Medium Duty, and Heavy-Duty vehicle classes.
2. **Calculate Emissions by Fuel Type:** The vehicle counts from the INBMV dataset were converted into percentages for each fuel type and class in a given year. These percentages were applied to the VMT data to estimate the proportional amount of VMT attributed to each vehicle type. Fuel economy statistics were then used to calculate the gallons of gasoline and diesel combusted by each vehicle fuel type and class. Light-duty vehicle fuel economy was based on the EPA's 2022 Automotive Trends Report, while medium- and heavy-duty vehicle fuel economies were estimated using data from the Department of Energy's (DOE) Alternative Fuels Data Center. Adjustments were made to account for hybrid vehicles being 25% more fuel-efficient and for the age of vehicles on the road, using data from the Bureau of Transportation Statistics on the average age of automobiles and trucks in the U.S. Emissions from the electric vehicles category were excluded to avoid double counting (these emissions are already accounted for in the Stationary Energy sector).
3. **Convert Emissions to CO2 Equivalents:** Using the calculated fuel consumption and the EPA's greenhouse gas emissions factors, CO_2, CH_4, and N_2O emissions were derived for each vehicle fuel type and class combination. These emissions were then converted into metric tons of CO_2 equivalent ($MTCO_2e$) to reflect the global warming potential of each greenhouse gas.
4. **Aggregate Emissions:** Finally, the $MTCO_2e$ values were aggregated by year to determine the total emissions from on-road transportation within the inventory boundaries. This step provided a complete emissions profile for on-road transportation, allowing for year-to-year comparisons and trend analysis.

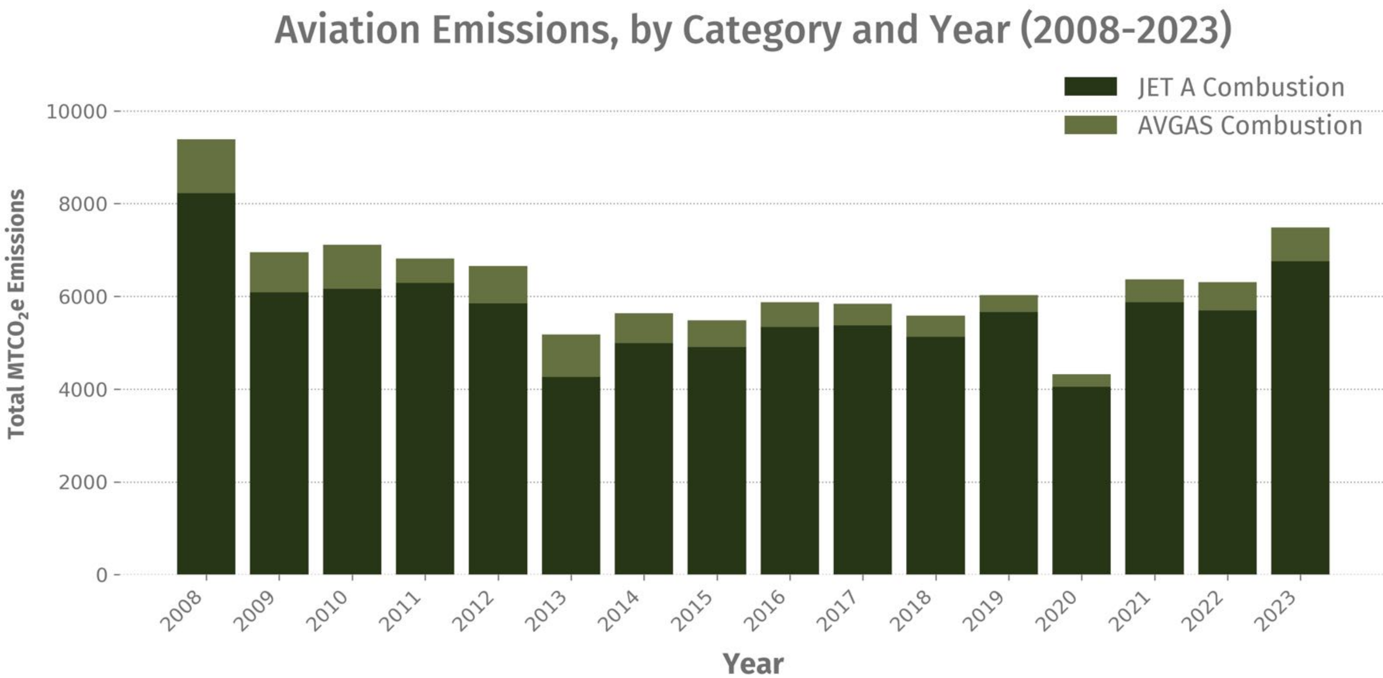
Aviation

The Aviation sub-sector refers to emissions from passenger and commercial cargo aircraft. Emissions from this sub-sector were determined based off of fuel sales by the fixed-based operator (FBO) serving the Monroe County Airport, the primary airport within the City of Bloomington's inventory boundaries.[4] Refueling operations which occur at the airport are an accurate proxy for emissions from flights both landing and departing from the airport and therefore provide a fairly holistic account of Scope 3 aviation-related emissions.

The Monroe County Airport refuels aircraft using two different types of fuels: Jet A and AVGAS. As the graph below shows, the majority of fuel sales at the airport are from Jet A, which in turn means the majority of fuel combustion and therefore emissions are the result of

[4] Note that while the Monroe County Airport is not fully located within the inventory boundaries (i.e., the city limits), the *Global Protocol for Community-Scale Emissions* requires the inclusion of airports and other major transportation facilities which are just outside of the city boundaries and exist primarily to serve the needs of the city.

JET A fuel usage. Jet A is a kerosene-based fuel used in larger and faster-moving aircraft, whereas AVGAS is a gasoline-based jet fuel that smaller, slower planes with piston engines primarily use. Therefore, it's expected that Jet A would account for the majority of emissions since it is used in higher quantities by much larger aircraft for commercial passenger and cargo flights.



The table below provides a breakdown of emissions from the aviation sub-sector by fuel type:

Aviation Emissions, by Category and Year ($MTCO_2e$)		
Year	Jet A	AVGAS
2008	8,223.22	1,159.53
2009	6,089.39	863.74
2010	6,163.28	947.21
2011	6,290.99	526.12
2012	5,845.56	807.40
2013	4,257.61	919.89
2014	4,987.92	651.97
2015	4,909.36	572.16
2016	5,336.03	539.14
2017	5,376.83	464.96
2018	5,123.98	463.13
2019	5,657.80	365.76
2020	4,049.60	267.28
2021	5,871.59	492.46
2022	5,696.94	611.78
2023	6,754.21	734.16

The methodology for calculating emissions for this sub-sector are described below:

1. **Gather Raw Data:** Data on aviation emissions was sourced from Monroe County Airport, which provided a report detailing the amount of jet fuel and aviation gas sold by their fixed base operator (FBO) within the calendar year. This data serves as the basis for estimating aviation-related emissions within the inventory boundaries.
2. **Calculate Emissions:** The volume of jet fuel sold was used as an approximation for the amount of fuel combusted for Scope 3 emissions, which includes transboundary flights originating or ending within the City. The amount of fuel was multiplied by the respective emissions factor for jet fuel to calculate the pounds of CO_2 emitted during combustion. The emissions factors were sourced from the U.S. Energy Information Administration (EIA).
3. **Convert Emissions to Metric Tons:** The calculated pounds of CO_2 emissions were converted to metric tons using the standard conversion factor for each type of aviation fuel, ensuring consistency with reporting standards.
4. **Aggregate Emissions:** Finally, emissions from jet fuel and aviation gas were summed to determine the total emissions from aviation for the given year. This provides an aggregate estimate of aviation-related greenhouse gas emissions within the inventory boundaries.

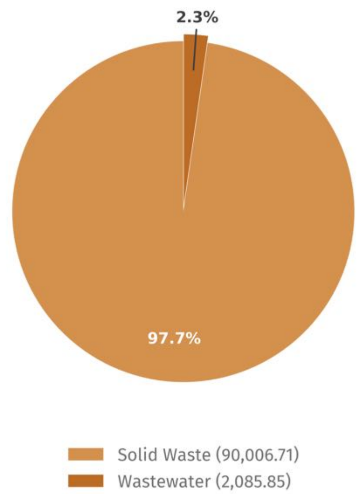
Solid Waste & Wastewater

Overall Solid Waste & Wastewater Emissions

Emissions from the Solid Waste and Wastewater sector represent 7.7% of Bloomington's total overall emissions. This sector encompasses the greenhouse gas emissions associated with the disposal and treatment of solid waste, as well as the treatment and transport of wastewater from throughout the City.

As shown in the pie chart to the right, the majority (97.7%) of emissions in this sector come from solid waste, with wastewater treatment contributing the remaining 2.3%. The total emissions from this sector in 2023 were 92,092.56 $MTCO_2e$.

Solid Waste and Wastewater Emissions, by Sub-Sector (2023)



Solid waste emissions primarily result from the decomposition of organic matter in landfills. When waste decomposes in anaerobic conditions (without oxygen), it produces methane (CH_4), a potent greenhouse gas.

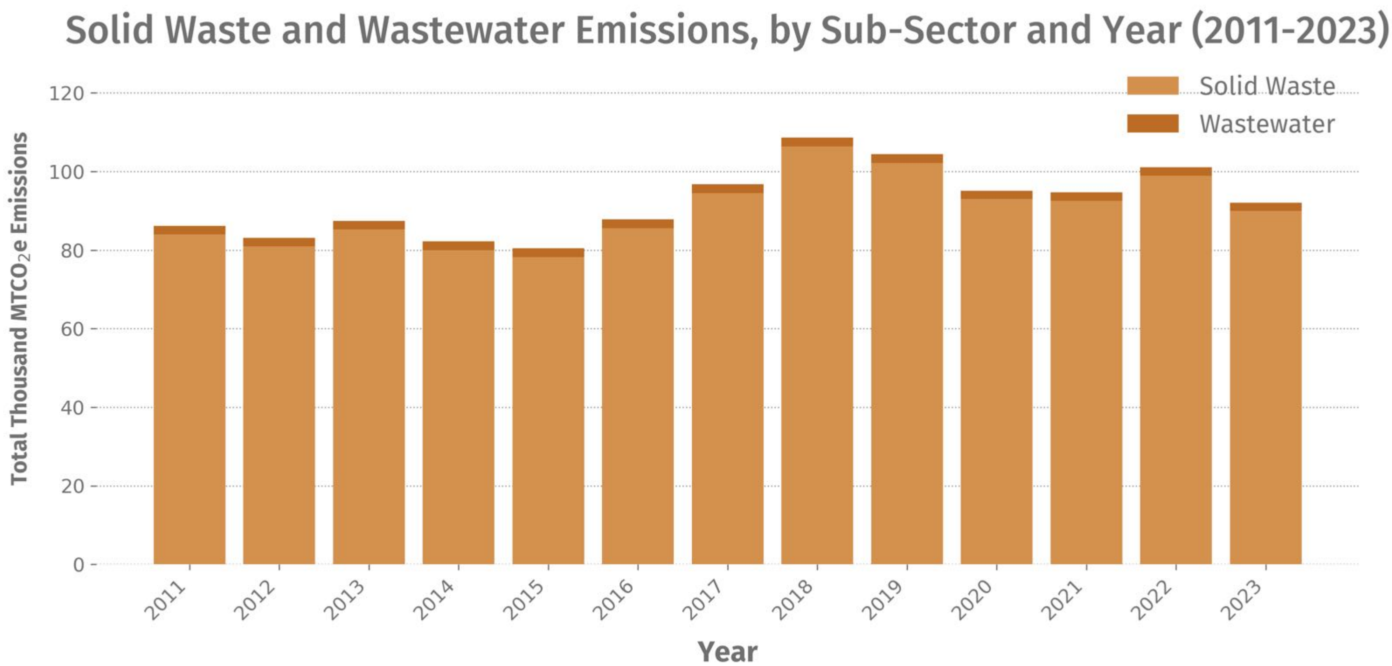
Wastewater treatment processes contribute to emissions primarily through three mechanisms. First, methane (CH_4) emissions can occur during secondary treatment, where organic matter is biologically broken down under conditions that may produce methane. Second, anaerobic digestion, commonly used to process sewage sludge, generates methane, which can be captured for energy or flared to reduce emissions. Third, the nitrification and denitrification processes, used to remove nitrogen from wastewater, produce nitrous oxide (N_2O), a potent greenhouse gas. Additionally, the energy required to operate wastewater treatment facilities contributes to electricity-related emissions, which are accounted for separately in the Stationary Energy sector.

Below is a table showing an overview of solid waste and wastewater emissions, by year, dating back to 2011. Additionally, a stacked bar chart is included to provide a relative view of how emissions from this sector have evolved over time.

