

CITY OF COLUMBUS  
**GREENHOUSE GAS  
INVENTORY**  
2020



MID-OHIO REGIONAL  
**MORPC**  
PLANNING COMMISSION

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## Contents

Introduction .....	3
Greenhouse Gas Inventory Tool.....	3
Changes in Model or Methodology .....	4
Greenhouse Gases .....	4
Sectors Included.....	5
2020 Government Operations Emissions .....	6
Sector relative emissions contributions.....	7
Sector emissions contributions between 2005 and 2020 .....	8
2020 Community-Wide Emissions.....	14
Sector relative emissions contributions.....	16
Sector emissions contributions between 2013 and 2020 .....	17
Appendix A .....	25
Inputs .....	25
Energy Consumption and Waste Values.....	25
Emission Rates from eGRID .....	27
Appendix B .....	28
Progress Towards the 2020 Emissions Reduction Goal .....	28

## Tables

Table 1. Sectors – Government Operations Inventory.....	5
Table 2. Sectors – Community Scale 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 Scale – Total Emissions by Sector – 2013-2020.....	15
Table 7. Community Scale – Emissions per capita – 2013-2020.....	16
Table 8. Community Scale – Percent Change in Emissions from 2013.....	18



## Figures

Figure 1. Government Operations – Total Emissions – 2020 .....	6
Figure 2. Government Operations – Emissions per Capita – 2020.....	7
Figure 3. Government Operations – Sector Percentage of Total Annual Emissions – 2020 .....	8
Figure 4. Government Operations – Annual Sector Contributions – 2013-2020 .....	9
Figure 5. Government Operations – Annual Water and Wastewater Treatment Facilities Contributions – 2013-2020 .....	10
Figure 6. Government Operations – Annual Solid Waste Facilities Contributions – 2013-2020 .....	10
Figure 7. Government Operations – Annual Fleet Vehicle Contributions – 2013-2020 .....	11
Figure 8. Government Operations – Annual Street Light and Traffic Signs Contributions – 2013-2020.....	11
Figure 9. Government Operations – Annual Building and Facilities Contributions – 2013-2020 .....	12
Figure 10. Government Operations – Percentage of Total Emissions by Sector – 2013-2020.....	13
Figure 11. City Comparison of Total Community Emissions – 2017 .....	14
Figure 12. Community Scale – Total Emissions – 2013-2020 .....	15
Figure 13. Community Scale – Emissions per capita – 2013-2020.....	16
Figure 14. Community Scale – Sector Percentage of Total Emissions - 2020 .....	17
Figure 15. Community Scale – Annual Sector Emission Contributions – 2013-2020 .....	19
Figure 16. Community Scale – Annual Waste and Wastewater Sector Contributions – 2013-2020.....	20
Figure 17. Community Scale – Annual Fugitive Emission Contributions – 2013-2020.....	20
Figure 18. Community Scale – Annual Solid Waste Sector Contributions – 2013-2020.....	21
Figure 19. Community Scale – Annual Transportation Sector Contributions – 2013-2020.....	21
Figure 20. Community Scale – Annual Industrial Sector Contributions – 2013-2020 .....	22
Figure 21. Community Scale – Annual Commercial Sector Contributions – 2013-2020.....	22
Figure 22. Community Scale – Annual Residential Sector Contributions – 2013-2020 .....	23
Figure 23. Community Scale – Percentage of Total Emissions by Sector – 2013-2020.....	24

# 2020 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 2020 city operations and community wide GHG inventory.

## Greenhouse Gas Inventory Tool

The 2020 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 scale 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 2018 were provided in 2020). 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 (RFCW, 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>

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<sup>1</sup> <http://icleiusa.org/clearpath/>. (Accessed August 11, 2020)

<sup>2</sup> <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid>. (Accessed August 11, 2020)

## Changes in Model or Methodology

The methodology utilized in the 2020 GHG Inventory is the same as in the 2019 GHG Inventory unless mentioned in this section. Significant changes to the model or methodology are noted below:

- Two changes were made regarding solid waste starting in 2019:
  - Solid waste was characterized utilizing a study from Ohio EPA<sup>3</sup> rather than using the national average.
  - A new methodology for calculating the impact of methane from landfills was utilized in this inventory. In previous inventories, emissions from the decomposition of solid waste only included those that occurred in that reporting year. However, decomposition occurs over multiple years releasing methane at varying rates throughout that time period. The methodology utilized in the 2019 and 2020 Inventory utilizes the methodology recommended by ICLEI.
- US EPA currently assumes a methane leakage (fugitive emissions) rate of 1.4%.<sup>4</sup> Previous City of Columbus GHG Inventories, when included, have used 0.3%. The 2019 and 2020 Inventory utilizes a 0.5% fugitive emissions rate to begin to bring reporting in-line with available data. This value should be updated if and when more accurate data become available.
- A sector breakdown of natural gas consumption is no longer available. Sector attribution is an estimate for this fuel. The methodology for this estimation is included in Appendix C.
- US EPA updated eGRID values for RFCW (eGRID 2018v2) provide a CO<sub>2</sub>e lbs/MWh of 1174.03, whereas eGRID 2019 provides 1074.41 lbs/MWh for CO<sub>2</sub>e. This is an 8.5% reduction in the emissions associated with electricity generation. This is a result of less coal being utilized to generate electricity in the sub-region.
- Water and Wastewater input values include natural gas and electricity consumption. The values are also included (inherently) in the values provided by Columbia Gas of Ohio and DPU. In previous analyses, these values should have been backed out and were not, resulting in a double counting of emissions in the commercial and industrial sectors. This has been corrected in the 2020 Inventory but has not been recalculated for previous inventories.

## 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 global warming potential (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 Intergovernmental

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<sup>3</sup> <https://www.epa.state.oh.us/Portals/41/OMM/Ohio-Waste-Characterization-Recycling-Economics-Report.pdf?ver=2019-08-29-123006-543>. (Accessed August 11, 2020)

<sup>4</sup> <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016>. (Accessed August 11, 2020)

Panel on Climate Change (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 Fourth Assessment Report. GWP values available in the Fifth Assessment Report are used for the 2018 through 2020 GHG Inventories.

## Sectors Included

The following sectors are included in the 2020 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 SCALE INVENTORY

Sectors – Community Scale 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



## 2020 Government Operations Emissions

Government operations contributed 330,566 metric tons of CO<sub>2</sub>e in 2020. This represents a 2% decrease from 2019. Green Memo III<sup>5</sup> utilizes 2005 as a benchmark for city initiatives impacting city operations.<sup>6</sup> 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 through 2015 has leveled off from 2016 to 2020, or slightly increased. This is a significant accomplishment as population increased over 13% during the same time period.

Compared to 2005, emissions have decreased over 19%. On a per capita basis, which would offer a leveled view of the City's efficiency in providing services, government operations created 0.36 metric tons of CO<sub>2</sub>e per person in 2020, a 34% decrease per capita from 2005.

FIGURE 1. GOVERNMENT OPERATIONS – TOTAL EMISSIONS – 2020

### City of Columbus

#### Government Operations CO<sub>2</sub>e Emissions

Total Emissions in Metric Tons of CO<sub>2</sub>e  
2020

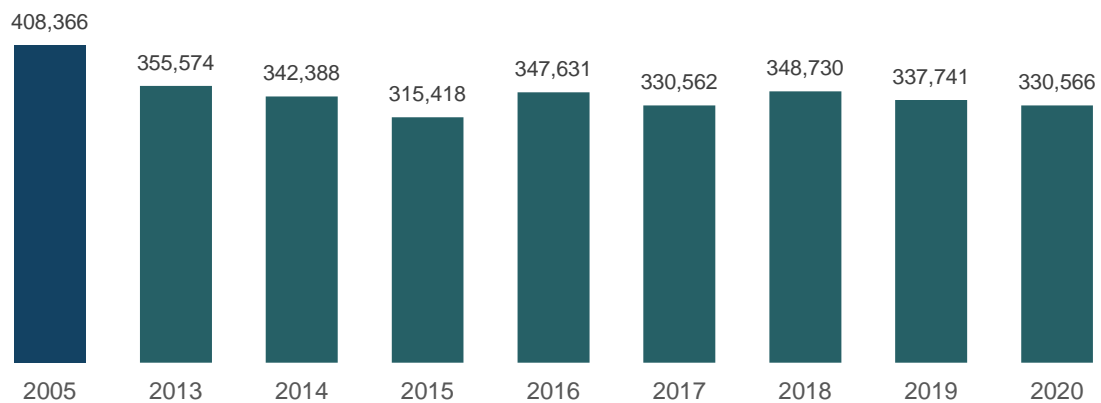


TABLE 3. GOVERNMENT OPERATIONS ANNUAL EMISSIONS BY SECTOR<sup>7</sup>

Government Operations Annual Emissions (Metric tons CO <sub>2</sub> e)	2005	2013	2014	2015	2016	2017	2018	2019	2020
Buildings & Facilities	87,931	76,431	87,309	79,818	88,451	81,284	86,011	75,347	63,071
Street Lights & Traffic Signals	29,134	26,749	32,442	31,788	30,471	21,616	25,265	18,733	23,587
Vehicle Fleet	33,965	30,281	29,459	26,184	23,587	22,564	23,473	23,445	20,141
Solid Waste Facilities	97,245	97,218	98,597	102,290	108,272	110,308	111,721	122,917	133,148
Water & Wastewater Treatment Facilities	160,091	124,895	94,582	75,337	96,851	94,790	102,259	97,300	90,619
<b>Total Emissions (Metric tons CO<sub>2</sub>e)</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>	<b>337,741</b>	<b>330,566</b>

<sup>5</sup> <https://www.columbus.gov/Templates/Detail.aspx?id=2147506164>. (Accessed August 11, 2020)

<sup>6</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.

<sup>7</sup> Totals may differ due to rounding.

FIGURE 2. GOVERNMENT OPERATIONS – EMISSIONS PER CAPITA – 2020

## City of Columbus Government Operations CO<sub>2</sub>e Emissions

Metric Tons of CO<sub>2</sub>e per Capita  
2020

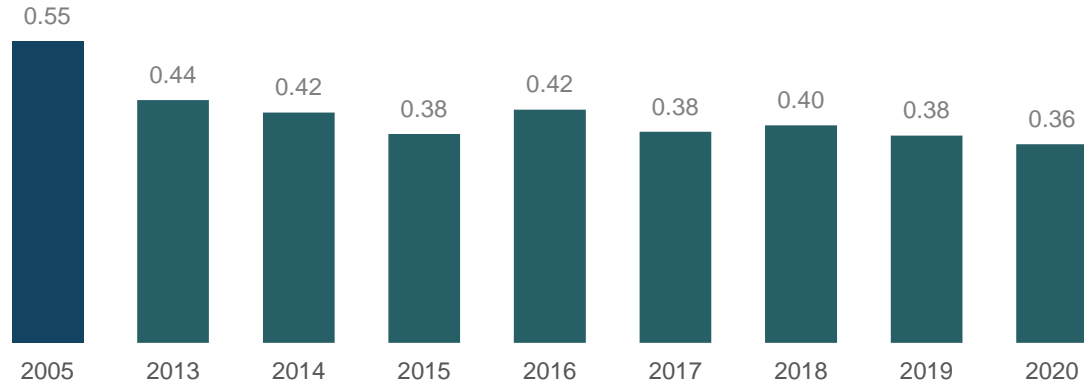


TABLE 4. GOVERNMENT OPERATIONS – ANNUAL EMISSIONS PER CAPITA

Government Operations Annual Emissions	2005	2013	2014	2015	2016	2017	2018	2019	2020
Population	743,511	805,348	817,383	829,690	818,912	861,141	880,828	895,877	914,850
Buildings & Facilities	0.12	0.09	0.11	0.10	0.11	0.09	0.10	0.08	0.07
Street Lights & Traffic Signals	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.02	0.03
Vehicle Fleet	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Solid Waste Facilities	0.13	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.15
Water & Wastewater Treatment Facilities	0.22	0.16	0.12	0.09	0.12	0.11	0.12	0.11	0.10
Total Emissions per Capita (Metric tons CO <sub>2</sub> e)	0.55	0.44	0.42	0.38	0.42	0.38	0.40	0.38	0.36

