

# CITY OF COLUMBUS GREENHOUSE GAS INVENTORY 2018

Brooke White, Ph.D.  
*Senior Air Quality Specialist*

Jon-Paul d'Aversa, AICP  
*Senior Energy Planner*



MID-OHIO REGIONAL  
**MORPC**  
PLANNING COMMISSION

Prepared for:  
City of Columbus, Office of Sustainability

Prepared by:  
Brooke White, Ph.D.  
Senior Air Quality Specialist  
Department of Planning and Sustainability, Mid-Ohio Regional Planning Commission  
[bwhite@morpc.org](mailto:bwhite@morpc.org)

-and-

Jon-Paul d'Aversa, AICP  
Senior Energy Planner  
Department of Planning and Sustainability, Mid-Ohio Regional Planning Commission  
[jpdaversa@morpc.org](mailto:jpdaversa@morpc.org)

#### TITLE VI NON-DISCRIMINATION CLAUSE

MORPC does not discriminate on the basis of age, race, color, national origin, gender, sexual orientation, familial status, ancestry, military status, religion or disability in programs, services or in employment. Information on non-discrimination and related MORPC policies and procedures is available at [www.morpc.org](http://www.morpc.org) under About MORPC/Policies.

#### FUNDING

Funding for the analysis and development of this report was provided by the City of Columbus.

# Contents

Introduction .....	3
Greenhouse Gas Inventory Tool .....	3
Changes in Model or Methodology .....	3
Greenhouse Gases .....	4
Sectors Included .....	4
2018 Government Operations Emissions.....	5
Sector relative emissions contributions .....	7
Sector emissions contributions between 2005 and 2018 .....	8
2018 Community-Wide Emissions .....	14
Sector relative emissions contributions .....	16
Sector emissions contributions between 2013 and 2018 .....	17
Appendix A.....	25
Inputs .....	25
Energy Consumption and Waste Values .....	25
Emission Rates from eGRID.....	27
Appendix B.....	28
Global Warming Potential Update.....	28
Background.....	28
Impact of GWP Value on Inventory Results .....	29

# Tables

Table 1. Sectors – Government Operations Inventory.....	4
Table 2. Sectors – Community Wide Inventory.....	5
Table 3. Government Operations Annual Emissions by Sector.....	6
Table 4. Government Operations – Annual Emissions per Capita .....	7
Table 5. Government Operations – Percent Change in Emissions from 2005 .....	8
Table 6. Community-Wide – Total Emissions by Sector – 2013-2018.....	15
Table 7. Community-Wide – Emissions per capita – 2013-2018.....	16
Table 8. Community-Wide – Percent Change in 2018 Emissions from 2013 .....	18





# Figures

- Figure 1. Government Operations – Total Emissions – 2018 ..... 6
- Figure 2. Government Operations – Emissions per Capita – 2018 ..... 7
- Figure 3. Government Operations – Sector Percentage of Total Annual Emissions – 2018 ..... 8
- Figure 4. Government Operations – Annual Sector Contributions – 2013-2018 ..... 9
- Figure 5. Government Operations – Annual Water and Wastewater Treatment Facilities Contributions – 2013-2018 ..... 10
- Figure 6. Government Operations – Annual Solid Waste Facilities Contributions – 2013-2018..... 10
- Figure 7. Government Operations – Annual Fleet Vehicle Contributions – 2013-2018 ..... 11
- Figure 8. Government Operations – Annual Street Light and Traffic Signs Contributions – 2013-2018 ..... 11
- Figure 9. Government Operations – Annual Building and Facilities Contributions – 2013-2018..... 12
- Figure 10. Government Operations – Percentage of Total Emissions by Sector – 2013-2018 ..... 13
- Figure 11. City Comparison of Total Community Emissions – 2017 ..... 14
- Figure 12. Community-Wide – Total Emissions – 2013-2018 ..... 15
- Figure 13. Community-Wide – Emissions per capita – 2013-2018 ..... 16
- Figure 14. Community-Wide – Sector Percentage of Total Emissions - 2018 ..... 17
- Figure 15. Community-Wide – Annual Sector Emission Contributions – 2013-2018 ..... 19
- Figure 16. Community-Wide – Annual Waste and Wastewater Sector Contributions – 2013-2018..... 20
- Figure 17. Community-Wide – Annual Fugitive Emission Contributions – 2013-2018 ..... 20
- Figure 18. Community-Wide – Annual Solid Waste Sector Contributions – 2013-2018 ..... 21
- Figure 19. Community-Wide – Annual Transportation Sector Contributions – 2013-2018 ..... 21
- Figure 20. Community-Wide – Annual Industrial Sector Contributions – 2013-2018..... 22
- Figure 21. Community-Wide – Annual Commercial Sector Contributions – 2013-2018 ..... 22
- Figure 22. Community-Wide – Annual Residential Sector Contributions – 2013-2018..... 23
- Figure 23. Community-Wide – Percentage of Total Emissions by Sector – 2013-2018..... 24



# 2018 CITY OF COLUMBUS GREENHOUSE GAS INVENTORY

## Introduction

The City of Columbus recognizes the impact of climate change on the economic well-being of the region and quality of life for residents. As a member of the Global Covenant of Mayors, the City of Columbus is actively engaged in mitigating and adapting to the effects of climate change. Per the requirements of the Global Covenant of Mayors, Columbus has committed to inventorying its annual greenhouse gas (GHG) emissions, setting targets for future year emissions, and creating a climate action and adaptation plan. The City of Columbus asked the Mid-Ohio Regional Planning Commission (MORPC), whose staff has extensive experience in the energy sector and developing GHG inventories, to complete the 2018 city operations and community wide GHG inventory.

## Greenhouse Gas Inventory Tool

The 2018 GHG inventory was conducted using the ICLEI-USA ClearPath<sup>1</sup> tool. ClearPath includes separate tracks for government operations and community-wide GHG inventories. Results from each track are presented in following sections. ClearPath includes tracks to inventory both local government operations and community-wide GHG emissions. The tracks are consistent with widely accepted, U.S.-based protocols, the Local Government Operations Protocol and the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions.

ICLEI-USA's ClearPath tool is provided as a recommended resource for all members of the Global Covenant of Mayors. It includes inventory, forecast, planning and monitoring modules.

The ClearPath tool relies on user-defined factor sets to analyze emissions that occur within a specific geography. In some instances, national averages are used when more locally-specific data are not available. Of particular note, the emissions resulting from the electricity grid rely on a factor set provided by the US Environmental Protection Agency (US EPA). The Emissions & Generation Resource Integrated Database (eGRID) provides sub-region emission factors for even years, on a two-year lag cycle (for example, emission rates for 2016 were provided in 2018). For odd years, the previous year's emission rates will be used as a place holder, as will be the case for even years if the GHG Inventory is produced prior to the release of updated data. If data provided in previous inventories are updated, the notation will appear below. For the Columbus GHG Inventory, the emissions factor set for Reliability First Corporation West (the sub-region that includes Columbus) is used to analyze emissions. More information on eGRID can be found on the US EPA's website.<sup>2</sup>

## Changes in Model or Methodology

Significant changes to the model or methodology are noted below:

- The Intergovernmental Panel on Climate Change (IPCC) updates the global warming potential (GWP) values for the greenhouse gases methane and nitrous oxide in each of their annual assessment reports based on current scientific knowledge. The 2005 Government Operations Inventory uses the IPCC Second Assessment Report GWP values. The 2013 to 2017 GHG Inventories use the IPCC Fourth Assessment Report GWP values. The 2018 GHG Inventory uses the IPCC Fifth Assessment Report

---

<sup>1</sup> <http://icleiusa.org/clearpath/>

<sup>2</sup> <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid>. (Accessed July 16, 2019)

GWP values for methane and nitrous oxide to align with current scientific knowledge. See the Appendix for details.

- The 2018 freight-rail fuel use calculation includes Rail Classes I, II, and III instead of only Rail Class I. Also, the scaling of national fuel use values is now based on total miles of rail within Columbus city boundaries instead of using population.
- As city boundaries and utility territories rarely line up, occasionally a query validation is run to ensure the analysis includes the appropriate utility accounts. A query validation affected values for residential, commercial and industrial energy use in the 2018 GHG Community Inventory. Whereas the total number of accounts did not vary significantly, the energy consumption within these accounts did. Attribution as to whether the consumption changes are due to efficiency improvements, behavioral changes, rate assignment changes, or other account differences will require further analysis.

## Greenhouse Gases

The following greenhouse gases are included in City of Columbus inventories:

- Carbon Dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous Oxide (N<sub>2</sub>O)

These three gases are used to calculate a total carbon dioxide equivalent (CO<sub>2</sub>e) value for City of Columbus emissions. In order to do so, ClearPath uses GWP values for both methane and nitrous oxide. The GWP allows for the non-CO<sub>2</sub> gases to be presented in common terms that indicate the relative strength of their greenhouse effect in the atmosphere. ClearPath utilizes GWP values presented in Assessment Reports from the IPCC. The GWPs are updated in each new Assessment Report from the IPCC. GWP values from the Second Assessment Report were used for the 2005 government operations inventory. Both government and community inventories from 2013-2017 used GWPs from the 4<sup>th</sup> Assessment Report. Updated GWP values available in the Fifth Assessment Report are used for the 2018 GHG Inventory. An analysis of the impact of using the Fifth instead of Fourth Assessment Report values is presented in the Appendix.

## Sectors Included

The following sectors are included in the 2018 GHG inventories:

TABLE 1. SECTORS – GOVERNMENT OPERATIONS INVENTORY

Sectors – Government Operations Inventory
Buildings and Facilities – Electricity Use
Buildings and Facilities – Natural Gas Use
Street Lights and Traffic Signals – Electricity Use
Vehicle Fleet – On Road Fuel Use
Vehicle Fleet – Off Road Fuel Use
Solid Waste Facilities – Refuse Collection
Water and Wastewater Treatment Facilities – Electricity Use
Water and Wastewater Treatment Facilities – Natural Gas Use
Water and Wastewater Treatment Facilities – Combustion of Digester Gas
Water and Wastewater Treatment Facilities – Flaring of Digester Gas

TABLE 2. SECTORS – COMMUNITY WIDE INVENTORY

Sectors – Community Wide Inventory
Residential Energy – Electricity Use
Residential Energy – Natural Gas Use
Commercial and Industrial Energy – Electricity Use
Commercial and Industrial Energy – Natural Gas Use
Transportation – On Road Fuel Use
Transportation – Off Road Fuel Use
Transportation – Public Transit Fuel Use
Transportation – Aviation Fuel Use
Transportation – Rail Fuel Use
Water and Wastewater Treatment Facilities – Electricity Use
Water and Wastewater Treatment Facilities – Natural Gas Use
Water and Wastewater Treatment Facilities – Combustion of Digester Gas
Water and Wastewater Treatment Facilities – Flaring of Digester Gas
Municipal Solid Waste
Biological Treatment of Biosolids
Biological Treatment of Yard Waste and Woody Material
Fugitive Emissions from Natural Gas Distribution

## 2018 Government Operations Emissions

Government operations contributed 348,730 metric tons of CO<sub>2</sub>e in 2018. This represents a 5% increase from 2017. Whereas population increased 2% during the same time period, it was not enough growth to be the sole explanation for an increase in emissions. When considering the total emissions from government operations since 2013, the year in which annual inventories began, the negative trend (decreasing emissions) that had been seen since 2014 has begun to level-off in the 2018 Inventory.

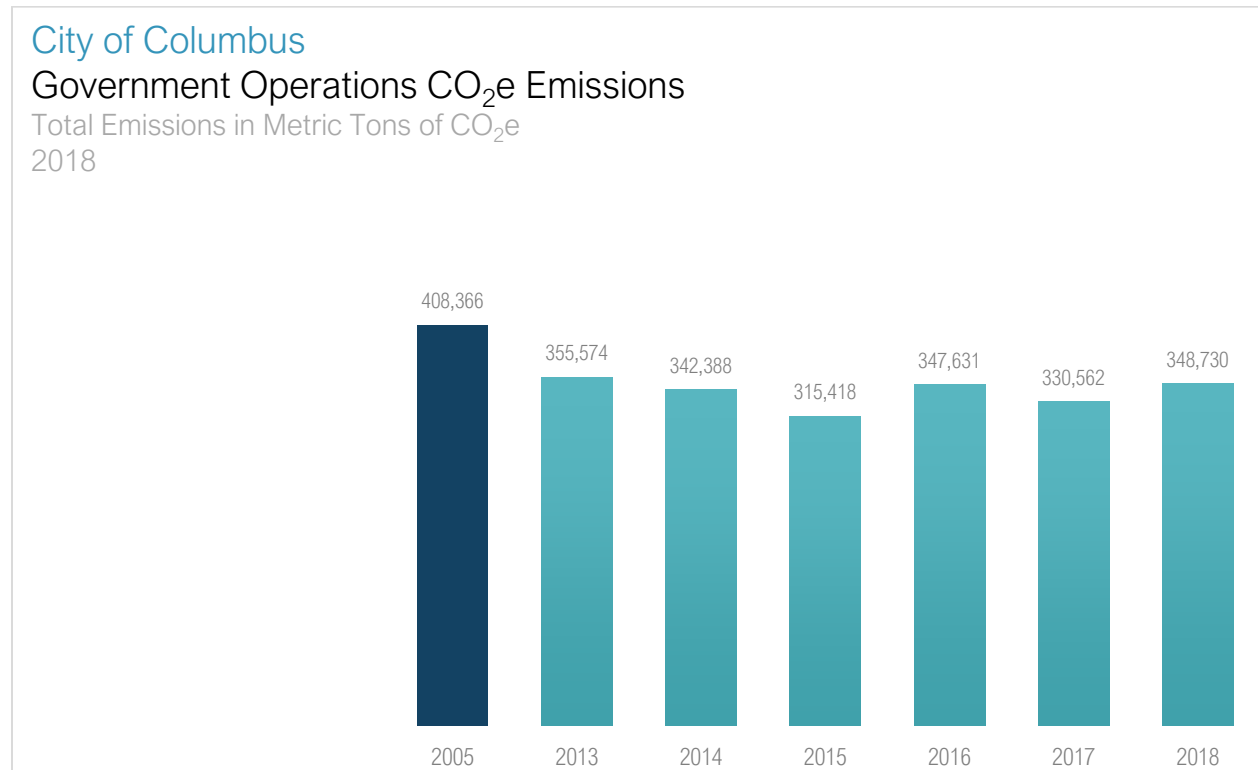
Green Memo III<sup>3</sup> utilizes 2005 as a benchmark for city initiatives impacting city operations.<sup>4</sup> Compared to 2005, emissions have decreased 15%. On a per capita basis, which would offer a leveled view of the City's efficiency in providing services, government operations create 0.40 metric tons of CO<sub>2</sub>e per person in 2018, a 28% decrease per capita from 2005.

