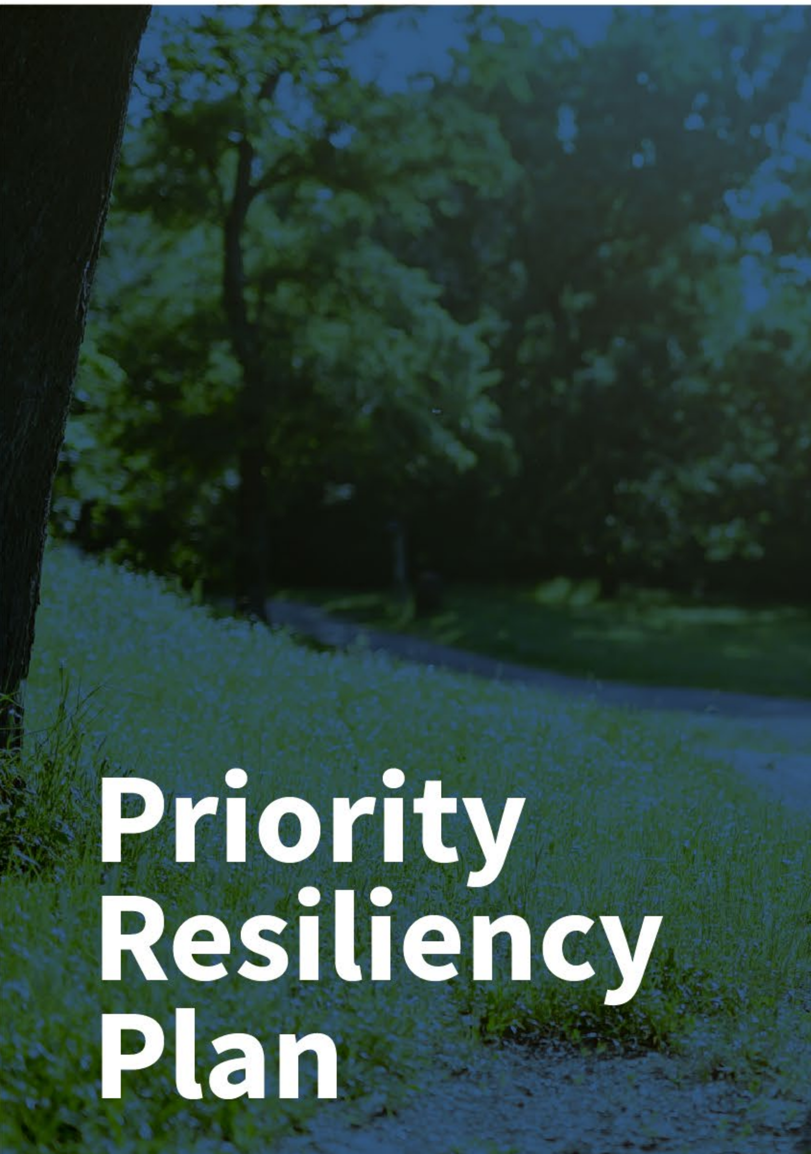

Priority Resiliency Plan

U.S. EPA Climate Pollution Reduction Grant Program

March 2024

Ohio Environmental Protection Agency

Executive Summary

The Climate Pollution Reduction Grant (CPRG) is a program administered by the United States Environmental Protection Agency (U.S. EPA) and authorized by the Inflation Reduction Act (IRA). The CPRG, a two-phase program, provides up to $5 billion in grants to states, local governments, tribes, and territories to develop and implement plans to reduce greenhouse gas (GHG) and other air emissions.

GHGs are gases that trap heat in the atmosphere and contribute to a long-term shift and change in temperatures and weather patterns.[1] Measuring and reducing GHG emissions is crucial to creating a more resilient future. Reducing emissions can also lead to other benefits, such as healthier Ohioans, especially those in high-risk groups like children and the elderly. This can also lead to new economic development created to support emerging technologies in the energy sector.

On behalf of the state, the Ohio Environmental Protection Agency (Ohio EPA), received planning grant funding from the CPRG and prepared this Priority Resiliency Plan (the Plan) in the first phase of planning for the broader GHG reduction goals for Ohio. We will develop a Comprehensive Resiliency Plan (CRP) in 2025, which will provide greater detail and analysis of the state's GHG reduction measures and implementation plans.

A key component of Plan development was our engagement with Ohioans, including leaders across the state representing different regions, communities, and areas of expertise. Outreach efforts and community engagement included one-on-one and small group interviews, a focus group with rural municipalities, two public webinars, a web-based survey, and by attending recurring meetings with target stakeholder groups. Through each conversation, we received feedback and recommendations for additional engagement and continuous process improvement. For this reason, the engagement approach resulted in a comprehensive, representative Plan.

This Plan summarizes:

- A statewide GHG inventory detailing the major sources of emissions in Ohio
- The primary emission reduction measures that the state will focus on to reduce emissions in the priority sectors in the near-term
- Our stakeholder engagement plan and efforts to date
- A preliminary analysis of the impact of the reduction measures on low-income and disadvantaged communities (LIDACs) in Ohio

This Plan focuses on near-term reduction measures that address GHG emissions by 2030 and can be implemented given current technological, programmatic, and regulatory capabilities.

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[1] https://www.epa.gov/ghgemissions/overview-greenhouse-gases

In Ohio, the largest sources of GHG emissions come from electric power production, energy used by residential, commercial, public, and industrial buildings, and energy used for transportation. Additional emissions come from sources such as waste, agricultural processes, industrial processes, and others, as detailed in the GHG Emissions Inventory section of this report. Emission-generating activities occur across the state but are generally concentrated in cities, where large volumes of energy consumption occur. Four of Ohio's largest metropolitan statistical areas (MSAs) have also received funding from the CPRG to develop their own emission reduction plans:

- Cincinnati, OH-KY-IN Metro area;
- Cleveland-Elyria, OH Metro area;
- Columbus, OH Metro area; and
- Dayton-Kettering, OH Metro area.

Ohio EPA is working with these regions to coordinate planning and considering reduction measures that will benefit regions of the state that did not receive funding from the CRPG.

The priority reduction measures identified in this Plan focus on GHG emissions from the largest sources in Ohio: electric power production, buildings, and transportation. Specific regions in Ohio identified waste as a priority sector; for that reason, we have included select measures to reduce emissions from waste. Additional non-priority measures are documented based on stakeholder feedback related to other sources of emissions.