## Sector relative emissions contributions

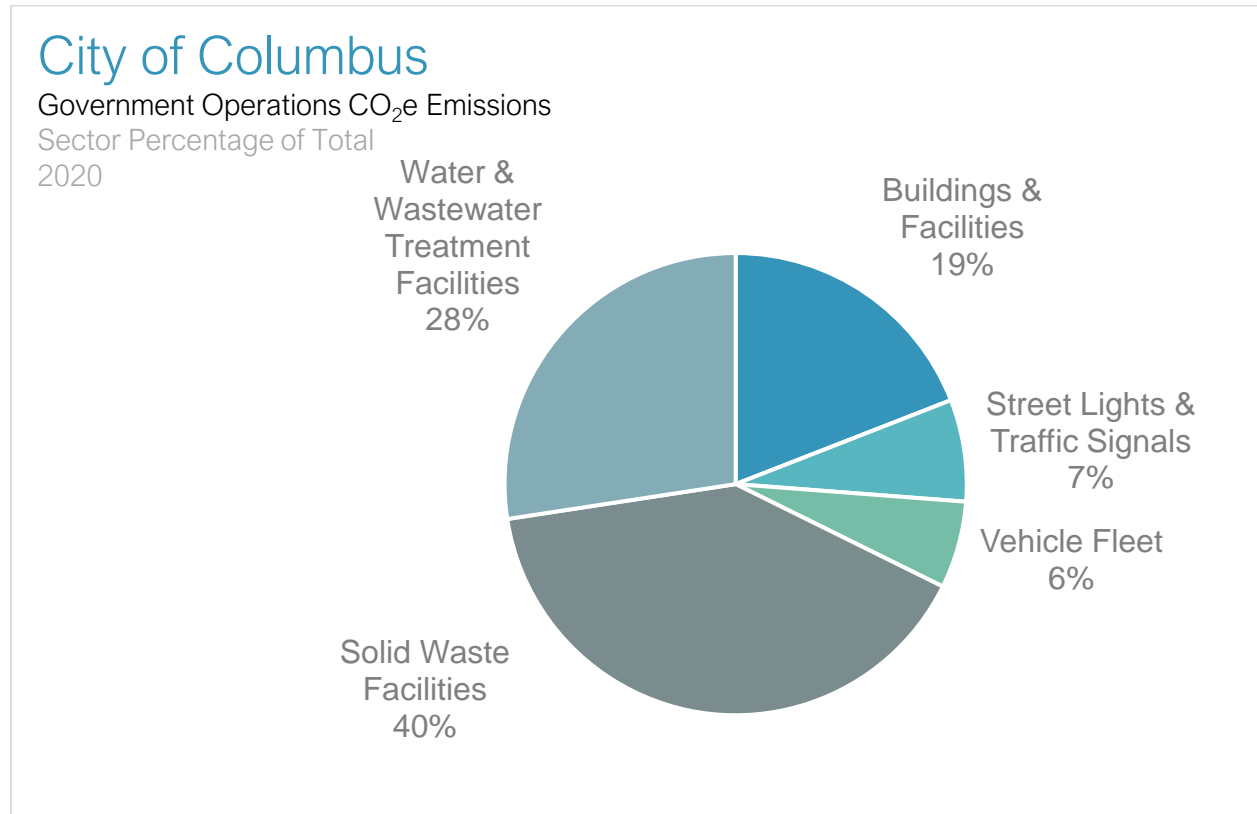
Emissions are relative to the fuel being consumed directly, the primary fuel mix of the electricity consumed, and the processes that occur during operations. Providing for the water and waste needs of a city are often the greatest contributors to emissions when looking at government operations alone. Both services have higher energy use intensities in their operations, and each produces emissions as a byproduct of their processes. In 2020, solid waste facilities and water service facilities accounted for 68% of emissions from government operations (40% and 28%, respectively). The increase in solid waste emissions is primarily due an 8% increase in the tonnage of waste delivered to the landfill.

Despite a lower energy use intensity and minimal emission byproducts of operations, city-owned buildings and facilities are still responsible for a large portion of emissions from city government operations (19%). As City of Columbus Fleets are primarily reliant on gasoline and diesel as fuel sources, fleet vehicles accounted for 6% of emissions from government operations.

The increase in emissions from street lights and traffic signals is most likely due to corrections in the attribution of accounts to this sector instead of buildings and facilities and likely accounts for some of the reduction in building emissions. The increase in emissions is directly related to the

higher energy use input value. Streetlights and traffic signals accounted for the remaining 6% of total City government operation emissions.

FIGURE 3. GOVERNMENT OPERATIONS – SECTOR PERCENTAGE OF TOTAL ANNUAL EMISSIONS – 2020



### Sector emissions contributions between 2005 and 2020

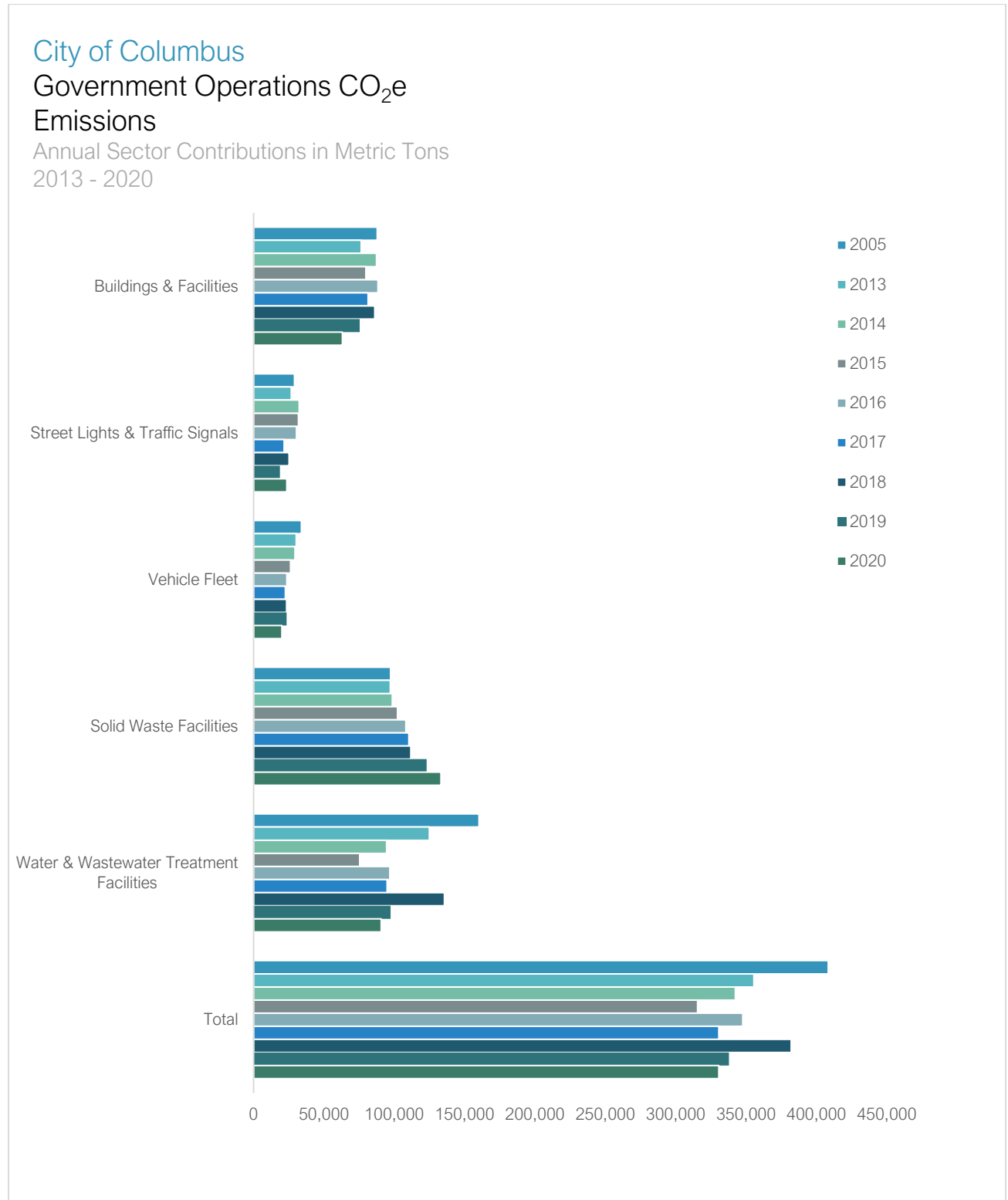
Nearly all sectors analyzed are currently producing fewer emissions in 2020 than they were in 2005. Only solid waste facilities produce more CO<sub>2</sub>e emissions in 2020 than in 2005, most of which can be accounted for in population growth and methodology changes that weighs methane heavier than in 2005.

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

Government Operations Emissions	Percent Change in Total Emissions 2005 to 2020	Percent Change in Emissions per Capita 2005 to 2020
Buildings & Facilities	-28.3%	-41.7%
Street Lights & Traffic Signals	-19%	-34.2%
Vehicle Fleet	-40.7%	-51.8%
Solid Waste Facilities	36.9%	11.3%
Water & Wastewater Treatment Facilities	-43.4%	-54%
<b>Total Emissions</b>	<b>-19.1%</b>	<b>-34.2%</b>

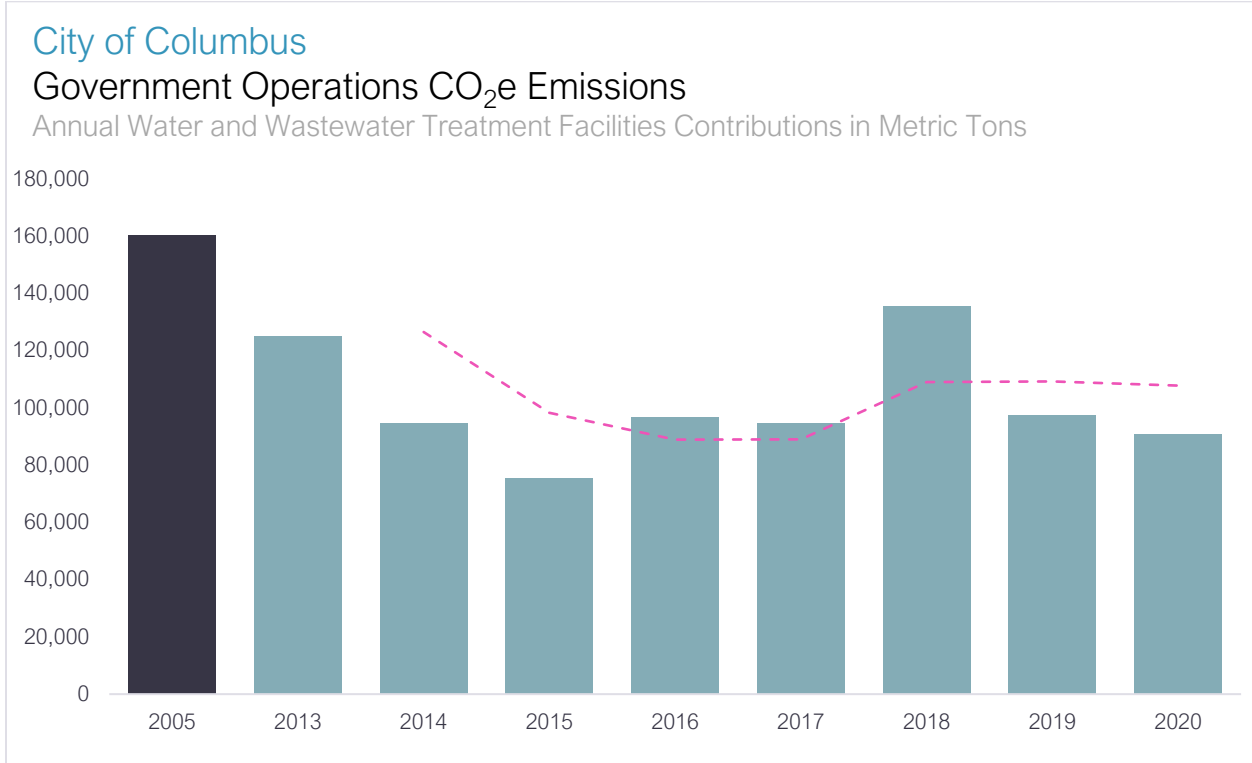
Annual emissions data for each sector are provided below with a three year moving average trend line for individual sectors. The benchmark year of 2005 is noted in dark blue.

