CITY OF LANCASTER

Greenhouse Gas Inventory

A community-wide and municipal operations greenhouse gas inventory for 2015

City of Lancaster

Department of Public Works – Douglas Smith

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Acknowledgement

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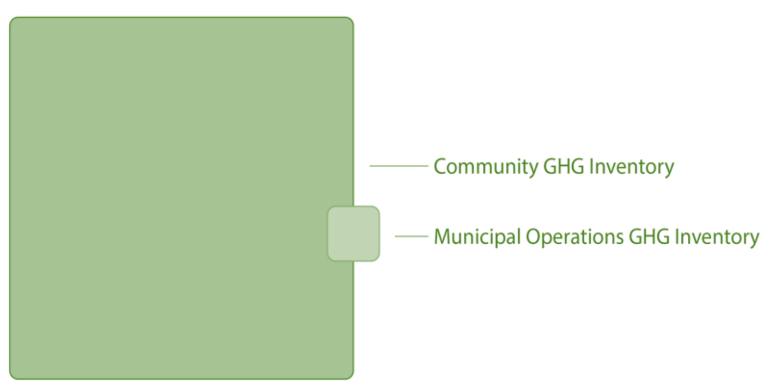
INTRODUCTION

The City of Lancaster's 2015-2017 Strategic Plan names four Strategic Focus Areas, including Community, Livability, Sustainability, and Vitality. The first Strategic Priority listed under Sustainability is, "Establish sustainability targets for energy, water, waste, and greenhouse gas emissions."[i] This Greenhouse Gas (GHG) Inventory fulfills part of that priority. It also begins to fulfill the City's recent commitment to the Paris Climate Agreement, which requires inventorying GHG emissions, setting a reduction target, and demonstrating progress towards it through monitoring.[ii] This is the first attempt by the City of Lancaster to comprehensively inventory GHG emissions resulting from the city at large and its municipal operations. Although there are numerous types of GHG emissions, this report presents all GHG emissions as an equivalent unit of carbon dioxide (CO_2). This document is intended to function as a benchmarking tool, which requires updates annually or biennially. It is the first step in a five-step process of climate action: GHG Measurement, Set a Target, Climate Action Plan, Implement Plan, and Monitor Success (Figure 1).

This document is comprised of six parts: (1) an introduction with background material; (2) an explanation of the methodology; (3) the results of the community GHG inventory; and (4) the results of the municipal operations GHG inventory; (5) municipal carbon offsets; (6) next steps. There are two inventories presented here; there is a community GHG inventory and a municipal operations GHG inventory ("inventory" for short). The difference is that the former looks at GHG emissions for the entire geographic area within the City boundaries, including residents, businesses, and industry, among other sources; the latter only looks at GHG emissions resulting from municipal operations, such as police, fire, and wastewater treatment. The two are distinct and should be considered separately. The community audit attempts to account for all emissions originating in the city, which includes most of those generated by City operations; however, the City operates facilities outside the municipal boundary and provides water and sewer services to adjacent municipalities. Therefore, the municipal operations inventory should be considered a partial subset of the community inventory. Most of the municipal operations GHG emissions occur within the City boundary and consequently are captured in the community inventory, but not all GHG emissions (Figure 2).

Figure 1. ICLEI's 5 Milestone Methodology to Climate Action starts with conducting a GHG inventory.

Figure 2. Conceptual illustration showing partial overlap between the community GHG inventory and the City operations GHG inventory.



This study is a response to a call to action that is loud and clear. All the world's national governments, all the national academies of sciences, and most of the major scientific bodies and climatologists accept that global climate change is occurring and that it is the result of human activities. It has also been shown that every scientific "worst-case scenario" has been exceeded, as the world continues to accelerate its emissions of climate-changing pollutants. Every decade since the 1980s has been hotter, globally, than the preceding decade. Furthermore, as evidenced by recent global weather calamities, it would be difficult to believe that the climate has not already changed.

1.2 National Context

The national conversation around climate change has become increasingly difficult as President Trump's administration advocates for defunding clean energy programs and questions whether humans are driving climate change. This came to a dramatic climax on June 1st of 2017 when President Trump withdrew from the

Paris Climate Agreement.[iii] In accordance with Article 28, as the agreement entered into force in the United States on November 4th, 2016, the earliest possible effective withdrawal date for the United States is November 4th, 2020; however, there are no penalties for non-compliance in the meantime.[iv] This action has inspired cities and states across the U.S. to make formal commitments to the Paris Climate Agreement, including nearly 300 cities representing 60 million citizens.[v] Meanwhile, the U.S. continues to suffer dramatic climate change impacts such as increased hurricane severity, massive wild fires, and noticeable sea level rise in low-lying places like Miami.

1.3 Pennsylvania Context

Pennsylvania is not an exception to climate change, and it has already suffered drought, flash flooding, and a stressed agricultural industry. Combined with international financial crises, decaying infrastructure, and increasing poverty, the stress on state and municipal resources is undeniable. Pennsylvania broached the topic with the Climate Change Act (Act 70 of 2008), which provides for a report on climate change impacts and economic opportunities for the Commonwealth, including a greenhouse gas inventory and climate change action plan.[vi] Topping the list of recommendations is making newly constructed buildings more energy efficient. While it is important for the state to help guide this effort, it is also necessary that municipal government begin climate action planning too. Inventorying emission sources is the first step to setting reduction targets and acting.

1.4 Local Context

On June 5th, 2017 City of Lancaster's Mayor Gray announced his commitment to the Paris Climate Agreement at a City Council Committee meeting. Council showed its support by formalizing this commitment through a resolution on June 13th, 2017, resolving to (1) reducing GHG emissions through development and implementation of a Climate Action Plan, (2) join other U.S. cities in the Climate Mayor's network in adopting and supporting the goals of the Paris Climate Agreement, and (3) commit to exploring the potential benefits and costs of adopting policies and programs that promote the long-term goal of GHG emissions reduction while maximizing economic and social co-benefits of such action.

METHODOLOGY & BACKGROUND

In this study, all GHGs are reported in carbon dioxide (CO_2) equivalents for simplicity. For example, methane is GHG gas that is about 30 times more potent than CO_2, which means that 1 unit of methane is reported here as 30 units of CO_2.[vii] All GHG units in this document are metric tons carbon dioxide equivalents and abbreviated as mtCO_2e.

ICLEI is an international association of local governments from around that world that are initiating climate action and other sustainability efforts. ICLEI identifies a list of community and municipal activities that are considered key sources of GHG emissions. The organization offers a free online tool called ClearPath ™ that enables communities to input data for these key sources and then estimate the GHG emissions. Although some GHG sources are not within a city's geographical boundary, like electricity production and or landfills, these emissions are included in the inventory because their ultimate causes – electricity demand and waste generation – occur in Lancaster

2.1 Community Emission Source Activities

The community inventory includes the following GHG producing activities from within Lancaster's city limits:

- **Transportation –** the miles driven by various vehicles within the City limits
- **Residential Energy–** energy use (electricity and natural gas usage) from PPL and UGI
- **Commercial Energy–** energy use (electricity and natural gas usage) from PPL and UGI
- **Industrial Energy–** energy use (electricity and natural gas usage) from PPL and UGI
- **Waste –** discarded by the community and collected by Lancaster County Solid Waste Management Authority

2.2 Municipal Operations Emission Source Activities

The municipal inventory includes the following GHG producing activities that are recorded for City activity:

- **Wastewater Facilities & Processes –** treatment, pumping, and related building energy use (electricity and natural gas usage) from PPL and UGI, including facilities outside the City limits and energy consumed to provide sewer services regionally, including N_2O emissions from centralized wastewater treatment facilities and from N_2O emissions from effluent discharge to the Conestoga River.
- **Water Treatment Facilities –** treatment, pumping, and related building energy use (electricity and natural gas usage) from PPL and UGI, including facilities outside the City limits and energy consumed to provide potable water services regionally.
- **Other Building Facilities –** energy use (electricity and natural gas usage) from PPL and UGI in City-owned buildings that are not a part of water or wastewater operations, including City Hall and the Police Station, among many others.
- **Vehicle Fleet –** miles driven by City operated vehicles according to annual odometer readings
- **Streetlights –**electricity use from PPL.
- **Parks** – electricity use from PPL used for outdoor park lighting, swimming pools, concession stands, ice-melt systems, and outlets for rented pavilions.
- **Traffic Lights –**electricity use from PPL.