Solid Waste & Wastewater Emissions, by Sub-Sector and Year ($MTCO_2e$)

Year	Solid Waste	Wastewater Treatment
2011	83,955.22	2,156.15
2012	80,953.77	2,173.69
2013	85,261.04	2,181.55
2014	80,008.77	2,200.20
2015	78,224.40	2,211.68
2016	85,561.13	2,232.61
2017	94,481.65	2,244.52

2018	106,345.83	2,252.51
2019	102,138.73	2,268.80
2020	93,002.28	2,092.12
2021	92,576.18	2,100.01
2022	98,952.96	2,091.25
2023	90,006.71	2,085.85



Solid Waste

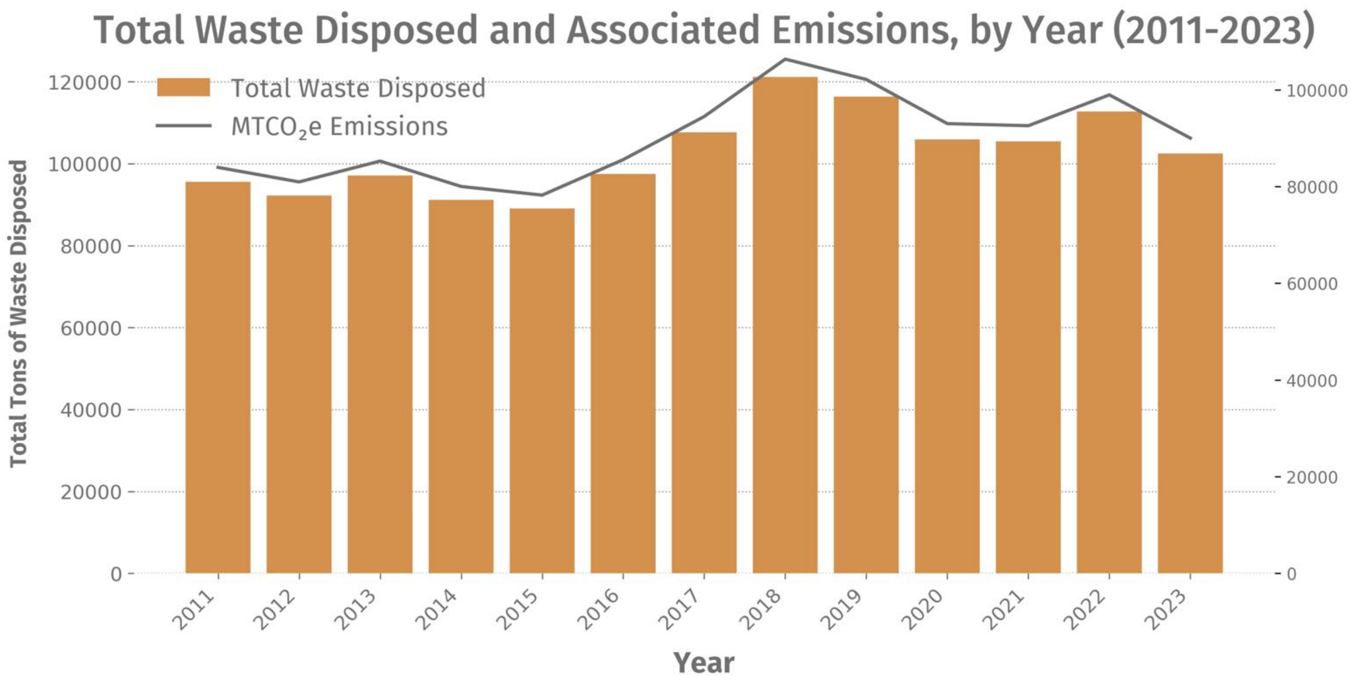
As mentioned at the beginning of this chapter, solid waste is a significant contributor to Bloomington's greenhouse gas emissions, and the primary driver of emissions within this sector.

The City of Bloomington's greenhouse gas inventory for solid waste disposal follows the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)*. The GPC provides two primary methods for estimating methane emissions from solid waste disposal: the First Order of Decay (FOD) model and the Methane Commitment (MC) approach.

- **First Order of Decay (FOD):** Estimates emissions based on waste decomposition over time, accounting for the fact that organic waste in landfills continues to emit methane for several decades after disposal. While this method provides a more accurate representation of annual emissions, it requires extensive historical waste disposal data, which can be challenging to obtain.
- **Methane Commitment (MC):** Calculates emissions based on the total amount of waste disposed in the inventory year, assuming all future emissions from that waste occur in the current year. While this method tends to overestimate short-term emissions, it offers advantages in simplicity, consistency with waste reduction efforts, and future-oriented decision-making.

For this inventory, the Methane Commitment approach was utilized. The primary advantage of this method is that it requires only current-year waste disposal data which was a requirement given limitations in the data available for this project. It is also the primary way the majority of municipalities in the United States calculate emissions from solid waste disposal for their community-wide greenhouse gas inventories, ensuring greater interoperability between this inventory and Bloomington's peer cities.

The graph below shows total waste disposed (in tons) and the associated emissions ($MTCO_2e$) generated for the years 2011-2023 in the City of Bloomington.



Despite year-to-year fluctuations, there appears to be a slight upward trend in both waste disposal and associated emissions, especially since 2018. This suggests that population growth or economic factors may be offsetting waste reduction efforts. This is despite the fact that Bloomington's population has actually declined very slightly in the past few years, suggesting that either commercial/industrial waste generation and/or residential waste generated on a per capita basis have been increasing.

A table with the data used in the chart above is included below:

Total Waste Disposed & Associated Emissions, by Year		
Year	Solid Waste Disposed (tons)	Associated Emissions ($MTCO_2e$)
2011	95,623.37	83,955.22
2012	92,204.77	80,953.77
2013	97,110.67	85,261.04
2014	91,128.44	80,008.77
2015	89,096.08	78,224.40
2016	97,452.46	85,561.13
2017	107,612.76	94,481.65
2018	121,125.83	106,345.83
2019	116,334.03	102,138.73
2020	105,927.80	93,002.28
2021	105,442.48	92,576.18
2022	112,705.50	98,952.96
2023	102,515.89	90,006.71

The methodology for calculating the City's emissions from solid waste disposal were as follows:

1. **Gather Raw Data:** Data was retrieved from the Indiana Department of Environmental Management (IDEM) for the years 2011-2023. The data was specifically filtered to only include waste originating from Monroe County, Indiana, and was limited to waste processed at "Municipal Solid Waste Landfills" and "Non-Municipal Solid Waste Landfills." The tonnage of solid waste received from Monroe County was collected for each year.
2. **Adjust for City-Level Estimation:** To approximate the amount of solid waste disposed of in landfills specifically at the City level, a population-based adjustment factor was applied to the Monroe County tonnage. This adjustment was calculated based on Bloomington's share of the population within Monroe County.
3. **Calculate Methane Emissions:** The total amount of methane (CH_4) emissions was calculated using the methane commitment estimate approach as described in the *Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC).* Equation 8.4 was applied to calculate L_0 , which represents the methane generation potential. The following parameters were used:
   - Methane Correction Factor (MCF): Assumed to be 1.0, indicating that landfills are anaerobic.
   - Degradable Organic Carbon (DOC): Set at 0.161 based on relevant literature.
   - DOC Fraction (DOC_F): Set at 0.6.
   - Fraction of Methane in Landfill Gas (F): Set at 0.5.
   - Methane Recovery Fraction (f_{rec}): Assumed to be 0.85 based on EPA recommendations for well-managed systems. However, since not all landfills have methane recovery systems, this recovery factor was not universally applied. Based on EPA data published in the Federal Register, it was assumed that 54% of U.S. landfills have methane recovery systems.
4. **Apply Oxidation Factor:** An oxidation factor of 0.1 was used, assuming all landfills in the dataset are well-managed. This accounts for the fraction of methane that is oxidized before it escapes into the atmosphere.
5. **Convert to CO_2 Equivalents:** The calculated metric tons of methane were then converted to metric tons of CO_2 equivalent ($MTCO_2e$) using the standard Global Warming Potential (GWP) value for methane provided by the IPCC. This conversion standardizes methane emissions based on their comparative impact on global warming relative to carbon dioxide.

Wastewater Treatment

Approximately 2.3% of Bloomington's emissions for the Solid Waste & Wastewater sector are due to emissions generated from the treatment and transport of wastewater throughout the City.

Emissions generated from the wastewater treatment process are highly dependent upon the specific industrial processes utilized during the treatment process. Wastewater is generally treated in a three-stage process. First, during primary treatment, physical processes like screening and sedimentation remove solid waste and larger particles from the water. Secondary treatment then employs biological processes where microorganisms break down organic matter and remove dissolved pollutants. Finally, tertiary treatment, also known as advanced treatment, uses additional chemical or physical processes such as filtration, disinfection, or nutrient removal to further polish the water to meet specific quality standards before discharge.

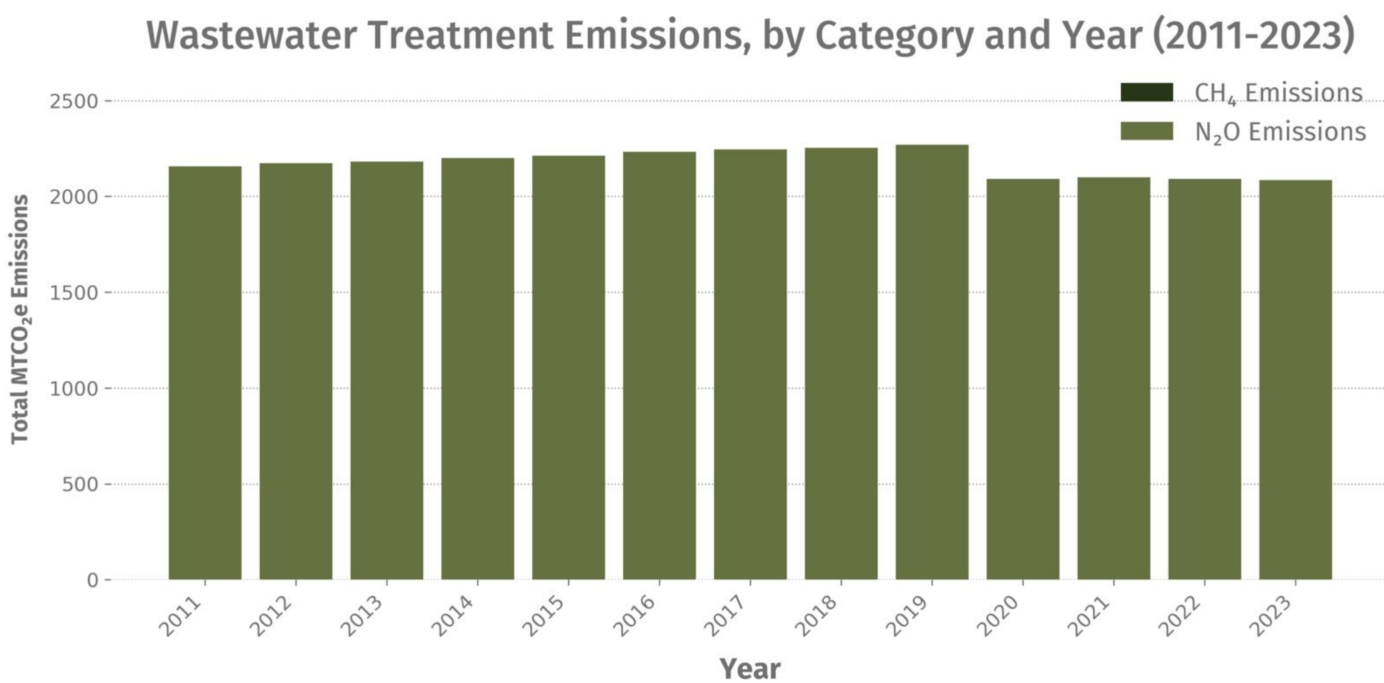
Emissions can be generated or mitigated at each stage of the treatment process. In the context of conducting a greenhouse gas inventory, generally three different possible sources of emissions are evaluated:

- **Methane (CH_4) Emissions from Secondary Treatment:** Carbon dioxide and methane are produced during the biological processes used to break down organic matter in the secondary treatment phase. Secondary treatment can be divided into either aerobic or anaerobic treatment processes, based on the amount of oxygen that is present during the decomposition process. Aerobic treatment, occurring in the presence of oxygen, is generally preferred as it produces primarily biogenic CO_2 and minimal methane emissions. In contrast, anaerobic treatment occurs without oxygen and produces significant methane emissions which are more potent in their contribution to global warming.
- **Methane (CH_4) Emissions from Use of an Anaerobic Digestor:** Some wastewater treatment plants employ the use of an anaerobic digestor to break down solid organic waste (sludge) and reduce its volume. Anaerobic digestors produce biogas which can be used as a fuel source (e.g., to be combusted and provide power to wastewater treatment plant or other biogas-powered systems in the area) or flared to prevent direct methane emissions to the atmosphere. Emissions are produced as a result of both of the combustion and flaring processes and must be accounted for accordingly.

- **Nitrous Oxide (N_2O) Emissions from Nitrification/Denitrification:** Nitrification and denitrification are biological processes used to remove nitrogen from wastewater. Nitrification converts ammonia to nitrate under aerobic conditions, while denitrification converts nitrate to nitrogen gas under anoxic conditions. These processes can produce nitrous oxide as a by-product, which is a potent greenhouse gas that must be accounted for within the greenhouse gas inventory.

The City of Bloomington Utilities (CBU) operates two wastewater treatment facilities that contribute to the City's greenhouse gas emissions profile. At both facilities, CBU employs aerobic digestion for secondary treatment, which helps minimize methane emissions compared to anaerobic alternatives. Neither facilities utilize anaerobic digestors to process solid waste, so associated emissions from this category were excluded from the calculations. Additionally, like all wastewater treatment plants, CBU's facilities emit nitrous oxide as a byproduct of the standard nitrification and denitrification processes used to remove nitrogen from the wastewater stream. The utility follows standard industry practices for sludge management, with no additional emissions from processes such as incineration.

The stacked bar chart below shows a breakdown of emissions from wastewater treatment in the City of Bloomington for the years 2011-2023. Emission estimates from CBU's two treatment plants have been combined and provided in the bar chart below.



As the chart demonstrates, N_2O emissions due to the nitrification/denitrification processes associated with wastewater treatment are the primary driver of emissions at these plants, whereas CH_4 emissions from aerobic treatment result in effectively zero net emissions due to the more environmentally friendly nature of this treatment method.

The emissions from this sector have stayed relatively flat over the years, which makes sense given that the primary driver of waste is the population of the City which has also remained stable.

