City of Philadelphia
Office of Sustainability

2022

GREENHOUSE GAS INVENTORY REPORT

City of Philadelphia

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ACRONYMS & ABBREVIATIONS

AFOLU	Agriculture, Forestry, And Other Land Use
AR	Assessment Report
CCD	Cooling Degree Days
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
eGRID	EPA's Emissions & Generation Resource Integrated Database
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GHGRP	EPA Greenhouse Gas Reporting Program
GPC	GPC for Community-Scale Greenhouse Gas Emission Inventories
GWP	Global Warming Potential
HDD	Heating Degree Days
HFC	Hydrofluorocarbons
IPCC	International Panel of Climate Change
IPPU	Industrial Processes and Product Use
MMT	Million Metric Tons
MWMP	Philadelphia's Municipal Waste Management Plan
N_2O	Nitrous Oxide
NE	Not estimated
ODS	Ozone-Depleting Substances
OOS	Office of Sustainability
PADEP	Pennsylvania Department of Environmental Protection
PFC	Perfluorocarbons
PGW	Philadelphia Gas Works
PWD	Philadelphia Water Department
SEPTA	Southeastern Pennsylvania Transportation Authority
SF_6	Sulfur Hexafluoride
EPA	Environmental Protection Agency
VMT	Vehicle Miles Traveled
WCSC	Waterborne Commerce Statistics Center
WTE	Waste-to-Energy

The City of Philadelphia is committed to cultivating a safer, cleaner, greener city, with access to economic opportunity for all through reducing greenhouse gas emissions and building climate resilience.

INTRODUCTION

Philadelphia's climate goals include achieving carbon neutrality by 2050, which is necessary to limit global temperature rise to under 2°C (and ideally under 1.5°C). Philadelphia's Office of Sustainability (OOS) has prepared this 2022 Greenhouse Gas (GHG) Inventory to continue tracking progress toward these goals.

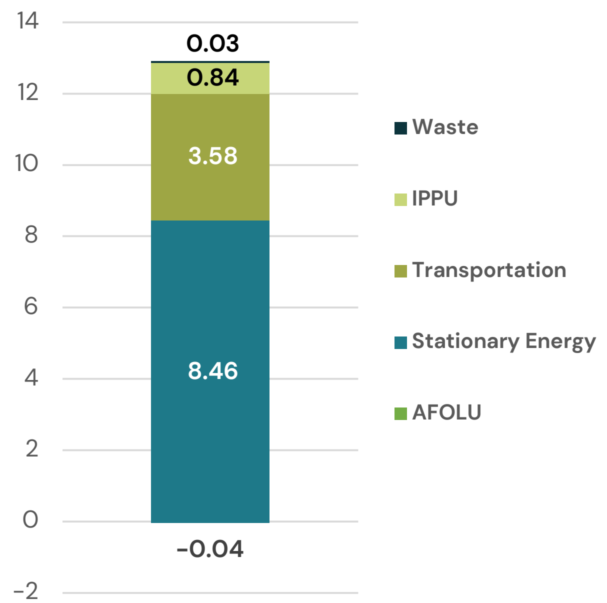
Climate action can provide the opportunity to reach GHG emissions reduction goals while promoting social equity, jobs creation, and sustainable infrastructure. The City of Philadelphia is pursuing net zero emissions through ambitious and bold climate action, while prioritizing the communities most burdened by air quality, energy and transportation costs, and those most vulnerable to climate change.

This report is a summary of the GHG inventory results for 2022 and the methodology used to develop it. The inventory includes the GHGs emitted in 2022 within Philadelphia's geographic boundary, as well as emissions occurring out-of-boundary due to activities within the city. To understand trends in emissions, the 2022 emissions are compared to the last inventory in 2019, as well as the 2014 inventory, and the baseline inventory from 2006.

CURRENT CITYWIDE EMISSIONS

The City of Philadelphia is home to 1.59 million residents[1] as of 2022, and emissions from the city were 12.9 MMT CO_2e (million metric tons of carbon dioxide equivalent for Scope 1 and Scope 2 emissions),[2] a 10% reduction from the last GHG inventory in 2019. Philadelphia's GHG emissions are affected by social, economic, institutional, and environmental factors. Changes in population, employment, and heating and cooling demands can all influence year-to-year variation in GHG emissions. In 2022, the three largest emissions sources were stationary energy (inclusive of energy used in buildings and industry), transportation, and industrial processes and product use (IPPU), totaling 12.7 MMTCO_2e, and making up 98% of the City's total emissions (Figure 1). Compared to the Commonwealth of Pennsylvania and total emissions for the United States, Philadelphia's 31% reduction from baseline emissions (2006) exceeded both commonwealth and national reductions over the same period.[3]

Figure 1
A breakdown of Philadelphia's 2022 GHG emissions by sector in MMTCO_2e.



[1] Data USA, 2022, Philadelphia, PA, https://datausa.io/profile/geo/philadelphia-pa

[2] A description and visualization of Scope 1, Scope 2 and Scope 3 can be found on page 12 and in Figure 5.

[3] The U.S. has set the target of achieving a 50 to 52 percent reduction in economy-wide emissions by 2030, relative to 2005 levels. As of 2022, gross GHG emissions were 15.4 percent lower than they were in 2005. Statista, April 2024, Annual total gross greenhouse gas emissions in the United States from 1990 to 2022, https://www.statista.com/statistics/517376/us-greenhouse-gas-emissions/#:~:text=In%202022%2C%20total%20gross%20greenhouse,below%20pre%2DCOVID%2019%20levels.

AT A GLANCE

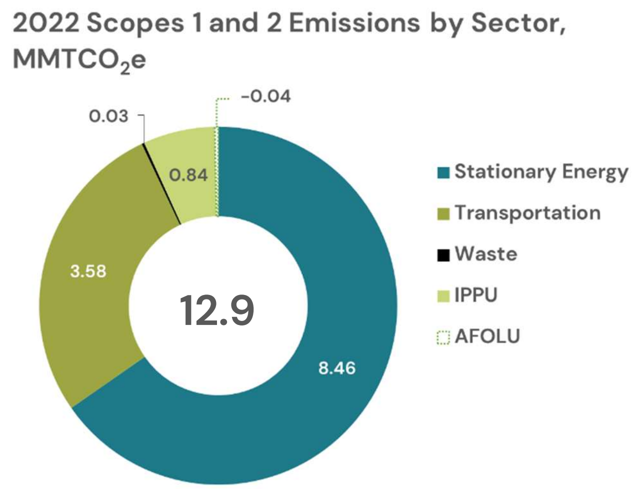
12.9

$MMTCO_2e$ in 2022

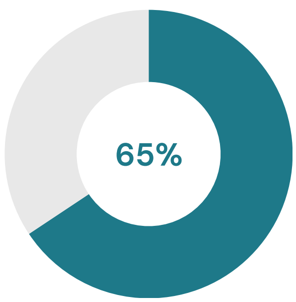
31%

Reduction from 2006

The City of Philadelphia has furthered its commitment to reaching the Commonwealth of Pennsylvania's 2050 climate goal of 80% emission reductions and carbon neutrality. In 2022, total GHG emissions were **12.9 $MMTCO_2e$**, a **31%** reduction from **2006 emission levels**.

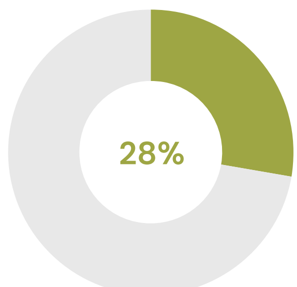


Stationary Energy



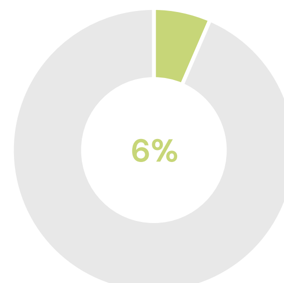
8.46 $MMTCO_2e$

Transportation

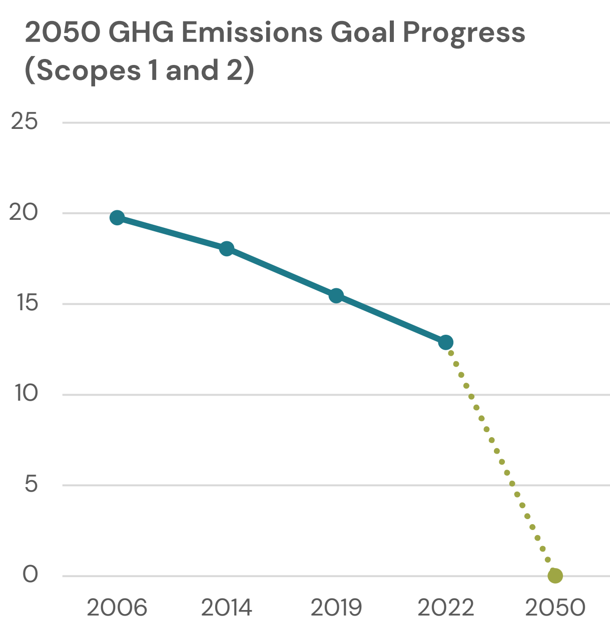


3.58 $MMTCO_2e$

IPPU



0.84 $MMTCO_2e$



Key Causes of Change in 2022

Stationary Energy

- Electricity generation from coal decreased from 12.3% in 2019 to 8.8% in 2022.
- The 2019 closure of the Philadelphia Energy Solutions refinery significantly reduced industrial facility emissions in the city in 2022. Total emissions from the facility in 2018, the last full year of operation was over 3.2 $MMTCO_2e$.
- Stationary energy use including gas and electricity use declined across residential, commercial and industrial buildings.

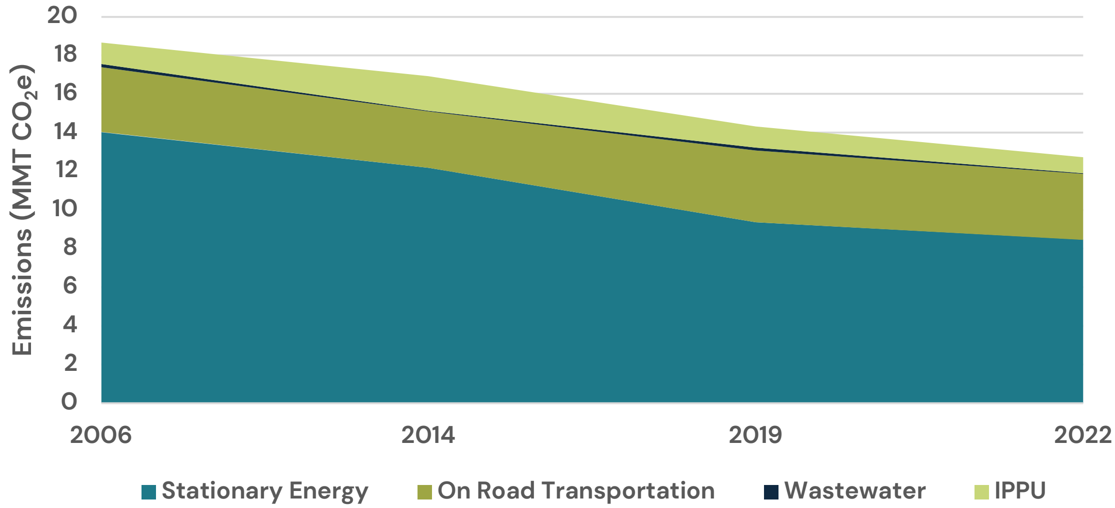
Transportation

- VMT emissions decreased by 10% from 2019, returning nearly to pre-2006 emission levels.
- Passenger rail and marine emissions increased by 19%.