2.3 Emissions by Scopes

This inventory classifies emissions sources by sector and energy source (or fuel type). Sector and fuel classification provides the most relevant information for legislation and program creation. Many GHG inventories also classify emission sources by Scopes, which express the directness of the relationship between an activity and the emissions it causes. An emission source's Scope is determined by where the emissions occur (at the activity site or in a remote location), and when the emissions occur (during, before, or after the activity). Scopes offer a method to prevent double counting for major categories such as electricity use and waste disposal. This inventory includes three Scopes:

Scope 1: All direct emissions from sources located within city limits (community inventory) or under municipal control (municipal inventory). This generally includes fuel combustion (e.g. natural gas) in buildings, vehicle emissions, and industrial process emissions.

Scope 2: Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, and cooling. Scope 2 emissions occur because of activities that take place within city limits or municipal control, but that occur at sources located outside of these boundaries.

Scope 3: All other indirect or embodied emissions not covered in Scopes 1 and 2, which occur because of activity within the City limit or municipal control. Under current reporting protocols, these sources are optional. This inventory includes the significant and reliably quantifiable Scope 3 emissions of waste.

2.4 Combined Methodologies

Several different tools and methodologies were used to create this inventory and that required special attention to be given to not double-counting any emissions. The primary tool in this methodology was ClearPathTM 's Community-Scale Track tool, which is offered for free to municipalities by ICLEI, Local Governments for Sustainability USA. Data collected from PPL, UGI, and City staff was input into the module. Facility Dude was a secondary tool used to calculate emissions from City buildings; staff collected 3-years' worth of electric and natural gas bills as part of a building benchmarking project, which also yielded GHG emissions for 2015. Facility Dude uses the Climate Registry's General Reporting Protocol. Finally, custom emissions calculations were used for community-wide transportation emissions and the City's vehicle fleet emissions. These results were tallied respective to each inventory. Below is a complete list of methodologies employed for each reported source of GHG emissions (Table 1).

Table 1. Methodology used for each inventory category in the 2015 community inventory and municipal inventory.

	CATEGORY	DATA SOURCE	METHODOLOGY	NOTES
COMMUNITY INVENTORY	Residential Energy	PPL Electric, UGI Utilities	ICLEI's ClearPath™ Tool	Scott Koch, a representative at PPL provided data. Lori Pepper, a representative at UGI provided data.
	Commercial Energy	PPL Electric, UGI Utilities	ICLEI's ClearPath™ Tool	Scott Koch, a representative at PPL provided data. Lori Pepper, a representative at UGI provided data.
	Industrial Energy	PPL Electric, UGI Utilities	ICLEI's ClearPath™ Tool	Scott Koch, a representative at PPL provided data. Lori Pepper, a representative at UGI provided data.
	Solid Waste	City of Lancaster	ICLEI's ClearPath™ Tool	Data originated from Lancaster County Solid Waste Management Authority. Emissions from Solid Waste Collection vehicles were omitted from this calculation to avoid double-counting in Transportation. DEP's 2003 Waste Composition Study provided the relative mix of waste types used for emissions factors.
	Transportation	PENNDOT	County data apportioned to City population	PENNDOT provided a preliminary 2014 County-level transportation emissions audit as part of a state-wide effort. Michael Baker of PENNDOT recommended apportioning this by employment population in the City as a proxy for car ownership: The 2015 ACS reported a 55% employment rate for the City (59,339*55%), which is 32,669 employees or 12% of the County population and so 12% of transportation emissions.
MUNICIPAL OPERATIONS INVENTORY	Other Building Facilities	City of Lancaster - Facilities	Facility Dude, Inc. (Climate Registry's General Reporting Protocol)	City electric and natural gas bills were input into Facility Dude, which converted energy used to carbon emissions using EPA's eGRID.
	Vehicle Fleet	City of Lancaster – Bureau of Operations	EPA's Recommended Method: Document EPA-420-F-14-040a	Only data from 2016 was readily available. Formula used: Annual Mileage x MPG x Fuel Specific Emissions Factor (kg CO2/ fuel unit)*1,000 = tCO2e
	Water Treatment Facilities	City of Lancaster – Bureau of Water	ICLEI's ClearPath™ Tool	Includes electric and natural gas use, the latter of which is only used for heating/cooling occupied buildings.
	Wastewater Treatment Processes	City of Lancaster – Bureau of Wastewater	ICLEI's ClearPath™ Tool	Carbon emissions equivalent from NO_2 released during denitrification and effluent releases.
	Streetlights	PPL Electric	Facility Dude, Inc. (Climate Registry's General Reporting Protocol)	City electric bills were input into Facility Dude, which converted energy used to carbon emissions using EPA's eGRID.
	Traffic Lights	PPL Electric	Facility Dude, Inc. (Climate Registry's General Reporting Protocol)	City electric bills were input into Facility Dude, which converted energy used to carbon emissions using EPA's eGRID.

2.5 Baseline Year

Carbon emissions inventories are most useful when they can demonstrate trends overtime, which is normally accomplished by picking a baseline year. The years 1990 and 2000 are common baseline years and goals are often set to reduce current emissions relative to them. However, this inventory only presents emissions in 2015, which means that trends overtime cannot yet be discussed. This is primarily an issue of staff capacity. The current inventory has taken the time and resources of several staff members and volunteers, estimated at over 100 hours. To further the usefulness of this document additional consideration should be given to establishing baseline years, so that the City's emissions trajectory can be considered.

2.6 Reproducibility & Maintenance

Consideration should be given to how this inventory will be maintained overtime. Ideally, these metrics will be refined and updated annually, so the community and the City operations can be held accountable for their emissions. Given that staff capacity was a limiting factor in the production of this study, partnerships with other community organizations should be investigated. Franklin & Marshall College, Millersville University, and Penn State Harrisburg all have environmental programs that could take on the maintenance of this inventory from year to year. However, methodologies must remain consistent across years, so careful attention should be given to the methodology outlined herein. If the methodology used in future inventories differs, then the results in this inventory or other inventories should be updated with the newer methodologies, if possible. Without that consistency between years it becomes difficult to track progress over time.

2.7 Accuracy

All GHG inventories are painted with broad brushes, especially at the community scale. Although the municipal operations inventory could be more accurate, there is no inventory that captures 100% of GHG emissions. With that said, there are standards for inventory techniques and for the quality of data. This inventory admittedly has room for improvement, and those opportunities are discussed within each section and summarized in the final section of the report.

The community inventory has the most opportunity for improvement. The transportation model is basic and the emissions from residential, commercial, and industrial sectors do not include energy sources combusted on-site that are not delivered from the grid. This excludes large industrial and institutional point sources such as oil deliveries.

The municipal operations inventory is arguably more accurate. That is mostly since it is dealing with smaller sets of data and it is unique to an organization. The City keeps excellent records on its facilities, energy use, vehicle miles, and water and wastewater treatment. Some of this record keeping is also required by state and federal regulations. There were no privacy issues with sharing data across City bureaus either, whereas there may be privacy concerns when asking institutions and businesses for energy and emissions data. However, there are also opportunities to improve the municipal operations inventory as well. Vehicle fleet data form 2016 was used because data from 2015 was not readily available. The exact number of streetlights and traffic lights is not currently known, although the City has a good approximation.

While these potential inaccuracies need to be kept in mind as this document is used, it does not undermine its usefulness or importance. If a consistent methodology is used across years, then measurable progress can be tracked.

COMMUNITY INVENTORY

Community-wide GHG emissions inventories help identify the largest collective sources of GHG emissions. Below is an estimate of all major sources of GHGs from within the City boundary. The City emits 684,920 tons for carbon annually, which is the equivalent of about 146,000 passenger vehicles traveling for 1 year. In 2015, the Census estimated the City population at 59,339, meaning the average Lancaster City resident emits about 12 $mtCO_2e$ per year. In 2013, the World Bank estimated the average U.S. citizen is responsible for 16.4 $mtCO_2e$ per year. Although urban centers tend to have lower emissions, the difference could also be attributed to missing GHG emissions sources, such as fugitive emissions from refrigerants.

Transportation is the largest source of emissions, followed in decreasing order by commercial energy, residential energy, industrial energy, and solid waste. However, the transportation sector potentially has the largest margin of error, which is discussed in detail below. The commercial, residential, and industrial energy sectors are a combination of natural gas and electricity. All solid waste was generated within the city and exported to facilities outside the city.

Figure 3. Proportions of 2015 GHG gas sources originating within the City of Lancaster municipal boundary in $mtCO_2e$.