The table below includes emissions from wastewater treatment broken down by process:

Wastewater Treatment Emissions, by Category and Year ($MTCO_2e$)			
Year	Aerobic Digestion (CH_4)[5]	Anaerobic Digestor (CH_4)	Nitrification/Denitrification (N_2O)
2011	0.0	N/A	2,156.15

[5] As discussed in the methodological notes below, emissions from aerobic digestion during secondary treatment are assumed to be zero. This assumption is based on using a methane correction factor of zero, following the IPCC's *2006 Guidelines for National Greenhouse Gas Inventories*. The IPCC recommends this factor for well-managed facilities that use aerobic digestion, where very little methane is produced and can thus be left out during calculation of the greenhouse gas inventory.

2012	0.0	N/A	2,173.69
2013	0.0	N/A	2,181.55
2014	0.0	N/A	2,200.20
2015	0.0	N/A	2,211.68
2016	0.0	N/A	2,232.61
2017	0.0	N/A	2,244.52
2018	0.0	N/A	2,252.51
2019	0.0	N/A	2,268.80
2020	0.0	N/A	2,092.12
2021	0.0	N/A	2,100.01
2022	0.0	N/A	2,091.25
2023	0.0	N/A	2,085.85

The methodology for calculating CH_4 emissions from the aerobic digestion process used during secondary treatment was as follows:

1. **Gather Raw Data:** CH_4 emissions from aerobic-based, secondary treatment were calculated using Equations 8.9 and 8.10 from the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC). Due to the unavailability of city-specific data for Bloomington, estimates made for California's Greenhouse Gas Inventory were used for key variables, including per capita Biochemical Oxygen Demand (BOD), maximum methane-producing capacity, and the methane correction factor (MCF).
2. **Apply Population-Based Assumptions:** The entire population was assumed to use the same emissions factor, as the GPC's recommended method of differentiating emissions factors by income group was simplified. In addition, it was assumed that each wastewater treatment plant (WWTP) serves 50% of Bloomington's population. As a result, the calculations were made in aggregate for the City, rather than differentiating between individual WWTPs.
3. **Calculate Methane Emissions:** The CH_4 emissions were calculated by applying the above parameters into the GPC's simplified equations (Equation 8.9 and 8.10). The resulting emissions are in metric tons of methane. However, because a methane correction factor (MCF) of 0.0 was used, the calculations resulted in an estimate of zero metric tons of methane emissions generated.
4. **Convert to CO_2 Equivalents:** The calculated methane emissions in metric tons were converted to CO_2 equivalents ($MTCO_2e$) using the global warming potential (GWP) factor for methane. This provides a standardized measure for the warming impact of methane emissions from wastewater treatment processes. Again, because the input was a value of zero, the resulting amount of CO_2-equivalent emissions was also zero.

CH_4 emissions resulting from the use of an anaerobic digestor were excluded from the analysis since neither of Bloomington's wastewater treatment plants utilizes this technology. However, emissions from nitrification/denitrification are still relevant and the methodology utilized to calculated them is described below:

1. **Gather Raw Data:** Nitrous oxide emissions were calculated using Equation 8.12 from the GPC Protocol. Most of the default values recommended by the GPC were used for the calculation, except for per capita protein consumption, which was estimated using data from the World Health Organization (WHO) on total protein supply by country.
2. **Apply Population-Based Assumptions:** As with the methane emissions, it was assumed that each WWTP serves 50% of the population of Bloomington. Calculations were therefore made in aggregate rather than by each treatment plant. The population served by the WWTPs was factored into the equation to estimate the N_2O emissions.
3. **Calculate Nitrous Oxide Emissions:** The N_2O emissions were calculated using the inputs from the GPC and WHO data, applied into Equation 8.12. The output represents the N2O emissions in metric tons.
4. **Convert to CO2 Equivalents:** The calculated nitrous oxide emissions in metric tons were then converted to CO_2 equivalents ($MTCO_2e$) using the global warming potential (GWP) for nitrous oxide. This conversion accounts for the higher warming potential of N_2O compared to CO_2.

Industrial Processes & Product Use

Explanation for Exclusion from Inventory

The Industrial Processes & Product Use (IPPU) sector within the *Global Protocol for Community-Scale Emissions (GPC)* framework includes two sub-sectors: industrial processes and product use, which focus solely on scope 1 (direct) emissions occurring within a city's boundaries.

Industrial Processes refer to emissions resulting from chemical or physical transformations during manufacturing and other industrial activities. Common examples include emissions from cement production or chemical manufacturing. However, in Bloomington, large-scale industrial processes that can be distinctly accounted for are minimal. Much of the emissions activity from industrial operations is already captured under other sectors, particularly stationary energy, where emissions from fuel combustion and grid-supplied electricity are included. Isolating additional emissions from industrial processes separately was neither feasible nor necessary when compiling this inventory.

Product Use includes emissions from the use of products that contain or release greenhouse gases, such as solvents and refrigerants like hydrofluorocarbons (HFCs). Obtaining reliable data for product use proved challenging due to the decentralized nature of the activities, as well as concerns around privacy and confidentiality, particularly for small businesses and residential users. This made it impossible to gather the necessary data to quantify emissions in this sub-sector.

Given these limitations, neither sub-sector could be calculated for the 2023 GHG inventory. As a result, no data is presented for the Industrial Processes & Product Use sector in this report.

Agriculture, Forestry, & Other Land Use

Explanation for Exclusion from Inventory

The Agriculture, Forestry, and Other Land Use (AFOLU) sector under the *Global Protocol for Community-Scale Emissions (GPC)* is divided into three sub-sectors: livestock, land, and aggregate sources and non-CO_2 emission sources on land. This sector generally tracks emissions from activities related to agriculture and land management, both of which contribute to greenhouse gas emissions through various mechanisms. However, given Bloomington's urbanized nature, this sector is largely irrelevant in the context of the City's emissions profile.

Livestock emissions refer to methane (CH_4) and nitrous oxide (N_2O) produced by animal digestion (enteric fermentation) and manure management. These emissions are significant in areas with large agricultural activity, particularly in rural regions with high concentrations of livestock such as cattle or poultry. Since Bloomington is primarily a residential and commercial college town with minimal agricultural activity, there are no significant livestock emissions to account for in this inventory.

Land emissions capture the carbon fluxes associated with changes in land use, such as deforestation, afforestation, or reforestation. Changes in vegetation cover, whether through clearing forests for development or adding green spaces, impact carbon storage. However, as Bloomington is a highly urbanized environment, there is limited land-use change of this nature, making emissions from this sub-sector negligible.

Aggregate sources and non-CO_2 emission sources on land include emissions from the use of synthetic fertilizers, soil cultivation, and the management of organic soils. These activities are typically associated with agricultural areas that require intensive land management, but Bloomington lacks the large-scale farming operations that would contribute to emissions from these sources.

For these reasons, emissions from the AFOLU sector have been marked as "not occurring" using GPC's notation system and excluded from the 2023 GHG inventory. The City's predominantly urban landscape and lack of significant agricultural activities make this sector unnecessary to evaluate for this report.

Municipal Operations Inventory

An inventory of greenhouse gas emissions due to the operations and activities of the municipal local government.

Overview

Introduction

The Municipal Operations Greenhouse Gas (GHG) Inventory focuses on emissions from government-owned and operated facilities, vehicles, and infrastructure within the City of Bloomington. This inventory covers all GHG emissions resulting from the City's local government operations for the 2023 calendar year.

The term "local government" can encompass a variety of entities serving different purposes, such as special districts, school boards, and other public authorities. However, in the context of this inventory, it specifically refers to the general-purpose government that is officially incorporated to serve the residents of Bloomington ("the City government").

This inventory focuses on emissions from activities and assets over which the local government has **operational control**—those areas where it has the authority and ability to drive emissions reductions. While this includes obvious areas such as City-owned buildings like City Hall, it also extends to other government-led organizations like City of Bloomington Utilities (CBU). As the owner and operator of public-sector organizations like CBU, the local government is responsible for emissions from these organizations' emissions too. Given the high energy use of many these organizations' infrastructure and facilities, accounting for their emissions is critical in providing a full picture of how municipal operations contributes to global emissions.

Municipal inventories are vital tools for several reasons:

- They help the local government understand its direct environmental impact.
- They identify opportunities for emissions reduction in government-managed activities.
- They guide policy decisions to improve operational efficiency and sustainability.
- They provide benchmarks for future performance, helping the city meet climate goals.

Inventory Methodology

This municipal operations inventory was completed using ICLEI's *Local Government Operations (LGO) Protocol*, which provides a clear and standardized approach for calculating GHG emissions from local government activities. The LGO Protocol ensures that all emission sources tied to government functions are comprehensively captured, offering a robust framework for consistent tracking and reporting.

The Municipal Operations Inventory covers emissions from city-owned buildings, vehicle fleets, water treatment facilities, streetlights, and waste management services. By isolating municipal activities from broader community emissions, this report provides actionable insights specific to the City's own carbon footprint.

Emissions Scopes

Similar to the community-wide inventory, the municipal operations inventory categorizes emissions into three distinct scopes based on the type and location of the emissions source.

- **Scope 1** covers direct emissions from sources owned or controlled by the local government, such as fuel combustion in City-owned vehicles or the natural gas used to heat municipal buildings.
- **Scope 2** includes indirect emissions from the consumption of purchased electricity, steam, or heating and cooling services for government operations, such as the electricity used in City Hall or at city-run facilities like water treatment plants.
- **Scope 3** accounts for other indirect emissions that occur as a consequence of government activities but are produced by sources not owned or controlled by the city. This includes emissions from waste generated by government operations and employee commutes to city offices.

These three scopes provide a comprehensive framework for understanding the full extent of emissions resulting from municipal operations.

Prior Inventories

The City of Bloomington has not conducted a municipal operations inventory prior to 2023, so this inventory serves as an important baseline to compare against when conducting this type of inventory in future years.

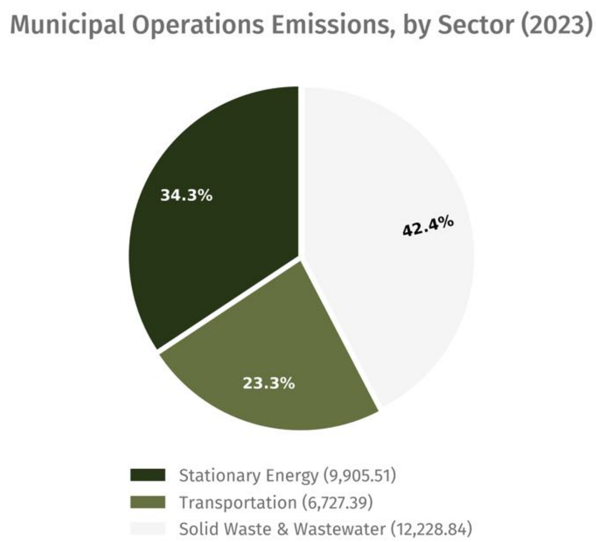
By establishing a comprehensive understanding of the City's operational emissions for the first time, this inventory provides a valuable tool for local municipal leaders to identify key sources of emissions and prioritize emissions strategies accordingly. It also provides a framework for tracking municipal emissions on a year-over-year basis and aligning municipal operations with the broader City-wide climate goals.

Overall Trends

A Breakdown of Municipal Operations Emissions

The City of Bloomington is estimated to have contributed 21,056 in metric tons of CO_2e emissions due to its municipal operations in the calendar year of 2023. As the pie chart below shows, just under half of this was (42.4%) from the solid waste & wastewater sector. The remaining half of emissions came from the transportation (23.3%) and stationary energy (31.1%) sub-sectors respectively.

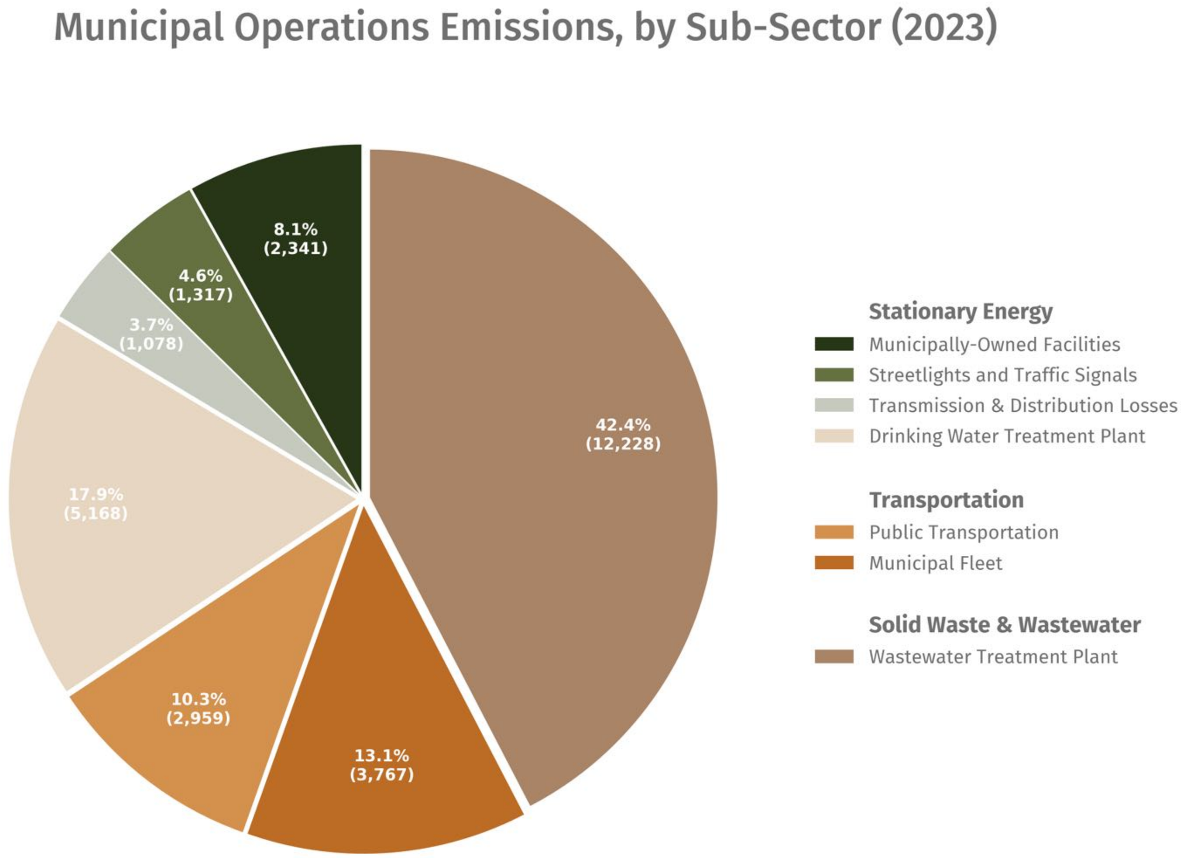
Emissions from each sector can be further segmented by their constituent sub-sectors which describe the different types of emission sources within each sector.



