Cleveland-Elyria MSA

2022 Regional Greenhouse Gas Emissions Inventory

Produced by:

City of Cleveland
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Table of Contents

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ICLEI USA updated this template in 2022.

Tables and Figures

List of Tables

List of Figures

Executive Summary

Northeast Ohio recognizes that greenhouse gas (GHG) emissions from human activity and natural sources contribute to climate change. The consequences pose substantial risks to the future health, well-being, and economic prosperity of our community. Northeast Ohio is a region that has long shown its commitment to climate action. The City of Oberlin, in Lorain County, developed the region's first climate action plan (CAP) in 2011. The City of Cleveland, Cuyahoga County, the City of Lakewood, and the City of Cleveland Heights followed suit in 2013, 2019, 2022, and 2025, respectively. Organizations of regional influence, including the Cleveland-Cuyahoga Port Authority and the Greater Cleveland Regional Transit Authority, have likewise produced their own CAPs. In fall 2021, the Northeast Ohio Areawide Coordinating Agency (NOACA), the region's metropolitan planning organization (MPO) responsible for transportation and environmental planning, built upon the work of these entities to initiate a regional plan that would provide a foundation for transformative action to reduce greenhouse gas emissions, build resilience, and enhance equity in Northeast Ohio.

During July 2023, NOACA and the City of Cleveland joined forces to execute a Climate Pollution Reduction Grant (CPRG) Program Planning Grant from the United States Environmental Protection Agency (U.S. EPA). CPRG, which was authorized by Section 60114 of the Inflation Reduction Act (IRA) provides financial and technical support to states, territories, municipalities, tribes, and other groups to develop and implement plans to reduce greenhouse gas emissions (GHGs). NOACA and the City of Cleveland have worked together to create a Priority Climate Action Plan (PCAP) for the MSA in February 2024 and are currently partnering to develop a Comprehensive Climate Action Plan (CCAP).

One of the required elements of the CPRG is a complete inventory of GHGs present in the Cleveland-Elyria Metropolitan Statistical Area (MSA). This report provides estimates of GHGs from activities in Northeast Ohio – including Cuyahoga, Geauga, Lake, Lorain, and Medina Counties – during 2022. It also includes a comparison of emissions between the 2022 and 2018 baseline years.

Figure 1 shows communitywide emissions by sector within Northeast Ohio during 2022. The largest contributor is Transportation with 29% of total emissions. The next largest contributors are Residential Energy (23%), Industrial Energy (16%), and Commercial Energy (16%). NOACA and City of Cleveland staff identified actions to reduce emissions in these sectors through the Cleveland-Elyria MSA PCAP, and the CCAP will build upon this work. Process and Fugitive Emissions, Solid Waste, Hydrofluorocarbons (HFCs), Agriculture, and Water and Wastewater were responsible for the remaining emissions (less than 16%). Forests and trees sequester nearly 4% of emissions.

GHG emissions in the 2022 baseline report were 14.2% lower than in the 2018 baseline report (see page 14). This reduction was more than twice the reduction (6.1%) that occurred nationally across that span.[1] Emissions fell for each of the five counties in the MSA and decreased for nearly all sectors. The only sector in which emissions increased was HFCs (Refrigerants).[2]

EMISSIONS AT A GLANCE

1 **Transportation** 29%

2 **Residential Energy** 23%

3 **Industrial Energy** 16%

4 **Commercial Energy** 16%

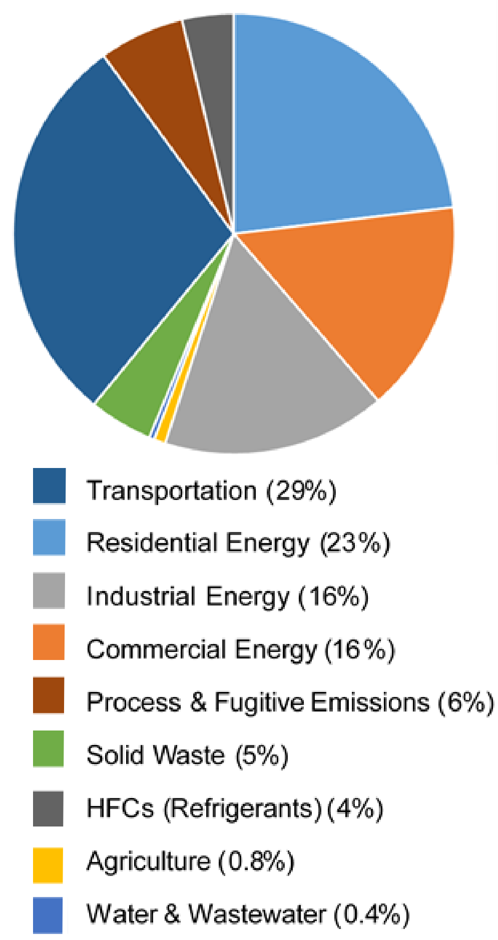


Figure 1: 2022 Total Regional GHG Emissions by Sector

This report enables the region to track its progress towards its climate targets. From 2018 to 2022, regional GHG emissions decreased by an average annual rate of 3.6%. While this rate is impressive, it only places the region on track to cut emissions 34.6% through 2030, compared to the 2018 baseline. This reduction through 2030 is lower than the region's emissions reduction target, which calls for cutting emissions by 49% from 2018 levels by 2030. It also means that the region is not currently on track to achieve its long-term goal of reaching net zero GHG emissions by 2050.

The Inventory Results section of this report provides a detailed profile of emissions sources within the Cleveland-Elyria MSA; this information is key to the identification of priority reduction measures.

This inventory report demonstrates that the Cleveland-Elyria MSA has much work remaining to put the region on a trajectory to eliminate climate pollution by 2050. Nevertheless, because this inventory does not include the impacts of investments from the IRA, the Infrastructure Investment and Jobs Act (IIJA), and other recent actions at the state and federal levels, the region can build off a series of recent successes to accelerate emissions reductions by 2030. These achievements include:

- $15 million in Charging and Fueling Infrastructure (CFI) Grant Program funds to expand the electric vehicle (EV) charging network (NOACA);
- $8.7 million in Clean School Bus Program grants to invest in electric buses (City of Euclid);
- $10.6 million in Low- and No-Emission Grant funds to purchase electric transit buses (GCRTA);
- Solar for All funds to install community and rooftop solar in low- to moderate-income areas (Cuyahoga County and the City of Cleveland);
- $3.4 million in Urban and Community Forestry Program funds (City of Cleveland);
- $94.2 million Clean Port Program grant (Port of Cleveland); and
- $129 million from the Climate Pollution Reduction Grant program to install solar and battery storage on brownfields, shutter a coal-fired power plant, and remediate brownfields into park and conservation land (Cuyahoga County, City of Painesville, and the City of Cleveland).

Northeast Ohio will continue to update this GHG inventory periodically to track progress toward the goal of net zero emissions by 2050.

Introduction to Climate Change

Naturally occurring gases dispersed in the atmosphere determine the Earth's climate when they trap solar radiation. This phenomenon is known as the greenhouse effect. Overwhelming evidence shows that human activities are responsible for the increase in the concentration of greenhouse gases in the atmosphere since the pre-industrial era, which is the primary driver of observed changes in the global climate. The most significant contributor is burning fossil fuels for transportation, electricity generation, and other purposes. Burning fossil fuels introduces large amounts of greenhouse gases into the atmosphere, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).[3] Figure 2, below, illustrates the nearly linear relationship between the rise in atmospheric CO_2 and the observed increase in global temperatures since 1850.

Collectively, these gases intensify the natural greenhouse effect, which causes global average surface and low-altitude atmospheric temperatures to rise. Rising temperatures may threaten the safety, quality of life, and economic prosperity of communities across the globe. In light of this, NOACA and the City of Cleveland are working to create a CCAP for the Cleveland-Elyria MSA that accelerates climate action to achieve carbon neutrality. Not only are NOACA, the City of Cleveland, and their partners building a more resilient region, they are also ensuring a safe and secure space for future generations to thrive. Ambitious climate action now will create extensive benefits for residents of the Cleveland-Elyria MSA today and position the region for long-term success.