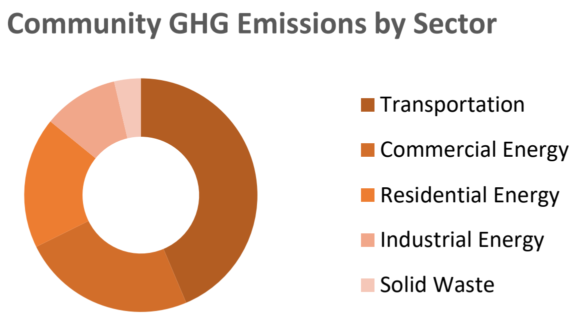


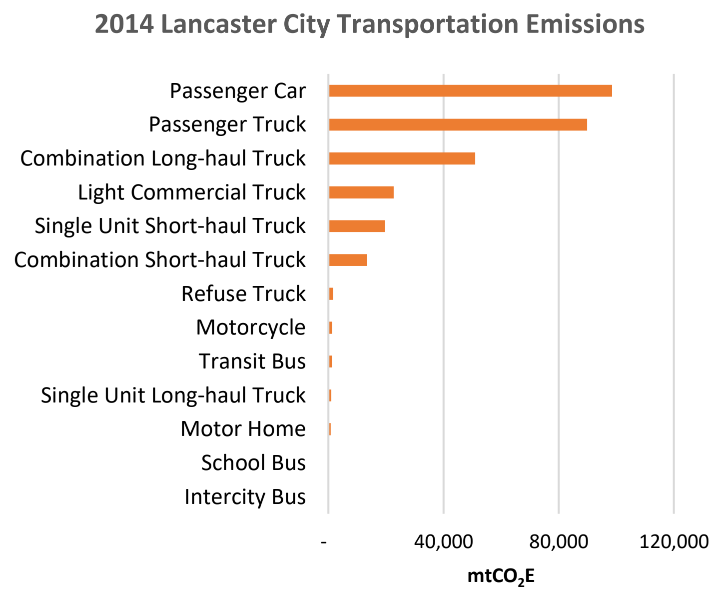
Table 2. 2015 GHG gas sources originating within the City of Lancaster municipal boundary in $mtCO_2e$.

SECTOR	$mtCO_2e$	%
Transportation	301,702	44
Commercial Energy	166,382	24
Residential Energy	125,602	18
Industrial Energy	72,198	11
Solid Waste	19,036	3
TOTAL	**684,920**	**100**

3.1 Transportation

Transportation emissions are estimated as the largest source of GHG emissions in Lancaster City; however, there is also the most uncertainty in this number. Community transportation GHG inventories are data intensive and complex, and there is always a margin of error involved. With the help of PENNDOT, the City can provide a basic estimate here. Using PENNDOT's 2014 unofficial Transportation GHG Emissions Inventory for Lancaster County, emissions were apportioned to the City based on the American Community Survey's 2015 estimate for employment ages 16-64, which is 55% of the City population or 32,669 people total. A PENNDOT official recommended using employment as a proxy for transportation. The City's employment population is 12% of the County's total employment population, yielding the emissions in Figure 4. Passenger vehicles are responsible for the most vehicle emissions.

Figure 4. 2015 Transportation Emissions for Lancaster City Apportioned by Employment Population from 2014 County Data



There are several opportunities to refine this calculation. For instance, this method assumes drivers are primarily commuters and that is not always true. For instance, many trips are for pleasure and errands, among other things. Additionally, apportioning County-wide emissions to the City assumes that the City has similar travel patterns to the County, and this is not accurate. Residents of cities tend to use low-carbon travel options like walking, biking, and transit more often than suburban and rural residents. Although the transportation emissions estimate is a crude measure, it is a useful placeholder until more accurate data is available.

Table 3. 2015 GHG Emissions for City of Lancaster by scope in mtCO2e.

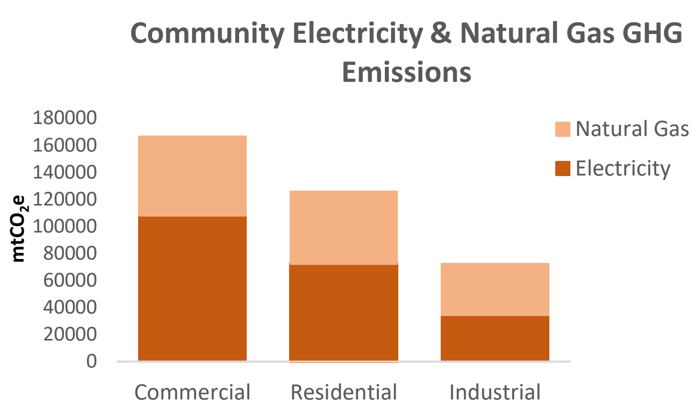
COMMUNITY WIDE EMISSIONS BY SCOPE

SCOPE	SOURCE	$mtCO_2e$	%
1	Transportation	301,702	44%
1	Nat Gas - Com	58467	9%
1	Nat Gas - Res	53356	8%
1	Nat Gas - Ind	37916	6%
2	Elec - Com	107915	16%
2	Elec - Res	72246	11%
2	Elec - Ind	34282	5%
3	Solid Waste	19,036	3%
		684,920	100%

3.2 Commercial, Residential, and Industrial

The City worked with both UGI and PPL customer support to collect electric and natural gas data for residential, commercial, and industrial users (Figure 5). The emissions reported here were estimated from electricity and natural gas that was delivered through the grid system. About 65% of commercial emissions comes from electricity and 45% from natural gas. Proportionally, natural gas is used more by the residential and industrial sector. About 57% of residential emissions come from electricity and 43% from natural gas, while the industrial sector produces more emissions from natural gas with about 47% of emissions from electricity and 53% from natural gas.

Figure 5. 2015 Transportation Emissions for Lancaster City Apportioned by Employment Population from 2014 County Data



Both PPL Electric and UGI assured the City they did their best to single out Lancaster City parcels; however, they warned that there may be small discrepancies. For instance, it may have been difficult to separate out some Lancaster Township accounts from Lancaster City accounts because of the intricate municipal boundaries. PPL and UGI could confirm that water, wastewater, and other City facilities are classified as commercial; neither party could provide their exact methodology for selecting City parcels.

One opportunity for improvement in this data set would be the estimate of other primary site energy sources. For instance, some landowners receive direct deliveries of natural gas, coal, and fuel oil that are not provided through a grid system and were not included in the data that created this portion of the inventory. The details of these deliveries are also not public knowledge. Large local institutions such as Franklin & Marshall College and Lancaster General Hospital likely receive direct fuel deliveries, but those emissions are not reflected here. Obtaining that data would not only improve the accuracy of emissions reporting, but would also be an opportunity for partnership with the wider community of Lancaster.

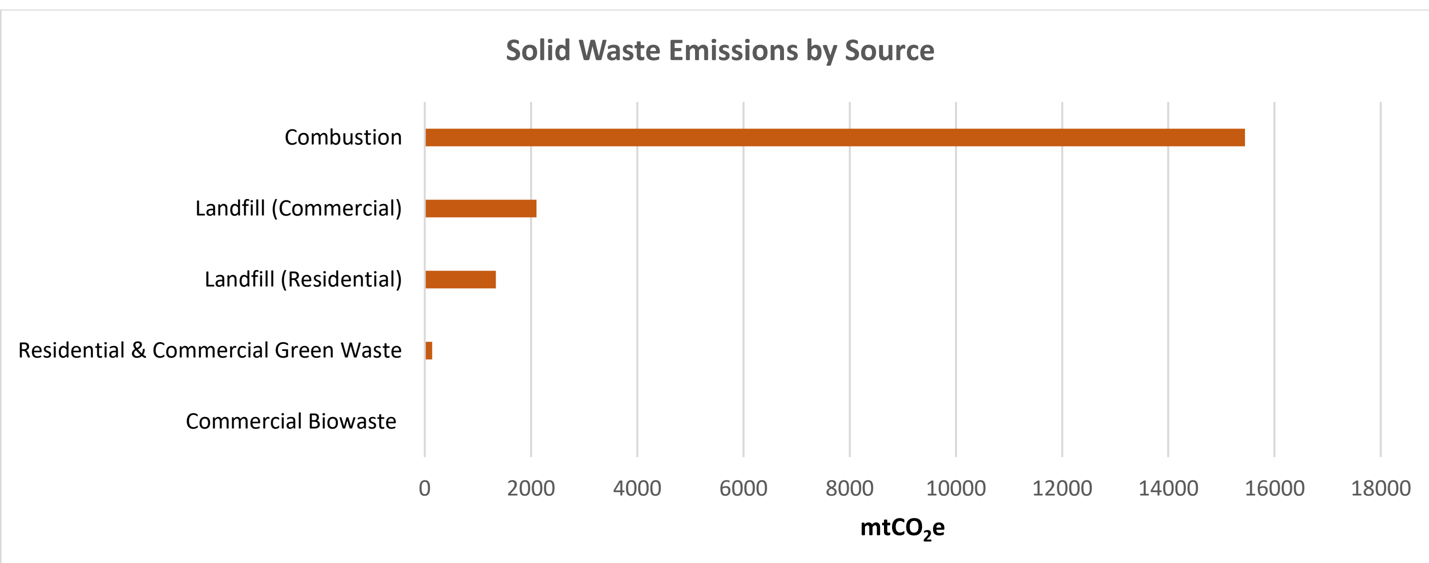
3.3 Solid Waste

The City and the Lancaster County Solid Waste Management Authority (LCSWMA) keep careful records of solid waste collection, which accounts for about 3% of the City's total emissions (Figure 6). Solid waste emissions were estimated using end-of-life emissions (i.e., projected future methane emissions) associated with disposal of waste generated by members of the community during the analysis year, regardless of disposal location or method.

