Pennsylvania Greenhouse Gas Inventory Report 2025

Pennsylvania
Department of
Environmental Protection

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Executive Summary

In this inventory, the Pennsylvania Department of Environmental Protection (DEP) provides data on Greenhouse Gas (GHG) emissions in the state from 2005 to 2022 and tracks progress toward the emissions reduction goals outlined in the 2024 Climate Action Plan (26%-28% reduction by 2025 from 2005 baseline and net zero by 2050). The data provided in this report were primarily obtained from the United States Environmental Protection Agency (U.S. EPA) State Inventory Tool (SIT) and the U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State report, which disaggregates the national inventory emissions to the state level. Preliminary data for 2023 from United States Energy Information Administration (U.S. EIA) estimates have also been included.

Overall Key Findings:

- **In 2022, net emissions decreased by 1.5% from 2021 levels.** Gross GHG emissions were **253.01 Million Metric Tons of Carbon Dioxide Equivalent (MMTCO$_2$e)** and net GHG emissions in 2022 were **224.39 MMTCO$_2$e**.
- **Statewide net emissions decreased 21.2% from the 2005 baseline** and this inventory represents a more accurate assessment of emissions reductions and progress towards the 2025 goal than the 2020 and 2021 inventories which were impacted by COVID-19.
- The sectors with the **largest contribution** to the Commonwealth's GHG emissions are the **industrial, electricity production, and transportation sectors accounting for 83%** of all gross GHG emissions in 2022.
- **In comparison to 2005 baseline levels, overall trends remained consistent with prior inventories** with most sectors seeing a decrease in emissions. I**n 2022, most of the changes from the prior year were minor fluctuations**.

Table 1 - Summary of Key Emissions Trends (MMTCO$_2$e)

	2022 Emissions	% Change from 2021	% Change from 2005
Residential	20.43	⬆ 4.5%	⬇ -15.8%
Commercial	12.18	⬆ 6.3%	⬇ -6.1%
Industrial	78.41	⬇ -1.8%	⬆ 13.8%
Transportation	56.08	⬇ -0.1%	⬇ -20.8%
Electricity Production	74.52	⬇ -4.1%	⬇ -41.0%
Agriculture	7.40	⬇ -5.7%	⬇ -6.4%
Waste Management	3.80	⬇ -0.1%	⬇ -23.4%
Forestry and Land Use Non-CO$_2$ Emissions	0.20	⬇ -21.6%	⬆ 123.1%
Total Gross Emissions	**253.01**	⬇ **-1.4%**	⬇ **-20.0%**
Forestry and Land Use Net Carbon Flux	-28.42	⬇ **-1.0%**	⬇ **-9.2%**
Total Net Emissions	**224.39**	⬇ **-1.5%**	⬇ **-21.2%**

Table Key: ⬇ = Decrease in emissions ⬆ = Increase in emissions

Pennsylvania Snapshot: 2005 vs. 2022

Pennsylvania has changed in many ways over the past two decades. This data is provided to add context about changes occurring across the commonwealth over the past few years to help add relevant information surrounding emissions changes. While some of these factors may be correlated to emissions changes, this data should not be interpreted as the cause of emission changes, nor will this report provide additional analysis beyond existing content in the report.

Category	2005 Estimate	2022 Estimate	Percent Change
Population[1]	**12,450,000**	**12,972,000**	**4%**
Gross State Product (billions)[2]	**$511,731**	**$ 844,392**	**39%**
Housing Units[3]	**5,454,141**	**5,814,781**	**6%**
Registered Businesses[4]	**237,397**	**234,852**	**-1%**
Passenger Vehicles[5]	**7,428,064**	**8,069,489**	**8%**
Vehicle Miles of Travel Per Capita	**8,700**	**7,684[6]**	**-13%**
Average Fuel Economy – Light Duty (MPG)[7]	**19.9**	**26.0**	**23%**
Electricity Generated (TWH)	**218**	**239**	**9%**
Oil & Gas Wells[8]	**49,750[9]**	**79,466**	**37%**
Quantity of Waste Disposed in Landfills (Tons)[10]	**7,881,999**	**7,501,530**	**-5%**
Acres of Farm Land[11]	**7,809,244**	**7,058,325**	**-11%**
Percent of Forested Land[12]	**59%**	**57%**	**-4%**

1 U.S. Census (via EPA's State Inventory Tool)

2 Bureau of Economic Analysis (via EPA's State Inventory Tool)

3 U.S. Census (National, State, and County Housing Unit Totals: 2020-2023; National, State, and County Housing Units Intercensal Totals: 2000-2010)

4 U.S. Census. April 2025 (Statistics of U.S. Businesses, 2022, Statistics of U.S. Businesses, 2005)

5 PennDOT (Annual Report of Registrations)

6 Federal Highway Administration Table PS-1 - Highway Statistics 2022 - Policy | Federal Highway Administration, Table 5-3: Highway Vehicle-Miles Traveled (VMT): 2005, 2010 | Bureau of Transportation Statistics

7 The 2024 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975 (EPA-420-R-24-022, November 2024)

8 DEP Bureau of Oil and Gas

9 Growth in the number of wells is primarily due to the rapid increase in unconventional wells within the Marcellus Shale since 2004, however, data on the number of unconventional wells is not available for 2005 because unconventional wells were not separately reported degj0210 217.257

10 EPA's State Inventory Tool

11 USDA Agriculture Census (USDA - National Agricultural Statistics Service - Census of Agriculture)

12 US Forest Service, Forests of Pennsylvania , 2019 | US Forest Service Research and Development, Pennsylvania Forest health Highlights 2005

Greenhouse Gas Inventory Overview

The global climate is changing due to rising concentrations of Greenhouse Gases (GHGs) such as Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O) in Earth's atmosphere that have increased during the last century.[13] The vast majority of GHG emissions are comprised of CO_2 resulting from the combustion of fossil fuels including coal, petroleum products, and natural gas. Within PA, CO_2 comprises 82.7% of GHG emissions, in terms of $MMTCO_2e$, followed by CH_4 at 12.7%. Pennsylvania's 2024 Climate Impacts Assessment[14] projects that the average annual temperature in Pennsylvania will increase 5.9°F by midcentury from the baseline period (1971-2000), and average annual precipitation will increase by 8% over the same timeframe. The Climate Impacts Assessment provides details on how these changes impact Pennsylvanians. These changes in GHG concentrations and the global climate have been linked to human activities and are long-lasting, as most GHGs take decades to break down and leave the atmosphere.

The Pennsylvania Climate Change Act (Act 70 of 2008, or Act) requires the DEP to:

- Administer a Climate Change Advisory Committee;[15]
- Set up a voluntary registry of GHG emissions;[16]
- Prepare a Climate Change Impacts Assessment and provide an update once every three years;
- Prepare a Climate Change Action Plan[17] and provide an update once every three years; and
- Develop an inventory of GHGs and update this inventory annually.

2024 Climate Action Plan
Emissions Reduction Goals

26-28% below 2005 levels by 2025
50% below 2005 levels by 2030
Net Zero by 2050

Greenhouse gas emissions data presented in this inventory help track overall emissions trends over time. The 2024 Climate Action Plan outlines the goals for reducing Pennsylvania's emissions over the coming decades (see call-out box for goals).

The year 2005 is used as a reference point for emissions reductions to maintain consistency with our emission calculation methodology as well as align with other national and international emissions baselines. As of 2022, Pennsylvania has achieved a 21.2% reduction in net GHG emissions compared to 2005. To reach the 2025 state emissions reduction goal, an additional reduction of 20.36 $MMTCO_2e$ from 2022 emissions levels is needed. Furthermore, to reach the 2050 goal, an additional reduction of 224.39 $MMTCO_2e$ from 2022 emission levels is needed. This underscores the need for more and continued policies aimed at reducing Pennsylvania's GHG emissions.

Pennsylvania has several sectors that contribute to GHG emissions, and GHG emissions from each of these sectors has undergone fluctuations since the year 2005. Changes in the amount and type of fuel consumption, growth and contraction in the economy, and changing weather patterns (i.e., increased average temperatures and heat waves) that influence energy use all have a role in the trends observed in the Commonwealth's GHG emissions.

[13] Intergovernmental Panel on Climate Change (IPCC). 2023. AR 6 Synthesis Report. ipcc.ch/report/ar6/syr/.

[14] Pennsylvania Department of Environmental Protections (DEP). 2025. Pennsylvania Climate Impacts Assessment. greenport.pa.gov/elibrary/GetDocument?docId=9587655&DocName=PA CLIMATE IMPACTS ASSESSMENT 2024.PDF <span style%3D"color%3Agreen%3B"><%2Fspan> <span style%3D"color%3Ablue%3B">(NEW)<%2Fspan>

[15] DEP. 2023. Climate Change Advisory Committee (CCAC) Home Page. Accessed 20 October 2023. dep.pa.gov/Citizens/climate/Pages/CCAC.aspx.

[16] The Climate Registry. Website Home Page. Accessed 20 October 2023. www.theclimateregistry.org/.

[17] DEP. 2021. Pennsylvania Climate Action Plan. dep.pa.gov/citizens/climate/Pages/PA-Climate-Action-Plan.aspx.

Key Findings (Table 2)

- **Gross GHG emissions in 2022 were 253.01 MMTCO$_2$e, and net GHG emissions in 2022 were 224.39 MMTCO$_2$e** This represents a decrease of 3.3 MMTCO$_2$e, or 1.5%, from 2021 net emissions levels. Nationally, there was an increase of 1.3% from 2021 to 2022[18]. Given the small changes from 2021 both at the state level and nationally, this reflects steady state emissions activity rather than impacts from the COVID-19 pandemic.
- Pennsylvania's forestry and land use sector was a net carbon sink, absorbing **28.62 MMTCO$_2$e** in 2022, which was approximately the same as absorbed in 2021. Forestry and land use sector emissions **sequestration decreased by 9.2% from 2005 to 2022**, which is partially driven by changes in land-use across the Commonwealth from forest-land to more developed land.
- Relative to Pennsylvania's 2005 baseline, statewide **net emissions decreased by 21.2%, and gross emissions decreased by 20.0%**. It will be important to continue to deploy more clean energy sources and identify and deploy other strategies to reduce emissions in order to meet the 26% by 2025 goal.
- The sectors with the **largest contribution** to the Commonwealth's GHG emissions are the **industrial, electricity production, and transportation sectors, accounting for 83%** of all gross GHG emissions in 2022 (Figure 1). Between 2005 and 2022, electricity production emissions decreased 41.0%, industrial sector emissions increased 13.9%, and transportation sector emissions decreased 20.8%. Continued efforts across all three sectors will be necessary to lower emissions.
- While the industrial sector emissions increased between 2005 and 2015, emissions began to decrease between 2016 and 2019. **However, following 2020 the emissions from the industrial sector have continued to rise.**
- Although there was a slight increase from 2021 to 2022, **the residential and commercial sector emissions have experienced an overall decline since 2005** by 15.8% and 6.1%.
- Emissions from the agricultural sector **decreased** between 2021 and 2022 and **decreased overall since 2005** by 6.4%. These decreases can be primarily attributed to better manure management techniques and a decrease in the number of livestock in the state.
- **Waste management sector emissions decreased by 23.4% from 2005 to 2022.** The majority of these decreases can be primarily attributed to a reduction of emissions from solid waste and combustion sources due to increased landfill gas collection and control systems as well as a reduction of decomposable materials (i.e. recyclable paper, yard trimmings) discarded in landfills[19], whereas wastewater emissions have remained relatively stable.

[18] EPA. 2024. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022 U.S. Environmental Protection Agency, EPA 430R-24004. www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022.

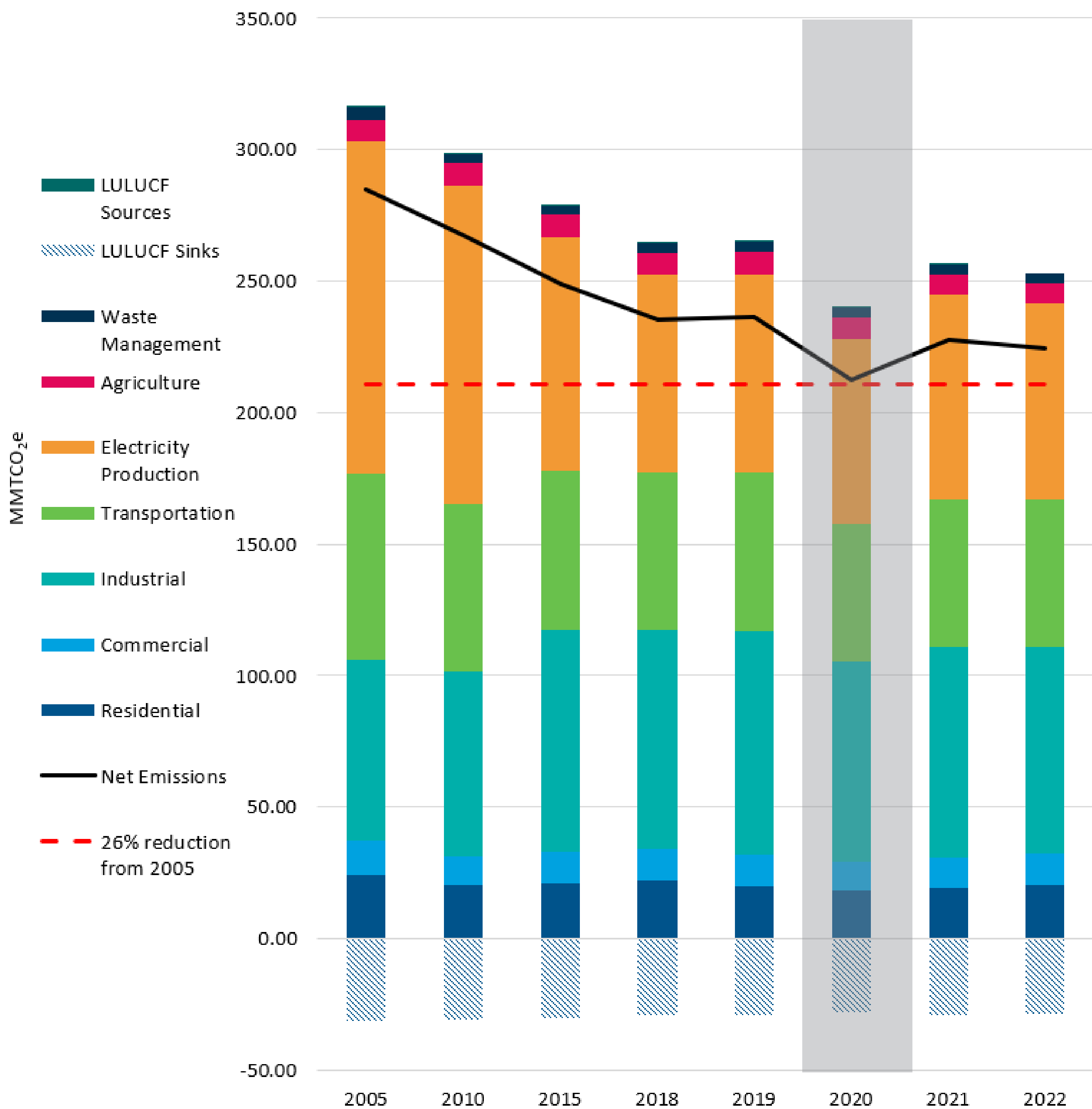
[19] Additional information can be found in the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022, Waste Chapter