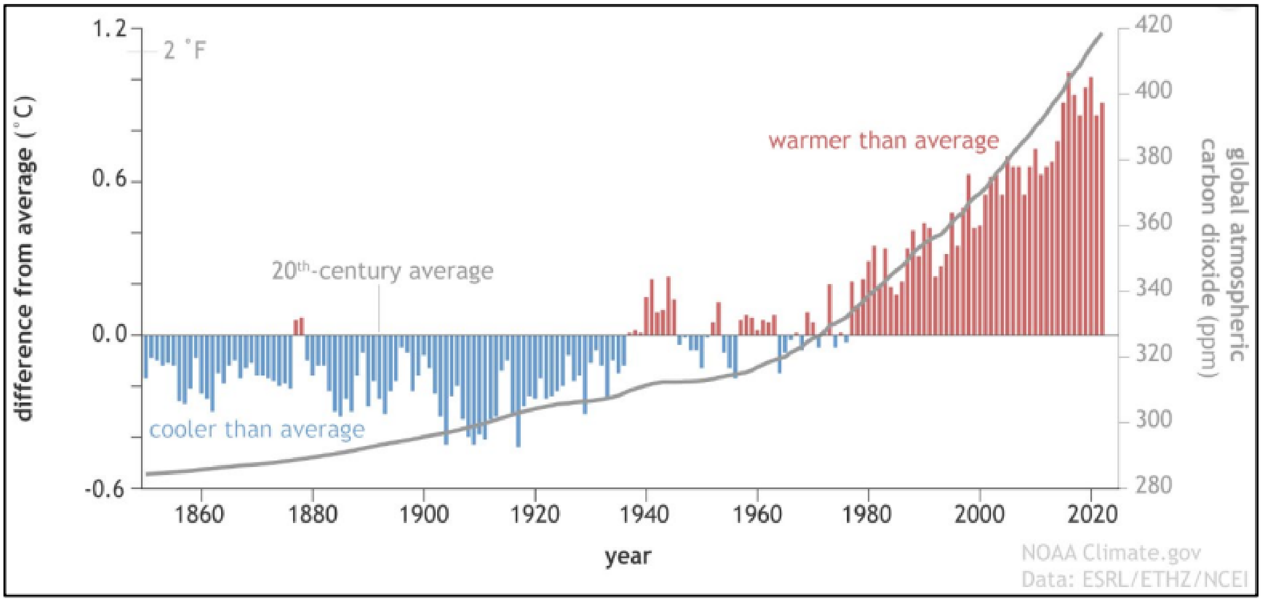
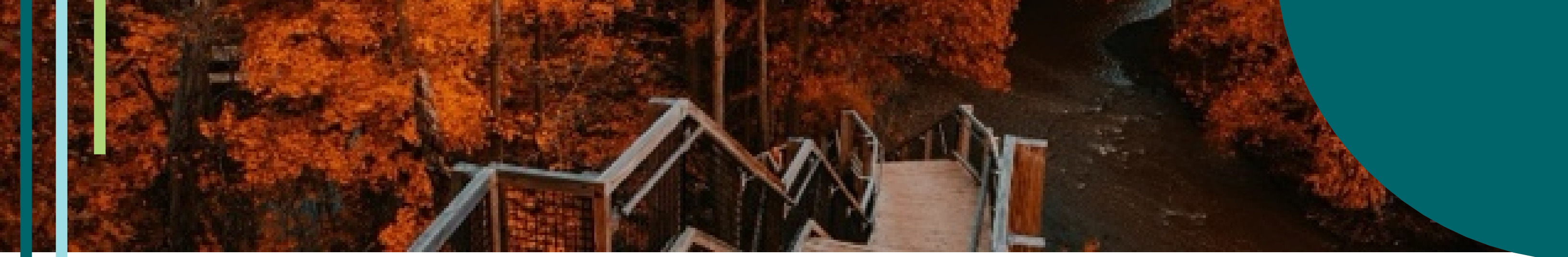


Figure 2: Atmospheric CO_2 and Earth's Surface Temperature (1850-2022)

According to the Intergovernmental Panel on Climate Change (IPCC), human activities “have unequivocally caused global warming” of 1.1 °C above pre-industrial levels, with a likely range of 0.8°C to 1.3°C (high confidence).[4] Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate (high confidence), with global temperatures reaching 1.48°C above average during 2023.[5] Warming due to emissions from human activities will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea-level rise, with associated impacts (high confidence). Taking immediate action to reduce GHG emissions is essential for limiting the impacts of climate change, as “every increment of global warming will intensify multiple and concurrent hazards” (high confidence).[6] These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and the choices and implementation of adaptation and mitigation options (high confidence).[7]

According to the *Fifth National Climate Assessment*, the Midwestern U.S. will experience potentially devastating impacts from seasonal changes and hazards occurring at unprecedented magnitudes.[8] Northeast Ohio is at particular risk for extreme precipitation and its associated consequences, including flooding. The region’s greatest natural resource, Lake Erie, will also face risks from a changing climate, including reduced ice cover, increases in the frequency and intensity of harmful algal blooms, and fluctuating lake levels. In addition, climate change will continue to produce warmer seasons and extreme temperatures that threaten many sectors within Northeast Ohio and the greater region, most notably public health, energy systems, and water and wastewater treatment.[9]



The Cleveland-Elyria MSA is already experiencing extreme weather tied to climate change, including increases in heavy precipitation and frequency of flooding.[10] These events have affected communities throughout the region, including incursions of smoke from Canadian wildfires in June 2023 and a cluster of tornadoes in August 2024. Because of its temperate climate and proximity to Lake Erie, the Cleveland-Elyria MSA has historically enjoyed moderate summer temperatures, relative to other parts of the Midwest. However, the region's relative lack of experience with extreme heat may make it less resilient to the rising temperatures and humidity levels. By 2050, the number of extreme heat events may increase by nearly 50%. Increased heat and humidity will affect all populations, especially vulnerable populations such as outdoor workers and people experiencing homelessness. By the end of the century, the U.S. EPA projects heat-related mortality rates could increase up to 17-fold without meaningful action to address climate change.[11]

Communities across Northeast Ohio have begun to address climate change at the local level. While these actions can have short-term costs, including higher energy prices and dislocation of workers in fossil fuel-related industries, curbing fossil fuel use also generates a wide array of co-benefits beyond reducing greenhouse gas emissions. Using energy in a more efficient manner decreases utility and transportation costs for residents and businesses. The work required to retrofit homes and businesses to be more efficient creates local jobs. Reduced fossil fuel use improves air quality, and increased opportunities for walking and bicycling improves residents' health. Research suggests that these co-benefits from eliminating emissions of climate pollution will more than offset the costs. According to one recent assessment, "the societal health savings that result from reduced air pollution are so significant that decarbonization should be seen as a compelling economic proposition on the basis of improved air quality alone."[12]

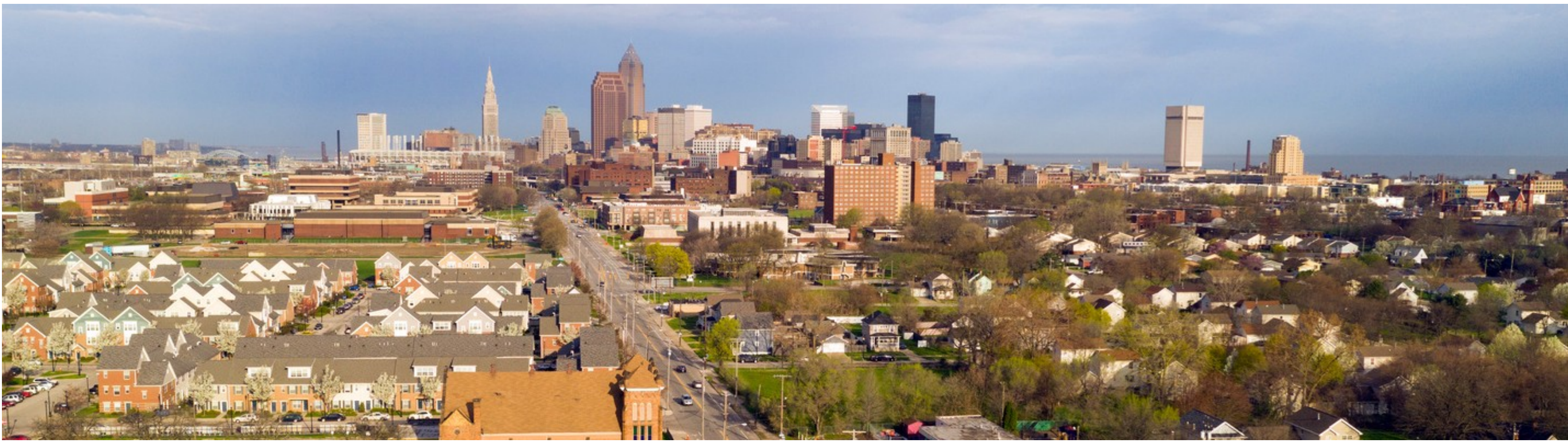
Greenhouse Gas Inventory as a Step Toward Carbon Neutrality

Since many of the major sources of greenhouse gas emissions are directly or indirectly controlled through local policies, local governments can play a strong role in reducing greenhouse gas emissions within their boundaries, as well as influencing regional emissions through partnerships and advocacy. Through proactive measures around land use patterns, transportation demand management, energy efficiency, green building, waste diversion, and more, local governments can dramatically reduce emissions in their communities. In addition, local governments are primarily responsible for the provision of emergency services and the mitigation of disaster impacts.

Local governments and partner organizations throughout the Cleveland-Elyria MSA, that best understand the challenge and are best positioned to take action, must make concerted effort to address climate change.

Through the CPRG Program, NOACA and the City of Cleveland work to create a regional roadmap to achieve climate neutrality by coordinating with stakeholders and the public to identify priority sectors for action. NOACA and the City of Cleveland simultaneously consider climate justice, inclusiveness, local job creation, and other benefits of sustainable development. NOACA and the City of Cleveland build upon the foundation of the PCAP, which identified priority climate actions for the region, to develop a broader, more thorough CCAP that will position the region to achieve its climate targets. The CCAP will also build upon ongoing updates to the City of Cleveland's municipal CAP, Cuyahoga County's countywide CAP, and proactive outreach to the public and stakeholder organizations throughout the five-county Cleveland-Elyria MSA.

To complete this inventory update, which represents the first essential component of the CCAP, the City of Cleveland utilized tools and guidelines from ICLEI USA, including the ClearPath inventory tool.