FIGURE 4. GOVERNMENT OPERATIONS – ANNUAL SECTOR CONTRIBUTIONS – 2013-2020<sup>8</sup>

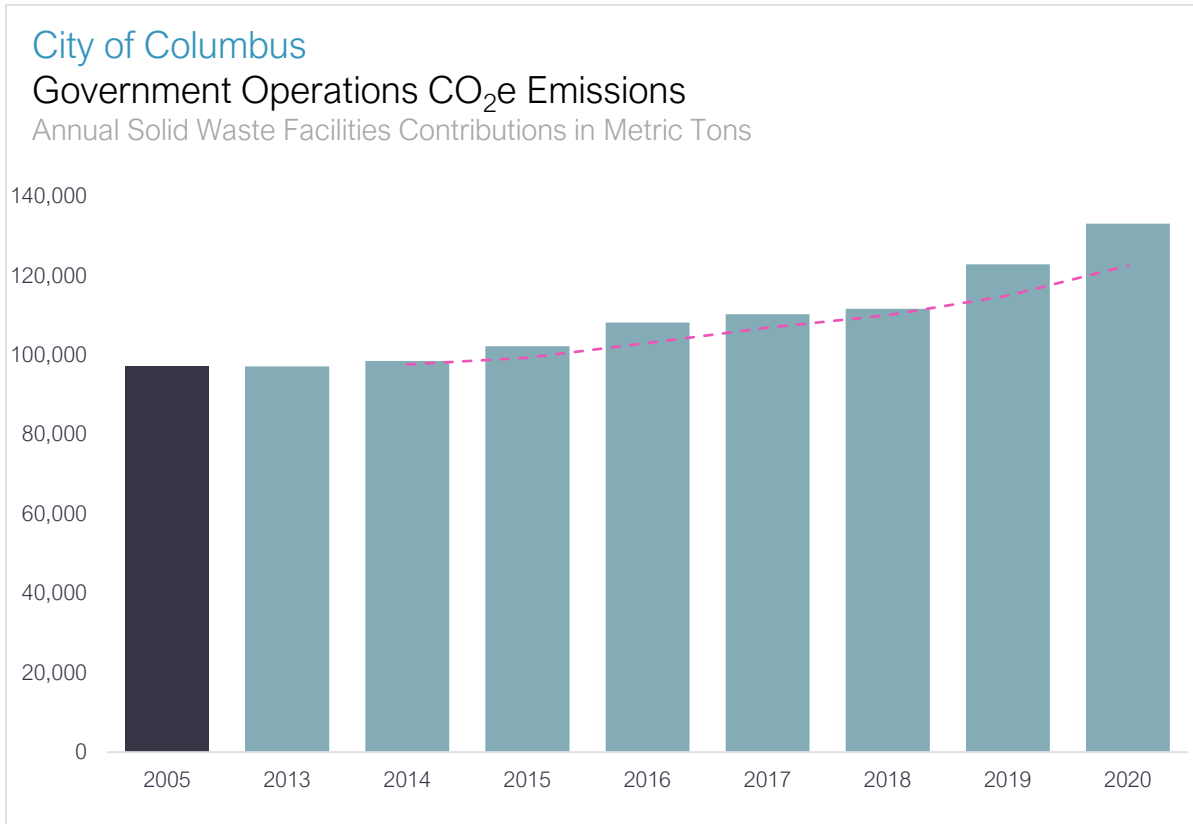


<sup>8</sup> Emissions from energy use at Waste and Wastewater Treatment Facilities is included in Buildings and Facilities in 2016. This methodology was corrected beginning in the 2017 City of Columbus Greenhouse Gas Inventory.

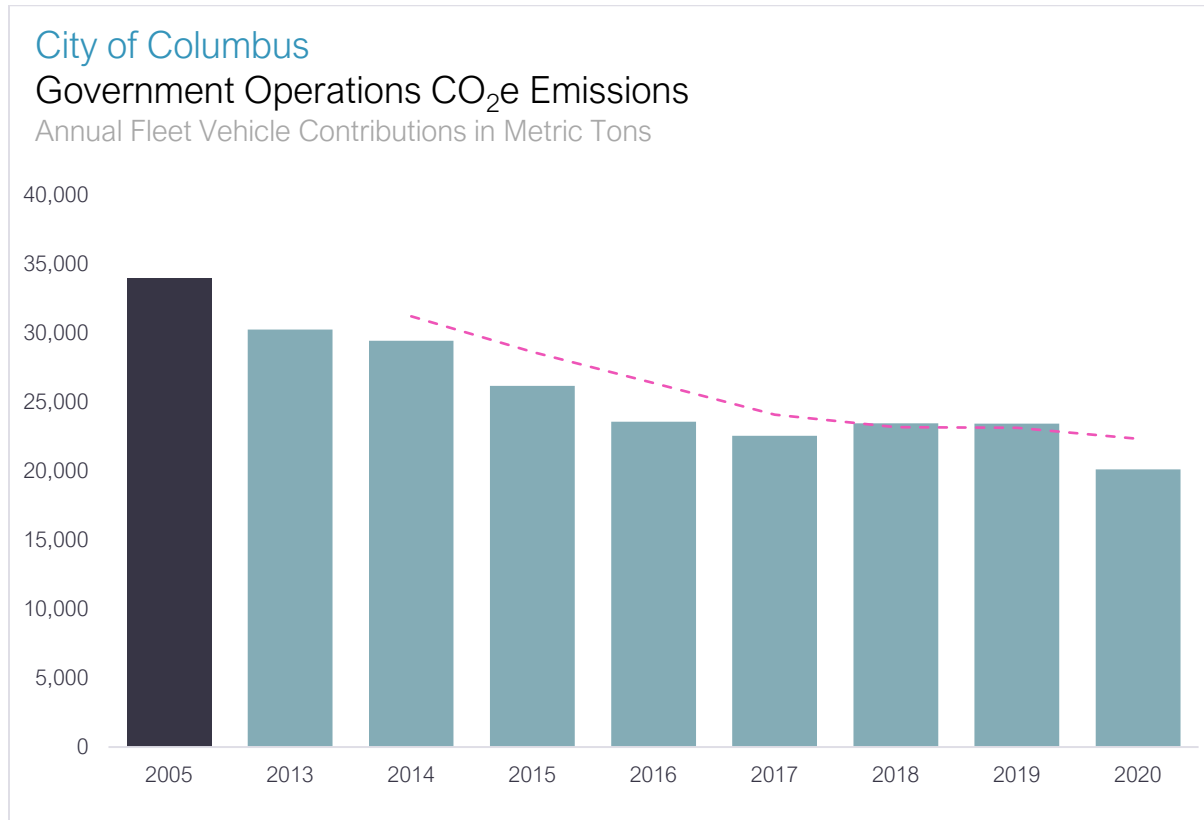
**FIGURE 5. GOVERNMENT OPERATIONS – ANNUAL WATER AND WASTEWATER TREATMENT FACILITIES CONTRIBUTIONS – 2013-2020**



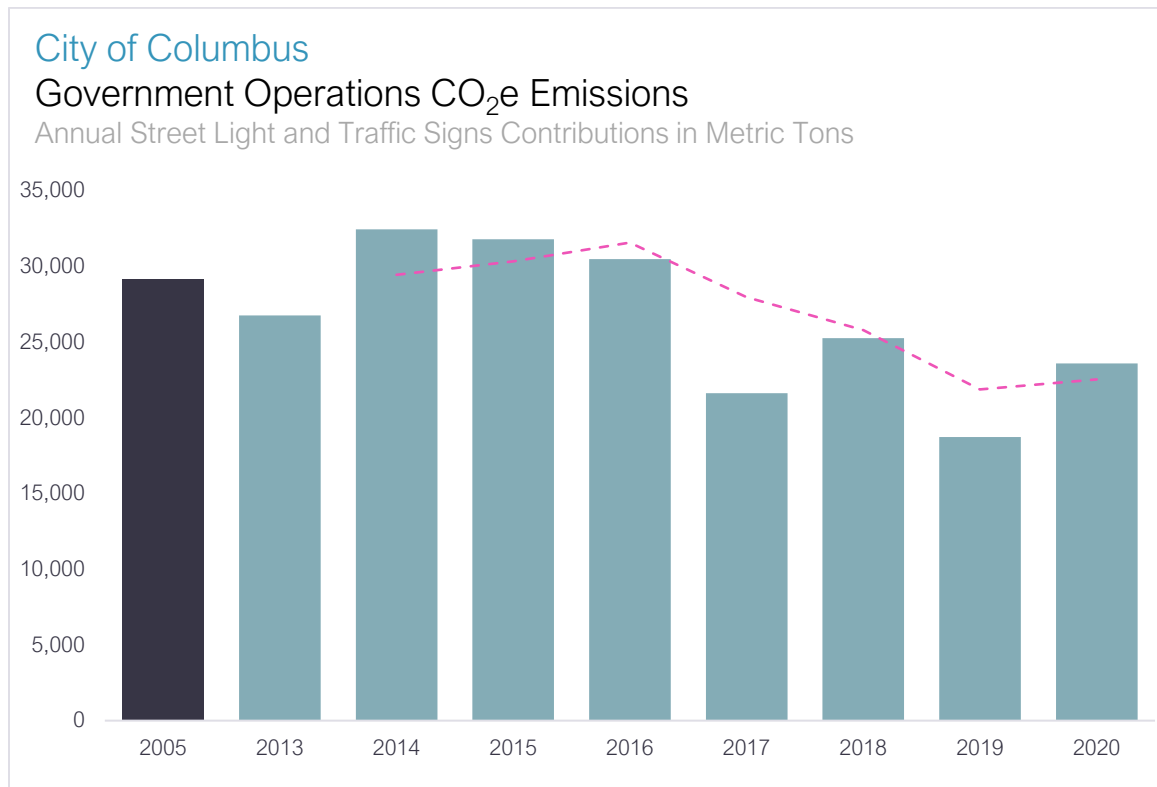
**FIGURE 6. GOVERNMENT OPERATIONS – ANNUAL SOLID WASTE FACILITIES CONTRIBUTIONS – 2013-2020**