Table 2 - GHG Emissions by Sector ($MMTCO_2e$)

Sector / Emission Sources (MMTCO2e)	2005	2010	2015	2018	2019	2020	2021	2022
Residential	**24.25**	**20.58**	**21.15**	**22.07**	**19.90**	**18.08**	**19.55**	**20.43**
Commercial	**12.98**	**10.63**	**11.53**	**12.22**	**11.97**	**10.76**	**11.46**	**12.18**
Industrial	**68.89**	**70.09**	**84.80**	**83.26**	**84.84**	**76.66**	**79.89**	**78.41**
Combustion of Fossil Fuels	32.08	28.98	37.69	38.23	37.89	33.05	36.45	37.37
Industrial Process	14.73	13.43	15.20	14.28	14.19	14.64	15.07	15.20
Coal Mining and Abandoned Mines	11.56	14.27	12.06	12.58	14.09	11.58	11.65	10.96
Natural Gas and Oil Systems	10.51	13.41	19.86	18.17	18.68	17.39	16.72	14.88
Transportation	**70.84**	**63.74**	**60.41**	**59.67**	**60.57**	**52.31**	**56.15**	**56.08**
Petroleum	67.66	60.11	57.34	56.54	57.21	49.20	52.70	52.37
Natural Gas	1.71	2.63	2.42	2.59	2.79	2.62	2.93	3.18
Non-CO_2 Emissions	1.46	1.01	0.66	0.54	0.58	0.49	0.52	0.53
Electricity Production	**126.31**	**121.35**	**88.87**	**75.10**	**75.30**	**70.22**	**77.67**	**74.52**
Coal	117.14	106.95	63.98	44.77	38.07	24.53	30.71	25.66
Petroleum	4.20	0.51	0.45	0.58	0.16	0.08	0.10	0.25
Natural Gas	4.43	13.39	24.14	29.52	36.86	45.46	46.68	48.45
Non-CO_2 Emissions	0.55	0.50	0.31	0.23	0.21	0.15	0.18	0.16
Agriculture	**7.90**	**8.47**	**8.24**	**8.53**	**8.55**	**8.00**	**7.85**	**7.40**
Enteric Fermentation	3.93	4.07	4.09	4.28	4.19	4.05	3.82	3.62
Manure Management	1.52	1.37	1.19	1.20	1.17	1.14	1.13	1.07
Agricultural Soil Management	2.40	2.64	2.84	2.89	2.99	2.66	2.79	2.57
Liming of Soils	0.03	0.38	0.08	0.11	0.15	0.10	0.05	0.08
Urea Fertilization	0.02	0.03	0.04	0.05	0.06	0.06	0.06	0.06
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry and Land Use	**0.09**	**0.12**	**0.25**	**0.20**	**0.18**	**0.18**	**0.25**	**0.20**
Non-CO_2 Emissions	0.09	0.12	0.25	0.20	0.18	0.18	0.25	0.20
Waste Management	**4.96**	**3.43**	**3.59**	**3.75**	**3.76**	**3.79**	**3.80**	**3.80**
Solid Waste and Combustion	3.74	2.16	2.31	2.46	2.46	2.47	2.47	2.48
Wastewater	1.22	1.27	1.28	1.30	1.30	1.32	1.33	1.32
Total Statewide Gross Emissions (Prod.)	**316.21**	**298.41**	**278.86**	**264.80**	**265.08**	**240.00**	**256.62**	**253.01**
Change relative to 2005		*-5.6%*	*-11.8%*	*-16.3%*	*-16.2%*	*-24.1%*	*-18.8%*	*-20.0%*
Forestry and Land Use Carbon Flux	**-31.52**	**-30.99**	**-30.11**	**-29.43**	**-28.97**	**-27.86**	**-28.89**	**-28.62**
Total Statewide Net Emissions (Prod w/ Sinks)	**284.69**	**267.42**	**248.76**	**235.37**	**236.11**	**212.14**	**227.72**	**224.39**
Change relative to 2005		*-6.1%*	*-12.6%*	*-17.3%*	*-17.1%*	*-25.5%*	*-20.0%*	*-21.2%*

Figure 1 displays the total contribution to the Commonwealth's GHG emissions for the residential, commercial, industrial, transportation, electricity production, agriculture, and waste management sectors.

Figure 1 - GHG Emissions by Sector ($MMTCO_2e$)



** LULUCF – Land Use, Land Use Change, and Forestry*

Table 1, Figure 2, and Figure 3 present GHG emissions by gas in units of $MMTCO_2e$.

Table 3 - GHG Emissions by Gas ($MMTCO_2e$)

Emissions ($MMTCO_2e$)	2005	2010	2015	2018	2019	2020	2021	2022
Gross CO_2	**275.84**	**253.51**	**228.17**	**215.48**	**214.10**	**192.85**	**209.75**	**209.01**
Net CO_2	**244.32**	**222.52**	**198.07**	**186.05**	**185.13**	**164.98**	**180.86**	**180.39**
CO_2 from Fossil Fuel Combustion	263.93	243.21	218.01	205.83	204.21	183.26	200.05	199.30
Industrial Processes	10.28	8.47	8.42	7.71	7.90	7.65	7.81	7.78
Waste	1.58	1.43	1.61	1.78	1.78	1.78	1.78	1.78
Agriculture	0.05	0.40	0.12	0.16	0.21	0.16	0.11	0.15
LULUCF	-31.52	-30.99	-30.11	-29.43	-28.97	-27.86	-28.89	-28.62
Natural Gas and Oil Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	**30.64**	**34.91**	**39.08**	**38.04**	**39.90**	**35.84**	**35.13**	**32.34**
Stationary Combustion	0.39	0.44	0.53	0.53	0.50	0.40	0.41	0.45
Mobile Combustion	0.14	0.10	0.07	0.06	0.07	0.06	0.06	0.06
Coal Mining	11.56	14.27	12.06	12.58	14.09	11.58	11.65	10.96
Natural Gas and Oil Systems	10.51	13.41	19.86	18.17	18.67	17.38	16.72	14.88
Agriculture	4.95	4.93	4.72	4.89	4.77	4.61	4.39	4.15
LULUCF	0.05	0.08	0.18	0.13	0.11	0.11	0.18	0.13
Waste	2.08	0.68	0.66	0.65	0.66	0.66	0.67	0.67
Wastewater	0.95	1.00	1.01	1.02	1.02	1.04	1.05	1.04
Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	**5.44**	**5.19**	**4.99**	**4.86**	**4.94**	**4.47**	**4.63**	**4.39**
Stationary Combustion	0.68	0.62	0.47	0.38	0.34	0.26	0.30	0.29
Mobile Combustion	1.32	0.91	0.59	0.48	0.51	0.44	0.45	0.47
Industrial Processes	0.16	0.15	0.15	0.15	0.14	0.15	0.15	0.14
Agriculture	2.90	3.14	3.41	3.48	3.57	3.24	3.35	3.10
LULUCF	0.03	0.04	0.07	0.07	0.07	0.07	0.08	0.07
Waste	0.09	0.06	0.04	0.03	0.03	0.03	0.03	0.03
Wastewater	0.26	0.26	0.26	0.27	0.28	0.29	0.28	0.28
HFC, PFC, SF_6 and NF_3 Emissions	**4.29**	**4.81**	**6.63**	**6.42**	**6.14**	**6.85**	**7.11**	**7.27**
Industrial Processes	4.29	4.81	6.63	6.42	6.14	6.85	7.11	7.27
Indirect CO_2 from Electricity Consumption*	**89.89**	**84.53**	**64.64**	**56.04**	**52.79**	**46.68**	**49.68**	**49.51**
Gross Emissions	**316.21**	**298.42**	**278.86**	**264.80**	**265.08**	**240.00**	**256.62**	**253.01**
Sinks	**-31.52**	**-30.99**	**-30.11**	**-29.43**	**-28.97**	**-27.86**	**-28.89**	**-28.62**
Net Emissions (Sources and Sinks)	**284.69**	**267.42**	**248.76**	**235.37**	**236.11**	**212.14**	**227.73**	**224.39**

* Emissions from Electricity Consumption are not included in totals in order to avoid double counting with Fossil Fuel Combustion estimates. Note: Totals shown here are slightly different than totals shown in Table 2 due to differences in accounting and rounding.

The vast majority of GHG emissions are comprised of CO_2 resulting from the combustion of fossil fuels including coal, petroleum products, and natural gas. In total, CO_2 comprises 82.7% of GHG emissions, in terms of $MMTCO_2e$, followed by CH_4 at 12.7% (Figure 2). CO_2 has also seen the greatest reduction of GHGs (Figure 3), which is primarily due to a decrease in emissions from fossil fuel combustion. Sources of other GHGs have remained relatively stable from 2005 to 2022.

Figure 2 - GHG Emissions by Gas, 2022 ($MMTCO_2e$)

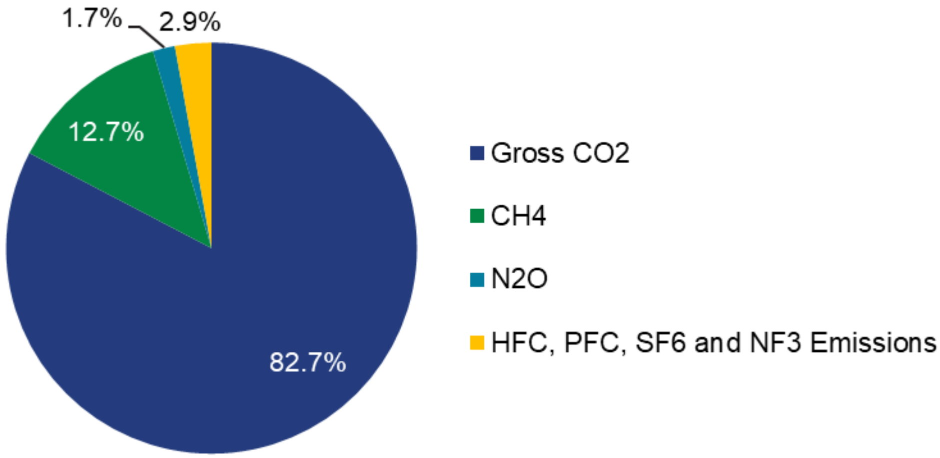
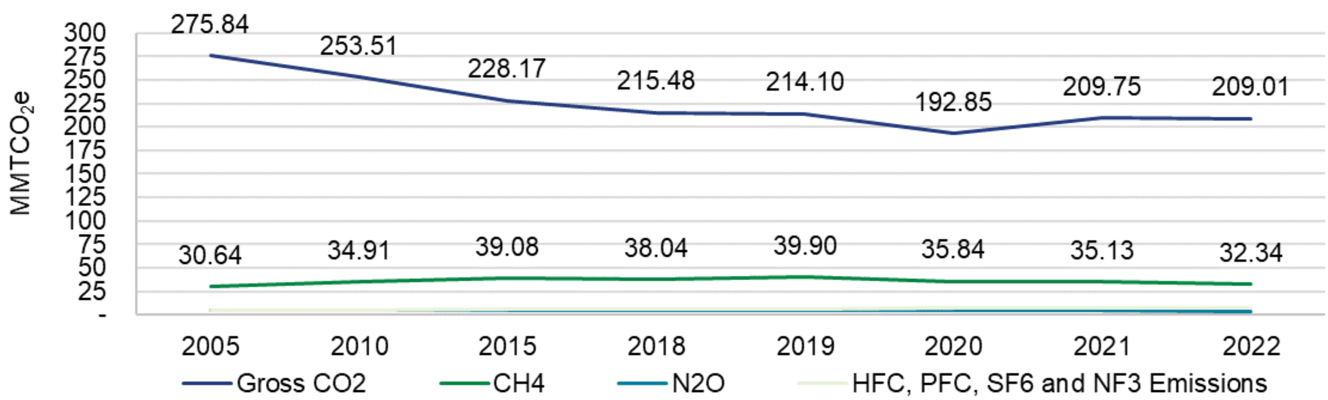


Figure 3 - GHG Emissions by Gas, 2005-2022 ($MMTCO_2e$)



Greenhouse Gas Emissions by Sector

<u>Residential Sector</u>

The residential sector includes emissions from heating, cooling and fuel use in single family and multi-family residential buildings. In 2022, emissions from the residential sector were 20.43 $MMTCO_2e$. Table 4 shows greenhouse gas emissions from this sector by fuel type.

Table 4 - Residential Sector GHG Emissions by Fuel Type ($MMTCO_2e$)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022
Coal	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	10.42	8.01	7.73	7.81	6.55	5.68	6.86	7.10
Natural Gas	13.56	12.34	13.11	13.94	13.05	12.21	12.48	13.09
Other	0.14	0.23	0.31	0.32	0.30	0.20	0.20	0.24
Total	**24.25**	**20.58**	**21.15**	**22.07**	**19.90**	**18.08**	**19.55**	**20.43**

The emissions attributed to the residential sector result from fuels combusted to provide heat and hot water to residential homes within the Commonwealth. These fuels, in order of decreasing use in 2022, are natural gas, heating oil, propane, and kerosene. Table 5 shows the amount of each fuel used (BBtu, or Billion British thermal units) in residential homes within the Commonwealth. Several factors influence the amount of a fuel being used, including the severity of the weather, efficiency of the heating or hot water system, and the price and availability of a particular fuel. Fuel consumption increased in 2022 relative to 2021. No electricity consumption is included in these values.

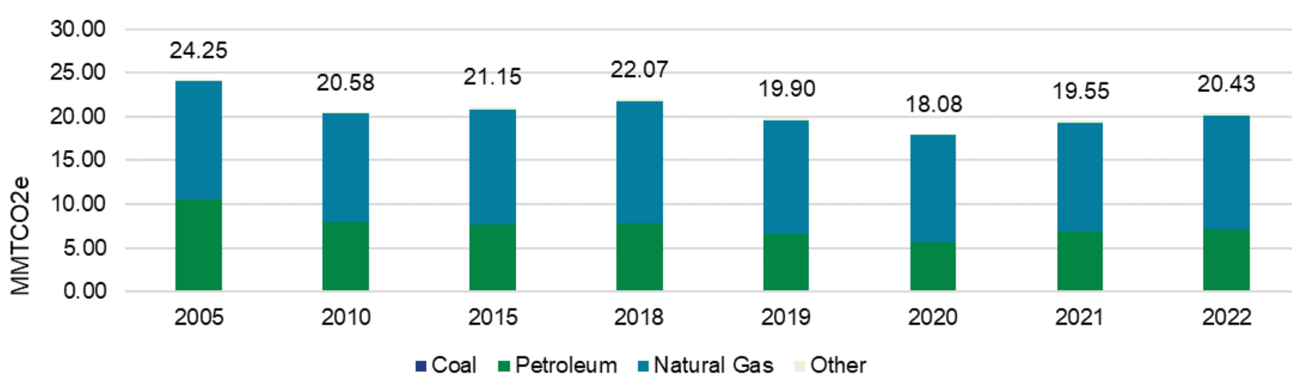
Each fuel used in residential homes emits GHGs at different rates. Emissions from this sector were calculated in the SIT CO_2FFC module by multiplying the total fuel consumption for each fuel type by the emissions factor for that fuel type. Non-CO_2 emissions (e.g., CH_4 and N_2O) produced during fuel combustion were calculated in the SIT Stationary Combustion Module.