Eight priority reduction measures are identified in this Plan for near-term implementation:

	PRIORITY REDUCTION MEASURE	DESCRIPTION
1.	**Light-duty Zero Emission Vehicles (ZEV) and modernization**	Increase the use of light-duty ZEVs, associated charging infrastructure, and other modernization technologies
2.	**Medium- and heavy-duty (MDHD) ZEVs and modernization**	Increase the use of MDHD ZEVs and associated charging infrastructure, and other modernization technologies
3.	**Transportation efficiencies**	Expand strategies that can affect changes in infrastructure, assets, and behavioral changes to create a more time-efficient, environmentally friendly, and sustainable transportation system
4.	**Renewable electricity generation**	Increase the use of renewable energy, such as solar and wind, to produce electricity in Ohio
5.	**Building energy efficiency**	Increase the energy efficiency of residential, commercial, public, and industrial buildings, by designing new buildings and retrofitting existing buildings with technologies to minimize energy consumption, reduce GHG emissions, and promote sustainability
6.	**Clean heating**	Reduce fossil fuel usage for building heating, through measures such as electrifying heating systems
7.	**Composting**	Promote the expansion of composting to reduce organic waste sent to landfill
8.	**Clean Waste-to-Energy (WtE)**	Promote the expansion of clean, organic WtE as a solution to transform organic waste materials into various forms of energy such as electricity, heat, or fuel

Ohio EPA expects implementation of this Plan to provide benefits to LIDACs. Through review of LIDACs across Ohio, and with input from stakeholders on challenges faced in these communities, we address the potential benefits and impacts for each of the proposed priority GHG reduction measures in these areas. We performed a high-level quantification of the potential impact of light-duty ZEVs on LIDACs in Franklin County as an illustrative example. We found that a 10% reduction of internal combustion engine (ICE) vehicle miles traveled (VMT) would have a potential annual benefit of $16.1 million to $18.0 million from the reduction in mortality and morbidity in Franklin County alone over the course of a single year (2030). These costs affect both individual residents and the community through loss of productivity, additional medications, treatment, hospital visits, and even death. A county-level analysis does not allow us to explicitly assign these costs to particular LIDACs. However, the location of LIDACs in Franklin County are mainly along the highway network making it apparent that a large share of benefits from this reduction in emissions would directly benefit LIDACs.

We summarize the key potential benefits and impacts for LIDACs for specific emissions reduction measures in the table below:

	PRIORITY REDUCTION MEASURE	POTENTIAL BENEFITS	POTENTIAL IMPACTS
1.	**Light-duty ZEVs and modernization**	• Reduction in co-pollutants[2] • Improved health outcomes • Employment opportunities for manufacturing, installation, and maintenance of charging stations and infrastructure	• Employment implications for fossil fuel-based transportation (e.g., mechanics, gas stations) • Affordability
2.	**MDHD ZEVs and modernization**	• Reduction in co-pollutants • Improved health outcomes • Employment opportunities for manufacturing, installation, and maintenance of charging stations and infrastructure	• Employment implications for fossil fuel-based transportation (e.g., mechanics, gas stations) • Affordability
3.	**Transportation efficiencies**	• Reduction in co-pollutants • Improved health outcomes • Reduction in commuting costs • Employment opportunities in transit	• Employment implications for taxi, rideshare, and private transportation • Less impactful in rural areas
4.	**Renewable electricity generation**	• Reduction in co-pollutants • Improved health outcomes • Reduction in energy costs and therefore energy burden • Employment opportunities for the construction, installation, and maintenance of renewable energy installations	• Employment implications in fossil fuel extraction and fossil fuel based electrical power generation • Current lack of skilled workforce • Land use conflict

[2] For this document, co-pollutants refer to other pollutants released along with GHGs, which have negative health impacts

5.	**Building energy efficiency**	• Reduction in co-pollutants • Improved health outcomes • Reduction in energy costs and therefore energy burden • Employment implications in particular industries	• Increase to land value and rent, impacting affordability for current residents
6.	**Clean heating**	• Reduction in co-pollutants • Improved health outcomes • Reduction in energy costs and therefore energy burden • Employment implications in particular industries	• Increase to land value and rent, impacting affordability for current residents • High costs of capital required for clean heating retrofits
7.	**Composting**	• Waste reduction leading to less garbage processing like landfilling, and environmental and direct costs • Supports local fresh food production	• Additional space/land requirements
8.	**Clean Waste-to-Energy (WtE)**	• Waste reduction • Reduction in co-pollutants by offsetting fuel combustion when clean WtE is used as vehicle fuel, heating fuel, or to generate electricity • Improved health outcomes • Reduction in energy costs and burden for those installing WtE at their facility	• Additional space/land requirements

This Plan lays the foundation for the next steps of Ohio's CPRG program. It is the first step in creating Ohio's Comprehensive Resiliency Plan (CRP), a more detailed plan addressing GHG reduction measures from all major and minor sources of emissions in Ohio. The CRP will be published in 2025.

Table of Contents

Introduction

The Ohio Environmental Protection Agency (Ohio EPA) produced this Priority Resiliency Plan (the Plan) to support investment in policies, practices, and technologies that reduce GHG emissions across the state. The Plan is designed to identify GHG reduction measures that reflect the priorities and concerns of different Ohio communities, while achieving a broader goal to reduce aggregate emissions produced in the state. Reducing GHG emissions through these measures will also have additional benefits, such as improving public health, creating high-quality jobs, spurring economic growth, and enhancing the quality of life for all Ohioans. This project was funded wholly or in part by the U.S. EPA under assistance agreement 00E03464 of $3 million to Ohio EPA. The contents of this document do not necessarily reflect the views and policies of the U.S EPA, nor does the U.S. EPA endorse trade names or recommend the use of commercial products mentioned in this document.

The measures contained herein should be construed as broadly available to any entity in the state eligible for receiving funding under the U.S. EPA's Climate Pollution Reduction Implementation Grant (CPRG) and other funding streams, as applicable.

The subsequent sections of the Plan will cover the following topic areas:

SECTION	DESCRIPTION
Greenhouse Gas Emissions Inventory	An overview of Ohio's GHG emissions footprint, identifying major priority and minor sectors contributing to Ohio's overall emissions.
Market Landscape	Current conditions of Ohio's electrical grid, building footprint, and transportation system, as it relates to the priority GHG emission sectors in Ohio.
Priority GHG Reduction Measures	Near-term GHG reduction measures related to the priority GHG emission sectors that Ohio will seek to implement as part of the CPRG program. Also provides an overview of potential additional measures that may be considered in the long-term by the State or near-term by other state constituents.
LIDAC Benefits Analysis	Results of the qualitative analysis over benefits and impacts of the GHG reduction measures outlined in this Plan.
Coordination and Outreach	An overview of Ohio EPA's stakeholder engagement efforts to date and plans for future outreach.
Comprehensive Resiliency Plan	An overview of the next steps of this program, including drafting a Comprehensive Resiliency Plan.

Greenhouse Gas Emissions Inventory

INVENTORY OVERVIEW

Ohio EPA developed a statewide inventory of major sources of GHG emissions in Ohio.[3] We prepared an estimate of emissions from each major source using the following data resources:

- State-level GHG inventories prepared by the U.S. EPA;[4]
- U.S. EPA's State Inventory Tool (SIT);[5]
- 2019 listing of registered motor vehicles and total vehicle miles traveled (VMT), obtained from Ohio Bureau of Motor Vehicles (BMV)
- U.S. Energy Information Administration's (EIA) 2019 Form EIA-923 (electric power generation data)[6]

The following GHGs are included in this inventory:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- fluorinated gases (F-gases) including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3)

Unless otherwise noted, the GHG inventory prepared for this Plan calculates GHG emissions in million metric tons (MMT) of carbon dioxide equivalent (CO_2e) for all economic sectors including, where available, emissions per fossil fuel type.[7,8] The calculated emissions for each included GHG are converted to CO_2e using global warming potentials (GWPs). This converts a unit of gas to the equivalent number of units of CO_2 required to create the same warming effect.[9] The Ohio GHG inventory includes emissions from the sectors defined in Table 1. Priority sectors have been identified as those that represent a significant portion of Ohio's emissions and are a focus of this Plan. Minor sectors will be further explored in the Comprehensive Resiliency Plan (CRP).