The following are some high-level observations about the breakdown of emissions on a sub-sector level for the municipal operations inventory:

- **The majority of emissions from municipal operations are due to the solid waste & wastewater sector, which itself is entirely based on emissions from the City's wastewater treatment plants.** This makes sense as the wastewater treatment plants provide a service used by essentially all of the City's residents and produce a significant number of emissions through their industrial processes. Thus, reducing emissions from these plants would be a consequential and high-leverage way to drive down the municipal operations emissions in the future.
- **The stationary energy sector is a larger driver of emissions than the transportation sector, which is similar to these sectors' relationship in the community-wide inventory.** Just under a quarter (23.3%) of municipal emissions are attributable to the City's operational fleet and public transit system run by Bloomington Transit, whereas 34.3% of emissions are from grid-supplied electricity consumed by the City's buildings and facilities. In the community-wide inventory, the same is the case with stationary energy generating more than four times the number of emissions as the transportation sector.
- **Within the Transportation sector, most emissions can be attributed to the municipal fleet, but public transportation is not far behind.** The municipal fleet refers to the City's operational fleet of vehicles used by local government departments in their everyday work such as the police's patrol vehicles and the landscaping team's trucks. The municipal fleet makes up 13.1% of overall emissions, whereas Bloomington Transit which facilitates the local bus and paratransit system in the City generates 10.3% of municipal emissions.

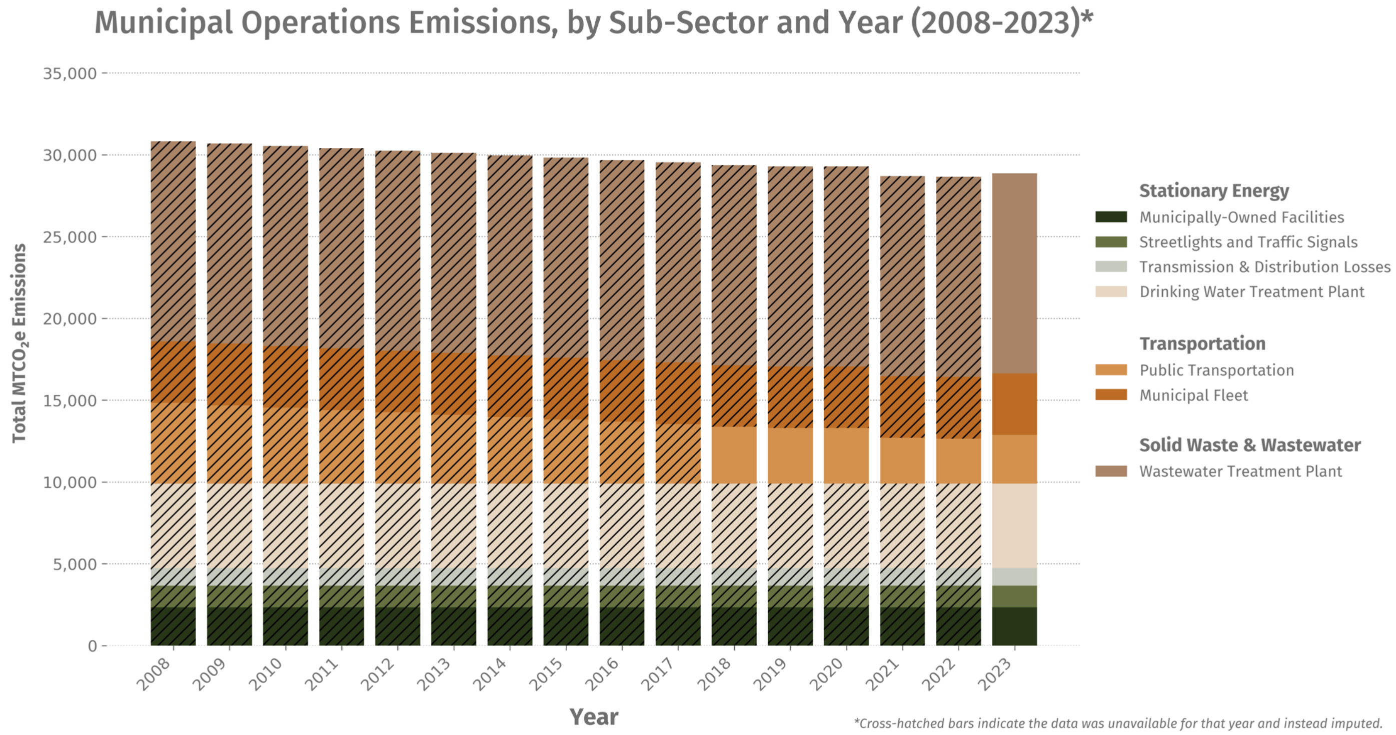
A pie chart of community-wide emissions broken out by each sub-sector is included below.



Understanding Historical Emissions

Just like with the community-wide inventory, comparing year-over-year emissions for the municipal operations inventory is a powerful way to understand how emissions have changed over time. Unfortunately, significant data limitations made it difficult to retrieve historical data for the municipal operations inventory.

However, an estimate of historical emissions has been provided below. It relies on an interpolation method similar to the one employed in the community-wide inventory. One difference is that a number of sub-sectors for municipal emissions contained only a single data point (i.e., the data for calendar year 2023), which makes this interpolation method infeasible. To resolve this problem, a slope approximation method based on the community-wide inventory was employed for these specific sub-sectors instead.[6]



The above graph demonstrates a few trends in Bloomington's municipal operations inventory over the years:

- **The City's wastewater treatment plants are consistently the greatest source of emissions for every year inventoried.** The historical emissions graph further underpins the importance of this effort and how high-leverage the opportunity it is for reducing municipal emissions.
- **Most sub-sectors have seen a gradual decrease in emissions year-over-year, except for those attributed to the energy used in powering streetlights and traffic signals.** The City is currently undergoing the process of transitioning to LED streetlights which are both more cost-effective and require less energy to power. This will hopefully reduce what has been an otherwise relatively constant and non-declining source of emissions since 2008.
- **The Transportation sector will likely be the most difficult sector to decarbonize in the coming years.** Transportation, made up by the municipal fleet and operational fleet administered by Bloomington Transit, are significant contributors to municipal emissions. Whereas the City's grid-supplied electricity sub-sectors have decarbonized gradually over the years without significant City-led investment (due to investment in renewables by the upstream utility companies like Duke Energy), the transportation sector will require significant capital investment to electrify the City's large fleet of operational vehicles. This will require significant budgetary foresight and financial prudence and will be a much more fragmented transition than just installing a single anaerobic digestor system at Dillman Wastewater Treatment Plant or procuring renewable energy via the centralized utility company.

The rest of this chapter explores each sector and sub-sector described in this overview section in more detail, providing a more in-depth understanding of the drivers of Bloomington's emissions from municipal operations in 2023 and years prior.

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[6] To explain in more detail: the graph estimates historical emissions data for years where it was unavailable, using two methods: (1) Interpolation: When at least two data points were available, the graph uses interpolation to estimate values for the missing years. (2) Slope approximation: For sub-sectors with only one data point (e.g., 2023 data for municipal grid-supplied electricity), the graph uses the rate of change from the corresponding community-wide sub-sector (where historical data was more readily available) to estimate earlier years' emissions. This method assumes that municipal operations emissions changed at a similar rate to community-wide emissions in the same sub-sector. These techniques allow the graph to show a complete historical emissions trend, even when data for some years or sub-sectors was limited.

Stationary Energy

Introduction

Emissions from the Stationary Energy sector represent 34.3% of Bloomington's total emissions from municipal operations. Unlike the community-wide inventory where stationary energy was the largest sector by overall share of emissions, it is the smallest sector for the municipal operations inventory.

Stationary Energy is primarily broken down into three sub-sectors, just as it is for the Community-Wide Inventory:

- **Grid-Supplied Electricity:** Emissions from the combustion of fossil fuels to generate electricity and transmit it via the power grid for use in powering municipal buildings and facilities.
- **Transmission and Distribution:** Emissions resulting from energy losses that occur during the transmission and distribution of electricity from power plants to municipal end users. These losses are mainly due to resistance in power lines and equipment inefficiencies.
- **Stationary Fuel Combustion:** Emissions generated directly from burning fossil fuels such as natural gas, propane, or oil on-site in municipal buildings and facilities for heating or other energy-related needs.

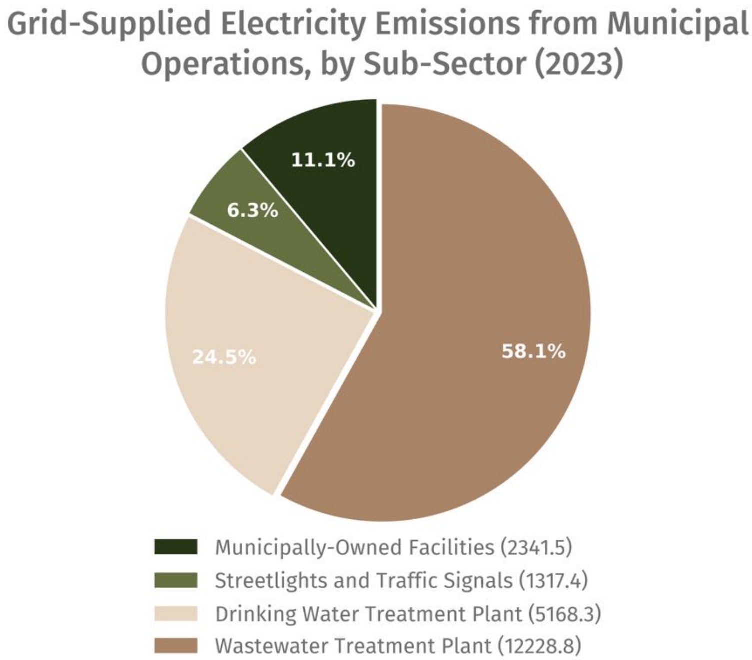
Note that only emissions from Stationary Fuel Combustion could not be calculated for the Municipal Operations Inventory, as CenterPoint Energy was unable to provide the relevant data at just the municipal operations level. However, the Community-Wide Inventory can be used as a proxy to estimate roughly the proportional number of emissions that would likely have been contributed to by stationary fuel combustion for municipal operations.

Grid-Supplied Electricity and Transmission & Distribution Losses

As previously mentioned, grid-supplied electricity is the sub-sector which refers to emissions generated in supplying electricity to power buildings, facilities, and machinery within the inventory boundaries—in this case, just for municipal operations purposes. Closely related to this sub-sector are emissions resulting from losses during the transmission and distribution (T&D) of that electricity to its end destination.

T&D losses are an inevitable result of energy dissipating as heat when electricity travels through power lines and transformers, leading to inefficiencies in the grid. These losses mean that for every kilowatt-hour of energy consumed within Bloomington, some additional percentage of energy had to be generated to compensate for the lost energy during transmission. As a result, the actual emissions associated with electricity use by municipal end users are slightly higher than the amount of electricity consumed would suggest, due to these grid inefficiencies. Those emissions are accounted for as "T&D Losses" within the inventory.

A breakdown of emissions from the grid-supplied electricity sub-sector is shown in the pie chart below. The majority of electricity-related emissions for municipal operations are the result of powering the City's wastewater treatment facilities. These are large, industrial facilities (and some of the only, major industrial facilities within the City boundaries), so it's sensible that they account for a majority of electricity-related emissions.



The remaining amount of emissions are from providing electricity to power municipally-owned buildings, streetlights & traffic lights, and the Monroe County Drinking Water Treatment Plant.

The table below provides a breakdown of emissions from sub-sector broken down by category and year.

Grid-Supplied Electricity Emissions from Municipal Operations, by Category and Year ($MTCO_2e$)				
Year	Municipally-Owned Facilities	Wastewater Treatment Plants	Streetlights & Traffic Signals	Drinking Water Treatment Plant[7]
2023	2,341.49	12,228.84	1,317.41	5,168.3

Note that while the Monroe County drinking water treatment plant services not just the City of Bloomington but also nearby jurisdictions, the entirety of the plant's estimated emissions are included in this municipal operations inventory. This is because the City of Bloomington owns and controls 100% of the water treatment plant, and the Local Government Operations Protocol calls for accounting for all emissions from owned and controlled assets, regardless of where the end users are located.

The methodology for calculating emissions from this sub-sector was identical to the analysis utilized in the Community-Wide Inventory, except adapted to use only consumption data from municipal operations:

1. **Gather Raw Data:** Total annual energy consumption in kilowatt-hours (kWh) for each year and category (municipally-owned facilities, wastewater treatment plants, the local drinking water treatment plant, and streetlights & traffic signals) is collected. For the City of Bloomington, this data was obtained from the local utility, Duke Energy.[8]
2. **Calculate Emissions:** The EPA's eGRID emissions factors are used to calculate total emissions for CO_2, CH_4, and N_2O. eGRID provides region-specific emissions factors that reflect the energy mix (e.g., coal, natural gas, renewable energy) used to generate the electricity consumed in Bloomington.