GHG TRENDS

Since 2006, the City of Philadelphia's annual net emissions (Scope 1 and 2) have dropped consistently from 18.6 $MMTCO_2e$ to 12.9 $MMTCO_2e$ (Figure 2). This represents a significant reduction across all sectors over the 16-year period.[4] However, over this time frame, significant weather and world events have caused fluctuations across various sectors.

Figure 2
Scope 1 and 2 GHG trends from 2006 through 2022.

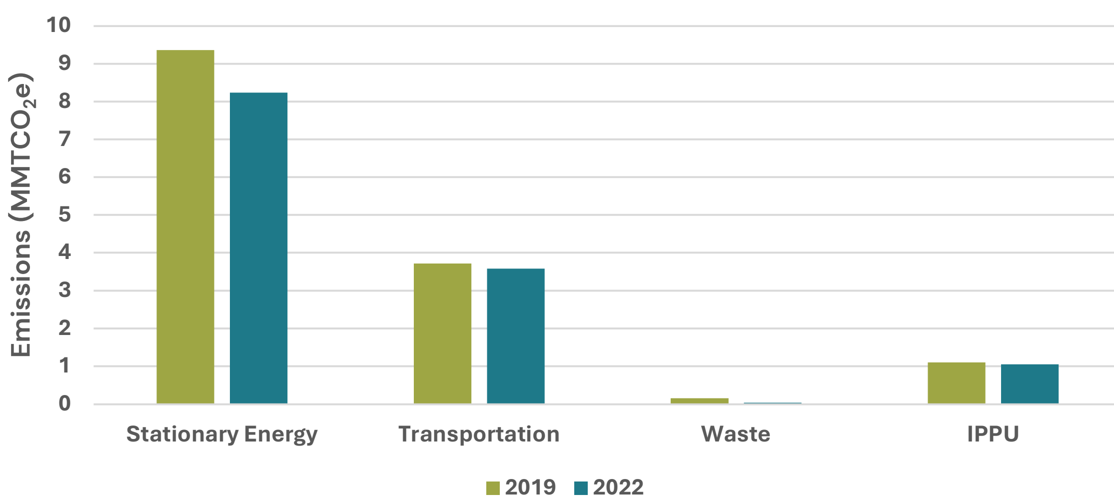


COVID-19 Impacts

The COVID-19 pandemic was a major world event that has lasting environmental, public health, and economic impacts. Since the last GHG Inventory for the city in 2019, there have been considerable transformations in the city's emissions profile due to COVID-19. The global response to the pandemic has reshaped our lives and, by extension, our emissions. This inventory acknowledges and analyzes the impacts of the COVID-19 pandemic to further inform policy decisions for the city that promote health, equity, and environmental protection.

The figure below (Figure 3) highlights the impact that COVID-19 had on emissions, particularly in transportation, as institutions and businesses integrated remote work programs that continue to the present day.

Figure 3
Comparison of GHG emissions by sector for 2019 and 2022 in $MMTCO_2e$.



GLOBAL WARMING POTENTIALS

Different greenhouse gases have varying effects on the planetary climate when viewed at different time scales. For example, on a 100-year scale, methane (CH_4) is 28 times stronger than CO_2; however, on a 20-year scale it increases drastically to 83 times stronger than CO_2. The Global Warming Potential (GWP) is a weighting factor that accounts for the difference in climate impact of various GHGs, using CO_2 as the reference (meaning that the GWP value of CO_2 is 1). The International Panel of Climate Change (IPCC) updates the GWP values as scientific models improve and as the atmosphere changes and publishes these updates in their Assessment Reports (AR).

Table 1
Global Warming Potential values by gas type

Gas	GWP-100	GWP-20
CO_2	1	1
CH_4	28	82.5
N_2O	265	273
SF_6	23,500	18,300

Sources:
IPCC Fifth Assessment Report (AR5)
IPCC Sixth Assessment Report (AR6)

Because methane is so much more powerful of a pollutant than CO_2 at a shorter scale, achieving significant reductions would have a more immediate effect on slowing the rate of global warming, while simultaneously working to mitigate carbon emissions in the long-term. Therefore, each sector's emissions were not only reviewed by emission type, but on both a GWP-100 and GWP-20 scale. In the 2019 GHG Inventory, GWP values for the 100-year horizon were presented using data from IPCC's Fourth Assessment Report (AR4). It should be noted that for this inventory, GWP-100 values are using data from IPCC's Fifth Assessment Report (AR5). However, the GWP-20 values remain the same, with the summary GHG emissions data being presented using values from IPCC's Sixth Assessment Report (AR6) to address the greater short-term impact of methane.

OVERVIEW

REPORTING REQUIREMENTS

Philadelphia's GHG emissions reporting requirements are in accordance with the Global Protocol for Community-Scale GHG Emission Inventories[5] (GPC), which is the standard for reporting local government GHG emissions inventories. The development of the GPC was completed in 2014, superseding the protocols used for Philadelphia's prior inventories. In accordance with the GPC, Philadelphia's inventories are organized by scope[6] (Scope 1, Scope 2, and Scope 3). These scopes reflect where GHG emissions and activities generating them are occurring. The GPC framework also includes reporting levels –BASIC and BASIC+, of which BASIC+ reporting is more comprehensive.[7] All previous inventories along with this 2022 inventory for Philadelphia comply with the BASIC+ reporting standard. Figures in the section above have all outlined emissions for Scope 1 and 2 only. As we move into other parts of this report, figures and report language will also include Scope 3 emissions as noted.

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[5] Greenhouse Gas Protocol, 2014, Global Protocol for Community-Scale GHG Emission Inventories, https://ghgprotocol.org/sites/default/files/standards/GPC_Full_MASTER_RW_v7.pdf

[6] A description and visualization of Scope 1, Scope 2 and Scope 3 can be found on page 11 and in Figure 5.

[7] The BASIC reporting level covers scope 1 and scope 2 emissions from stationary energy and transportation, as well as scope 1 and scope 3 emissions from waste. BASIC+ also includes emissions from IPPU, AFOLU and transboundary transportation.

SECTOR BREAKDOWN

The sectors identified in the GPC and used for this inventory include:

Stationary Energy

Fuel and electricity use in residential and commercial buildings, manufacturing and construction, and energy industries.

Transportation

Fuel and electricity use for commutes, travel, and transport of goods by all transportation modes (on-road, rail, waterborne, aviation).

Waste

Solid waste management and wastewater treatment.

Industrial Processes and Product Use (IPPU)

Non-energy related industrial activities that chemically or physically transform materials (e.g., iron and steel industry and manufacturing of ammonia), as well as the use of certain GHG containing products, such as refrigerants, foams, and aerosols. In this report, other scope 1 emissions such as gas losses have been included IPPU in many graphs based on work from previous inventories.

Agriculture, Forestry, and Other Land Use (AFOLU)

Emissions associated with livestock, land use and land use change (e.g., clearing of forested), and emissions from other land practices, such as the use of fertilizers.

GEOGRAPHIC AND DEMOGRAPHIC INFORMATION

GHG emissions are, to a large extent, a result of human activity. Therefore, indicators of human activity, such as population and employment, are important to consider when tracking changes in emissions over time. Furthermore, it is important to consider the temperature variability when comparing GHG emissions from different years to account for differences in energy used for building heating and cooling. A good indicator of the heating and cooling needs are the heating and cooling degree days (HDD and CCD) metrics. Table 2 provides an overview of Philadelphia's key demographic and geographic indicators for 2019 and other inventory years.

Philadelphia experienced an increase in population and employment of 4.1% and 14.4%, respectively, since 2006. The table below shows not only the expansion in these two indicators, but for the heating and cooling demand due to increased heating degree days and cooling degree days since the baseline year. The changing need for efficient heating and cooling and Philadelphia's approach to that can be seen in the residential and commercial/industrial buildings electricity use section of the inventory.

Table 2
Philadelphia's demographic and geographic information for past and current years.

Year	Population	Employment	HDD	CDD
2006	1,504,950	711,418	3,972 degree days	1,234 degree days
2014	1,560,297	747,899	4,776 degree days	1,220 degree days
2019	1,584,064	790,653	4,331 degree days	1,477 degree days
2022	1,567,258	814,365	4,157 degree days	1,671 degree days

Sources:
United States Census Bureau, ACS Age and Sex Estimates for Philadelphia County, Total Population
United States Census Bureau, Selected Economic Characteristics for Philadelphia County, Population 16 and over in labor force
Heating and Cooling Degree Days, Energy Star

EMISSIONS BY GREENHOUSE GAS

As noted in previous sections, this inventory includes greenhouse gas emissions values at the 100-year and 20-year GWP level. The total emissions for 2022 calculated using the 20-year horizon GWP values (from AR6-20) are 20.6 $MMTCO_2e$, which is approximately 23% higher than the emissions of 16.7 $MMTCO_2e$ calculated using the 100-year horizon GWP values (from AR5-100).

To effectively mitigate the negative impacts from climate change and reduce GHG emissions, it is vital to analyze data in the short and long term. Figure 4 highlights the different levels of contribution that the different GHGs have at a 20-year and 100-year GWP level.

Figure 4
Comparison of emissions percentage by GHG based on 100-year and 20-year GWPs.