Figure 4 shows the GHG emission (MMTCO_2e) attributed to each fuel used in the residential sector. The emissions related to electricity use for residential homes using electricity for heating or cooling purposes are accounted for in the electricity production sector.

Table 5 - Residential Sector Fuel Consumption by Year (BBtu)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022	2023[20]
Coal[21]	1,253	-	-	-	-	-	-	-	-
Heating Oil	115,753	85,432	86,789	86,087	66,666	59,300	74,997	78,256	73,572
Kerosene	10,330	4,211	1,350	930	1,056	1,000	1,060	981	1,690
Propane	15,122	20,812	18,230	20,768	23,752	18,625	18,812	18,766	17,188
Natural Gas	255,038	231,854	247,059	262,667	245,940	230,053	235,221	246,528	214,385
Other	-	-	-	-	-	-	-	-	-
Total	**397,496**	**342,309**	**353,428**	**370,452**	**337,414**	**308,978**	**330,090**	**344,531**	**306,835**

Figure 4 - Residential Sector GHG Emissions by Fuel Type (MMTCO_2e)



Commercial Sector

The commercial sector includes emissions from heating, cooling and fuel use in commercial buildings, including businesses, institutional facilities (e.g. schools, hospitals) and other large buildings. In 2022, emissions from the commercial sector were 12.18 MMTCO_2e. Table 6 shows greenhouse gas emissions from this sector by fuel type.

[20] 2023 data were compiled from U.S. Energy Information Administration's State Energy Data System (SEDS), preliminary report released 3/28/2025. 2023 data are not available for all sectors presented in this inventory and will be presented in full in the 2026 Pennsylvania Greenhouse Gas Inventory Report.

[21] The U.S. Energy Information Administration, which is the source of default fuel consumption data used in the SIT, assumes that coal use for residential heating is zero from 2008 on.

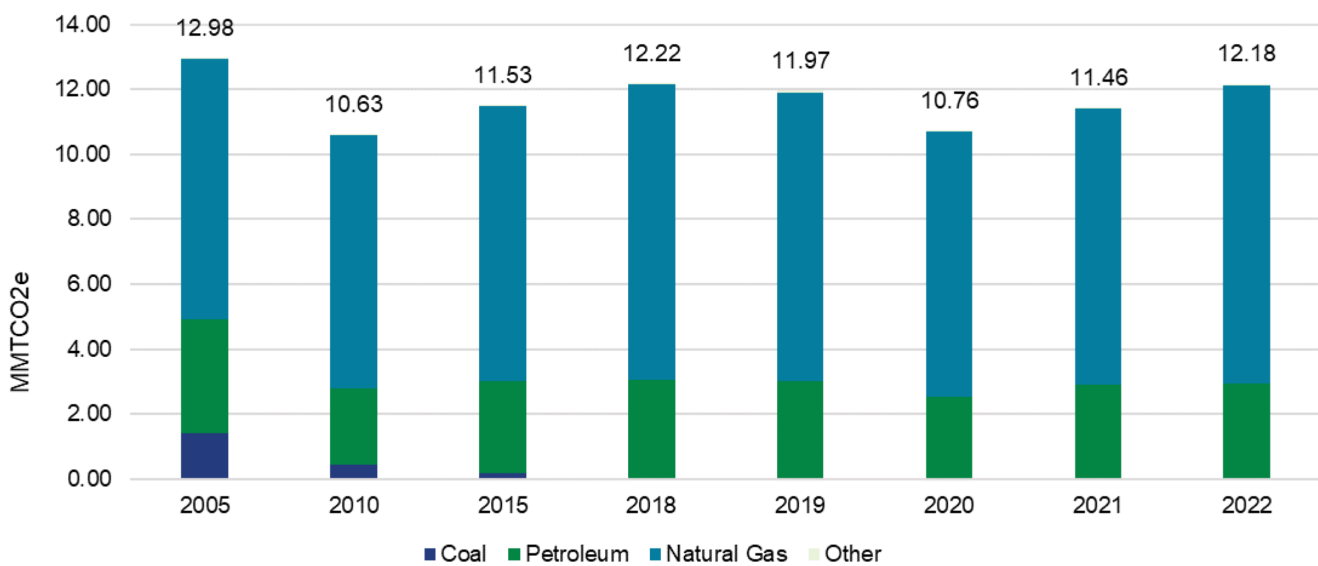
Table 6 - Commercial Sector GHG Emissions by Fuel Type (MMTCO2e)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022
Coal	1.39	0.45	0.19	0.03	0.03	0.02	0.02	0.01
Petroleum	3.55	2.33	2.84	3.02	2.98	2.52	2.89	2.94
Natural Gas	8.02	7.82	8.46	9.11	8.91	8.18	8.51	9.19
Other	0.02	0.03	0.05	0.05	0.04	0.05	0.05	0.05
Total	**12.98**	**10.63**	**11.53**	**12.22**	**11.97**	**10.76**	**11.46**	**12.18**

Table 7 - Commercial Sector Fuel Consumption (BBtu)

	2005	2010	2015	2018	2019	2020	2021	2022
Coal	14,407	4,729	1,963	362	311	224	171	78
Heating Oil	35,632	23,625	18,765	20,328	19,943	13,707	18,203	18,747
Kerosene	2,610	755	144	179	217	176	166	154
Propane	5,480	6,853	7,829	8,409	8,019	7,966	8,367	8,099
Motor Gasoline[22]	462	428	13,062	13,533	13,620	13,724	14,910	15,329
Residual Fuel	3,934	570	53	5	0	0	3	3
Natural Gas	150,849	146,902	159,442	171,616	167,982	154,048	160,399	173,203
Other	0	0	0	0	0	0	0	0
Total	**213,374**	**183,862**	**201,258**	**214,432**	**210,092**	**189,845**	**202,219**	**215,613**

Figure 5 - Commercial Sector GHG Emissions by Fuel Type (MMTCO2e)



The emissions attributed to the commercial sector result from fuels that are combusted to provide heat and hot water to commercial buildings within the Commonwealth. These fuels, in order of decreasing use in 2022 are natural gas, heating oil, motor gasoline, propane, coal, and kerosene. Table 7 shows the amount of each fuel used (BBtu) in commercial buildings within the Commonwealth. Several factors will

[22] Beginning in 2015, the Federal Highway Administration (FHWA) has revised its methods of estimating non-highway use of motor gasoline. Therefore, estimates for motor gasoline consumption by sector from 2015 forward are not compatible with data before 2015.

influence the amount of fuel being used, including the severity of the weather, the efficiency of the heating or hot water system, and the price and availability of a particular fuel. No electricity consumption is included in these values.

As in the residential sector, each fuel used in commercial buildings emits GHGs at different rates. Emissions from this sector were also calculated in the SIT CO_2FFC module by multiplying the total fuel consumption for each fuel type by the emissions factor for that fuel type. Non-CO_2 emissions (e.g., CH_4 and N_2O) produced during fuel combustion were calculated in the SIT Stationary Combustion Module. Figure 5 shows the GHG emissions (MMTCO_2e) attributed to each fuel used in the commercial sector. The emissions from burning firewood to heat commercial buildings are accounted for in the forestry and land use sector. The emissions related to electricity use for commercial buildings using electricity for heating or cooling purposes are accounted for in the electricity production sector.

Industrial Sector

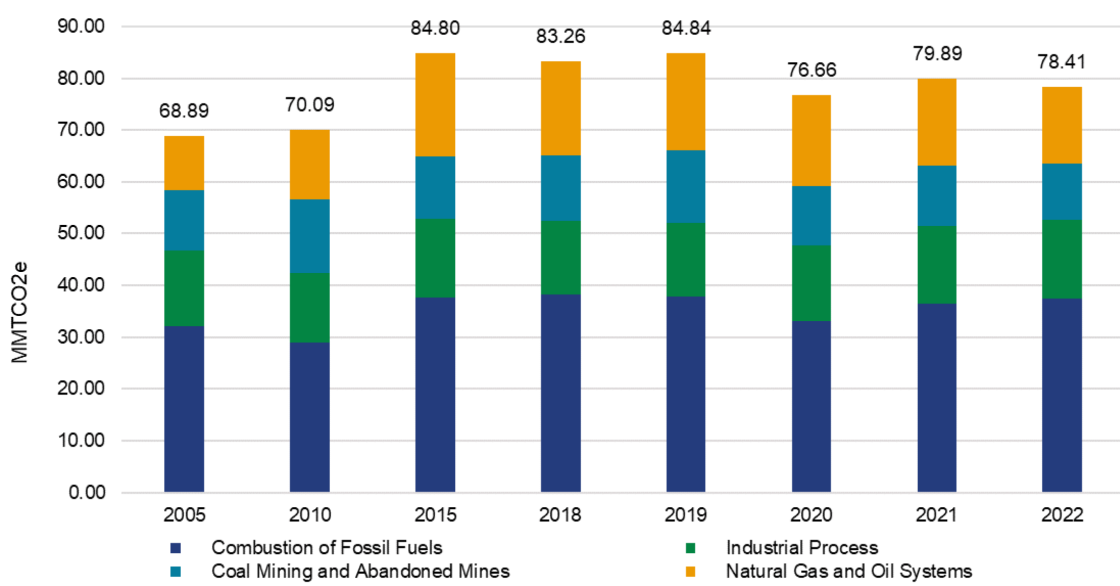
GHG emissions from the industrial sector differ from the residential and commercial sectors in that these emissions come from four separate subgroups: combustion of fossil fuels for industrial uses, industrial processes, activities involving coal mining and abandoned coal mines, and activities involving natural gas and oil systems (i.e. production, transmission, and distribution). In 2022, emissions from the industrial sector were 78.41 MMTCO_2e. Within the four subgroups, combustion of fossil fuels consistently accounts annually for approximately half of the GHG emissions from the industrial sector.

Table 8 shows greenhouse gas emissions from this sector by subgroup.

Table 8 - Industrial Sector GHG Emissions by Subgroup (MMTCO_2e)

	2005	2010	2015	2018	2019	2020	2021	2022
Combustion of Fossil Fuels	32.08	28.98	37.69	38.23	37.89	33.05	36.45	37.37
Industrial Process	14.73	13.43	15.20	14.28	14.19	14.64	15.07	15.20
Coal Mining and Abandoned Mines	11.56	14.27	12.06	12.58	14.09	11.58	11.65	10.96
Natural Gas and Oil Systems	10.51	13.41	19.86	18.17	18.68	17.39	16.72	14.88
Total	**68.89**	**70.09**	**84.80**	**83.26**	**84.84**	**76.66**	**79.89**	**78.41**

Figure 6 - GHG Emissions from Industrial Sector by Source (MMTCO_2e)



Combustion of Fossil Fuels in the Industrial Sector

The emissions attributed to the industrial sector result from fuels combusted to heat and cool industrial buildings and equipment within the Commonwealth. These fuels, in order of decreasing use in 2022 are natural gas, coal/coke, heating oil, and various other fuels. In 2022, emissions from the combustion of fossil fuels in the industrial sector were 37.37 $MMTCO_2e$.

Table 9 shows the amount of each fuel used (BBtu) in the industrial sector within the Commonwealth. Several factors will influence the amount of each fuel being used, including the severity of the weather, efficiency of the heating or cooling system, and the price and availability of a particular fuel.

Table 9 - Industrial Sector Fuel Consumption (Energy and Non-Energy Use) (BBtu)

	2005	2010	2015	2018	2019	2020	2021	2022
Coking Coal	23,835	15,755	34,734	38,555	34,734	17,870	37,814	15,920
Other Coal	63,541	47,710	10,518	11,940	10,518	10,769	10,036	8,375
Asphalt And Road Oil	60,964	46,840	45,301	43,561	45,301	37,252	42,158	46,812
Aviation Gasoline Blending Components	390	-11	-28	-50	-28	-12	-13	-10
Crude Oil	0	0	0	0	0	0	0	0
Heating Oil	32,990	33,972	43,808	43,301	43,808	32,102	42,926	43,398
Feedstocks, Naphtha Less Than 401°F	0	0	0	0	0	0	0	0
Feedstocks, Other Oils Greater Than 401°F	0	0	0	0	0	0	0	0
Kerosene	663	281	63	79	63	60	62	47
Hydrocarbon Gas Liquids[23]	22,823	29,624	20,711	21,164	20,711	21,922	22,493	74,377*
Lubricants[24]	14,716	5,920	5,303	5,423	5,303	5,303	5,257	4,879
Motor Gasoline	9,486	9,712	7,150	7,163	7,150	7,211	7,112	7,457
Motor Gasoline Blending Components	0	0	0	0	0	0	0	0
Misc. Petro Products	1,493	1,795	2,349	2,582	2,349	2,226	2,227	2,392
Petroleum Coke	36,889	26,859	12,613	22,396	12,613	7,802	8,299	8,255
Pentanes Plus	0	0	0	0	0	0	0	0
Residual Fuel	9,551	920	0	0	0	0	66	36
Still Gas	70,200	67,173	35,455	51,797	35,455	20,781	22,566	22,670
Special Naphthas	3,265	1,653	6,559	6,314	6,559	5,937	5,572	6,115
Unfinished Oils[25]	131	1,276	3,142	992	3,142	2,818	749	0
Waxes	1,871	894	641	764	641	566	725	802
Natural Gas	189,474	220,566	495,875	456,088	495,875	470,239	514,058	521,669
Other	0	0	0	0	0	0	0	0
Total	**542,282**	**510,940**	**724,195**	**712,069**	**724,195**	**642,845**	**722,107**	**763,195**

[23] Hydrocarbon gas liquids include Ethane, Propane, Butanes, Natural gasoline or pentanes plus, Ethylene, Propylene and Normal butylene and isobutylene