Inventory Methodology

Understanding a Greenhouse Gas Emissions Inventory

The first step toward achieving tangible greenhouse gas (GHG) emissions reductions requires identifying baseline emissions levels and sources and activities generating emissions in the community/region. This report presents emissions from the five-county Cleveland-Elyria MSA as a whole. The government operations inventory is mostly a subset of the community inventory (see Figure 3). For example, data on commercial energy use by the community include energy consumed by municipal buildings, and community vehicle-miles-traveled (VMT) estimates include miles driven by municipal fleet vehicles.

Figure 3: Relationship of Regional and Government Operations Emissions Inventories

As local governments continue to act on climate, the need for a standardized approach to quantify GHG emissions has proven essential. This inventory uses the approach and methods provided by the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (Community Protocol), discussed below.

This inventory includes emissions of the three most common GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Throughout this report, emissions are expressed as metric tons of carbon dioxide equivalent ($MTCO_2e$), calculated using the Global Warming Potential (GWP) values for methane and nitrous oxide from the IPCC's Fifth Assessment Report.

Table 1: Global Warming Potential Values (IPCC, 2018)

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265

Regional Emissions Protocol

ICLEI released Version 1.2 of the U.S. Community Protocol for Accounting and Reporting GHG Emissions (Protocol) in 2019, and represents a national standard in guidance to help U.S. local governments develop effective community GHG emissions inventories.[13] The Protocol establishes reporting requirements for all community GHG emissions inventories, provides detailed accounting guidance for quantifying GHG emissions associated with a range of emission sources and community activities, and provides a number of optional reporting frameworks to help local governments customize their community GHG emissions inventory reports based on their local goals and capacities.

The regional inventory in this report includes emissions from the five Basic Emissions Generating Activities required by the Protocol. These activities are:

- Use of electricity by the region
- Use of fuel in residential and commercial stationary combustion equipment
- On-road passenger and freight motor vehicle travel
- Use of energy in potable water and wastewater treatment and distribution
- Generation of solid waste by the region

The regional inventory also includes the following activities to make it a Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) Basic-compliant inventory:

- Wastewater treatment processes
- Rail, marine and off-road transportation
- Forest and trees
- Industrial processes
- Scope 3 air travel

Data is collected from a variety of entities in the region, including electric, gas, water and wastewater utilities. Methodology and data source details are provided in the appendix to this report.

Quantifying Greenhouse Gas Emissions

Sources and Activities

Communities contribute to greenhouse gas emissions in many ways. As Table 2 explains, there are two main categorizations of emissions in a community inventory: 1) GHG emissions that are produced by "sources" located within the community boundary, and 2) GHG emissions produced as a consequence of community "activities."

Table 2: Source vs. Activity for Greenhouse Gas Emissions (GHG)

Source	Activity
Any physical process inside the jurisdictional boundary that releases GHG emissions into the atmosphere	The use of energy, materials, and/or services by members of the community that result in the creation of GHG emissions.

Local governments can develop and promote a deeper understanding of GHG emissions associated with their communities by reporting on both GHG emissions sources and activities. A purely source-based emissions inventory could be summed to estimate total emissions released within the community's jurisdictional boundary. In contrast, a purely activity-based emissions inventory could provide perspective on the efficiency of the community, even when the associated emissions occur outside the jurisdictional boundary.

Base Year

The inventory process requires the selection of a baseline year with which to compare current emissions. NOACA and ICLEI USA staff utilized 2018 as the baseline year for an initial GHG inventory report produced in 2022, as it was the most recent and complete pre-COVID year for which all data were available. NOACA and City of Cleveland staff utilized 2022 as the baseline year for this updated inventory in 2024, as it is the most recent year for which complete data are currently available.

Quantification Methods

GHG emissions can be quantified in two ways:

- Measurement-based methodologies refer to the direct measurement of GHG emissions (from a monitoring system) emitted from a power plant flue, wastewater treatment plant, landfill, or industrial facility.
- Calculation-based methodologies calculate emissions using activity data and emission factors. To calculate emissions accordingly, staff used the basic equation below:

Activity Data x Emission Factor = Emissions

Staff quantified most emission sources in this inventory with calculation-based methodologies. Activity data refer to the relevant measurement of energy use or other GHG-generating processes, such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Staff usually express emissions factors as emissions per unit of activity data (e.g., lbs CO_2/kWh of electricity). For this inventory, staff made calculations with ICLEI's ClearPath tool. Detailed methodologies are discussed below.

Updates to 2018 Baseline Inventory

During the development of the 2022 baseline inventory, City of Cleveland staff made corrections to the 2018 baseline inventory to reflect the best available data. These changes revised 2018 emissions downward from 35.96 $MMTCO_2e$ to 33.8 $MMTCO_2e$, a decrease of nearly 2.2 $MMtCO_2e$ (-6.0%). Nearly all of this difference stemmed from overcounting emissions for residential, commercial, and industrial natural gas use.[14] All 2018 data marked with an asterisk (*) in Tables 3-8 (see below) include corrections from the original 2018 baseline inventory report.

GHG Inventory Methodologies by Fuel or Source

Electricity

Data on electricity consumption by customer class (residential, commercial, and industrial) in the Cleveland-Elyria MSA came from public and private electric utilities operating throughout the metro area. Twelve (12) electric utilities operated within the MSA during 2022, including nine (9) municipal utilities, two (2) rural electricity cooperatives, and one (1) investor-owned utility (IOU) (FirstEnergy, operating as The Illuminating Company and Ohio Edison Company). The City of Cleveland received electricity consumption data for 2022 from 10 of these utilities, covering 98.9% of total electricity usage in the region. Staff then extrapolated regional consumption from the remaining two utilities, covering 1.1% of total electricity consumption, using public data from the United States Energy Information Administration (U.S. EIA). This population-based approach differed from the county-based approach used in the 2018 inventory. This methodology increased total electricity consumption for these utilities; however, because these utilities accounted for just 1.1% of consumption, the impact on regional electricity usage was negligible.[15]

Where possible, City of Cleveland staff applied utility-specific electricity emissions factors, expressed in pounds per megawatt hour (lbs per MWh), which are outlined in Table 10 (see Appendix). Where utility-specific emissions factors were not available, staff used the average emissions factors for CO_2, CH_4, and N_2O for the ReliabilityFirst Corporation West (RFCW) electricity region, which covers Ohio. Staff obtained these average emissions factors from the U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID) tool.

Natural Gas

Data on natural gas consumption by customer class (residential, commercial, and industrial) in the Cleveland-Elyria MSA came from public and private electric utilities. Six (6) gas utilities operated within the MSA during 2022, including two IOUs (Columbia Gas of Ohio and Dominion East Ohio Gas) and four (4) smaller, cooperative utilities. The City of Cleveland received gas consumption data for 2022 from two (2) of these utilities, covering 97.6% of total usage in the MSA. Staff extrapolated consumption from the remaining four utilities, which provided 2.4% of total gas deliveries, using public data from the U.S. EIA (see Appendix). The population-based approach that staff used differed from the county-based approach used in the 2018 inventory. There is a noticeable difference in gas consumption for these two approaches (21.8%). Nevertheless, the impact on total regional gas usage is negligible.[16]

Industrial Processes and Product Use (IPPU)

Data on IPPU energy use and emissions came from the U.S. EPA's Facility Level Information on GreenHouse gases Tool (FLIGHT). This tool provides facility-level data for entities covered by the Greenhouse Gas Reporting Program (GHGRP), which mandates annual emissions reporting from facilities that directly emit at least 25,000 $MTCO_2e$.[17] During 2022, 21 facilities reported to the GHGRP. Staff excluded energy use and emissions from electricity and natural gas consumption to avoid double counting, which left nine (9) facilities that reported emissions from IPPU. Industrial processes generate GHGs several ways, including the conversion of iron ore to metal during steelmaking and the creation of lime from limestone during concrete production. Emissions from industrial product use in the Cleveland-Elyria MSA stem from the use of a variety of non-utility fuels, including blast furnace gas and fuel oils.

Transportation and Mobile Sources

Data for the transportation and mobile sources sector comes from a variety of sources. NOACA staff used U.S. EPA's MOtor Vehicle Emissions Simulator (MOVES) model to quantify emissions for on-road vehicles, which generates emissions estimates based on the composition of the vehicle fleet (e.g., vehicle age, type, fuel), road network, meteorology, and VMT. For transit vehicles that run on alternative fuels (i.e., compressed natural gas and propane), the City of Cleveland collected data from the National Transit Database. For non-road vehicles, City of Cleveland staff ran MOVES in its non-road setting to quantify GHGs across 12 classes of vehicles, including construction equipment and airport ground equipment.

Railroad emissions come from U.S. EPA's 2020 *National Emissions Inventory* (NEI), the most recent year for which data is available. The NEI is a triennial publication, released three years after the inventory year; U.S. EPA plans to publish its 2023 NEI sometime in 2026. Because this inventory captures emissions from a wider array of railroad vehicles, rather than just locomotives, there is a substantial increase relative to 2018. Staff is confident this approach is more accurate.