<sup>3</sup> <https://www.columbus.gov/Templates/Detail.aspx?id=2147506164>. (Accessed July 16, 2019)

<sup>4</sup> It is important to note that values presented in Green Memo III may differ from those presented in this report. This is primarily due to sector attribution, which may vary when goals and programs are being developed in order to align initiatives, funding sources, etc. This report keeps attribution of emissions within sectors as analyzed, and as is consistent with CDP reporting.



FIGURE 1. GOVERNMENT OPERATIONS – TOTAL EMISSIONS – 2018

TABLE 3. GOVERNMENT OPERATIONS ANNUAL EMISSIONS BY SECTOR<sup>5</sup>

Government Operations Annual Emissions (Metric tons CO <sub>2</sub> e)	2005	2013	2014	2015	2016	2017	2018
Buildings & Facilities	87,931	76,431	87,309	79,818	88,451	81,284	86,011
Street Lights & Traffic Signals	29,134	26,749	32,442	31,788	30,471	21,616	25,265
Vehicle Fleet	33,965	30,281	29,459	26,184	23,587	22,564	23,473
Solid Waste Facilities	97,245	97,218	98,597	102,290	108,272	110,308	111,721
Water & Wastewater Treatment Facilities	160,091	124,895	94,582	75,337	96,851	94,790	102,259
<b>Total Emissions</b>	<b>408,366</b>	<b>355,574</b>	<b>342,388</b>	<b>315,418</b>	<b>347,631</b>	<b>330,562</b>	<b>348,730</b>

<sup>5</sup> Totals may differ due to rounding.

FIGURE 2. GOVERNMENT OPERATIONS – EMISSIONS PER CAPITA – 2018

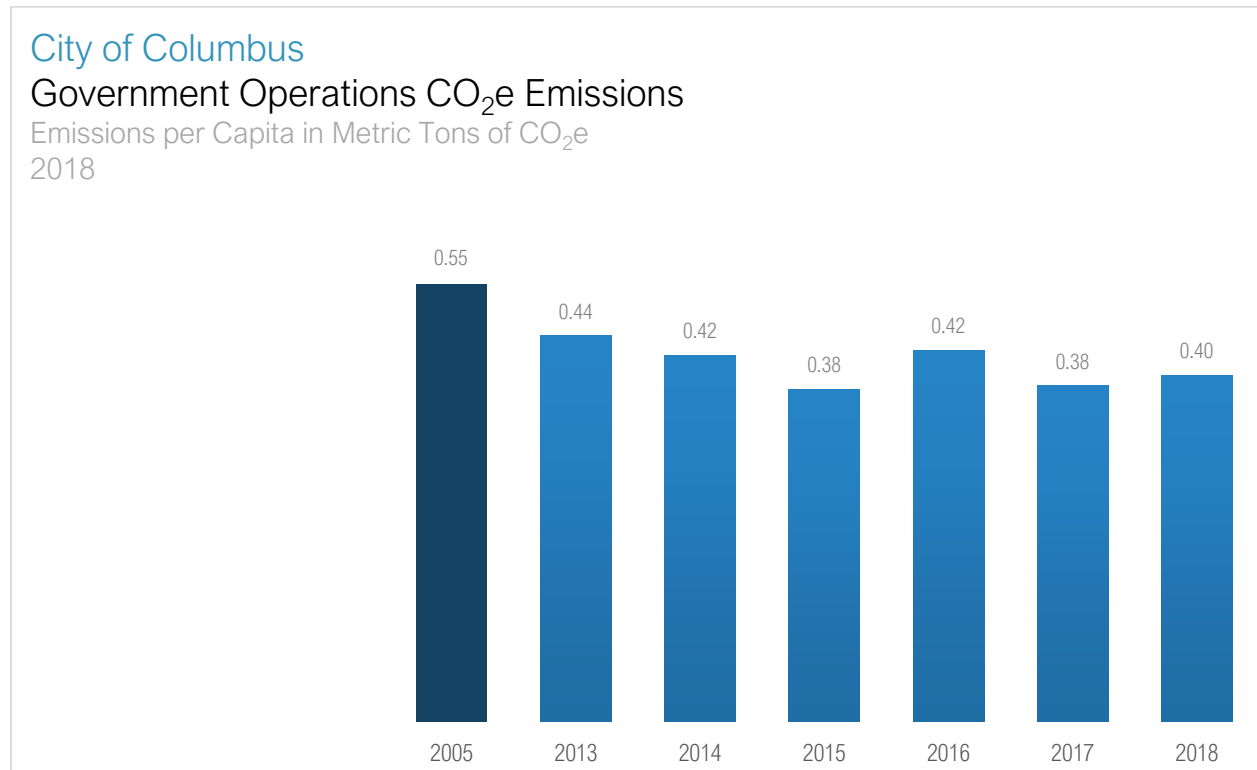


TABLE 4. GOVERNMENT OPERATIONS – ANNUAL EMISSIONS PER CAPITA

Government Operations Emissions	2005	2013	2014	2015	2016	2017	2018
Population	743,511	805,348	817,383	829,690	818,912	861,141	880,828
Buildings & Facilities	0.12	0.09	0.11	0.10	0.11	0.09	0.10
Street Lights & Traffic Signals	0.04	0.03	0.04	0.04	0.04	0.03	0.03
Vehicle Fleet	0.05	0.04	0.04	0.03	0.03	0.03	0.03
Solid Waste Facilities	0.13	0.12	0.12	0.12	0.13	0.13	0.13
Water & Wastewater Treatment Facilities <sup>6</sup>	0.22	0.16	0.12	0.09	0.12	0.11	0.12
<b>Emissions per capita (Metric tons CO<sub>2</sub>e)</b>	<b>0.55</b>	<b>0.44</b>	<b>0.42</b>	<b>0.38</b>	<b>0.42</b>	<b>0.38</b>	<b>0.40</b>

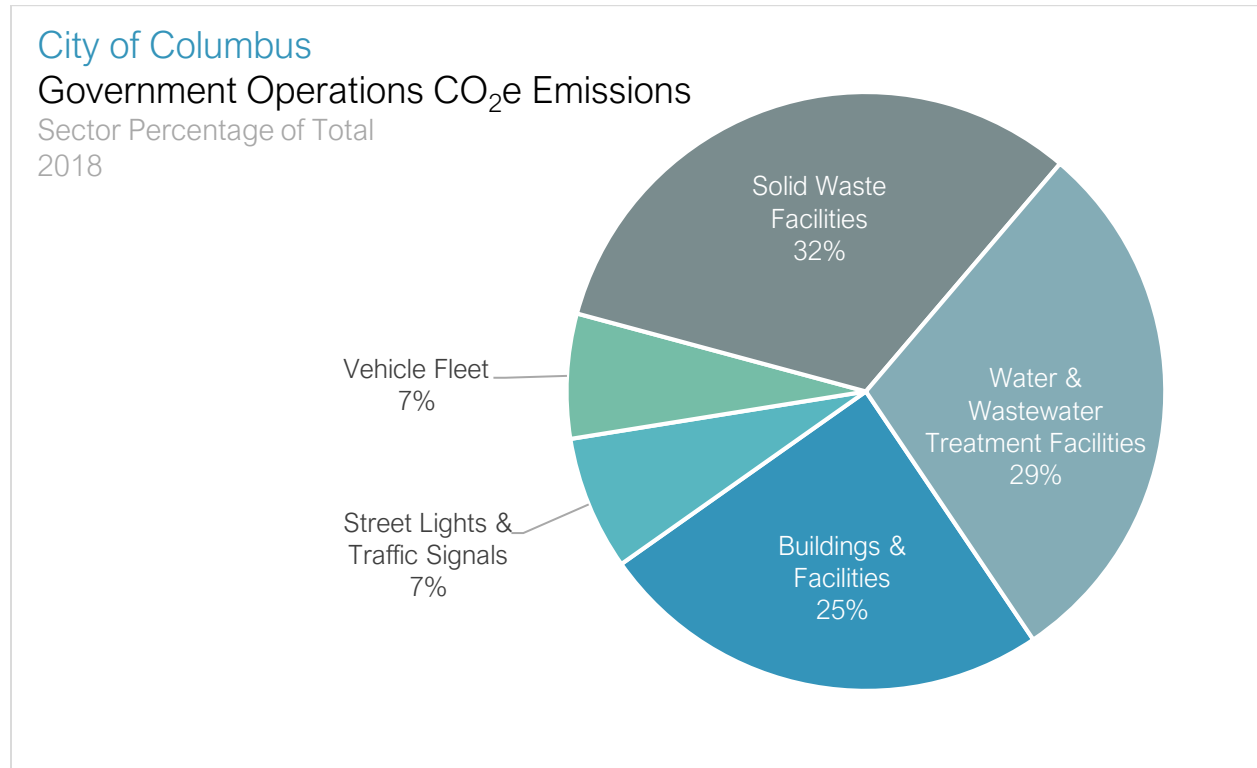
## Sector relative emissions contributions

Emissions are relative to the fuel being consumed directly, the primary fuel mix of the electricity consumed, and the processes that occur during operations. Providing for the water and waste needs of a city are often the greatest contributors to emissions when looking at government operations alone. Both services have higher energy use intensities in their operations, and each produces emissions as a byproduct of their processes. In 2018, solid waste facilities and water service facilities accounted for 61% of emissions from government operations (32% and 29%, respectively). Despite a lower energy use intensity and minimal, if any, emission

<sup>6</sup> It should be noted that the City of Columbus provides water and wastewater service to multiple municipalities. The emissions per capita value provided in Table 4 is calculated using the population of Columbus only, rather than the population served by all water and wastewater activities. This would be similar to a business that has customers outside of the City of Columbus. Although the end-use may occur outside of the City, the emissions associated with the activity would be registered at the location of the business. For assessing the emissions efficiency of water and wastewater services, one would calculate a per capita value based on total population served (the population of Columbus plus the population of the additional municipalities served by water and wastewater activities).

byproducts of operations, city-owned buildings and facilities are still responsible for a large portion of emissions from city government operations (25%). As City of Columbus Fleets are primarily reliant on gasoline and diesel as fuel sources, fleet vehicles accounted for 7% of emissions from government operations. Streetlights and traffic signals accounted for the remaining 7% of total City government operation emissions.

FIGURE 3. GOVERNMENT OPERATIONS – SECTOR PERCENTAGE OF TOTAL ANNUAL EMISSIONS – 2018



## Sector emissions contributions between 2005 and 2018

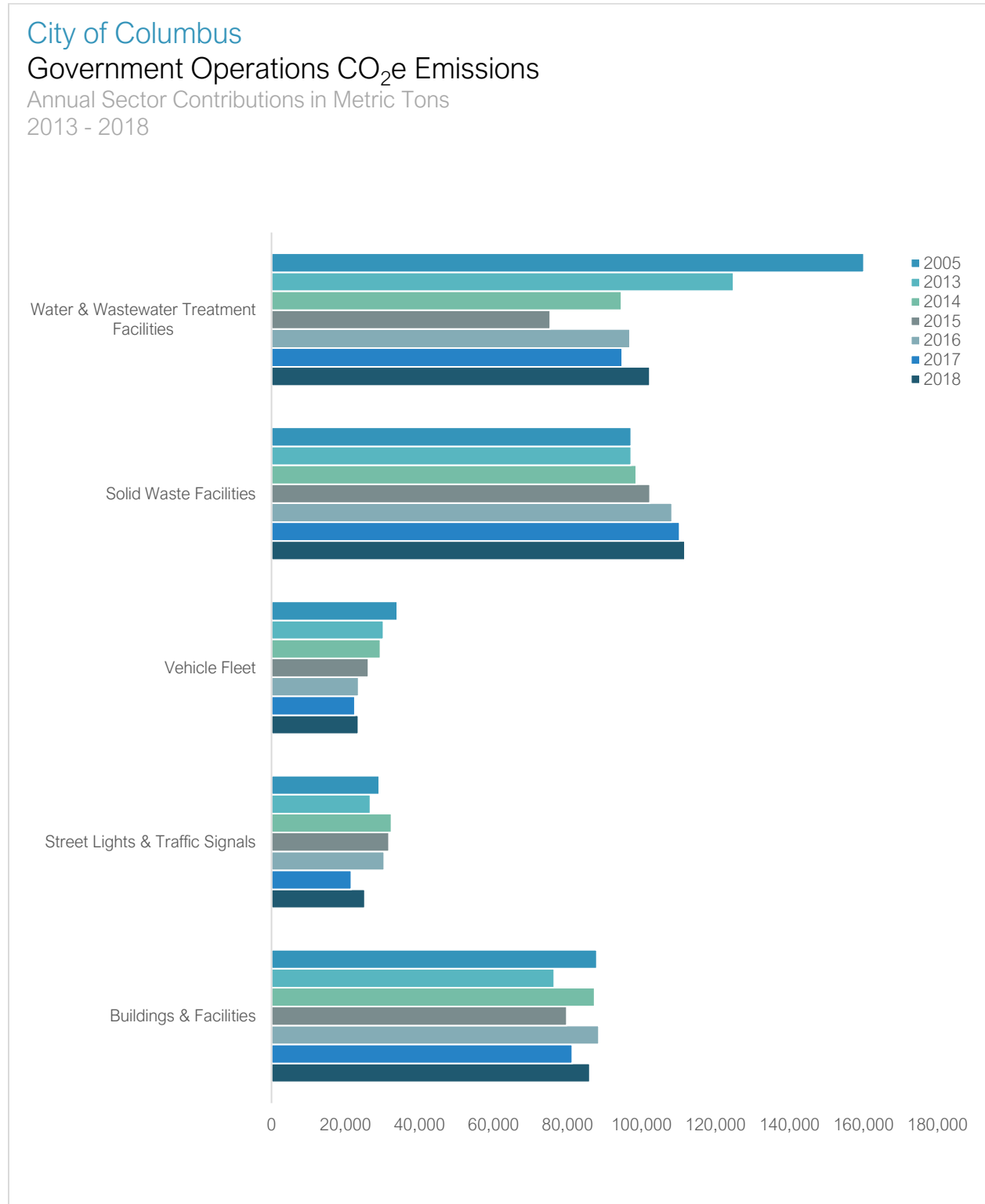
Although emissions increased between 2017 and 2018, it should be noted that nearly all sectors analyzed are currently producing fewer emissions in 2018 than they were in 2005. Only solid waste facilities produce more CO<sub>2</sub>e emissions in 2018 than in 2005, most of which can be accounted for in population growth and methodology changes that weighs methane heavier than in 2005.