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[3] Ohio EPA prepared a Quality Assurance Project Plan (QAPP) that includes a detailed methodology for the GHG inventory. The QAPP was submitted to and approved by the U.S. EPA in October 2023

[4] https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals

[5] https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool

[6] Form EIA-923 detailed data with previous form data (EIA-906/920) - U.S. Energy Information Administration (EIA)

[7] Global warming potentials (GWPs) in SIT convert all GHG gas types listed into CO_2e

[8] See Appendix II for fossil fuel types included in SIT calculations by sector

[9] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

Table 1. Sectors Included in Ohio's GHG Inventory

	SECTOR	DEFINITION[10]
PRIORITY	**Electric Power Generation**	Emissions from fossil fuel combustion at power plants for the purpose of generating electricity at power plants.
PRIORITY	**Buildings**	Emissions from fossil fuel combustion that occurs at residential, commercial, public, and industrial buildings.[11] Buildings also have indirect electricity emissions from electric power consumption.
PRIORITY	**Transportation**	Emissions from fossil fuel consumption in transportation, including on-road vehicles, aviation, boats and vessels, locomotives, other non-road vehicle sources, and alternative fuel vehicles. Transportation also has indirect electricity emissions from electric power consumption.[12]
MINOR	**Other Energy**	Emissions from international bunker fuels used in marine and aviation transport originating in the United States with international destinations, coal mining, abandoned coal mines, and natural gas and oil systems, including production, transmission, distribution, and venting and flaring of natural gas, and petroleum systems.
MINOR	**Industrial Processes and Materials**	Emissions from industrial processes, including, but not limited to, cement production, iron and steel production, ammonia manufacturing, and other material production and manufacturing activities.
MINOR	**Waste**	Emissions from municipal solid waste management, including landfilled waste.
	Agriculture	Emissions from agricultural processes, including enteric fermentation, manure management, soils, rice cultivation, liming of soils, urea fertilization, and agricultural residue burning.
	Land Use, Land-use Change, and Forestry (LULUCF)	Emissions and carbon sequestration (the absorption of carbon from the atmosphere) resulting from land-use change and forest management activities.

[10] Sector definitions are aligned to the definition provided by the U.S. EPA in the SIT

[11] For buildings, emissions capture major fuel types used in buildings including natural gas, propane, and coal. Minor fuel types and fugitive emissions from building HVAC systems are not captured currently due to lack of data. See Appendix for a complete list of fuel types considered for electric power, building, and other energy sectors.

[12] Electric and other zero emission vehicles like hydrogen or fuel-cell were not accounted for in the SIT as Ohio BMV VMT data utilized does not distinguish vehicles by fuel types; these can be integrated into the GHG Inventory for the CRP

OHIO STATEWIDE GHG EMISSIONS BY SECTOR

As shown in Figure 1, total gross emissions within Ohio are 245 $MMTCO_2e$. The three most significant sectors in Ohio are electric power generation, buildings, and transportation, which account for most of Ohio's emissions (79% of gross emissions):

- Electric power: 28%
- Buildings: 25%
  - Direct fossil fuel combustion at buildings is 25% of gross emissions. However, indirect electric power consumption from buildings is 28% of gross emissions. This results in 53% of gross emissions being attributable to buildings.
- Transportation: 26%[13]

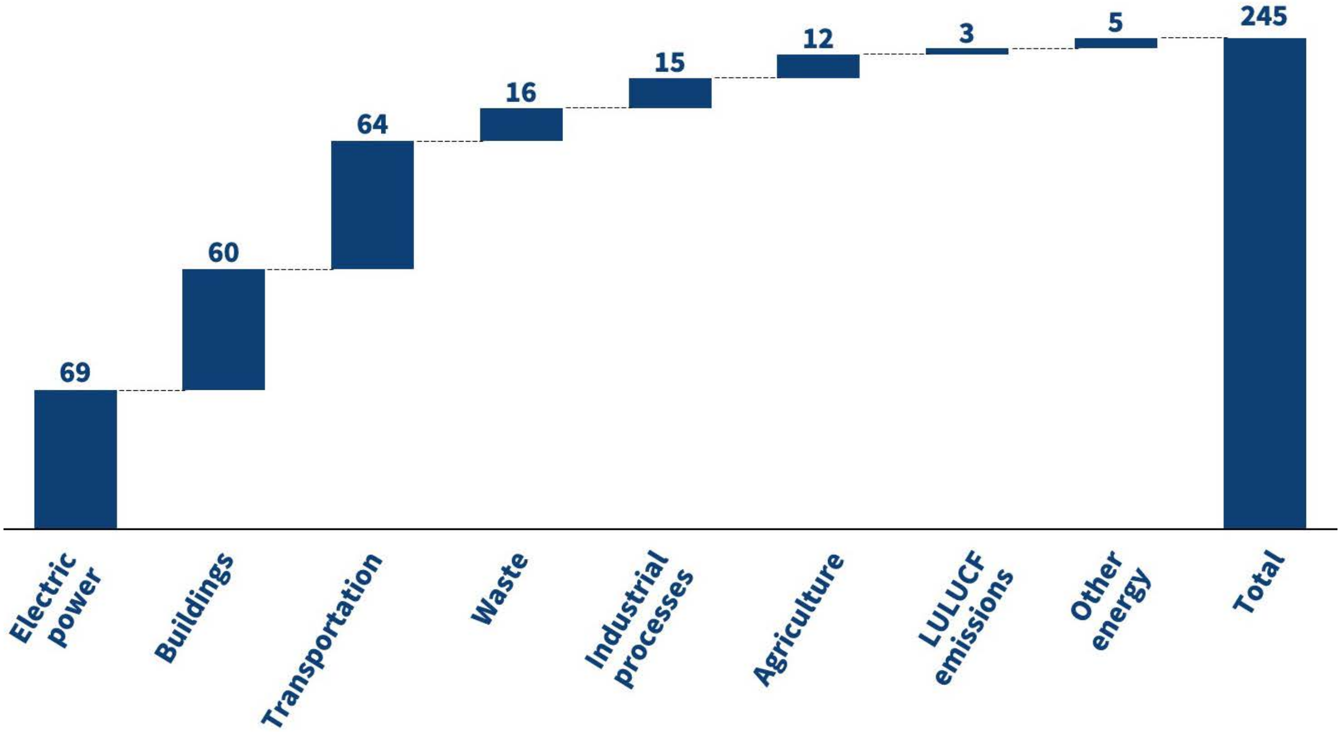

Figure 1. Ohio Statewide Gross GHG Emissions by Sector ($MMTCO_2e$)[14]

As shown in Figure 1, there are additional sectors aside from electric power, buildings, and transportation that are minor contributors to the statewide gross emissions total:

- Waste: 7%
- Industrial processes: 6%
- Agriculture: 5%
- LULUCF: 1%
- Other Energy: 2%

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[13] Indirect electricity emissions are less than 1% for transportation. Electric and other zero emission vehicles like hydrogen or fuel-cell were not accounted for in the SIT as Ohio BMV VMT data utilized does not distinguish vehicles by fuel types; these can be integrated into the GHG Inventory for the CRP

[14] "Other Energy" includes fossil fuels combusted in international bunker fuels (shipping and airfare fuels), coal mining, and natural gas and oil systems

Figure 2 shows net emissions within Ohio by reflecting emissions sinks and avoided emissions (negative values) in the waste and LULUCF sectors.