All the City's residential solid waste that is picked up at the curb through the single hauler contract is sent to a waste-to-energy facility for combustion. It is operated by LCSWMA along the Conestoga and in 2015 it produced about 81% of solid waste emissions, or 15,444 tons mtCO_2e (Figure 6). Tipping stations around the County also receive construction debris directly from residents and commercial businesses, which is sent to the landfill; this category accounts for 15% of solid waste emissions. Transportation emissions for solid waste collection were omitted and are instead captured in the Transportation section. The proportions of solid waste emissions also parallel the proportions of tons of solid waste (i.e., 81% combusted = 81% of emissions).

Emissions from solid waste depend heavily on the composition of the waste, but there is not current data on the composition of waste in Lancaster County much less Lancaster City. The best available data was the PA Department of Environmental Protection's Statewide Waste Composition Study from 2003 by RW Beck, which broke the state into sections. Lancaster was included in the Southcentral section of PA (Adams, Bedford, Berks, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry, and York). While there are similarities, the waste categories between DEP and ICLEI's ClearPath tool didn't match exactly; the categories that did match were filled in (newspaper, office paper, corrugated cardboard, glossy paper, food waste, grass, leaves, branches, and lumber) and the percentage of total waste left over was assumed to be mixed solid waste (49%). That leaves a large mass of solid waste that is unspecified and that makes the emissions less precise.

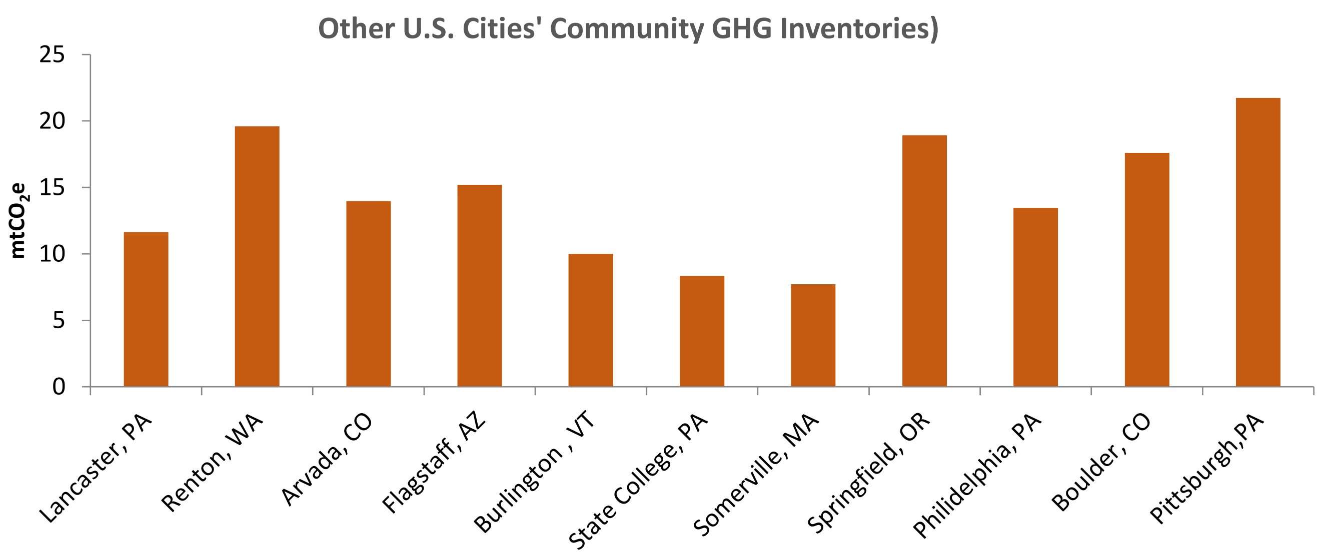
Figure 6. 2015 Solid Waste GHG Emissions for City of Lancaster.



3.4 Comparison to Other Cities

A comparison to other cities' greenhouse gas inventories provides some helpful context. Below the City of Lancaster is compared to other U.S. cities' estimated GHG emissions. Each of the cities' inventories differ slightly in methodology; nonetheless, it appears that the estimate for Lancaster City is on par with many other U.S. communities' CO_2 emissions estimates, which range between 8 and 22 in Figure 7. The ten cities that are included were chosen based on their similarity to the City of Lancaster due to size or location, but were also selected due to their availability because not every city has conducted their own emissions audit. Figure 7 also appears to approximately reflect the World Bank's per capita estimate for the U.S. of 16 metric tons per person, annually.

Figure 7. Community GHG Emissions per capita for Lancaster and other comparable cities (mtCO_2e/Capita) between 2000-2015.



MUNICIPAL OPERATIONS INVENTORY

The municipal operations inventory is a function of both the City's operations, urban form, and its customers' demands for services. For instance, vehicle fleet emissions are driven by operations, maintenance, and size whereas water and wastewater energy is largely driven by consumption. The largest source of emissions appears to be the Wastewater Treatment Facilities and Processes (Figure 8) accounting for about 12,427 mtCO_2e or 45% of the municipal emissions (Table 4); the clear majority of that is the Wastewater Treatment Plant electric, which produced 7,527 mtCO_2e in 2015. Wastewater and Water Treatment combined make up 82% of this municipal emissions inventory, while all other buildings contribute 10% followed by streetlights (4%), vehicle fleet (3%), parks (1%), and traffic signals (<1%).

Figure 8. Proportions of 2015 GHG emissions sources originating from City of Lancaster operations in mtCO_2e.

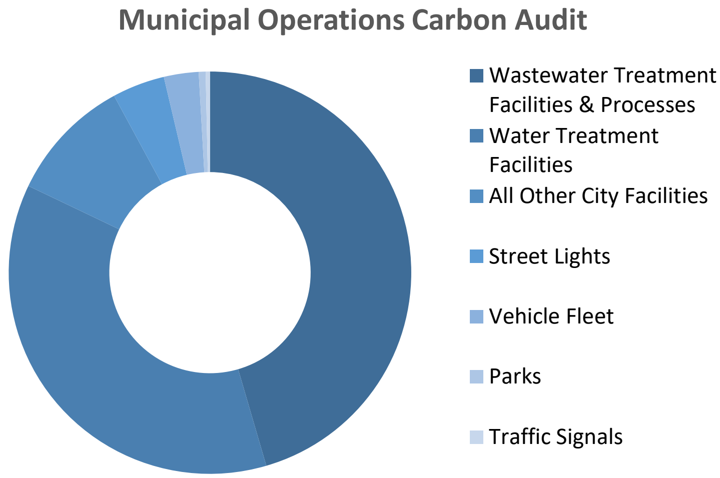


Table 4. 2015 GHG sources originating from City of Lancaster operations in mtCO_2e.

SECTOR	mtCO_2e	%
Wastewater Treatment Facilities & Processes	12,427	45
Water Treatment Facilities	10,004	37
All Other City Facilities	2,732	10
Street Lights	1,152	4
Vehicle Fleet	724	4
Parks	151	1
Traffic Signals	93	<1
TOTAL	**27,283**	**100**

4.1 Wastewater Treatment Facilities & Processes

The wastewater treatment system is unique to this inventory. Although it is a City-owned and operated system, it provides services to adjacent municipalities and therefore generates some emissions that are not a result of city residents. In fact, the main plant exists outside of the city boundary. The primary emissions source for wastewater is the electricity used to pump and treat waste. Electricity use makes up about 80% of all wastewater emissions and most of that 80% is attributed to the main plant's electricity use (Figure 9). Natural gas is used only for temperature control in the wastewater buildings where there is office space.

