

CITY OF COLUMBUS
**GREENHOUSE GAS
INVENTORY**
2021



MID-OHIO REGIONAL
MORPC
PLANNING COMMISSION

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2021 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 and developed inventorying its annual greenhouse gas (GHG) emissions since 2017 and setting targets for future year emissions through publishing its climate action and adaptation plan in December of 2021. 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 2021 city operations and community-wide GHG inventory.

Greenhouse Gas Inventory Tool

The 2021 GHG inventory was conducted using the ICLEI-USA ClearPath tool.¹ ClearPath includes tracks to inventory both local government operations and community-scale GHG emissions. Results from each track are presented in following sections. Each track is consistent with widely accepted, US-based protocols, the Local Government Operations Protocol and the US 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.²

¹ <http://icleiusa.org/clearpath/>. (Accessed August 11, 2022)

² <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid>. (Accessed August 11, 2022)

Changes in Model or Methodology

The methodology utilized in the 2021 GHG Inventory is the same as in the 2020 GHG Inventory unless mentioned in this section. Significant changes to the model or methodology are noted below:

- As was the case for the 2020 inventory, a sector breakdown of natural gas consumption is no longer available. Sector attribution is an estimation for this fuel. The methodology and approach for this estimation is different than that taken for the 2020 inventory and is included in Appendix C.
- In January 2022, the US EPA updated eGRID values for RFCW (eGRID 2020). These updated values are lower than previous years as a result of less coal being utilized to generate electricity in the sub-region. More detailed information is included in Appendix A.

Greenhouse Gases

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

- Carbon Dioxide (CO₂)
- Methane (CH₄)
- Nitrous Oxide (N₂O)

These three gases are used to calculate a total carbon dioxide equivalent (CO₂e) 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-CO₂ 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 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 2021 GHG Inventories.

Sectors Included

The following sectors are included in the 2021 GHG inventories:

TABLE 1. SECTORS – GOVERNMENT OPERATIONS INVENTORY

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

TABLE 2. SECTORS – COMMUNITY-SCALE INVENTORY

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

2021 Government Operations Emissions

Captured in Figures 1 and 2 and Tables 3 and 4 below, government operations contributed 311,031 metric tons of CO₂e in 2021. This represents nearly a 6% decrease from 2020. Green Memo III³ utilizes 2005 as a benchmark for city initiatives impacting city operations.⁴ 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 leveled off, or slightly increased from 2016-2020; however, and of significance, 2021 emissions from government operations is the lowest total in the City’s recorded annual inventory. This is a significant accomplishment as population increased around 13% from 2013 – 2021.

Compared to 2005, emissions have decreased over 23%. On a per capita basis, which would offer a leveled view of the City’s efficiency in providing services, government operations created 0.34 metric tons of CO₂e per person in 2021, a 37% decrease per capita from 2005.

FIGURE 1. GOVERNMENT OPERATIONS – TOTAL EMISSIONS – 2021

City of Columbus Government Operations CO₂e Emissions

Total Emissions in Metric Tons of CO₂e | 2021

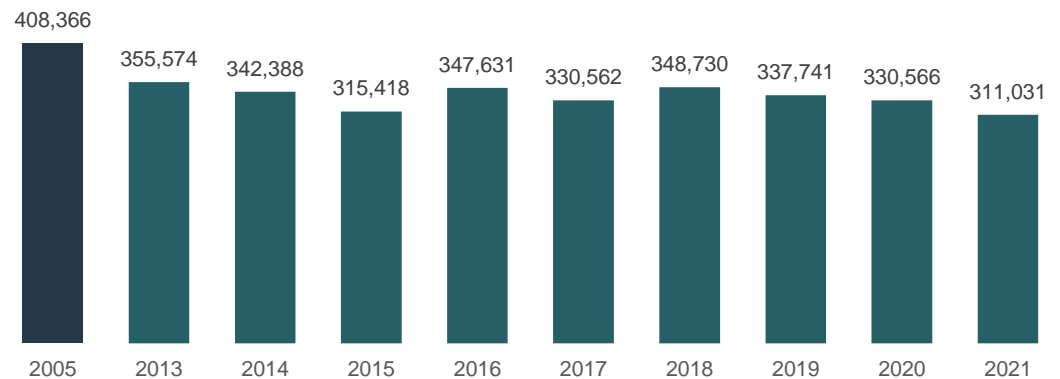


TABLE 3. GOVERNMENT OPERATIONS ANNUAL EMISSIONS BY SECTOR

Government Operations Sector	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021
Buildings & Facilities	87,931	76,431	87,309	79,818	88,451	81,284	86,011	75,347	63,071	61,829
Street Lights & Traffic Signals	29,134	26,749	32,442	31,788	30,471	21,616	25,265	18,733	23,587	17,966
Vehicle Fleet	33,965	30,281	29,459	26,184	23,587	22,564	23,473	23,445	20,141	19,649
Solid Waste Facilities	97,245	97,218	98,597	102,290	108,272	110,308	111,721	122,917	133,148	130,287
Water & Wastewater Treatment Facilities	160,091	124,895	94,582	75,337	96,851	94,790	102,259	97,300	90,619	81,300
Total Emissions (Metric tons CO₂e)	408,366	355,574	342,388	315,418	347,631	330,562	348,730	337,741	330,566	311,031

³ <https://www.columbus.gov/Templates/Detail.aspx?id=2147506164>. (Accessed October 3, 2022)

⁴ 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 2. GOVERNMENT OPERATIONS – EMISSIONS PER CAPITA – 2021

City of Columbus

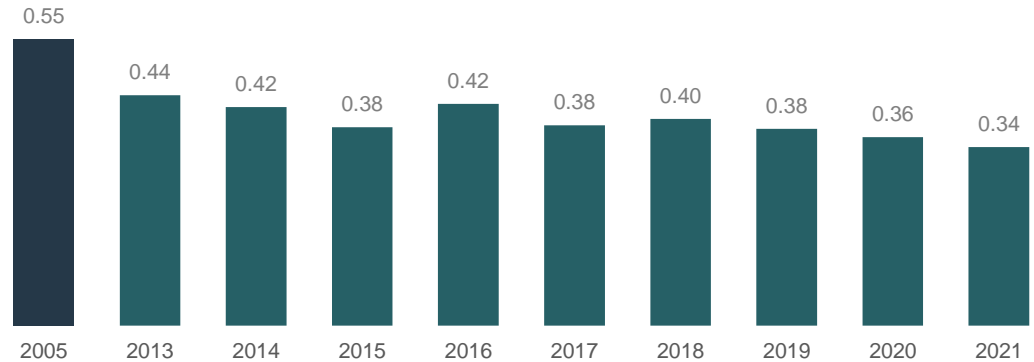
Government Operations CO₂e EmissionsMetric Tons of CO₂e per Capita | 2021

TABLE 4. GOVERNMENT OPERATIONS – ANNUAL EMISSIONS PER CAPITA

Government Operations Sector	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021
Population	743,511	805,348	817,383	829,690	818,912	861,141	880,828	895,877	914,850	909,686
Buildings & Facilities	0.12	0.09	0.11	0.10	0.11	0.09	0.10	0.08	0.07	0.07
Street Lights & Traffic Signals	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.02	0.03	0.02
Vehicle Fleet	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02
Solid Waste Facilities	0.13	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.15	0.14
Water & Wastewater Treatment Facilities	0.22	0.16	0.12	0.09	0.12	0.11	0.12	0.11	0.10	0.09
Total Emissions per Capita (Metric tons CO ₂ e)	0.55	0.44	0.42	0.38	0.42	0.38	0.40	0.38	0.36	0.34

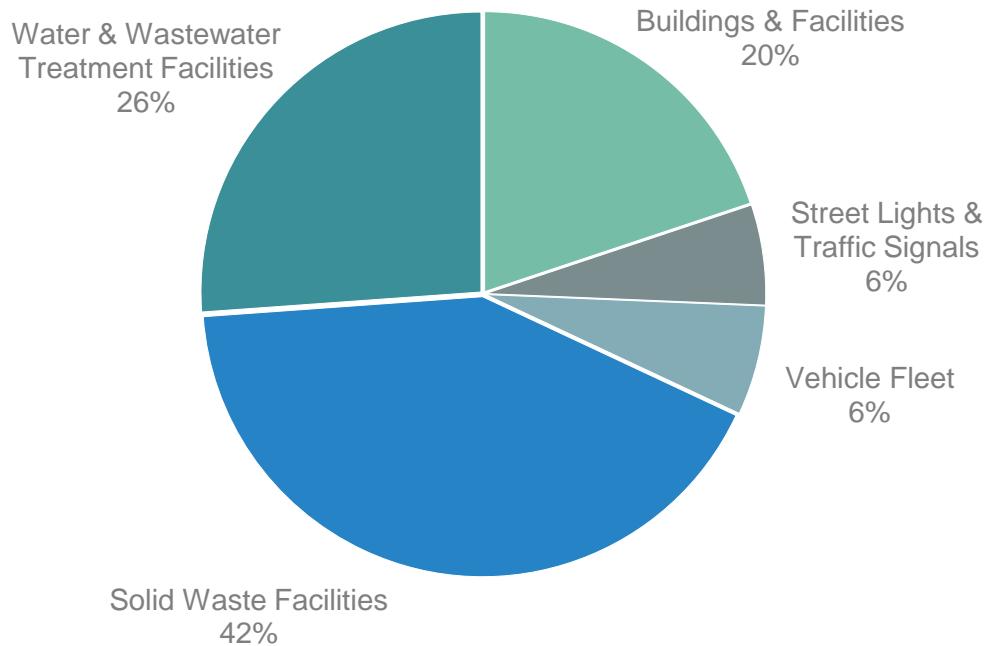
Sector-relative Emissions Contributions

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 2021, as seen in Figure 3, solid waste facilities and water service facilities accounted for 68% of emissions from government operations, 42% and 26%, respectively, the same collective amount seen in 2020.

Despite a lower energy use intensity and minimal emission byproducts of operations, city-owned buildings and facilities were still responsible for a large portion of emissions—20%—from city government operations. 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. Street lights and traffic signals accounted for the remaining 6% of total City government operation emissions.

FIGURE 3. GOVERNMENT OPERATIONS – SECTOR PERCENTAGE OF TOTAL ANNUAL EMISSIONS – 2021

City of Columbus
Government Operations CO₂e Emissions
Sector Percentage of Total | 2021



Sector Emissions Contributions Between 2005 and 2021

As seen in Table 5, nearly all sectors analyzed produced fewer emissions in 2021 than in 2005. Only solid waste facilities produced more CO₂e emissions in 2021 than in 2005, most of which can be accounted for in population growth and methodology changes that weighs methane heavier than in 2005.