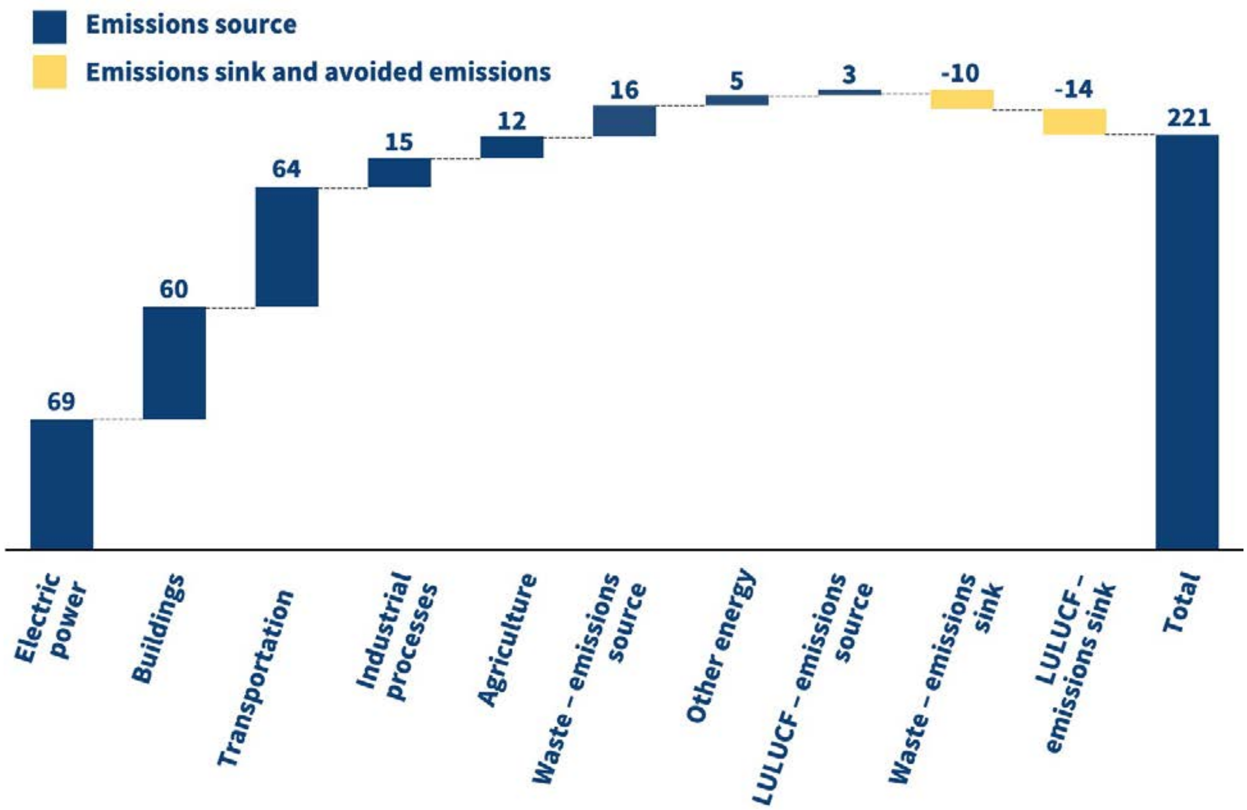

Figure 2. Ohio Statewide Net GHG Emissions by Sector (MMTCO$_2$e)[15]

Considering both gross and net emissions, the three sectors contributing the most to GHG emissions in Ohio are electric power, buildings, and transportation.

[15] "Other Energy" includes fossil fuels combusted in international bunker fuels (shipping and airfare fuels), coal mining, and natural gas and oil systems. "LULUCF – Emissions Source" includes emissions from conversion of forest land to land and N_2O emissions from settlement soils. "LULUCF – Emissions Sink" includes carbon sequestration or from forests; converting land to forest land; urban trees; landfilled yard trimmings and food scraps; and agricultural soil carbon flux. Emissions from Waste include CH_4 production from municipal solid waste generation and industrial generation, while emissions sinks, and avoided emissions include avoided CH_4 emissions from flaring and landfill gas-to-energy and oxidation at landfills

ELECTRIC POWER AND BUILDINGS

Fossil fuel combustion to generate electricity – referred to as "electric power" – results in 28% of total statewide gross emissions, as shown in Figure 1.

Electric power generation is the largest sector contributor to GHG emissions. Energy use in buildings (including residential, commercial, and industrial) consumes the vast majority of this produced electricity (99%), and transportation consumes the remainder (1%).[16] Energy use in buildings drives demand for electric power in Ohio and impacts the total emissions generated from this sector.

As shown in Figure 3, when considering both electricity consumed by buildings and fossil fuel combustion onsite, buildings are responsible for 129 MMTCO_2e, or 58% of total net emissions in Ohio.

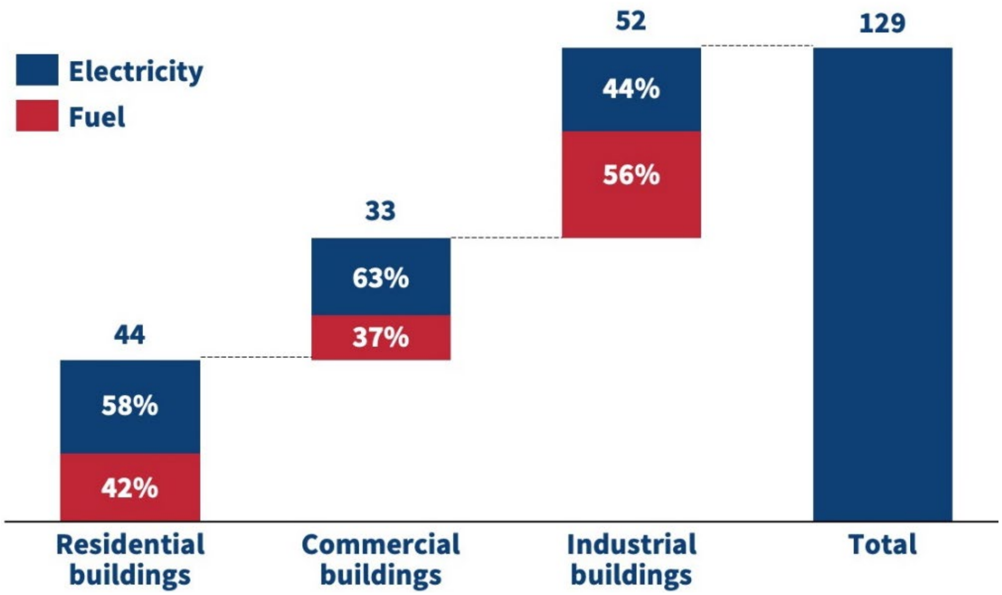

Figure 3. Building Emissions from Consumption of Energy (MMTCO_2e) [17]

Electricity is a larger source of residential and commercial building emissions than fuel, which means that more emissions are generated offsite at power plants as opposed to onsite combustion of fossil fuels at the buildings.[18]

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[16] Electric and other zero emission vehicles like hydrogen or fuel-cell were not accounted for in the SIT as Ohio BMV VMT data utilized does not distinguish vehicles by fuel types; these can be integrated into the GHG Inventory for the CRP

[17] See Appendix II for fossil fuel types included in SIT calculations by sector

[18] Emission from public buildings were not calculated separately in this Plan, but will be analyzed in the CRP

In industrial buildings, fuel emissions are higher than electricity emissions, meaning more emissions are generated from onsite combustion of fossil fuels as opposed to emissions generated offsite at power plants.