Emissions from air travel are based on enplanements at airports within the Cleveland-Elyria MSA. Data on enplanements at Cleveland Hopkins International Airport and Burke Lakefront Airport come from the Cleveland Department of Port Control. Data for enplanements at the other MSA airports came from the Federal Aviation Administration's (FAA's) *National Plan of Integrated Airport Systems (NPIAS)*.[18] Emissions from marine water transportation are based on the number of cargo vessels entering and exiting the Ports of Cleveland, Lorain, and Fairport Harbor. These data come from the U.S. Army Corps of Engineers' (USACE's) *Waterborne Commerce of the United States (WCUS) Ports and Waterways Report*.[19]

Solid Waste

Data on the production and disposal of solid waste in the Cleveland-Elyria MSA during 2022 came from the five (5) solid waste management districts (SWMDs) operating in the region. These SWMDs provided the City of Cleveland with data on residential/commercial and industrial waste generation and disposal, composting, waste incineration, and recycling, where available. Data also included the final location of waste disposal (i.e., inside or outside the MSA). When data were not available from the SWMDs, staff referenced the Ohio EPA's 2022 *Waste Flow Report* or its *Compost Facility Analytical Planning Report*.[20]

Water and Wastewater

Data on emissions from water and wastewater in the Cleveland-Elyria MSA came from public and private electric utilities operating throughout the metro area. There were 41 water and wastewater utilities operating in the metro area during 2022. The City of Cleveland requested data from the 18 utilities that serve at least 50,000 customers (water) or treated at least five million gallons (MGD) of wastewater per day in 2022. The City received data from 16 of these utilities, covering 92.9% of the total wastewater treated in the region. For utilities that did not provide data, staff estimated emissions of N_2O from the wastewater treatment process and from effluent. See methodology in Table 11.

Other Household Fuel Use (Fuel Oil and Propane)

City of Cleveland staff first used American Community Survey (ACS) data to determine the number of households in each county that utilize fuel oil and propane as their primary home heating fuel.[21] Staff then converted this number of households into energy use, in million British thermal units (MMBtu) with the average consumption per household for residents of the East North Central Census division, which includes Ohio.[22]

Fugitive Emissions

City of Cleveland staff quantified fugitive emissions of GHGs from natural gas infrastructure and oil and gas wells in operation throughout the Cleveland-Elyria MSA. For fugitive emissions from natural gas infrastructure, staff assumed a leakage rate of 0.3%, based on guidance from the Environmental Defense Fund (EDF).[23] For leakage from oil and gas wells, staff collected data on the number of existing wells located within the MSA from the Ohio Department of Natural Resources (ODNR). Staff then estimated GHGs based on the U.S. EPA's recommended average leak rate of 0.3% .[24]

HFCs (Refrigerants)

City of Cleveland staff downscaled national HFC emissions with 2022 estimates from the U.S. EPA.[25] Staff estimated HFC emissions per capita, based on 2022 U.S. population data, then multiplied this per capita emissions value by the estimated population of each county in the MSA.

Agriculture

City of Cleveland staff utilized the methodology developed in partnership with NOACA and ICLEI USA for the PCAP, based on 2022 data from U.S. EPA. and the U.S. Department of Agriculture (USDA). Staff downscaled agricultural GHG emissions for the State of Ohio to the county level. Staff first determined the share of cropland located in Cuyahoga, Geauga, Lake, Lorain, and Medina Counties during 2022, according to the USDA's *Census of Agriculture*. Staff then allocated each county a share of statewide agricultural GHG emissions equal to its share of statewide cropland.[26]

Emission Removals from Forests and Trees

City of Cleveland staff utilized the methodology developed in partnership with NOACA and ICLEI USA for the PCAP. They calculated emissions and sequestration (negative emissions) from forests and trees outside of forests with the Land Emissions And Removals Navigator (LEARN) tool.[27] The LEARN tool applies the methodology in the US Community Protocol Appendix J, which has also been adopted by the Global Protocol for Community-Scale GHG Emissions (GPC).[28] The LEARN tool combines land cover and tree canopy data from the National Land Cover Database (NLCD) with emissions and sequestration factors developed by experts with the United States Forest Service (USFS), Woodwell Climate Research Center, and World Resources Institute (WRI). Staff used this tool to estimate net emissions from trees within forests and trees outside of forests for each county in the region.

2022 Emissions Inventory Results

Table 3: 2022 Total Regional Emissions Inventory

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Residential Energy	Electricity	7,503,332,440	7,554,518,825	kWh	2,775,682	3,490,047	
	Natural Gas	77,316,450	81,428,970*	MMBtu	4,108,092	4,331,927*	
	Propane	1,160,042	1,170,862	MMBtu	74,469	72,662	
	Fuel Oil	439,171	710,679	MMBtu	32,698	52,915	
	Residential Energy Total				**6,990,940**	**7,947,551***	**-12.0%**
Commercial Energy	Electricity	7,061,745,524	7,820,324,931	kWh	2,577,490	4,059,675	
	Natural Gas	39,939,787	39,476,927*	MMBtu	2,124,130	2,099,640*	
	Commercial Energy Total				**4,701,619**	**6,159,315***	**-23.7%**
Industrial Energy	Electricity	6,744,776,571	7,544,519,035	kWh	2,504,137	3,948,446	
	Natural Gas	10,426,661	9,567,373*	MMBtu	553,390	507,783*	
	Non-Utility Fuels				1,881,758	2,331,816	
	Industrial Energy Total				**4,939,298**	**6,788,045***	**-27.2%**
Transportation & Mobile Sources	Gasoline	16,221,006,125	15,539,152,438	VMT	5,906,666	6,303,887	
	Diesel	1,171,752,406	1,167,907,440	VMT	1,963,690	2,018,767	
	Aviation				422,032	422,056	
	Rail Transportation				160,461	6,522	
	Public Transit				20,815	37,750	
	Water Transportation				207,269	249,241	
	Off-Road				76,245	106,369	
	Transportation & Mobile Sources Total				**8,757,178**	**9,144,592**	**-4.2%**

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Solid Waste	Waste Generation	2,429,767	2,450,730	Tons	1,370,110	1,422,575	
	Composting	246,735	304,938	Tons	34,042	21,233	
	Combustion of Solid Waste	1,838	890	Tons	637	308	
	Solid Waste Total				**1,404,789**	**1,444,115**	**-2.7%**
Water & Wastewater	Septic Systems				86,966	89,524	
	Combustion of Digester Gas				1,305	19	
	Combustion of Biosolids & Sludges				10,152	12,480	
	N2O Emissions				15,390	14,049	
	Water & Wastewater Total				**113,813**	**116,072**	**-1.9%**
Process & Fugitive Emissions	Natural Gas Distribution	131,437,016	169,904,636	MMBtu	232,603	319,055	
	Gas and Oil Wells				587,892	587,892	
	Other Process and Fugitive Emissions				1,027,611	1,148,564	
	Process & Fugitive Emissions Total				**1,848,105**	**2,055,510**	**-10.1%**
	HFCs (Refrigerants)				**1,140,996**	**1,014,496**	**12.5%**
	Agriculture				**254,470**	**296,577**	**-14.2%**
	Total Gross Emissions				**30,151,210**	**34,966,243***	**-13.8%**
	Removals from Forest & Trees Emissions Total					**-1,169,371**	
	Total Emissions with Sequestration				**28,981,839**	**33,796,872***	**-14.2%**

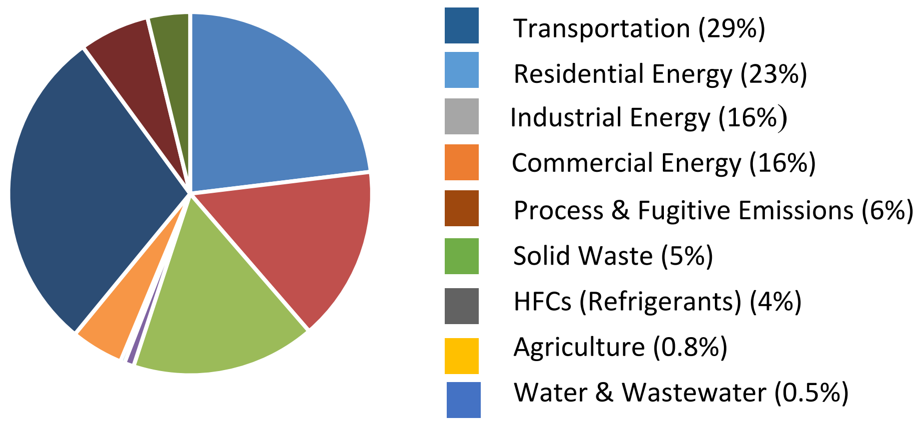


Figure 4: 2022 Total Regional GHG Emissions by Sector

Figure 4 shows the distribution of regional emissions by sector during 2022. Transportation (29.0%) is the largest contributor, followed by Residential Energy (23.1%), Industrial Energy (16.4%), and Commercial Energy (15.6%). GHG emissions in 2022 were 14.2% lower than during the baseline year of 2018. The largest sectoral decreases occurred for Industrial Energy (-27.2%), Commercial Energy (-23.7%), and Residential Energy (-12.0%). The only sector in which emissions increased was HFCs (Refrigerants) (12.5%). Per capita emissions fell by 14.5%, to 14.5 metric tons of carbon dioxide equivalent ($MTCO_2e$) in 2022. Accounting for inflation, regional gross domestic product (GDP) increased by 6% from $130.5 to $138.3 billion, in 2017 dollars. As a result, $MTCO_2e$ per million dollars of GDP fell by 18.6%, demonstrating the decoupling of economic growth from GHGs.