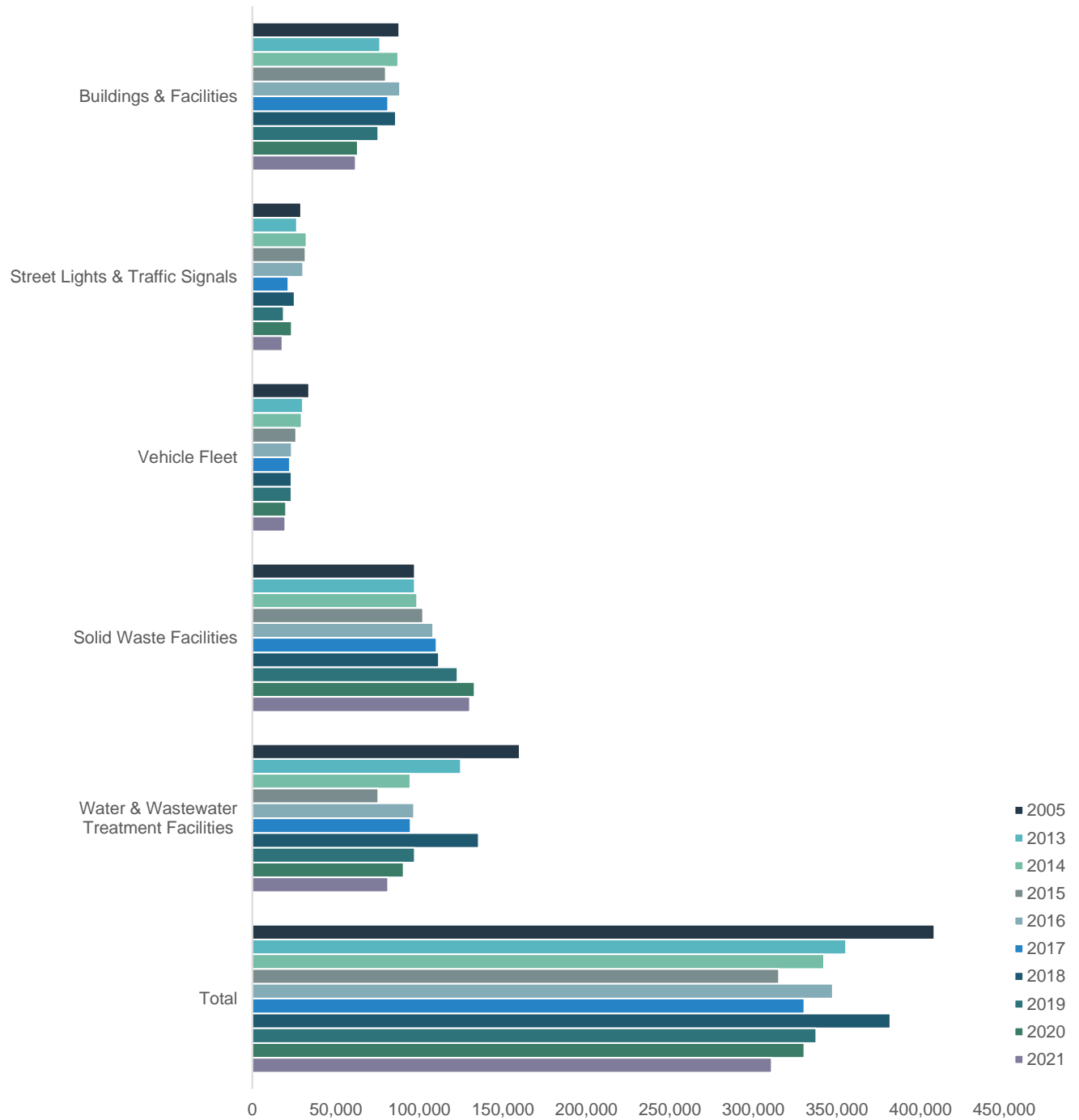
TABLE 5. GOVERNMENT OPERATIONS – PERCENT CHANGE IN EMISSIONS FROM 2005

Government Operations Sector	Percent Change in Total Emissions 2005 - 2021	Percent Change in Emissions per Capita 2005 - 2021
Buildings & Facilities	-29.7%	-42.5%
Street Lights & Traffic Signals	-38.3%	-49.6%
Vehicle Fleet	-42.1%	-52.7%
Solid Waste Facilities	34.0%	9.5%
Water & Wastewater Treatment Facilities	-49.2%	-58.5%
Total Emissions (Metric tons CO₂e)	-23.8%	-37.7%

Annual emissions data for each sector are provided below in Figure 4, accompanied by the sector breakdown by percentage in Figure 5. Both are set against the benchmarking year 2005 for comparison purposes, noted in dark blue in Figure 4.

FIGURE 4. GOVERNMENT OPERATIONS – ANNUAL SECTOR CONTRIBUTIONS – 2013-2021⁵

City of Columbus
 Government Operations CO₂e Emissions
 Annual Sector Contributions in Metric Tons | 2013 - 2021



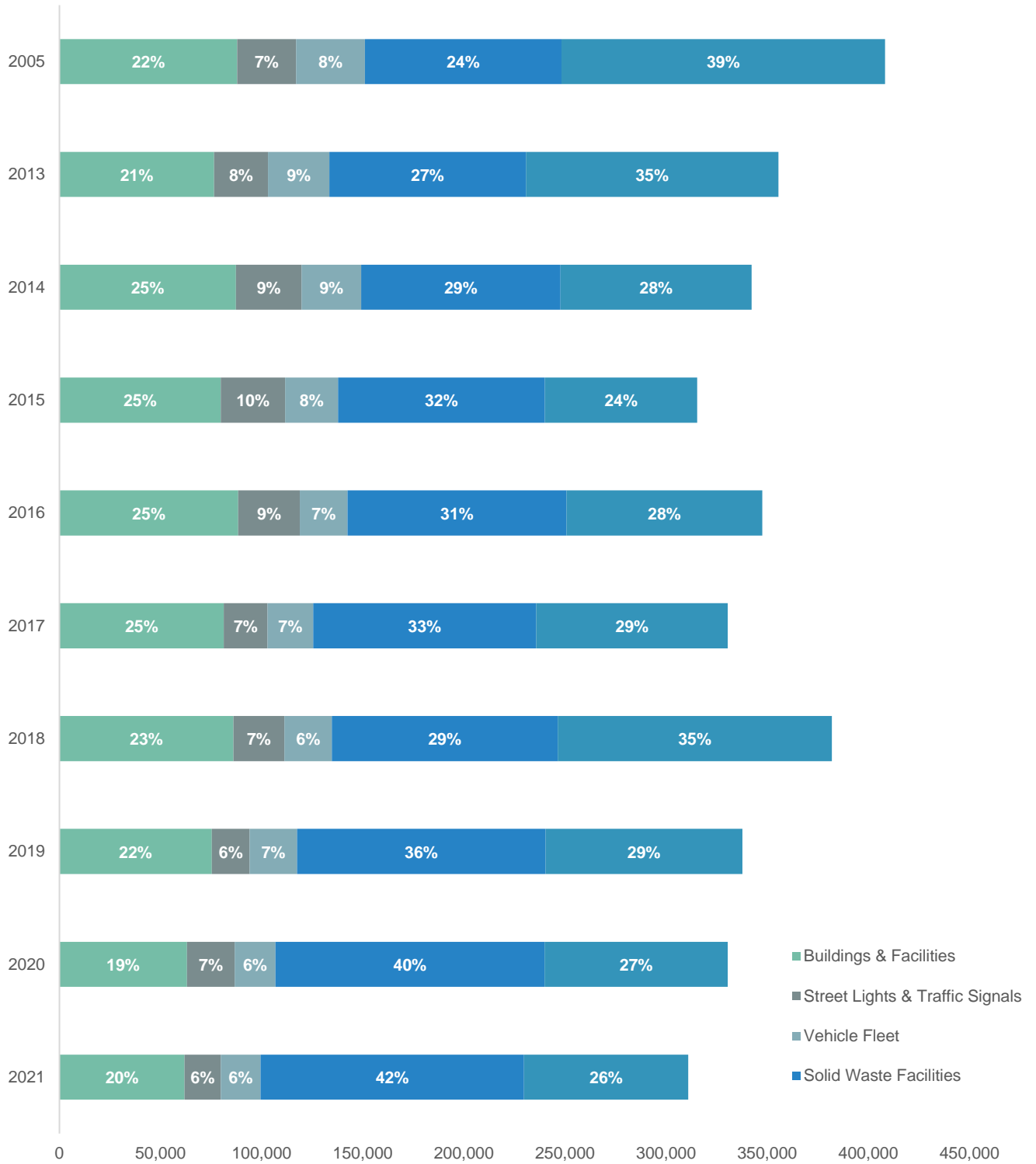
⁵ Emissions from energy use at Waste and Wastewater Treatment Facilities is included in Buildings and Facilities in 2016. This methodology was corrected beginning in the 2017 City of Columbus Greenhouse Gas Inventory.

FIGURE 5. GOVERNMENT OPERATIONS – PERCENTAGE OF TOTAL EMISSIONS BY SECTOR – 2013-2021

City of Columbus

Government Operations CO₂e Emissions

Total Emissions by Sector Percentage in Metric Tons | 2013 - 2021



Below in Figures 6-10 are annual emissions data for each individual sector from 2013-2021 with a three-year moving average trend line. The benchmark year of 2005 is noted in dark blue.