**FIGURE 7. GOVERNMENT OPERATIONS – ANNUAL FLEET VEHICLE CONTRIBUTIONS – 2013-2020**



**FIGURE 8. GOVERNMENT OPERATIONS – ANNUAL STREET LIGHT AND TRAFFIC SIGNS CONTRIBUTIONS – 2013-2020**



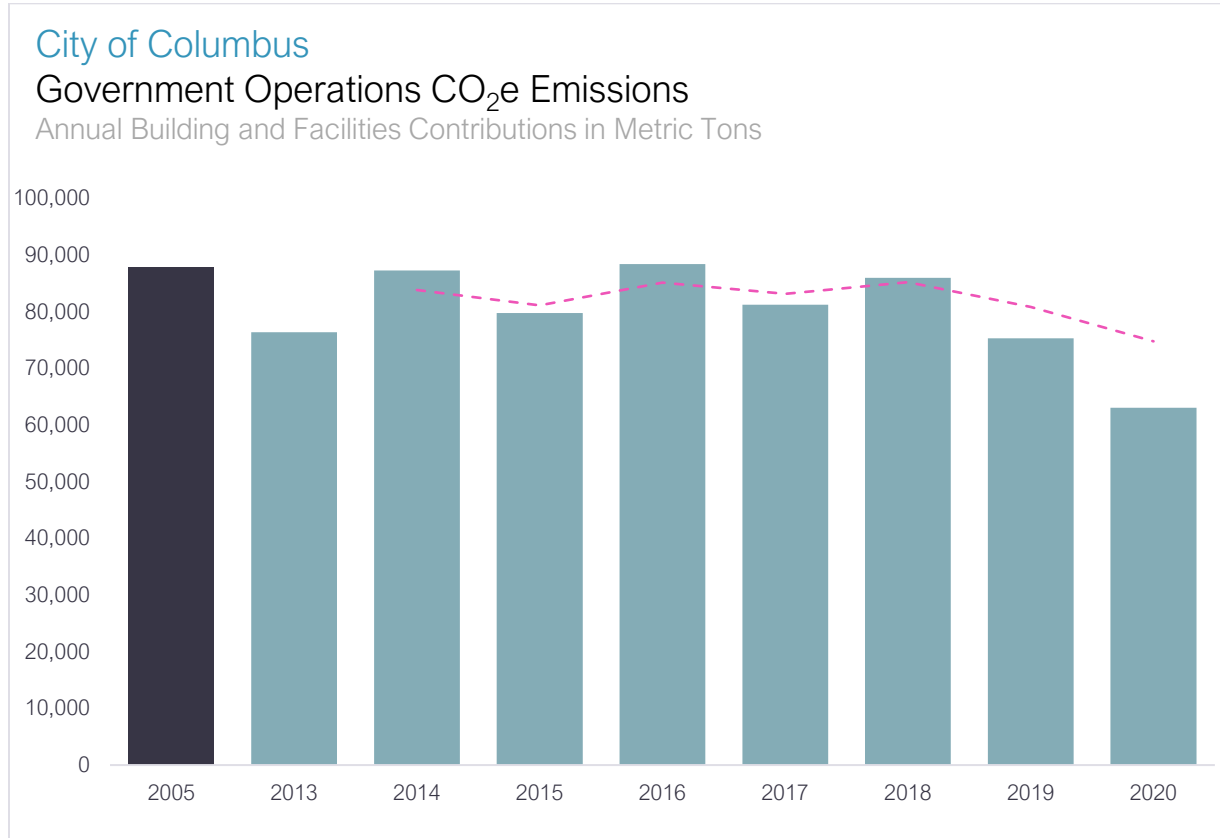
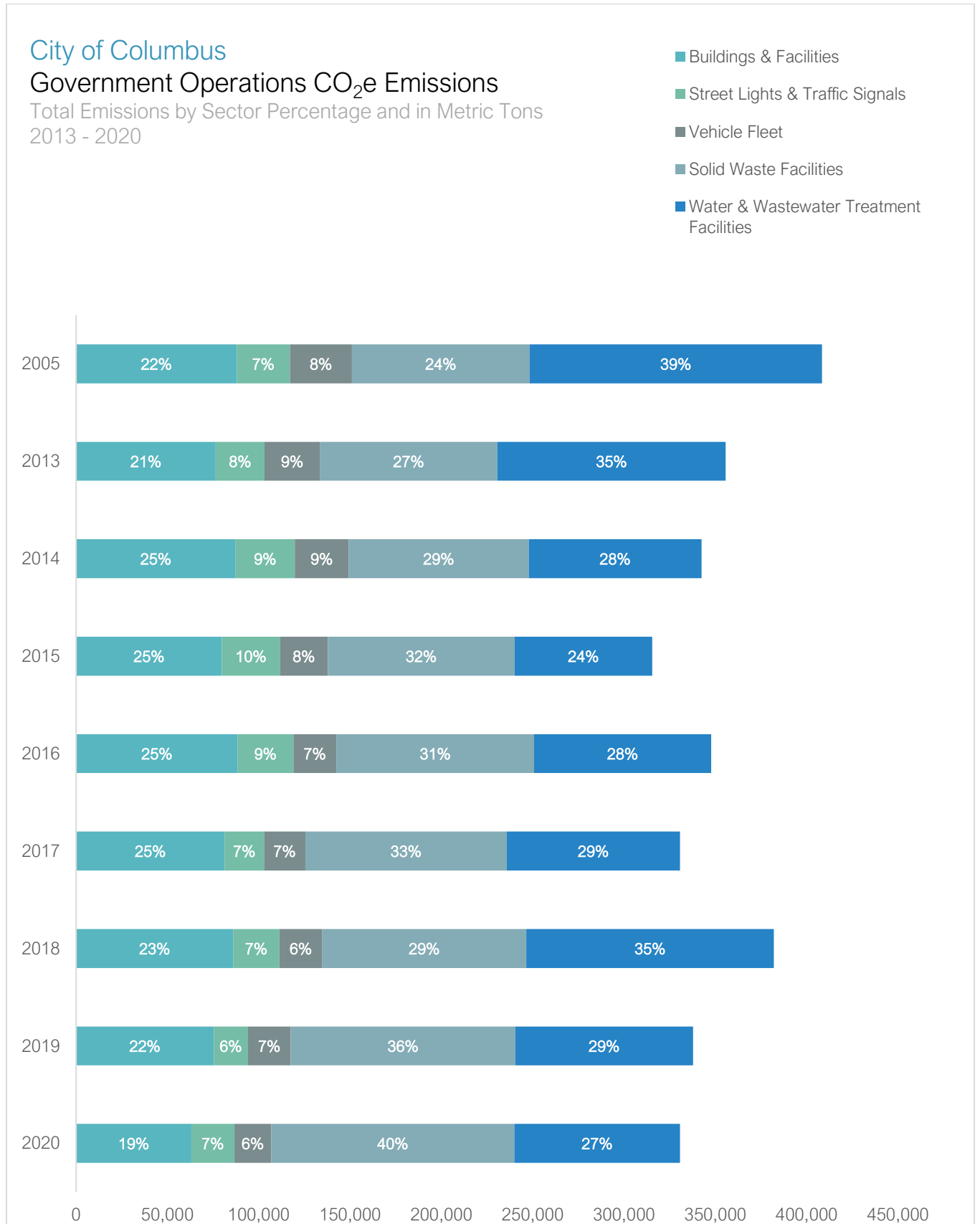
**FIGURE 9. GOVERNMENT OPERATIONS – ANNUAL BUILDING AND FACILITIES CONTRIBUTIONS – 2013-2020**

FIGURE 10. GOVERNMENT OPERATIONS – PERCENTAGE OF TOTAL EMISSIONS BY SECTOR – 2013-2020

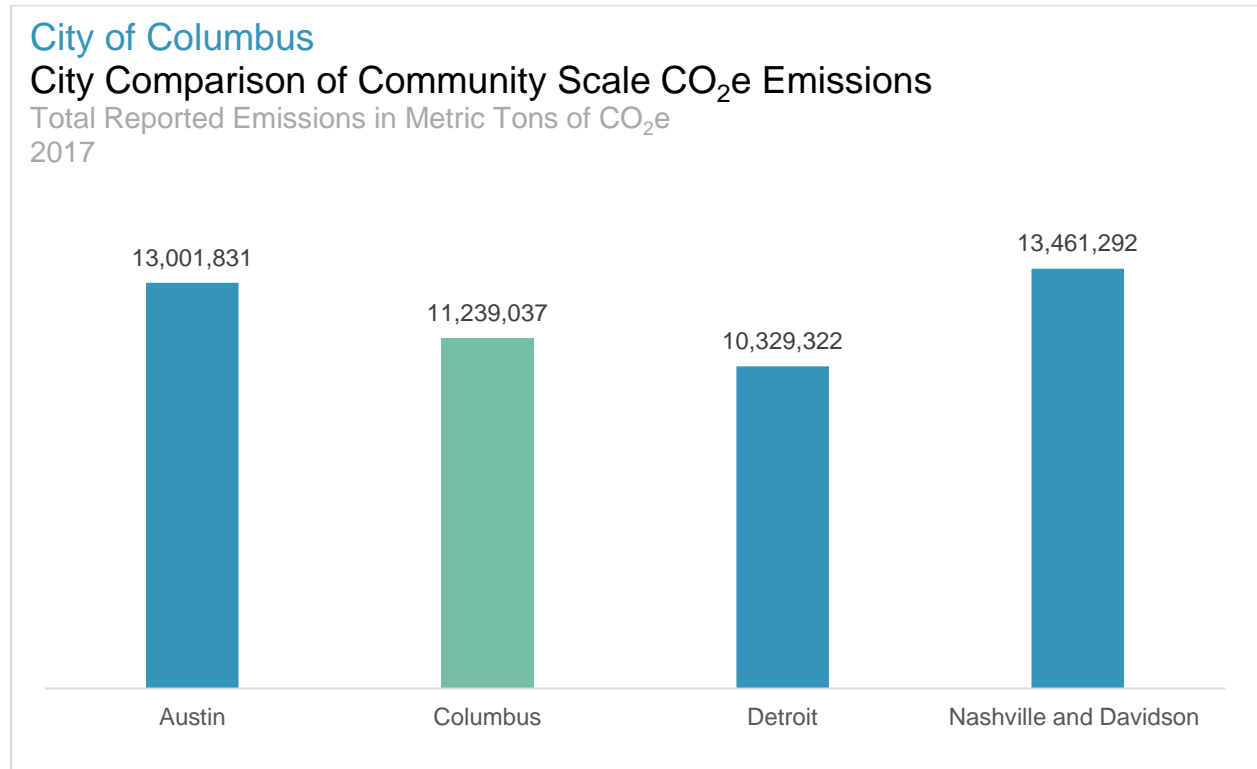




## 2020 Community-Wide Emissions

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 9,393,744 metric tons of CO<sub>2</sub>e in 2020. This represents a 16% decrease from 2019. Green Memo III<sup>9</sup> utilizes 2013 as a benchmark for community-wide emissions. When considering the total emissions community-wide from 2013 to 2018, 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. However, the 5% reduction in emissions in 2019 suggested a downward trend was developing. The further 14% reduction in emissions in 2020 reinforces this trend but also reflects unique changes in energy use during the pandemic. It is important to note that population increased over 13% from 2013 to 2020. That emissions have remained stable despite such significant growth in the city is a notable accomplishment.

Compared to 2013, total emissions have decreased by almost 16%. On a per capita basis, the community of Columbus creates 10.27 metric tons of CO<sub>2</sub>e per person, a nearly 16% decrease in the per capita emissions from 2019, and a nearly 26% decrease in emissions per capita from 2013.

<sup>9</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 SCALE – TOTAL EMISSIONS – 2013-2020

City of Columbus  
 Community Scale CO<sub>2</sub>e Emissions  
 Total Emissions in Metric Tons of CO<sub>2</sub>e  
 2020

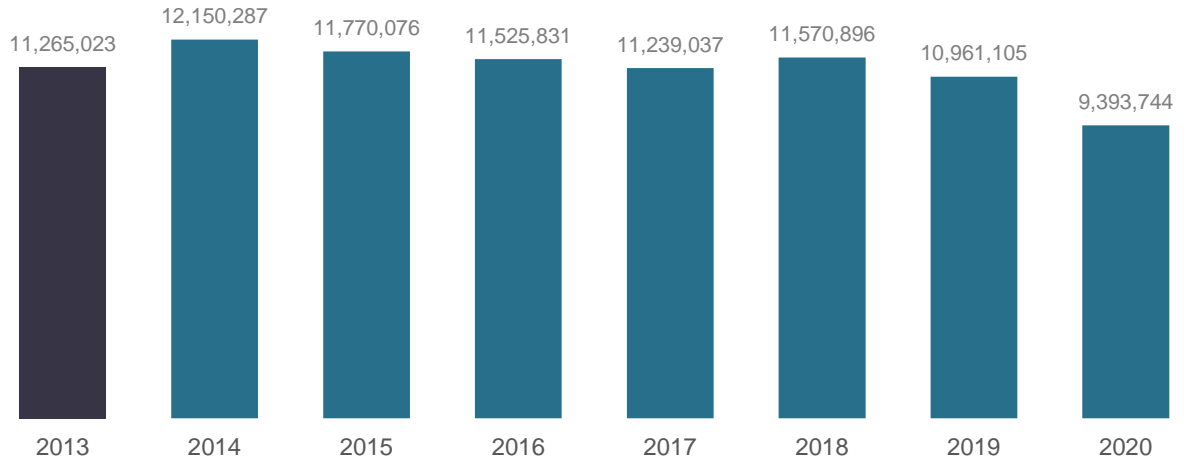


TABLE 6. COMMUNITY SCALE – TOTAL EMISSIONS BY SECTOR – 2013-2019

Community Scale Sector Emissions	2013	2014	2015	2016	2017	2018	2019	2020
Residential Energy	2,641,935	3,020,841	2,700,722	2,614,721	2,423,504	2,763,887	2,492,497	2,406,417
Commercial Energy	4,883,764	4,640,654	4,216,227	4,170,874	3,748,313	3,573,927	3,343,330	2,759,194
Industrial Energy	287,152	713,266	657,967	626,048	611,877	371,757	347,443	139,625
Transportation	3,015,878	3,365,275	3,796,842	3,696,430	4,029,621	4,373,857	4,292,211	3,615,510
Solid Waste	249,007	249,877	244,372	263,633	275,496	332,321	304,904	307,564
Fugitive Emissions	59,171	63,481	57,928	56,682	55,435	52,887	83,420	74,815
Water/Wastewater	128,116	96,893	96,017	97,444	94,790	102,259	97,300	90,619
<b>Total Emissions (Metric tons CO<sub>2</sub>e)</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>	<b>10,961,105</b>	<b>9,393,744</b>

FIGURE 13. COMMUNITY SCALE – EMISSIONS PER CAPITA – 2013-2020

City of Columbus  
Community-Wide CO<sub>2</sub>e Emissions  
Metric Tons of CO<sub>2</sub>e per Capita  
2020