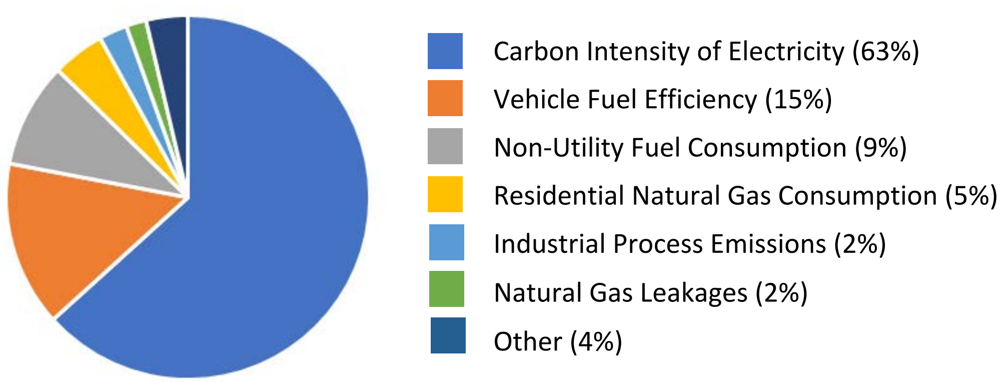


Figure 5: Sources of Regional GHG Emissions Reductions

Figure 5 identifies the major sources of the observed GHG reductions from 2018 to 2022. The average carbon intensity of electricity in Northeast Ohio fell 26.5%, from 1,106 pounds per megawatt hour (lbs per MWh) to 813 lbs per MWh. This reduction in carbon intensity from grid electricity reduced GHG emissions by 3.76 million $MTCO_2e$ (63.3%). The fuel efficiency of gasoline and diesel vehicles improved by 17.2% and 1.6%, respectively, which accounted for 14.8% of the total reduction in emissions. This reduction occurred despite a 4.1% increase in vehicle miles traveled (VMT). Industry made up 11.9% of the observed reduction, due to lower non-utility fuel use (9.3%) and reduced industrial process emissions (2.5%). The remaining reductions were due to decreased residential natural gas usage (4.6%), reduced natural gas leakages (1.8%), and other sources (3.7%).

Cuyahoga County

Table 4: 2022 Cuyahoga County Emissions Inventory

Sector	Fuel or Source	Usage 2022	Usage 2018	Unit	Emissions (MTCO2e) 2022	Emissions (MTCO2e) 2018	Percent Change
Residential Energy	Electricity	4,041,822,934	4,220,828,789	kWh	1,491,333	1,839,880	
	Natural Gas	51,930,121	55,215,074*	MMBtu	2,761,815	2,936,698*	
	Propane	526,327	497,744	MMBtu	32,663	30,889	
	Fuel Oil	46,078	84,972	MMBtu	3,431	6,327	
	Residential Energy Total				**4,289,242**	**4,813,793***	**-10.9%**
Commercial Energy	Electricity	4,770,754,859	5,224,248,774	kWh	1,757,422	2,781,715	
	Natural Gas	27,127,596	27,123,308*	MMBtu	1,445,128	1,442,594*	
	Commercial Energy Total				**3,202,550**	**4,224,309***	**-24.2%**
Industrial Energy	Electricity	4,860,439,583	5,566,716,131	kWh	1,792,250	2,964,066	
	Natural Gas	5,183,373	3,489,616 *	MMBtu	275,118	185,210*	
	Non-Utility Fuels				1,779,750	2,242,573	
	Industrial Energy Total				**3,847,118**	**5,391,849***	**-28.6%**
Transportation & Mobile Sources	Gasoline	8,932,129,598	8,763,716,875	VMT	3,240,546	3,534,879	
	Diesel	671,278,205	658,621,243	VMT	1,120,922	1,137,775	
	Aviation				422,031	422,044	
	Rail Transportation				72,191	6,335	
	Public Transit				18,956	37,750	
	Water Transportation				159,484	202,686	
	Off-Road				41,510	59,275	
	Transportation & Mobile Sources Total				**5,075,639**	**5,400,744**	**-6.0%**

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Solid Waste	Waste Generation	1,533,251	1,509,312	Tons	864,578	876,110	
	Composting	137,661	185,105	Tons	18,993	12,888	
	Combustion of Solid Waste	938		Tons	325		
	Solid Waste Total				**883,896**	**888,998**	**-0.6%**
Water & Wastewater	Septic Systems	242,078	242,078	Service Population	28,571	29,412	
	Combustion of Digester Gas	86,600	83,600	Service Population	38	8	
	Combustion of Biosolids & Sludges				10,152	12,480	
	N2O Emissions				11,321	11,945	
	Water & Wastewater Total				**50,082**	**53,845**	**-7.0%**
Process & Fugitive Emissions	Natural Gas Distribution	88,891,205	102,309,483	MMBtu	156,040	196,978	
	Gas and Oil Wells				143,385	143,385	
	Other Process and Fugitive Emissions				830,389	918,180	
	Process & Fugitive Emissions Total				**1,129,813**	**1,258,543**	**-10.2%**
	HFCs (Refrigerants)				**689,406**	**614,462**	**12.2%**
	Agriculture				**1,364**	**2,135**	**-36.1%**
	Total Gross Emissions				**19,169,110**	**22,648,678***	**-15.4%**
	Removals from Forest & Trees Emissions Total					**-233,766**	
	Total Emissions with Sequestration				**18,935,344**	**22,414,912***	**-15.5%**

Figure 6 shows the distribution of Cuyahoga County's emissions by sector. Transportation is the largest contributor, followed by Residential Energy, then Industrial Energy.

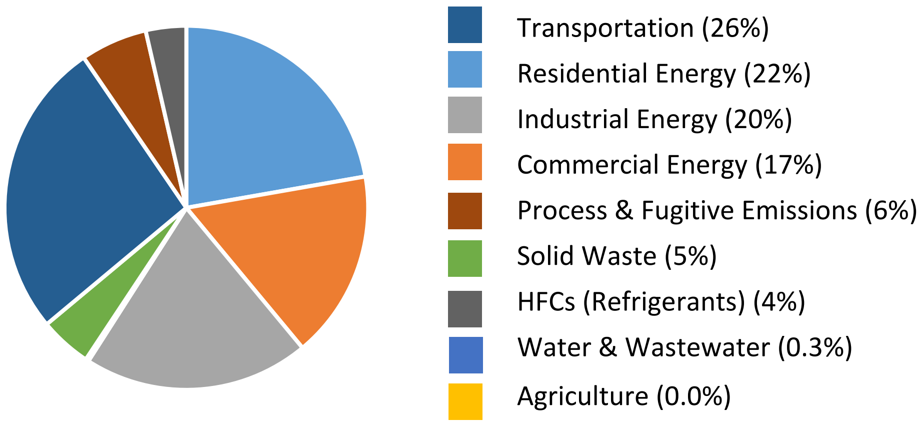


Figure 6: 2022 Cuyahoga County GHG Emissions by Sector

GHG emissions in Cuyahoga County were 15.5% lower than during 2018, the largest decrease of any county from 2018 to 2022. The largest sectoral decreases occurred for Industrial Energy (-28.6%) and Commercial Energy (-24.2%).[29] Improved efficiency was responsible for 70.4% of this decline in emissions, with reductions in the carbon intensity of electricity and improvements in fuel economy making up 59.1% and 11.3% of the improved efficiency total, respectively. Electricity in Cuyahoga County was 27% less carbon intensive in 2022 than during 2018. Per capita emissions fell by 16.2%, to 15.3 from 18 $MTCO_2e$. This number is 5.5% higher than the regional average of 14.5 $MTCO_2e$, due to the concentration of commercial, industrial, aviation, and maritime activity within the county.

Geauga County

Table 5: 2022 Geauga County Emissions Inventory

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Residential Energy	Electricity	458,200,020	480,096,397	kWh	169,694	207,535	
	Natural Gas	2,734,405	2,747,811*	MMBtu	145,423	146,147*	
	Propane	88,171	91,272*	MMBtu	5,472	5,664	
	Fuel Oil	196,857	315,188*	MMBtu	14,657	23,468	
	Residential Energy Total				**335,245**	**382,814***	**-12.4%**
Commercial Energy	Electricity	281,974,308	335,961,964	kWh	104,429	145,228	
	Natural Gas	1,232,970	1,078,0398	MMBtu	65,573	57,337*	
	Commercial Energy Total				**170,002**	**202,565***	**-16.1%**
Industrial Energy	Electricity	256,001,509	244,082,189	kWh	94,810	105,511	
	Natural Gas	242,149	315,578*	MMBtu	12,852	16,749*	
	Non-Utility Fuels						
	Industrial Energy Total				**107,662**	**122,260***	**-11.9%**
Transportation & Mobile Sources	Gasoline	825,101,261	783,783,448	VMT	300,834	317,712	
	Diesel	62,009,008	58,994,453	VMT	103,636	98,384	
	Aviation						
	Rail Transportation						
	Public Transit						
	Water Transportation						
	Off-Road				4,877	6,484	
	Transportation & Mobile Sources Total				**409,347**	**422,580**	**-3.1%**

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Solid Waste	Waste Generation	77,953	73,078	Tons	43,957	42,420	
	Composting	33,607	37,702	Tons	4,637	2,625	
	Combustion of Solid Waste	4		Tons	2		
	Solid Waste Total				**48,595**	**45,045**	**7.9%**
Water & Wastewater	Septic Systems	93,859	93,859	Service Population	11,078	11,404	
	Combustion of Digester Gas						
	Combustion of Biosolids & Sludges						
	N2O Emissions				312	30	
	Water & Wastewater Total				**11,389**	**11,434**	**-0.4%**
Process & Fugitive Emissions	Natural Gas Distribution	4,125,566	3,652,561	MMBtu	7,189	7,368	
	Gas and Oil Wells				134,546	134,546	
	Other Process and Fugitive Emissions						
	Process & Fugitive Emissions Total				**141,735**	**141,914**	**-0.1%**
	HFCs (Refrigerants)				**52,368**	**46,345**	**13.0%**
	Agriculture				**58,335**	**66,863**	**-12.8%**
	Total Gross Emissions				**1,334,679**	**1,441,821***	**-7.4%**
	Removals from Forest & Trees Emissions Total				**-361,018**		
	Total Emissions with Sequestration				**973,661**	**1,080,803***	**-9.9%**

Figure 7 shows the distribution of Geauga County's emissions by sector. Transportation is the largest contributor, followed by Residential Energy, then Commercial Energy.