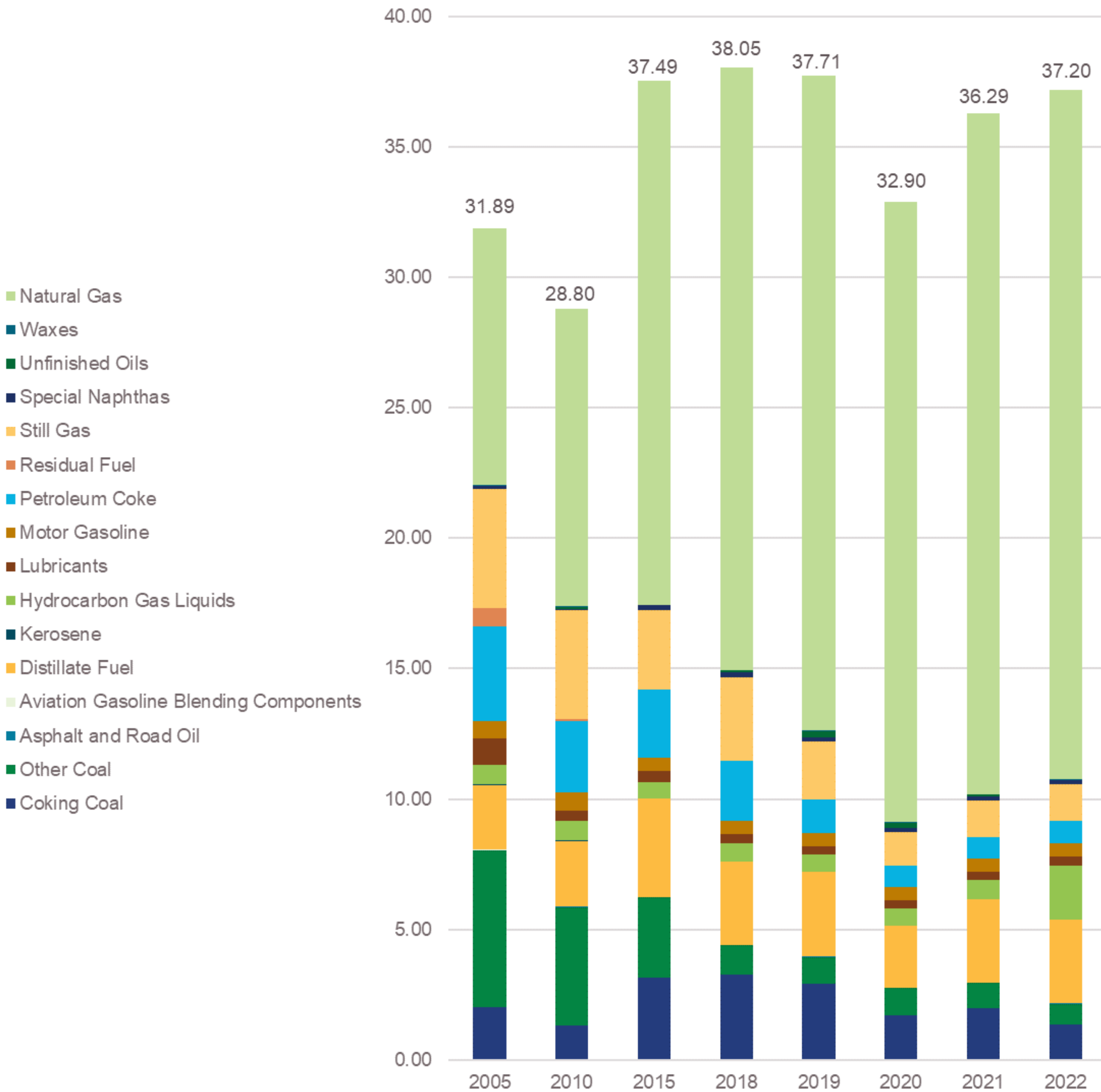
[24] EIA's State Energy Data System (SEDS) modified the methodology for deriving lubricants consumption in data year 2016. Source: www.eia.gov/state/seds/seds-data-changes.php?sid=US#2016.

[25] Negative values represent storage of energy since oils are manufactured from other fuels. Negative emissions serve to correct the overestimation of emissions attributed to the parent fuel. Source: SIT.

* Increased use of propane use in 2022 is due to the ethylene cracker plant "Shell Pennsylvania Petrochemicals Complex" in Monaca that opened in late-2022. Shell Polymers Monaca | About Us

As in the residential and commercial sectors, each fuel used in the industrial sector emits GHGs at different rates. Emissions from this sector were also calculated in the SIT CO_2FFC module by multiplying the total fuel consumption for each fuel type by the emissions factor for that fuel type. Non-CO_2 emissions (e.g., CH_4 and N_2O) produced during fuel combustion were calculated in the SIT Stationary Combustion Module. Figure 7 shows the GHG emissions ($MMTCO_2e$) attributed to each fuel used in the industrial sector. The emissions related to electricity within the industrial sector are accounted for in the electricity production sector.

Figure 7 - Industrial Sector GHG Emissions by Fuel Type ($MMTCO_2e$)



Industrial Processes

Some of the industrial processes that are accounted for in this group include cement manufacturing, lime manufacturing, limestone and dolomite use, iron and steel production, substitutes for Ozone-Depleting Substances (ODS), and electric power transmission and distribution systems. Emissions from these sources were estimated in the SIT Industrial Processes Module. Emissions from ferroalloy production, zinc production, carbon dioxide consumption, glass production, lead production, carbide production and consumption, caprolactam production, titanium dioxide production, petrochemical production, chlorodifluoromethane (HCFC-22) production, phosphoric acid production, and N_2O from product use were estimated from the U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State report. Table 10 shows the GHG emissions ($MMTCO_2e$) attributed to each of the processes included within the industrial processes sector. In 2022, emissions from industrial processes were 15.20 $MMTCO_2e$.

Table 10 - Industrial Sector Process Emissions ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
CO_2 Emissions								
Cement Manufacture	3.13	1.65	1.80	1.61	1.80	1.71	1.79	1.84
Lime Manufacture	0.85	0.85	0.71	0.65	0.71	0.64	0.69	0.65
Limestone and Dolomite Use	0.49	0.80	0.55	0.44	0.55	0.58	0.56	0.64
Soda Ash	0.11	0.09	0.08	0.08	0.08	0.07	0.08	0.07
Aluminum Production, CO_2	-	-	-	-	-	-	-	-
Iron & Steel Production	4.48	3.80	3.80	3.80	3.80	3.80	3.80	3.80
Ammonia Production	-	-	-	-	-	-	-	-
Urea Consumption	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Ferroalloy Production	0.18	0.24	0.38	0.57	0.38	0.29	0.33	0.22
Zinc Production	0.67	0.60	0.22	0.21	0.22	0.22	0.21	0.21
Carbon Dioxide Consumption	0.06	0.18	0.19	0.16	0.19	0.19	0.19	0.19
Glass Production	0.25	0.20	0.15	0.15	0.15	0.13	0.14	0.14
Lead Production	0.06	0.04	0.02	0.02	0.02	0.01	0.01	0.01
Carbide Production and Consumption	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caprolactam Production	-	-	-	-	-	-	-	-
Titanium Dioxide Production	-	-	-	-	-	-	-	-
Petrochemical Production	-	-	-	-	-	-	-	-
HCFC-22 Production	-	-	-	-	-	-	-	-
Phosphoric Acid Production	-	-	-	-	-	-	-	-
N_2O Emissions								
N_2O From Product Uses	0.16	0.15	0.14	0.15	0.14	0.15	0.15	0.14
CH_4 Emissions								
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petrochemical Production	-	-	-	-	-	-	-	-
HFC, PFC, SF6 and NF3 Emissions								
ODS Substitutes	3.78	4.48	5.90	6.22	5.90	6.61	6.87	7.07
Semiconductor Manufacturing	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Magnesium Production	-	-	-	-	-	-	-	-
Electric Power Transmission and Distribution Systems	0.48	0.31	0.23	0.19	0.23	0.22	0.23	0.19
HCFC-22 Production	-	-	-	-	-	-	-	-
Aluminum Production, PFCs	-	-	-	-	-	-	-	-
Total	**14.73**	**13.43**	**14.19**	**14.28**	**14.19**	**14.64**	**15.07**	**15.20**

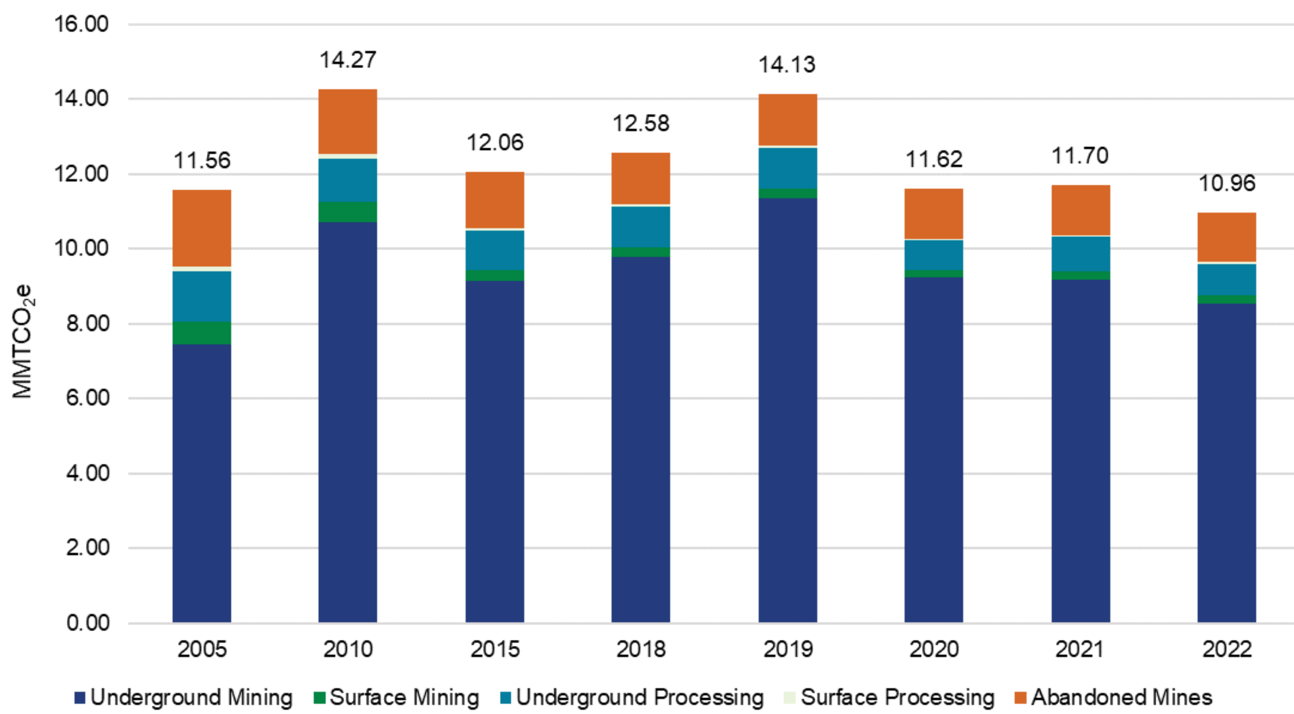
Coal Mining and Abandoned Coal Mines

In 2022, emissions from coal mining and related processes were 10.69 $MMTCO_2e$. The GHG emissions associated with underground and surface mining coal processing, and abandoned coal mines are accounted for in this section. Table 11 and Figure 8 show the GHG emissions ($MMTCO_2e$) attributed to underground and surface coal mining, coal processing, and abandoned underground mines.

Table 11 - CH_4 from Coal Mining-Related Process Emissions ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Underground Mining	7.44	10.73	9.14	9.79	11.35	9.24	9.18	8.53
Surface Mining	0.62	0.53	0.30	0.25	0.26	0.20	0.21	0.22
Underground Processing	1.33	1.16	1.07	1.08	1.08	0.78	0.92	0.86
Surface Processing	0.14	0.11	0.06	0.05	0.06	0.04	0.05	0.05
Abandoned Mines	2.04	1.75	1.49	1.40	1.37	1.35	1.33	1.31
Total	**11.56**	**14.27**	**12.06**	**12.58**	**14.13**	**11.62**	**11.70**	**10.96**

Figure 8 - CH_4 from Coal Mining-Related Process Emissions ($MMTCO_2e$)



Emissions from coal mining and abandoned coal mines were calculated using the SIT Coal Module. Most emissions accounted for come from underground mining activity. The results are determined by measuring ventilation air from underground mines and applying emission factors for surface mines, abandoned mines, and coal processing.

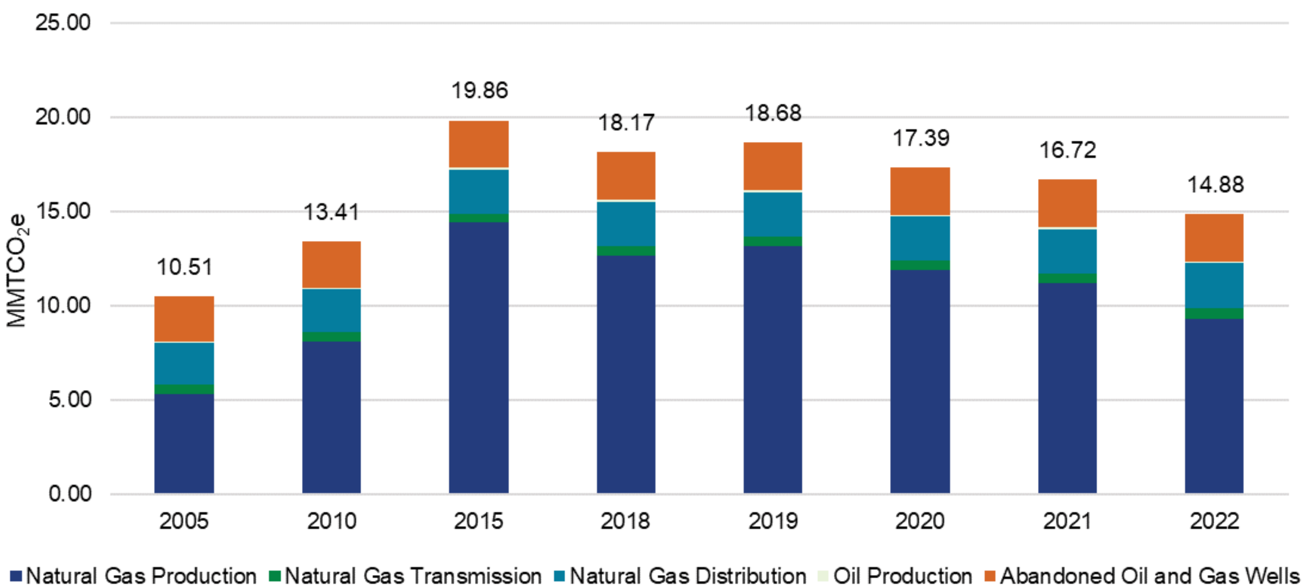
Natural Gas and Oil Systems

In 2022, emissions from natural gas and oil systems were 14.88 $MMTCO_2e$. Emissions from natural gas production, transmission, and distribution, oil production, and abandoned oil and gas wells are accounted for in this section and are shown in Table 12 and Figure 9. Emissions from natural gas production 2022 decreased due to new federal-level regulations for equipment (NSPS OOOOb), resulting in decreased fugitive emissions of methane from compressor stations. The methodology for this sector was updated in this 2025 inventory release to include emission factor estimates based on observed emissions in Pennsylvania from DEP's Bureau of Air Quality annual reporting. For more detail on methodology updates, see Appendix C.