Among building types in Ohio, there are different sources of electricity consumption. While there are average trends for residential and commercial building types, the age, size, geography, climate, heating system, and other characteristics, dictate how this energy is consumed in the building and the resulting production of emissions from fuel and electricity use.[19] For example, older buildings may be more inefficient or rely on more carbon-intensive fuels for heating, while newer buildings are more likely to be electrified and efficient. Geography may also influence the emissions profile of a building. For example, buildings in colder areas may require more fuel for heating than buildings in warmer climates, thus leading to more emissions from the use of fuels.

It is notable that electricity use represents a greater share of the carbon footprint for residential and commercial buildings, whereas fuel use is a greater share of the carbon footprint for industrial buildings. This is driven by a combination of greater usage of onsite fuel compared to electricity in some cases as well as the carbon intensity of the onsite fuel type versus electricity. Because fuel usage is a significant portion of industrial building carbon footprints, there is an opportunity to look at specific decarbonization measures that target fuel use in industrial buildings to reduce the overall contribution of these buildings to Ohio's GHG emissions.

ELECTRICITY EMISSIONS FROM BUILDINGS

Figure 4 shows an assessment of electricity use in residential, commercial, and industrial buildings broken out by these building types. The breakout of electricity uses by building type allows for the assessment of how residential, commercial, and industrial buildings use electricity.

- For the average Ohio residential building, the largest proportion of electricity use emissions stem from lighting and appliances (54%).
- Lighting (18%), computers (9%), and other appliances (27%) are also the predominant sources (54%) of electricity use emissions for commercial buildings.
- In industrial buildings, manufacturing process equipment result in the most emissions (69%), with lighting (12%) and other appliances (4%) being relatively smaller sources of electricity use emissions.

[19] Space heating emissions only capture emissions from space heating via electricity from electric resistance and/or electric heat pumps. It does not include space heating emissions from fossil fuel combustion

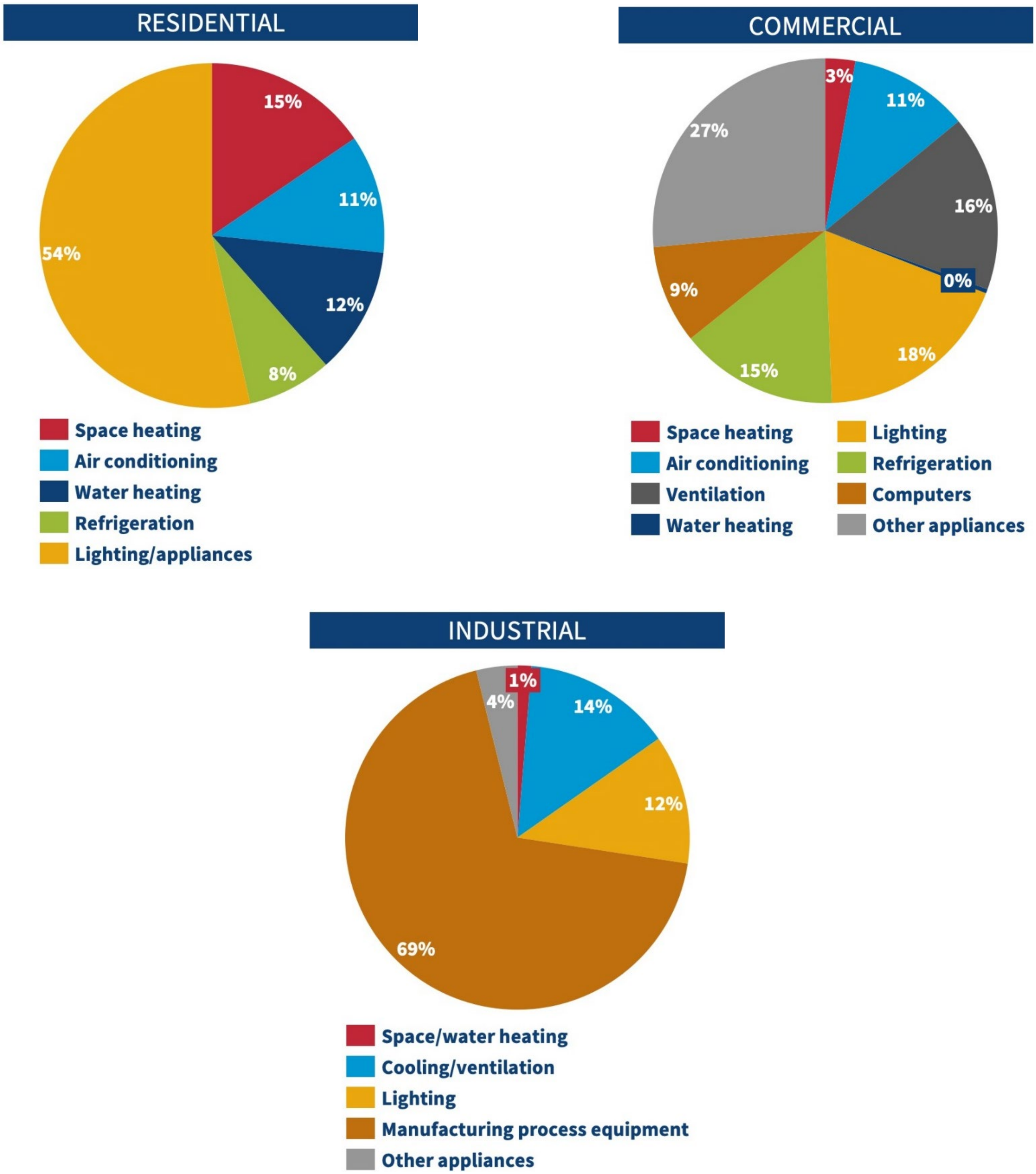

Figure 4. Ohio Statewide Buildings Electricity Emissions by Source [20]

[20] Electricity emission sources reported in SIT vary by residential, commercial, and industrial building types

FOSSIL FUEL COMBUSTION

The primary fuel types included in this inventory for electric power and buildings are coal, petroleum, and natural gas. Electric power generation burns fuel at power plants to produce electricity, whereas buildings commonly burn fossil fuels onsite for the following reasons:

- Space (air) and water heating
- Cogeneration (e.g., combined heat and power for routine onsite electricity generation)
- Backup power generation (e.g., generators used during power outages)

As shown in Figure 5, emissions from natural gas are the majority of overall emissions from the electric power and buildings sectors (38%). Natural gas use causes nearly one-third (30%) of electricity generation emissions and nearly three-quarters (73%) of building fuel emissions.