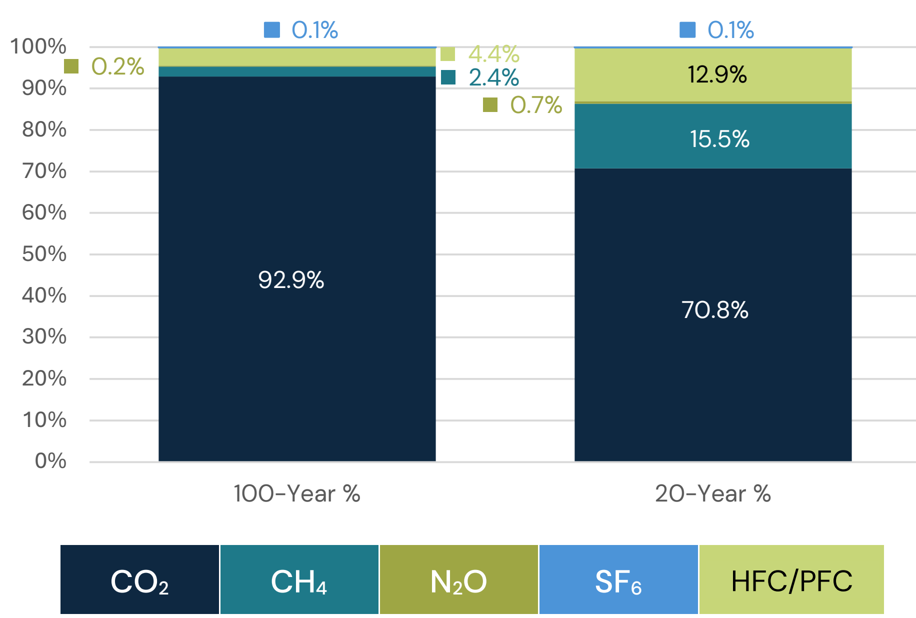


Figure 4 shows the contributions of different gases to the overall emissions in the inventory. The figure shows that carbon dioxide (CO_2) is the predominant GHG emitted. Figure 4 illustrates how the use of different GWP values affects the overall emissions and the contributions by gas. Using 20-year horizon GWPs (AR6-20), results in calculated emissions that are higher than emissions calculated using the 100-year horizon GWPs (AR4-100). Over the shorter (20-year) time horizon, the methane (CH_4) GWP is greater and contributes more to the overall emissions (15.5% vs. 2.4%). By targeting methane emissions across sectors, Philadelphia can achieve a shorter-term reduction in emissions. Methane emissions included in Philadelphia's GHG inventory are primarily the result of waste decomposition in landfills and utility gas operational losses due to issues like pipe leakage.

EMISSIONS BY SCOPE

This inventory and all previous inventories organize their emissions by scope, in accordance with the GPC.

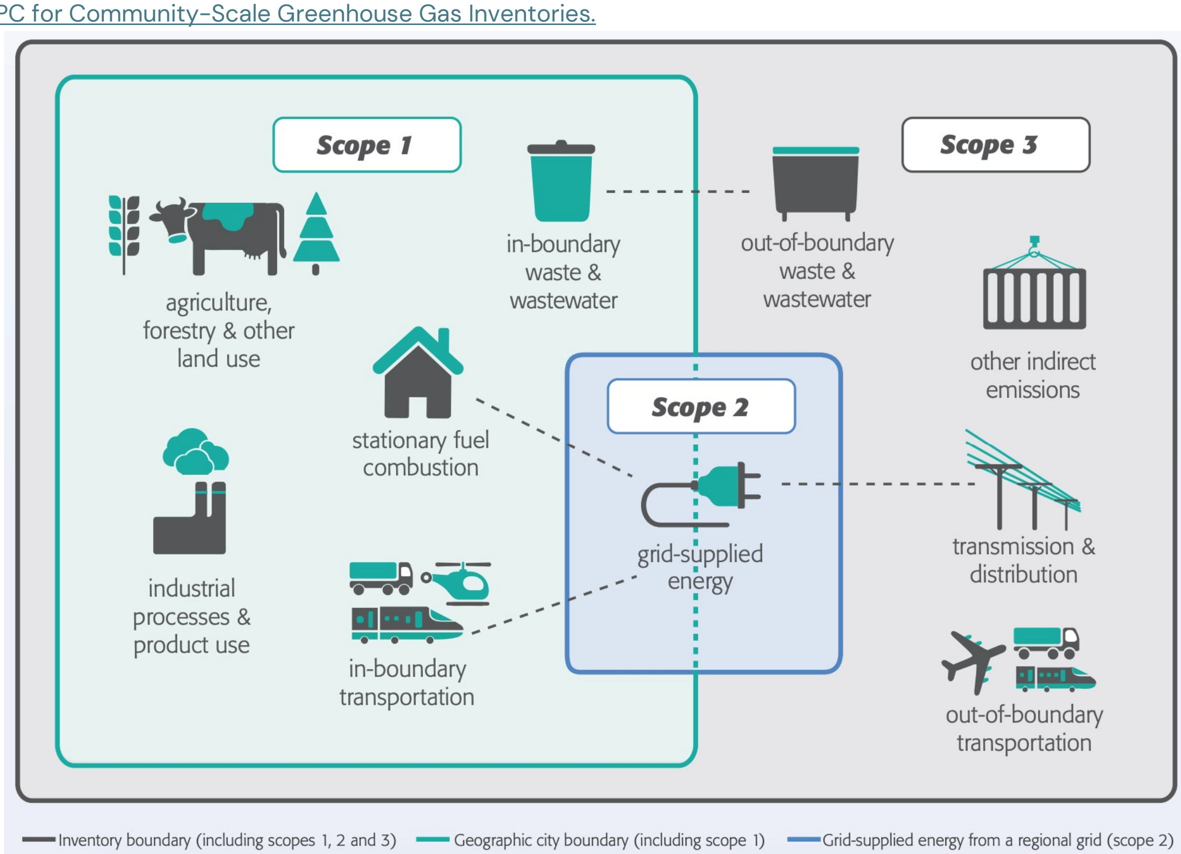
Scope 1 emissions are from sources located directly within the city boundary.

Scope 2 emissions are emissions that occur as a consequence of the use of grid-supplied electricity, heat, steam, and/or cooling within the city boundary.

Scope 3 emissions are all other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Figure 5
A visual depiction of GHG emissions organized by Scopes 1, 2, and 3.

Source: GPC for Community-Scale Greenhouse Gas Inventories.



The breakdown of Philadelphia's emissions by scope are detailed in Table 3, where a distinct downward trend across all scopes is shown, the greatest reduction being seen in Scope 2 emissions.

Table 3

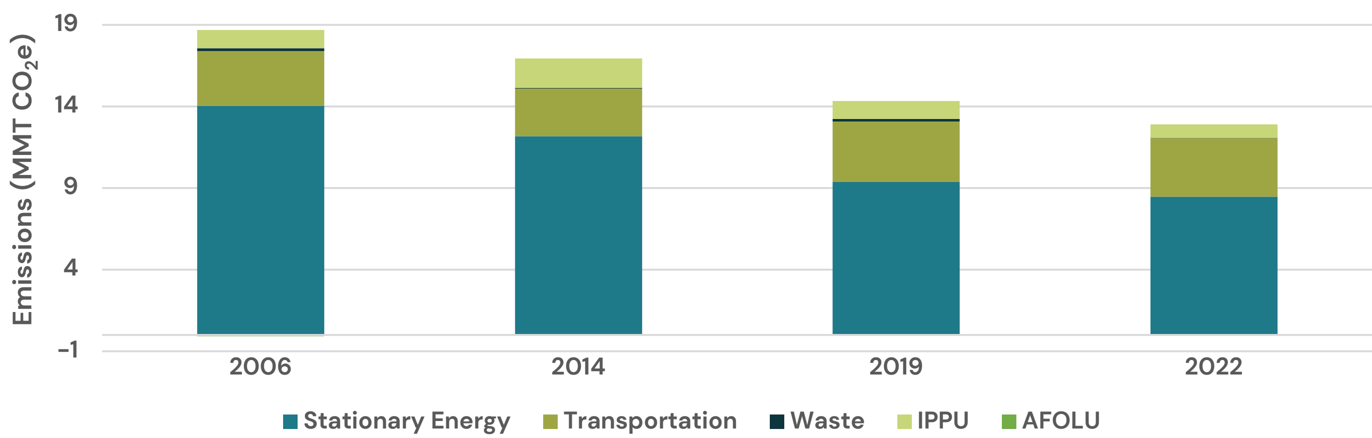
Emissions for the years 2006, 2014, 2019, and 2022 summarized by scope and percent change from baseline.

Year	Scope 1	Scope 2	Scope 3	Total	Total (S1&2)
2006	11.23	7.38	5.8	24.41	18.61
2014	11.62	5.58	0.61[8]	17.81	17.20
2019	10.06	4.33	4.98	19.37	14.39
2022	8.61	4.29	3.44	16.33	12.90
Change from 2006 Baseline	-23%	-42%	-41%	-32%	-31%

EMISSIONS BY SECTOR

Figure 6

Breakdown of Scope 1 and 2 emissions by sector for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.



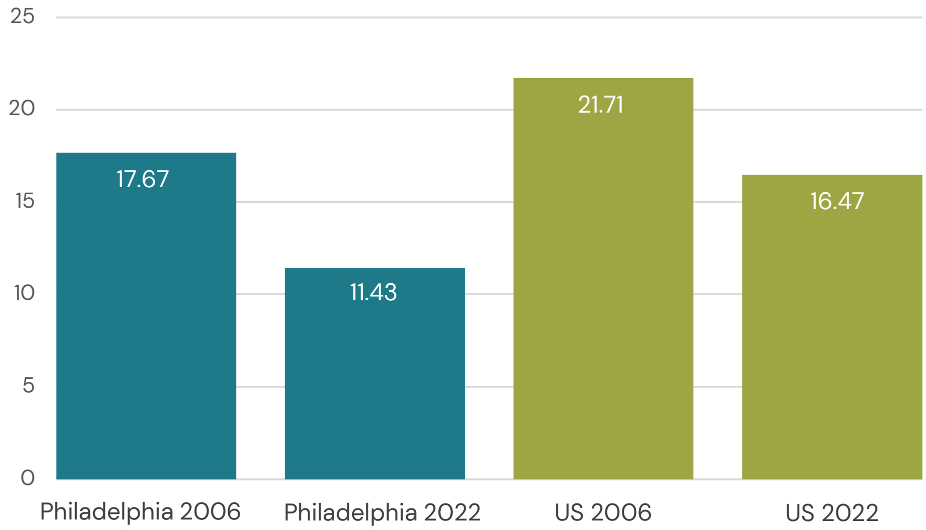
A detailed look into each sector's emissions and emissions as a percentage of total emissions (for each year) and the percent change in emissions by sector in 2022 as compared with the 2006 baseline can be found in the Appendix summary tables.

[8] Aviation emissions were excluded in 2014.

PER CAPITA EMISSIONS

Figure 7

Per capita emissions (Scopes 1 and 2) in Philadelphia compared to US for 2019 and 2022 in $MTCO_2e$ per person.