FIGURE 6. GOVERNMENT OPERATIONS – ANNUAL BUILDING AND FACILITIES CONTRIBUTIONS – 2013-2021

City of Columbus

Government Operations CO₂e Emissions

Annual Building and Facilities Contributions in Metric Tons with 3-Year Moving Average Trend | 2013 - 2021

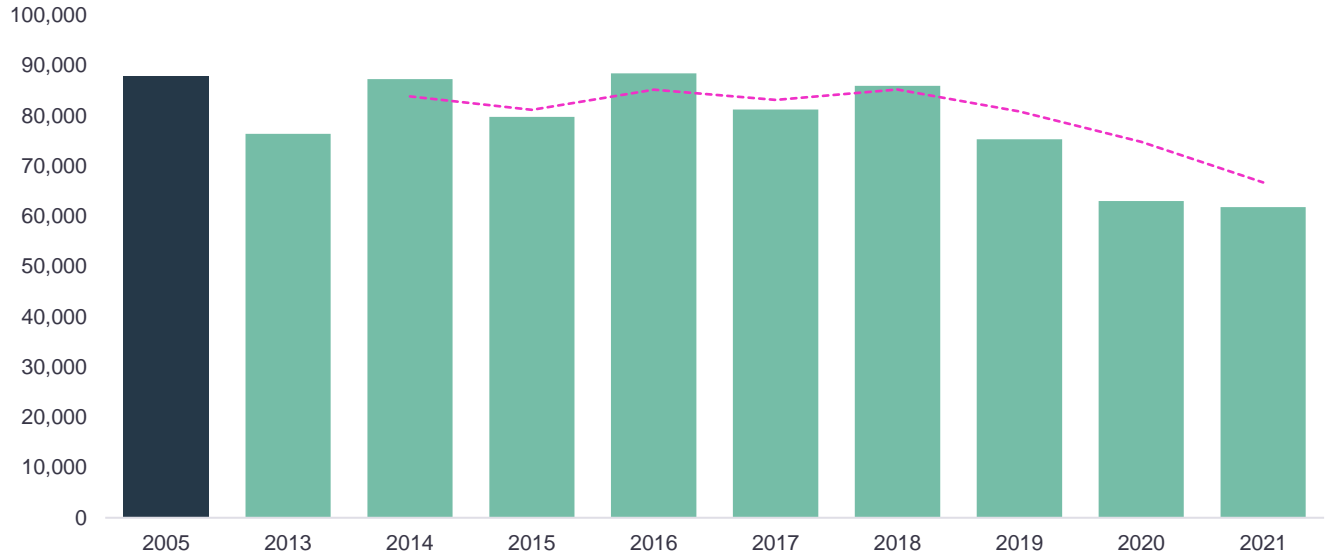


FIGURE 7. GOVERNMENT OPERATIONS – ANNUAL STREET LIGHT AND TRAFFIC SIGNALS CONTRIBUTIONS – 2013-2021

City of Columbus

Government Operations CO₂e Emissions

Annual Street Light and Traffic Signs Contributions in Metric Tons with 3-Year Moving Average Trend | 2013 - 2021

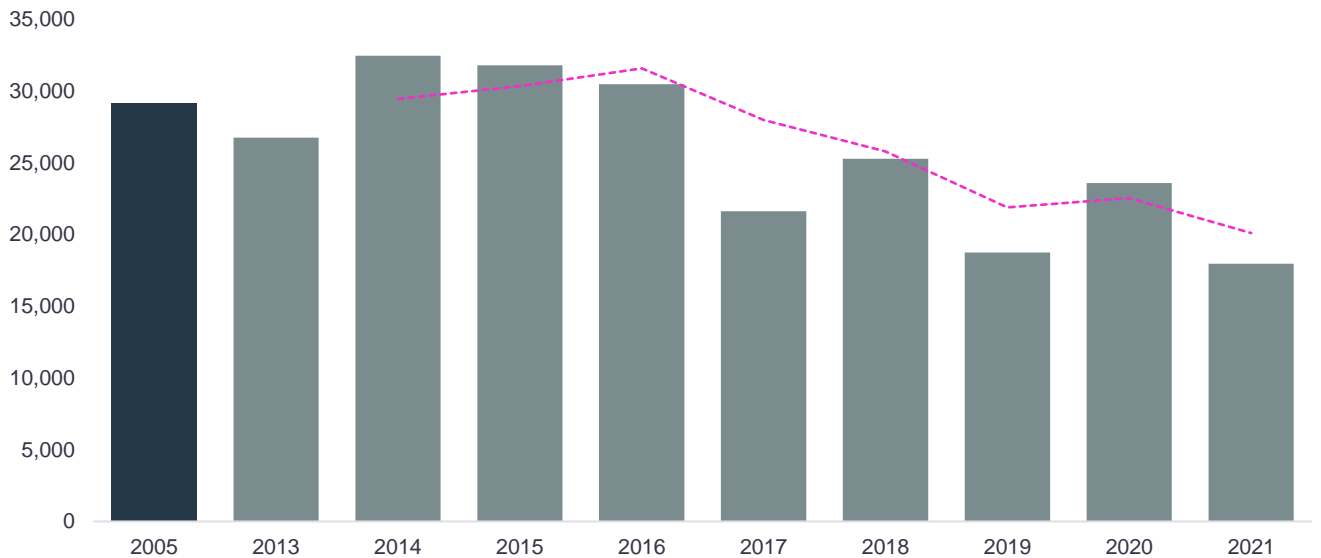


FIGURE 8. GOVERNMENT OPERATIONS – ANNUAL FLEET VEHICLE CONTRIBUTIONS – 2013-2021

City of Columbus
Government Operations CO₂e Emissions
Annual Fleet Vehicle Contributions in Metric Tons
with 3-Year Moving Average Trend | 2013 - 2021

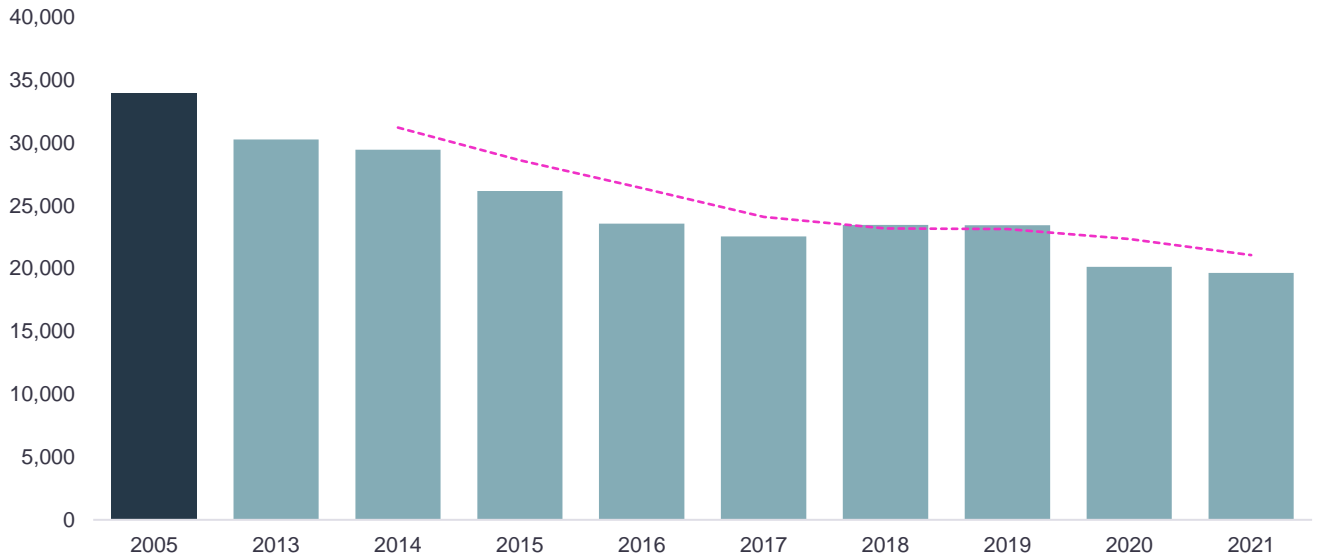


FIGURE 9. GOVERNMENT OPERATIONS – ANNUAL SOLID WASTE FACILITIES CONTRIBUTIONS – 2013-2021

City of Columbus
Government Operations CO₂e Emissions
Annual Solid Waste Facilities Contributions in Metric Tons
with 3-Year Moving Average Trend | 2013 - 2021

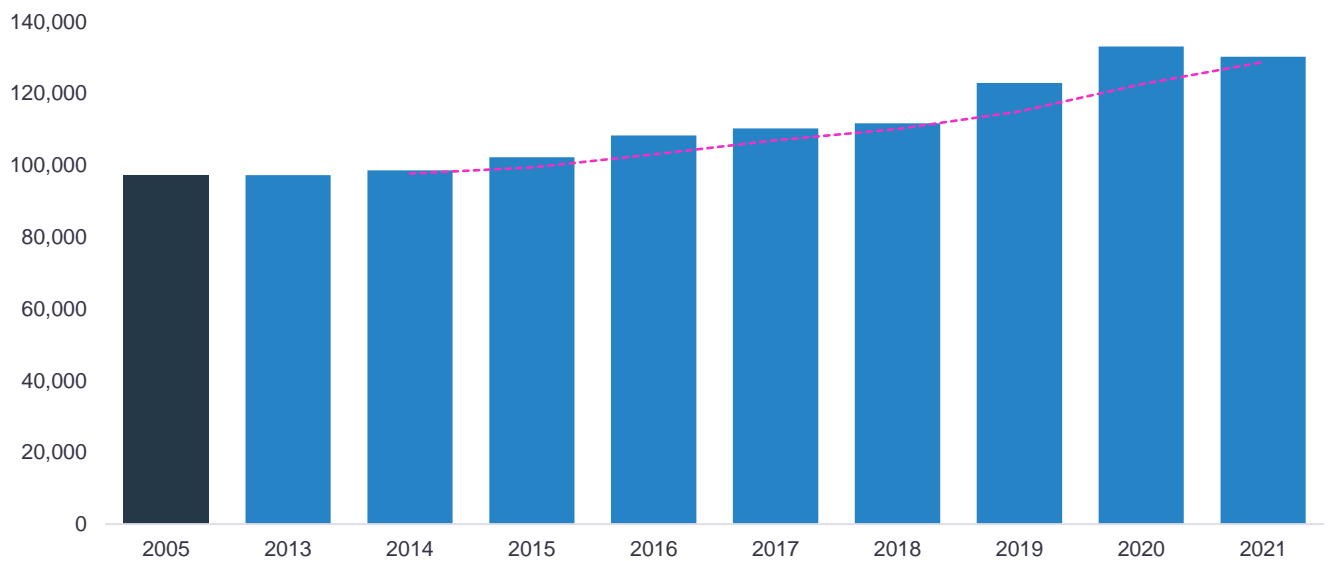
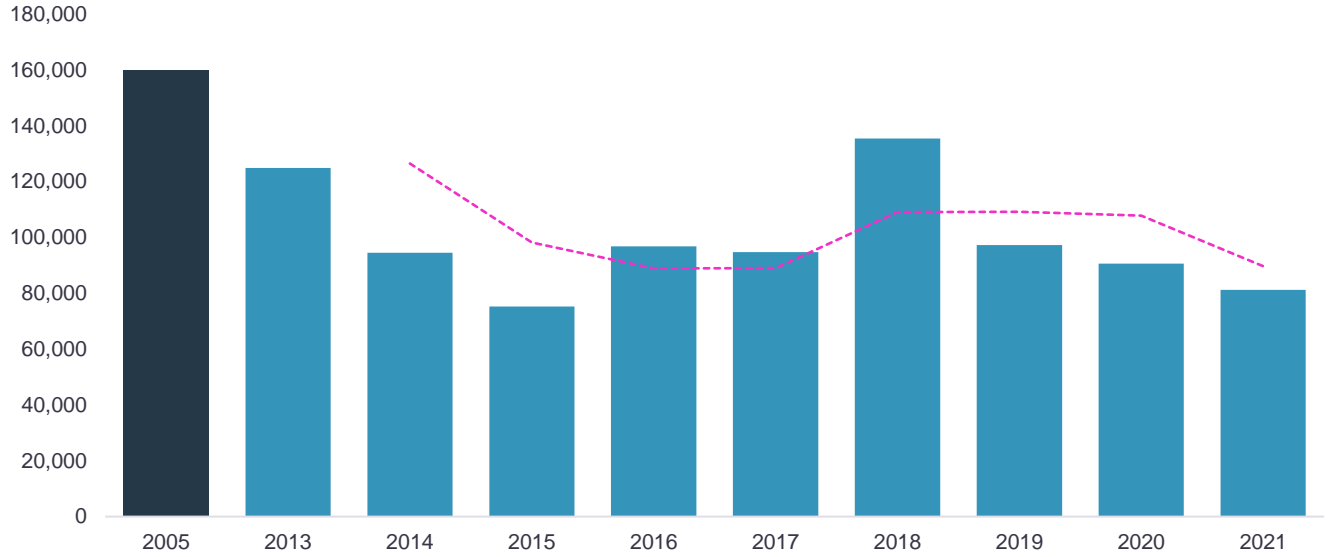