Table 12 - CH_4 and CO_2 from Natural Gas Production Process Emissions ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Natural Gas Production	5.36	8.13	14.43	12.70	13.21	11.91	11.22	9.35
Natural Gas Transmission	0.47	0.48	0.49	0.51	0.51	0.51	0.52	0.56
Natural Gas Distribution	2.21	2.26	2.32	2.34	2.34	2.36	2.36	2.39
Oil Production	0.09	0.10	0.15	0.12	0.11	0.08	0.09	0.05
Abandoned Oil and Gas Wells	2.40	2.43	2.47	2.50	2.51	2.53	2.54	2.54
Total	**10.51**	**13.41**	**19.86**	**18.17**	**18.68**	**17.39**	**16.72**	**14.88**

Figure 9 - CH_4 and CO_2 from Natural Gas Production Process Emissions ($MMTCO_2e$)



Emissions from natural gas production, natural gas transmission, natural gas distribution, and oil production were estimated using the SIT Natural Gas and Oil Module and augmented with additional data from national and state sources as available. In the SIT, the total GHG emissions are determined based on the number of natural gas wells, miles of transmission pipeline, and number and types of services used for distribution in the Commonwealth.[26] The natural gas transmission data became available in 2001

Emissions from abandoned oil and gas wells are not estimated within SIT and were instead estimated from U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State report. The U.S. Inventory calculated emissions from abandoned oil and gas wells by estimating the number and type (plugged and unplugged) of abandoned oil and gas wells in each state using a combination of Enverus[27],

[26] U.S. Department of Transportation (U.S. DOT) Pipeline and Hazardous Materials Safety Administration. 2025 Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data. Last Updated 6 March 2025. www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids.

[27] www.enverus.com/

a proprietary information database regarding the oil and gas industry, and historical data, and multiplying the total count for each well type by its respective emissions factor. U.S. EPA established different emissions factors for wells in and outside of the Appalachia region due to their varied geographic qualities that impact the magnitude of leak rates. These well counts are estimates, and the uncertainty surrounding the number of abandoned oil and gas wells impacts the rigor of this analysis. More information about the methodology used to calculate emissions from oil and gas wells can be found in the U.S. Inventory Methodology for Emissions Estimates by State.[28]

Transportation Sector

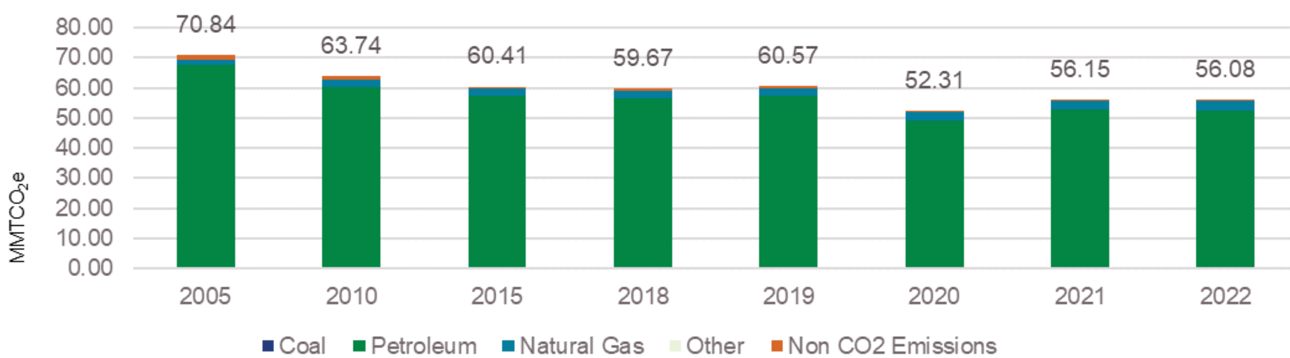
Emissions from the transportation sector come from on-road vehicles including, passenger vehicles, light and heavy-duty trucks, RVs, motorcycles and buses, as well as emissions from airplanes, trains, and marine vehicle. In 2022, emissions from the transportation sector were 56.08 $MMTCO_2e$. Table 13 shows greenhouse gas emissions from this sector by fuel type.

Table 13 - Transportation Sector Emissions by Fuel Consumption (MMTCO2e)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022
Coal	-	-	-	-	-	-	-	-
Petroleum	67.66	60.11	57.34	56.54	57.21	49.20	52.70	52.37
Natural Gas	1.71	2.63	2.42	2.59	2.79	2.62	2.93	3.18
Other	-	-	-	-	-	-	-	-
Non-CO_2 Emissions	1.46	1.01	0.66	0.54	0.58	0.49	0.52	0.53
Total	**70.84**	**63.74**	**60.41**	**59.67**	**60.57**	**52.31**	**56.15**	**56.08**

As in the previous sectors, each fuel used in transportation will have different rates of GHG emissions. Emissions from this sector were calculated in the SIT CO_2FFC module by multiplying the total fuel consumption for each fuel type by the emissions factor for that fuel type. Non-CO_2 emissions (e.g., CH_4 and N_2O) produced during fuel combustion were calculated in the SIT Mobile Combustion Module. Figure 10 shows the GHG emission ($MMTCO_2e$) attributed to each fuel used in the transportation sector.

Figure 10 - Transportation Sector Emissions by Fuel Consumption ($MMTCO_2e$)



[28] EPA. 2024. Methodology Report: Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990–2022. U.S. Environmental Protection Agency, EPA 430-R-22-005.

The emissions attributed to the transportation sector result from fuels combusted to provide transportation for various types of vehicles within the Commonwealth. In order of decreasing use in 2022, these fuels include gasoline, diesel, natural gas and jet fuel (see Table 14). Several factors influence the amount of a fuel being used, such as the mode of transportation, efficiency of the vehicle, and the price and availability of a particular fuel. The emissions related to electricity use in transportation are accounted for in the electricity production sector.

Table 14 - Transportation Sector Fuel Use (BBtu)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022	2023[29]
Aviation Gasoline	505	537	517	369	425	338	386	400	379
Diesel	225,678	208,177	214,410	210,825	214,525	203,729	207,527	210,817	211,492
Jet Fuel	95,404	69,561	69,271	74,608	77,791	45,128	52,689	56,665	62,751
Hydrocarbon Gas Liquids	755	96	289	488	370	175	398	631	554
Motor Gasoline	628,121	571,588	532,669	522,404	524,467	444,535	483,183	473,724	509,622
Residual Fuel	28,923	5,015	2,074	1,272	1,694	677	1,440	1,475	1,225
Natural Gas	32,312	49,517	45,700	48,893	52,681	49,507	55,405	60,044	53,913
Other	-	-	-	-	-	-	-	-	-
Total	**1,011,698**	**904,491**	**864,930**	**858,859**	**871,953**	**744,089**	**801,028**	**803,756**	839,936

Electricity Production Sector

Emissions from the electricity production sector include emissions from the generation, transmission and distribution of electricity from sources like fossil fuel-fired power plants. In 2022, emissions from electricity production were 74.52 $MMTCO_2e$. Table 15 and Figure 11 show greenhouse gas emissions from this sector by fuel type.

Table 15 - Electricity Production Sector GHG Emissions by Fuel Type ($MMTCO_2e$)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022
Coal	117.66	107.43	64.26	44.97	38.24	24.64	30.84	25.78
Petroleum	4.21	0.51	0.45	0.58	0.17	0.08	0.10	0.25
Natural Gas	4.43	13.40	24.16	29.55	36.90	45.50	46.72	48.49
Other	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total	**126.31**	**121.35**	**88.87**	**75.10**	**75.30**	**70.22**	**77.67**	**74.52**

The emissions attributed to the electricity production sector result from fuels that are combusted to generate electricity within the Commonwealth. Electricity production is one of the largest contributors of GHG emissions in Pennsylvania. 29 percent of the statewide gross emissions in 2022 came from the electricity production sector; however, a sizable percentage of these emissions are associated with electricity that is produced and exported to meet the needs of surrounding states. Electricity is produced in several different ways within the Commonwealth. The three primary forms of electricity generation in Pennsylvania are natural gas, nuclear, and coal.

[29] 2023 data were compiled from U.S. Energy Information Administration's State Energy Data System (SEDS), preliminary report released 3/28/2025. 2023 data are not available for all sectors presented in this inventory and will be presented in full in the 2026 Pennsylvania Greenhouse Gas Inventory Report.

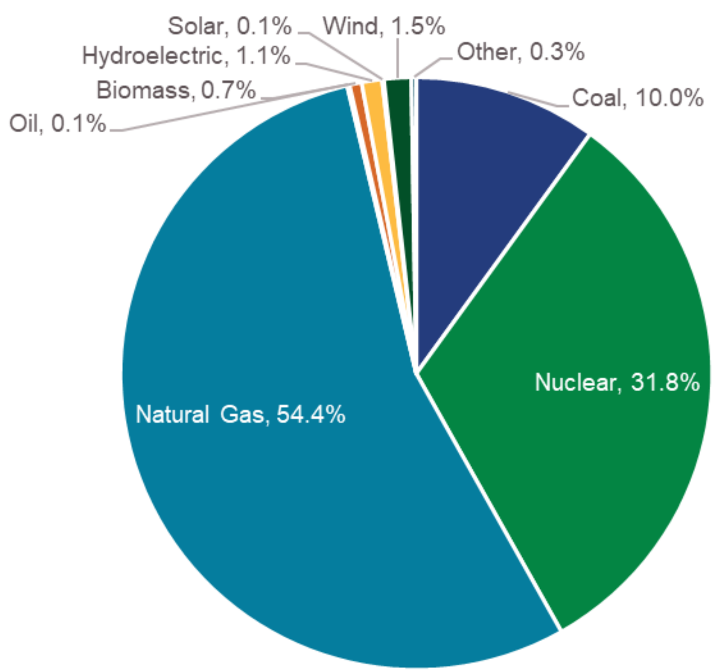
The largest changes in the production of electricity since 2005 have occurred in the use of coal and natural gas. As supply of natural gas increased resulting in lower prices, natural gas has largely replaced coal in electricity production. From 2021 to 2022, electricity generation from coal slightly decreased from 12.1% of total generation to 10.0%, while electricity generation from natural gas slightly increased to 54.4% of total generation.

Table 16 and Figure 11 give the relative percentages of each fuel used to generate electricity in Pennsylvania.

Table 16 - Electricity Generation by Fuel Type (%)[30]

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022	2023[31]
Coal	55.5%	48.0%	30.1%	20.5%	16.6%	10.2%	12.1%	10.0%	5.4%
Nuclear	35.0%	33.9%	37.5%	38.8%	36.3%	33.2%	31.5%	31.8%	31.5%
Natural Gas	5.0%	14.7%	27.7%	35.5%	42.8%	52.5%	52.5%	54.4%	58.2%
Oil	2.3%	0.2%	0.3%	0.3%	0.1%	0.0%	0.1%	0.1%	0.0%
Biomass	0.9%	1.0%	1.1%	1.1%	0.9%	0.8%	0.7%	0.7%	0.5%
Hydroelectric	1.0%	1.0%	1.2%	2.0%	1.5%	1.2%	1.3%	1.1%	1.2%
Solar	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%
Wind	0.1%	0.8%	1.6%	1.7%	1.4%	1.6%	1.4%	1.5%	1.4%
Other	0.3%	0.3%	0.4%	0.3%	0.3%	0.4%	0.3%	0.3%	0.2%

Figure 11 - Electricity Generation by Type for 2022



[30] U.S. Energy Information Administration (U.S. EIA). 2025. Net Generation by State by Type of Producer by Energy Source (EIA-906, EIA-920, and EIA-923). Accessed March 2025. www.eia.gov/electricity/data/state/.

[31] 2023 data were compiled from U.S. Energy Information Administration's State Energy Data System (SEDS), preliminary report released 3/28/2025. 2023 data are not available for all sectors presented in this inventory and will be presented in full in the 2026 Pennsylvania Greenhouse Gas Inventory Report.

Since electricity produced from nuclear fuel, hydroelectric, solar, and wind creates no direct GHG emissions, the primary fuels associated with GHG emissions from electricity production are coal and natural gas.

Table 17 shows the amount of each of these fuels consumed (BBtu) for electricity generation in Pennsylvania.

Table 17 - Fuel Use for Electricity Generation (BBtu)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022	2023[32]
Coal	1,224,911	1,119,758	669,244	467,959	398,101	256,047	320,427	267,748	152,122
Natural Gas	83,531	252,182	456,219	557,750	696,798	859,161	882,142	915,384	983,230
Oil	51,783	6,810	6,008	7,847	2,222	1,015	1,410	3,339	729
Electric Power Distillate Fuel	7,406	4,243	6,008	7,787	2,179	963	1,389	3,192	691
Electric Power Residual Fuel	44,377	2,567	0	60	43	52	21	147	38
Total	**1,360,225**	**1,378,750**	**1,131,471**	**1,033,556**	**1,097,121**	**1,116,223**	**1,203,979**	**1,186,471**	**1,136,081**

As in the previous sectors, each fuel used in electricity production emits GHGs at different rates. Emissions from this sector were also calculated in the SIT CO_2FFC module by multiplying the total fuel consumption for each fuel type by the emissions factor for that fuel type. Non-CO_2 emissions (e.g., CH_4 and N_2O) produced during fuel combustion were calculated in the SIT Stationary Combustion Module.

Figure 12 shows the GHG emission ($MMTCO_2e$) attributed to the three primary fossil fuels used in the electricity production sector. In 2022, emissions from fossil fuel combustion increased across fuel types. While this fuel-switching from coal to natural gas has accelerated our emissions reduction to date, other strategies, like increased zero emissions generation, will be needed to continue to decrease emissions.

Figure 12 – Electricity Production Sector GHG Emissions by Fuel Type ($MMTCO_2e$)

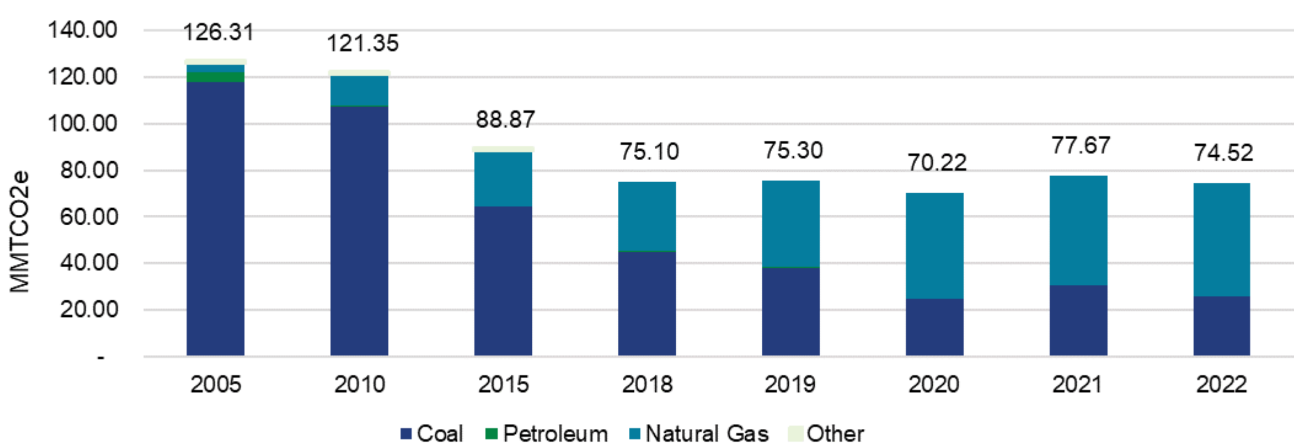


Table 18 gives the relative percentage of GHG emissions attributed to the three primary fossil fuels used in the electricity production sector.