Philadelphia's lower per capita emissions can be attributed to dense urban development, which is generally more energy efficient than suburban areas, to Philadelphia's well-developed public transit system, efficient land use patterns, biking infrastructure, and the initiatives that Philadelphia implemented to reduce emissions. Philadelphia is also one of the most walkable cities in the country, ranking as the 8th most walkable city in the country and 5th most walkable on the east coast in 2021.[9]

[9] Walk Score, 2025, Cities and Neighborhoods, https://www.walkscore.com/cities-and-neighborhoods/

RESULTS BY SECTOR

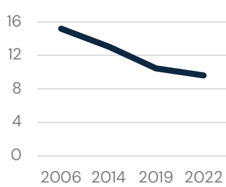
SUMMARY

Stationary Energy

8.46 MMTCO₂e

10% ▼ change from 2019

Emissions Trend



Largest Contributors

Commercial and Industrial, **5.08**

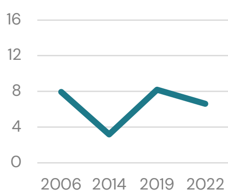
Residential, **3.37**

Transportation (Including Scope 3)

6.61 MMTCO₂e

18% ▼ change from 2019

Emissions Trend



Largest Contributors

On-Road, **3.34**

Aviation, **3.05**

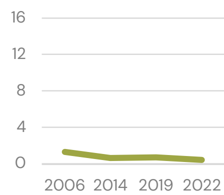
Passenger Rail, **0.17**

Waste (Including Scope 3)

0.44 MMTCO₂e

39% ▼ change from 2019

Emissions Trend



Largest Contributors

Solid Waste, **0.40**

Wastewater, **0.03**

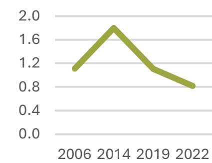
Incineration, **<0.01**

Industrial Processes and Product Use (IPPU) and Other Scope 1

0.86 MMTCO₂e

25% ▼ change from 2019

Emissions Trend

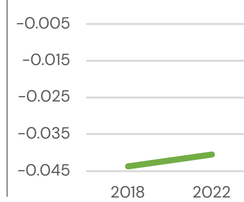


Agriculture, Forestry, and Other Land Use (AFOLU)

0.04 MMTCO₂e sequestered

7% ▼ change from 2018

Emissions Trend



Note: The 2014 Inventory excludes several sources of emissions that are included in the 2006, 2019, and 2022 inventories which account for the dip in emissions as shown in some of these graphics

Results by sector outline the total emissions (Scope 1, 2, and 3) by sector, their change from 2019, an emissions trend line, as well as the largest contributors of emissions.

STATIONARY ENERGY

Overview

Emissions from the stationary energy sector include emissions from fuel and electricity use in residential, commercial, and institutional buildings and facilities. They also include emissions from manufacturing and construction industries, energy industries, and fugitive emissions from fossil fuel systems, such as gas leaks from distribution mains. It is important to note that utilities commonly aggregate information on energy use by commercial and industrial customers. For this reason, commercial and industrial emissions are aggregated in Philadelphia's inventory. Energy use and the associated emissions from institutional buildings (e.g., libraries, court houses, and museums) are also aggregated within the commercial and industrial subsector.

Figure 8
Stationary energy emissions for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.

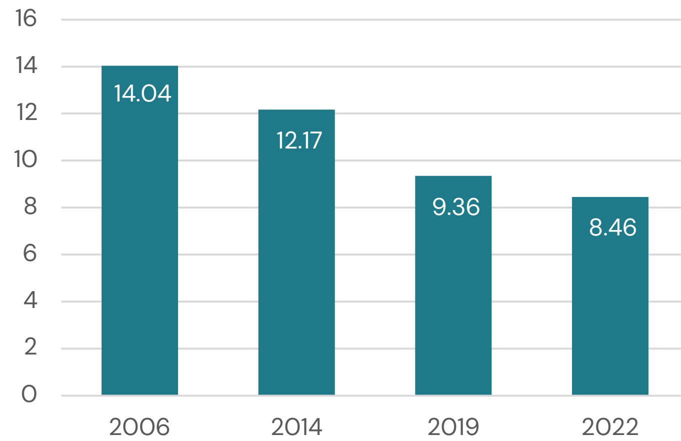
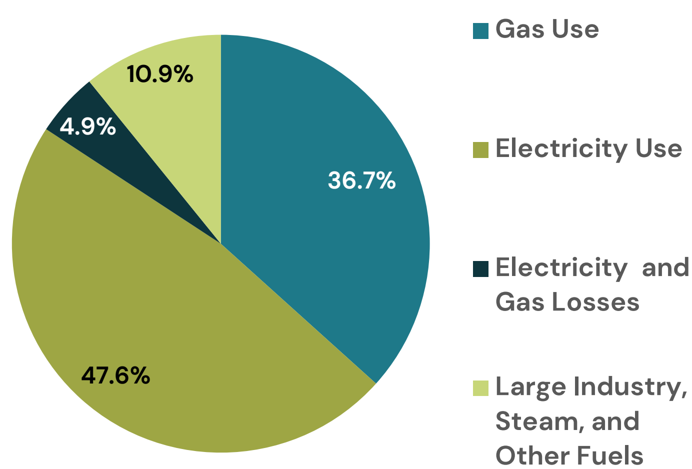


Figure 9
Subsector contributions to 2022 emissions by percentage.



In 2022, Philadelphia's stationary energy emissions were approximately 8.46 $MMTCO_2e$, a 10% reduction compared to 2019 stationary energy emissions, which were 9.36 $MMTCO_2e$. Since 2006, stationary energy emissions have reduced from 14.04 $MMTCO_2e$ to 8.46 $MMTCO_2e$, a nearly 40% reduction. The highest contribution to stationary energy emissions in 2022 was from electricity use at 4.02 $MMTCO_2e$, followed by gas use at 3.1 $MMTCO_2e$, shown in Figure 9.

Residential, Commercial, and Industrial Emissions from Gas Use

Utility gas (also referred to as natural gas) is the primary fuel used for heating and cooking in Philadelphia's homes and businesses. Gas is also used to power cooling equipment, to generate electricity, and in industrial processes.

Two utilities provided information on 2022 gas consumption – Philadelphia Gas Works (PGW), Philadelphia's municipally owned gas utility, and PECO (which provides gas to a small number of Philadelphia customers). Emissions from this energy use were calculated using U.S. Environmental Protection Agency (EPA) emission factors.

PGW provided gas usage data for every year; however, for 2006 and 2014, gas consumption was aggregated for commercial and industrial customers. For 2019 and 2022, more detailed data is available from PGW.

Overall, the gas consumption for Philadelphia in 2022 was lower than all previous years, totaling 3.2 $MMTCO_2e$ and 60.2 trillion BTU.

Gas Losses

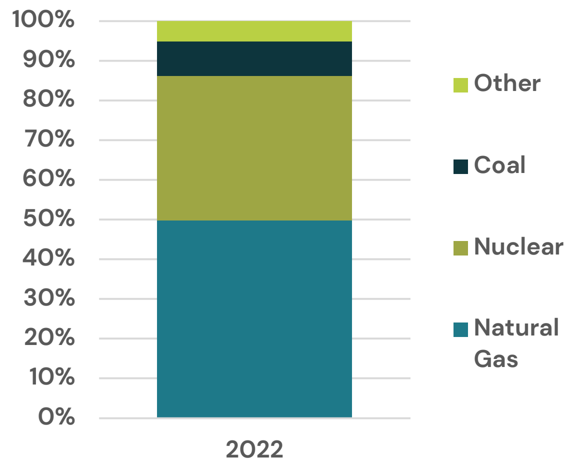
Leaks from natural gas pipelines and other gas systems release methane into the atmosphere, producing what is called fugitive emissions. Leaks often begin as cracks in pipes due to age and from shifting through freeze-thaw cycles throughout seasons. In 2019, emissions from these losses were 309,499 MT CO_2e, and in 2022 there was a substantial decrease with only 230,930 MT CO_2e in gas losses. Improvements in gas infrastructure (pipes and transmission meters) help reduce pipeline loss, leading to this reduction in losses.

Residential, Commercial, and Industrial Emissions Associated with Electricity Use

Electricity is used in residences, businesses, institutions, and industries for lighting, cooling, and powering equipment and machinery. Electricity can also be used for heating, cooking, water heating, and for charging electric vehicles. Electricity supplied to Philadelphia customers is generated from a variety of sources, including fossil fuels, which produce CO_2, CH_4, and N_2O emissions. In 2022, the primary source of electricity came from natural gas at 50%, followed by nuclear, coal, renewables, biomass, and oil (Figure 10). Since 2006, natural gas has become the primary source of electricity generation as the regional grid shifted away from coal; however, in future years, there will need to be a secondary shift from natural gas to lower carbon electricity generation sources to continue reductions.

Figure 10

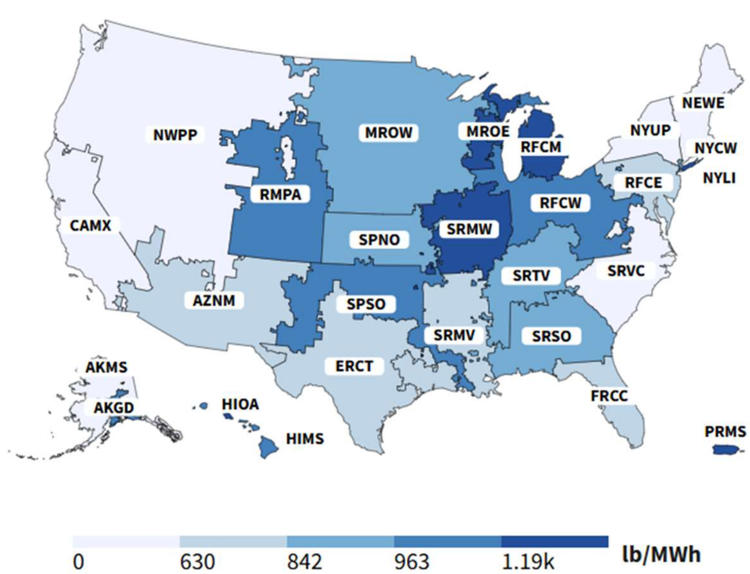
2022 Electricity generation by source.



Other includes hydro, wind, solar, biomass, oil, geothermal, and all other electricity generation sources.

Figure 11

Map of eGRID subregions and CO_2 emission rates for 2022.



The region's emission rate is on the lower end of data compared to the rest of the country according to EPA's Emissions & Generation Resource Integrated Database (eGRID). In 2022, the eGRID region that Philadelphia is in, RFCE, had an output emission rate of 657.39 lb. CO_2e/MWh, as seen in Figure 11.

Stationary electricity use and associated emissions declined in 2022, as compared with 2019, 2014, and the 2006 baseline. The electricity use in Philadelphia for 2022 was 13,108 GWh and generated emissions of 3.9 $MMTCO_2e$. This is a 4.3% reduction in emissions compared to 2019 emissions of 4.1 $MMTCO_2e$, despite a growth of 1.2% in electricity use.

Philadelphia's population increased approximately 4% between 2006 and 2022 and both the number of cooling degree days and heating degree days were greater in 2022 than it was in 2006 (see Table 2). The number of HDD and CDD are indicators of energy demand for heating and cooling. Although Philadelphia had more residents and greater heating and cooling demands in 2022 as compared with 2006, electricity consumption in 2022 has remained relatively stable over that time period, indicating that energy efficiency improvements and energy conservation efforts may have started to have an effect.

Over the same period, emissions associated with electricity use dropped by almost 40%, mainly due to a decreased regional reliance on coal for electricity production. While less carbon intensive than coal, the use of natural gas to generate electricity results in GHG emissions that would need to be cut for Philadelphia to reach the stated climate goals.