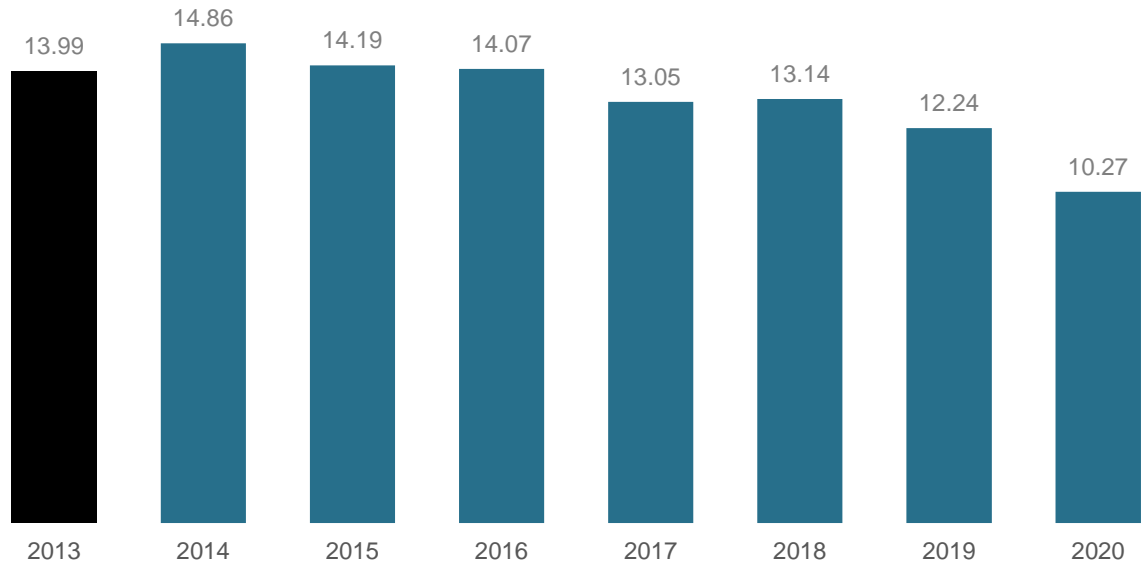


TABLE 7. COMMUNITY SCALE – EMISSIONS PER CAPITA – 2013-2019

Community Scale Sector Emissions	2013	2014	2015	2016	2017	2018	2019	2020
Population	805,348	817,383	829,690	818,912	861,141	880,828	895,877	914,850
Residential Energy	3.28	3.70	3.26	3.19	2.81	3.14	2.78	2.63
Commercial Energy	6.06	5.68	5.08	5.09	4.35	4.06	3.73	3.02
Industrial Energy	0.36	0.87	0.79	0.76	0.71	0.42	0.39	0.15
Transportation	3.74	4.12	4.58	4.51	4.68	4.97	4.79	3.95
Solid Waste	0.31	0.31	0.29	0.32	0.32	0.38	0.34	0.34
Fugitive Emissions	0.07	0.08	0.07	0.07	0.06	0.06	0.09	0.08
Water/Wastewater	0.16	0.12	0.12	0.12	0.11	0.12	0.11	0.10
<b>Total Emissions (Metric tons CO<sub>2</sub>e)</b>	<b>13.99</b>	<b>14.86</b>	<b>14.19</b>	<b>14.07</b>	<b>13.05</b>	<b>13.14</b>	<b>12.24</b>	<b>10.27</b>

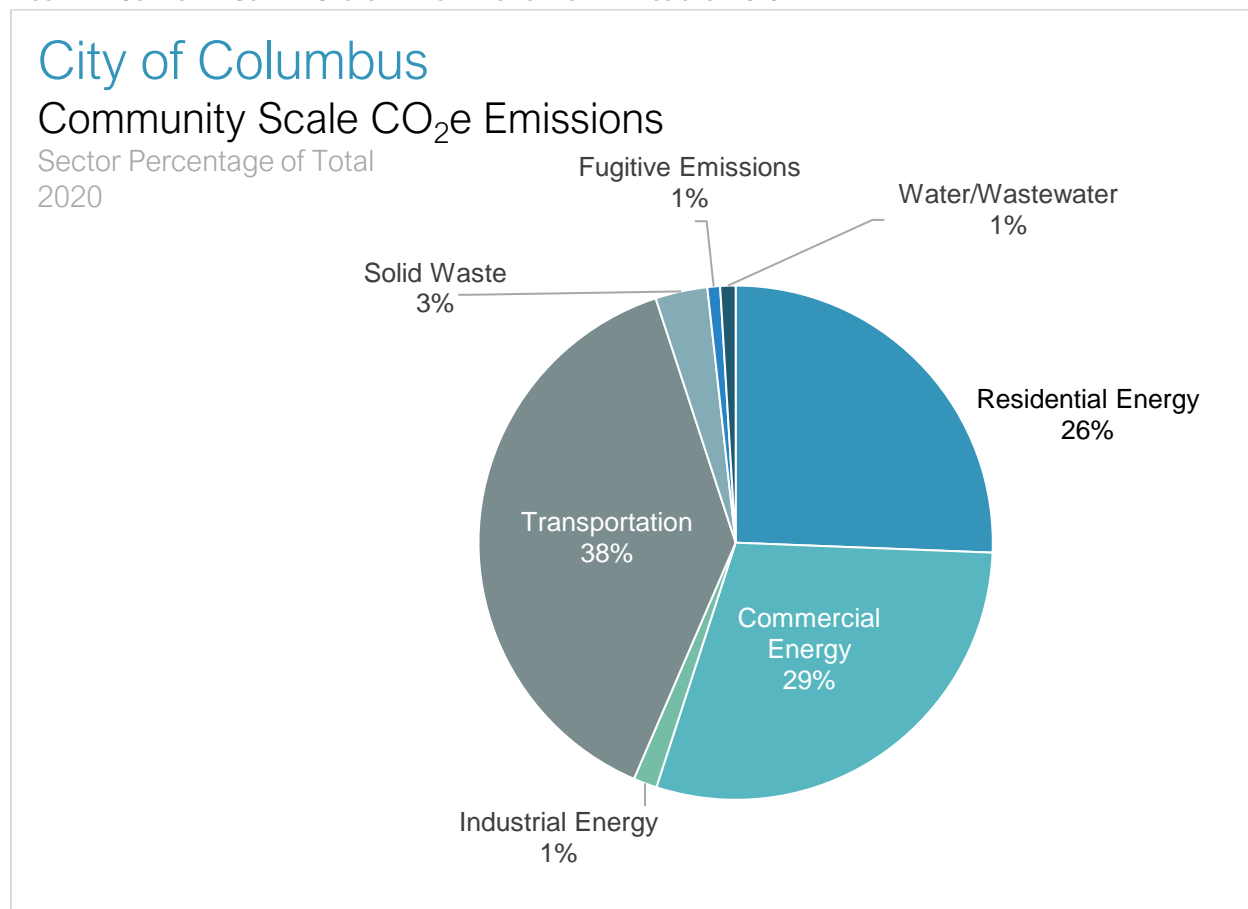
## Sector relative emissions contributions

In 2017, 2018, 2019, and 2020 the transportation sector accounts for the greatest portion of emissions on a community-wide basis (38%, in 2020). In typical years, this dominance is associated with a 78% single-occupancy vehicle rate as well as increasing population leading to increasing congestion and commute times. Increasing vehicle efficiency and adoption of fuel-efficient and alternative fuel vehicles is not expected to offset the increase in vehicles on the road. In 2020, the pandemic resulted in an overall decrease of 18% in fuel use in the transportation sector. However, the resulting emissions reduction was similar in proportion to those seen in

residential and commercial energy, resulting in a similar distribution of emissions among the sectors as previous years.

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 (29% and 26%, respectively). There was a slight increase in emissions from the residential sector as would be expected during the pandemic with increased residential occupation. The industrial sector accounts for 1% of total emissions in 2020, which is in line with its contribution to the City's economic activity. Solid waste and water services make up 3% of emissions, with the final 1% being accounted for by process and fugitive emissions.

FIGURE 14. COMMUNITY SCALE – SECTOR PERCENTAGE OF TOTAL EMISSIONS - 2020



## Sector emissions contributions between 2013 and 2020

Columbus is experiencing a relatively low emissions rate compared to historical values. The City's population has grown more than 13% since 2013, while the metropolitan statistical area for Columbus experienced an 11% growth in gross domestic product 2013 to 2020<sup>10</sup>. In 2020, more than half of the community sectors were emitting less greenhouse gases than in 2013, and most

<sup>10</sup> According to the Bureau of Economic Analysis <https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1>. (Accessed August 11, 2020)

were doing so at a lower rate per person than has been seen in most previous analyses for Columbus.

TABLE 8. COMMUNITY SCALE – PERCENT CHANGE IN EMISSIONS FROM 2013

Community Scale Emissions	Percent Change in Total Emissions 2013 to 2020	Percent Change in Emissions per Capita 2013 to 2020
Residential Energy	-8.9%	-19.8%
Commercial Energy	-43.5%	-50.3%
Industrial Energy	-51.4%	-57.2%
Transportation	19.9%	5.5%
Solid Waste	23.5%	8.7%
Fugitive Emissions	26.4%	11.3%
Water/Wastewater	-29.3%	-37.7%
<b>Total Emissions</b>	<b>-16.6%</b>	<b>-26.6%</b>

In 2020, all sectors saw lower emissions from the previous year except for solid waste. For the waste sector, this is partly due to a new methodology in calculating emissions due to solid waste and an updated global warming potential value for methane (both discussed earlier in the report), but also partly due to a 4% increase in waste tonnage over 2019.

Residential energy use emissions declined from 2019 to 2020. Despite a 3% increase in electricity use, less coal being utilized to generate electricity in the region lead to lower emissions in generating this electricity.

Commercial and Industrial energy use emissions both decreased from 2019 due to reductions in energy use during the pandemic. These values were also impacted by correcting for double-counting of electricity and natural gas use at water and wastewater facilities as discussed earlier in the report.

Emissions from transportation decreased for all fuel types from 2019 to 2020 due to the pandemic. Notably, passenger vehicle gasoline and freight diesel consumption, the two largest contributors to transportation emissions, decreased 18% and 6%, respectively. Previous to 2020, increases in emissions from the transportation sector consistently outpaced growth in population and economic activity. They remain 20% higher in 2020 than in 2013 despite the impact of the pandemic.

Fugitive emissions are a function of the quantity of natural gas used in the analysis area. Fugitive emissions decreased from 2019 due to a decrease in natural gas use. Emissions from water and wastewater facilities also decreased due to less coal being utilized to generate electricity in the region.

Annual emissions data for each sector are provided below with a three year moving average trend line for individual sectors. The benchmark year of 2013 is noted in dark blue.