[32] 2023 data were compiled from U.S. Energy Information Administration's State Energy Data System (SEDS), preliminary report released 3/28/2025. 2023 data are not available for all sectors presented in this inventory and will be presented in full in the 2026 Pennsylvania Greenhouse Gas Inventory Report.

Table 18 - Contribution to GHG Emissions, Fuel Type, in the Electricity Sector (%)

Fuel Type	2005	2010	2015	2018	2019	2020	2021	2022
Coal	93.1%	88.5%	72.2%	59.8	50.7	35.0%	39.6%	34.5%
Oil	3.3%	0.4%	0.5%	0.8	0.2	0.1%	0.1%	0.3%
Natural Gas	3.5%	11.1%	27.3%	39.4	49.1	64.9%	60.2%	65.2%

Table 18 shows Pennsylvania's electricity generation by sector in 2022. Coal produced 34.5% of the GHG emissions while producing 10.0% of the electricity. Natural gas produced 65.2% of the GHG emissions while producing 54.4% of the electricity. Nuclear power, which produces no GHG emissions, was responsible for generating 31.8% of the Commonwealth's electricity.

As has been noted in previous inventory reports, Pennsylvania has historically been, and is projected to remain, an exporter of electricity to neighboring states.

Table 19 shows the total consumption of electricity (TWh) within the residential, commercial, industrial, and transportation sectors.

Table 19 - Electricity Consumption by Sector (TWh)

	2005	2010	2015	2018	2019	2020	2021	2022	2023[33]
Direct Use by Electricity Generation Sector	3.29	2.78	4.33	5.39	4.82	5.14	5.74	6.39	6.95
Residential	53.66	55.25	54.42	55.90	54.40	55.31	55.95	56.41	52.33
Commercial	45.78	47.37	43.75	43.22	40.14	35.38	36.99	37.22	35.80
Industrial	47.95	45.46	47.40	49.16	50.42	48.61	50.00	50.88	50.15
Transportation	0.88	0.89	0.78	0.70	0.62	0.43	0.41	0.53	0.43
Total	**151.56**	**151.75**	**150.67**	**154.37**	**150.40**	**144.86**	**149.09**	**151.43**	**145.66**

Table 20 presents the total amount of electricity (TWh) generated and consumed in Pennsylvania, as well as electricity exports. A small amount of electricity is lost during transmission or cannot be accounted for.

Table 20 - Electricity Generated, Consumed and Exported (TWh)

	2005	2010	2015	2018	2019	2020	2021	2022	2023[34]
Electricity Generated	218.09	229.75	214.57	215.39	229.00	230.14	241.33	239.26	235.92
Electricity Consumed	151.56	151.75	150.67	154.37	150.40	144.86	149.08	151.43	145.66
Total electric industry retail sales	148.27	148.96	146.34	148.98	145.58	139.72	143.34	145.04	138.71
Direct use	3.29	2.78	4.33	5.39	4.82	5.14	5.74	6.39	6.95
Estimated Losses	9.91	9.20	7.30	7.68	7.89	7.78	6.74	7.85	6.14
Unaccounted	0.00	1.31	2.28	0.93	0.36	-0.21	0.92	-0.26	0.70
Electricity Exported	52.86	68.26	54.86	52.46	70.34	77.71	84.59	80.24	83.42
Total international exports	0.32	0.35	0.03	0.01	0.00	0.00	0.00	0.00	0.00
Net interstate exports	52.55	67.92	54.83	52.45	70.34	77.71	84.59	80.24	83.42

[33] U.S. Energy Information Administration (U.S. EIA). 2025. Net Generation by State by Type of Producer by Energy Source (EIA-906, EIA-920, and EIA-923). Accessed March 2025. www.eia.gov/electricity/data/state/.

[34] Ibid

Agriculture Sector

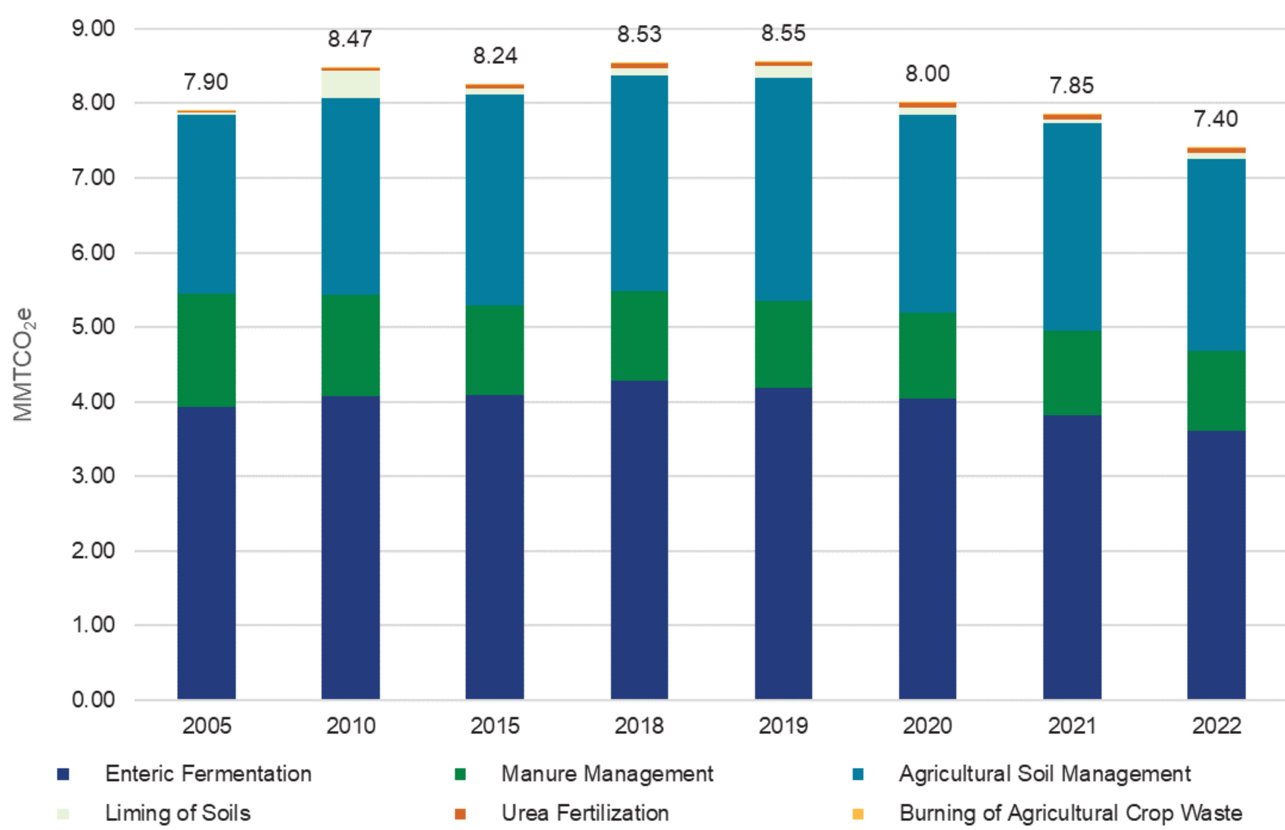
Emissions from the agriculture sector include emissions from livestock, agriculture land management and farming operations. In 2022, emissions from the agriculture sector were 7.40 MMTCO₂e. The current release of the SIT included updates to the historical time series, particularly in estimates to the manure management emissions, that resulted in decreases in net emissions across all years. Additional details on these changes can be found in Appendix C.

Table 21 and Figure 13 show greenhouse gas emissions from this sector by process.

Table 21 - Agricultural Sector GHG Emissions by Subgroup (MMTCO2e)

Source	2005	2010	2015	2018	2019	2020	2021	2022
Enteric Fermentation	3.93	4.07	4.09	4.28	4.19	4.05	3.82	3.62
Manure Management	1.52	1.37	1.19	1.20	1.17	1.14	1.13	1.07
Agricultural Soil Management	2.40	2.64	2.84	2.89	2.99	2.66	2.79	2.57
Liming of Soils	0.03	0.38	0.08	0.11	0.15	0.10	0.05	0.08
Urea Fertilization	0.02	0.03	0.04	0.05	0.06	0.06	0.06	0.06
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**7.90**	**8.47**	**8.24**	**4.28**	**4.19**	**8.00**	**7.85**	**7.40**

Figure 13 - GHG Emissions from Agricultural Sector by Source (MMTCO2e)



The GHG emissions from the agriculture sector are significantly lower than emissions from the industrial, transportation, and electricity production sectors. Like the industrial sector, GHG emissions in the agriculture sector are broken down into smaller subgroups consisting of enteric fermentation, manure management, agricultural soil management, and liming and urea fertilization.

Emissions from the agriculture sector were estimated in the SIT Agriculture Module using the default activity data for animal population, crop cultivation, and fertilizer application.

Table 22 lists the number (1,000 head) of each type of farm animal accounted for in the SIT.

Table 22 - Animal Populations Contributing to GHG Emissions (1,000 Head)

Animal Type	2005	2010	2015	2018	2019	2020	2021	2022
Dairy Cows	566	540	530	525	505	480	475	470
Dairy Replacement Heifers	278	300	306	308	290	272	217	193
Beef Cows	154	160	150	215	225	220	215	190
Beef Replacement Heifers	61	57	73	77	78	74	74	63
Heifer Stockers	55	50	55	60	55	50	50	45
Steer Stockers	85	75	69	60	62	62	62	64
Feedlot Heifers	24	30	31	32	35	36	29	26
Feedlot Steer	44	56	62	60	66	66	52	47
Bulls	25	25	25	25	25	20	20	20
Sheep	100	94	86	96	95	96	97	96
Goats	52	54	52	53	54	54	55	55
Swine	1,088	1,133	1,165	1275	1265	1,395	1,323	1,350
Horses	115	118	101	82	76	69	63	57

Enteric Fermentation

The enteric fermentation group includes animals that produce methane emissions due to their unique digestive process. Each type of farm animal has an associated methane emission factor associated with the enteric fermentation process. The total estimated GHG emissions from enteric fermentation is a summation of the product of the size of the statewide herd of each particular farm animal and the emission factor for that animal.

Table 23 shows the GHG emissions (MMTCO_2e) attributed to each animal in the agriculture sector due to enteric fermentation.

Table 23 - GHG Emissions (CH_4), by Livestock Type, from Enteric Fermentation ($MMTCO_2e$)

Animal Type	2005	2010	2015	2018	2019	2020	2021	2022
Dairy Cows	2.116	2.127	2.122	2.129	2.056	1.996	1.983	1.957
Dairy Replacement Heifers	0.797	0.898	0.925	0.939	0.884	0.843	0.673	0.598
Beef Cows	0.398	0.420	0.394	0.567	0.594	0.581	0.568	0.502
Beef Replacement Heifers	0.107	0.104	0.132	0.140	0.141	0.133	0.135	0.113
Heifer Stockers	0.092	0.084	0.093	0.101	0.093	0.084	0.084	0.076
Steer Stockers	0.136	0.121	0.113	0.097	0.101	0.101	0.100	0.105
Feedlot Heifers	0.027	0.037	0.038	0.039	0.042	0.044	0.035	0.032
Feedlot Steer	0.047	0.066	0.073	0.071	0.077	0.078	0.062	0.056
Bulls	0.067	0.068	0.068	0.068	0.068	0.055	0.055	0.055
Sheep	0.025	0.024	0.022	0.024	0.024	0.024	0.024	0.024
Goats	0.013	0.014	0.013	0.013	0.014	0.014	0.014	0.014
Swine	0.046	0.048	0.049	0.054	0.053	0.059	0.056	0.057
Horses	0.058	0.060	0.051	0.041	0.038	0.035	0.032	0.029
Total	**3.928**	**4.069**	**4.092**	**4.284**	**4.186**	**4.046**	**3.821**	**3.616**

Manure Management

The second agricultural subgroup is manure management. As with the enteric fermentation subgroup, each type of farm animal has an associated emission factor for the GHG emission (CH_4 and N_2O) based on the amount of manure that the animal produces. The total GHG emissions from manure management are equal to the summation of the product of the statewide livestock herd size by animal and the emission factor for that animal. Table 24 shows the GHG emission ($MMTCO_2e$) attributed to each animal type in the agriculture sector from manure management. The "other" category includes sheep, goats, and horses.

Table 24 - GHG Emissions (CH_4 and N_2O), by Livestock Type, from Manure Management ($MMTCO_2e$)

Animal Type	2005	2010	2015	2018	2019	2020	2021	2022
Dairy Cattle	1.249	1.107	0.888	0.867	0.849	0.793	0.771	0.739
Beef Cattle	0.048	0.049	0.052	0.055	0.055	0.071	0.060	0.055
Swine	0.033	0.018	0.016	0.017	0.017	0.018	0.012	0.012
Poultry	0.205	0.193	0.222	0.242	0.241	0.253	0.280	0.257
Other	0.013	0.012	0.010	0.010	0.009	0.009	0.006	0.005
Total	**1.548**	**1.378**	**1.188**	**1.191**	**1.172**	**1.145**	**1.129**	**1.068**

Agricultural Soil Management

The third subgroup of the agriculture sector is the soil management group. GHG emissions (N_2O) from agricultural soils are calculated from the direct and indirect biochemical interactions of fertilizers, livestock manure, and crop residue with the soil. Direct N_2O emissions occur when fertilizer, manure, or crop residue is applied to soils and N_2O is released to the atmosphere. Indirect N_2O occurs when nitrogen is volatized to the atmosphere or through leaching and runoff.

N_2O emissions are calculated by multiplying the amount of fertilizer, livestock manure, and crop residue applied to soils by the direct and indirect N_2O emissions factors. The agricultural soils management subgroup also includes emissions from histosols in Pennsylvania. Histosols are soils rich in organic matter, and they produce N_2O emissions when drained for agricultural use. The total acreage of histosols within the Commonwealth is small, SIT does not contain default data on the area of histosols. Table 25 below shows the estimated GHG emissions ($MMTCO_2e$) resulting from agricultural soils management.