Nitrous oxide (N_2O) is also a potent greenhouse gas. The City wastewater engineers track the daily nitrogen load in the effluent discharged into the Conestoga River. A daily average of 1,850 kg N/day was used to generate the Process N_2O effluent emissions, which accounts for a small portion of emissions from wastewater operations.

Nitrous oxide (N_2O) may be generated during both nitrification and denitrification of the nitrogen present, usually in the form of urea, ammonia, and proteins. These are converted to nitrate via nitrification, an aerobic process converting ammonia-nitrogen into nitrate (NO_3-). Denitrification occurs under anoxic conditions (without free oxygen), and involves the biological conversion of nitrate into dinitrogen gas (N_2). Nitrous oxide (N_2O) can be an intermediate product of both processes, but is more often associated with denitrification. Commercial and industrial operations are often the largest contributors to this process.[viii] It is not clear to what degree they are contributing in Lancaster. ICLEI's ClearPath tool recommends a multiplier of 1.25 if the specific contribution from commercial and industrial operations is unknown, which was used in this inventory.

Table 5. 2015 GHG sources originating from City of Lancaster operations by scope in $mtCO_2e$.

MUNICIPAL OPERATIONS EMISSIONS BY SCOPE			
SCOPE	SOURCE	$mtCO_2e$	%
1	Transportation (Fleet)	724.13	2.7%
1	Other City Facilities - Natural Gas	936.62	3.4%
1	Wastewater Treatment Facilities - Natural Gas	573.54	2.1%
1	Propane - Buildings	2.44	0.0%
1	Fuel Oil #2 Buildings	27.23	0.1%
1	Water Treatment Facilities - natural gas	548.5	2.0%
1	Process N2O from Effluent	1580	5.8%
2	Other City Facilities - Electricity	1,795.53	6.6%
2	Traffic Signals	93.29	0.3%
2	Street Lights	1152.27	4.2%
2	Wastewater Treatment Facilities - Electricity	9,919.80	36.4%
2	Water Treatment Facilities - electricity	9,425.33	34.5%
2	Parks	151.51	0.6%
3	Nitrification/Denitrification	354	1.3%
		27,284	100%

Figure 9. 2015 GHG emissions from wastewater treatment facilities and processes.

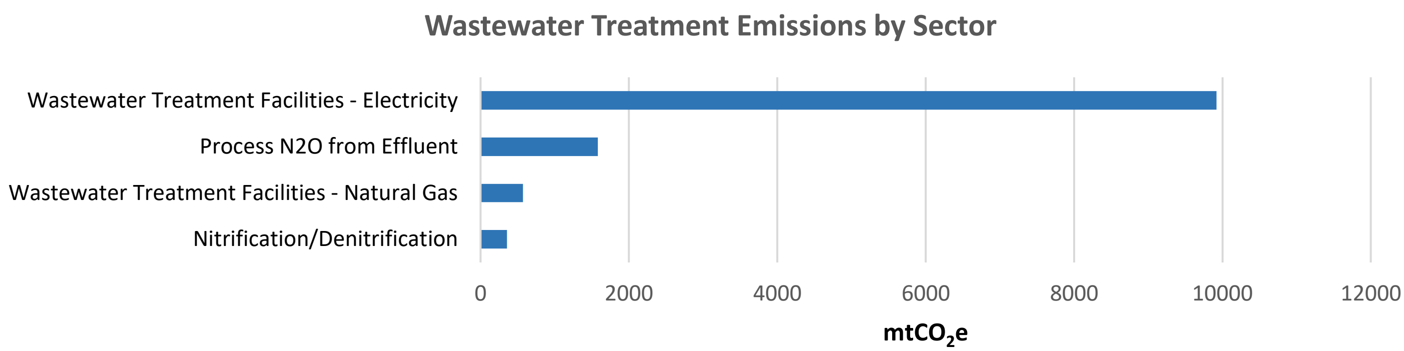
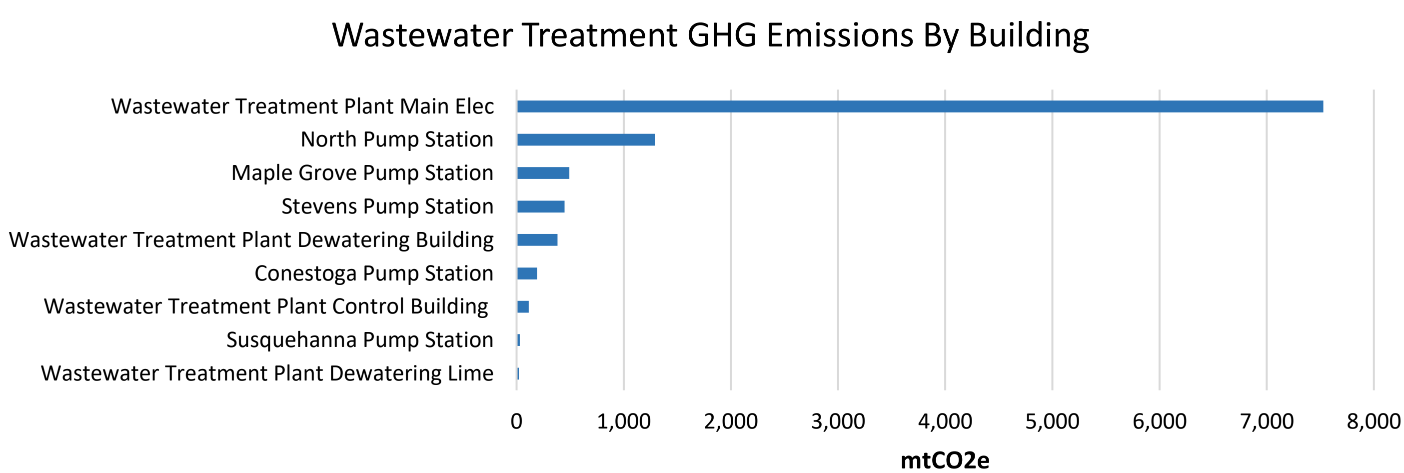


Figure 10. 2015 GHG emissions from wastewater treatment buildings.



4.2 Water Treatment Facilities

Like the City's wastewater system, the water treatment system extends beyond the City. The system services nearly 140,000 people, which is more than twice the population of the City. The largest treatment plant is in Columbia, PA along the Susquehanna River and the smaller treatment plant is on the Conestoga River in the City. Water Treatment primarily uses electricity for power and a relatively small amount of natural gas for temperature control (Figure 11). Of the 13 water treatment facilities, the Susquehanna Treatment Plant, its Pump, and the Conestoga Treatment Plant produce about 90% of the emissions. These three meters rank #2, #3, and #4 out of all energy accounts at the City (Figure 12). This is significant because water distribution is estimated to have large loss rate because of the historic infrastructure it runs through. Improving the efficiency of water transmissions and distribution lines could provide large emissions reductions and energy savings.

Figure 11. GHG emissions from water treatment facilities by source in 2015, including outlying pump stations.