FIGURE 15. COMMUNITY SCALE – ANNUAL SECTOR EMISSION CONTRIBUTIONS – 2013-2020

### City of Columbus Community Scale CO<sub>2</sub>e Emissions Annual Sector Contributions in Metric Tons 2013 - 2020

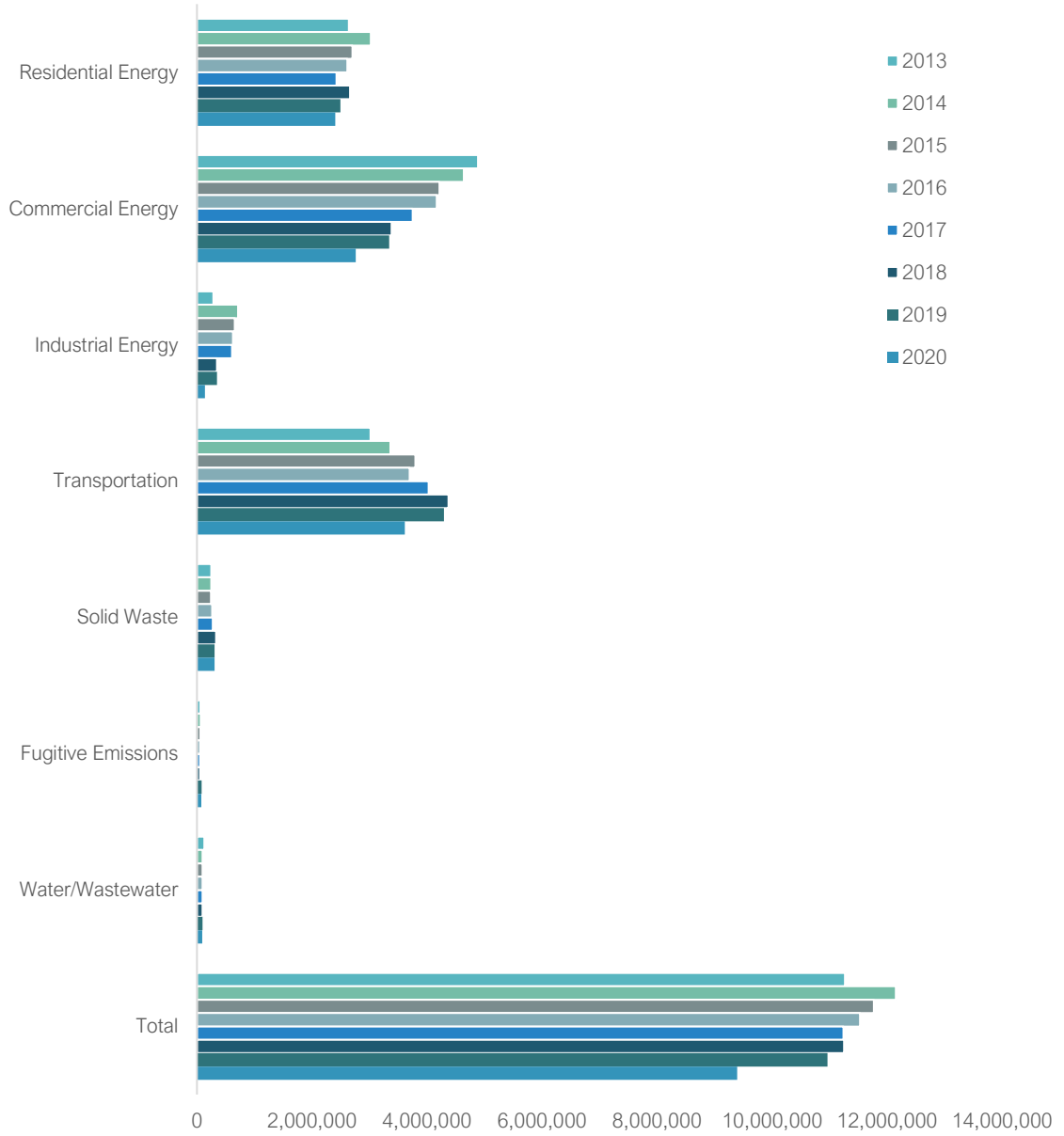


FIGURE 16. COMMUNITY SCALE – ANNUAL WASTE AND WASTEWATER SECTOR CONTRIBUTIONS – 2013-2020

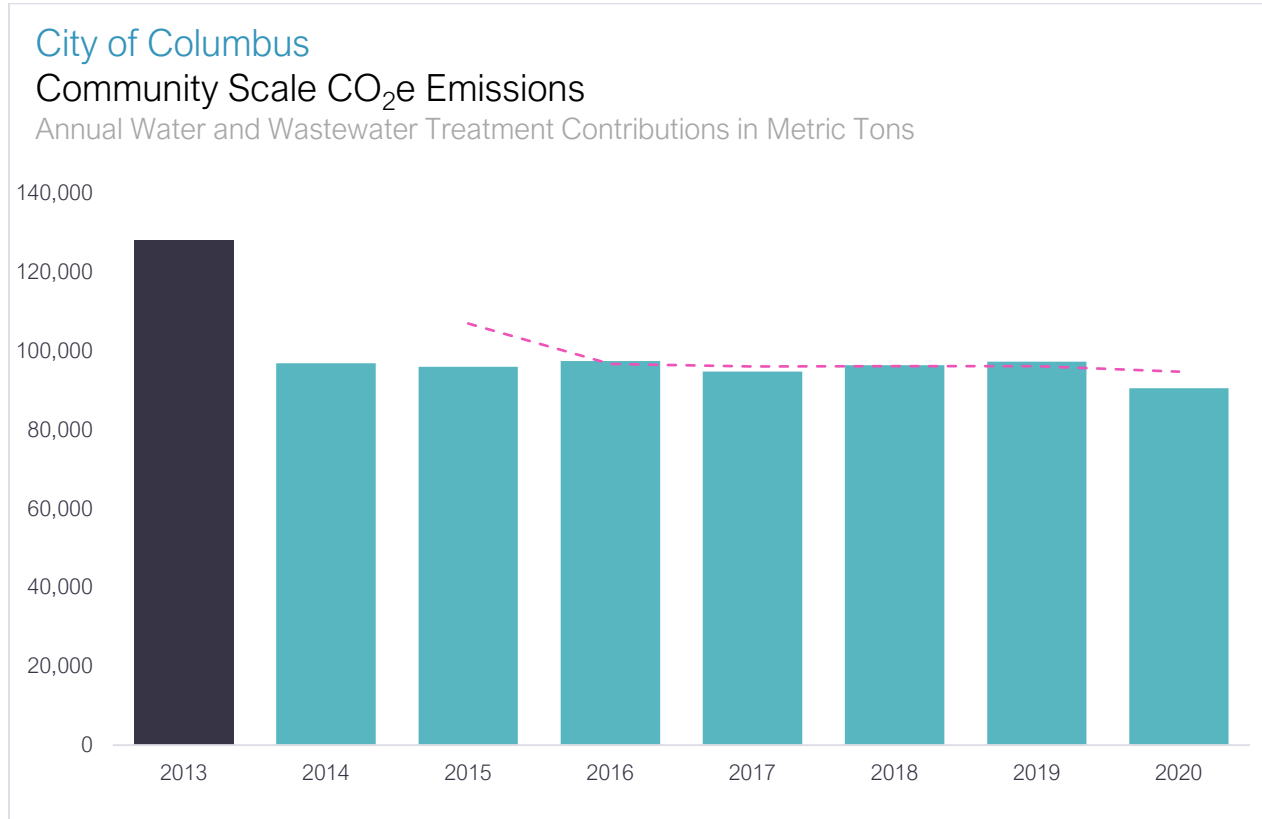
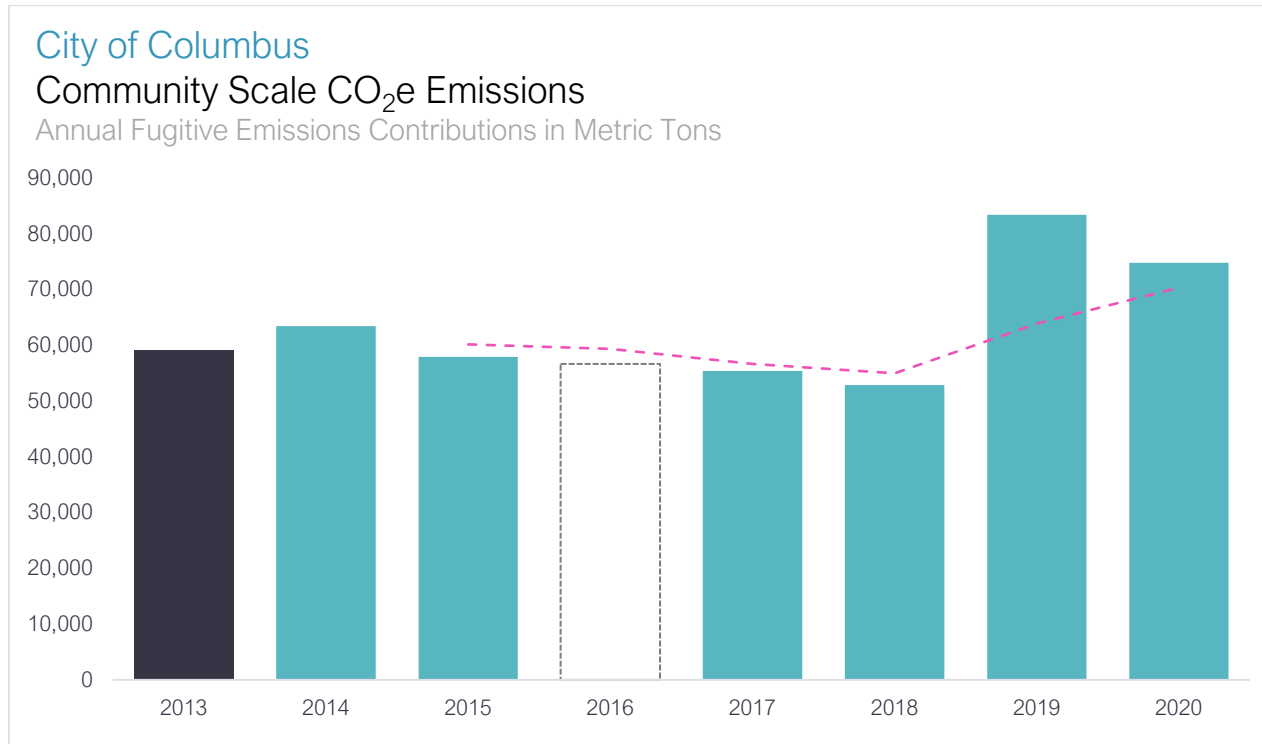
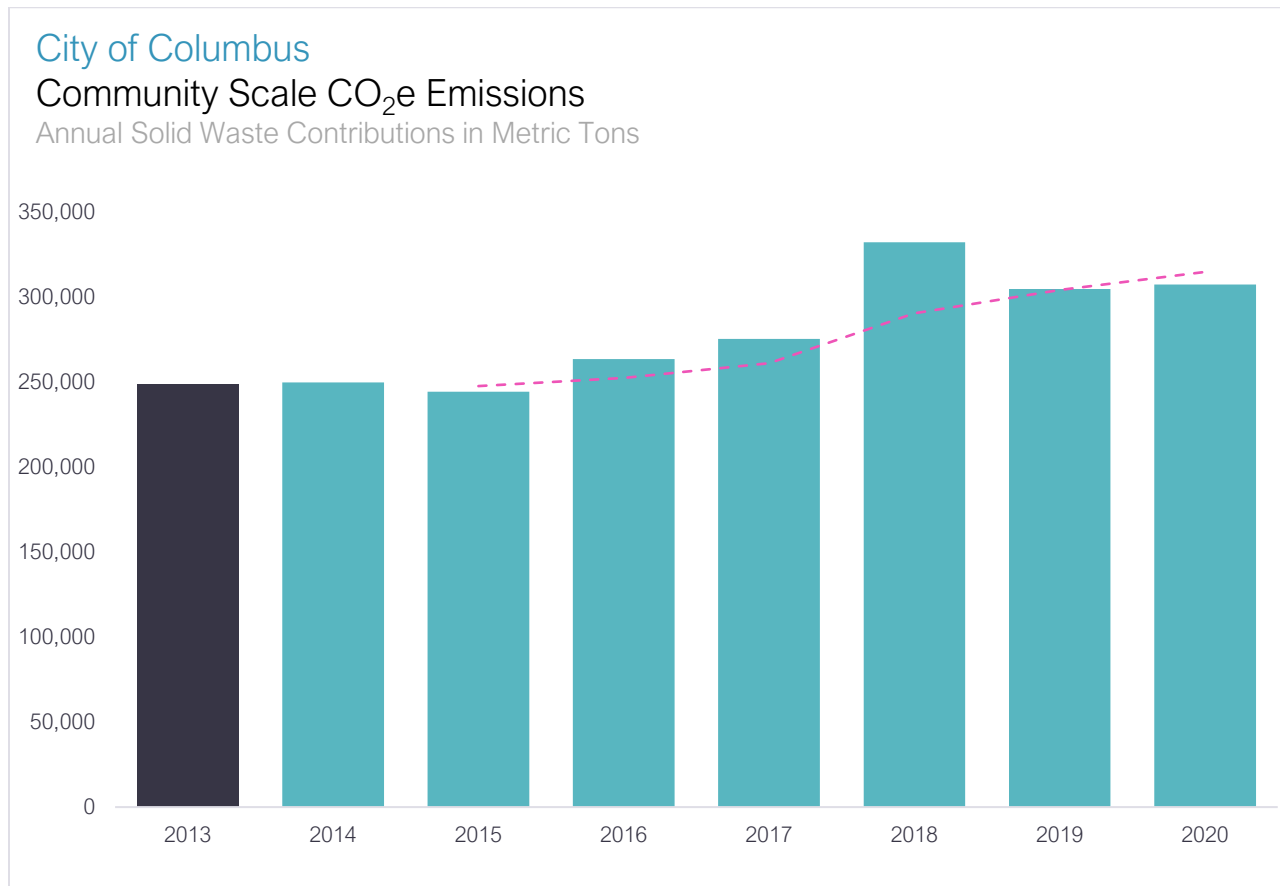


FIGURE 17. COMMUNITY SCALE – ANNUAL FUGITIVE EMISSION CONTRIBUTIONS – 2013-2020<sup>11</sup>



<sup>11</sup> Fugitive emissions were not calculated or included in the 2016 GHG Inventory. The dotted box represents an assumed value.