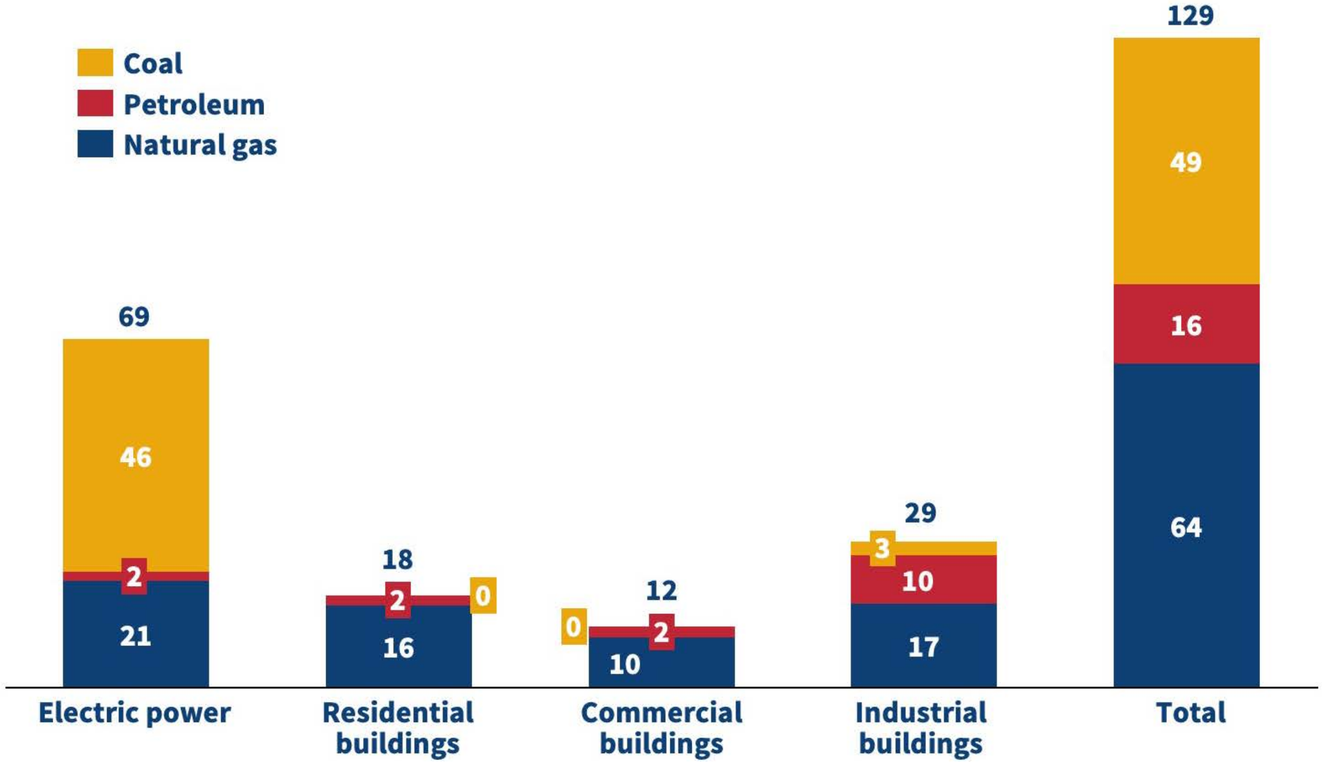

Figure 5. Ohio Emissions from Electric Power and Building Sectors, by Fuel Type (MMTCO$_2$e)[21]

Residential and commercial buildings predominately burn natural gas for heating, cogeneration, and/or back up power generation (approximately 87% of residential and commercial fuel emissions are from natural gas).

[21] See Appendix II for fossil fuel types included in SIT calculations by sector

Industrial buildings burn proportionally less natural gas (59%) than residential and commercial buildings, with greater consumption of petroleum (34%).

For electric power generation specifically, coal use is the cause of two thirds of emissions (67% of total electric power emissions). Coal is more emissions intensive than natural gas, meaning for one unit of energy, coal produces more emissions than natural gas. The use of coal in Ohio's electricity production contributes to higher overall emissions from Ohio's electric power generation when compared to other possible fuel mixes.

TRANSPORTATION

Transportation is the second largest individual contributor to statewide emissions (26% of gross emissions). Emissions from transportation come from the combustion of fossil fuels in vehicles, which releases GHG emissions into the atmosphere. In Ohio, these emissions predominantly come from on-road vehicles, such as passenger cars and trucks. Transportation also captures emissions from aviation, boats, and rail transport. Transportation is responsible for a small share of electricity consumption emissions, including use of electricity by electric rail.[22] Figure 6 shows the proportion of total transportation emissions that come from each type of vehicle.

On-road vehicles account for 84% of total transportation emissions in Ohio, including:

- Passenger cars
- Light-duty trucks
- Heavy-duty vehicles
- Heavy-duty buses
- Motorcycles

[22] Electric and other zero emission vehicles like hydrogen or fuel-cell were not accounted for in the SIT as Ohio BMV VMT data utilized does not distinguish vehicles by fuel types; these can be integrated into the GHG Inventory for the CRP

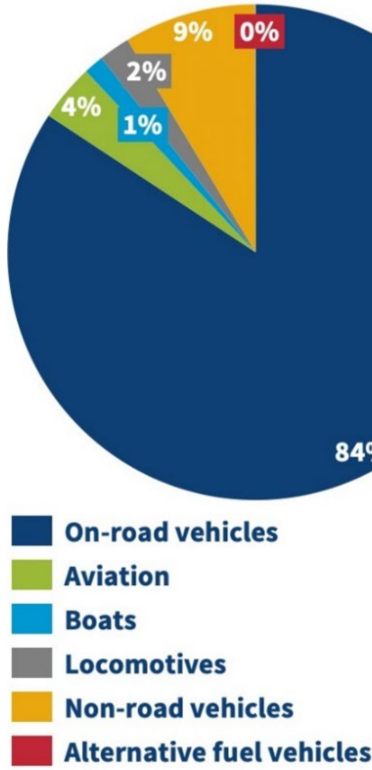

Figure 6. Ohio Statewide Transportation Emissions by Vehicle Type[23]

As seen in Figure 7, the vehicle types that contribute to most on-road vehicle emissions are passenger cars, light-duty trucks, and heavy-duty vehicles:

- Light-duty vehicles, including passenger cars and light-duty trucks, are the largest contributors representing 44% of total transportation emissions
- Heavy-duty vehicles, including large freight trucks (excluding transit and school buses) represent 24% of total transportation emissions
- Light-duty trucks represent 16% of total transportation emissions

[23] "Non-road vehicles" includes other miscellaneous mobile equipment, such as farm equipment, construction equipment, snowmobiles, small gasoline powered utility equipment, heavy-duty gasoline powered utility equipment, and heavy-duty diesel-powered utility equipment