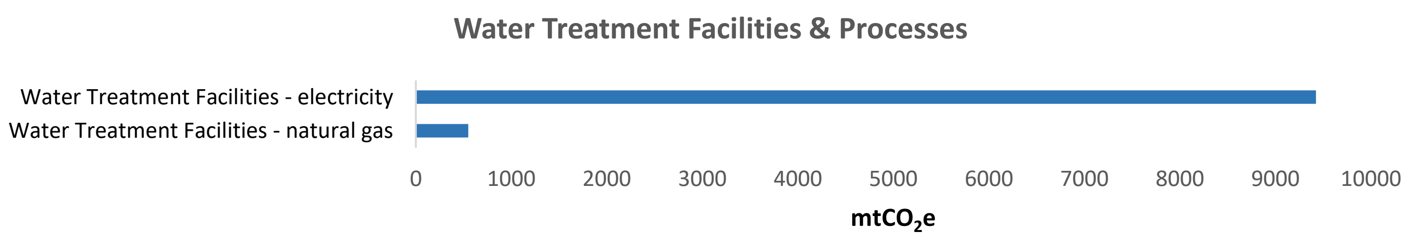
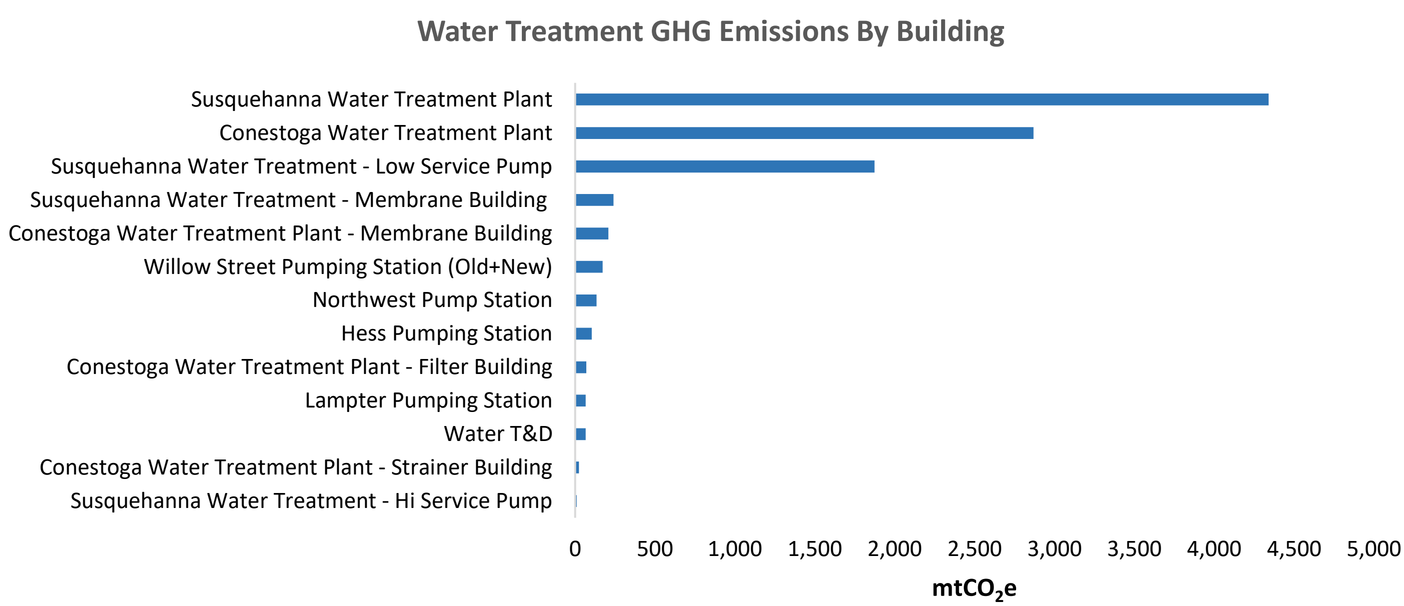


Figure 12. GHG emissions from water treatment buildings in 2015, including outlying pump stations.



4.3 All Other City Facilities

Due to the large energy use of the wastewater and water treatment facilities they have been separated into their own section. Nearly every other structure owned and operated by the City is included here. Starting in 2016, the City of Lancaster Department of Public Works began inventorying its buildings and benchmarking their energy performance beginning with data from 2014. This effort included nearly every structure for public safety, water, wastewater, parks, operations, streets and sign fabrication, and other administrative offices. The City Facilities Manager gathered energy bills for electric, natural gas, propane, and fuel oil, and input them into Facility Dude, a cloud-based energy management service. This effort doubled as a GHG inventory for the City buildings.

Emissions for City facilities are presented in three graphs below. Figure 13 displays the proportion of emissions from electricity use and natural gas use for these facilities. About two-thirds of emissions from these facilities comes from electricity and about one-third from natural gas. Natural gas use is higher in these facilities compared to water and wastewater because most of them are offices and require temperature control.

Figure 13. GHG emissions from water treatment buildings in 2015, including outlying pump stations.

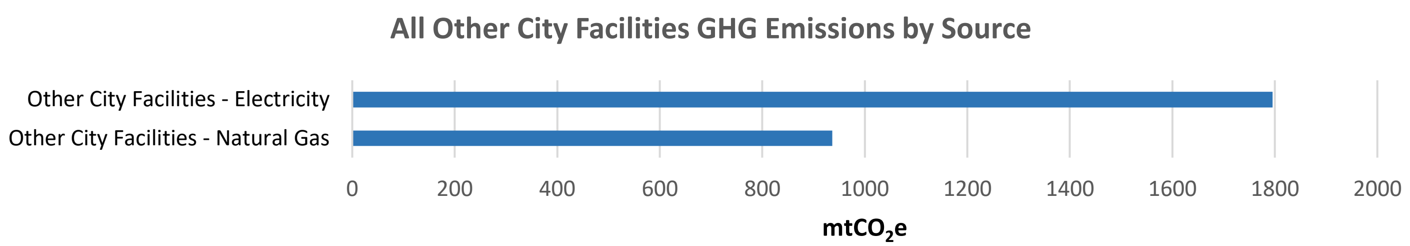
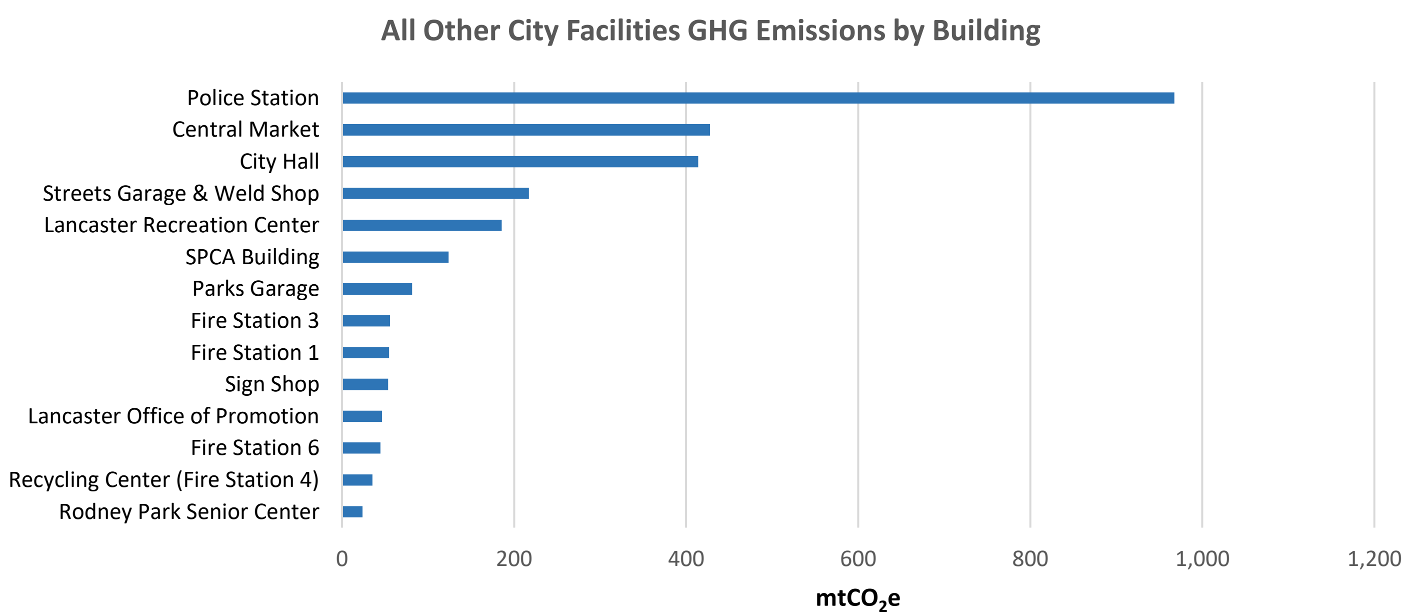