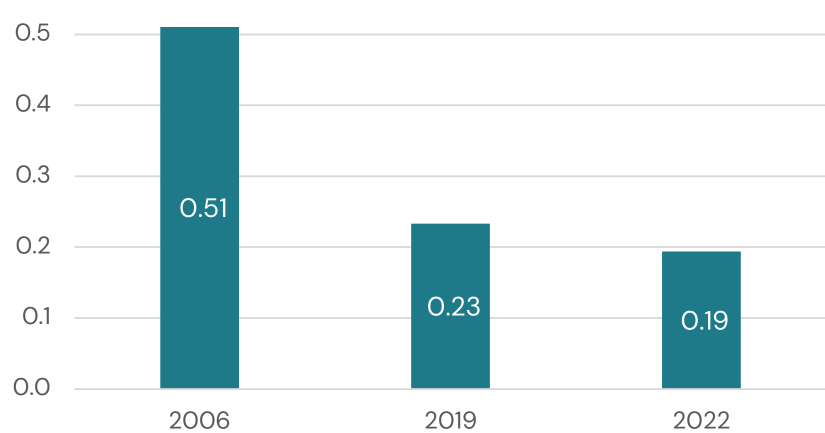
Electricity Emission Rates

Electricity emissions calculations for Philadelphia are based on electricity emission rates, as shown in Table 4 below and outline the steady decrease in electricity emissions rate since 2005.

Table 4
Electricity emission rates.

GHG	2005	2014	2019	2022	Emission Rate Units
CO_2	1,139.1	829.4	695	657.4	CO_2 (lbs/MWh)
CH_4	30.3	73.9	53	45	CH_4 (lbs/GWh)
N_2O	18.7	11.2	7	6	N_2O (lbs/GWh)

Figure 12
Emissions from electricity losses in 2022, 2019, and 2006 baseline in $MMTCO_2e$.



Electricity Losses

Not all electricity produced at power plants reaches customers. Rather, 5-6% of the energy dissipates in the conductors (electric wires), transformers, and other equipment used for transmission, transformation, and distribution of power.[10] This electricity is referred to as "grid losses" or "transmission and distribution losses." The emissions associated with Philadelphia's contribution to these losses are based on the 2022 loss factor of 5.1%.

[10] EPA, 2025, Frequent Questions about eGRID: What is Grid Gross Loss? https://www.epa.gov/egrid/frequent-questions-about-egrid#What%20is%20Grid%20Gross%20Loss

Steam Production Emissions

Philadelphia's district steam system carries pressurized steam to buildings to meet heating and operational needs. In 2022, this system was operated by Vicinity Energy to deliver steam to buildings in both West Philadelphia and Center City. The steam system includes three generating facilities: Grays Ferry, Edison Street, and Schuylkill. The emissions from these facilities are detailed in Figure 13. The emissions are based on information obtained from the U.S. EPA Greenhouse Gas Reporting Program (GHGRP).

Figure 13
Emissions from steam production in Philadelphia from 2006, 2014, 2019, and 2022 in $MMTCO_2e$.

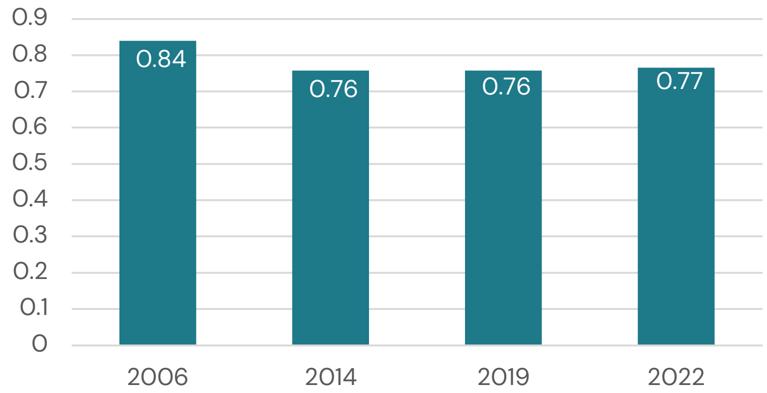
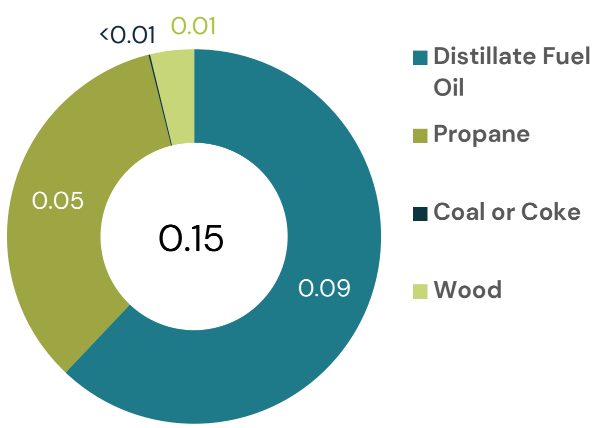


Figure 14
Emissions from other fuel use by source for 2022 in $MMTCO_2e$.



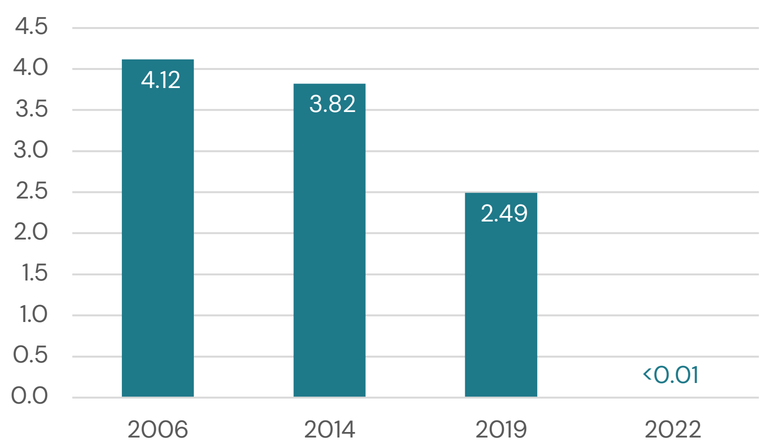
Emissions from Other Fuel Use in Residential and Commercial Subsectors

Gas and electricity use are the main sources of emissions in the residential and commercial subsectors. Other fuels, such as fuel oil, are also used in some homes and businesses. As multiple delivery companies distribute these fuels, centralized information on non-utility fuel consumption is not available. Data from the American Community Survey information (prepared by the U.S. Census Bureau) served as the basis for estimating consumption and associated emissions from the use of non-utility fuels.

Emissions from Large Industrial and Commercial/Institutional Sources

Emission sources for this subsector of stationary energy include the former Philadelphia Energy Solutions refinery and a range of other facilities in the city, all of which report emissions to the EPA annually. In the process of collecting data for this 2022 inventory, data from previous inventories was revisited to ensure there were no instances of double counting emissions. In many cases, it was found that previous inventories counted gas use in two places (from both PGW and the through the EPA's FLIGHT reporting platform).

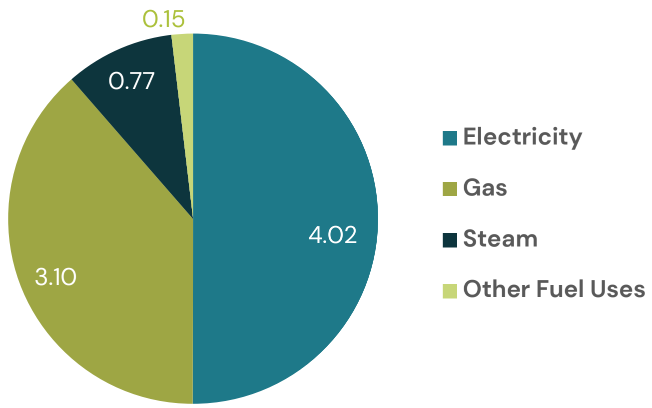
Figure 15
Emissions from large industrial and commercial/ institutional sources for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.



This double counting has since been resolved across the historical inventories and is detailed further in the Appendix. Remaining non gas emissions from manufacturing facilities were very small in 2022 as most facilities required to report to EPA have switched almost entirely to utility-provided natural gas.

Figure 16

Energy source of emissions in 2022 in $MMTCO_2e$.



Energy Use Summary

To meet local, Commonwealth, and federal GHG reduction goals, efforts are under way to electrify transportation and buildings (e.g., to enable the use of electricity for heating). It is therefore important to track the use of gas, electricity, steam, and other fuels in buildings, as well as to prepare for the increase in electricity demand over time. To meet GHG reduction goals, it will be important to ensure that the electrification effort does not outpace the transition to lower carbon electricity sources.

TRANSPORTATION

The transportation sector includes on-road vehicles (e.g. cars, trucks, and buses), non-road vehicles and equipment (e.g., construction equipment, golf carts, and lawnmowers), commuter and regional passenger rail, freight rail, waterborne navigation, and aviation.

In 2022, transportation emissions accounted for 6.6 $MMTCO_2e$, an 18% reduction compared to 2019 transportation emissions, which was 8.05 $MMTCO_2e$ (Figure 17).[11] The highest contributor of transportation emissions in 2022 was on-road emissions at 3.3 $MMTCO_2e$, followed by aviation at 3.1 $MMTCO_2e$.

Figure 17

Transportation emissions for 2006, 2014, 2019, and 2022 in $MMTCO_2e$ (Scope 1, 2 and 3).

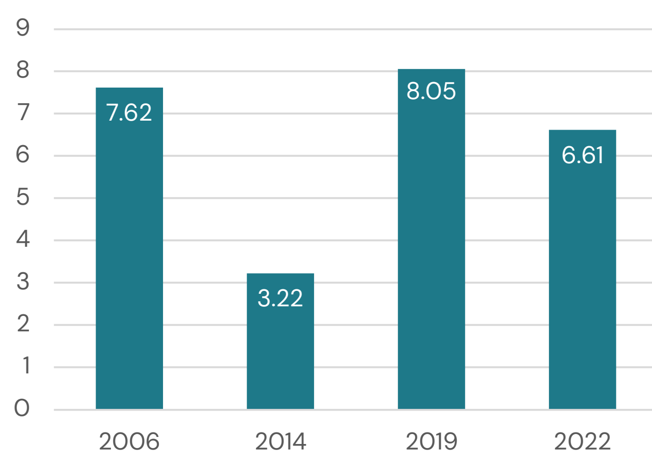
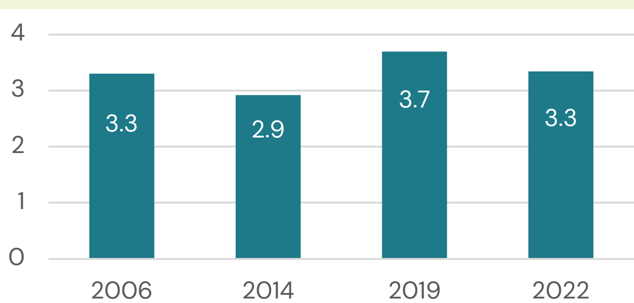


Figure 18

On-road emissions for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.