FIGURE 10. GOVERNMENT OPERATIONS – ANNUAL WATER AND WASTEWATER TREATMENT FACILITIES CONTRIBUTIONS – 2013-2021

City of Columbus

Government Operations CO₂e Emissions

Annual Water and Wastewater Treatment Facilities Contributions in Metric Tons with 3-Year Moving Average Trend | 2013 - 2021



2021 Community-Wide Emissions

Activities community-wide contributed 9,627,789 metric tons of CO₂e in 2021. This represents a 2.5% increase from 2020, as reflected below in Figure 11 and Table 6. Green Memo III⁶ utilizes 2013 as a benchmark for community-wide emissions. When considering the total emissions community-wide from 2013-2018, 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 CO₂e per year. From 2018-2020, there's been a 14% reduction in emissions suggesting a downward trend developing. However, a 2.5% increase seen in 2021 from 2020 might reflect more people returning to a pre-pandemic pace of life. It is important to note that the only true increase in energy use was seen in the transportation sector. Transportation emissions increased by 18% in 2021 from 2020, almost the same levels seen in 2019. While emissions data shows a huge increase in industrial energy in 2021 from 2020, this is merely a change in methodology, which is explained in Appendix C. In fact, when looking at commercial and industrial (C&I) emissions, collectively, there was over a 6% decrease from 2020 and nearly a 48% decrease since 2013.

It is also important to note that population increased around 13% from 2013-2021, as seen below in Figure 12 and Table 7. In this time, total emissions community-wide decreased by over 14%. On a per capita basis in 2021, the community of Columbus created 10.58 metric tons of CO₂e per person, a 3% increase in the per capita emissions from 2020; however, compared to pre-pandemic 2019 levels, there was a 13.5% decrease in emissions, and a 24% decrease in emissions per capita from 2013 levels.

Despite the slight increase in emissions in 2021 from 2020, both overall and per capita, the fact that emissions have decreased from 2019—12.2% and 13.5% respectively—and even more so since 2013—14.5% and 24.3% respectively—despite such significant growth in the city is a notable accomplishment.

⁶[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)/) (Accessed October 3, 2022)

FIGURE 11. COMMUNITY-SCALE – TOTAL EMISSIONS – 2013-2021

City of Columbus
 Community-Scale CO₂e Emissions
 Total Emissions in Metric Tons of CO₂e | 2021

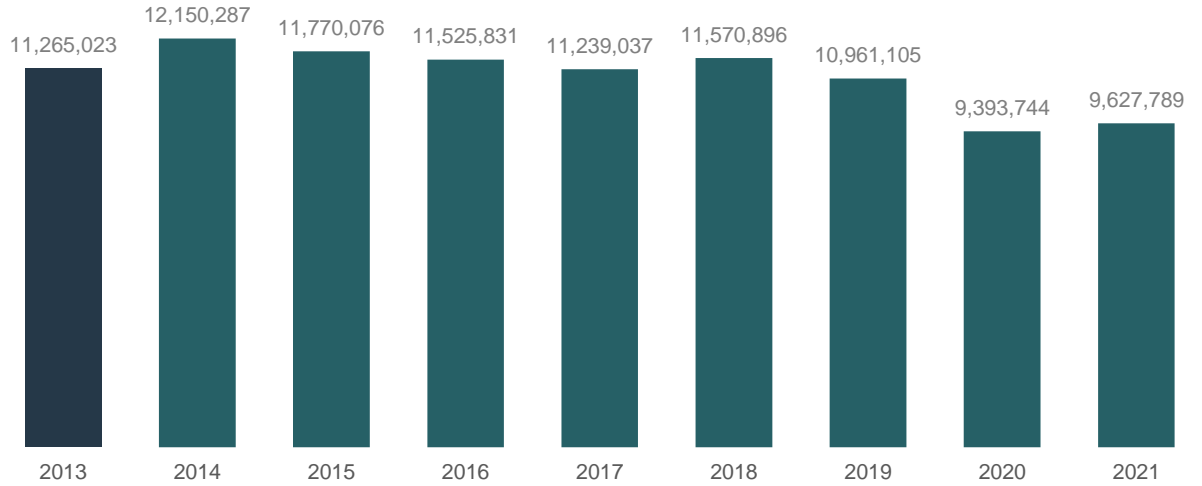


TABLE 6. COMMUNITY-SCALE – TOTAL EMISSIONS BY SECTOR – 2013-2021

Community-Scale Sector	2013	2014	2015	2016	2017	2018	2019	2020	2021
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	2,178,011
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	2,340,597
Industrial Energy	287,152	713,266	657,967	626,048	611,877	371,757	347,443	139,625	366,358
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	4,271,031
Solid Waste	249,007	249,877	244,372	263,633	275,496	332,321	304,904	307,564	310,579
Fugitive Emissions	59,171	63,481	57,928	56,682	55,435	52,887	83,420	74,815	79,913
Water/Wastewater	128,116	96,893	96,017	97,444	94,790	102,259	97,300	90,619	81,300
Total Emissions (Metric tons CO₂e)	11,265,023	12,150,287	11,770,076	11,525,831	11,239,037	11,570,896	10,961,105	9,393,744	9,627,789

FIGURE 12. COMMUNITY-SCALE – EMISSIONS PER CAPITA – 2013-2021

City of Columbus
Community-Scale CO₂e Emissions
Metric Tons of CO₂e per Capita | 2021

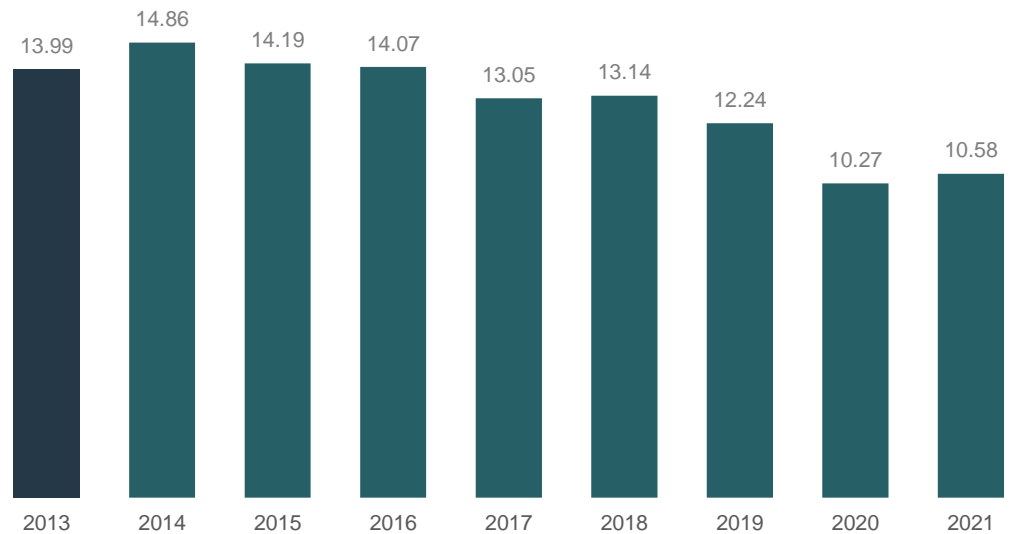


TABLE 7. COMMUNITY-SCALE – EMISSIONS PER CAPITA – 2013-2021

Community-Scale Sector	2013	2014	2015	2016	2017	2018	2019	2020	2021
Population	805,348	817,383	829,690	818,912	861,141	880,828	895,877	914,850	909,686
Residential Energy	3.28	3.70	3.26	3.19	2.81	3.14	2.78	2.63	2.39
Commercial Energy	6.06	5.68	5.08	5.09	4.35	4.06	3.73	3.02	2.57
Industrial Energy	0.36	0.87	0.79	0.76	0.71	0.42	0.39	0.15	0.40
Transportation	3.74	4.12	4.58	4.51	4.68	4.97	4.79	3.95	4.70
Solid Waste	0.31	0.31	0.29	0.32	0.32	0.38	0.34	0.34	0.34
Fugitive Emissions	0.07	0.08	0.07	0.07	0.06	0.06	0.09	0.08	0.09
Water/Wastewater	0.16	0.12	0.12	0.12	0.11	0.12	0.11	0.10	0.09
Total Emissions (Metric tons CO₂e)	13.99	14.86	14.19	14.07	13.05	13.14	12.24	10.27	10.58

Sector-Relative Emissions Contributions

Since 2017, the transportation sector accounts for the greatest portion of emissions on a community-wide basis, 44% in 2021. The *2021: ACS 1-Year Estimates Subject Tables* note that in 2021, 64% of people commute via single-occupancy vehicles,⁷ a drop of roughly 14% seen in 2019 and 2020. Even though this value decreased, with population high and expected to grow, this leads to increased 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, at least not currently. As noted in the previous section, there was an 18% increase in

⁸<https://data.census.gov/cedsci/table?q=Columbus%20city,%20Ohio&y=2021&d=ACS%201-Year%20Estimates%20Data%20Profiles&tid=ACSDP1Y2021.DP03>. (Accessed October 3, 2022)

transportation emissions, possibly illustrating more people returning to pre-pandemic travel patterns.