[7] Note that the emissions calculations for the drinking water treatment plant also include on-site combustion of natural gas that occurs at the plant, in addition to the consumption of grid-supplied electricity throughout the plant's various facilities. This provides a more comprehensive look at operational emissions occurring within the City's drinking water treatment plant.

[8] The same issue described in the Community-Wide Inventory applies here, which is that Duke Energy was unable to provide data prior 2023 due to a billing system modernization which occurred in 2022. Additionally, they were unable to break out the data into the more granular categories as requested by the *Local Government Operations Protocol*. The above categories were decided upon based on Duke's commitment and capacity to consistently query the data using these same categories in future inventory years.

3. **Convert to Metric Tons:** The emissions calculated in pounds (lbs) for each greenhouse gas are converted to metric tons, as metric tons are the standard unit used in greenhouse gas reporting.
4. **Convert to CO_2 Equivalents:** The metric tons of each gas are converted to metric tons of CO_2 equivalent ($MTCO_2e$). This step accounts for the global warming potential (GWP) of each gas, where methane (CH_4) and nitrous oxide (N_2O) have a higher GWP than carbon dioxide (CO_2).
5. **Aggregate Emissions:** The $MTCO_2e$ values for each greenhouse gas are summed to obtain the total standardized emissions by year and category. This aggregated data provides a comprehensive view of Bloomington's grid-supplied electricity emissions from municipal operations and helps identify trends over time.

Next, emissions from transmission and distribution losses were calculated for each category described above to provide a better picture of total emissions stemming from the consumption of grid-supplied electricity for municipal operations. The following methodology was applied:

1. **Calculate the T&D Loss Rate:** Table 10 from the Energy Information Administration's (EIA) *State Electricity Profile for Indiana* was used, which was only updated through 2022 at the time of inventory compilation. Using the Energy Information Administration (EIA)'s preferred formula, the estimated rate for T&D losses was calculated by dividing the estimated losses by the result of total disposition minus direct use. Since data for 2023 was unavailable, the loss rate from 2022 was imputed.
2. **Apply the Loss Rate:** After determining the T&D loss rate, it was applied to each category of $MTCO_2e$ emissions for stationary energy. This allowed for the calculation of the proportional increase in emissions due to energy lost during transmission and distribution, which occurs upstream of actual stationary energy consumption within the inventory boundaries.

The table below provides an estimate of transmission and distribution losses which occurred in the use of grid-supplied electricity for municipal operations.

Transmission & Distribution Losses Emissions from Municipal Operations, by Category and Year ($MTCO_2e$)				
Year	Municipally-Owned Facilities	Wastewater Treatment Plants	Streetlights & Traffic Signals	Drinking Water Treatment Plant
2023	120.36	628.61	67.72	261.63

As the table shows, stationary energy emissions increase a small amount due to these transmission and distribution losses. For the calendar year 2023, the estimated T&D loss rate was 5.14%, resulting in an aggregate of 1,078.32 additional metric tons of CO_2 emissions approximately.

Transportation

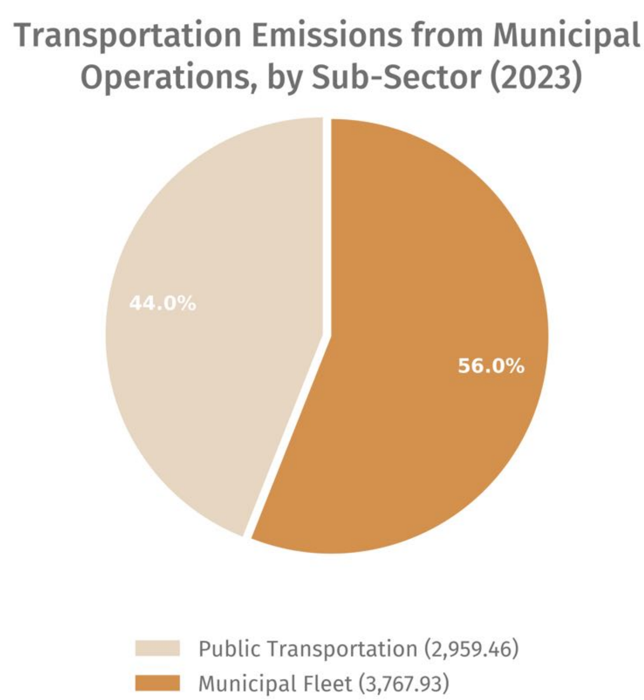
Introduction

Emissions from the Transportation sector represent 23.3% of Bloomington's total emissions from municipal operations—making this the second largest source of emissions for the local government.

Transportation-related emissions can stem from a variety of different sources, but the majority of these emissions are attributable to two sub-sectors:

- **Local Government Operational Fleet:** Vehicles used by various city departments, such as public works, police, and other administrative services.
- **Public Transportation:** Vehicles used for facilitating public transportation services, which includes fixed-route buses, paratransit vehicles, and shuttles used by residents.

The pie chart on the below shows a breakdown of transportation-related emissions from municipal operations and the relative percentages of the two sub-sectors described above. For the City of Bloomington, the majority of emissions (56.0%) originate from the City's operational fleet, whereas public transit makes up the remaining number of emissions (44.0%).



The table below includes a breakdown of transportation-related emissions from municipal operations on a year-by-year basis[9]:

Transportation Emissions from Municipal Operations, by Sub-Sector and Year ($MTCO_2e$)		
Year	**City of Bloomington Fleet**	**Bloomington Transit**
2018	-	3,459.77
2019	-	3,390.18
2020	-	3,390.18
2021	-	2,791.14
2022	-	2,743.41
2023	3,767.9294	2,959.46

Local Government Operational Fleet

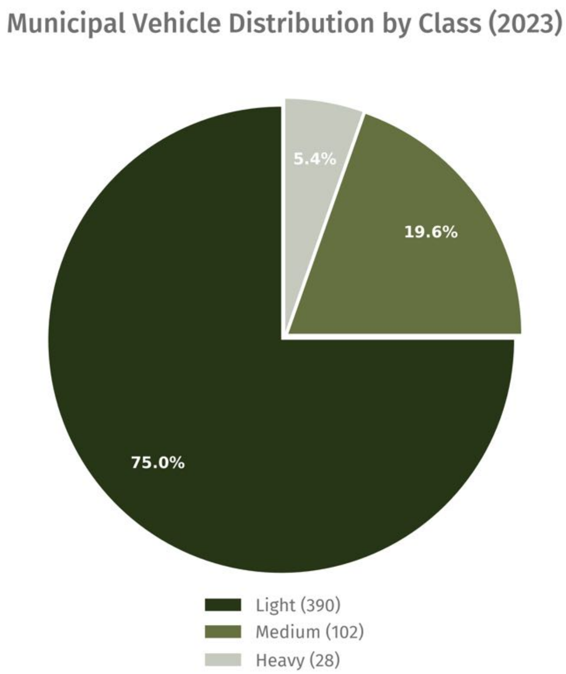
The City of Bloomington's fleet encompasses over 500 different vehicles used by various departments and government authorities under the City's operational control.

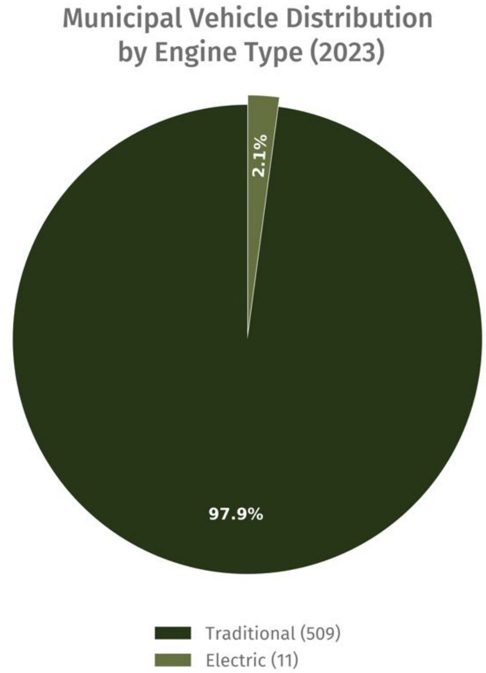
While detailed historical data and vehicle-level mileage information could not be gathered due to limitations with the City's fleet maintenance software, a breakdown of the fleet by class (light, medium, or heavy-duty) and engine type (traditional combustion vs. electric) was calculated.

As the charts below show, the majority of Bloomington's operational fleet consists of light-duty vehicles such as sedans or lightweight pickup trucks. Around a fifth of the vehicles are medium-duty in nature such as large vans or trailers. Heavy-duty vehicles, while the largest producers of emissions, make up a small percentage of the City's overall fleet (5.4%).

The City has only recently begun to explore vehicle electrification in recent years, so just 2.1% of the overall fleet is electric. However, vehicle electrification is significantly picking up in pace in municipalities across the US and the City of Bloomington's long-term plans aim toward full vehicle electrification. This means the percentage of vehicles which are electric should increase in the years to come. This is important because vehicle electrification is the primary way that the City can reduce its transportation-related emissions, so this will be an important metric to track in the coming years.

[9] Historical emissions dating back to 2018 were able to be calculated for Bloomington Transit. However, only emissions from 2023 were calculated for the City of Bloomington's Fleet due to limitations with the City's fleet maintenance software and challenges around historical data availability.





The methodology for calculating emissions from this sub-sector was as follows:

1. **Data Collection:** Data on the number of municipal vehicles was obtained from the City of Bloomington's Fleet Department. Due to limitations in their tracking systems, vehicle-level mileage data was unavailable. Instead, data on the number of vehicles was categorized by class (light, medium, heavy) and type (combustion vs. electric). Only data from 2023 was available, as historical records were not accessible.
2. **Assumption of Mileage:** In the absence of specific mileage data, average annual mileage per vehicle was estimated using assumptions based on a Federal Highway Administration (FHWA) report. This provided an estimate for annual mileage per vehicle across different vehicle classes.
3. **Fuel Consumption Estimation:** For combustion vehicles, the average fuel economy was determined using the same assumptions applied to community-wide on-road transportation emissions, which are based on vehicle class. The assumed mileage per vehicle was then multiplied by this average fuel economy to estimate the total fuel consumption (in gallons) for each vehicle class.
4. **Emissions Calculation:** The total fuel consumption for each vehicle class was combined with emissions factors provided by the Environmental Protection Agency (EPA) to calculate the emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) for each vehicle class. This process resulted in emissions data in pounds for each class.
5. **Global Warming Potential Conversion:** Emissions of CH_4 and N_2O were converted to their respective carbon dioxide equivalent ($MTCO_2e$) using the global warming potential (GWP) factors. This conversion ensured that emissions were comparable across gases with different climate impacts.
6. **Aggregation of Results:** Finally, the emissions across all vehicle classes were aggregated to produce a total emissions figure for the City of Bloomington's municipal fleet in 2023. This allowed for reporting in metric tons of CO_2 equivalent ($MTCO_2e$), providing a clear picture of the fleet's impact on greenhouse gas emissions.

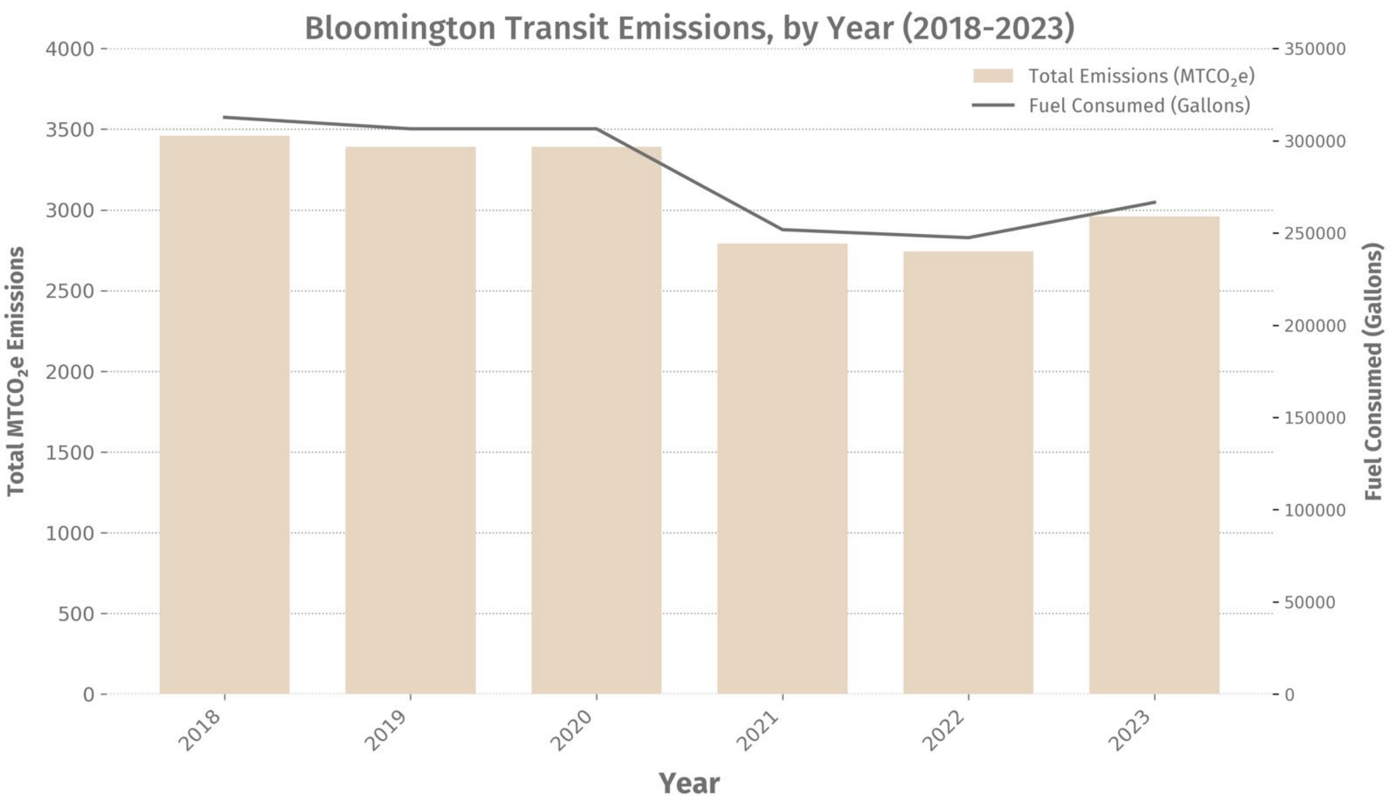
Public Transportation

Public transportation accounts for a substantial portion (44.0%) of Bloomington's transportation-related emissions from municipal operations. Decarbonizing this sub-sector is a priority, as electric buses offer cleaner air and improved fuel efficiency. Although electric bus technology isn't as far along as that for electric sedans and SUVs—posing challenges like higher upfront costs, limited range, and charging infrastructure needs—ongoing advancements continue to make the transition to sustainable public transit increasingly feasible.