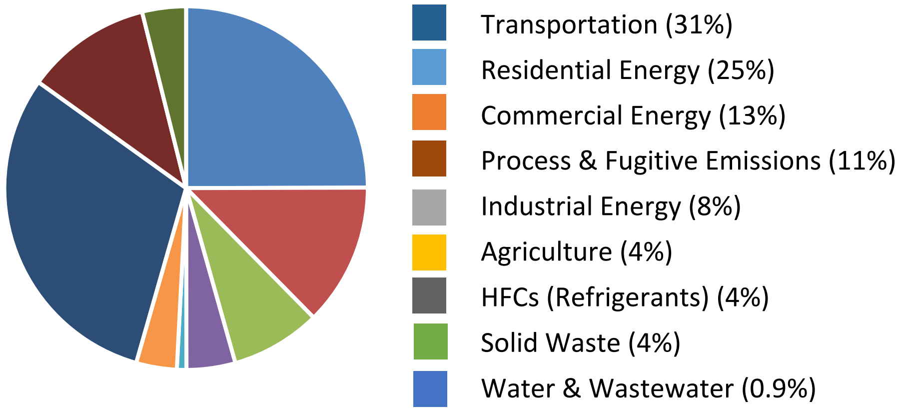


Figure 7: 2022 Geauga County GHG Emissions by Sector

Geauga County's GHG emissions were 9.9% lower in 2022 than 2018. Emissions fell fastest for Commercial Energy (-16.1%), Agriculture (-12.8%), and Residential Energy (-12.4%). Improved efficiency was responsible for nearly all (90.9%) of the reduction in GHGs. Electricity was 14.3% less carbon intensive in 2022, and fuel economy improved by 7.7%. In turn, emissions from both Solid Waste (7.8%) and HFCs (Refrigerants) (13%) increased in 2022.

Geauga County is home to the largest intact forests in the region, and trees within the county removed 361,018 $MTCO_2e$ of emissions during 2022, equal to 26.9% of total GHGs. Overall, per capita emissions fell by 8.8%, to 14.1 from 15.3 $MTCO_2e$.

Lake County

Table 6: 2022 Lake County Emissions Inventory

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Residential Energy	Electricity	883,041,980	906,150,299	kWh	334,437	506,729	
	Natural Gas	7,930,031	8,351,461*	MMBtu	421,745	444,185*	
	Propane	94,451	85,581	MMBtu	5,862	5,311	
	Fuel Oil	67,813	102,668	MMBtu	5,049	7,644	
	Residential Energy Total				**767,092**	**963,869***	**-20.4%**
Commercial Energy	Electricity	839,859,052	967,757,939	kWh	318,282	539,165	
	Natural Gas	3,722,638	3,371,014*	MMBtu	197,982	179,292*	
	Commercial Energy Total				**516,264**	**718,457***	**-28.1%**
Industrial Energy	Electricity	548,761,691	577,753,228	kWh	206,946	319,314	
	Natural Gas	1,248,587	559,026*	MMBtu	66,268	29,670*	
	Non-Utility Fuels				96,603	84,850	
	Industrial Energy Total				**369,817**	**433,834***	**-14.8%**
Transportation & Mobile Sources	Gasoline	2,327,756,398	1,775,729,312	VMT	853,752	727,972	
	Diesel	147,938,364	133,451,715	VMT	215,316	231,624	
	Aviation					6	
	Rail Transportation				28,438		
	Public Transit				1,859		
	Water Transportation				30,342	33,795	
	Off-Road				9,796	14,002	
	Transportation & Mobile Sources Total				**1,139,549**	**1,007,399**	**13.1%**

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Solid Waste	Waste Generation	275,550	238,705	Tons	155,378	138,561	
	Composting	30,297	38,372	Tons	4,180	2,672	
	Combustion of Solid Waste			Tons			
	Solid Waste Total				**159,559**	**141,233**	**13.0%**
Water & Wastewater	Septic Systems	119,913	119,913	Service Population	14,153	14.569	
	Combustion of Digester Gas	149,642	55,567	Service Population	9	3	
	Combustion of Biosolids & Sludges						
	N2O Emissions				1,187	826	
	Water & Wastewater Total				**15,349**	**15.398**	**-0.3%**
Process & Fugitive Emissions	Natural Gas Distribution	12,884,994	11,734,203	MMBtu	22,415	23,671	
	Gas and Oil Wells				65.436	65,436	
	Other Process and Fugitive Emissions				197.222	230,384	
	Process & Fugitive Emissions Total				**285,074**	**319,491**	**-10.8%**
	HFCs (Refrigerants)				**127,409**	**113,001**	**12.8%**
	Agriculture				**12,112**	**12,545**	**-3.5%**
	Total Gross Emissions				**3,392,180**	**3,725,227***	**-8.9%**
	Removals from Forest & Trees Emissions Total					**-165,452**	
	Total Emissions with Sequestration				**3,226,728**	**3,559,775***	**-9.4%**

Figure 8 shows the distribution of Lake County's emissions by sector. Transportation is the largest contributor, accounting for more than one-third of total emissions, followed by Residential Energy, then Commercial Energy. GHGs were 9.4% lower in Lake County during 2022 than 2018.

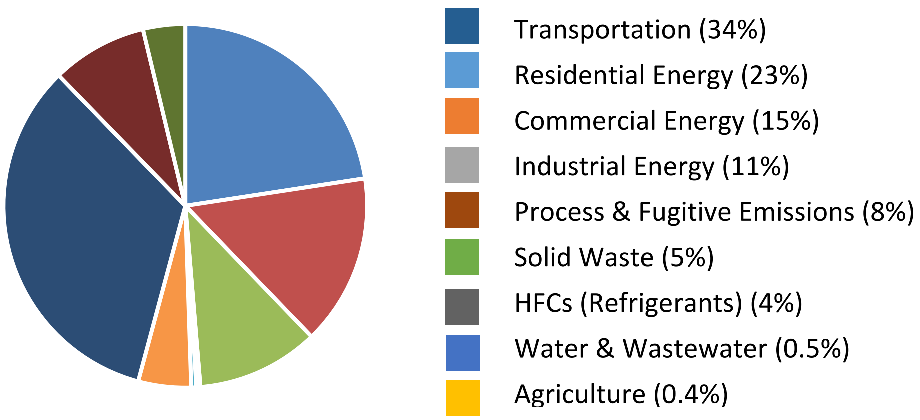


Figure 8: 2022 Lake County GHG Emissions by Sector

Emissions fell fastest for Commercial Energy (-28.1%), Residential Energy (-20.4%), and Industrial Energy (-14.8%). The carbon intensity of electricity declined by nearly one-third (32%), while the fuel economy for on-road vehicles increased by 15%. Emissions increased by 13% for both Transportation and Solid Waste sectors and by 12.8% for HFCs (Refrigerants), which demonstrates the need for continued climate actions in these sectors. Per capita emissions in Lake County fell by 9.6%, to 14.6 from 16.2 $MTCO_2e$.

Lorain County

Table 7: 2022 Lorain County Emissions Inventory

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Residential Energy	Electricity	1,307,302,496	1.173.965.126	kWh	475,290	566.728	
	Natural Gas	9,361,754	9.562.577*	MMBtu	494,039	508.601*	
	Propane	251,200	275.145	MMBtu	15,589	17.075	
	Fuel Oil	46,823	74.104	MMBtu	3,486	5.518	
	Residential Energy Total				**988,404**	**1.097.923***	**-10.0%**
Commercial Energy	Electricity	764,282,012	855.797.279	kWh	253.280	391.673	
	Natural Gas	4,954,905	4.892.982*	MMBtu	263.518	260.241*	
	Commercial Energy Total				**516.799**	**651.914***	**-20.7%**
Industrial Energy	Electricity	646,218,556	704,467,502	kWh	525.078	313.334	
	Natural Gas	2,474,828	3,536,054*	MMBtu	131.350	187.674*	
	Non-Utility Fuels				5.405	4.393	
	Industrial Energy Total				**388.833**	**505.401***	**-23.1%**
Transportation & Mobile Sources	Gasoline	2,327,756,398	2,367,586,799	VMT	857,294	973.673	
	Diesel	174,938,364	177,931,690	VMT	295,379	309.532	
	Aviation				1	6	
	Rail Transportation				50,351	187	
	Public Transit						
	Water Transportation				17.443	12,760	
	Off-Road				12,854	17,242	
	Transportation & Mobile Sources Total				**1,233,321**	**1,313,400**	**-6.1%**