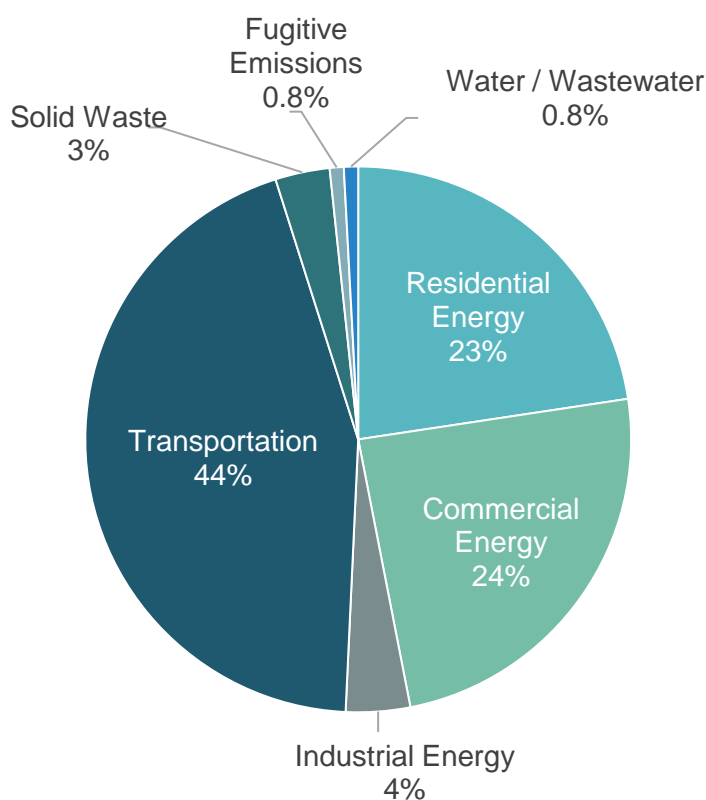
As is typical of similar-sized cities in the United States, as noted below in Figure 13, commercial and residential sectors made up the next two largest contributors to emissions in the City of Columbus, 24% and 23%, respectively. In 2021, compared to 2020, there was a slight decrease in emissions from the residential sector as might be expected with people returning to work and going out more regularly. As noted in the previous section, due to a change in methodology, the industrial sector increased to 4% of total emissions in 2021. Combined, solid waste and water services made up near 4% of emissions, with the remaining emissions, a little less than 1%, being accounted for by process and fugitive emissions.

FIGURE 13. COMMUNITY-SCALE – SECTOR PERCENTAGE OF TOTAL EMISSIONS - 2021

City of Columbus

Community-Scale CO₂e Emissions

Sector Percentage of Total | 2021



Sector Emissions Contributions Between 2013 and 2021

Columbus is experiencing a relatively low emissions rate compared to historical values. The City's population has grown near 13% since 2013, while the metropolitan statistical area for Columbus experienced a 12% growth in gross domestic product 2013-2020.⁸ Even though the majority of community sectors are emitting more greenhouse gases than in 2013, most were doing so at a lower rate per person than has been seen in most previous analyses for Columbus, as illustrated

⁸ According to the Bureau of Economic Analysis: <https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1>. (Accessed October 3, 2022)

below in Table 8. In 2021, all sectors returned to their 2019 trends but, for the majority, in greater percentages. Despite these trends, total emissions in 2021 were lower than in 2019, the last year when pre-pandemic trends were seen, by 12%.

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

Community Scale Sector		Percent Change in Total Emissions 2013 to 2021		Percent Change in Emissions per Capita 2013 to 2021	
Residential Energy		-17.6%		-27.0%	
Commercial (C) Energy	C&I Energy Combined	-52.1%	-47.7%	-57.6%	-53.7%
Industrial (I) Energy		27.6%		13.0%	
Transportation		41.6%		25.4%	
Solid Waste		24.7%		10.4%	
Fugitive Emissions		35.1%		19.6%	
Water/Wastewater		-36.5%		-43.8%	
Total Emissions		-14.5%		-24.3%	

Across community sectors compared to 2020, 2021 emissions remained the same or lower, except in transportation and fugitive emissions.⁹ Transportation increased by 18% in 2021 compared to 2020; however, this transportation is only slightly below 2019, pre-pandemic levels. Similarly, almost all fuel types increased their emissions in 2021 compared to 2020; but the majority of fuel types decreased compared to 2019. Of note, diesel bus, gasoline freight, and helicopter use all decreased by nearly 50% or greater; and in the largest fuel type—gasoline passenger vehicles—declined over 8% compared to 2019 levels.

Fugitive emissions are a function of the quantity of natural gas used in the analysis area. Fugitive emissions increased over 6% from 2020 due to an increase in natural gas use.

Residential energy use emissions declined from 2020 to 2021. Despite a 2% increase in electricity use, less coal being utilized to generate electricity in the region led to lower emissions in generating this electricity.

As noted in red, commercial and industrial (C&I) energy use emissions, collectively, decreased from 2020. This continues a trend first seen back in 2015. And since 2013, C&I total emissions have decreased by almost 48%.

Emissions from water and wastewater facilities also decreased by a little more than 10% due to less coal being utilized to generate electricity in the region.

Annual emissions data for each sector are provided below in Figure 14, accompanied by the sector breakdown by percentage in Figure 15. Both are set against the benchmarking year 2013 for comparison purposes, noted in dark blue in Figure 14.

⁹ Again, the industrial sector saw a large increase, 162%, only due to a change in methodology to better capture energy use. This change came about with the 2020 inventory when Columbia Gas no longer categorized natural gas use. More detail in Appendix C.

FIGURE 14. COMMUNITY-SCALE – ANNUAL SECTOR EMISSION CONTRIBUTIONS – 2013-2021

City of Columbus

Community-Scale CO₂e Emissions

Annual Sector Contributions in Metric Tons | 2013 - 2021

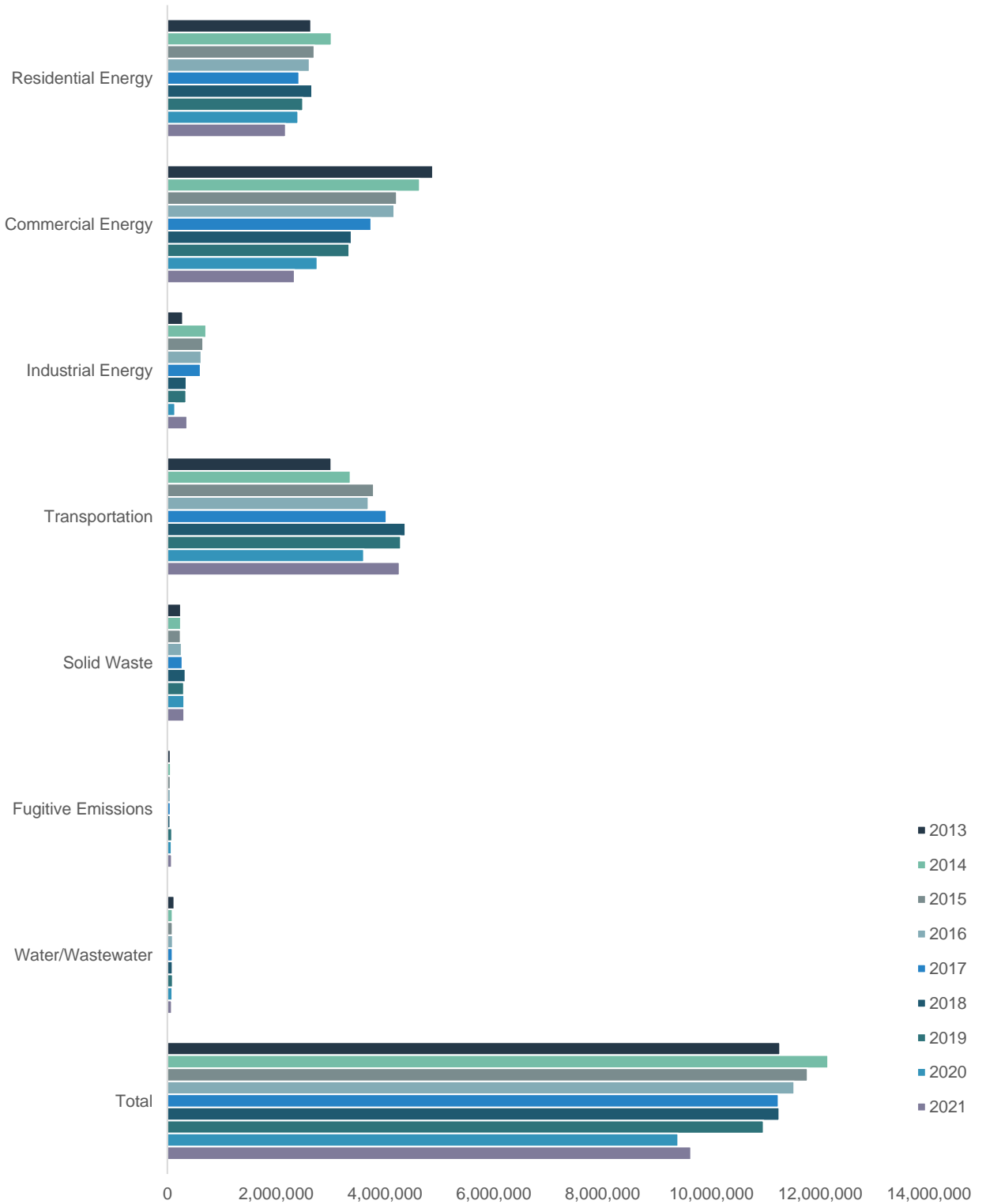
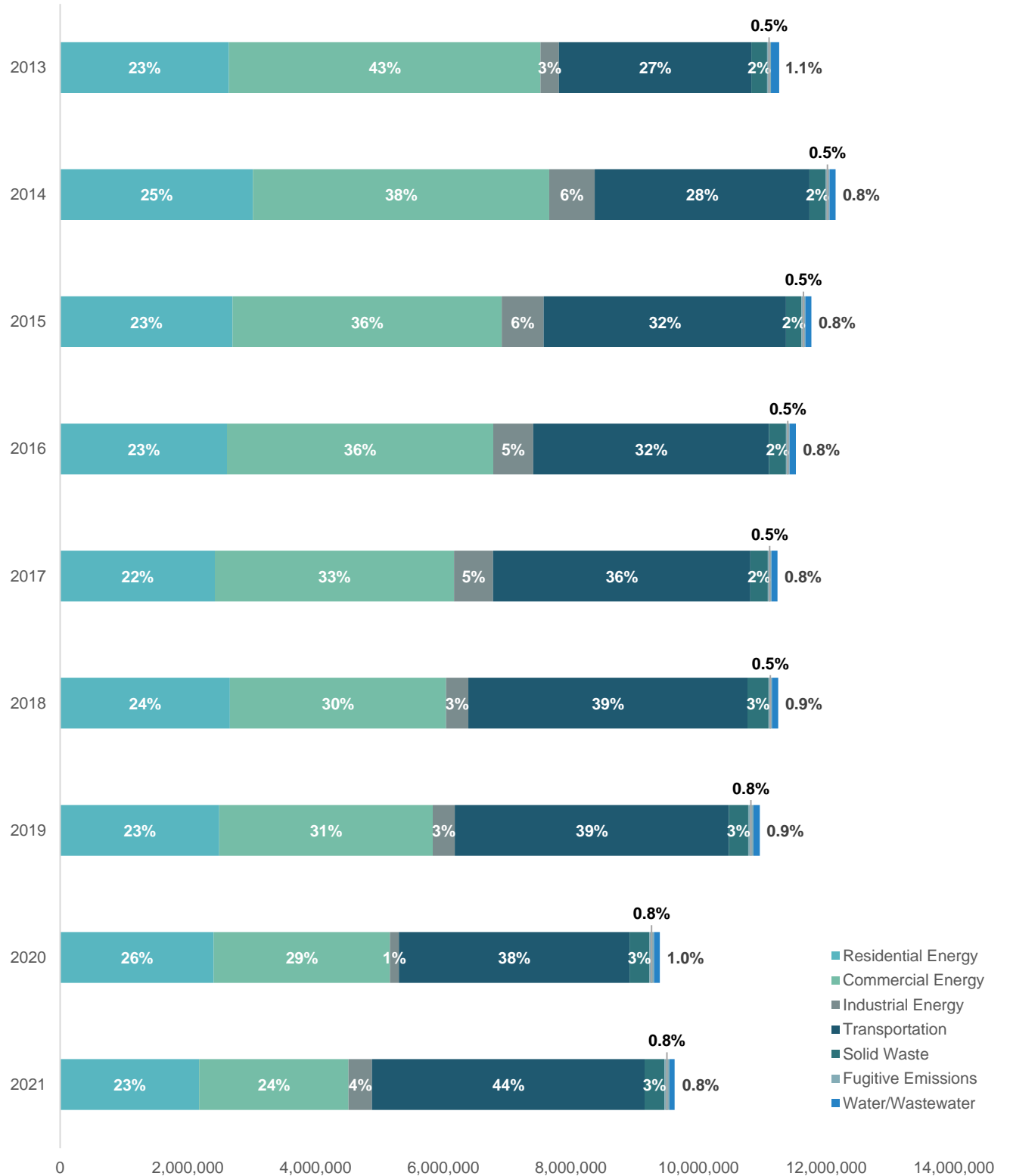