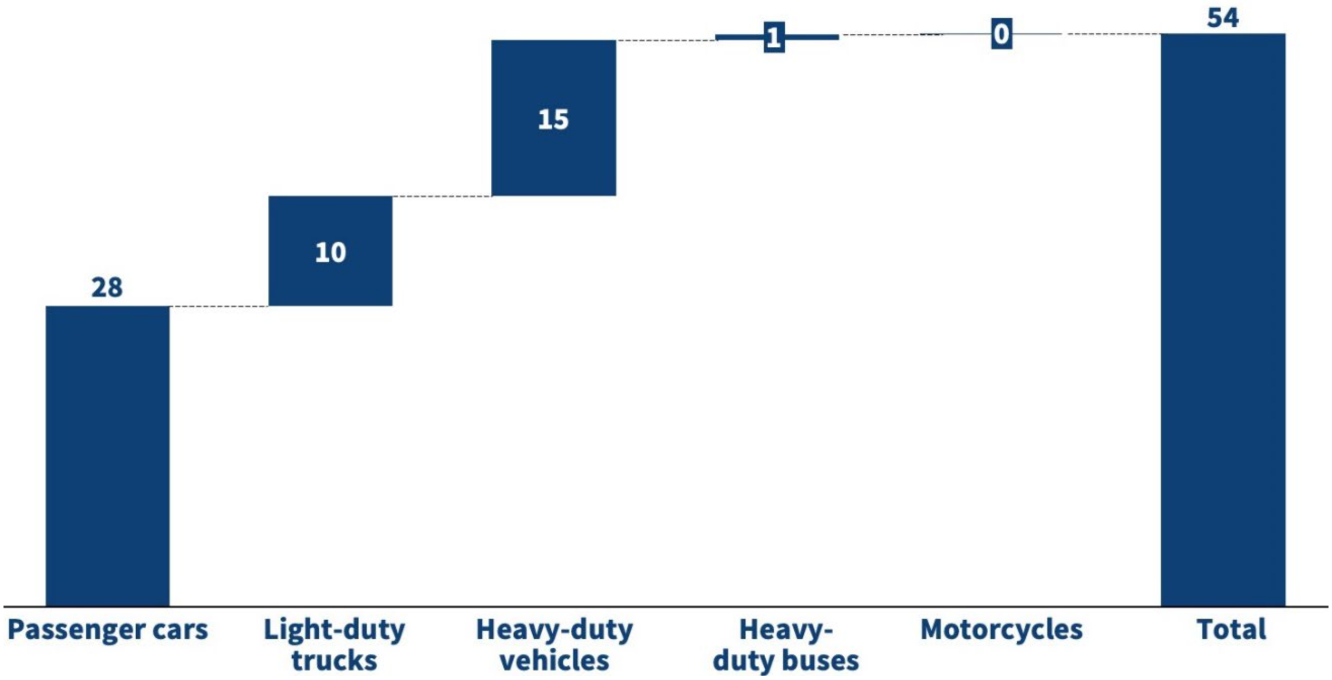

Figure 7. Ohio Statewide Transportation Emissions from On-road Vehicles (MMTCO$_2$e)

OHIO STATEWIDE EMISSIONS BY GHG TYPE

There are several types of greenhouses gases emitted from different types of sources that are included in Ohio's GHG inventory. While CO_2 is the primary GHG of focus, CH_4, N_2O, and fluorinated gases including HFCs, PFCs, SF_6, and NF_3, all have higher global warming potentials (GWP) than CO_2. [24] GWP is a metric developed to allow different types of GHGs to be compared based on their warming impact. It measures how much energy 1 metric ton of gas will absorb over time. The U.S. EPA SIT uses a period of 100 years for calculations. CO_2 is the reference gas for global warming potential and has a GWP of 1. The following are the GWPs of the GHGs included in Ohio's GHG inventory:

- CO2 = 1
- CH4 = 28
- N2O = 273
- Fluorinated gases = range from nearly thousands to tens of thousands

Figure 8 shows that CO_2 accounts for 86% of total statewide net emissions, even when accounting for the GWPs of the other GHGs.

The largest sources of CO_2 are electric power, buildings, and transportation. Meanwhile the largest sources of CH_4, N_2O, and fluorinated gases, respectively, are waste, agriculture, and industrial processes and materials manufacturing.

[24] Understanding Global Warming Potentials | US EPA

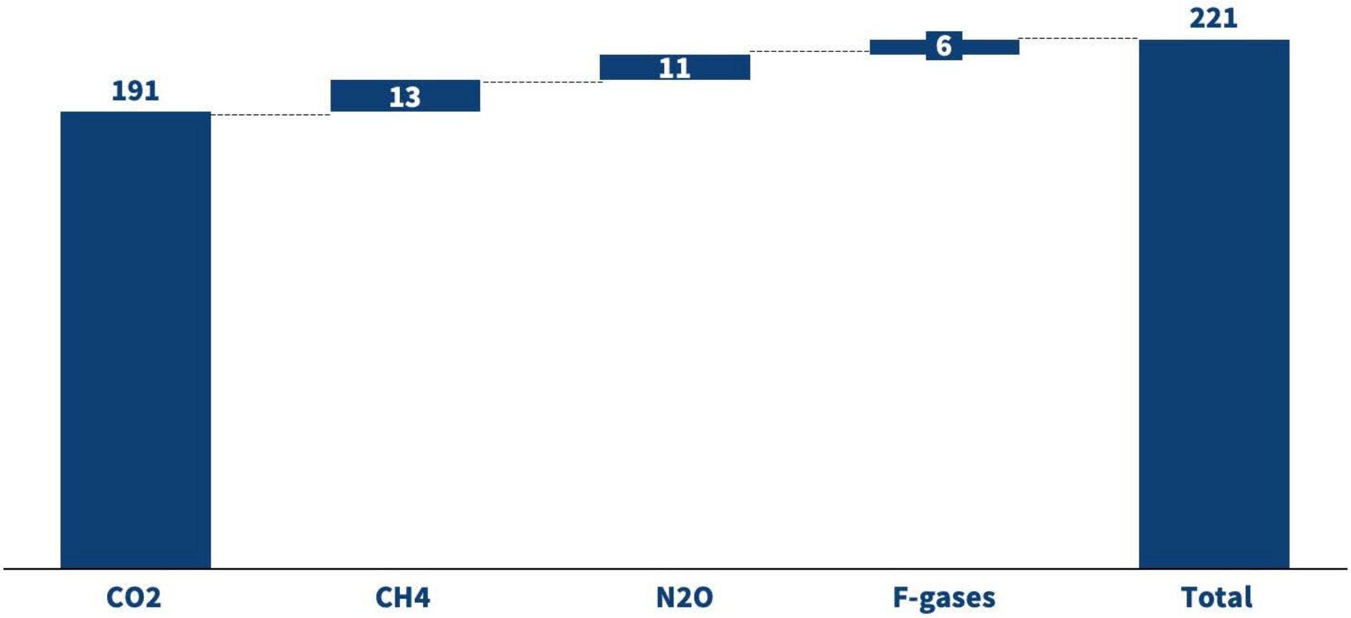

Figure 8. Total Statewide Net Emissions by GHG Type (MMTCO$_2$e)

Market Landscape

An analysis of key trends that affect GHG emission patterns was conducted for the three most emission-intensive sectors: 1) electricity generation; 2) buildings; and 3) transportation.

ELECTRICITY GENERATION

In Ohio, electricity generation is fueled primarily by the combustion of fossil fuels at power plants to create energy. There are a total of 31 investor-owned utilities (IOUs) and cooperative electric utilities (co-ops) in Ohio, plus municipal owned utilities, which are primarily responsible for the transmission and distribution of electricity in the state.[25] Currently, Ohio imports 20-25% of its electricity from regions outside the state, including Canada and neighboring states.[26,27]

Figure 9 shows the annual generation mix, or the mix of fuels and energy sources that are used to generate utility-scale electricity for Ohio in 2022. Eighty-four percent (84%) of Ohio's total electricity generation comes from fossil fuels, indicating a significant opportunity to increase the share of clean energy for electricity production to reduce Ohio's impact from this high-emitting sector. Ohio's emissions per megawatt-hour (MWh) of electricity production is 1,162 pounds (lbs) CO2e/MWh, which is higher emitting than the U.S. average (828 lbs CO2e/MWh).[28] As of 2022, in terms of electricity generation, Ohio is the 12th highest carbon dioxide-emitting state in the U.S.[29]

Natural gas is the most utilized energy source to generate electricity at 51% of total MWh, followed by coal at 32%. Petroleum represents a minor share of electricity generation (1%), while other energy sources represent less than 1%.