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Solid Waste	Waste Generation	337,393	406,699	Tons	190,251	237,818	
	Composting	41,085	33,902	Tons	5,669	2,361	
	Combustion of Solid Waste	890	890	Tons	309	308	
	Solid Waste Total				**196,228**	**240,487**	**-18.4%**
Water & Wastewater	Septic Systems	171,461	171,461	Service Population	20,237	20,832	
	Combustion of Digester Gas	118,000	113,844	Service Population	90	7	
	Combustion of Biosolids & Sludges						
	N2O Emissions				2,160	1,141	
	Water & Wastewater Total				**22,488**	**21,980**	**2.3%**
Process & Fugitive Emissions	Natural Gas Distribution	16,279,432	35,634,279	MMBtu	30,059	61,824	
	Gas and Oil Wells				62,566	62,566	
	Other Process and Fugitive Emissions						
	Process & Fugitive Emissions Total				**92,625**	**124,390**	**-25.5%**
	HFCs (Refrigerants)				**171,773**	**152,041**	**13.0%**
	Agriculture				**94,931**	**120,144**	**-21.0%**
	Total Gross Emissions				**3,705,403**	**4,227,680***	**-12.4%**
	Removals from Forest & Trees Emissions Total				**-206,873**		
	Total Emissions with Sequestration				**3,498,530**	**4,020,807***	**-13.0%**

Figure 9 shows the distribution of Lorain County's emissions by sector. The largest contributor, Transportation, was responsible for one-third of total emissions, followed by Residential Energy, then Commercial Energy. These three sectors combined for nearly three-quarters of GHGs.

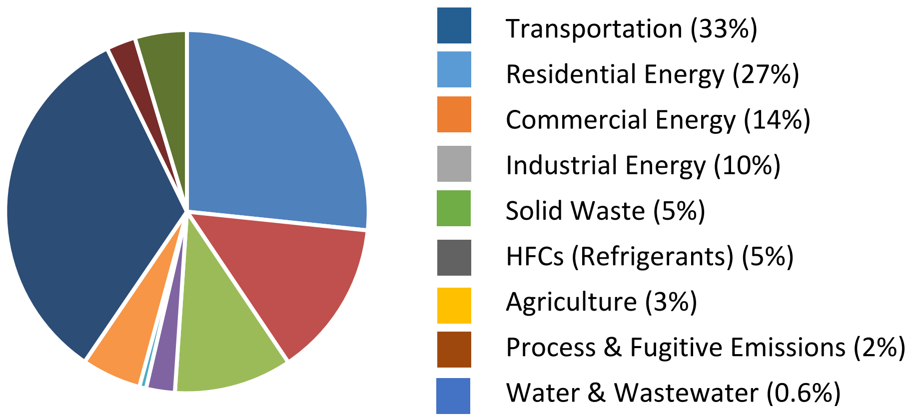


Figure 9: 2022 Lorain County GHG Emissions by Sector

From 2018 to 2022, GHG emissions fell by 13.0% in Lorain County. Emissions fell fastest for Process & Fugitive Emissions (-25.5%), Industrial Energy (-23.1%), and Agriculture (-21.0%). Emissions from HFCs (Refrigerants) and Water and Wastewater increased by 13% and 2.3%, respectively. Electricity became 22.7% less carbon intensive during this span, accounting for 55.7% of the observed reduction in emissions. The fuel economy of on-road vehicles improved by 8.6%, which was responsible for another 21.2% of the GHG reduction. Per capita emissions fell by 13.4%, to 11.8 from 13.7 $MTCO_2e$.

Medina County

Table 8: 2022 Medina County Emissions Inventory

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Residential Energy	Electricity	812,965,010	773,478,214	kWh	304,929	369.176	
	Natural Gas	5,360,139	5,552,047*	MMBtu	285,070	296.296*	
	Propane	199,892	221,121	MMBtu	14,883	13.723	
	Fuel Oil	81,559	133,746	MMBtu	6,075	9.958	
	Residential Energy Total				**610,957**	**689.152***	**-11.3%**
Commercial Energy	Electricity	404,875,293	436,558,974	kWh	144,077	201,894	
	Natural Gas	2,856,678	3,011,584*	MMBtu	151,928	160,176*	
	Commercial Energy Total				**296,004**	**362,070***	**-18.2%**
Industrial Energy	Electricity	423,355,232	451,505,985	kWh	158,054	246,221	
	Natural Gas	1,277,725	1,667,099*	MMBtu	67,815	88,480*	
	Non-Utility Fuels						
	Industrial Energy Total				**225,869**	**334,701***	**-32.5%**
Transportation & Mobile Sources	Gasoline	1,808,330,158	1,848,336,004	VMT	654,240	749,651	
	Diesel	135,901,815	138,908,339	VMT	228,436	241,452	
	Aviation						
	Rail Transportation				9,436		
	Public Transit						
	Water Transportation						
	Off-Road				7,208	9,366	
	Transportation & Mobile Sources Total				**899,321**	**1,000,469**	**-10.1%**

Sector	Fuel or Source	Usage		Unit	Emissions (MTCO2e)		Percent Change
		2022	2018		2022	2018	
Solid Waste	Waste Generation	205,620	219,936	Tons	115,946	127,666	
	Composting	9,857	9,857	Tons	564	686	
	Combustion of Solid Waste	6		Tons	2		
	Solid Waste Total				**116,512**	**128,352**	**-9.2%**
Water & Wastewater	Septic Systems	109,535	109,535	Service Population	12,928	13,308	
	Combustion of Digester Gas	82,600	25,000	Service Population	1,168		
	Combustion of Biosolids & Sludges						
	N2O Emissions				409	107	
	Water & Wastewater Total				**14,505**	**13,415**	**8.1%**
Process & Fugitive Emissions	Natural Gas Distribution	9,255,819	16,574,163	MMBtu	16,900	29,214	
	Gas and Oil Wells				181,958	181,958	
	Other Process and Fugitive Emissions						
	Process & Fugitive Emissions Total				**198,858**	**211,172**	**-5.8%**
	HFCs (Refrigerants)				**100,039**	**88,646**	**12.9%**
	Agriculture				**87,728**	**94,890**	**-7.5%**
	Total Gross Emissions				**2,549,792**	**2,922,867**	**-12.8%**
	Removals from Forest & Trees Emissions Total					**-202,262**	
	Total Emissions with Sequestration				**2,347,530**	**2,720,605**	**-13.7%**

Figure 10, below, shows the distribution of Medina County's emissions by sector. Transportation is the largest contributor; at 35%, it makes up a larger share of Medina's emissions than it does within any other county in the MSA. Residential Energy makes up nearly one-quarter of remaining emissions, followed by Commercial Energy.

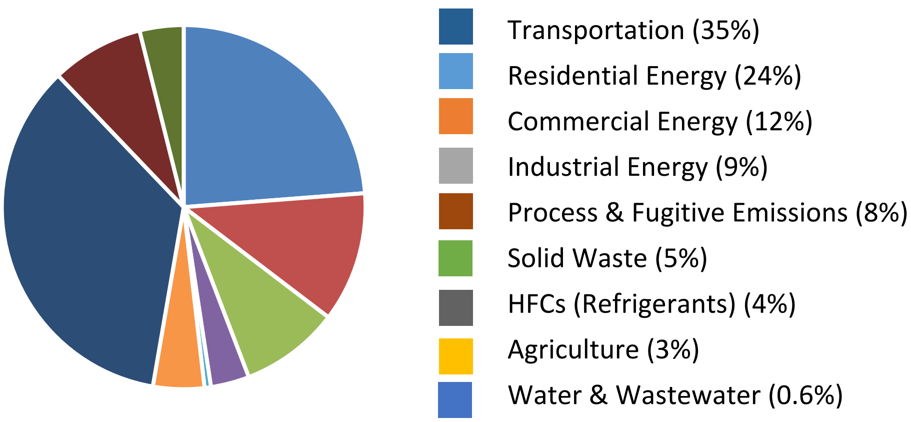


Figure 10: 2022 Medina County GHG Emissions by Sector

GHGs were 13.7% lower in Medina County during 2022 than 2018. Emissions fell fastest for Industrial Energy (-32.5%), Commercial Energy (-18.2%), and Residential Energy (-11.3%). Emissions increased for both HFCs (Refrigerants) (12.9%) and Water and Wastewater (8.1%). The carbon intensity of electricity declined by nearly one-quarter (24.8%), while the fuel economy for on-road vehicles increased by 9%. These gains in efficiency made up 78.3% of total emissions reductions from 2018 to 2022. Per capita emissions fell by 14.3%, to 14 from 16.3 $MTCO_2e$.

Conclusion

The 2022 baseline inventory marks an update to the Cleveland-Elyria MSA's 2018 baseline inventory, which was a key milestone in the completion of the PCAP. As part of the development of the region's CCAP, the City of Cleveland and NOACA will establish regional emissions-reduction targets and consider sector-specific emissions reduction targets. Furthermore, the City of Cleveland and NOACA staff will identify specific, quantified emissions reduction strategies that may cumulatively help the region meet these targets.

In addition, as the Cleveland-Elyria MSA completes its CCAP and moves from climate action planning into climate action implementation, the region will continue to track key energy use and emissions indicators. Staff will complete a regular update to the MSA GHG inventory on at least a biennial basis, with the next update likely occurring as part of the development of the CPRG Status Report during 2027. By completing regular GHG inventory updates, the Cleveland-Elyria MSA can gain better insight into sustained changes over time to track trends and chart progress towards targets. The 2022 baseline inventory shows that residential and commercial energy, as well as region-wide transportation patterns, remain key sectors for the region's focus. Through these efforts and others, the Cleveland-Elyria MSA can achieve environmental, economic, and social benefits beyond emissions reduction.