FIGURE 15. COMMUNITY-SCALE – PERCENTAGE OF TOTAL EMISSIONS BY SECTOR – 2013-2021

City of Columbus

Community-Scale CO₂e Emissions

Total Emissions by Sector Percentage and in Metric Tons | 2013 - 2021



Below in Figures 16-22 are annual emissions data for each individual sector from 2013-2021 with a three-year moving average trend line. The benchmark year of 2013 is noted in dark blue.

FIGURE 16. COMMUNITY-SCALE – ANNUAL RESIDENTIAL SECTOR CONTRIBUTIONS – 2013-2021

City of Columbus

Community-Scale CO₂e Emissions

Annual Residential Energy Contributions in Metric Tons with 3-Year Moving Average Trend | 2013 - 2021

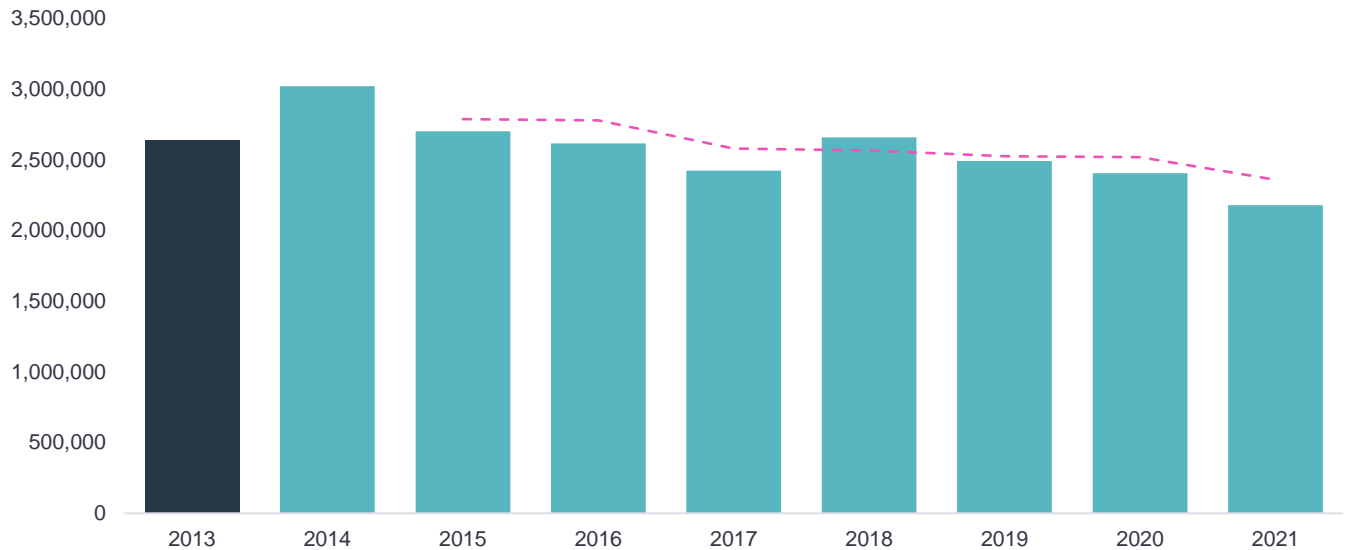


FIGURE 17. COMMUNITY-SCALE – ANNUAL COMMERCIAL SECTOR CONTRIBUTIONS – 2013-2021

City of Columbus

Community-Scale CO₂e Emissions

Annual Commercial Energy Contributions in Metric Tons with 3-Year Moving Average Trend | 2013 - 2021

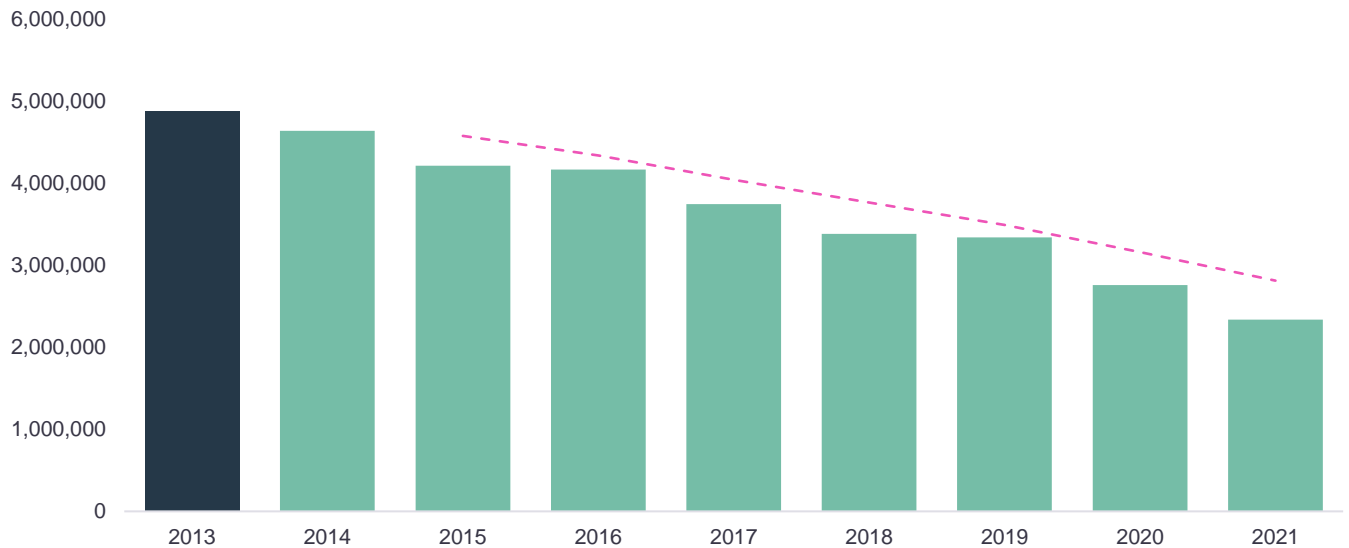


FIGURE 18. COMMUNITY-SCALE – ANNUAL INDUSTRIAL SECTOR CONTRIBUTIONS – 2013-2021

City of Columbus
 Community-Scale CO₂e Emissions
 Annual Industrial Energy Contributions in Metric Tons
 with 3-Year Moving Average Trend | 2013 - 2021

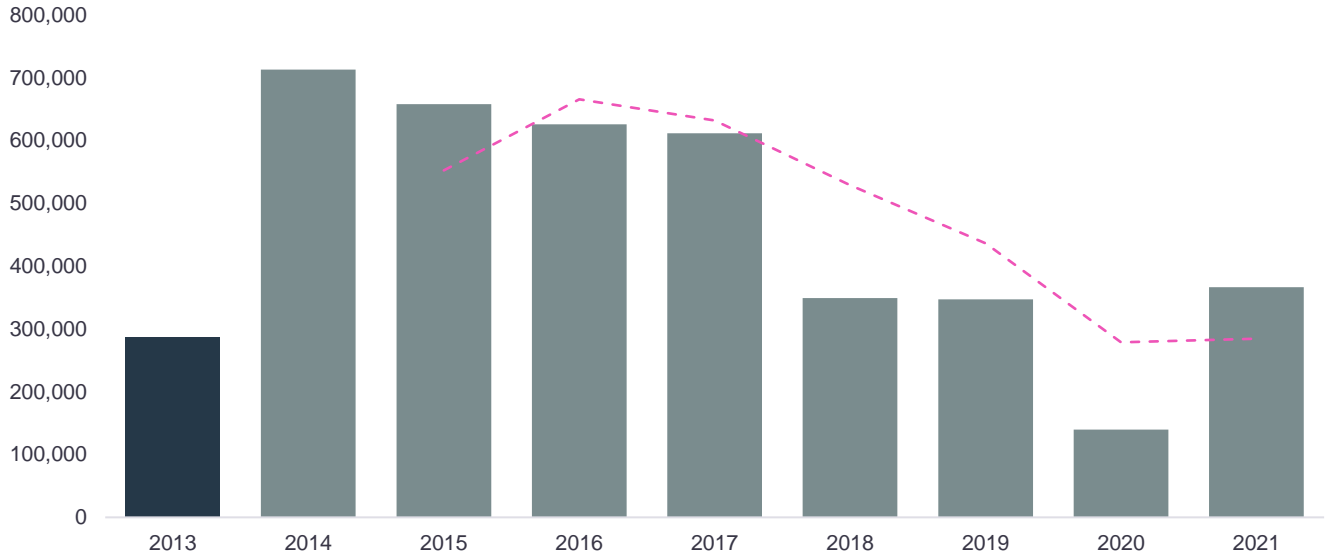


FIGURE 19. COMMUNITY-SCALE – ANNUAL TRANSPORTATION SECTOR CONTRIBUTIONS – 2013-2021

City of Columbus
 Community-Scale CO₂e Emissions
 Annual Transportation Contributions in Metric Tons
 with 3-Year Moving Average Trend | 2013 - 2021