TABLE 5. GOVERNMENT OPERATIONS – PERCENT CHANGE IN EMISSIONS FROM 2005

Government Operations Emissions	Percent Change in 2018 from 2005
Buildings & Facilities	-2.2%
Street Lights & Traffic Signals	-13.3%
Vehicle Fleet	-30.9%
Solid Waste Facilities	14.9%
Water & Wastewater Treatment Facilities	-36.1%
<b>Total Emissions</b>	<b>-14.6%</b>

Annual emissions data for each sector are provided below with a three year moving average trend line for individual sectors.

FIGURE 4. GOVERNMENT OPERATIONS – ANNUAL SECTOR CONTRIBUTIONS – 2013-2018<sup>7</sup>



<sup>7</sup> Emissions from energy use at Waste and Wastewater Treatment Facilities is included in Buildings and Facilities in 2016. This methodology was corrected beginning in the 2017 City of Columbus Greenhouse Gas Inventory.

FIGURE 5. GOVERNMENT OPERATIONS – ANNUAL WATER AND WASTEWATER TREATMENT FACILITIES CONTRIBUTIONS – 2013-2018

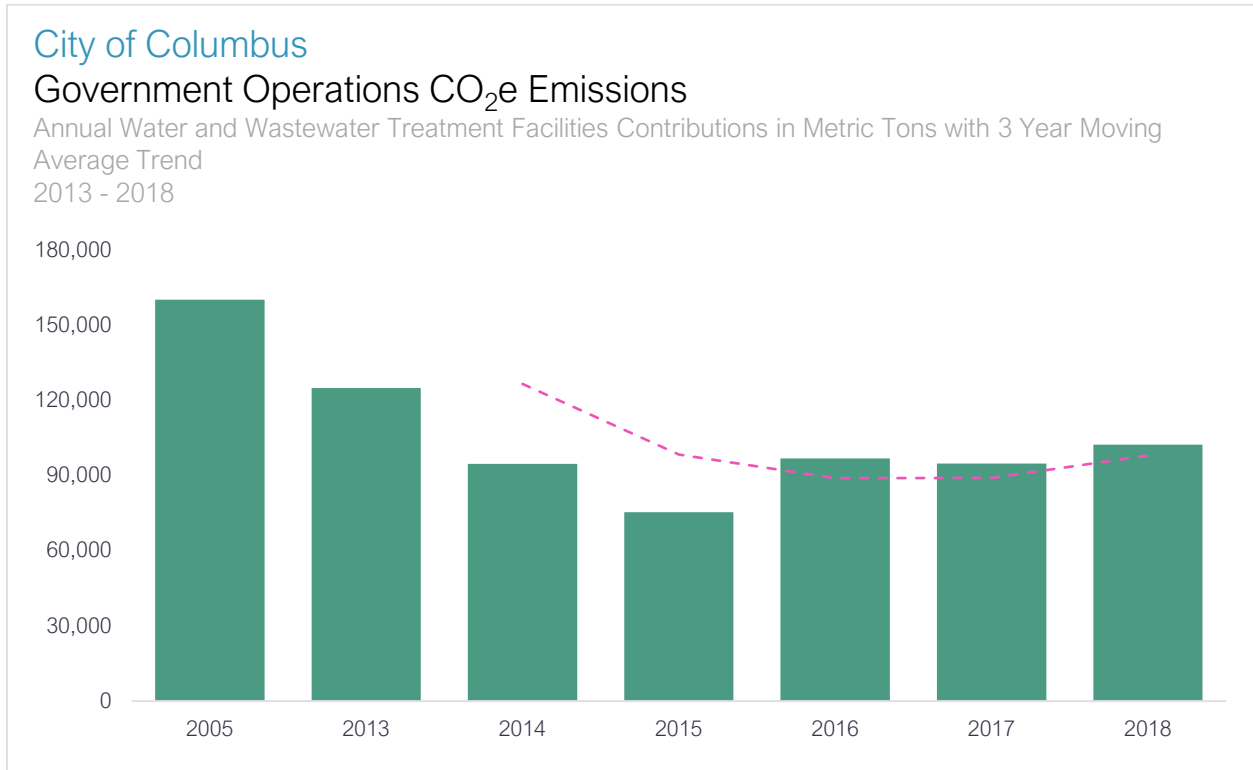


FIGURE 6. GOVERNMENT OPERATIONS – ANNUAL SOLID WASTE FACILITIES CONTRIBUTIONS – 2013-2018

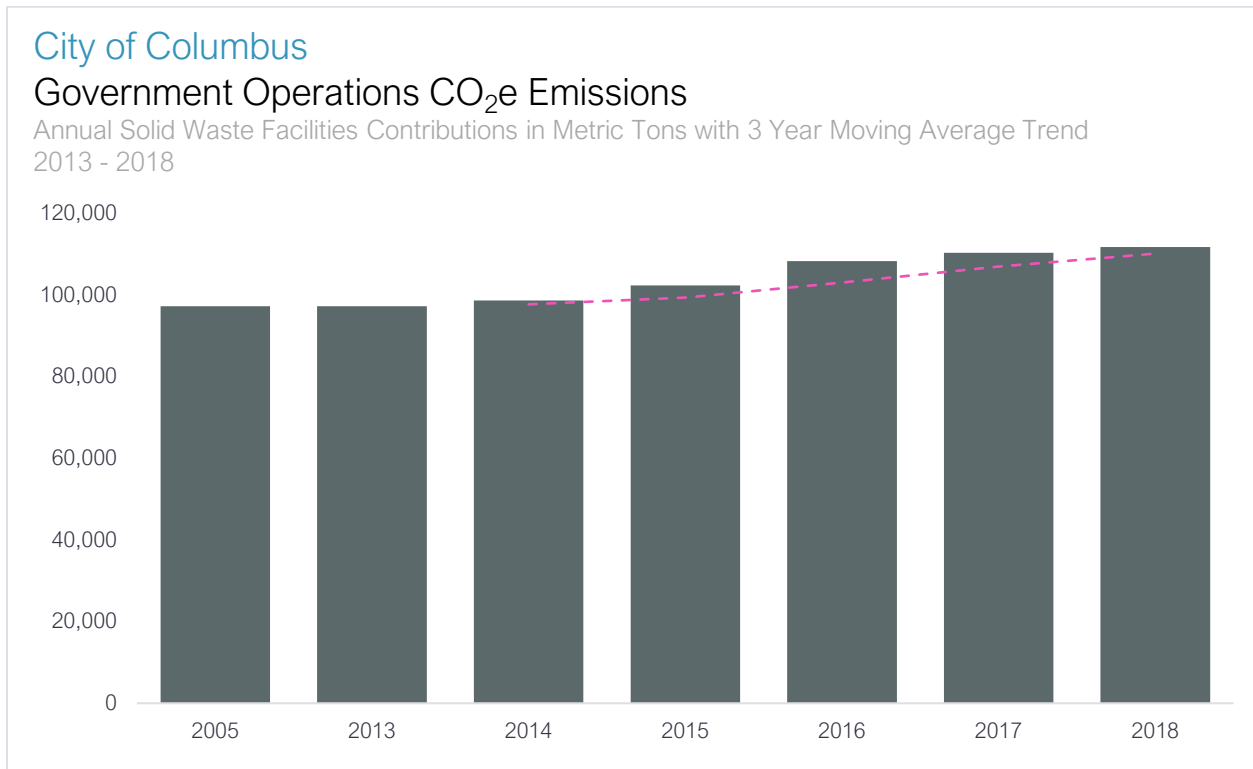


FIGURE 7. GOVERNMENT OPERATIONS – ANNUAL FLEET VEHICLE CONTRIBUTIONS – 2013-2018

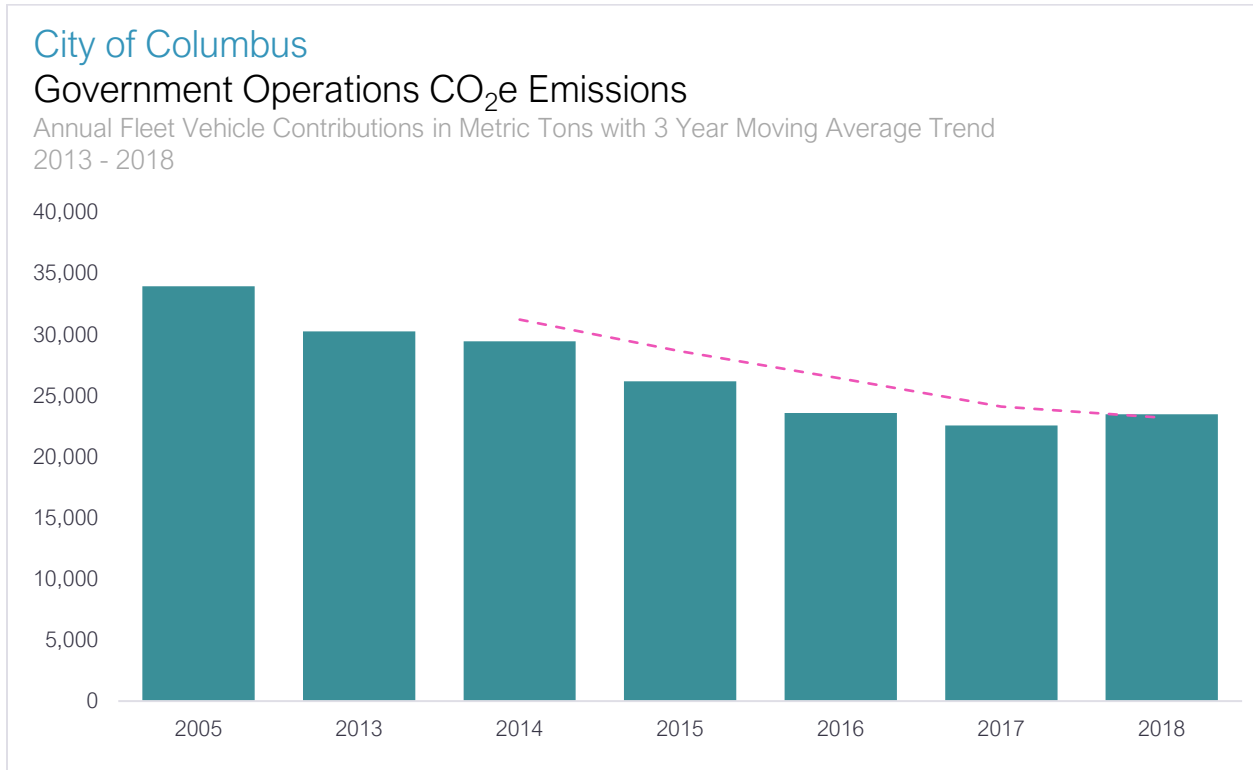


FIGURE 8. GOVERNMENT OPERATIONS – ANNUAL STREET LIGHT AND TRAFFIC SIGNS CONTRIBUTIONS – 2013-2018

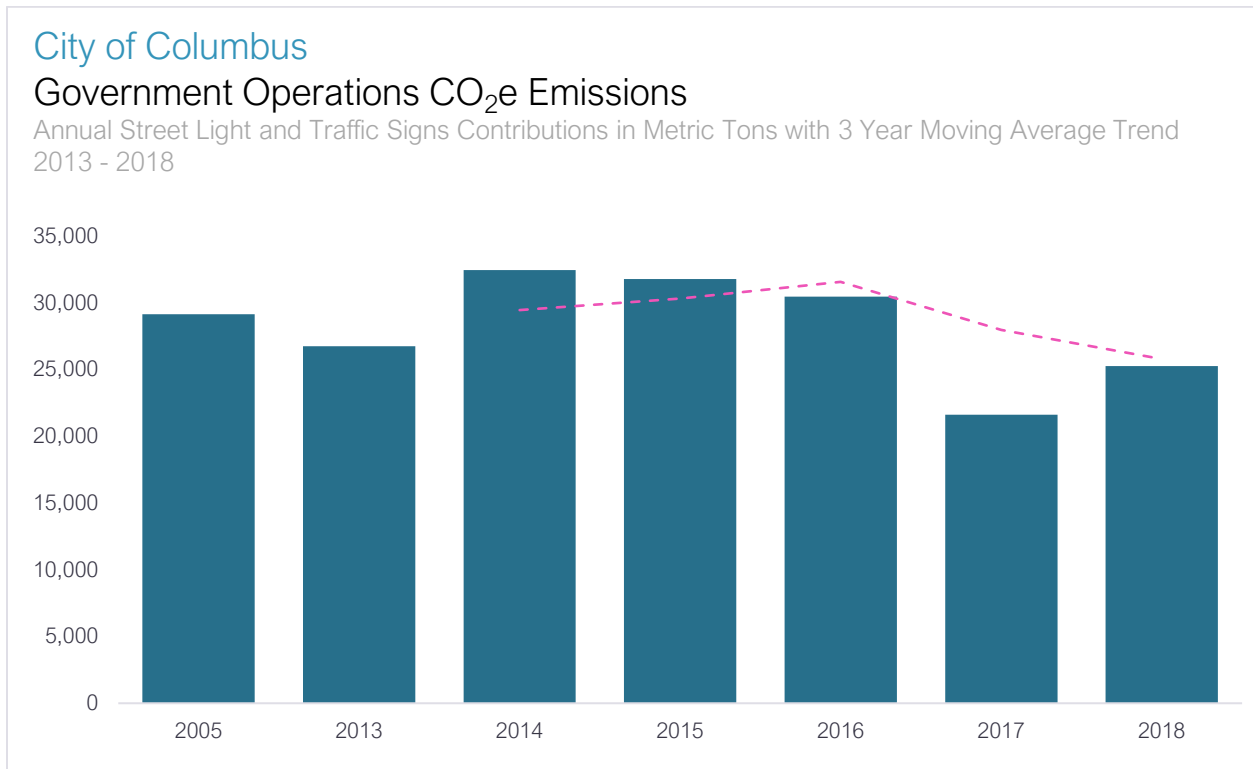


FIGURE 9. GOVERNMENT OPERATIONS – ANNUAL BUILDING AND FACILITIES CONTRIBUTIONS – 2013-2018

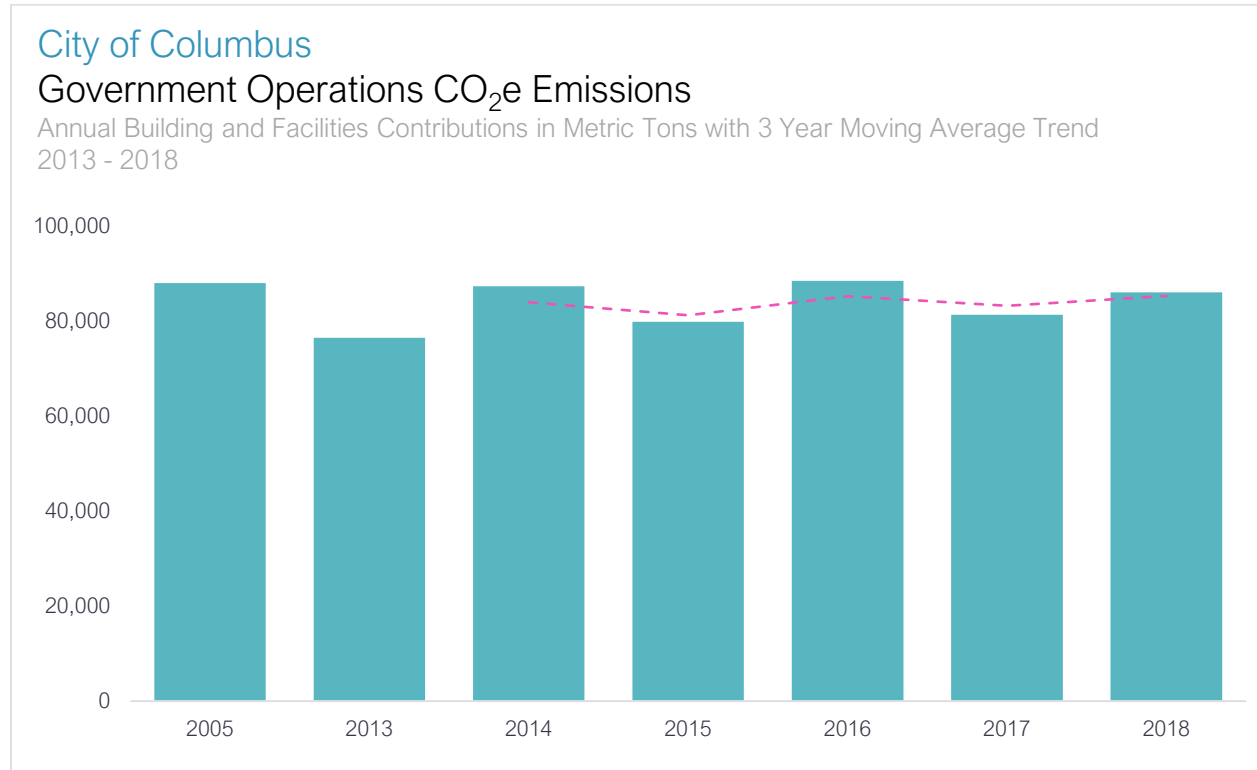
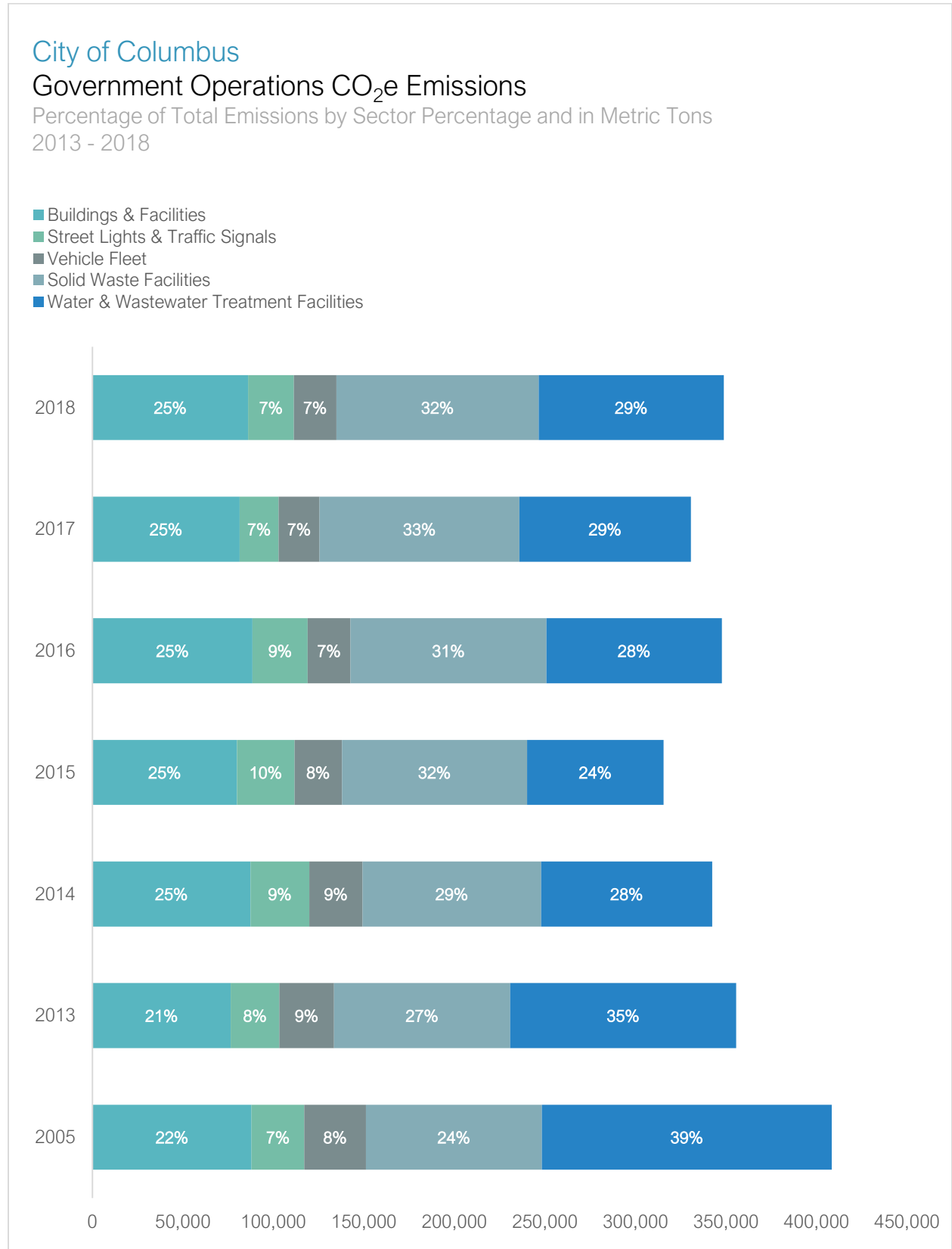


FIGURE 10. GOVERNMENT OPERATIONS – PERCENTAGE OF TOTAL EMISSIONS BY SECTOR – 2013-2018

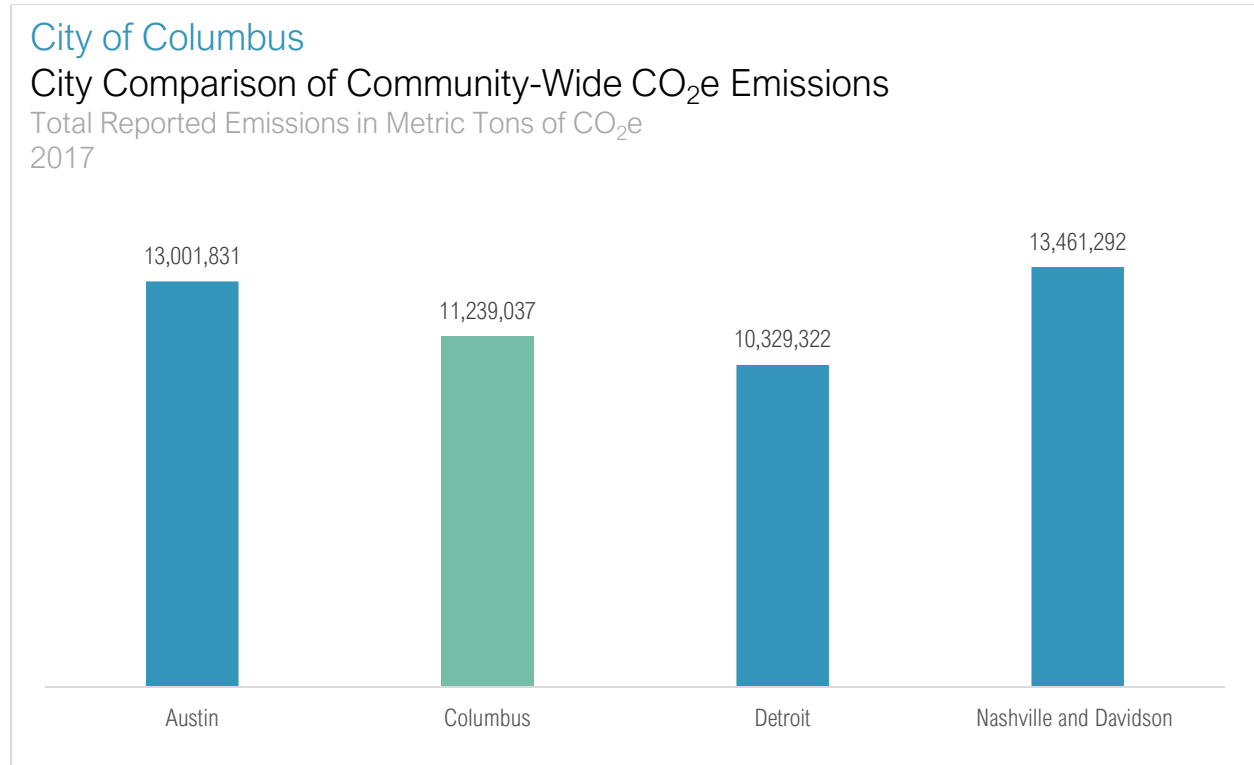




## 2018 Community-Wide Emissions

Cities across the world report emissions, although some methodologies vary as do gasses that are included. For comparison, below is a graph of cities that use the same methodology that are relatively similar to Columbus in terms of population, GDP, and land use. These values reflect 2017 emissions produced community-wide.