Appendix: Methodology Details

Energy

Table 9: Energy Data Sources with Estimation Applied

Activity	Data Source	Data Gaps/Assumptions
Region-wide		
Residential, Commercial, and Industrial Electricity	Firelands Electric Cooperative	Interpolated electricity usage for Lorain County by dividing total consumption for residential and commercial users during 2022, as reported to the United States Energy Information Administration (U.S. EIA), by the total number of residential customers, reported by the utility
	Lorain Medina Rural Electricity Cooperative	Interpolated electricity usage for Lorain and Medina Counties by dividing the total consumption for residential, commercial, and industrial users during 2022, as reported to the U.S. EIA, by the share of the total population of the utility's five-county territory located in Lorain and Medina Counties
Residential, Commercial, and Industrial Natural Gas	Columbia Gas of Ohio	Includes agricultural data
	Knox Energy Cooperative	Interpolated natural gas usage for each county by dividing the total consumption for residential, commercial, and industrial users during 2022, as reported to the U.S. EIA, by the share of the total population of the utility's 33-county territory located in Cuyahoga, Geauga, Lake, Lorain, and Medina Counties
	Northeast Ohio Natural Gas	Interpolated natural gas usage for Geauga and Lake Counties by dividing the total consumption for residential, commercial, and industrial users during 2022, as reported to the U.S. EIA, by the share of the total population of the utility's 15-county territory located in Geauga and Lake Counties
	Northern Industrial Energy Development	Interpolated natural gas usage for Medina County by dividing the total consumption for industrial users during 2022, as reported to the U.S. EIA, by the share of the total population of the utility's three-county territory located in Medina County

Table 10: Emissions Factors for Electricity Consumption

Utility / Year	CO_2 (lbs per MWh)	CH_4 (lbs per GWh)	N_2O (lbs per GWh)	Data Gaps/Assumptions
City of Amherst / 2022	1,042	87	12	Provided by American Municipal Power (AMP)
City of Oberlin / 2022	172	87	12	Provided by AMP
City of Wadsworth / 2022	774.41	43.87	6	Provided by AMP
Cleveland Public Power (CPP) / 2022	779.85	87	12	Calculated based on electricity data by source provided by CPP
FirstEnergy / 2022	810.84	87	12	Provided by FirstEnergy
Village of Grafton / 2021	825	87	12	Provided by AMP
Village of Seville / 2022	780.59	55.19	7.61	Provided by AMP

Wastewater

Table 11: Wastewater Data Sources with Estimation Applied

Activity	Data Source	Data Gaps/Assumptions
Region-wide		
N_2O from Effluent Discharge	Cuyahoga County (Bedford, Bedford Heights, Chagrin Falls, North Royalton, Strongsville)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N_2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county
	Geauga County (Burton, Chardon, Geauga County Department of Water Resources)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N_2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county
	Lorain County (Amherst, Avon Lake, Grafton, LaGrange, Lorain County Rural Wastewater District (LORCO), Oberlin, Wellington)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N_2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county
	Medina County (Lodi, Seville, Spencer, Westfield Center)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N_2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county

Table 11: Wastewater Data Sources with Estimation Applied (continued)

Activity	Data Source	Data Gaps/Assumptions
Process N_2O Emissions	Cuyahoga County (Bedford, Bedford Heights, Chagrin Falls, North Royalton, Strongsville)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county
	Geauga County (Burton, Chardon, Geauga County Department of Water Resources)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county
	Lorain County (Amherst, Avon Lake, Grafton, LaGrange, Lorain County Rural Wastewater District, Oberlin, Wellington)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county
	Medina County (Lodi, Seville, Spencer, Westfield Center)	Estimated emissions for small utilities for which staff did not receive data. Estimates based on the tons of N2O per million gallons per day (MGD) of wastewater treated, based on reported data for smaller utilities (less than five (5) MGD) located in the county

Inventory Calculations

City of Cleveland staff followed the US Community Protocol and utilized ICLEI's ClearPath software to develop the 2022 baseline inventory. As discussed in Inventory Methods, staff used global warming potential (GWP) values to convert methane and nitrous oxide to CO_2 equivalent units. ClearPath's inventory calculators allow for input of the sector activity (i.e. kWh or VMT) and emission factors to calculate the final carbon dioxide equivalent (CO_2e) emissions.

Endnotes

[1] U.S. EPA, 2024, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022*. Washington, DC: U.S. EPA, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022, accessed August 31, 2024.
[2] The 2018 version of this report did not include emissions for Agriculture or HFCs (Refrigerants), making it impossible to directly compare Figure 1 from that report to this one. The updated 2018 inventory included in the PCAP added these sectors, and that formed the basis for the revised 2018 inventory discussed throughout this report.
[3] IPCC, 2023: "Summary for Policymakers," in: *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, H. Lee and J. Romero (eds.)]. Geneva, Switzerland: IPCC, pp. 1-34, https://www.ipcc.ch/report/ar6/syr/summary-for-policymakers/, accessed August 31, 2024.
[4] Ibid.
[5] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge, UK and New York City: Cambridge University Press, , pp. 3-24, https://www.ipcc.ch/sr15/chapter/spm/, accessed August 31, 2024.
Copernicus Programme, 2024, "Copernicus: 2023 is the hottest year on record, with global temperatures close to the 1.5°C limit," https://climate.copernicus.eu/copernicus-2023-hottest-year-record, accessed August 31, 2024.
[6] IPCC, 2023, *Climate Change 2023: Synthesis Report*.
[7] IPCC, 2018, *Global Warming of 1.5°C.*
[8] Wilson, A.B., J.M. Baker, E.A. Ainsworth, J. Andresen, J.A. Austin, J.S. Dukes, E. Gibbons, B.O. Hoppe, O.E. LeDee, J. Noel, H.A. Roop, S.A. Smith, D.P. Todey, R. Wolf, and J.D. Wood, 2023: Ch. 24. Midwest. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA., https://nca2023.globalchange.gov/chapter/24/, accessed August 31, 2024.
[9] Ibid.
[10] Ibid.
[11] U.S. EPA, 2021, *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts*. Washington, DC: U.S. EPA, https://www.epa.gov/cira/social-vulnerability-report, accessed August 31, 2024.
[12] Haley, B., Jones, R.A., Williams, J.H., Kwok, G., Farbes, J., Hargreaves, J., Pickrell, K., Bentz, D., Waddell, A., Leslie, E., 2022, *Annual Decarbonization Perspective: Carbon Neutral Pathways for the United States 2022*, San Francisco: Evolved Energy Research.
[13] ICLEI, 2012, US Community Protocol for Accounting and Reporting Greenhouse Gas Emissions, http://www.icleiusa.org/tools/ghg- protocol/community-protocol, accessed August 31, 2024.
[14] The original 2018 baseline GHG inventory double-counted emissions from residential, commercial, and natural gas consumption from a large gas utility for Cuyahoga, Lorain, and Medina Counties. The original 2018 baseline inventory also failed to include emissions from a smaller gas utility that operated in Cuyahoga, Lorain, and Medina Counties. Furthermore, the original 2018 baseline inventory included inaccurate estimates for another, smaller gas utility that operated in all five counties. Finally, the original 2018 baseline inventory transposed residential fuel oil and propane use for Geauga County. The revised 2018 baseline inventory data includes corrections of these errors.
[15] The region consumed a total of 21,309.9 gigawatt hours (GWh) of electricity in 2022. The City of Cleveland received data for 21,083.1 GWh (98.1%) of this electricity directly from utilities. It extrapolated the remaining 226.7 GWh using the population-based method discussed in this section. The county-based approach that NOACA employed in the 2018 GHG inventory would have produced a total of 131.7 GWh, which is 71.9% lower than the population-based approach. While this difference is significant, it amounts to just 0.44% of total regional electricity usage.
[16] The region consumed a total of 127,682,897.3 MMBtu of natural gas in 2022. The City of Cleveland received data for 124,613,410 MMBtu (97.6%) of this natural gas directly from utilities. It extrapolated the remaining 3,069,487.3 MMBtu (2.4%) using the population-based method discussed in this section. The county-based approach that NOACA employed in the 2018 GHG inventory would have produced a total of 2,400,936.2 MMBtu, which is 21.8% lower than the population-based approach. While this difference is significant, it amounts to just 0.5% of total regional gas usage.

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[18] Federal Aviation Administration (FAA), 2022, *National Plan of Integrated Airport Systems: 2023-2027*, Washington, DC: FAA, https://www.faa.gov/airports/planning_capacity/npias/current, accessed August 31, 2024.

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[25] U.S. EPA, 2024, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022*, Washington, DC: U.S. EPA. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022, accessed August 31, 2024.

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[28] ICLEI USA, 2019, *United States Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Appendix J: Forest Land and Trees*, https://d1ps9kreypzu9a.cloudfront.net/GHGInventory/Appendix%20J%20-%20Forest%20Land%20and%20Trees.pdf, accessed August 31, 2024.

[29] The largest reduction actually came in the Agriculture sector, where emissions declined by 36.1% from 2018 to 2022. Nevertheless, this sector only accounted for 0.009% and 0.007% of total GHGs in Cuyahoga County during 2018 and 2022, respectively. As a result, staff chose not to call it out in the text of the report.