**FIGURE 18. COMMUNITY SCALE – ANNUAL SOLID WASTE SECTOR CONTRIBUTIONS – 2013-2020**



**FIGURE 19. COMMUNITY SCALE – ANNUAL TRANSPORTATION SECTOR CONTRIBUTIONS – 2013-2020**

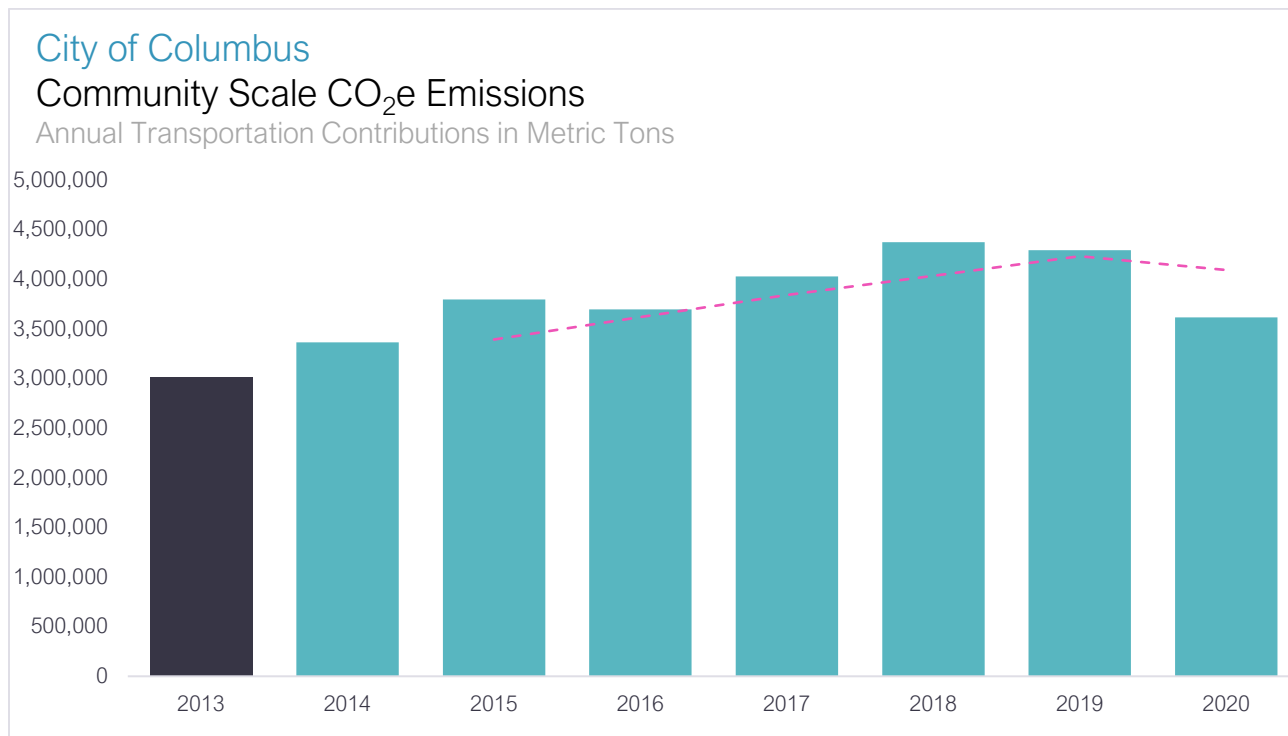




FIGURE 20. COMMUNITY SCALE – ANNUAL INDUSTRIAL SECTOR CONTRIBUTIONS – 2013-2020

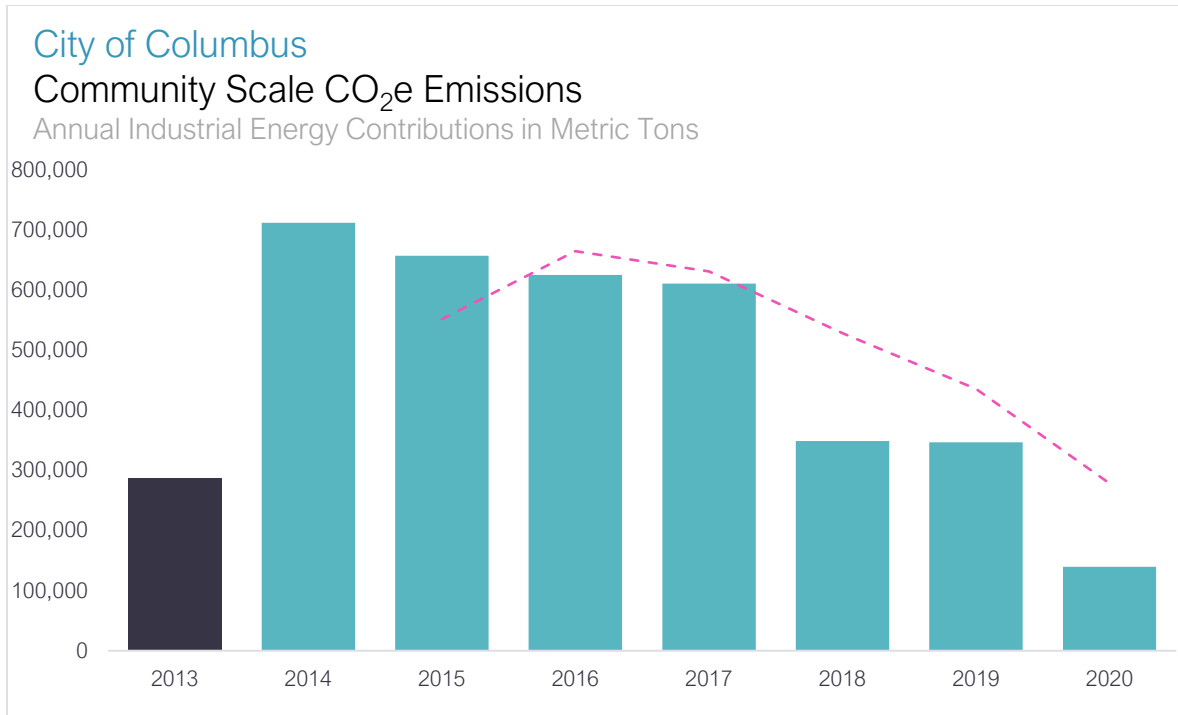


FIGURE 21. COMMUNITY SCALE – ANNUAL COMMERCIAL SECTOR CONTRIBUTIONS – 2013-2020

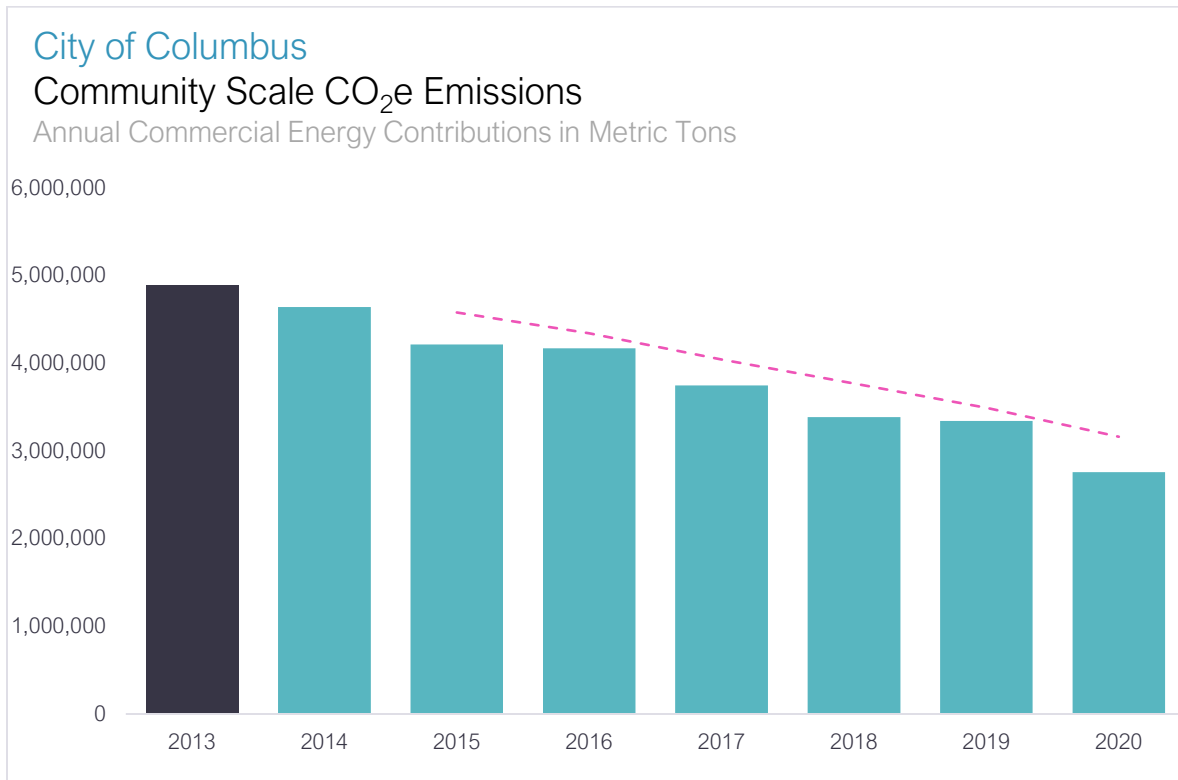


FIGURE 22. COMMUNITY SCALE – ANNUAL RESIDENTIAL SECTOR CONTRIBUTIONS – 2013-2020

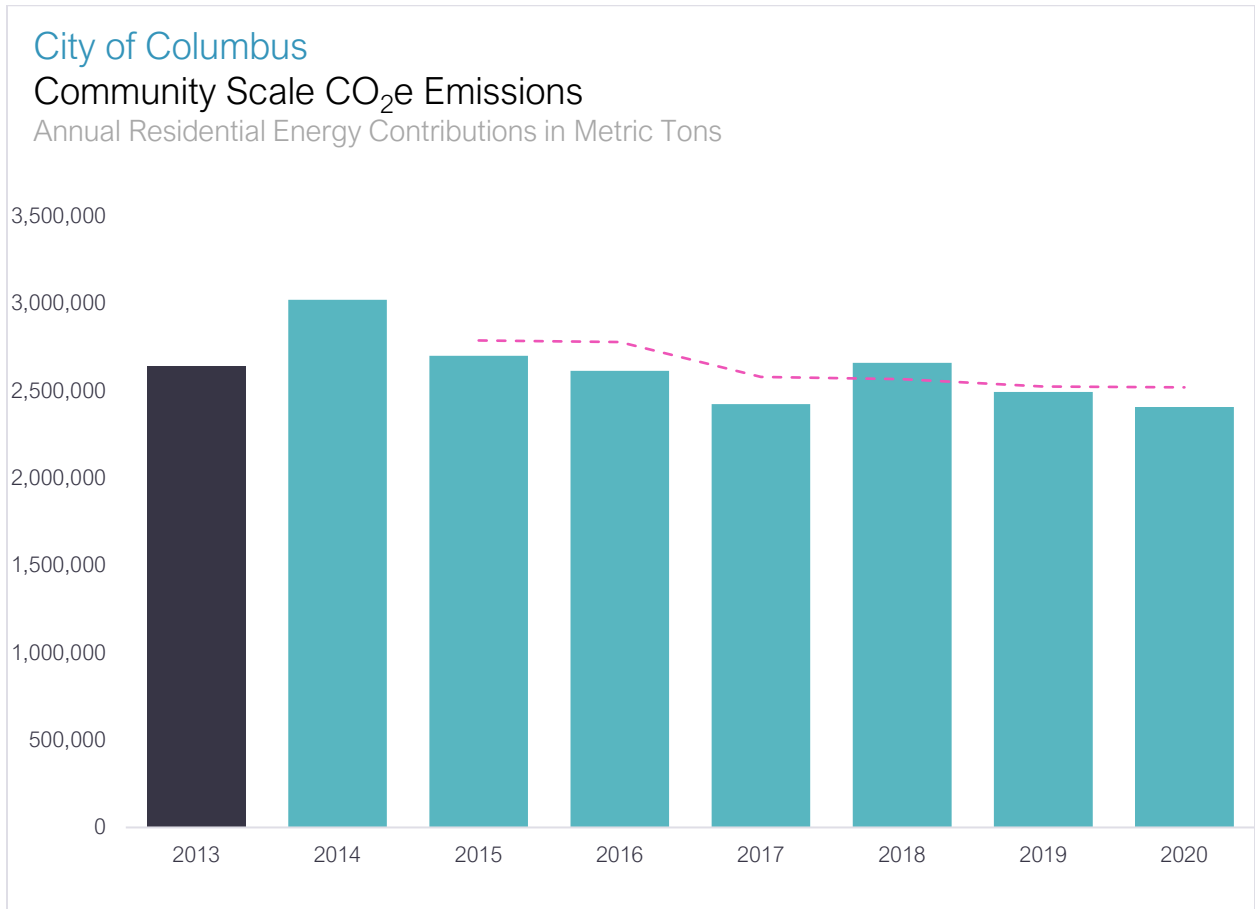
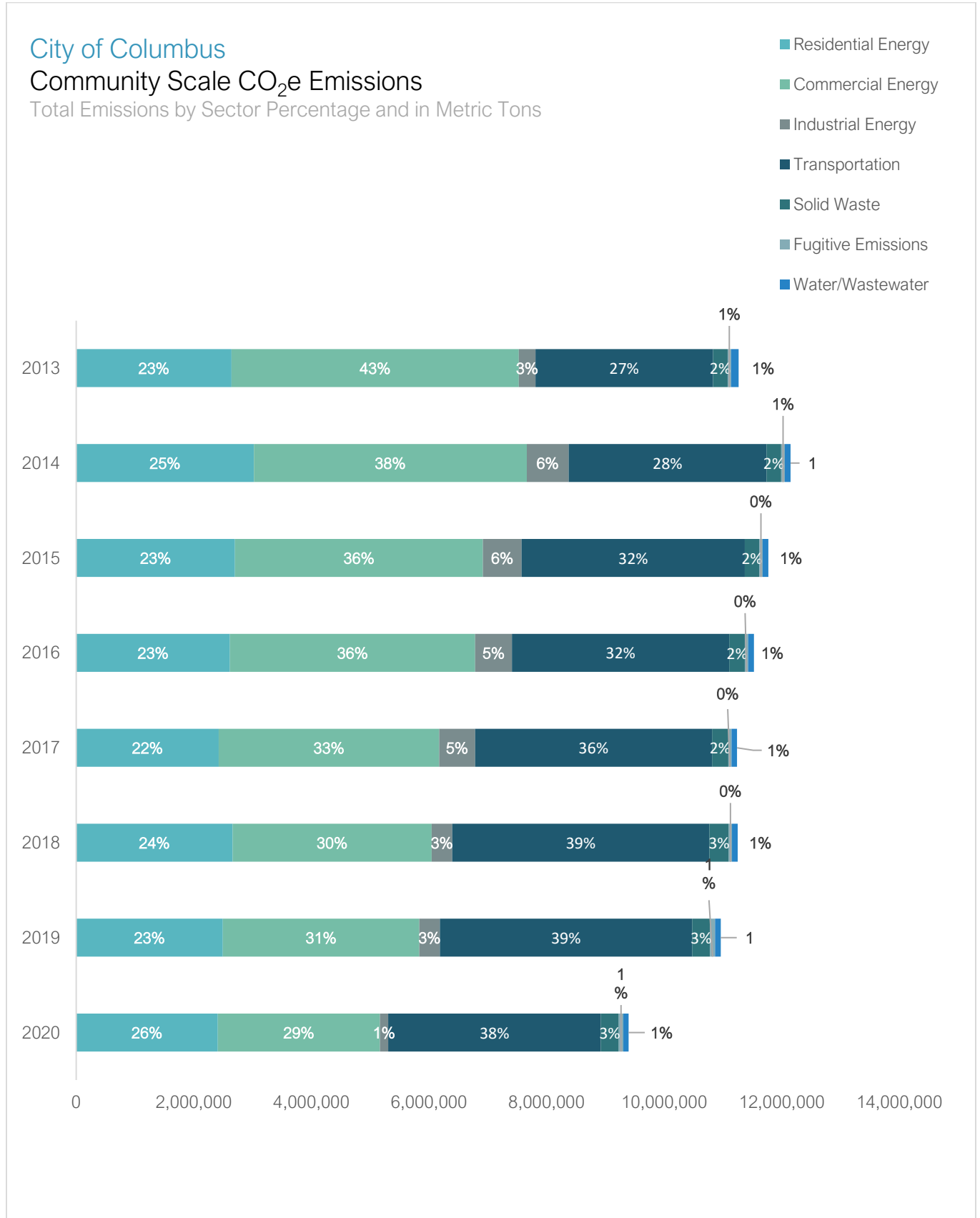