Table 25 - GHG Emissions (N_2O) from the Management of Agricultural Soils ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Direct	2.27	2.49	2.68	2.72	2.83	2.52	2.65	2.44
Indirect	0.13	0.14	0.16	0.16	0.16	0.14	0.14	0.13
Volatilization & Atmospheric Deposition	0.06	0.07	0.07	0.08	0.07	0.07	0.06	0.06
Leaching/Runoff	0.07	0.08	0.08	0.09	0.08	0.07	0.07	0.07
Total	**2.40**	**2.64**	**2.84**	**2.89**	**2.99**	**2.66**	**2.79**	**2.57**

Liming of Soils and Urea Fertilization

The fourth subgroup of the agriculture sector is liming of soils and urea fertilization. In 2022, these groups produced 0.08 and 0.06 $MMTCO_2e$ respectively, as shown in **Error! Reference source not found.**.

Table 26 – GHG Emissions from Liming of Soils and Urea Fertilization ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Liming of Soils	0.03	0.38	0.08	0.11	0.15	0.10	0.05	0.08
Urea Fertilization	0.02	0.03	0.04	0.05	0.06	0.06	0.06	0.06

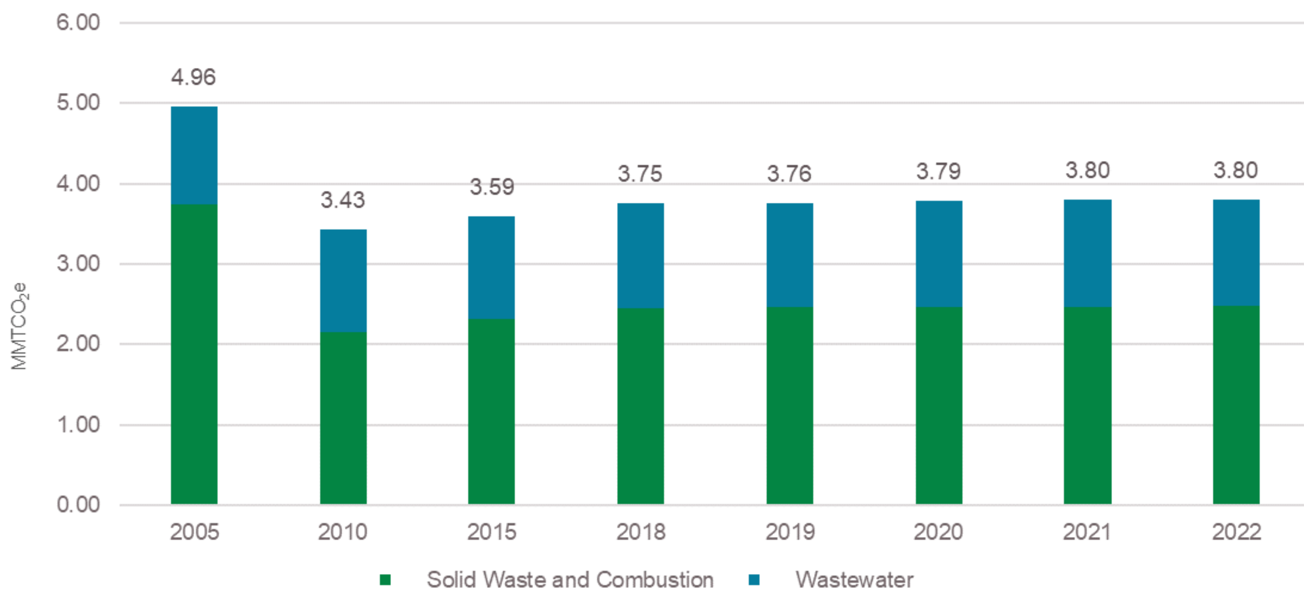
Waste Management Sector

Emissions in the waste management sector primarily come from the following three subgroups: landfill gas, solid waste combustion, and wastewater treatment. In 2022, emissions from the waste management sector were 3.80 $MMTCO_2e$. Landfill gas, which is approximately 50% methane, is generated by the decomposition of solid waste within a landfill. Some solid waste in the Commonwealth is combusted in waste-to-energy plants, thus avoiding the production of methane that would otherwise be produced in a landfill, but also resulting in the release of carbon dioxide. Both municipal wastewater treatment and industrial wastewater treatment are accounted for in the third subgroup. Emissions from waste management were calculated using the SIT Solid Waste Module. Table 27 and Figure 14 show greenhouse gas emissions from this sector by subgroup.

Table 27 - Waste Management Emissions by Subgroup ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Solid Waste and Combustion	3.74	2.16	2.31	2.46	2.46	2.47	2.47	2.48
Wastewater	1.22	1.27	1.28	1.30	1.30	1.32	1.33	1.32
Total	**4.96**	**3.43**	**3.59**	**3.75**	**3.76**	**3.79**	**3.80**	**3.80**

Figure 14 - Waste Management Emissions by Source (MMTCO2e)[35]



Landfill Gas

Default data in the SIT regarding the amount of landfilled solid waste in Pennsylvania was used to calculate the potential landfill methane emissions. The methane avoided value in Table 28 was calculated using data in the SIT and reflects the amount of methane that otherwise could have entered the atmosphere but was instead combusted in either a flare or a landfill gas to energy project. A small amount of oxidation occurs in landfills each year, which reduces the amount of methane emitted by approximately ten percent.

Table 28 shows the GHG emissions (MMTCO$_2$e) attributable to the potential landfill gas, the avoided methane emissions, and the avoided emissions due to solid waste oxidation.

Table 28 - GHG Emissions Associated with Landfilling Operations (MMTCO$_2$e)

	2005	2010	2015	2018	2019	2020	2021	2022
Potential Landfill CH_4	9.59	10.65	10.82	10.97	11.06	11.15	11.24	11.32
CH_4 Avoided	-7.37	-9.96	-10.11	-10.25	-10.34	-10.42	-10.50	-10.58
Oxidation	-0.22	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
Total CH_4 Emissions (Landfills)	**2.00**	**0.63**	**0.64**	**0.65**	**0.65**	**0.66**	**0.66**	**0.67**

Solid Waste Combustion

The GHG emissions in the solid waste combustion subgroup result from the combustion of certain types of solid waste including plastics, synthetic rubber, and synthetic fibers. To avoid the potential for double counting, the emissions from the combustion of natural or biogenic materials such as cotton and paper are omitted because the combustion of these items returns CO_2 that was already part of the natural carbon cycle back into the atmosphere. Along with CO_2 emissions from waste combustion, this section accounts for N_2O and CH_4 gases that are generated in the waste combustion process. Data from the SIT for total solid waste combusted and the relative percentage of each of the materials listed previously were

[35] Solid waste and combustion emissions rapidly decreased between 2000-2010 due to the widespread adoption of new methane capture/flaring techniques and the growth of voluntary EPA programs like the Landfill Methane Outreach Program (LMOP).

used in the calculation. Table 29 shows the GHG emissions ($MMTCO_2e$) attributable to the combustion of plastics, synthetic rubber, and synthetic fibers included in the waste combustion portion of the waste management sector.

Table 29 - GHG Emissions Associated with Waste Combustion ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
CO_2	1.58	1.43	1.61	1.78	1.78	1.78	1.78	1.78
N_2O	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1.61**	**1.45**	**1.64**	**1.81**	**1.81**	**1.81**	**1.81**	**1.81**

Recycling diverts material from solid waste landfills that would otherwise be contributing to GHG emissions from this sector. While these avoided emissions are not accounted for in the SIT, they can be estimated based on tons of recycled materials.

Table 30 shows estimated CO_2 emissions avoided by recycling for the years 2012 through 2022.[36]

Table 30 - GHG Emissions Avoided from Recycling

Year	Tons Recycled (millions)	$MMTCO_2$ saved per year	Equivalent Passenger Vehicles Taken off the Road for One Year (millions)	Homes Worth of Electricity Use Per Year Saved (millions)
2022	5.46	7.57	1.69	1.47
2021	4.63*	6.81	1.48	1.24
2020	4.99	7.11	1.55	1.29
2019	5.25	7.68	1.6	1.34
2018	5.47	9.11	1.98	1.65
2017	6.36	9.71	2.06	1.69
2016	7.84	10.23	2.21	1.73
2015	7.78	10.59	2.29	1.79
2014	16.91	16.37	3.53	2.77
2013	6.12	7.67	1.66	1.3
2012	8.50	17.6**	3.81	2.99

* 2021 statewide recycling continued to be impacted by the pandemic with an overall reduction of 0.36 million tons (7.16%) from 2020. 45 counties reported more materials recycled and 22 counties reported less materials recycled.

** The number is high due to an unusual increase in the amount recycled for Mixed Metals that year.

[36] Values converted to metric tons here: DEP. 2025. Statewide Recycling Data. Accessed March 2025. dep.pa.gov/Business/Land/Waste/Recycling/Pages/Recycling-Reports-and-Studies.aspx.

Wastewater Treatment

The GHG emissions from the wastewater portion of the waste management sector are a combination of municipal wastewater treatment (CH_4 and N_2O) and some types of industrial wastewater treatment (e.g., red meat, poultry, pulp and paper, and fruit and vegetable production). The SIT Wastewater Module was used to calculate the municipal and industrial wastewater GHG emissions. Production data were collected from the United States Department of Agriculture's National Agricultural Statistics Service for the poultry and fruit and vegetable industrial wastewater treatment sector, which was multiplied by the SIT-supplied emission factors to determine the total GHG emissions. Table 31 shows the GHG emissions ($MMTCO_2e$) attributed to the treatment of wastewater from municipal and industrial sources in the waste management sector.

Table 31 - GHG Emissions Associated with Wastewater Treatment ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Municipal CH_4	0.85	0.87	0.87	0.88	0.87	0.89	0.89	0.89
Municipal N_2O	0.26	0.26	0.26	0.27	0.28	0.29	0.28	0.28
Industrial CH_4	0.10	0.14	0.14	0.15	0.14	0.15	0.16	0.15
Total	**1.22**	**1.27**	**1.28**	**1.30**	**1.30**	**1.32**	**1.33**	**1.32**

Table 32 shows the GHG emissions ($MMTCO_2e$) totals for the solid waste and wastewater treatment portions of the waste management sector.

Table 32 - Total GHG Emissions (CO_2, CH_4, N_2O) from the Waste Management Sector ($MMTCO_2e$)

	2005	2010	2015	2018	2019	2020	2021	2022
Solid Waste	3.74	2.16	2.31	2.46	2.46	2.47	2.47	2.47
Wastewater	1.22	1.27	1.28	1.30	1.30	1.32	1.33	1.32
Total	**4.96**	**3.43**	**3.59**	**3.75**	**3.76**	**3.79**	**3.80**	**3.79**

Forestry and Land Use Sector

The forestry and land use sector sequesters or absorbs CO_2, reducing the net GHG emission in the Commonwealth. This section tallies carbon flux resulting from changes within and conversions between all land use types including: forest land, cropland, grassland, wetlands, and settlements (as well as other land)[37]. In 2022, the forestry and land use sector resulted in a slight net decrease in carbon stocks of 28.42 $MMTCO_2e$ of GHG and includes forested lands and soils, trees located in urban settings, yard waste, and forest fires.

Prior to the 2018 release of the SIT, liming and fertilization of agricultural soils were included in the forestry and land use sector, but those sources are now accounted for in the agricultural sector. Emissions and carbon sequestration from the forestry and land use sector were estimated using the SIT Land-Use, Land-Change, and Forestry (LULUCF) Module. The current release of the SIT included updates to the historical timeseries based on land classification that resulted in decreases in net emissions across all years. Additional details on these changes can be found in Appendix C.

Default data in the SIT LULUCF Module was the primary source of information for this section; however, forest fire acreage was collected from the National Interagency Fire Center and Pennsylvania's

[37] Additional details on land use and forestry types included in the inventory can be found in the EPA's National Inventory of Greenhouse Gas Emissions and Sinks – Land Use and Forestry Chapter.

Department of Conservation & Natural Resources and multiplied by the default emissions factors for CH_4 and N_2O from forest fires in the LULUCF module.[38]

Table 33 shows the total GHG emissions produced (positive values) and emissions sequestered (negative values) ($MMTCO_2e$) totals for the forestry and land use sector.

Table 33 - Total GHG Emissions from the Forestry and Land Use Sector (MMTCO2e)

	2005	2010	2015	2018	2019	2020	2021	2022
Forest Carbon Flux	-28.50	-27.90	-27.00	-26.27	-25.92	-25.59	-25.25	-24.89
Urban Trees, Carbon Flux	-3.15	-3.31	-3.46	-3.56	-3.59	-2.94	-3.40	-3.40
Landfilled Yard Trimmings and Food Scraps, Carbon Flux	-0.39	-0.44	-0.40	-0.42	-0.42	-0.43	-0.43	-0.43
Forest Fires, CH_4 and N_2O	0.01	0.04	0.17	0.12	0.10	0.10	0.18	0.12
N_2O from Settlement Soils	0.03	0.04	0.06	0.06	0.06	0.06	0.06	0.06
Agricultural Soil Carbon Flux	-2.51	-2.27	-1.92	-1.71	-1.54	-1.38	-2.26	-2.35
Land Converted to Settlements	3.04	2.93	2.68	2.53	2.50	2.47	2.45	2.45
Wetlands Remaining Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Settlements Remaining Settlements: Changes in Organic Soil Carbon Stocks	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.02
Land Converted to Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest Land Remaining Forest Land: Drained Organic Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland Remaining Grassland: Grassland Fires	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total[39]	**-31.43**	**-30.87**	**-29.85**	**-29.23**	**-28.79**	**-27.68**	**-28.64**	**-28.42**

[38] National Interagency Fire Center. 2025. Statistics Home Page. Last Updated 3 April 2025. www.nifc.gov/fireInfo/fireInfo_statistics.html.

[39] Note that totals presented in this row are equal to the sum of Forestry and Land Use emission and carbon flux rows shown in Table 3.

Conclusion and Looking Forward

The U.S. EPA's SIT is updated and rereleased annually, and as methods for compiling GHG emissions data are refined, estimates for previous years may change with each iteration of the inventory. Details on the methodology updates can be found in the Appendix B.

Pennsylvania has achieved a 21.2% reduction in GHG emissions in 2022 compared to 2005. Further emissions reductions across all sectors are needed to reach the 2025 goal of a 26-28% emissions reduction from 2005 baseline levels. While this reduction continues the progress towards the 2025 goals, there was only a small decrease from 2021 emissions levels. Most sectors had similar levels of emissions to 2021 or small variations. Additionally, there may still be lingering data anomalies from the COVID-19 pandemic, particularly in the transportation sector. Levels of fuel consumption of jet fuel, motor gasoline and diesel were observed to be still below pre-pandemic levels during 2022 and may increase in 2023 resulting in higher emissions from the transportation sector.

Upcoming inventories will continue to gauge progress towards the 2025 goal and begin to assess the impacts of decarbonization and emissions reduction initiatives. Pennsylvania's recently released 2024 Climate Action Plan further defines approaches to continued emissions reductions and pathways to reach the 2025 goal.