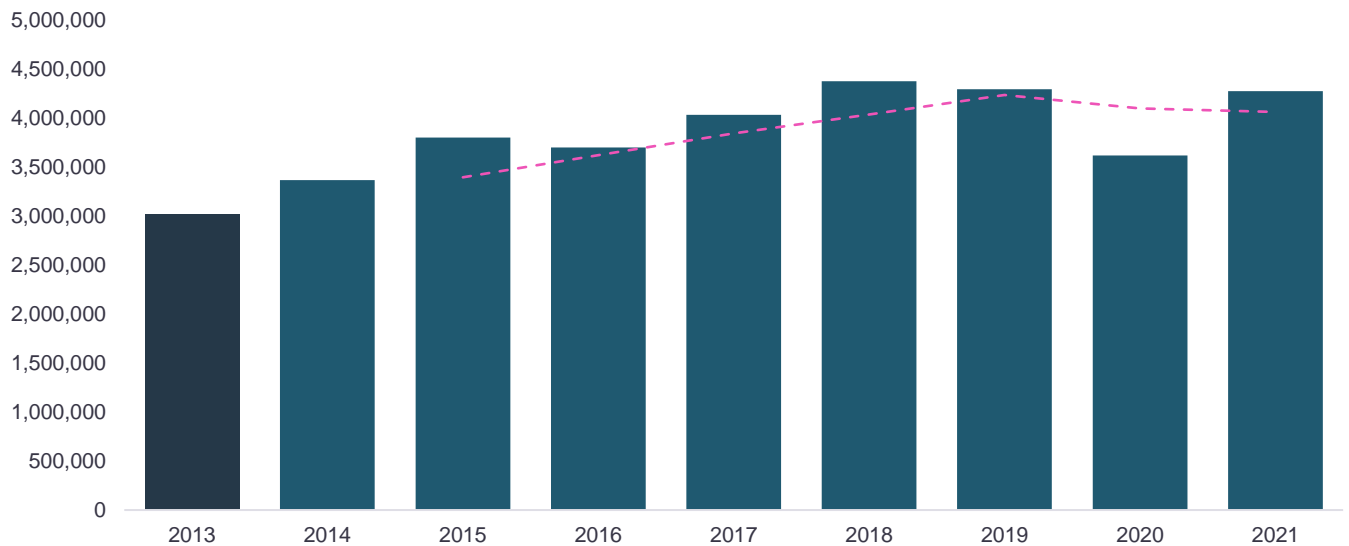


FIGURE 20. COMMUNITY-SCALE – ANNUAL SOLID WASTE SECTOR CONTRIBUTIONS – 2013-2021

City of Columbus
 Community-Scale CO₂e Emissions
 Annual Solid Waste Contributions in Metric Tons
 with 3-Year Moving Average Trend | 2013 - 2020

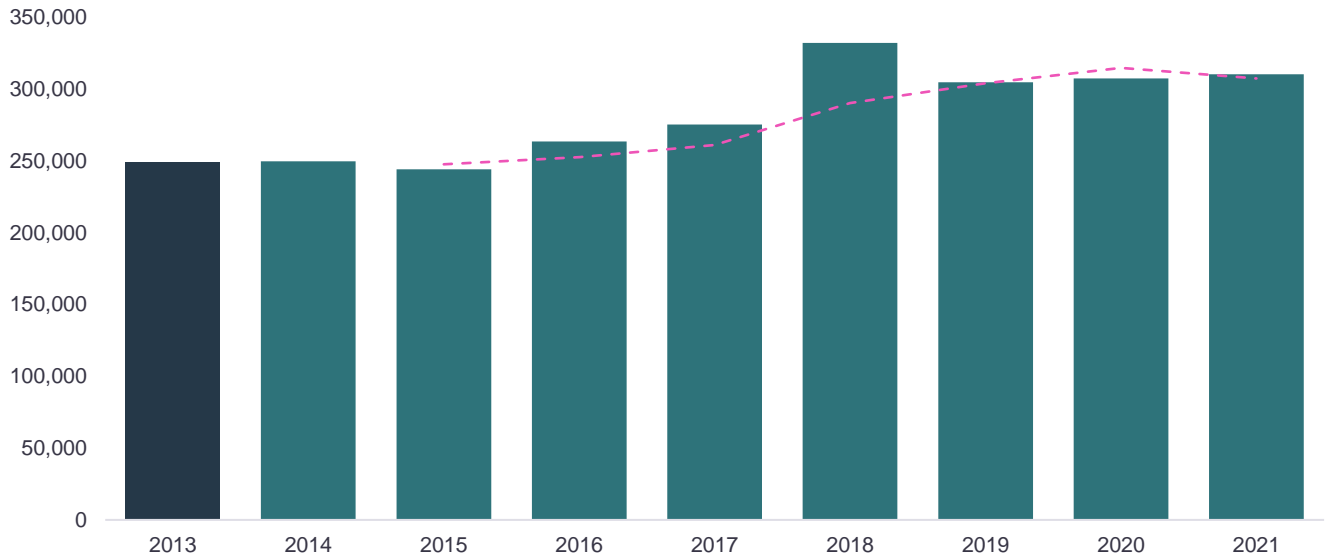
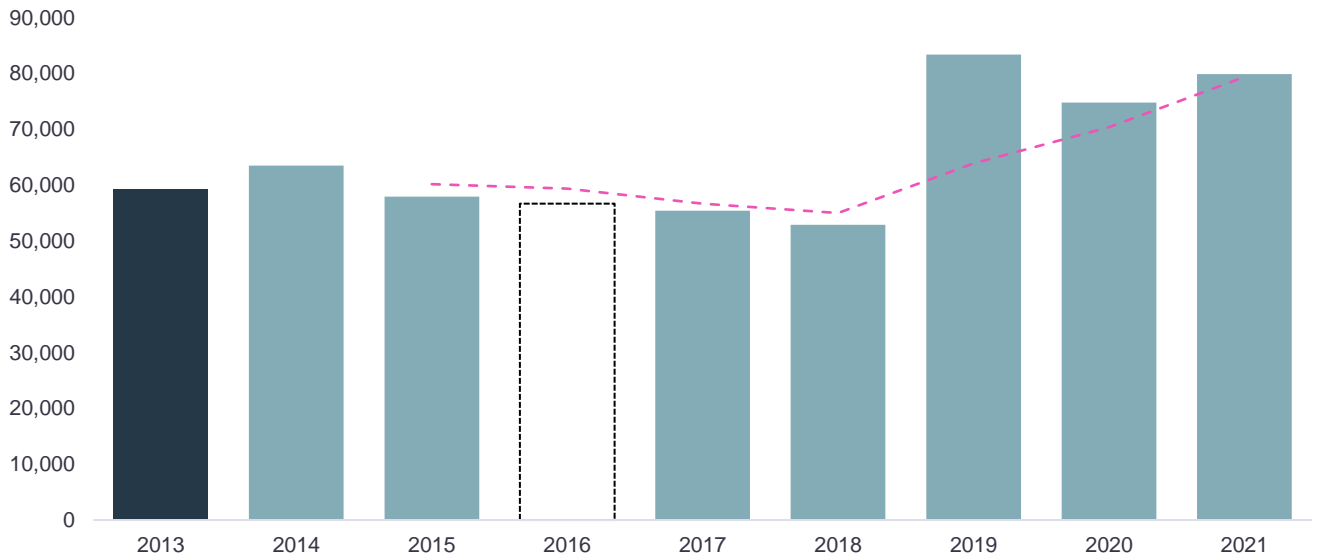


FIGURE 21. COMMUNITY-SCALE – ANNUAL FUGITIVE EMISSION CONTRIBUTIONS – 2013-2021¹⁰

City of Columbus
 Community-Scale CO₂e Emissions
 Annual Fugitive Emissions Contributions in Metric Tons
 with 3-Year Moving Average Trend | 2013 - 2021



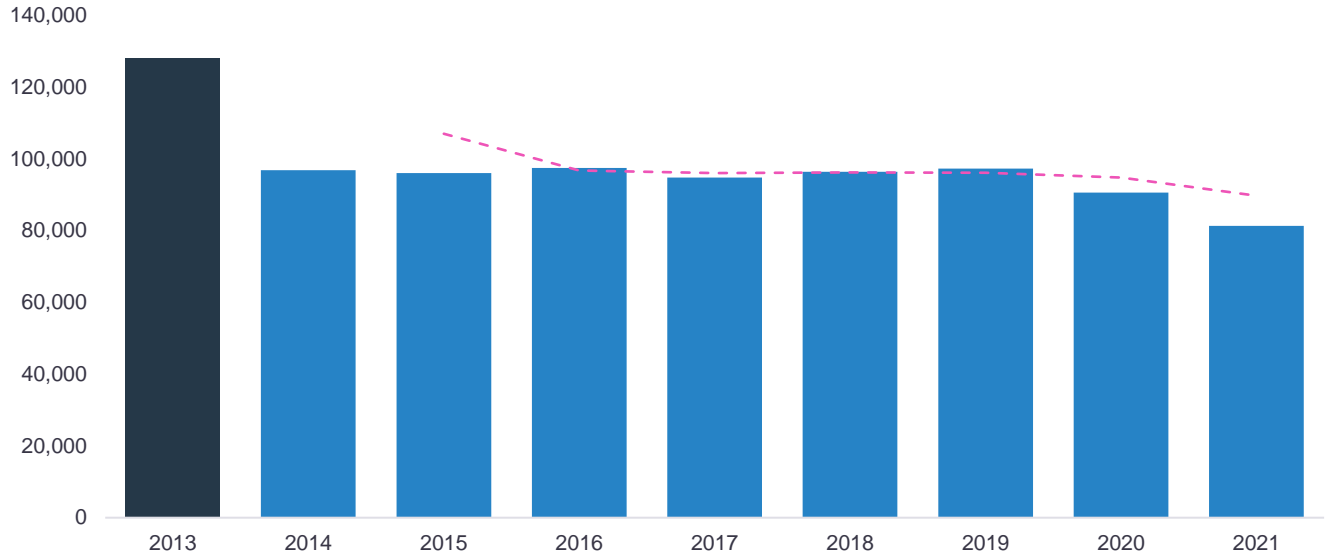
¹⁰ Fugitive emissions were not calculated or included in the 2016 GHG Inventory. The dotted box represents an assumed value.