FIGURE 11. CITY COMPARISON OF TOTAL COMMUNITY EMISSIONS – 2017



Activities community-wide contributed 11,570,896 metric tons of CO<sub>2</sub>e in 2018. This represents a 3% increase from 2017. Population growth likely accounts for some of this increase. When considering the total emissions community-wide since 2013, a clear trend does not emerge other than Columbus typically varies year-to-year by a few percentage points, hovering between 11 and 12 million metric tons of CO<sub>2</sub>e per year.

Green Memo III<sup>8</sup> utilizes 2013 as a benchmark for community-wide emissions. Compared to 2013, emissions have increased by just under 3%. On a per capita basis, the community of Columbus creates 13.14 metric tons of CO<sub>2</sub>e per person, a 1% increase in the per capita emissions from 2017, and a 6% decrease in emissions per capita from 2013.

<sup>8</sup> [https://www.columbus.gov/Sustainable-Columbus/Columbus-Green-Community-Plan-\(Green-Memo-3\)/](https://www.columbus.gov/Sustainable-Columbus/Columbus-Green-Community-Plan-(Green-Memo-3)/)

FIGURE 12. COMMUNITY-WIDE – TOTAL EMISSIONS – 2013-2018

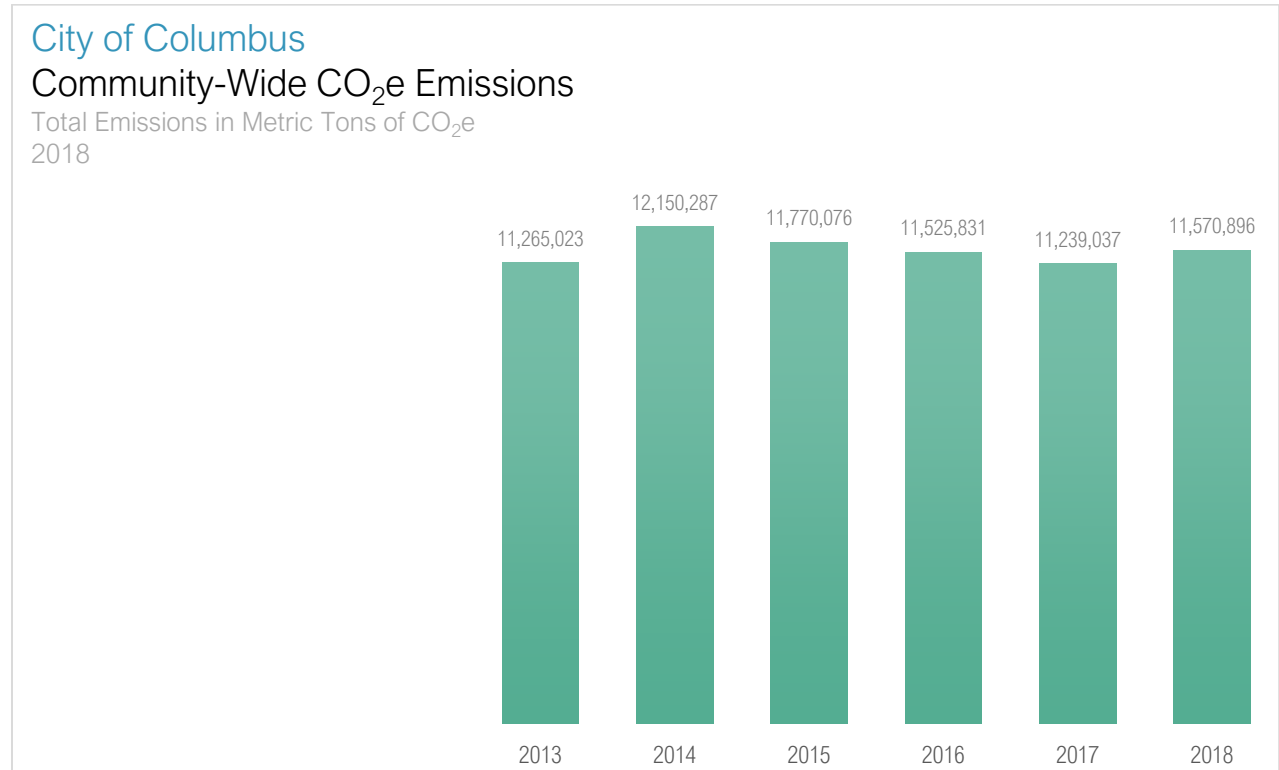


TABLE 6. COMMUNITY-WIDE – TOTAL EMISSIONS BY SECTOR – 2013-2018

Community-Wide Sector Emissions (Metric tons CO <sub>2</sub> e)	2013	2014	2015	2016	2017	2018
Residential Energy	2,641,935	3,020,841	2,700,722	2,614,721	2,423,504	2,763,887
Commercial Energy	4,883,764	4,640,654	4,216,227	4,170,874	3,748,313	3,573,927
Industrial Energy	287,152	713,266	657,967	626,048	611,877	371,757
Transportation	3,015,878	3,365,275	3,796,842	3,696,430	4,029,621	4,373,857
Solid Waste	249,007	249,877	244,372	263,633	275,496	332,321
Fugitive Emissions	59,171	63,481	57,928	56,682	55,435	52,887
Water and Wastewater Treatment Facilities	128,116	96,893	96,017	97,444	94,790	102,259
<b>Total Emissions</b>	<b>11,265,023</b>	<b>12,150,287</b>	<b>11,770,076</b>	<b>11,525,831</b>	<b>11,239,037</b>	<b>11,570,896</b>