FIGURE 23. COMMUNITY SCALE – PERCENTAGE OF TOTAL EMISSIONS BY SECTOR – 2013-2020



# Appendix A

## Inputs

### Energy Consumption and Waste Values

Community Scale Inputs	Unit	2016	2017	2018	2019	2020
Residential Natural Gas Usage	MMBtu	15,549,233	15,710,210	20,280,912	19,014,639	19,109,712
Commercial Natural Gas Usage	MMBtu	13,831,531	14,529,943	10,040,435	9,649,676	6,550,352
Industrial Natural Gas Usage	MMBtu	4,839,784	4,963,302	161,932	127,198	101,56
Residential Electric Usage - AEP	kWh	2,776,284,947	2,675,953,721	2,890,640,718	2,701,175,306	2,770,146,643
Commercial/Industrial Electric Usage - AEP	kWh	5,332,567,481	5,134,004,677	5,241,305,315	5,077,234,606	3,741,204,447
Residential Electric Usage - DPU	kWh	66,851,275	66,621,085	78,522,037	80,561,233	946,904,053
Commercial Electric Usage - DPU	kWh	130,435,929	106,813,606	113,923,918	113,998,160	82,783,991
Industrial Electric Usage - DPU	kWh	587,071,546	613,696,855	639,762,013	639,841,221	109,530,729
Transit Buses, Diesel	Gallons	2,012,291	1,950,033	1,907,288	1,730,300	1,166,032
Transit Buses, CNG	Gallons	1,497,898	1,779,363	2,061,696	2,232,396	1,745,451
Paratransit Buses, Diesel	Gallons	339,773	346,180	340,861	308,109	225,537
Paratransit Buses, Gasoline	Gallons	34,127	30,258	28,302	27,259	10,670
Aviation – Airport, kerosene jet fuel	Gallons	59,713,628	68,362,002	73,251,020	81,766,923	53,560,625
Aviation – Airport, gasoline	Gallons	84,767	54,479	75,315	81,903	89,568
Aviation – Helicopter (kerosene jet fuel)	Gallons	61,708	100,154	111,161	118,244	64,024
On Road, Passenger, Gasoline	Miles	7,363,342,017	7,475,738,443	7,835,788,415	7,934,217,355	6,469,814,775
On Road, Passenger, Diesel	Miles	22,156,496	22,494,699	23,578,100	28,092,665	19,467,848
On Road, Freight, Gasoline	Miles	6,659,384	6,736,467	11,908,782	26,721,204	9,647,639
On Road, Freight, Diesel	Miles	259,715,974	262,722,228	464,442,498	400,590,749	376,257,919
Freight Rail, Diesel	Gallons	-	9,910,732	2,119,594	2,242,506	6,875,188,180
Wastewater Treatment Plants - Electricity - DPU	kWh	75,205,564	92,829,836	98,662,456	97,313,001	94,829,970
Water Treatment Plants - Electricity - DPU	kWh	58,228,740	60,707,038	67,114,035	68,130,723	69,370,103
Wastewater Treatment Plants - Natural Gas	MMBtu	66,640	75,325	67,778	109,264	101,564
Water Treatment Plants - Natural Gas	MMBtu	36,523	31,681	51,733	21,294	49,603
Gas Production - Jackson Pike	scf/day	-	1,000,000	810,000	932,918	917,846
Gas Composition - Jackson Pike	Percent Methane	-	65%	62%	61%	61%

Heat Content - Jackson Pike	Btu/scf	-	580	570	588	588
Gas Production - Southerly	scf/day	-	700,000	700,000	882,767	1,143,037
Gas Composition - Southerly	Percent Methane	-	56%	56%	63%	63%
Heat Content - Southerly	Btu/scf	-	512	512	554	554
Destruction Efficiency – Jackson Pike and Southerly	Percent	-	99%	99%	99%	99%

Government Operations Inputs	Unit	2016	2017	2018	2019	2020
Natural Gas	MMBtu	276,538	407,557	656,413	528,845	389,895
Electric	kWh	107,802,332	104,989,940	90,052,367	88,680,470	86,887,794
Street Lights and Signals - Electricity - DPU	kWh	42,520,846	38,069,976	44,058,418	35,181,696	48,412,050
Aviation - Helicopter	Gallons	61,708	100,154	111,161	118,244	64,024
City Fleet EVs (on road)	kWh	n/a	n/a	34,850	34,850	121,835
City Fleet CNG (on road)	Gallons	476,151	562,787	658,932	750,904	863,167
City Fleet Biodiesel (on road)	Gallons	0	470,960	353,342	459,112	324,762
City Fleet Diesel (on road)	Gallons	868,701	300,396	966,559	246,845	237,226
City Fleet Gasoline (on road)	Gallons	1,569,238	1,402,088	918,043	1,547,154	1,394,834
City Fleet E85 (on road)	Gallons	2,060	5,190	0	8,755	4,004
City Fleet CNG (off road)	Gallons	-	672	1,510	11,616	16,512
City Fleet Biodiesel (off road)	Gallons	-	93,886	95,908	170,324	130,196
City Fleet Diesel (off road)	Gallons	-	2,928	9,033	9,070	17,313
City Fleet Gasoline (off road)	Gallons	-	5,842	4,444	26,657	31,217
City Fleet E85 (off road)	Gallons	-	-	-	446	0
City Fleet Propane (off road)	Gallons	-	-	15,716	19,146	15,580
Municipal Solid Waste Generation (Landfill Total)	Tons	320,807	326,839	331,027	325,178	352,242
Wastewater Treatment Plants - Electricity	kWh	75,205,564	92,829,836	98,662,456	97,313,001	94,829,970
Water Treatment Plants - Electricity	kWh	58,228,740	60,707,038	67,114,035	68,130,723	69,370,103
Wastewater Treatment Plants - Natural Gas	MMBtu	66,640	75,325	67,778	109,264	101,564
Water Treatment Plants - Natural Gas	MMBtu	36,523	31,681	51,733	21,294	49,603
Gas Production - Jackson Pike	scf/day	-	1,000,000	810,000	932,918	917,846
Gas Composition - Jackson Pike	Percent Methane	-	65%	62%	60.6%	61%
Heat Content - Jackson Pike	Btu/scf	-	580	570	588	588
Gas Production - Southerly	scf/day	-	700,000	700,000	882,767	1,143,037
Gas Composition - Southerly	Percent Methane	-	56%	56%	63.35%	63%
Heat Content - Southerly	Btu/scf	-	512	512	554	554

Destruction Efficiency – Jackson Pike and Southerly	Percent	-	99%	99%	99%	99%
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## Emission Rates from eGRID

Community Scale					
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
2019	EPA eGRID 2018 Proxy for 2019	RFCW	1166.1	117	17
2020	EPA eGRID 2018v2 Proxy for 2019	RFCW	1068	99	14

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
2019	EPA eGRID 2018 Proxy for 2019	RFCW	1166.1	117	17
2020	EPA eGRID 2018v2 Proxy for 2019	RFCW	1068	99	14

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

### Progress Towards the 2020 Emissions Reduction Goal

Renewable Energy Credits (RECs), commonly known as offsets, are an important mechanism utilized by cities and communities to help reach emission reduction goals while in-boundary renewable energy resources are being built out. RECs are not factored into a greenhouse gas inventory. To estimate the impacts of RECs, one would reduce total emissions reported in an inventory by the emissions reductions associated with RECs purchased in the same year.

The City of Columbus set a community-wide emissions reduction target of 20% by 2020, utilizing 2013 as the baseline year. During this same time period, the City's population grew by 13%, making an absolute emissions reduction more difficult to achieve. The tables below thus present progress towards achieving the 20% goal in absolute and per capita terms in order to capture the levelized impacts of emission reduction activities. Inclusive of RECs, but without factoring in population growth, the City of Columbus has achieved 89% of its 2020 emissions target. When adjusting for population growth, the City has achieved 133% of its 2020 emissions target inclusive of emissions offset by the purchase of RECs.

Absolute Emissions	From GHG Inventory Report
2013 Emissions Benchmark (metric tons)	11,265,023
2020 Emissions Reduction Goal	20%
2020 Goal Emissions (metric tons)	9,012,018
Absolute Reduction Needed to Meet Goal (metric tons)	2,253,005
2020 Emissions (metric tons)	9,393,744
2020 RECs Offset (metric tons)	125,160
2020 Emissions Including RECs (metric tons)	9,268,584
<b>Percent of Target Achieved</b>	<b>89%</b>

Per Capita	From GHG Inventory Report
2013 Population	805,348
2013 Emissions per Capita (metric tons)	13.99
2020 Population	914,850
2020 Emissions per Capita (metric tons)	10.27
2020 Emissions per Capita Including RECS (metric tons)	10.13
2020 Per Capita Goal - 20% Reduction from 2013 (metric tons)	11.19
Absolute Reduction Needed to Meet Per Capita Goal (metric tons)	2.80
<b>Percent of Target Achieved</b>	<b>133%</b>

## Appendix C

### Methodology for Estimated Sector Breakdown for Natural Gas

Unlike in previous years, a sector breakdown of the total natural gas consumed was not available from the major regional natural gas utility. In order to estimate this breakdown, a residential consumption increase of .05% was assumed to account for the significant portion of the workforce working from home. The observed increase of 3% for electricity consumption in the residential sector was used as the upper bound, with no increase used as the lower bound. There is no reason to assume a negative growth rate for the residential sector would occur in 2020.

The industrial sector consumption assumes water and wastewater facility consumption is included plus 10% to account for other industrial activities. The remaining fuel consumption is attributed to the commercial sector.



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