FIGURE 22. COMMUNITY-SCALE – ANNUAL WASTE AND WASTEWATER SECTOR CONTRIBUTIONS – 2013-2021

City of Columbus

Community-Scale CO₂e Emissions

Annual Water and Wastewater Treatment Contributions in Metric Tons with 3-Year Moving Average Trend | 2013 - 2021



Appendix A

Inputs

Energy Consumption and Waste Values

Government Operations Inputs	Unit	2016	2017	2018	2019	2020	2021
Aviation - Helicopter	Gallons	61,708	100,154	111,161	118,244	64,024	60,988
City Fleet Biodiesel (off road)	Gallons	-	93,886	95,908	170,324	130,196	100,847
City Fleet Biodiesel (on road)	Gallons	0	470,960	353,342	459,112	324,762	267,172
City Fleet CNG (off road)	Gallons	-	672	1,510	11,616	16,512	6,668
City Fleet CNG (on road)	Gallons	476,151	562,787	658,932	750,904	863,167	906,003
City Fleet Diesel (off road)	Gallons	-	2,928	9,033	9,070	17,313	26,611
City Fleet Diesel (on road)	Gallons	868,701	300,396	966,559	246,845	237,226	276,312
City Fleet E85 (off road)	Gallons	-	-	-	446	-	-
City Fleet E85 (on road)	Gallons	2,060	5,190	0	8,755	4,004	1,163
City Fleet EVs (on road)	kWh	n/a	n/a	34,850	34,850	121,835	470,259
City Fleet Gasoline (off road)	Gallons	-	5,842	4,444	26,657	31,217	21,984
City Fleet Gasoline (on road)	Gallons	1,569,238	1,402,088	918,043	1,547,154	1,394,834	1,364,318
City Fleet Propane (off road)	Gallons	-	-	15,716	19,146	15,580	16,973
Destruction Efficiency - Jackson Pike & Southerly	Percent	-	99%	99%	99%	99%	99%
Electric	kWh	107,802,332	104,989,940	90,052,367	88,680,470	86,887,794	97,455,182
Gas Composition - Jackson Pike	Percent Methane	-	65%	62%	61%	61%	61%
Gas Composition - Southerly	Percent Methane	-	56%	56%	63%	63%	63%
Gas Production - Jackson Pike	scf/day	-	1,000,000	810,000	932,918	917,846	907,001
Gas Production - Southerly	scf/day	-	700,000	700,000	882,767	1,143,037	1,123,029
Heat Content - Jackson Pike	Btu/scf	-	580	570	588	588	588
Heat Content - Southerly	Btu/scf	-	512	512	554	554	577
Municipal Solid Waste Generation (Landfill Total)	Tons	320,807	326,839	331,027	325,178	352,242	344,677
Natural Gas	MMBtu	276,538	407,557	656,413	528,845	389,895	339,205
Street Lights and Signals - Electricity - DPU	kWh	42,520,846	38,069,976	44,058,418	35,181,696	48,412,050	39,984,663
Wastewater Treatment Plants - Electricity	kWh	75,205,564	92,829,836	98,662,456	97,313,001	94,829,970	91,405,025
Wastewater Treatment Plants - Natural Gas	MMBtu	66,640	75,325	67,778	109,264	101,564	101,564
Water Treatment Plants - Electricity	kWh	58,228,740	60,707,038	67,114,035	68,130,723	69,370,103	66,982,970
Water Treatment Plants - Natural Gas	MMBtu	36,523	31,681	51,733	21,294	49,603	41,244

Community-Scale Inputs	Unit	2016	2017	2018	2019	2020	2021
Aviation – Airport, gasoline	Gallons	84,767	54,479	75,315	81,903	89,568	99,517
Aviation – Airport, kerosene jet fuel	Gallons	59,713,628	68,362,002	73,251,020	81,766,923	53,560,625	84,189,599
Aviation – Helicopter (kerosene jet fuel)	Gallons	61,708	100,154	111,161	118,244	64,024	60,988
Commercial Electric Usage - DPU	kWh	130,435,929	106,813,606	113,923,918	113,998,160	82,783,991	111,032,869
Commercial Natural Gas Usage	MMBtu	13,831,531	14,529,943	10,040,435	9,649,676	6,550,352	9,581,980
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	4,811,760,557
Destruction Efficiency - Jackson Pike & Southerly	Percent	-	99%	99%	99%	99%	99%
Freight Rail, Diesel	Gallons	-	9,910,732	2,119,594	2,242,506	2,205,206	2,442,340
Gas Composition - Jackson Pike	Percent Methane	-	65%	62%	61%	61%	61%
Gas Composition - Southerly	Percent Methane	-	56%	56%	63%	63%	63%
Gas Production - Jackson Pike	scf/day	-	1,000,000	810,000	932,918	917,846	907,001
Gas Production - Southerly	scf/day	-	700,000	700,000	882,767	1,143,037	1,123,029
Heat Content - Jackson Pike	Btu/scf	-	580	570	588	588	588
Heat Content - Southerly	scf/day	-	512	512	554	554	577
Industrial Electric Usage - DPU	kWh	587,071,546	613,696,855	639,762,013	639,841,221	109,530,729	622,180,746
Industrial Natural Gas Usage	MMBtu	4,839,784	4,963,302	161,932	127,198	101,56	1,635,415
On Road, Freight, Diesel	Miles	259,715,974	262,722,228	464,442,498	400,590,749	376,257,919	407,500,363
On Road, Freight, Gasoline	Miles	6,659,384	6,736,467	11,908,782	26,721,204	9,647,639	10,448,727
On Road, Passenger, Diesel	Miles	22,156,496	22,494,699	23,578,100	28,092,665	19,467,848	21,923,288
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	7,285,839,350
Paratransit Buses, Diesel	Gallons	339,773	346,180	340,861	308,109	225,537	208,618
Paratransit Buses, Gasoline	Gallons	34,127	30,258	28,302	27,259	10,670	31,656
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	2,819,054,398
Residential Electric Usage - DPU	kWh	66,851,275	66,621,085	78,522,037	80,561,233	946,904,053	91,296,975
Residential Natural Gas Usage	MMBtu	15,549,233	15,710,210	20,280,912	19,014,639	19,109,712	16,363,597
Transit Buses, CNG	Gallons	1,497,898	1,779,363	2,061,696	2,232,396	1,745,451	2,460,280
Transit Buses, Diesel	Gallons	2,012,291	1,950,033	1,907,288	1,730,300	1,166,032	843,806
Wastewater Treatment Plants - Electricity - DPU	kWh	75,205,564	92,829,836	98,662,456	97,313,001	94,829,970	91,405,025
Wastewater Treatment Plants - Natural Gas	MMBtu	66,640	75,325	67,778	109,264	101,564	101,564
Water Treatment Plants - Electricity - DPU	kWh	58,228,740	60,707,038	67,114,035	68,130,723	69,370,103	66,982,970
Water Treatment Plants - Natural Gas	MMBtu	36,523	31,681	51,733	21,294	49,603	41,244

Emission Rates from eGRID¹¹

Government Operations					
Analysis Year	Name	Region	CO ₂ lbs/MWh	CH ₄ lbs/GWh	N ₂ 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
2021	EPA eGRID 2020	RFCW	985	86	12

Community-Scale					
Analysis Year	Name	Region	CO ₂ lbs/MWh	CH ₄ lbs/GWh	N ₂ 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
2021	EPA eGRID 2020	RFCW	985	86	12

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.

¹¹ US EPA eGRID Summary Tables 2020: https://www.epa.gov/system/files/documents/2022-01/eGRID2020_summary_tables.pdf. (Accessed October 3, 2022)

Appendix B

Progress Towards the Climate Action Plan Emissions Reduction Goals by 2030 and 2050

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.

In December of 2021, the City of Columbus published their first-ever Climate Action Plan (CAP). In the CAP, the City set a community-wide emissions reduction target of 45% by 2030 and 100% by 2050, utilizing 2013 as the baseline year. From 2013-2021, the City's population grew nearly 13%, making an absolute emissions reduction more difficult to achieve. The tables below present progress towards achieving the 45% by 2030 and 100% by 2050 goals in both 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 33% of its 2030 CAP emissions target and 15% of its 2050 CAP emissions target. When adjusting for population growth, the City has achieved 55% of its 2030 CAP emissions target and 25% of its 2050 CAP emissions target, again, inclusive of emissions offset by the purchase of RECs.

Climate Action Plan Emissions Reduction Goals		
Absolute Emissions	2030	2050
2013 Emissions Benchmark (metric tonnes)	11,265,023	11,265,023
Emissions Reduction Goal	45%	100%
Emissions Goal Absolute Reduction (metric tonnes)	5,069,260	11,265,023
Emissions Goal Target (metric tonnes)	6,195,763	0
2021 Emissions (metric tonnes)	9,627,789	9,627,789
RECs Offset (metric tonnes)	56,919	56,919
2021 Emissions including RECs (metric tonnes)	9,570,870	9,570,870
Percent of Target Achieved	33%	15%

Per Capita	2030	2050
2013 Population	805,348	805,348
2013 Emissions per Capita Benchmark (metric tonnes)	13.99	13.99
2021 Population	909,686	909,686
2021 Emissions per Capita (metric tonnes)	10.58	10.58
2021 Emissions per Capita inclusive of RECS (metric tonnes)	10.52	10.52
Per Capita Goal Absolute Reduction (metric tonnes)	6.29	13.99
Per Capita Goal Target	7.69	0.00
Percent of Target Achieved	55%	25%

Appendix C

Methodology for Estimated Sector Breakdown for Natural Gas

Unlike data collection for this report from 2016-2019, a sector breakdown of the total natural gas consumed was not available from the major regional natural gas utility. In order to estimate a sector breakdown, the averages of residential, commercial, and industrial consumption from 2016-2019, the years when the major gas utility provided true natural gas consumption by sector, were calculated and applied to this year's total natural gas consumption value. This methodology was validated by the ICLEI-USA ClearPath technical assistance team.

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