Appendix A - Acronyms and Abbreviations

BBTu..............................Billion British thermal units

CH_4................................Methane

CO_2................................Carbon dioxide

CO_2FFC........................Carbon dioxide from fossil fuel combustion

DEP...............................Pennsylvania Department of Environmental Protection

FHWA............................United States Federal Highway Administration

GHG..............................Greenhouse gas

GWP..............................Global warming potential

HCFC-22.......................Chlorodifluoromethane

LNG...............................Liquefied natural gas

LULUCF –....................Land use, land-use change, and forestry

MWh..............................Megawatt hours

MMTCO2e......................Million Metric Tons of Carbon Dioxide Equivalent

$N_2$0................................Nitrous oxide

ODS...............................Ozone depleting substances

SIT..................................State Inventory Tool

TWh...............................Terawatt hour

UNGS.............................Underground natural gas storage

U.S. DOT.......................United States Department of Transportation

U.S. EIA.........................United States Energy Information Agency

U.S. EPA.......................United State Environmental Protection Agency

Appendix B – Inventory Methodology

The following sectors emit GHGs in Pennsylvania and are included in this inventory: residential, commercial, industrial, transportation, electricity production, agriculture, waste management, and forestry and land use. Data for this inventory were primarily obtained from the U.S. EPA SIT. Additional data for sources not estimated in SIT were obtained from the U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State as well as data from the United States Department of Agriculture, National Interagency Fire Center, U.S. Energy Information Administration, and the Pennsylvania Department of Conservation and Natural Resources.

Table 34 - Global Warming Potentials (GWPs) Used Previous and Current Reports

Gas	AR4 GWPs used in report prior to 2023	AR5 GWPs used in current report
CO_2	1	1
CH_4	25	28
N_2O	298	265
HFC-23	14,800	12,400
HFC-32	675	677
HFC-125	3,500	3,170
HFC-134a	1,430	1,300
HFC-143a	4,470	4,800
NF_3	17,200	16,100
SF_6	22,800	23,500

Note: *This and previous inventories use GWPs with a 100-year time horizon in accordance with Mandatory GHG Reporting (EPA 2021c).*

Source: *IPCC Fifth Assessment Report (2013).*

U.S. EPA State Inventory Tools

SIT is an interactive Excel spreadsheet model designed to help states develop GHG emissions inventories and provides a streamlined way to update an existing inventory or complete a new inventory.

The SIT consists of 11 estimation modules applying a top-down approach to calculate GHG emissions and one module to synthesize estimates across all modules. The default data are gathered by federal agencies and incorporate reported data from private, state, and local sources covering fossil fuels, electricity consumption, agriculture, forestry, waste management, and industry. As is customary, the units for the GHG emissions are given in $MMTCO_2e$. A metric ton is equal to 2,204.6 pounds or approximately 1.1 short tons (U.S. tons). The GHGs the SIT typically accounts for are CO_2, CH_4, and N_2O. Each GHG has a different Global Warming Potential (GWP), which is accounted for when converting emissions to $MMTCO_2e$. The default GWPs used by the SIT are one for CO_2, 28 for CH_4, and 265 for N_2O, which correspond to AR5 (Table 34) In inventories prior to 2020, AR4 GWPs were used, but to maintain consistency with the national inventory and the transition in SIT to use AR5, emissions results for Pennsylvania are now estimated using AR5 GWPs. The GWP of a GHG will vary depending on the time scale selected, and the default time scale for the SIT is 100 years.

Pennsylvania's GHG inventory was primarily produced using the default activity data included in each SIT module, with supplemental data included for categories that can be estimated in SIT but do not have default data (e.g., forest fires). To supplement the SIT, additional data for several emissions sources were obtained from the U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State report, as detailed in the following section.[40]

[40] GHG inventories produced exclusively using the SIT modules' default settings do not account for several categories of emissions, which are primarily excluded from the modules due to lack of readily available default data at the state level and significance of emissions. Unless the user estimates emissions from these sources using other approaches and integrates them into inventory totals, they will be excluded from the inventory, which may undercount emissions and impact other climate planning endeavors such as the development of a Climate Action Plan.

U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by State

Alongside the national Inventory of U.S. Greenhouse Gas Emissions and Sinks, EPA publishes a dataset of national GHG emissions disaggregated by state.[41] While these emissions estimates are not intended to fully supplant official state-level GHG inventories, they are helpful for comparing results between state and the national inventory and for obtaining supplemental data to augment state inventories (e.g., for categories not estimated in SIT, categories best estimated with complex modeling tools, etc.).

Pennsylvania obtained emissions data for several additional source categories from 1990 to 2022 by state dataset from EPA. Data were obtained for the following sectors: natural gas and oil sector (abandoned oil and gas wells), forestry and land uses (carbon stocks from Land Converted to Settlements, Wetlands Remaining Wetlands, Land Converted to Wetlands), industrial processes (ferroalloy production, zinc production, carbon dioxide consumption, N_2O from product uses, glass production, lead production, carbide production and consumption), and solid waste (composting and anaerobic digestion at biogas facilities). Because the emissions source categories obtained from the U.S. Inventory by state disaggregation are not estimated within SIT, there is no double-counting, and these additional categories can be directly added to emissions results estimated by the SIT.[42]

Quality Assurance and Quality Control

Quality assurance and quality control measures were implemented during the inventory development process. These measures help to ensure the accuracy and consistency of emissions estimates over time. Quality assurance and quality control measures implemented during this inventory process include tracking and citing of default and external data sources, aggregating emissions results in Microsoft Excel workbooks, conducting multiple rounds of review for emissions results, and clearly documenting methodology.

Uncertainty of Emissions Estimates

Uncertainty is inherent in any emissions estimate for all GHG inventories. Uncertainty may stem from incomplete data, use of average emission factors rather than more granular emission factors, use of national-level data rather than more granular state-specific data, and user error. Additionally, emissions from certain sectors carry greater uncertainty than other sectors. For example, emissions from natural systems, such as CO_2 from agricultural soil carbon or carbon flux from forestry, are more difficult to comprehensively model and thus carry greater uncertainty than emissions from other sources, such as CO_2 from fuel combustion.

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[41] Available for download here: www.epa.gov/system/files/other-files/2024-09/allstateghgdata90-22_v082924.zip. The latest version of the state-level emissions was published on October 3rd, 2024.

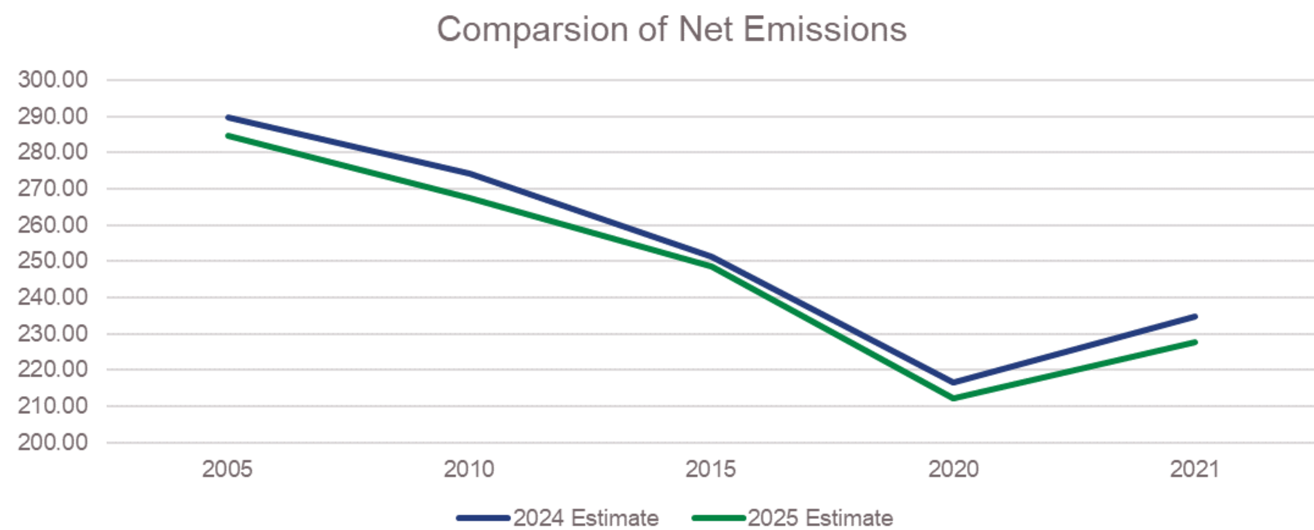
[42] U.S. EPA's crosswalk of SIT estimates and the U.S. Inventory by state disaggregation is available for download here: www.epa.gov/system/files/documents/2022-03/factsheet-crosswalk-between-ghg-by-state-and-sit.pdf

Appendix C - Summary of Updates to Emission Estimates in the 2025 Inventory Compared to Previous Reports

For the current update to include emissions from 2022, there were several changes to the SIT methodology across all sectors to enhance the accuracy of the inventory and bring the methodology more in line with that of the national GHG inventory.[43] SIT modules are updated in January each year but occasionally have mid-cycle updates in June. Additionally, DEP reviews the report annually to identify opportunities to improve the report and enhance accuracy.

Overall Report Emissions Estimate Comparison

This year's report resulted in several updates that yielded a lower estimate of emissions for the Commonwealth compared to prior years. In particular, the Agriculture, Forestry and Land-Use and Natural Gas and Oil Sectors were affected by these updates. Updates are described below with a graph comparing overall emissions estimates between the prior inventory released in 2024 and this current inventory report. Collectively, all methodological changes and historical data updates made in the current Inventory resulted in an annual average decrease of 2% for net emissions.



SIT Methodological Updates

The SIT modules are updated annually with new activity data, which can affect historical emissions estimates if the update is implemented across the entire time series. Specific SIT modules were also recently revised in January 2025 and include the following updates:

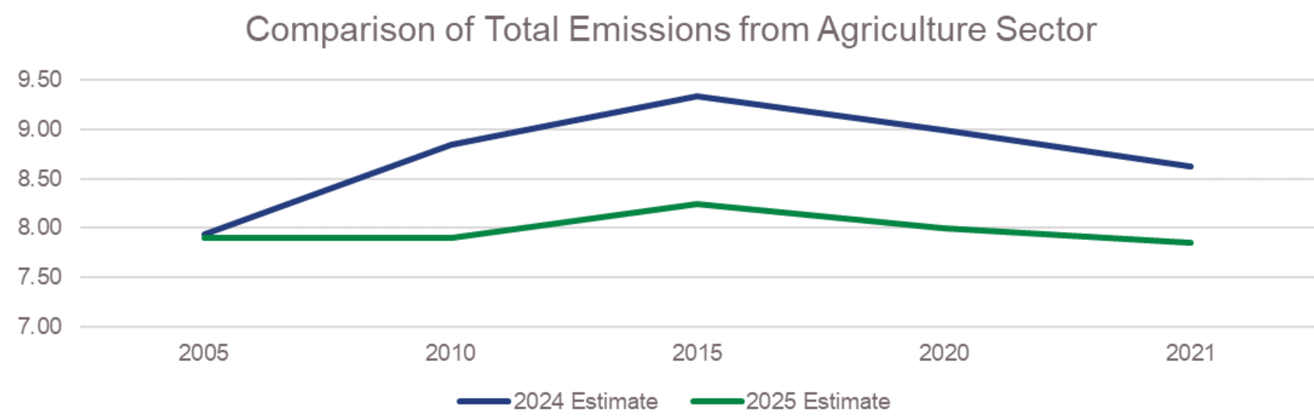
- The Ag Soil C flux changed significantly this year for some states due to changes in the land categorizations of the underlying U.S. Forest Service dataset.
- Updates for the entire historical time series for crop and animal data from NASS, causing changes in Ag Residue Burning and Direct Emissions from Ag Soils (and correspondingly, the national adjustments for direct emissions from grassland).
- Revised manure management system distributions to align with the latest categories from the U.S. Greenhouse Gas Inventory.
- Updates for the default consumption values in the Municipal WW N_2O Effluent tab, resulting in changes to emissions compared to the previous version of the module.

[43] Crosswalk between the Inventory U.S. Greenhouse Gas Emissions and Sinks by U.S. State: 1990-2020 and the State Inventory Tool (SIT) (January 2022 edition). Source: factsheet-crosswalk-between-ghg-by-state-and-sit.pdf (epa.gov)

These updates to the SIT tool resulted in significant changes to the agriculture, as well as forestry and land use sectors, compared to the previous inventory. These changes were also implemented in the EPA's National Inventory of U.S. Greenhouse Gas Emissions and Sinks.

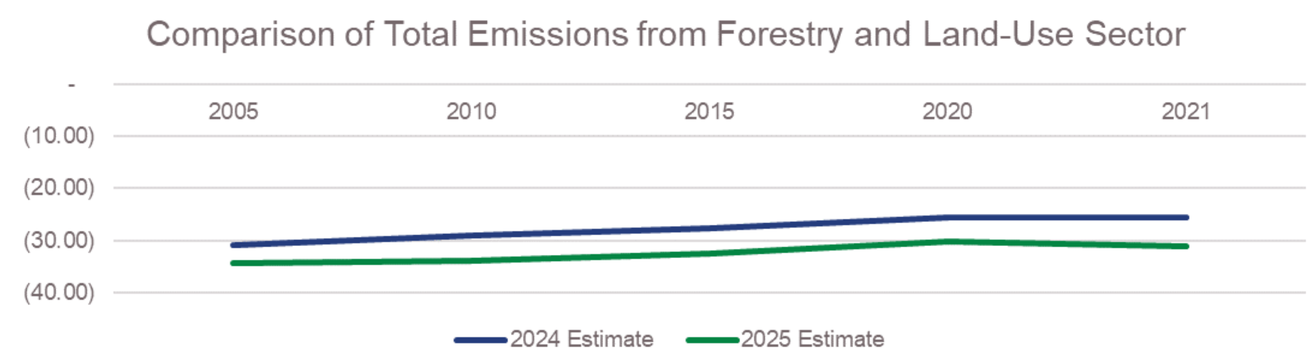
Agriculture Sector

Below is a graph demonstrating the changes to the historical time series between the prior inventory and the current inventory for agricultural emissions. The changes in this sector were driven primarily by lower estimates of emissions from manure management, agricultural soils, and agricultural residue burning. These changes resulted in about an 11% decrease in emissions reported from this sector.



Forestry and Land Use Sector

Below is a graph demonstrating changes to the historical time series between the prior inventory and the current inventory for Forestry and Land-Use emissions. The changes in this sector were driven primarily by changes in the classification of land from the U.S. Forest Service dataset, resulting in an average of about 15% decrease in net emissions (meaning more carbon sequestered) per year for this sector.



Additional Methodology Changes for 2025 Inventory

In addition to the SIT methodology updates, DEP reviews underlying data included in the SIT to identify opportunities for improvement and refinement. DEP identified several opportunities to refine underlying data in this updated inventory, including revisions to:

Natural Gas and Oil Module – Updated emissions factors for well pads and compression stations based on DEP's Bureau of Air Quality annual reporting. This information was provided for the inventory in March 2025.