Bloomington Transit, the primary provider of public transportation within the City, offers a variety of different transportation services for residents, including both fixed-route and paratransit vehicles.

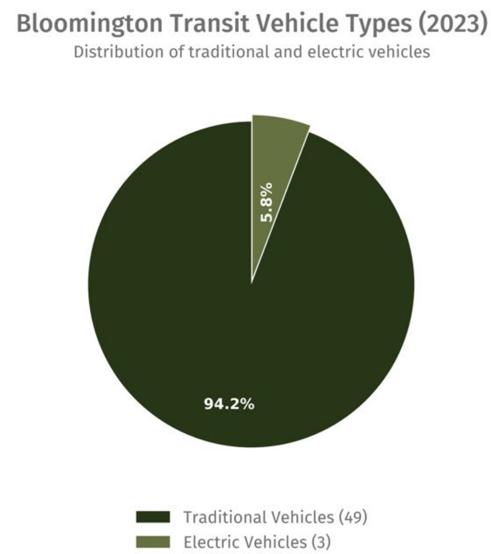
- **Fixed-route vehicles** follow predetermined routes and schedules, serving high-traffic areas with frequent stops, making them a reliable option for commuters and daily riders.
- **Paratransit vehicles** provide flexible, on-demand transportation for individuals with disabilities or mobility challenges, offering door-to-door service to ensure accessibility for all residents.

The bar chart below shows total emissions from Bloomington Transit's operations since 2018, as well as the total gallons of fuel consumed each year.[10] Since the primary driver of vehicle emissions is the mobile combustion of fuel, the trendline for the bars and the fuel consumption line track each other closely.



[10] The metric for total gallons of fuel consumed each year accounts for the mobile combustion of both gasoline and diesel fuel.

Since 2021, Bloomington Transit's emissions have decreased a small percentage, which is uncoincidentally the same year that the agency began purchasing electric buses. As of the end of 2023, the agency owns and operates three electric buses. As the pie chart to the right shows, this means 5.8% of the agency's fixed-route buses and paratransit vehicles are electric.



The methodology for calculating emissions from this sub-sector was as follows:

1. **Data Collection:** Data was sourced from Bloomington Transit, which provided annual fuel consumption figures as well as vehicle counts by year. The fuel consumption data was disaggregated by type of service provided. Since the shuttles operated in partnership with Indiana University were not consistent with Bloomington Transit's other data, they were excluded from the analysis.
2. **Assumption of Fuel Economy:** The assumptions used for the community-wide on-road transportation emissions were applied to estimate the fuel economy by vehicle class. Specifically, Bloomington Transit's fixed-route buses and paratransit vehicles were classified as medium-duty, while staff cars were categorized as light-duty vehicles.
3. **CO_2 Emissions Calculation:** The total fuel consumption for each vehicle class (medium and light-duty) was combined with the Environmental Protection Agency (EPA) emissions factors for the combustion of gasoline or diesel fuel. This enabled the calculation of carbon dioxide (CO_2) emissions by year and by vehicle class.
4. **CH_4 and N_2O Emissions Calculation:** To estimate the vehicle miles traveled (VMT) for each class, the fuel consumption was divided by the assumed average fuel economy per vehicle class. The resulting VMT was multiplied by the EPA's emissions factors for methane (CH_4) and nitrous oxide (N_2O) to determine the quantities of each gas generated annually by vehicle class.
5. **Global Warming Potential Conversion:** The emissions of CH_4 and N_2O were converted to their carbon dioxide equivalent (CO_2e) values using the global warming potential (GWP) factors, allowing for consistent comparison of the greenhouse gas impacts across different gases.
6. **Aggregation of Results:** The emissions were aggregated across vehicle classes and types of gas (CO_2, CH_4, N_2O) to produce a total emissions profile for Bloomington Transit's vehicle operations in a given year, expressed in metric tons of CO_2 equivalent ($MTCO_2e$).

Solid Waste & Wastewater

Introduction

Emissions from the Solid Waste and Wastewater sector represent a plurality (42.4%) of Bloomington's total municipal operations emissions, making this the primary source of emissions from local government activities. This sector encompasses the greenhouse gas emissions associated with the disposal and treatment of solid waste generated from City operations, as well as the treatment and transport of wastewater managed by City of Bloomington Utilities.

It's important to note that while the City has the ability to reduce its emissions from its own facilities,' solid waste disposal emissions data for this sub-sector could not be collected from the City's Sanitation Department due to data availability limitations. This gap in data should be considered when interpreting the overall emissions picture for municipal operations.

Wastewater emissions, on the other hand, are fully accounted for in the municipal operations inventory, as the City of Bloomington Utilities are owned and operated by the City and were able to provide the necessary data.

As with community-wide emissions, solid waste emissions in municipal operations primarily result from the decomposition of organic matter in landfills. When waste decomposes in anaerobic conditions (without oxygen), it produces methane (CH_4), a potent greenhouse gas.

Wastewater treatment processes contribute to emissions through three main mechanisms. First, methane (CH_4) emissions can occur during secondary treatment, where the biological breakdown of organic matter produces both carbon dioxide and methane, depending on the presence or absence of oxygen. Second, anaerobic digestion, used to treat sewage sludge, generates additional methane, which can be captured for energy recovery or flared to reduce emissions. Third, nitrification and denitrification processes, used to remove nitrogen from wastewater, produce nitrous oxide (N_2O), a potent greenhouse gas. Additionally, electricity consumed in operating wastewater treatment facilities contributes to emissions, which are already accounted for in the Stationary Energy sector of the Municipal Operations Inventory.

The distribution of emissions between solid waste and wastewater treatment in the municipal operations context may differ from the community-wide data due to the specific nature of city-controlled operations and the aforementioned data limitations for solid waste. A precise breakdown of these emissions sources for municipal operations would require further data collection and analysis.

The table below includes the relevant emissions data for this sector. Note that the emissions from wastewater treatment are identical to the emissions listed in the community-wide inventory since the City has full operational control over wastewater treatment facilities through the City of Bloomington Utilities (CBU), meaning all of these emissions must be accounted for in the municipal operations inventory.

Solid Waste & Wastewater Emissions from Municipal Operations, by Sub-Sector and Year ($MTCO_2e$)

Year	Solid Waste	Wastewater Treatment
2011	-	2,156.15
2012	-	2,173.69
2013	-	2,181.55
2014	-	2,200.20
2015	-	2,211.68

2016	-	2,232.61
2017	-	2,244.52
2018	-	2,252.51
2019	-	2,268.80
2020	-	2,092.12
2021	-	2,100.01
2022	-	2,091.25
2023	-	2,085.85

Wastewater Treatment

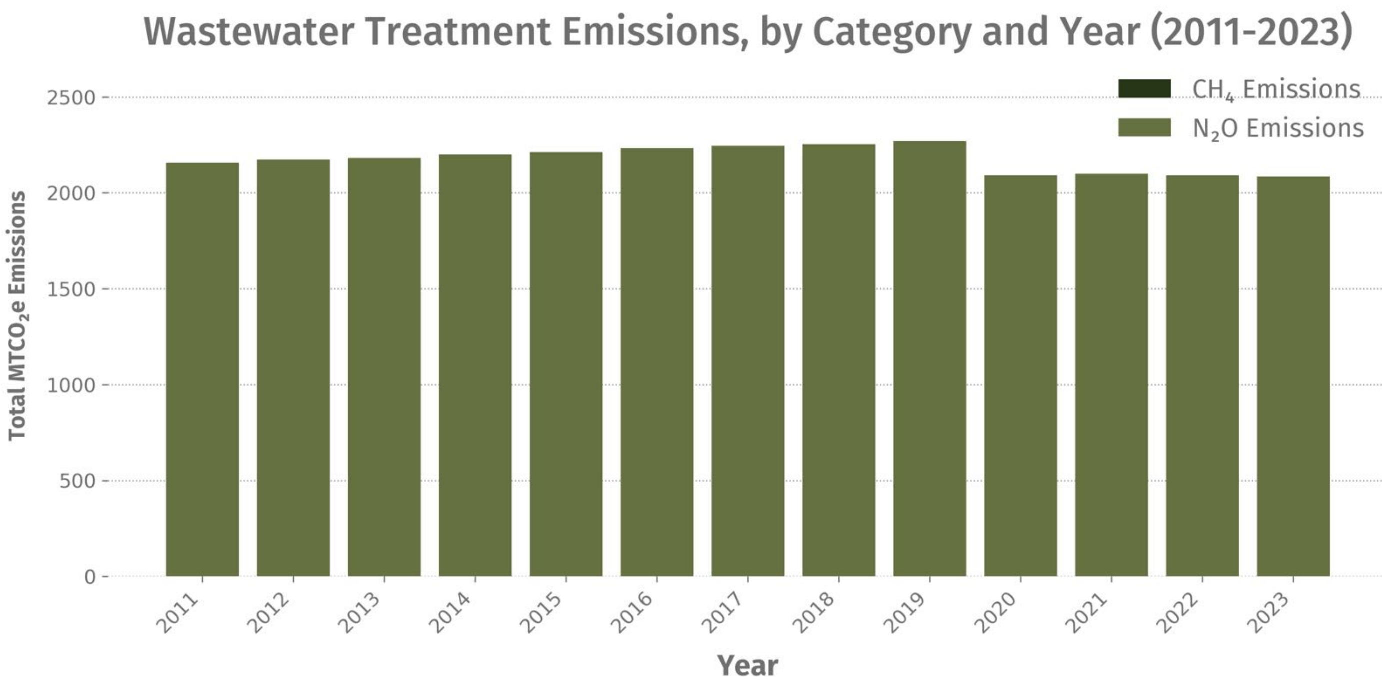
In the context of Bloomington's municipal operations inventory, wastewater treatment emissions are identical to those reported in the community-wide inventory. This is because the City of Bloomington Utilities, which manages wastewater treatment, is entirely controlled by the local government. Consequently, all emissions from this sector must be fully accounted for in the municipal operations inventory.

As previously discussed in the community-wide inventory, emissions from this sub-sector come from three sources primarily:

- **Methane (CH_4) Emissions from Secondary Treatment:** Carbon dioxide and methane are produced during the biological processes used to break down organic matter in the secondary treatment phase. Secondary treatment can be divided into either aerobic or anaerobic treatment processes, based on the amount of oxygen that is present during the decomposition process. Aerobic treatment, occurring in the presence of oxygen, is generally preferred as it produces primarily biogenic CO_2 and minimal methane emissions. In contrast, anaerobic treatment occurs without oxygen and produces significant methane emissions which are more potent in their contribution to global warming.
- **Methane (CH_4) Emissions from Use of an Anaerobic Digestor:** Some wastewater treatment plants employ the use of an anaerobic digestor to break down solid organic waste (sludge) and reduce its volume. Anaerobic digestors produce biogas which can be used as a fuel source (e.g., to be combusted and provide power to wastewater treatment plant or other biogas-powered systems in the area) or flared to prevent direct methane emissions to the atmosphere. Emissions are produced as a result of both of the combustion and flaring processes and must be accounted for accordingly.
- **Nitrous Oxide (N_2O) Emissions from Nitrification/Denitrification:** Nitrification and denitrification are biological processes used to remove nitrogen from wastewater. Nitrification converts ammonia to nitrate under aerobic conditions, while denitrification converts nitrate to nitrogen gas under anoxic conditions. These processes can produce nitrous oxide as a by-product, which is a potent greenhouse gas that must be accounted for within the greenhouse gas inventory.

The City of Bloomington Utilities (CBU) operates two wastewater treatment facilities that contribute to the City's greenhouse gas emissions profile. At both facilities, CBU employs aerobic digestion for secondary treatment, which helps minimize methane emissions compared to anaerobic alternatives. Neither facilities utilize anaerobic digestors to process solid waste, so associated emissions from this category were excluded from the calculations. Additionally, like all wastewater treatment plants, CBU’s facilities emit nitrous oxide as a byproduct of the standard nitrification and denitrification processes used to remove nitrogen from the wastewater stream. The utility follows standard industry practices for sludge management, with no additional emissions from processes such as incineration

The stacked bar chart below shows a breakdown of emissions from wastewater treatment in the City of Bloomington for the years 2011-2023. There are two primary wastewater treatment plants, one located on Dillman Rd and another on Blucher Poole Rd, which treat the entirety of Bloomington's wastewater.



As the chart demonstrates, N_2O emissions due to the nitrification/denitrification processes associated with wastewater treatment are the primary driver of emissions at these plants, whereas CH_4 emissions from aerobic treatment result in effectively zero net emissions due to the more environmentally friendly nature of this treatment method.