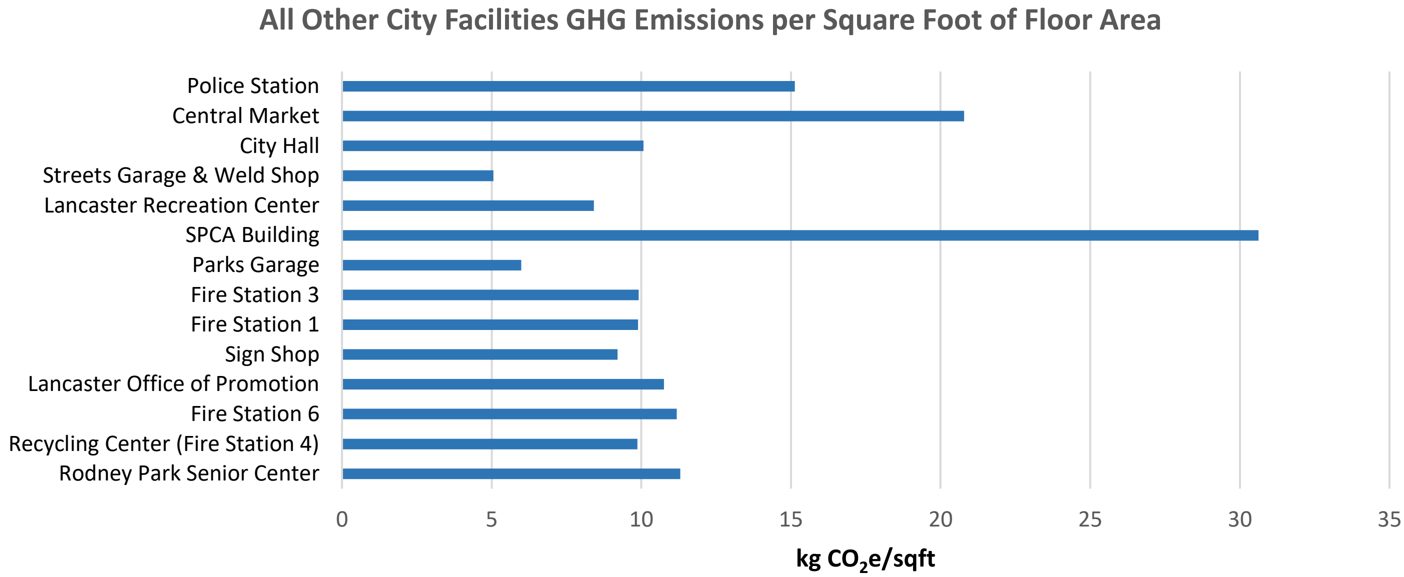
Figure 14 displays the total $mtCO_2e$ emissions for 2015 for each facility. The Police Station is the largest overall emitter, followed by Central Market and City Hall. These are among the largest facilities. On the contrary, the smallest buildings tend to be the smallest emitters.

Figure 14. 2015 GHG emissions from all other buildings (not water or wastewater related).



The final graph displays the $kgCO_2e$ per square foot (Figure 15). The CO_2 emissions unit was reduced from metric tons to kilograms so it could be legible on a square foot basis. This figure helps demonstrate the intensity of emissions for a building, which normalizes for the size of a building. In other words, emissions across different size buildings can be compared. The SPCA building is a small facility of only 4,047 sqft but its emissions are the highest per sqft because of the ventilation requirements necessary for indoor caged animals. The Central Market and Police Station are the next most intensive emitters of CO_2.

Figure 15. 2015 GHG emissions from water treatment buildings in 2015, including outlying pump stations.



4.4 Streetlights

Out of the 7 categories of emission sources documented in this inventory streetlights are the fourth largest source. At present, PPL Electric owns and operates about 3,450 streetlights and the City of Lancaster owns and operates about 100. PPL's lights are all high-pressure sodium halide and were responsible for producing 1,123 mtCO_2e in 2015. The City's lights are a mix of high-pressure sodium halide and LED and were responsible for producing 29 mtCO_2e, totaling 1,152 mtCO_2. In 2016 the Department of Public Works began the process of purchasing all of PPL's streetlights in the city, so it could more easily convert the lights to LEDs for energy efficiency and cost savings.

4.5 Vehicle Fleet

The City operates 235 vehicles that produced 762 metric tons of carbon in 2015, which is equivalent to the electricity use for about 100 homes in the US. This only accounts for 3% of the City's reported emissions in 2015. Vehicle maintenance, purchasing, and records are overseen by the Bureau of Operations and the Fire Department. The mpg and fuel type of each vehicle was considered in the emissions calculations. Fifteen vehicles were CNG, 44 vehicles were diesel, and the remaining 176 were standard gasoline. While the CNG vehicles can operate on either CNG or gasoline, we assumed in this inventory that they used exclusively CNG. Fuel records would need to be obtained for further insight into emissions avoided through CNG use.

This report uses 2016 vehicle data because 2015 vehicle data was not available at the time this report was compiled. Total annual miles driven by all City vehicles totaled 1,233,681 miles in 2016 (Table 5.) Gasoline vehicles were responsible for the most miles driven and the most mtCO_2e among the three fuel types (Figures 16 and 17). However, CNG vehicles had the highest average annual miles driven (Figure 18). Annual mileage ranged from 2 mi/year (Streets Peterbilt Dump Truck) to 26,077 mi/year (Police Chevrolet Tahoe). To lower vehicle emissions the CNG vehicles should be the ones driven the most, so this is welcomed news. CNG is a very low-carbon fuel and this is demonstrated in Figures 16 and 17; although CNG vehicles were responsible for 8% of the total annual mileage, their carbon emissions were less than 1%. On the other hand, diesel vehicles were 10% of annual miles driven, but responsible for 22% of fleet emissions. The top 10 most driven City vehicles were all gasoline powered, so replacement of these vehicles should be a priority for fleet emissions reductions.

Table 5. 2016 Total Tons GHG Emissions from City Vehicle Fleet by Grouping

Bureau/Grouping	Count	Total Annual Miles	Average Annual Miles	Fuel Units	$kgCO_2e$	$mtCO_2e$
Police	71	509506	7,229	30,927	261,145	261.15
Streets	34	127571	3,370	9,795	87,137	87.14
Parks	23	126476	5,859	9,630	82,284	82.28
Fire	17	50797	3,894	5,955	56,121	56.12
Water T&D	15	56586	2,813	4,330	41,324	41.32
Codes	14	52189	4,567	3,213	22,057	22.06
Wastewater Collections	14	66391	5,802	7,363	63,188	63.19
Wastewater Operations	10	47207	4,967	2,524	18,852	18.85
Meter Shop	10	53443	6,001	3,900	35,452	35.45
Conestoga Water Plant	9	63848	6,554	5,277	42,405	42.41
Solid Waste	8	25837	1,890	827	7,713	7.71
Susquehanna Water Plant	7	39396	4,605	3,571	36,067	36.07
Traffic	3	14434	6,620	1,699	8,736	8.74
TOTAL	**235**	**1,233,681**	**4,936**	**89,011**	**762,482**	**762**

Figure 16. 2016 City Vehicle Fleet Total Miles by Fuel Type

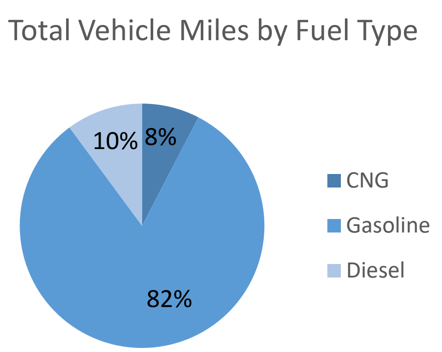


Figure 17. 2016 City Vehicle Fleet $mtCO_2$/year by Fuel Type

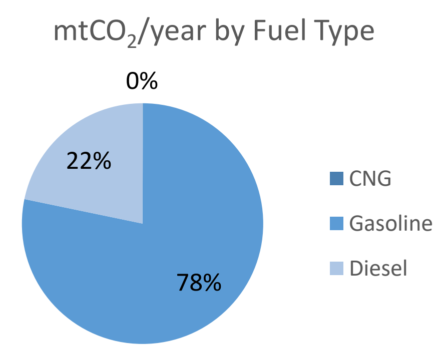
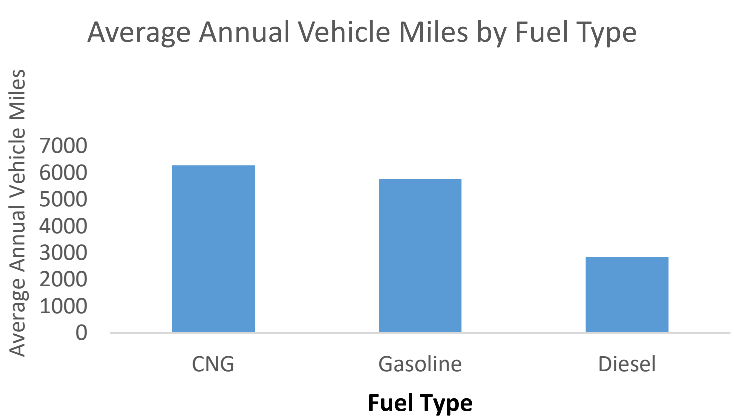