FIGURE 13. COMMUNITY-WIDE – EMISSIONS PER CAPITA – 2013-2018

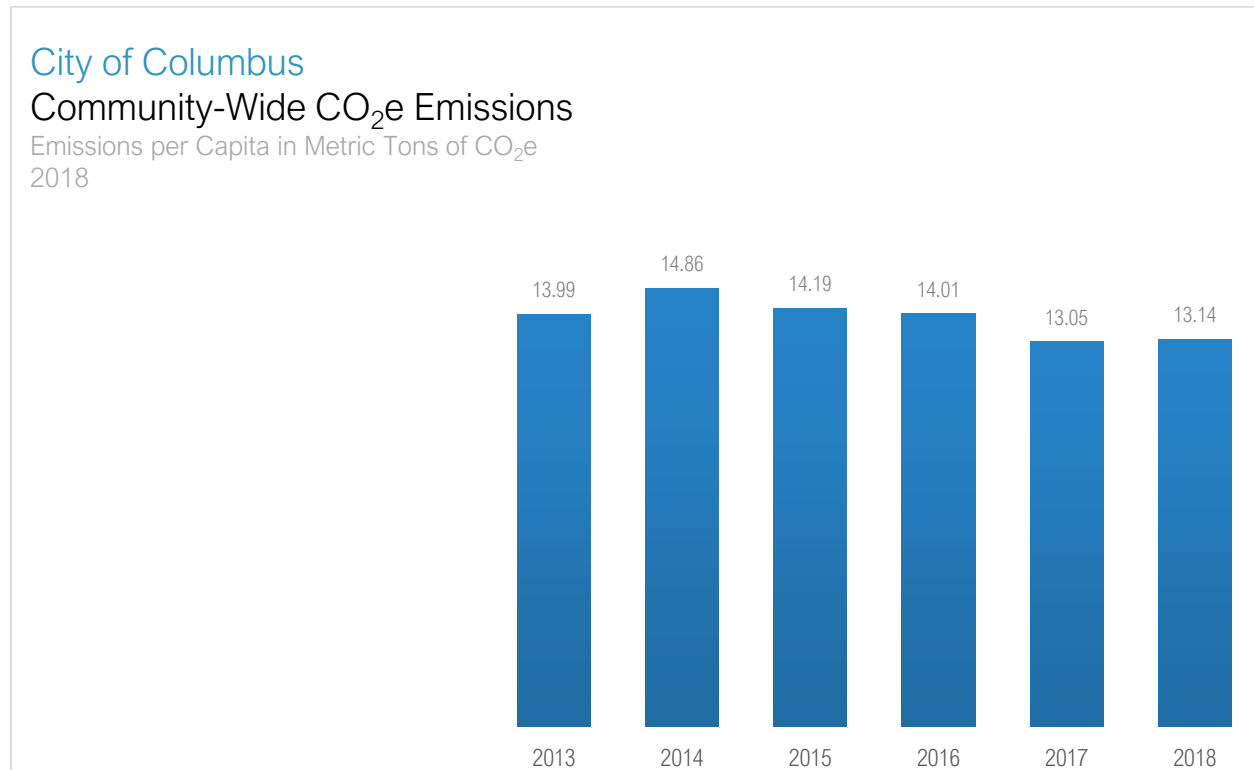


TABLE 7. COMMUNITY-WIDE – EMISSIONS PER CAPITA – 2013-2018

Community-Wide Emissions	2013	2014	2015	2016	2017	2018
Population	805,348	817,383	829,690	818,912	861,141	880,828
Residential Energy	3.28	3.70	3.26	3.19	2.81	3.14
Commercial Energy	6.06	5.68	5.08	5.09	4.35	4.06
Industrial Energy	0.36	0.87	0.79	0.76	0.71	0.42
Transportation	3.74	4.12	4.58	4.51	4.68	4.97
Solid Waste	0.31	0.31	0.29	0.32	0.32	0.38
Fugitive Emissions	0.07	0.08	0.07	0.07	0.06	0.06
Water and Wastewater Treatment Facilities <sup>9</sup>	0.16	0.12	0.12	0.12	0.11	0.12
<b>Emissions per capita (Metric Tons of CO<sub>2</sub>e)</b>	<b>13.99</b>	<b>14.86</b>	<b>14.19</b>	<b>14.01</b>	<b>13.05</b>	<b>13.14</b>

## Sector relative emissions contributions

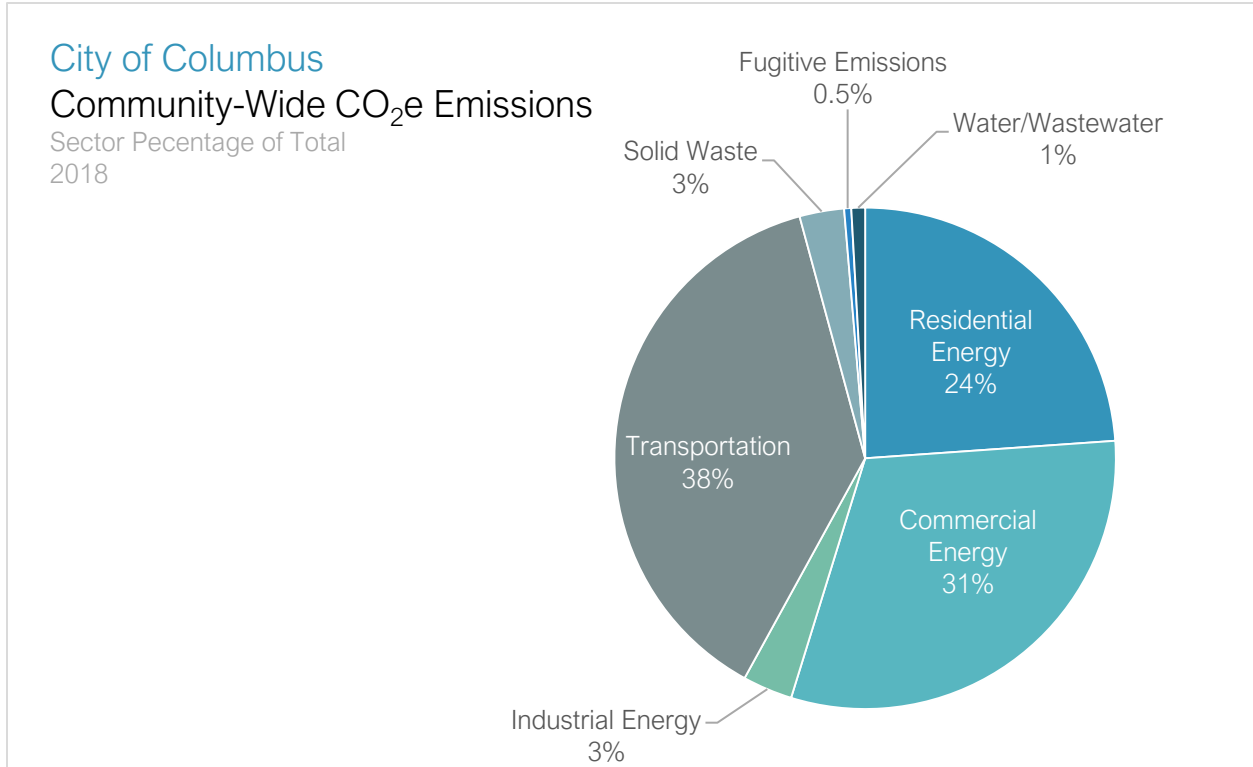
In both 2017 and 2018, the transportation sector accounts for the greatest portion of emissions on a community-wide basis (38%). The American Community Survey 5-Year Estimates note that in 2017, 80% of people commute via single-occupancy vehicles<sup>10</sup> and it should be assumed that 2018 will see a similar value. As population increases, so do commute times due to increased congestion, and thus emissions. Whereas vehicle efficiency is increasing due to increased standards and the adoption of fuel-efficient and alternative fuel

<sup>9</sup> See footnote 6.

<sup>10</sup> <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF>

vehicles, it is not expected to offset the increase in vehicles on the road. As is typical of similar-sized cities in the United States, commercial and residential sectors make up the next two largest contributors to emissions in the City of Columbus (31% and 24%, respectively). The industrial sector accounts for 3% of total emissions in 2018, which is in line with its contribution to the City's economic activity. Solid waste and water services make up 4% of emissions, with the final 0.5% being accounted for by process and fugitive emissions.

FIGURE 14. COMMUNITY-WIDE – SECTOR PERCENTAGE OF TOTAL EMISSIONS - 2018



## Sector emissions contributions between 2013 and 2018

Although emissions increased between 2017 and 2018, it should be noted that on a per capita basis, Columbus is experiencing a relatively low emissions rate compared to historical values. The City's population has grown 9% since 2013, while the metropolitan statistical area for Columbus has experienced an average of 5% growth in gross domestic product since 2013<sup>11</sup>. Even though the majority of community sectors are emitting more greenhouse gases than in 2013, most are doing so at a lower rate per person than has been seen in most previous analyses for Columbus.

<sup>11</sup> According to the Bureau of Economic Analysis 2015-2017. <https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1>. (Accessed July 17, 2019)

TABLE 8. COMMUNITY-WIDE – PERCENT CHANGE IN 2018 EMISSIONS FROM 2013

Community-Wide Emissions	Percent Change in 2018 from 2013
Residential Energy	4.6%
Commercial Energy	-26.8%
Industrial Energy	29.5%
Transportation	45.0%
Solid Waste	33.5%
Fugitive Emissions	-10.6%
Water/Wastewater	-20.2%
<b>Total Emissions</b>	<b>2.7%</b>

Annual emissions data for each sector are provided below with a three year moving average trend line for individual sectors.

It should be noted that increases in emissions from the transportation sector consistently outpace growth in population and economic activity and are 45% higher than they were in 2013. However, 28% of the 2017 to 2018 increase in emissions within the transportation sector are due to a change in methodology of calculating on-road freight mileage. It is believed that this new methodology more accurately reflects the freight energy consumption.

Although emissions from the industrial sector have increased nearly 30% since 2013, it may not be indicative of decreased efficiency in operations as new industrial activity may have located in the area, or if existing businesses have seen an increase in productivity. There is a significant reduction in emissions from 2017. This drop is due to the reported values for natural gas (see Community-Wide Inputs in Appendix A), which changed as a part of the validation exercise for accounts within the City of Columbus boundary.