On-Road

On-road transportation emissions from passenger cars, vans, trucks and buses initially declined steadily between 2006 and 2014 before rising in 2019 to 3.7 $MMTCO_2e$ and finally falling again in 2022 down to 3.3 $MMTCO_2e$.

Vehicle miles traveled (VMT) followed a similar pattern, increasing substantially in 2019 to 7.3 billion and then

[11] This extensive reduction in transportation emissions in 2014 is primarily due to Aviation not being included.

falling to pre-2006 levels (6 billion) in 2022 at 5.6 billion. This consistent decrease in both emissions and VMT can be attributed most likely to the shift to working from home that occurred due to the COVID-19 pandemic. In 2019, approximately 5.7% of Americans worked from home, compared to 15.2% in 2022.[12] This increase in remote work had a significant impact on VMT and passenger transportation emissions across the U.S.

The vehicle miles and emissions summarized in Figures 19 and 20 do not include transit buses. To account for those emissions, the Southeastern Pennsylvania Transportation Authority (SEPTA) provided data on fuel and electricity used in 2022 for on-road sources. Total 2022 on-road emissions, including SEPTA's, were approximately 3.5 $MMTCO_2e$.

Figure 19
VMT estimates for cars and trucks for 2006, 2014, 2019, and 2022 in billion VMT.

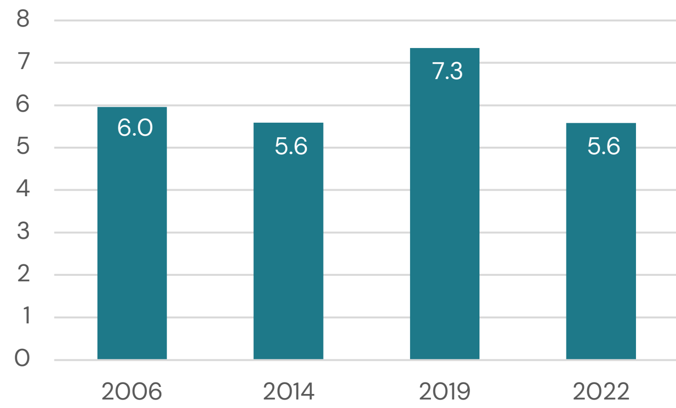
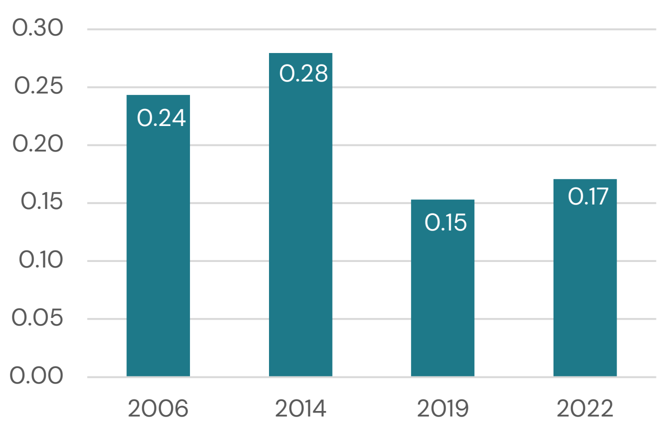


Figure 20
Passenger rail emissions for 2006, 2014, 2019, and 2022 in MMT CO_2e.



Railways

Emissions associated with passenger rail electricity consumption were provided by SEPTA for trolleys, subways, and rail in 2022, which were 337 GWh. This GHG inventory also includes emissions associated with trips on Amtrak, originating or destined to Philadelphia, which contributed 194 GWh in 2022. The total emissions from the electricity use for passenger rail in 2022 was 0.17 $MMTCO_2e$, a 12% increase from 2019. See Figure 20 for the total emissions associated with passenger rail.

Freight rail emissions are based on tons of freight moved by rail in the greater Philadelphia region[13] and information on nation-wide rail freight emissions[14] scaled by tonnage. Freight rail GHG emissions were approximately 0.06 $MMTCO_2e$ in 2022, a 173% increase from 2019 emissions, which were 0.02 $MMTCO_2e$. Approximately 76% of these emissions occur outside of the city's boundary and are therefore included under scope 3 emissions.

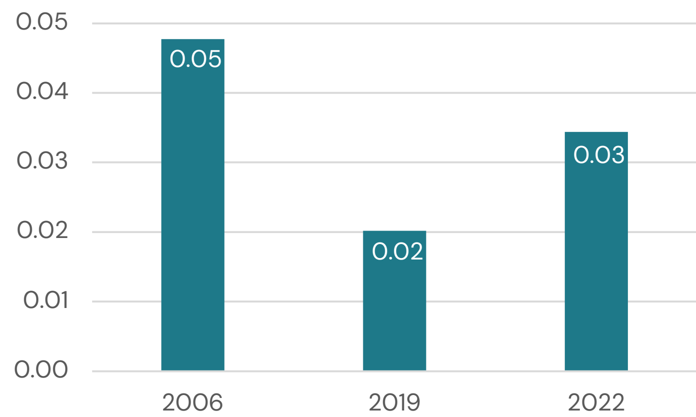
[12] United States Census Bureau, Commuting Characteristics by Sex, https://data.census.gov/table/ACSST1Y2022.S0801?q=Employment
[13] Oak Ridge National Laboratory (ORNL)'s Freight Analysis Framework (FAF) database, https://faf.ornl.gov/faf5/dtt_total.aspx
[14] EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022, https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf

Marine Emissions

Philadelphia's inventory includes emissions associated with the shipping of freight via the Port of Philadelphia which includes areas of the Delaware River. The emissions are based on the estimated amount of freight, fuel use, and the applicable emission factor from the EPA. Annual data on tonnage of marine freight shipped to and from major U.S. ports is provided by the U.S. Army Corps of Engineers Waterborne Commerce Statistics Center.

Figure 21

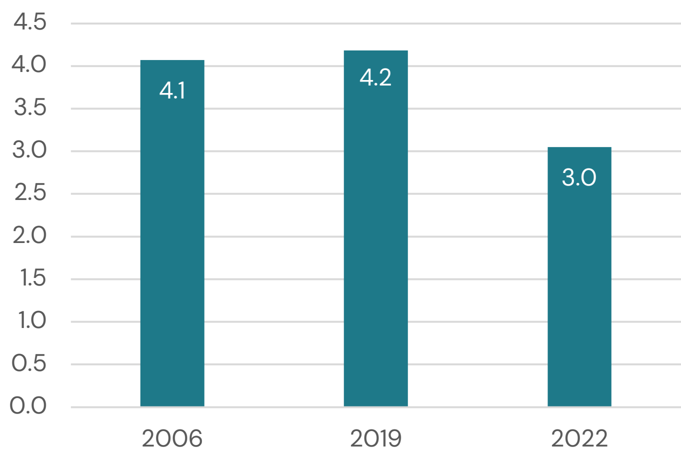
Marine emissions for 2006, 2019, and 2022 in $MMTCO_2e$.



Between 2019 and 2022, marine freight tonnage increased from 16.3 to 31.8 million tons, and emissions increased from 20,171 to 34,378 MT CO_2e following the same trend identified in freight rail emissions. Since 2006, the total marine emissions in Philadelphia have decreased by 25%. There were no marine emissions calculated in the 2014 inventory.

Figure 22

Aviation emissions for 2006, 2019, and 2022 in $MMTCO_2e$.



Aviation[15]

The Philadelphia International Airport GHG Emissions Inventory reported aviation data for the years 2006, 2019, and 2022, shown in Figure 22. In 2022, there was a 27% decrease in emissions compared to 2019 data, which could be attributed to less recreational travel. This is likely due to the COVID-19 pandemic, which experienced several waves throughout the year, most notably the Omicron outbreak in January 2022. The data to support this comes from other aviation activities, specifically total passenger count, which showed 25.2 million passengers in 2022 compared to 33 million in 2019. There were no aviation emissions calculated in the 2014 inventory.

Off-Road

Off-road emission sources include equipment and vehicles such as construction equipment, agricultural equipment, lawnmowers, golf carts, etc. Acquiring activity and emissions data for offroad vehicles is challenging, and inventories commonly exclude emissions from these sources. In the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks, emissions from off-road mobile sources made up a negligible percent

[15] The Philadelphia International Airport is a regional asset that does not reflect emissions solely from Philadelphians, but for the purpose of this inventory, emissions from the airport are allocated solely to the City.

of total emissions. Due to the smaller impact and the lack of data, off-road emissions were not estimated (NE) for any of Philadelphia's inventories.

In summary, aviation contributes 46.1% of transportation emissions in Philadelphia. Besides aviation, on-road contributes approximately 50.6%, and passenger rail contributes 2.6%. Freight and marine subsectors contribute less than 1% each to the overall transportation emissions.

Figure 23
2022 Transportation emission contributions by subsector.

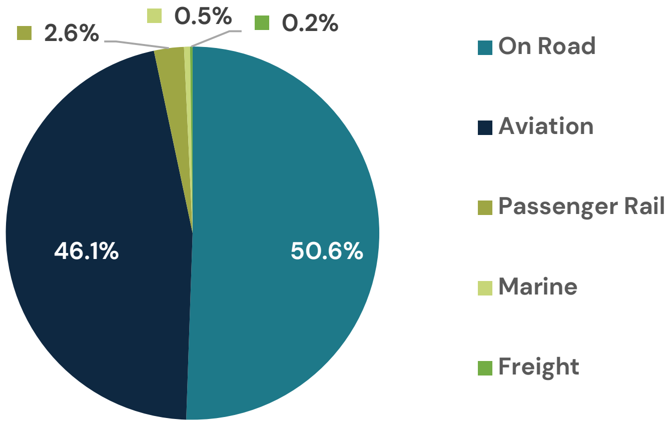
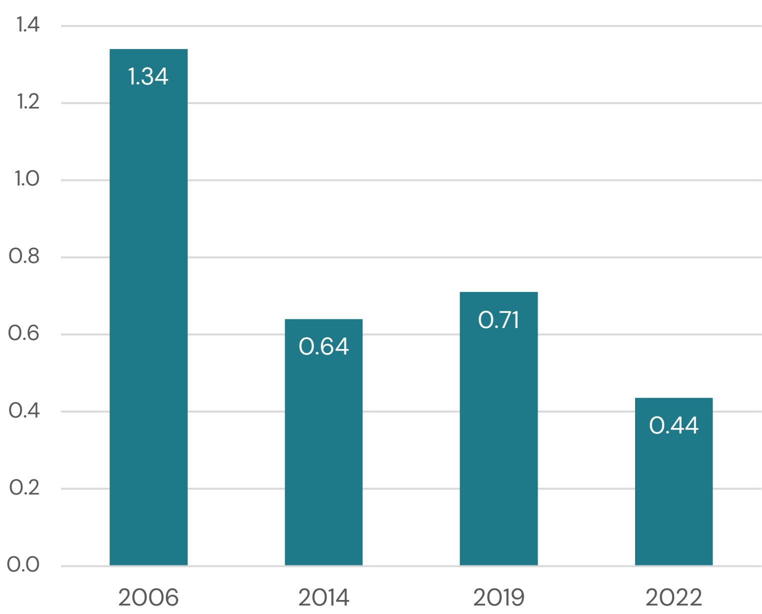


Figure 24
Waste and Wastewater combined emissions for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.