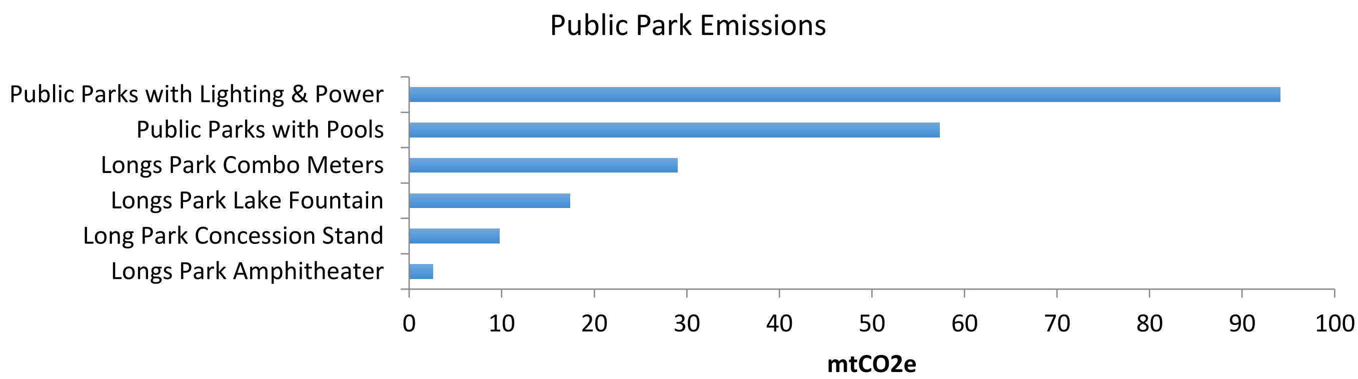
Figure 18. 2016 City Vehicle Fleet Total Miles by Fuel Type



4.6 Parks

The City owns and operates 30 public parks that are diverse in size and amenities. Some are pocket parks with no metered utilities, while others include pools, fountains, and lights. Although some of these parks include buildings, those emissions are reported in the All Other Facilities section and are not included here. This section includes emissions from electricity for lighting, pools, fountains, concession stands, outlets, an amphitheater, bathrooms, and a snowmelt system. It is the second smallest source of emissions from City operations. “Public Parks with Lighting & Power” includes a mix of 10 parks from across the City and “Public Park with Pool” include 7 parks with pools.

Figure 19. 2015 GHG Emissions from Public Park Amenities.



4.7 Traffic Signals

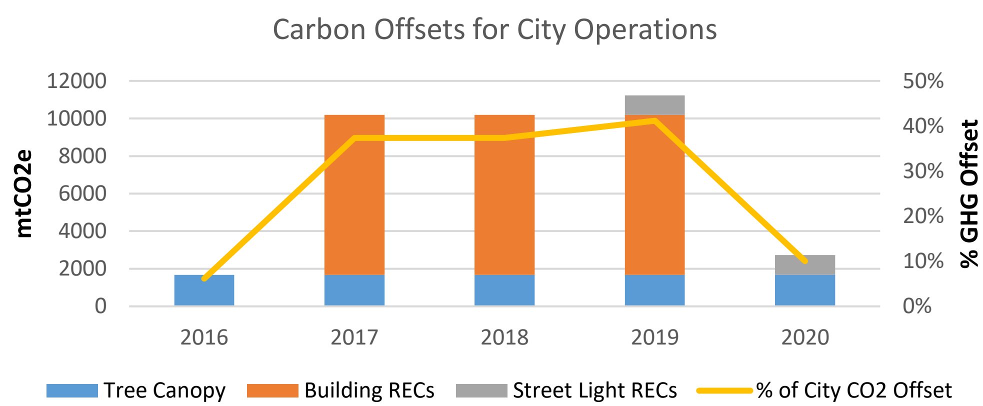
It is not known precisely how many traffic signals are in the City, but there are 120 accounts with PPL for traffic signals. Each of these accounts is an intersection, which could have anywhere between 4 to 8 traffic signals and up to 4 pedestrian signals. If there is an average of 6 lights at each intersection, then that is over 700 traffic signals. Collectively, these signals and pedestrian lights produced 93 $mtCO_2e$ in 2015, making it the smallest source of emissions from City operations.

CARBON OFF SETS

A carbon offset is a compensatory measure made by an individual or company for carbon emissions, usually through sponsoring activities or projects which increase carbon dioxide absorption or limit its release. Some examples of carbon offsets are tree planting, energy efficiency, methane collection/combustion, and carbon trading. Offsets can be a supplementary strategy to taking direct actions that reduce carbon emissions, such as reducing electricity use in one's own building.

Renewable Energy Credits (RECs) are a common strategy of offsetting carbon emissions. These credits represent renewable energy resources that are producing power. When they are certified, they can be sold or traded, and they represent electricity that is produced by a renewable source (e.g., solar, wind) and delivered to the commercial power grid.

Figure 19. GHG Emissions from Public Park Amenities in 2015.



5.1 City's Renewable Energy Credits

As of 2016, the City of Lancaster began purchasing Renewable Energy Credit's (RECs) through Constellation NewEnergy, Inc. Between 11/28/18 – 10/26/20 all streetlight accounts are offset 100%, adding up to 2,101 metric tons of $mtCO_2e$ over the course of three years, or 1,050 metric tons of $mtCO_2e$ per year. Also, between December 2016 – December 2019 all other City accounts are offset with 40% RECs, adding up to 25,520 $mtCO_2e$ over the course of three years, or 8,507 metric tons of $mtCO_2e$ per year. Although these RECs don't overlap entirely, they average out to an offset of 6,905 $mtCO_2e$ over 4 years, or approximately 25% of all City operations GHG emissions, assuming the City's emissions remain constant from 2015-2020. The methodology by which Constellation calculates these offsets is unknown. Although, on the certificate it states "Renewable Energy Certificate Purchases result in avoided CO_2 emissions due to a reduction in indirect emissions associated with displaced generation of grid electricity. The conversion of REC acquisition to CO_2 equivalents above is an estimate based on forecasted electricity usage of the accounts as well as US EPA eGRID NERC region non-base load output emissions rates as posted at the time of contracting. (eGRID2010 Version 1.0)."

5.2 City's Tree Canopy

The City of Lancaster has about 8,000 public trees inventoried, and about 7,000 are along streets and 1,000 are in parks. This inventory has been uploaded into the Pennsylvania Department of Conservation and Natural Resources' PA Tree Map, which calculates the eco-benefits of these trees, including carbon sequestration. This tool estimates that the City's public trees remove 3,695,154 lbs CO_2/year, or 1,676 $mtCO_2$, adding up to about 6% of the City's 2015 GHG emissions. Combined with the City's RECs the City could be offsetting about 31% of its annual GHG emissions if the 2015 emissions remain constant moving forward. If the City reduces its GHG emissions, then these offsets become even great proportionally.

NEXT STEPS

The results above are a starting point that provide the City of Lancaster a benchmark to assess progress at the community and City operations level. While GHG emissions can feel quite abstract in nature, they are derived from real world actions by residents, businesses, and City operations that can be changed. For example, the trash that was collected from the curb, the gallons of shower water used, the lights left on, and the energy it takes to pump clean and dirty water is reflected in the data provided here. In part, these actions are also a reflection of the City codes, infrastructure, and community outreach on sustainability.

There are also numerous opportunities to improve the City's GHG emissions tracking and reporting, many of which are mentioned throughout this document. These improvements could include:

- Completing historic GHG inventories for the years 1990 and 2000, so progress can be evaluated
- Transportation emissions modeling for the City rather than apportioning from County data
- Clarifying methods used by UGI and PPL to aggregate City data
- Adding primary site fuel sources like coal, delivered natural gas, and fuel oil, especially for institutions
- Researching fuel records to determine how often CNG is used in hybrid vehicles
- Surveying City employees on how they commute to work
- Update vehicle fleet emissions in this report from 2016 to 2015 data

As Figure 1 illustrates, GHG inventorying is the first step in Climate Action Planning. Aside from improving this inventory, the next step is to set a realistic target for reduction over some period. Many countries and cities are setting goals for carbon neutrality, which means the measured amount of carbon released is offset by an equivalent amount sequestered or offset, or buying enough carbon credits to make up the difference. The Carbon Neutral Cities Alliance, which includes NYC and Washington DC, consists of 17 cities that have committed to reducing their GHG emissions by 80% by 2050. A goal such as this could be set through a planning process or beforehand, but a Climate Action Plan is an essential step to address the City of Lancaster's GHG contributions and resilience to changing climate. These planning efforts are far reaching and touch nearly every sector of society and certainly all divisions of the City government. Climate action strategies could include bicycling infrastructure, energy efficiency programs, renewable energy generation, land use policies, water conservation, and green infrastructure, among many others. A task this large requires a comprehensive and fully-integrated approach that starts with the City Administration and is incorporated into the goals and daily operations of each Bureau under the direction of Department leadership.

Although the goals are large the need is even greater. In 2017 the world has seen the most powerful hurricanes, the most widespread fires, and the hottest temperatures. The future depends on small cities marking a big difference by developing a new paradigm of delivering services that enhances our environmental resources rather than destroys them. This is an obligation to the City residents now and all those to come.

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