FIGURE 15. COMMUNITY-WIDE – ANNUAL SECTOR EMISSION CONTRIBUTIONS – 2013-2018

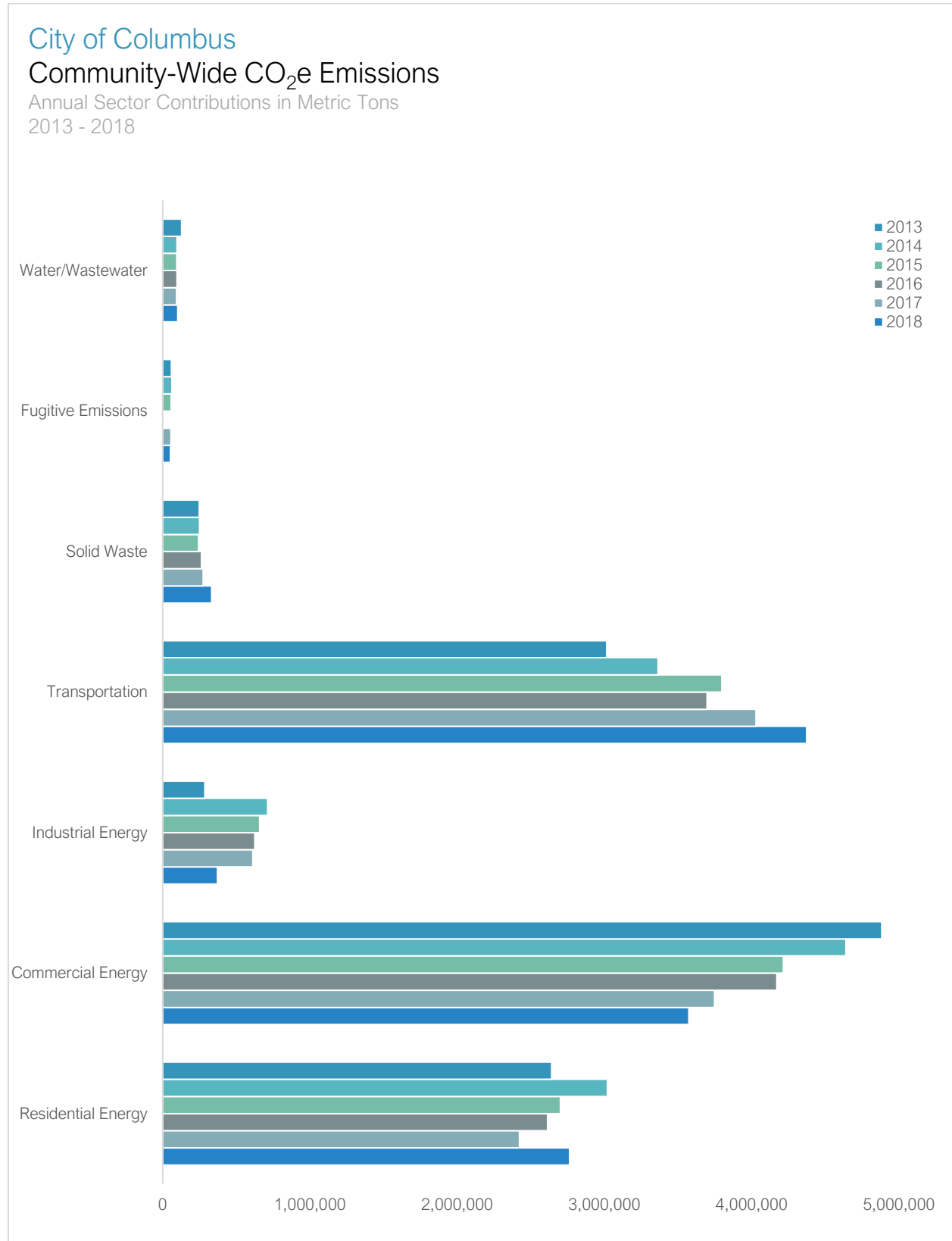


FIGURE 16. COMMUNITY-WIDE – ANNUAL WASTE AND WASTEWATER SECTOR CONTRIBUTIONS – 2013-2018

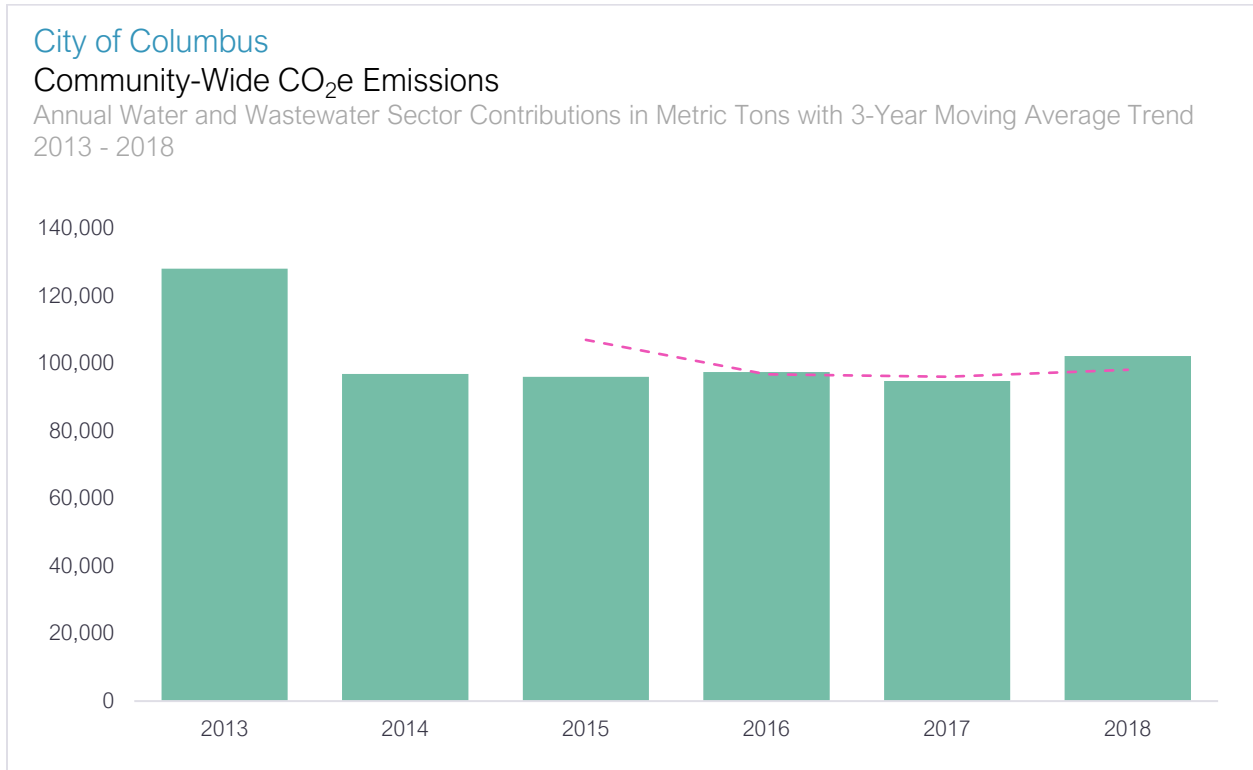
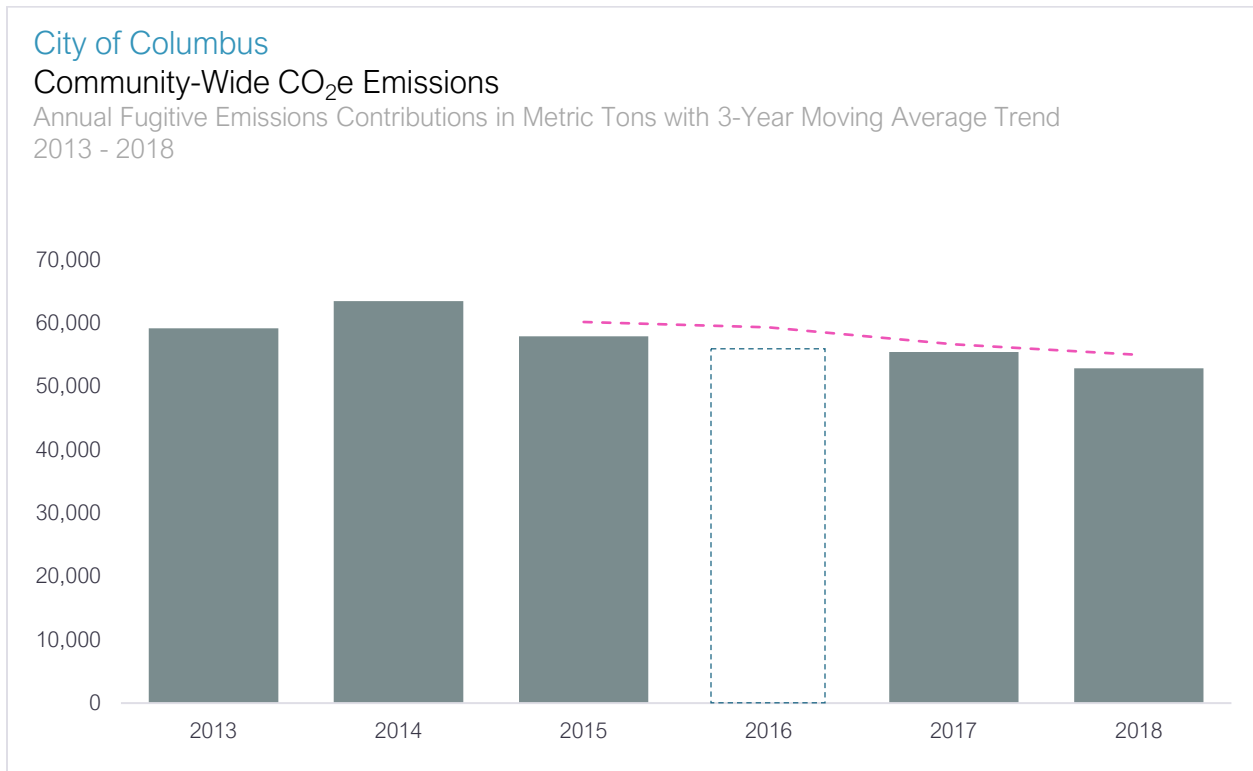


FIGURE 17. COMMUNITY-WIDE – ANNUAL FUGITIVE EMISSION CONTRIBUTIONS – 2013-2018<sup>12</sup>



<sup>12</sup> Fugitive emissions were not calculated or included in the 2016 GHG Inventory. The dotted box represents an assumed value.