WASTE AND WASTEWATER

Philadelphia's waste is hauled outside of the city and incinerated in Waste-to-Energy (WTE) combustion facilities or brought to landfills. Information on 2022 waste disposal was sourced from the Pennsylvania Department of Environmental Protection (PADEP) Waste Management Bureau,[16] Philadelphia's Municipal Waste Management Plan (MWMP),[17] and the Philadelphia Streets Department[18]. Emissions are based on calculations within the ClearPath tool.[19]

In 2022, waste and wastewater emissions accounted for 0.44 $MMTCO_2e$, a 39% decrease compared to 2019 emissions, which was 0.71 $MMTCO_2e$. Since the 2006 baseline, waste and wastewater emissions have gradually decreased with fluctuations based on waste generation (Figure 24).

[16] Commonwealth of Pennsylvania, 2025, Solid Waste Disposal Information, https://www.dep.pa.gov/Business/Land/Waste/SolidWaste/MunicipalWaste/Pages/MW-Disposal-Info.aspx
[17] City of Philadelphia, 2020, Municipal waste management plans, https://www.phila.gov/documents/municipal-waste-management-plan/
[18] Philadelphia Streets Department data was used for waste characterization and attribution of total emissions from waste to the Commercial and Residential subsectors.
[19] Local Governments for Sustainability USA (ICLEI), 2025, ClearPath, https://icleiusa.org/clearpath/

Solid Waste

Waste created in Philadelphia is disposed via landfill, recycling or incineration in WTE facilities. When organic matter is decomposed in a landfill, methane is released into the atmosphere. Emissions from landfilled waste are based on the total amount of waste landfilled and waste characterization information provided by the Streets Department. Similarly, when organic matter is burned, it results in methane emissions released into the atmosphere.

Landfilled waste is the primary disposal method in Philadelphia, and in 2022, 1.3 million tons of waste were landfilled resulting in methane emissions equating to 0.40 $MMTCO_2e$. Incinerated waste accounted for 105,853 tons resulting in less than 0.01 $MMTCO_2e$. Emissions from solid waste have decreased due to a decrease in waste generated and a decrease in incineration of waste at WTE facilities. Figure 25 breaks down the contribution of tons of waste based on the disposal method.

Figure 25

Million Tons of Waste Disposed by Year and Type of Waste Management.

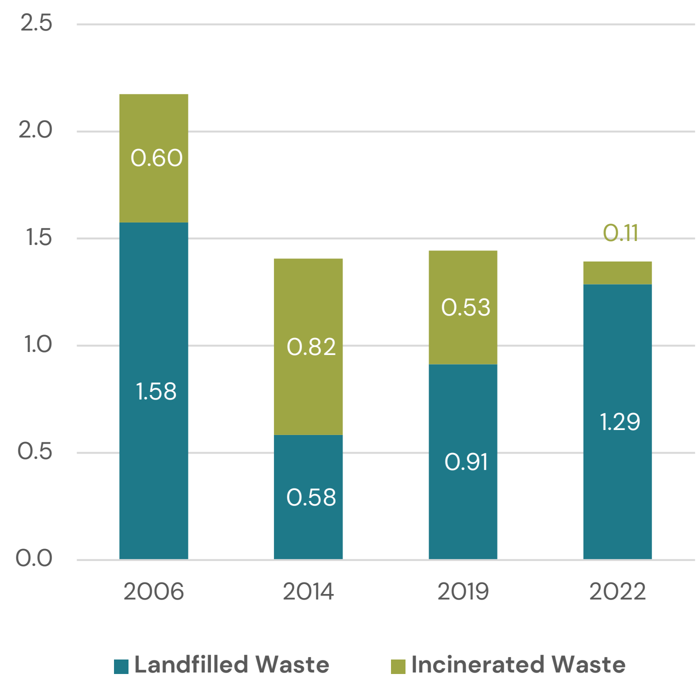
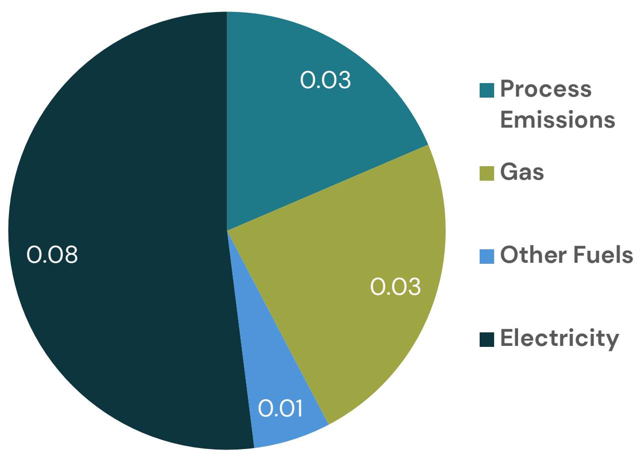


Figure 26

Wastewater emissions from energy use by source for 2022 in $MMTCO_2e$.



Wastewater Treatment and Discharge

The Philadelphia Water Department (PWD) operates the city's drinking water system which includes treating and pumping clean water to residences and businesses, as well as the wastewater (sewage) system. There are three wastewater treatment plants that operate in Philadelphia. The emissions from energy used to operate these facilities (electricity, gas, and other fuels) are shown in Figure 26. Emissions from energy use for water supply and wastewater treatment are calculated utilizing the data provided by PWD, the electricity emission rates summarized in Table 4, emissions from electricity losses, and applicable EPA emission factors for use of gas and other fuels.

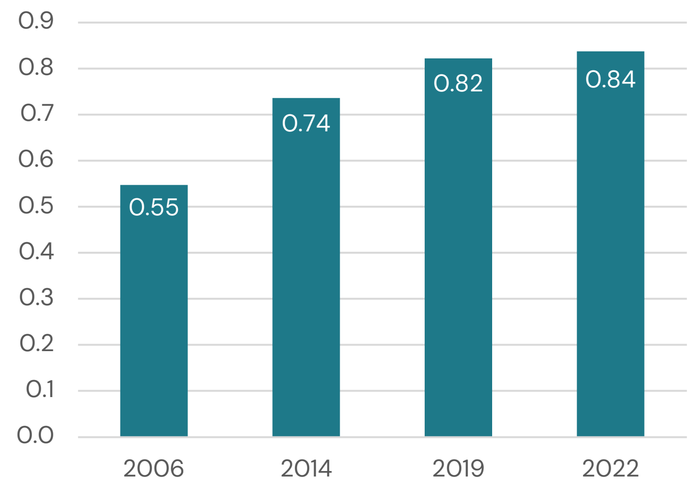
The biological treatment of waste at wastewater treatment plants produces biogas, which is approximately 68% methane and can be used as fuel. Unused (fugitive) methane emissions from the wastewater treatment process are included as process emissions in this inventory. In addition, the wastewater treatment process includes nitrogen removal, to maintain the quality of waters to which treated wastewater is discharged. The beneficial removal of nitrogen from water results in the emissions of nitrous oxide (N_2O), a GHG also accounted for in Philadelphia's inventory.

INDUSTRIAL PROCESSES AND PRODUCT USES (IPPU)

The industrial processes and product uses (IPPU) sector includes emissions from non-energy uses of fossil fuels, chemicals, and other substances.[20] The product use subsector includes emissions from the use of alternatives to ozone-depleting substances (ODS). Many ODS, found in refrigerants, aerosols, air conditioners, and other products, were phased out as part of the Clean Air Act and the Montreal Protocol. Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs) are often used as substitutes for these substances. While these products don't have the same ozone-depleting properties as the previously used substances, they do still contribute to climate change. Emissions from the use of HFCs and PFCs were calculated by scaling the national emissions of ODS substitutes by population.

Figure 27

IPPU emissions for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.



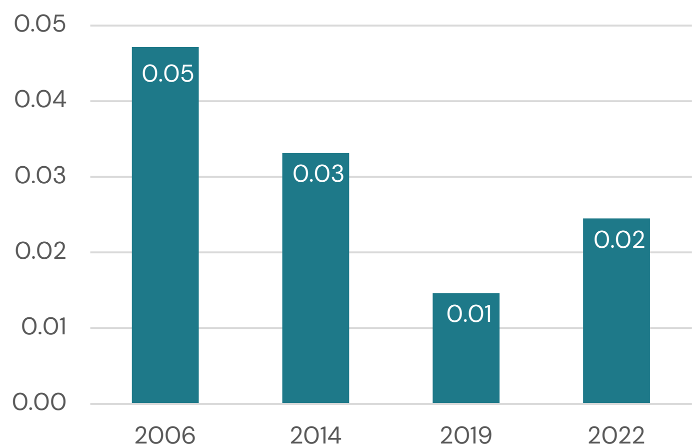
The national use of ODS substitutes increased between 2006 and 2022, which is also reflected in Philadelphia's emissions inventory. In 2022, the total emissions from product use were 0.84 $MMTCO_2e$, a 2% increase from 2019 emissions, and a 54% increase from 2006 baseline emissions, as shown in Figure 28.

OTHER SCOPE 1

Other Scope 1 emissions in Philadelphia come from sulfur hexafluoride (SF_6) which is an insulator used in circuit breakers, switches, and other electrical equipment. SF_6 is a potent GHG, with a 100-year GWP of 23,500. During transmission and distribution of electricity, SF_6 leaks from equipment during equipment installation, maintenance, and decommissioning. SF_6 emissions accounted for 0.02 $MMTCO_2e$ in 2022, which is a 67% increase from 2019. Since 2006, however, SF_6 emissions have decreased by 48%, which can be attributed to industry improvements facilitated by the EPA.[21] Throughout this report other scope 1 emissions from SF_6 are included in charts with IPPU for simplicity of communication.

Figure 29

SF_6 emissions for 2006, 2014, 2019, and 2022 in $MMTCO_2e$.

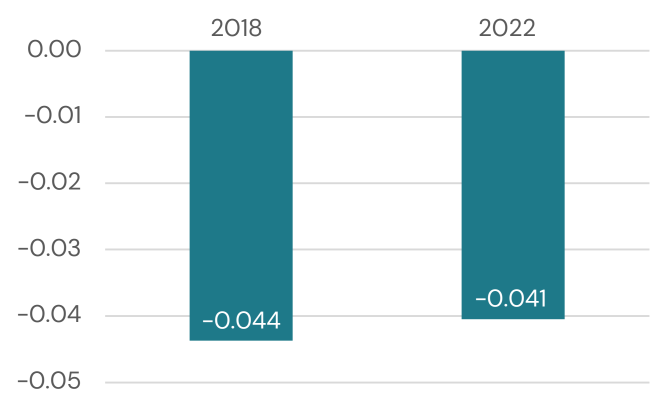


[20] Emissions for IPPU were not initially included in the 2014 Philadelphia Greenhouse Gas Inventory.