The emissions from this sector have stayed relatively flat over the years, which makes sense given that the primary driver of waste is the population of the City which has also remained stable.

For the municipal operations inventory, it's crucial to note that these emissions represent a significant portion of the City's direct operational impact. Efforts to reduce these emissions through improved treatment technologies or increased biogas capture could have a substantial effect on the City's overall emissions profile.

The methodology for calculating emissions from this sub-sector were identical to those used in the community-wide inventory. First, the methodology for calculating CH_4 emissions from the aerobic digestion process used during secondary treatment was as follows:

1. **Gather Raw Data:** CH_4 emissions from aerobic-based, secondary treatment were calculated using Equations 8.9 and 8.10 from the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC). Due to the unavailability of city-specific data for Bloomington, estimates made for California's Greenhouse Gas Inventory were used for key variables, including per capita Biochemical Oxygen Demand (BOD), maximum methane-producing capacity, and the methane correction factor (MCF).
2. **Apply Population-Based Assumptions:** The entire population was assumed to use the same emissions factor, as the GPC's recommended method of differentiating emissions factors by income group was simplified. In addition, it was assumed that each wastewater treatment plant (WWTP) serves 50% of Bloomington's population. As a result, the calculations were made in aggregate for the City, rather than differentiating between individual WWTPs.
3. **Calculate Methane Emissions:** The CH_4 emissions were calculated by applying the above parameters into the GPC's simplified equations (Equation 8.9 and 8.10). The resulting emissions are in metric tons of methane. However, because a methane correction factor (MCF) of 0.0 was used, the calculations resulted in an estimate of zero metric tons of methane emissions generated.

4. **Convert to CO_2 Equivalents:** The calculated methane emissions in metric tons were converted to CO_2 equivalents ($MTCO_2e$) using the global warming potential (GWP) factor for methane. This provides a standardized measure for the warming impact of methane emissions from wastewater treatment processes. Again, because the input was a value of zero, the resulting amount of CO_2-equivalent emissions was also zero.

Secondly, emissions resulting from the use an anaerobic digestor system were excluded since neither of Bloomington's wastewater treatment plants utilize this technology. Finally, the methodology for calculating N_2O-related emissions from nitrification and denitrification processes is described below:

1. **Gather Raw Data:** Nitrous oxide emissions were calculated using Equation 8.12 from the GPC Protocol. Most of the default values recommended by the GPC were used for the calculation, except for per capita protein consumption, which was estimated using data from the World Health Organization (WHO) on total protein supply by country.
2. **Apply Population-Based Assumptions:** As with the methane emissions, it was assumed that each WWTP serves 50% of the population of Bloomington. Calculations were therefore made in aggregate rather than by each treatment plant. The population served by the WWTPs was factored into the equation to estimate the N_2O emissions.
3. **Calculate Nitrous Oxide Emissions:** The N_2O emissions were calculated using the inputs from the GPC and WHO data, applied into Equation 8.12. The output represents the N2O emissions in metric tons.
4. **Convert to CO2 Equivalents:** The calculated nitrous oxide emissions in metric tons were then converted to CO_2 equivalents ($MTCO_2e$) using the global warming potential (GWP) for nitrous oxide. This conversion accounts for the higher warming potential of N_2O compared to CO_2.

Industrial Processes & Product Use

Explanation for Exclusion from Inventory

The Industrial Processes and Product Use (IPPU) sector within the *Local Government Operations (LGO) Protocol* includes two sub-sectors: industrial processes and product use. For municipal operations, this sector primarily focuses on fugitive emissions from specific equipment and systems used in city-owned facilities and operations.

In the context of Bloomington's municipal operations, the primary sources of IPPU emissions are:

- **Fugitive Emissions from Refrigerants:** These emissions are associated with Heating, Ventilation, and Air Conditioning (HVAC) systems in city-owned buildings and facilities. Refrigerants, such as hydrofluorocarbons (HFCs), can leak during operation, maintenance, or disposal of these systems.
- **Fugitive Emissions from Fire Suppression Equipment:** This includes emissions from fire extinguishers and other fire prevention systems installed in municipal buildings and vehicles. These systems often contain gases that can contribute to greenhouse gas emissions if released.

Similar to the community-wide inventory, calculating emissions for this sector in municipal operations presents several challenges related to data availability. The City's Public Works Department does not currently track the data required to calculate fugitive emissions, and the methods which can be used to calculate proxies of these emissions were also missing the required inputs to be considered accurate and meet the inventory's required quality standards.

For these reasons, specific calculations for the IPPU sector have not been included due to these data collection and quantification challenges.

A Note Regarding Emissions from Fire Suppression Equipment

While the City's Public Works Department does not have data available to estimate fugitive emissions, they noted that the City has entirely transitioned away from conventional fire extinguishers toward water-vapor-based equipment.

These eco-friendly fire extinguishers do not release fugitive emissions compared to their traditional counterparts which foam, carbon dioxide, or other emissions-generating chemicals for fire suppression. As a result, while approximate fugitive emissions from municipal operations cannot be estimated, the City likely has lower fugitive emissions than its peers of equivalent size.

Concluding Remarks & Appendices

Some remarks to conclude this report and a set of appendices including a detailed breakdown of emissions sources and accompanying glossary.

Concluding Remarks

This 2023 Greenhouse Gas Inventory Report represents the most exhaustive and comprehensive analysis of emissions ever conducted for the City of Bloomington. Notably, this report marks a significant milestone, as it includes, for the first time, a dedicated Municipal Operations Inventory alongside the Community-Wide Inventory. This achievement underscores the City's commitment to understanding and addressing its environmental impact at all levels.

This report is part of a broader effort to establish a yearly reporting mechanism around greenhouse gas emissions in the City of Bloomington. The City plans to update both of these inventories annually, providing a level of transparency at a frequency which surpasses the norm for even the most climate-conscious municipalities.

Opportunities for the Future

While this report represents a significant step forward in understanding Bloomington's emissions profile, there remain opportunities for future improvement, particularly in data collection and analysis. Several data sources, especially for the Municipal Operations Inventory, were unavailable or incomplete, which limited the ability to calculate emissions for all sub-sectors that the relevant emissions protocols recommend.

Although the bulk of emissions from major sources in both the Community-Wide and Municipal Operations inventories was successfully accounted for, there is potential to further refine and expand upon the analysis included here. Building stronger partnerships with data providers and implementing more comprehensive data tracking systems where they don't already exist will be crucial in addressing these gaps in future years.

Some specific areas for future improvement for the community-wide inventory include:

- More detailed data on industrial processes and product use within city limits
- Improved estimates of emissions from urban green spaces and small-scale agriculture
- Enhanced data on off-road vehicle and equipment usage
- Detailed waste characterization studies for more precise methane generation estimates
- City-specific data on per capita Biochemical Oxygen Demand (BOD) for wastewater treatment

And some areas of improvement for the municipal operations inventory are:

- Detailed mileage data for the City's vehicle fleet
- Comprehensive data on refrigerant use in municipal HVAC systems located in City-owned facilities
- Data on the volume and type of solid waste generated in municipal operations
- Enhanced data collection on employee commuting patterns and other Scope 3-related emissions sources

By addressing these data gaps, future inventories can provide an even more comprehensive picture of Bloomington's emissions, further enhancing the City's ability to target and reduce its carbon footprint effectively.

Acknowledgments

The success of this inventory report would not have been possible without the contributions and support of numerous individuals and organizations. The ClimateNav Team would like to extend our heartfelt gratitude to:

- All external data providers, including Duke Energy, CenterPoint Energy, Indiana Bureau of Motor Vehicles, the Indiana Department of Transportation, the Indiana Department of Environmental Management, and the Monroe County Airport for their timely provision of data and invaluable assistance in setting up a streamlined reporting system for future years.
- The various City departments, including Public Works, Fleet, Utilities, and Bloomington Transit, for their cooperation and support in gathering crucial data for the Municipal Operations Inventory.
- The City of Bloomington Sustainability Team for their unwavering commitment to data-driven decision-making and their collaborative spirit throughout the development of this report.
- Mayor Kerry Thomson and the City Council for their leadership and support of Bloomington's climate initiatives, which made this comprehensive inventory not only possible, but a priority for municipal leaders.

We look forward to collaborating with the individuals and organizations mentioned above in the coming years as we continue our partnership with the City of Bloomington.

Most importantly, we invite the broader community to join us in taking climate action and advancing sustainability efforts to help preserve this beautiful and vibrant city for future generations to come.

Appendix A: Breakdown of Emissions for Community-Wide Inventory

The table below provides an overview of the sectors, sub-sectors, and categories included in the community-wide inventory, along with the data provider and applicable GPC reporting notation for each.

The GPC reporting notations used in the tables below are defined as follows:

- **Included (I):** The emissions source is estimated and included in the inventory.
- **Included Elsewhere (IE):** The emissions source is estimated but included in aggregate in another category of the inventory.
- **Not Estimated (NE):** The emissions source cannot be estimated due to data limitations.
- **Not Occurring (NO):** The emission source does not exist within the City of Bloomington, or it produces a relatively small number of emissions that are difficult to quantify in aggregate.
- **Confidential (C):** The emissions data is confidential and not able to be publicly reported.

This structured breakdown allows for a clear understanding of which emission sources are included, where data gaps exist, and what potential opportunities exist for expanding reporting in future inventories.

STATIONARY ENERGY

Category	Scope	Description	Notation	Data Provider	Reporting Level
Residential buildings	1	*On-site natural gas combustion in residential buildings.*	Included (I)	CenterPoint Energy	BASIC
	2	*Grid-supplied electricity consumption in residential buildings.*	Included (I)	Duke Energy	BASIC
	3	*T&D losses from grid-supplied electricity consumption in residential buildings.*	Included (I)	Duke Energy	BASIC+
Commercial and institutional buildings and facilities	1	*On-site natural gas combustion in commercial and institutional buildings.*	Included (I)	CenterPoint Energy	BASIC
	2	*Grid-supplied electricity consumption in commercial and institutional buildings. Voluntarily reporting the sub-categories of Commercial & Non-Government Institutional and Government separately.*	Included (I)	Duke Energy	BASIC
	3	*T&D losses from grid-supplied electricity consumption in commercial and institutional buildings. Voluntarily reporting the sub-categories of Commercial & Non-Government Institutional and Government separately.*	Included (I)	Duke Energy	BASIC+
Manufacturing industries and construction	1	*On-site natural gas combustion in industrial buildings.*	Included (I)	CenterPoint Energy	BASIC
	2	*Grid-supplied electricity consumption in industrial facilities.*	Included (I)	Duke Energy	BASIC
	3	*T&D losses from grid-supplied electricity consumption in industrial facilities.*	Included (I)	Duke Energy	BASIC+
Energy industries	1	*Included elsewhere in Scope 3, Stationary Energy: Commercial and institutional buildings and facilities and Scope 3, Stationary Energy: Manufacturing industries and construction. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: Commercial and institutional buildings and facilities and Scope 2, Stationary Energy: Manufacturing industries and construction. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*Included elsewhere in Scope 3, Stationary Energy: Commercial and institutional buildings and facilities and Scope 3, Stationary Energy: Manufacturing industries and construction. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC+
Energy generation supplied to the grid	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	Territorial
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Agriculture, forestry, and fishing activities	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: Commercial and institutional buildings and facilities. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC+
Non-specified sources	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
	2	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
	3	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC+
Fugitive emissions	1	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-	BASIC
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-

TRANSPORTATION

Category	Scope	Description	Notation	Data Provider	Reporting Level
On-Road Transportation	1	*In-boundary fuel consumption for on-road transportation (excludes electric vehicles).*	Included (I)	Indiana Department of Transportation, Indiana Bureau of Motor Vehicles	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*N/A → Emissions from this categorycould not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-	BASIC+
Railways	1	*N/A → Emissions from this category could not be calculated due to reasons of data confidentiality and privacy.*	Confidential (C)	-	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*N/A → Emissions from this category could not be calculated due to reasons of data confidentiality and privacy.*	Confidential (C)	-	BASIC+
Water Transport	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC+
Aviation	1	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable. This category encompasses flights which start and stop within the inventory boundaries (e.g., short helicopter rides) which are fairly rare, so emissions from this category are insignificant.*	Not Estimated (NE)	-	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*Aviation fuel consumption by flights with an origin or destination point within the inventory boundaries.*	Included (I)	Monroe County Airport	BASIC+
Off-Road Transportation	1	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-	BASIC
	2	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy	BASIC
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-

SOLID WASTE & WASTEWATER

Category	Scope	Description	Notation	Data Provider	Reporting Level
Solid waste generated in the city disposed in landfills or open dumps	1	*Included elsewhere in Solid Waste & Wastewater, Scope 3: Solid waste generated in the city disposed in landfills or open dumps.*	Included Elsewhere (IE)	Indiana Department of Environmental Management	BASIC
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Municipal solid waste (MSW) and non-MSW disposed in landfills within the state of Indiana (inside or outside of the City boundaries). Includes waste generated both inside and outside of the city—cannot be disaggregated further due to data limitations.*	Included (I)	Indiana Department of Environmental Management	BASIC
Solid waste generated outside the city disposed in landfills or open dumps	1	*Included elsewhere in Solid Waste & Wastewater, Scope 3: Solid waste generated in the city disposed in landfills or open dumps.*	Included Elsewhere (IE)	Indiana Department of Environmental Management	Territorial
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Solid waste generated in the city that is treated biologically	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
Solid waste generated outside the city that is treated biologically	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	Territorial
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Solid waste generated in the city incinerated or burned in the open	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-	BASIC
Solid waste generated outside the city incinerated or burned in the open	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	Territorial
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Wastewater generated in the city	1	*CH_4 and N_2O emissions from wastewater treatment and nitrification/denitrification processes respectively at in-boundary wastewater treatment plants.*	Included (I)	City of Bloomington Utilities	BASIC
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC
Wastewater generated outside the city	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	Territorial
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-

INDUSTRIAL PROCESSES & PRODUCT USE

Category	Scope	Description	Notation	Data Provider	Reporting Level
Industrial Processes	1	*N/A → Emissions from this category could not be calculated due to reasons of data confidentiality and privacy.*	Confidential (C)	-	BASIC+
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Product Use	1	*N/A → Emissions from this category could not be calculated due to reasons of data confidentiality and privacy.*	Confidential (C)	-	BASIC+
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-

AGRICULTURE, FORESTY, & OTHER LAND USE

Category	Scope	Description	Notation	Data Provider	Reporting Level
Livestock	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC+
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Land	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC+
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
Aggregate sources and non-CO_2 emission sources on land	1	*N/A → No emissions of this type are substantially present within the inventory boundaries.*	Not Occurring (NO)	-	BASIC+
	2	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-
	3	*Non-applicable emissions for this scope according to GPC guidelines.*	-	-	-

Appendix B: Breakdown of Emissions for Municipal Operations Inventory

The table below provides an overview of the sectors, sub-sectors, and categories included in this municipal operations inventory, along with the data provider and applicable GPC-inspired reporting notation for each.