FIGURE 18. COMMUNITY-WIDE – ANNUAL SOLID WASTE SECTOR CONTRIBUTIONS – 2013-2018

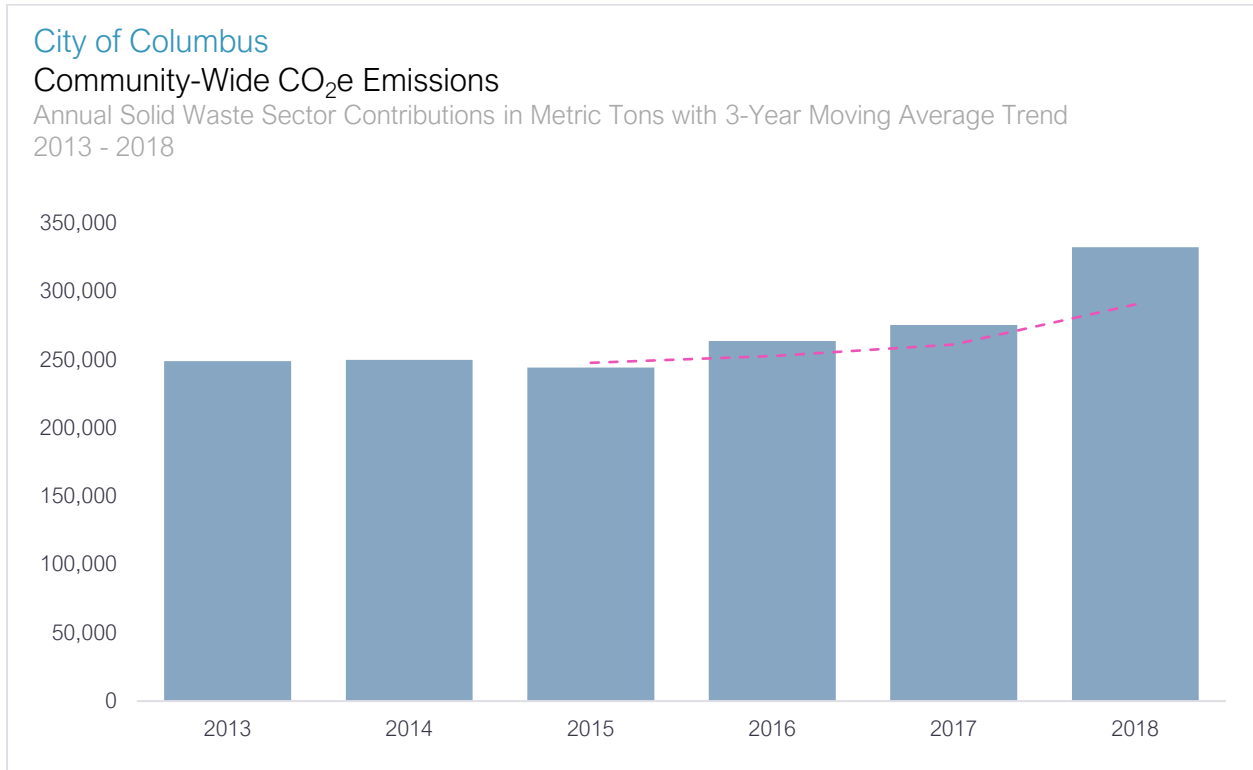


FIGURE 19. COMMUNITY-WIDE – ANNUAL TRANSPORTATION SECTOR CONTRIBUTIONS – 2013-2018

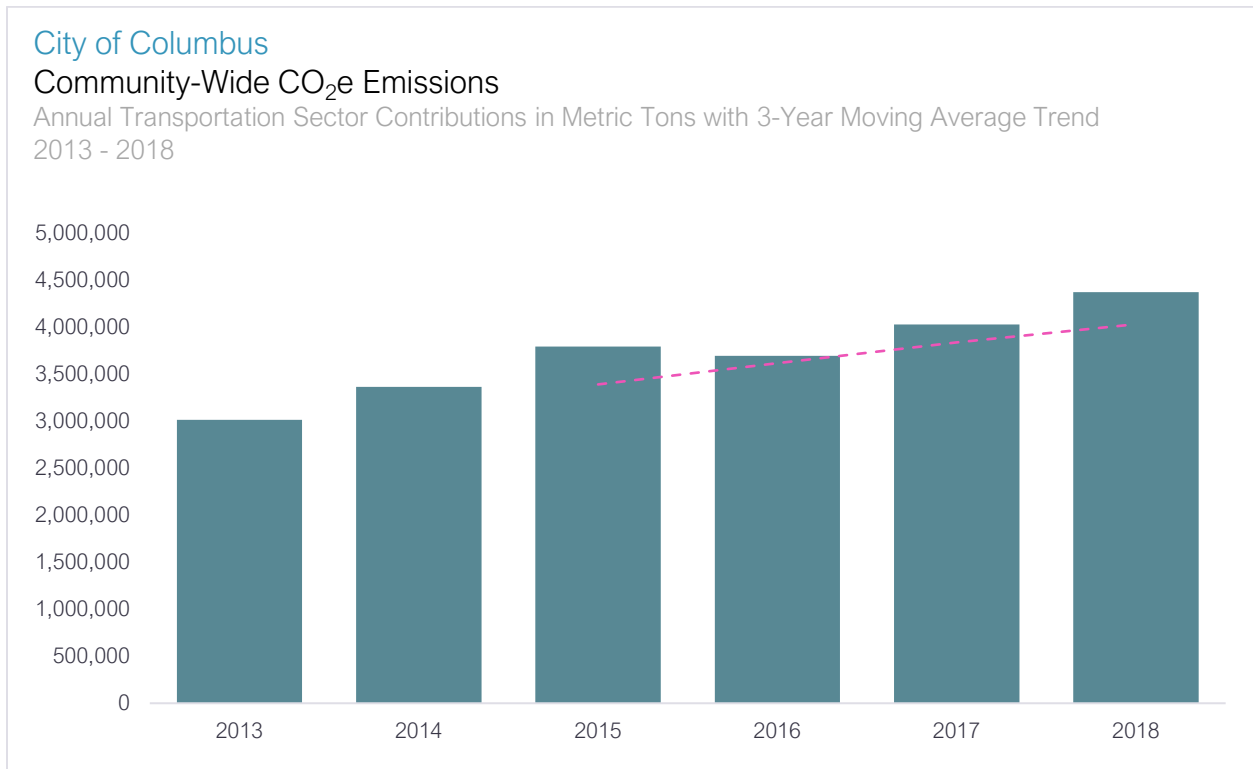




FIGURE 20. COMMUNITY-WIDE – ANNUAL INDUSTRIAL SECTOR CONTRIBUTIONS – 2013-2018

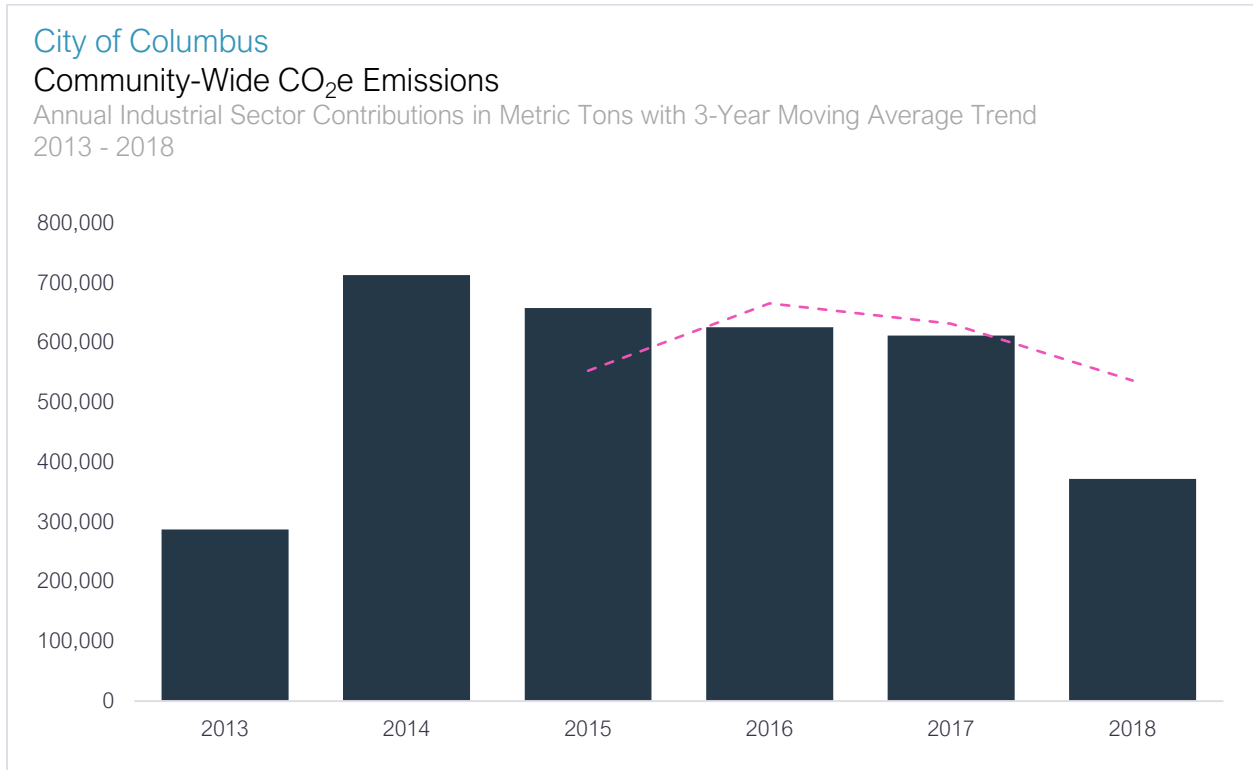


FIGURE 21. COMMUNITY-WIDE – ANNUAL COMMERCIAL SECTOR CONTRIBUTIONS – 2013-2018

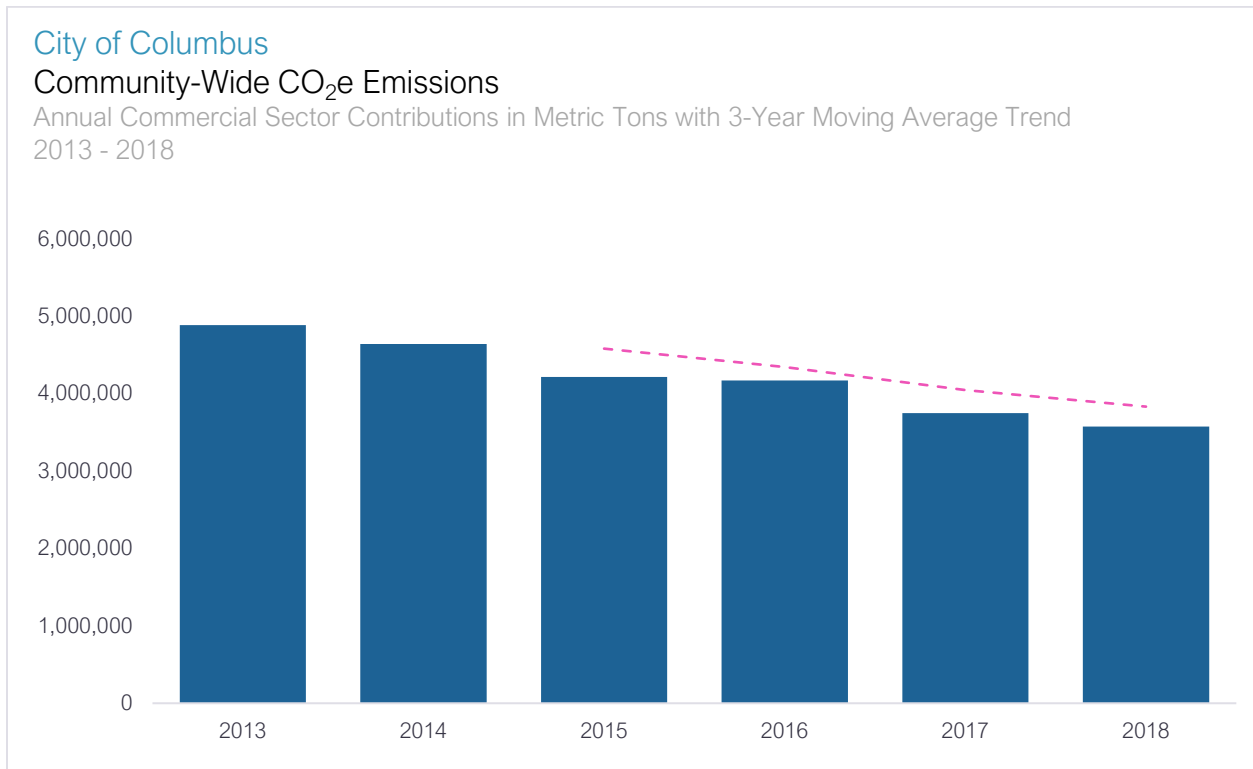


FIGURE 22. COMMUNITY-WIDE – ANNUAL RESIDENTIAL SECTOR CONTRIBUTIONS – 2013-2018

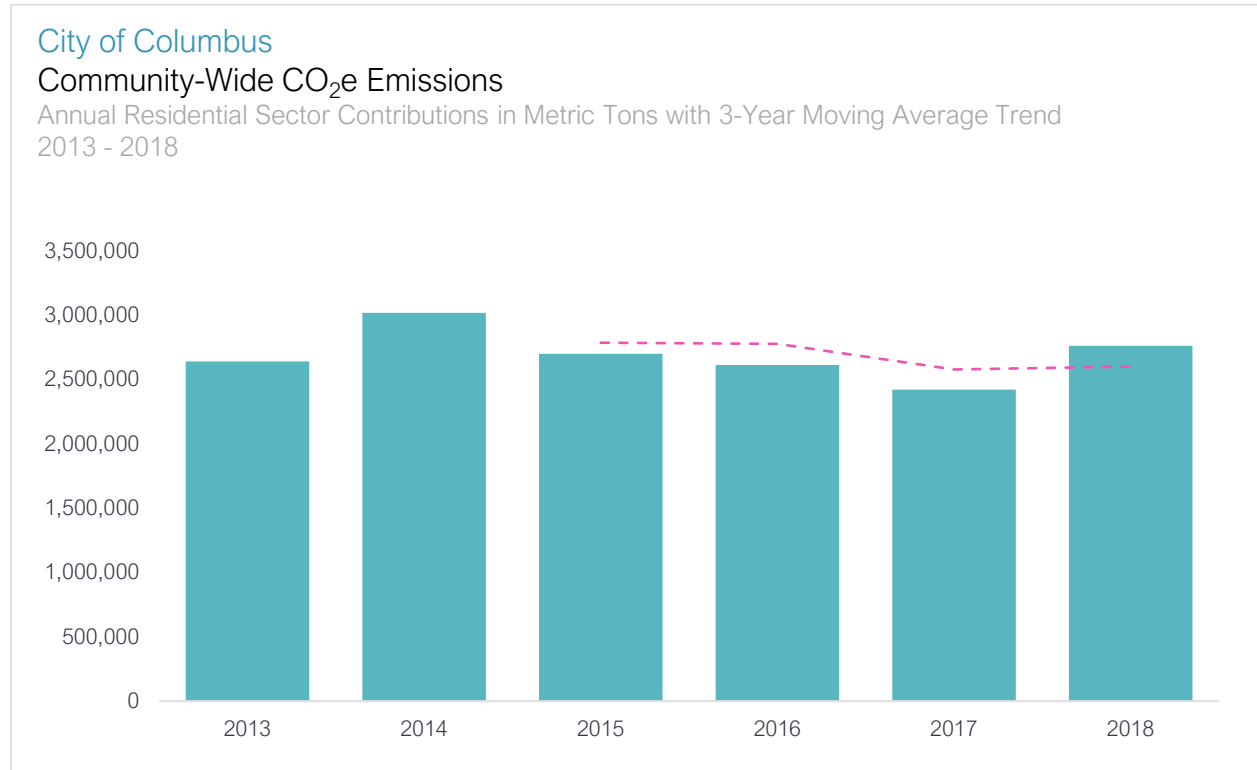
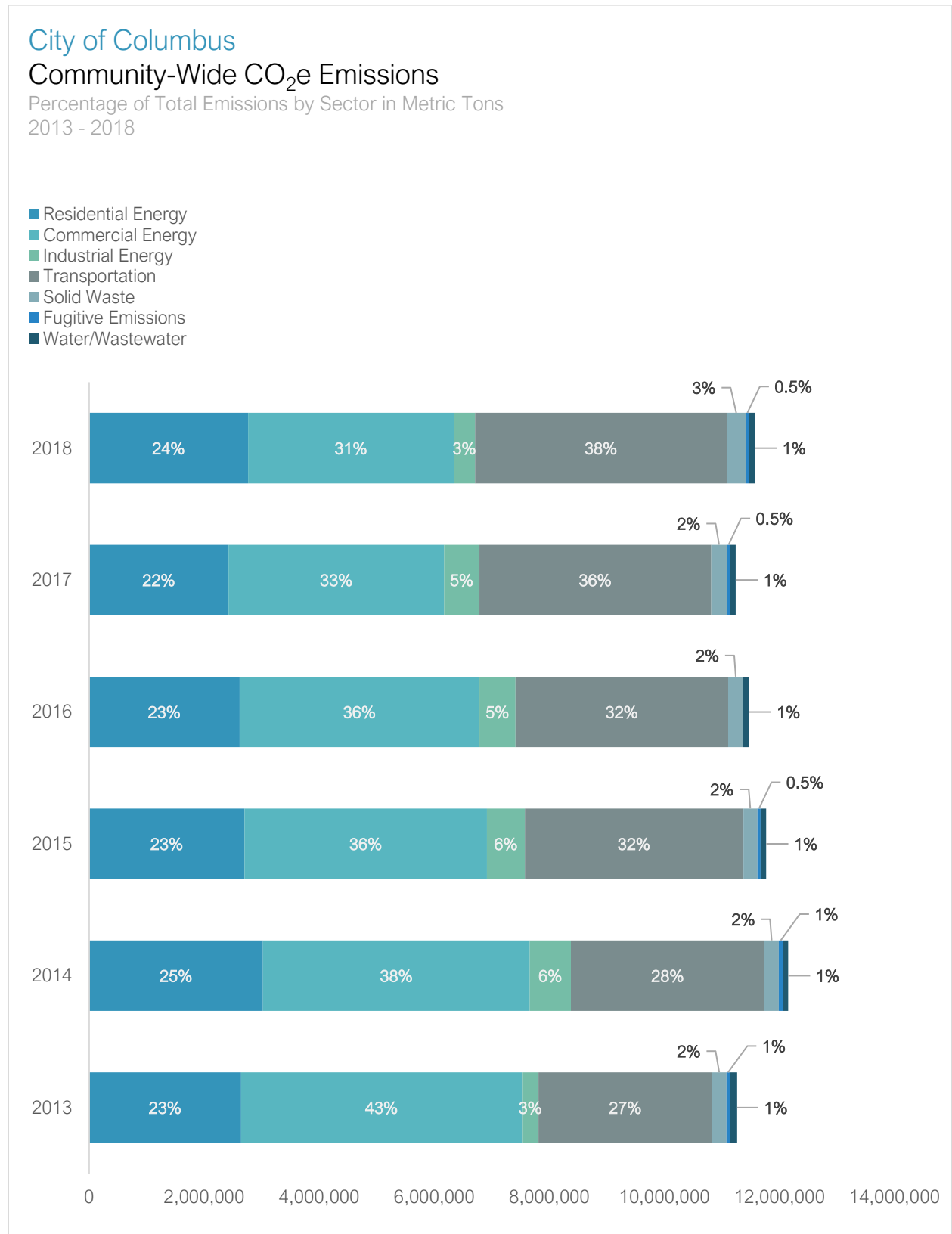


FIGURE 23. COMMUNITY-WIDE – PERCENTAGE OF TOTAL EMISSIONS BY SECTOR – 2013-2018



## Appendix A

### Inputs

#### Energy Consumption and Waste Values

Community-Wide Inputs	Unit	2016	2017	2018
Residential Natural Gas Usage	MMBtu	15,549,233	15,710,210	20,280,912
Commercial Natural Gas Usage	MMBtu	13,831,531	14,529,943	10,040,435
Industrial Natural Gas Usage	MMBtu	4,839,784	4,963,302	161,932
Residential Electric Usage - AEP	kWh	2,776,284,947	2,675,953,721	2,890,640,718
Commercial/Industrial Electric Usage - AEP	kWh	5,332,567,481	5,134,004,677	5,241,305,315
Residential Electric Usage - DPU	kWh	66,851,275	66,621,085	78,522,037
Commercial Electric Usage - DPU	kWh	130,435,929	106,813,606	113,923,918
Industrial Electric Usage - DPU	kWh	587,071,546	613,696,855	639,762,013
Transit Buses, Diesel	Gallons	2,012,291	1,950,033	1,907,288
Transit Buses, CNG	Gallons	1,497,898	1,779,363	2,061,696
Paratransit Buses, Diesel	Gallons	339,773	346,180	340,861
Paratransit Buses, Gasoline	Gallons	34,127	30,258	28,302
Aviation - Airport, kerosene jet fuel	Gallons	59,713,628	68,362,002	73,251,020
Aviation - Airport, gasoline	Gallons	84,767	54,479	75,315
Aviation - Helicopter	Gallons	61,708	100,154	111,161
On Road, Passenger, Gasoline	Gallons	7,363,342,017	7,475,738,443	7,835,788,415
On Road, Passenger, Diesel	Gallons	22,156,496	22,494,699	23,578,100
On Road, Freight, Gasoline	Gallons	6,659,384	6,736,467	11,908,782
On Road, Freight, Diesel	Gallons	259,715,974	262,722,228	464,442,498
Freight Rail, Diesel	Gallons	-	9,910,732	2,119,594
Wastewater Treatment Plants - Electricity - DPU	kWh	75,205,564	92,829,836	98,662,456
Water Treatment Plants - Electricity - DPU	kWh	58,228,740	60,707,038	67,114,035
Wastewater Treatment Plants - Natural Gas	MMBtu	66,640	75,325	67,778
Water Treatment Plants - Natural Gas	MMBtu	36,523	31,681	51,733
Gas Production - Jackson Pike	scf/day	-	1,000,000	810,000 <sup>13,16</sup>
Gas Composition - Jackson Pike	Percent Methane	-	65%	62% <sup>13,16</sup>
Heat Content - Jackson Pike	Btu/scf	-	580	570 <sup>13,16</sup>
Gas Production - Southerly	scf/day	-	700,000	700,000 <sup>13,16</sup>
Gas Composition - Southerly	Percent Methane	-	56%	56% <sup>14,16</sup>
Heat Content - Southerly	Btu/scf	-	512	512 <sup>15,16</sup>
Destruction Efficiency – Jackson Pike and Southerly	Percent	-	99%	99%