[21] U.S. EPA, 2018, Overview of SF6 Emissions Sources and Reduction Options in Electric Power Systems, https://www.epa.gov/sites/default/files/2018-08/documents/12183_sf6_partnership_overview_v20_release_508.pdf

Figure 30

Carbon sequestration from trees for 2018 and 2022 in $MMTCO_2e$.



AGRICULTURE, FORESTRY, AND OTHER LAND USE (AFOLU)

Philadelphia accounts for emission reduction benefits of Philadelphia's trees through carbon sequestration.[22] Carbon sequestration is defined by EPA as the process by which trees and plants absorb CO_2, release the oxygen, and store the carbon.[23] Sequestration from trees is based on information on tree canopy cover from the Tree Canopy Assessment Report and the U.S. Forest Service's i-Tree Canopy tool.[24] Of the City's land area of approximately 85,000 acres, 22,615 acres had tree canopy in 2022, which sequestered 0.04 $MMTCO_2e$. This was a 7% decrease in sequestration from 2018, the last available year of data for Philadelphia.

Other agriculture, forestry, and fishing activities were NE in 2022 or in previous inventories.[25] While there are some agricultural, fishing, and forestry-related activities in Philadelphia (generally for educational purposes, community engagement, or entertainment), there are no largescale operations within these subsectors. The resulting emissions are therefore not significant.

CONCLUSIONS

Philadelphia achieved a 31% reduction in GHG emissions in 2022 compared to 2006. Nearly one third of GHG emission reductions (10%) have occurred since the release of the 2019 GHG Inventory.

This inventory shows the progress made in reducing emissions throughout the City of Philadelphia. Transportation saw a significant decrease in emissions in 2022, most notably in passenger car emissions, showcasing how impacts of the COVID-19 pandemic resulted in more remote working environments and less recreational travel. In the stationary energy sector, emissions continue to decrease, driven by a cleaner electricity grid and modest reductions in energy use in 2022 compared to 2019. Overall, key contributing factors to emissions reductions include:

- ✓ A decrease in coal use as an electricity generating source;
- ✓ A decrease in building energy use;

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[22] The only historical data for this sector is from 2018.

[23] EPA, Glossary of Climate Change Terms, https://19january2017snapshot.epa.gov/climatechange/glossary-climate-change-terms_.html#C

[24] O'Neil-Dunne, Tree Canopy Assessment, Philadelphia Parks and Recreation, December 2019. https://treephilly.org/wp-content/uploads/2019/12/Tree-Canopy-Assessment-Report-Philadelphia-2018.pdf

[25] The 2014 inventory did not include AFOLU sector emissions (marked as not estimated — NE).

- ✓ PES Refinery closure in 2019; and
- ✓ A decrease in vehicle miles traveled and recreational air travel.

While decreases to stationary energy cannot be attributed to any individual programs, a range of state, local, and federal efforts may have contributed to decreased energy consumption. Such programs include appliance standards, updated building energy codes, utility energy efficiency programs and the Commercial Property Assessed Clean Energy (C-PACE) program which provides financing options for energy efficiency upgrades to commercial and industrial buildings.

Philadelphia continues to make progress towards Pennsylvania's GHG reduction goal of 26% by 2025 and maintains momentum toward the 2050 carbon neutrality goal. Reaching net zero emissions will require the expansion of current programs as well as additional efforts. Regular reporting of GHG emissions helps create accountability for this work and continued use of the GPC and C40 protocol will help ensure consistency of results.

In addition to aggressive GHG emission reductions, Philadelphia recognizes that climate change does not affect all Philadelphian's equally. There are communities that are impacted disproportionately by the effects of climate change due to income, housing, and historical discriminatory practices, such as redlining and disinvestment. Therefore, as Philadelphia and the Commonwealth of Pennsylvania work to reduce climate change impacts, it is vital to address these inequities and ensure that all Philadelphians see reductions in their communities.

Climate action can provide the opportunity to reach GHG reduction goals while increasing social equity, creating jobs, and improving infrastructure. Net zero can only be achieved through ambitious and bold climate action, and Philadelphia intends to pursue this in a way that prioritizes the communities most burdened by pollution, most burdened by energy and transportation costs, as well as the communities most vulnerable to climate change, while benefiting the future wellbeing of all citizens.

APPENDIX

METHODOLOGY UPDATES

This inventory follows the same methodology as implemented in the 2019 GHG inventory with the exception of the following changes:

Stationary Energy

Non-Utility Fuel Use

The methodology for estimating non-utility fuel use from the commercial and industrial building sector was updated for this report. In the 2019 inventory the values were based on a single scaling factor between reported residential fuel use and commercial buildings. To improve this estimation, large building benchmarking data containing commercial fuel oil use and the ratio between the amount of residential distillate fuel oil use and the remaining fuels was utilized to generate more accurate commercial and industrial estimates of non-utility fuels.

Large Industrial and Commercial/Institutional Sources

During the compilation of the 2022 inventory, emissions from large industrial sources were double counted where facilities reported utility natural gas use in EPA's FLIGHT platform and in gas use data provided by PGW. This double counting extended throughout previous inventory years and historical inventories were revised to resolve this issue. The remaining non-gas emissions from industrial sources were very small in 2022 but were still significant in previous years due to the Philadelphia Energy Solutions.

Waste and Wastewater

Wastewater Treatment and Discharge

Emissions from wastewater treatment and discharge were calculated for 2022 by scaling the 2019 wastewater treatment and discharge emissions. 2022 emissions were scaled using changes to wastewater flows reported by PWD. This was done due to a lack of available direct emissions data.

SUMMARY TABLES

Summary of 2022 emissions by subsector and gas type.

Source	2022 (MT CO2e, AR5, 100 Year)					
	CO_2	CH_4	N_2O	HFCs	SF_6	Total
Total Inventory Emissions	15,141,810.82	422,845.76	26,729.03	758,296.08	24,477.32	16,333,686.85
Stationary Energy	8,441,009.73	10,252.19	12,354.33	–	–	8,463,616.24
Residential, Commercial, and Industrial Emissions from Gas Use	3,192,713.19	1,684.81	1,594.55			3,195,992.55
Residential, Commercial, and Industrial Emissions from Electricity Use	3,908,683.03	7,491.70	9,453.82			3,925,628.55
Electricity Losses (Stationary and Transportation)	192,877.06	369.68	466.51			193,713.25
Steam Production	764,820.48	403.57	381.95			765,606.00
Emissions from Other Fuels used in the residential and commercial subsectors	151,090.16	180.69	342.29			151,613.13
Emissions from Large Industrial and Commercial/Institutional Sources	132.70	–	–			132.70
Gas Losses (Fugitive Emissions)	230,693.11	121.74	115.22			230,930.07
Transportation	6,609,250.45	2,324.82	1,384.98			6,612,960.25
On-Road	3,339,940.43	902.09	221.68			3,341,064.20
SEPTA On-Road	110,366.42	1,809.69	471.05			112,647.16
Passenger Railways	170,068.06	325.97	411.34			170,805.37
Freight Rail	60,383.71	132.48	407.49			60,923.67
Waterborne Navigation	33,638.27	591.32	148.42			34,378.01
Aviation	3,005,219.99	372.96	196.05			3,005,789.00
Waste and Wastewater	12,101.15	410,268.76	12,989.71			435,359.62
Solid Waste Disposal		398,025.29				398,025.29
Incineration and Open Burning	4,403.83	17.76	106.54			4,528.14
Wastewater Treatment and Discharge (Process Emissions)		12,217.68	12,863.81			25,081.50
Wastewater Emissions from Other Fuels Use	7,697.32	8.03	19.36			7,724.70
Industrial Process and Product Use (IPPU)	79,449.50			758,296.08		837,745.57
Product Use (ODS)	79,449.50			758,296.08		837,745.57

Source	2022 (MT CO2e, AR5, 100 Year)					
	CO_2	CH_4	N_2O	HFCs	SF_6	Total
Agriculture, Forestry, and Other Land Uses (AFOLU)						(40,472.15)
AFOLU						(40,472.15)
Other Scope 3					24,477.32	24,477.32
SF_6 Emissions					24,477.32	24,477.32

Summary of 2022 emissions by scope and source.

Source	2022 (MT CO2e)			
	Scope 1	Scope 2	Scope 3	Total
Total Inventory Emissions	**8,605,455.27**	**4,290,147.17**	**3,438,084.42**	**16,333,686.85**
Stationary Energy	4,344,274.45	4,119,341.80		8,463,616.24
Residential, Commercial, and Industrial Emissions from Gas Use	3,195,992.55			
Residential, Commercial, and Industrial Emissions from Electricity Use		3,925,628.55		
Electricity Losses (Stationary and Transportation)		193,713.25		
Steam Production	765,606.00			
Emissions from Other Fuels used in the residential and commercial subsectors	151,613.13			
Emissions from Large Industrial and Commercial/Institutional Sources	132.70			
Gas Losses (Fugitive Emissions)	230,930.07			
Transportation	3,577,429.26		3,035,530.99	6,612,960.25
On-Road	3,341,064.20			
Railways	185,427.05		46,301.99	
Waterborne Navigation	34,378.01			
Aviation	16,560.00		2,989,229.00	
Waste and Wastewater	32,806.20		402,553.42	435,359.62
Solid Waste Disposal			398,025.29	
Incineration and Open Burning			4,528.14	

Source	2022 (MT CO2e)			
	Scope 1	Scope 2	Scope 3	Total
Wastewater Treatment and Discharge, Process Emissions	25,081.50			
Wastewater Emissions from Other Fuels Use	7,724.70			
Industrial Process and Product Use (IPPU)	837,745.57			837,745.57
Product Use (ODS)	837,745.57			
Agriculture, Forestry, and Other Land Uses (AFOLU)	(40,472.15)			(40,472.15)
AFOLU	(40,472.15)			
Other Scope 3	24,477.32			24,477.32
SF_6 Emissions	24,477.32			

Change in Emissions by Sector (Scope 1 and 2)

Sector	2006	2014	2019	2022	% Change 2006-2022
Emissions (MMT CO_2e)					
Stationary Emissions	14.04	12.17	9.36	8.46	-40%
Transportation	3.35	2.92	3.72	3.58	+7%
Waste	.17	.03	.15	.03	-81%
IPPU	1.19	1.80	1.15	.86	-26%
AFOLU*	-.08	NE	-.04	-.04	+52%
Total	18.67	16.96	14.33	12.90	-31%
Sector Contribution to Total Emissions					
Stationary Emissions	75%	72%	65%	66%	-13%
Transportation	18%	17%	26%	28%	+55%
Waste	1%	0%	1%	0%	-72%
IPPU	6%	11%	8%	7%	+4%
AFOLU*	0%		0%	0%	+30%
Total	100%	100%	100%	100%	

*AFOLU emissions were not estimated in the 2014 inventory.

May not sum to total values due to rounding