While the *Local Government Operations (LGO) Protocol* does not dictate nor require a specific notation format, this inventory uses a derivative of GPC's notation format to provide maximal reporting clarity. The reporting notations used in the tables below are defined as follows:

- **Included (I):** The emissions source is estimated and included in the inventory.
- **Included Elsewhere (IE):** The emissions source is estimated but included in aggregate in another category of the inventory.
- **Not Estimated (NE):** The emissions source cannot be estimated due to data limitations.
- **Not Occurring (NO):** The emission source does not exist within the City of Bloomington, or it produces a relatively small number of emissions that are difficult to quantify in aggregate.
- **Confidential (C):** The emissions data is confidential and not able to be publicly reported.
- **Non-Controlling (NC):** The City of Bloomington does not have operational control over this emissions source, so it should be counted as part of the Community-Wide Inventory but not included in the Municipal Operations Inventory.

Note that this expands upon the GPC notation format by adding a category for Non-Controlling (NC) to specify cases where the City does not have operational control over a given emissions source. Without operational control, the City has a different scope of authority and policy control to mitigate these emissions, so the inventory excludes emissions from these sources and chooses to count them solely as part of the community-wide inventory instead.

STATIONARY ENERGY

Emissions Source	Description	Notation	Data Provider
Scope 1: Emissions from fuel combustion and fugitive emissions due to municipal operations.			
Municipally-owned facilities, natural gas combustion	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Wastewater treatment plant, natural gas combustion	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Water delivery facilities, natural gas combustion	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Power generation facilities, natural gas combustion and fugitive emissions	*N/A → The City of Bloomington does not have operational control over power generation facilities.*	Non-Controlling (NC)	-
Solid waste facilities, natural gas combustion	*N/A → The City of Bloomington does not have operational control over solid waste facilities.*	Non-Controlling (NC)	-
Port facilities, natural gas combustion	*N/A → The City of Bloomington does not have operational control over port facilities.*	Non-Controlling (NC)	-
Airport facilities, natural gas combustion	*N/A → The City of Bloomington does not have operational control over airport facilities.*	Non-Controlling (NC)	-
Scope 2: Emissions from consumption of grid-supplied energy due to municipal operations.			
Municipally-owned facilities, electricity usage	*Grid-supplied electricity consumption in municipally-operated facilities.*	Included (I)	Duke Energy
Wastewater treatment plant, electricity usage	*Grid-supplied electricity consumption at the municipally-operated wastewater treatment plants on Dillman Road and Blucher Poole.*	Included (I)	Duke Energy
Streetlights and traffic signals, electricity usage	*Grid-supplied electricity consumption for municipally-operated streetlights and traffic signals.*	Included (I)	Duke Energy
Municipally-owned vehicle fleet, electricity usage	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy
Municipally-owned transit fleet, electricity usage	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy
Water delivery facilities, electricity usage	*Included elsewhere in Scope 2, Stationary Energy: All categories. Unable to disaggregate the data further due to the data limitations.*	Included Elsewhere (IE)	Duke Energy
Port facilities, electricity usage	*N/A → The City of Bloomington does not have operational control over port facilities.*	Non-Controlling (NC)	-
Airport facilities, electricity usage	*N/A → The City of Bloomington does not have operational control over airport facilities.*	Non-Controlling (NC)	-
Power generation facilities, electricity usage	*N/A → The City of Bloomington does not have operational control over power generation facilities.*	Non-Controlling (NC)	-
Power generation facilities, transmission & distribution losses	*N/A → The City of Bloomington does not have operational control over power generation facilities.*	Non-Controlling (NC)	-
Solid waste facilities, electricity usage	*N/A → The City of Bloomington does not have operational control over solid waste facilities.*	Non-Controlling (NC)	-
Steam purchased from third parties	*N/A → The City of Bloomington does not purchase steam from third parties.*	Not Occurring (NO)	-
District heating and cooling from third parties	*N/A → The City of Bloomington does not purchase district heating and/or cooling from third parties.*	Not Occurring (NO)	-
Scope 3: Not applicable.			

Emissions from this scope are not applicable to the Municipal Operations Inventory under the Local Government Operations Protocol.

TRANSPORTATION

Emissions Source	Description	Notation	Data Provider
Scope 1: Emissions from fuel combustion and fugitive emissions in municipally-owned vehicles.			
Municipally-owned vehicle fleet, fuel consumption	*Fuel consumption for the municipally-owned vehicle fleet used in City operations. This includes CO_2, CH_4, and N_2O emissions.*	Included (I)	City of Bloomington Fleet Department
Municipally-owned transit fleet, fuel consumption	*Fuel consumption for the municipally-owned transit fleet used in public transportation. This includes CO_2, CH_4, and N_2O emissions.*	Included (I)	Bloomington Transit
Municipally-owned vehicle fleet, fugitive emissions	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Municipally-owned transit fleet, fugitive emissions	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Scope 2: Not applicable.			
Emissions from this scope are not applicable to the Municipal Operations Inventory under the Local Government Operations Protocol.			
Scope 3: Not applicable.			
Emissions from this scope are not applicable to the Municipal Operations Inventory under the Local Government Operations Protocol.			

SOLID WASTE & WASTEWATER

Emissions Source	Description	Notation	Data Provider
Scope 1: Emissions from fuel combustion and fugitive emissions due to municipal operations.			
Solid waste disposed of in municipally-operated landfills	*N/A → The City of Bloomington does not have operational control over solid waste facilities.*	Non-Controlling (NC)	-
Organic waste disposed of in municipally-operated composting facilities	*N/A → The City of Bloomington does not have operational control over composting facilities.*	Non-Controlling (NC)	-
Process emissions in municipally-operated wastewater treatment plants	*CH_4 and N_2O emissions from wastewater treatment and nitrification/denitrification processes respectively at municipally-operated wastewater treatment plants.*	Included (I)	City of Bloomington Utilities
Scope 2: Emissions from consumption of grid-supplied energy due to municipal operations.			
Emissions from this scope are not applicable to the Municipal Operations Inventory under the Local Government Operations Protocol.			
Scope 3: Not applicable.			
Solid waste from municipal operations	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Organic waste from municipal operations	*Organic waste from municipal operations disposed in composting facilities outside of the City's boundaries.*	Not Occurring (NO)	-

Industrial Processes & Product Use

Emissions Source	Description	Notation	Data Provider
Scope 1: Emissions from fuel combustion and fugitive emissions due to municipal operations.			
Fugitive emissions from refrigerants	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Fugitive emissions from fire suppression equipment	*N/A → Emissions from this category could not be calculated due to the required data not existing or being unavailable.*	Not Estimated (NE)	-
Scope 2: Emissions from consumption of grid-supplied energy due to municipal operations.			
Emissions from this scope are not applicable to the Municipal Operations Inventory under the Local Government Operations Protocol.			
Scope 3: Not applicable.			
Emissions from this scope are not applicable to the Municipal Operations Inventory under the Local Government Operations Protocol.			

Appendix C: Glossary

Aerobic Digestion

A biological wastewater treatment process that uses oxygen to break down organic matter. In the presence of oxygen, aerobic digestion primarily produces biogenic carbon dioxide (CO_2) and minimizes methane (CH_4) emissions, making it a preferred option for secondary treatment in well-managed facilities.

Anaerobic Digestor

An enclosed tank or system used to break down sewage sludge and other organic waste in the absence of oxygen. This process produces biogas, a mixture of methane (CH_4) and carbon dioxide (CO_2), which can be captured and combusted for energy recovery or flared to reduce greenhouse gas emissions.

BASIC/BASIC+ Reporting

Two levels of reporting under the GPC, with BASIC+ being more comprehensive and including more complex emissions sources.

Carbon Dioxide Equivalent (CO_2e)

A standard unit for measuring carbon footprints, usually expressed in metric tons ($MTCO_2e$). It expresses the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of warming.

Category

A grouping of the end consumers who engage in emissions-generating activities (e.g., Residential buildings is a category that groups similar consumers of grid-supplied electricity and stationary fuel combustion). Note that this is the equivalent of the *Global Protocol for Community-Scale Emissions's* use of the term "sub-sector," which has a different definition within this inventory.

Community-Wide Inventory

An inventory that accounts for all GHG emissions occurring within the city's geographic boundaries, from residential and commercial activities to industrial processes and transportation.

Degradable Organic Carbon (DOC)

A parameter in the calculation of methane emissions from waste disposal, representing the portion of organic carbon in waste that can degrade into methane under anaerobic conditions.

eGRID

The Emissions & Generation Resource Integrated Database, providing emissions factors for calculating electricity-related emissions and maintained by the US EPA. It divides the U.S. into regions based on grid interconnections, allowing for more accurately estimating emissions on a regional basis.

First Order of Decay (FOD)

An alternative method to calculate methane emissions from solid waste, accounting for the fact that organic waste emits methane over several decades as it decomposes. This method is more accurate than other approaches but requires historical waste data that is generally not available in most jurisdictions.

Fugitive Emissions

GHG emissions that are released during the use, maintenance, or disposal of equipment, such as leaks from HVAC systems, fire suppression systems, or on-site natural gas systems within inventory boundaries.

Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC)

The international standard for calculating and reporting city-scale GHG emissions. The GPC defines emissions into three "scopes" (Scope 1, 2, and 3) and provides levels of reporting such as BASIC and BASIC+.

Global Warming Potential (GWP)

A measure of how much heat a greenhouse gas traps in the atmosphere over a specific time period compared to carbon dioxide (CO_2). Methane (CH_4) and nitrous oxide (N_2O) have higher GWP values, reflecting their greater heat-trapping ability.

Greenhouse Gas (GHG) Inventory

A comprehensive accounting of GHG emissions produced by an entity over a specified period. It serves as a tool to understand emissions sources and develop climate action plans.

Local Government Operations (LGO) Protocol

A framework for calculating GHG emissions from local government activities, ensuring consistency and accuracy in tracking municipal emissions.

Methane Commitment (MC) Approach

A method for estimating methane emissions from solid waste disposal that assumes all future methane emissions from waste occur in the year the waste is deposited. This simplifies calculations by using current-year disposal data.

Methane Correction Factor (MCF)

Used in waste disposal emissions calculations to adjust for landfill conditions. An MCF of 1.0 is used for anaerobic landfills.

Municipal Operations Inventory

A separate inventory focusing on emissions from government-owned and operated facilities, vehicles, and infrastructure. It specifically only focuses on emissions which the local government has operational control over.

Nitrification/Denitrification

Biological processes used in wastewater treatment to remove nitrogen, producing nitrous oxide as a by-product.

Oxidation Factor

Applied in solid waste disposal calculations to account for the fraction of methane oxidized in landfills before it escapes into the atmosphere. In this report, an oxidation factor of 0.1 was used for well-managed landfills.

Sector

A broad grouping of emissions sub-sectors that share a function or activity (e.g., Stationary Energy or Transportation). Each sector represents a major contributor to global greenhouse gas emissions.

Scope 1 Emissions

Direct emissions from sources within the city boundary, such as fuel combustion in buildings or vehicles. An example of Scope 1 emissions would be the emissions resultingfrom natural gas combustion in residential homes.

Scope 2 Emissions

Indirect emissions from the consumption of grid-supplied electricity, heat, or steam within the city boundary. An example of Scope 2 emissions would be the emissions resulting from generating electricity at a coal-fired power plant outside of the city's boundaries but used within the city to power homes.

Scope 3 Emissions

Other indirect emissions that occur outside the city boundary due to activities taking place within the city, such as emissions from the upstream production and transportation of fuel. An example of Scope 3 emissions would be the emissions resulting from the disposal of waste generating inside of the City boundaries but landfilled elsewhere.

Stationary Energy

Emissions from energy used to power residential, commercil, and industrial buildings, as well as other facilities that consume energy for heating, cooling, lighting, and powering appliances and machinery.

Stationary Fuel Combustion

Emissions resulting from the burning of fuels (such as natural gas, oil, or coal) in fixed equipment or facilities, including boilers, furnaces, and engines, primarily for purposes like heating, industrial processes, or power generation within buildings or plants.

Sub-Sector

A more granular description of where emissions within a given sector originate from (e.g., grid-supplied electricity is a sub-sector of the stationary energy sector). Note that the *Global Protocol for Community-Scale Emissions* has a different definition of sub-sector, but the definition shown here is used throughout the report instead as it more commonly reflects the way inventories are presented in the United States.

Transmission and Distribution (T&D) Losses

Energy lost during the process of delivering electricity from power plants to end users.

Vehicle Miles Traveled (VMT)

A measure of the total miles driven by vehicles within the city boundary. VMT data is used to estimate emissions from transportation, typically multiplied by emissions factors for CO_2, CH_4, and N_2O.

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