Government Operations Inputs	Unit	2016	2017	2018
Natural Gas	MMBtu	276,538	407,557	656,413
Electric	kWh	107,802,332	104,989,940	90,052,367
Street Lights and Signals - Electricity - DPU	kWh	42,520,846	38,069,976	44,058,418
Aviation - Helicopter	Gallons	61,708	100,154	111,161
City Fleet EVs (on road)	kWh	n/a	n/a	34,850
City Fleet CNG (on road)	Gallons	476,151	562,787	658,932
City Fleet Biodiesel (on road)	Gallons	0	470,960	353,342
City Fleet Diesel (on road)	Gallons	868,701	300,396	966,559
City Fleet Gasoline (on road)	Gallons	1,569,238	1,402,088	918,043
City Fleet E85 (on road)	Gallons	2,060	5,190	0
City Fleet Propane (on road)	Gallons	-	-	7,317
City Fleet CNG (off road)	Gallons	-	672	1,510
City Fleet Biodiesel (off road)	Gallons	-	93,886	95,908
City Fleet Diesel (off road)	Gallons	-	2,928	9,033
City Fleet Gasoline (off road)	Gallons	-	5,842	4,444
City Fleet Propane (off road)	Gallons	-	-	15,716
Municipal Solid Waste Generation (Landfill Total)	Tons	320,807	326,839	331,027
Wastewater Treatment Plants - Electricity	kWh	75,205,564	92,829,836	98,662,456
Water Treatment Plants - Electricity	kWh	58,228,740	60,707,038	67,114,035
Wastewater Treatment Plants - Natural Gas	MMBtu	66,640	75,325	67,778
Water Treatment Plants - Natural Gas	MMBtu	36,523	31,681	51,733
Gas Production - Jackson Pike	scf/day	-	1,000,000	810,000 <sup>13,16</sup>
Gas Composition - Jackson Pike	Percent Methane	-	65%	62% <sup>13,16</sup>
Heat Content - Jackson Pike	Btu/scf	-	580	570 <sup>13,16</sup>
Gas Production - Southerly	scf/day	-	700,000	700,000 <sup>13,16</sup>
Gas Composition - Southerly	Percent Methane	-	56%	56% <sup>14,16</sup>
Heat Content - Southerly	Btu/scf	-	512	512 <sup>15,15</sup>
Destruction Efficiency – Jackson Pike and Southerly	Percent	-	99%	99%

<sup>13</sup> Technical Memorandum No.1 – Gas Quantity, obtained from Todd Krenelka, City of Columbus Department of Public Utilities

<sup>14</sup> Technical Memorandum No.2 – Gas Quality Estimates, obtained from Todd Krenelka, City of Columbus Department of Public Utilities

<sup>15</sup> In future year inventories, Southerly and Jackson Pike wastewater treatment facility data will be sourced from the City of Columbus Fee Emissions Report.

## Emission Rates from eGRID

Community Emissions					
Analysis Year	Name	Region	CO <sub>2</sub> lbs/MWh	CH <sub>4</sub> lbs/GWh	N <sub>2</sub> O lbs/GWh
2013	EPA eGrid 2010 Proxy for 2013	RFCW	1503.5	18.2	24.8
2014	EPA eGrid 2010 Proxy for 2014	RFCW	1503.5	18.2	24.8
2015	EPA eGrid 2012 Proxy for 2015	RFCW	1379.5	17.1	21.7
2016	EPA eGrid 2014 Proxy for 2016	RFCW	1497.1	161.3	23.7
2017	EPA eGrid 2016 Proxy for 2017	RFCW	1243.4	108	19
2018	EPA eGrid 2016 Proxy for 2018	RFCW	1243.4	108	19

Government Operations					
Analysis Year	Name	Region	CO <sub>2</sub> lbs/MWh	CH <sub>4</sub> lbs/GWh	N <sub>2</sub> O lbs/GWh
2005	EPA eGrid 2007 Year 2005	Ohio	1771.8	20.99	29.9
2013	EPA eGrid 2010 Proxy for 2013	RFCW	1503.5	18.2	24.8
2014	EPA eGrid 2010 Proxy for 2014	RFCW	1503.5	18.2	24.8
2015	EPA eGrid 2012 Proxy for 2015	RFCW	1379.5	17.1	21.7
2016	EPA eGrid 2014 Proxy for 2016	RFCW	1497.1	161.3	23.7
2017	EPA eGrid 2016 Proxy for 2017	RFCW	1243.4	108	19
2018	EPA eGrid 2016 Proxy for 2018	RFCW	1243.4	108	19

Whereas all values are stated to come from EPA's eGRID value tables, it should be noted that EPA eGRID 2014 values noted in the tables above are not accurate. Documentation does not exist as to why there is a discrepancy, although EPA eGRID value tables note a V2, which could mean that the values for 2014 were updated after the greenhouse gas inventory for 2014 was conducted. Reliability First Corporation West (or RFCW) is the correct region to use for this analysis.

## Appendix B

### Global Warming Potential Update

The purpose of this document is to record the process of updating the global warming potential for the City of Columbus Greenhouse Gas Inventories.

#### Background

As is common practice in greenhouse gas inventories, the following three greenhouse gases are included in City of Columbus inventories:

- Carbon Dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous Oxide (N<sub>2</sub>O)

These gases are used to calculate a total carbon dioxide equivalent (CO<sub>2</sub>e) emissions value for City of Columbus emissions. To do so, Global Warming Potential (GWP) factors for both methane and nitrous oxide are used. Global warming potential is described by the United States EPA as follows:

*The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO<sub>2</sub>). The larger the GWP, the more that a given gas warms the Earth compared to CO<sub>2</sub> over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases.<sup>16</sup>*

ClearPath utilizes the GWP values presented in the annual Assessment Reports from the Intergovernmental Panel on Climate Change (IPCC). The IPCC is the United Nations body for assessing the science related to climate change. Global Warming Potentials are provided for both 20 year and 100 year timescales in each Assessment Report and are updated in each subsequent report. GWP values from the 2nd Assessment Report were used for the 2005 government operations inventory. Both government and community inventories from 2013-2017 used GWPs from the 4<sup>th</sup> Assessment Report. Table 1 gives the 100 year GWP values for the three greenhouse gases included in the City of Columbus inventory from the second, fourth, and fifth IPCC Assessment Reports. These values, along with the 20 year GWP potentials from the 5<sup>th</sup> Assessment Report, are the available options in the ClearPath tool.

---

<sup>16</sup> U.S. EPA <https://www.epa.gov/ghgemissions/understanding-global-warming-potentials> (accessed March 23, 2019)

TABLE 1 – GWP<sup>17,18</sup>

Greenhouse Gas	IPCC 2 <sup>nd</sup> Assessment Report 100 Year Value	IPCC 4 <sup>th</sup> Assessment Report 100 Year Value	IPCC 5 <sup>th</sup> Assessment Report 100 Year Value
Carbon Dioxide	1	1	1
Methane	21	25	28
Nitrogen Oxide	310	298	265

## Impact of GWP Value on Inventory Results

Results from annual City of Columbus greenhouse gas inventories from 2014 to 2017 were compared with the 100 year GWP values from the IPCC Fourth Assessment Report and IPCC Fifth Assessment Report applied. Table 2 gives the total change in emissions that results from applying the Fifth Assessment Report GWP values instead of the Fourth Assessment Report values in both total metric tons and in terms of the percentage change in emissions.

TABLE 2 – IMPACT OF GWP CHANGES

Year	Change in total CO <sub>2e</sub> emissions (metric tons)	Change in total CO <sub>2e</sub> emissions (%)
2014	32,614	0.28
2015	30,644	0.27
2016	45,611	0.40
2017	29,608	0.26

For all years the percent change in total emissions is less than one percent.

The impact of this change in emissions varies across sectors. However, the changes are largely consistent between years. Figure 1 shows the median change in carbon dioxide equivalent emission for each sector across the 2014 to 2017 inventories. The impact is largest and positive on Solid Waste and Process and Fugitive Emissions sectors. This reflects the primacy of methane as an emission from these sectors and the increasing GWP value for methane from the Fourth to Fifth Assessment Reports. The impact is smaller and negative for all other sectors. Figure 2 gives the outer bounds of changes in carbon dioxide equivalent emission for each sector across the 2014 to 2017 inventories.

<sup>17</sup> IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. [https://www.ipcc.ch/site/assets/uploads/2018/05/ar4\\_wg1\\_full\\_report-1.pdf](https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf)

<sup>18</sup> IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp. [https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5\\_all\\_final.pdf](https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_all_final.pdf)



FIGURE 1 – MEDIAN CHANGE IN CO<sub>2</sub>e EMISSIONS BY SECTOR – 2014-2017

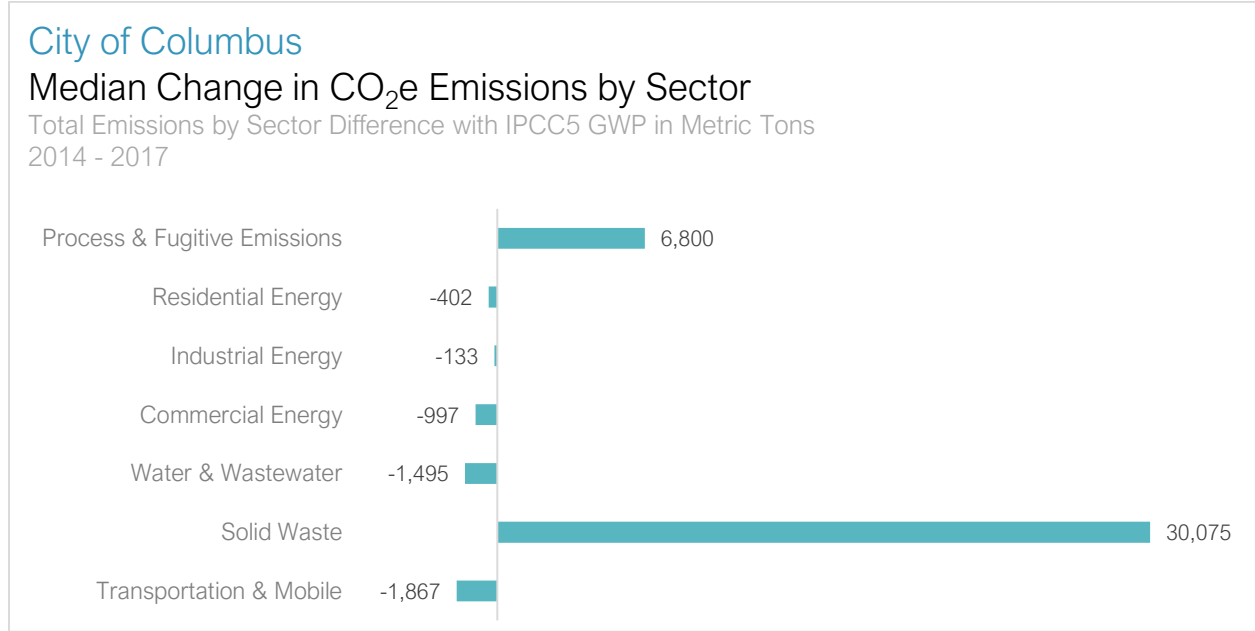
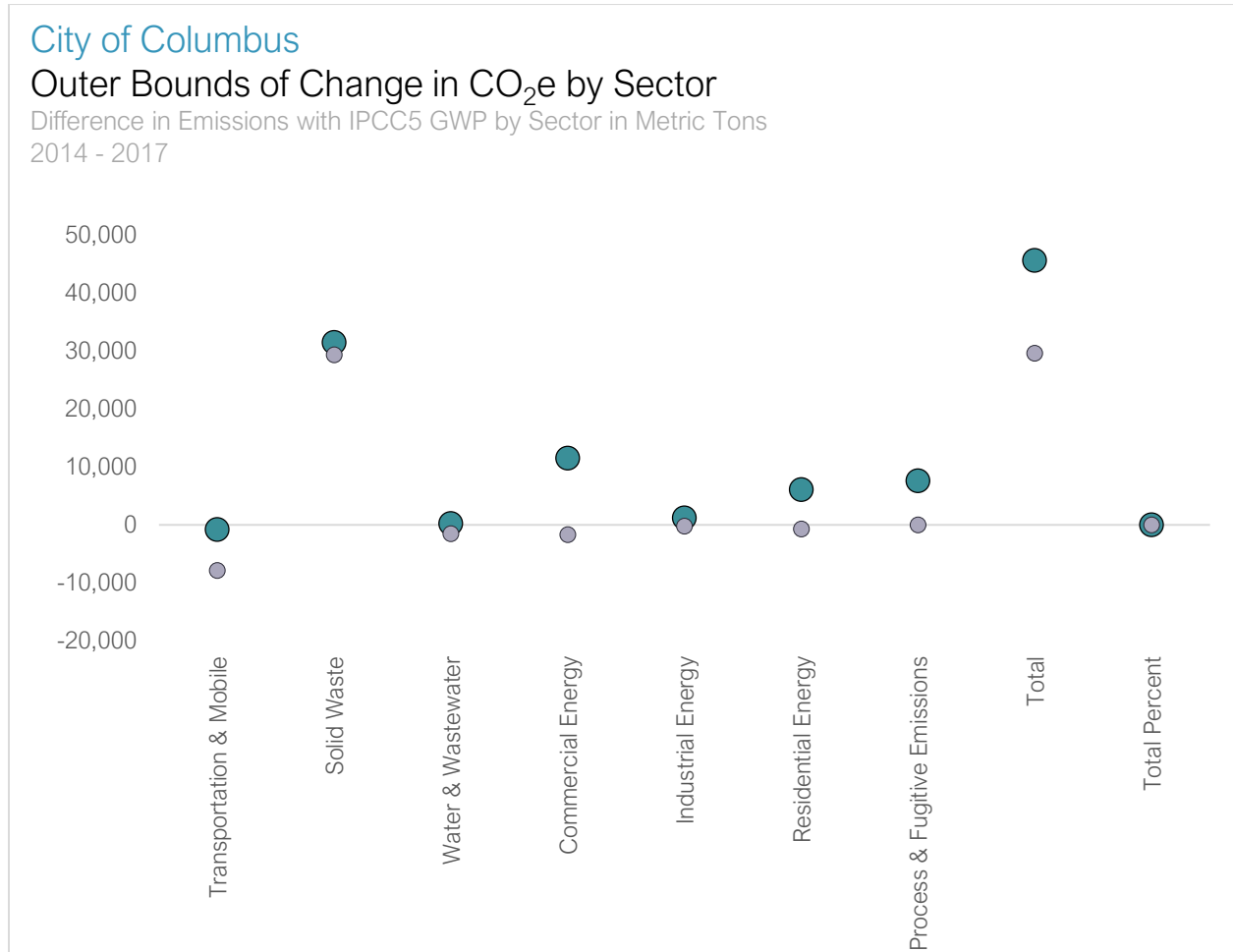


FIGURE 2 – OUTER BOUNDS OF DIFFERENCE IN CO<sub>2</sub>e EMISSIONS BY SECTOR – 2014-2017



[THIS PAGE INTENTIONALLY LEFT BLANK]



MID-OHIO REGIONAL  
**MORPC**  
PLANNING COMMISSION