Clean energy, including renewables, currently represent a small percentage of Ohio's total electricity generation (16%), indicating there is significant opportunity for Ohio to maximize the use of clean energy to decarbonize its power generation. Clean energy, including renewables, currently represent a small percentage of Ohio's total electricity generation (16%), indicating there is significant opportunity for Ohio to maximize the use of clean energy to decarbonize its power generation.

Figure 10 shows the breakdown of electricity generation sources from clean energy in Ohio in 2022. Nuclear represents the largest share of total electricity generation from clean energy (76%), followed by wind (14%) and utility-scale solar (4%).

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[25] Ohio EV Charger Planning Map for Public (arcgis.com)

[26] U.S. Energy Information Administration – EIA – Independent Statistics and Analysis

[27] Imported electricity emissions are not included in Ohio's statewide GHG inventory boundary.

[28] US EPA eGrid 2022

[29] EIA Rankings: Total Carbon Dioxide Emissions (2021)

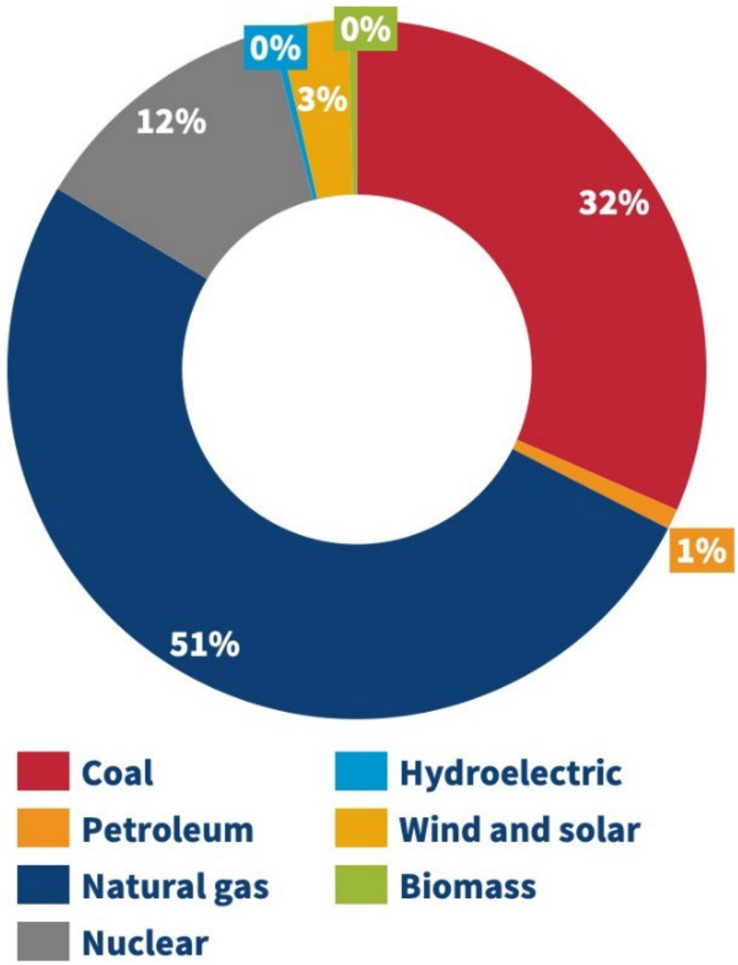

Figure 9. Ohio Annual Generation Mix (MWh) [30]

[30] Last year reported (2022) U.S. Energy Information Agency (EIA) data for Ohio's electricity generation. Natural gas includes contribution from other gases including blast furnace gas, natural gas, and other gas (undefined by EIA). More information can be found in the Technical Notes to this data

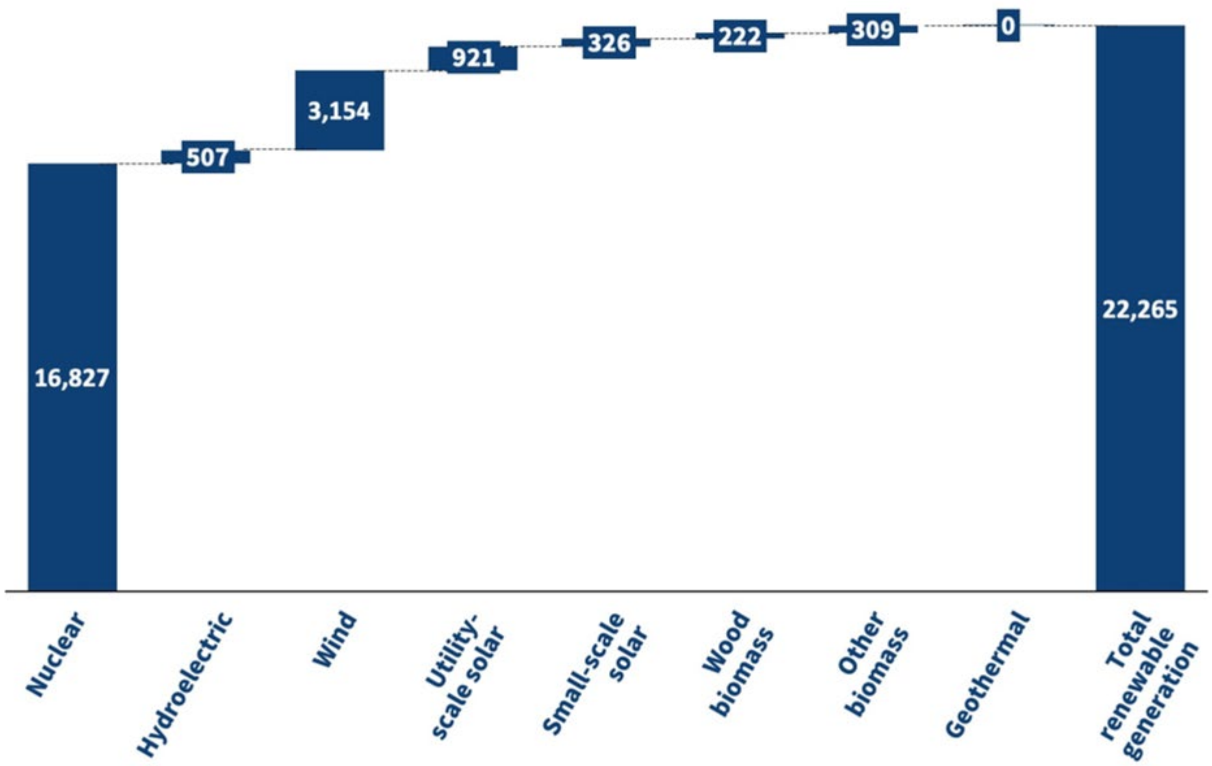

Figure 10. Ohio Annual Clean Energy Generation (MWh)[31]

BUILDINGS

The National Renewable Energy Laboratory (NREL)'s ResStock tool assesses the energy efficiency and electrification of residential homes in each state. Figure 11 shows the breakdown of homes in Ohio based on their year of construction. Older homes are typically less energy efficient due to poor insulation and outdated HVAC systems.[32] The majority of homes in Ohio were built between 1940 and 2000 (68%).[33]

Furthermore, most residential buildings in Ohio currently rely on fossil fuels or inefficient electric technologies for heating (Figure 12). Heating via a boiler or furnace burns fossil fuels to produce heat. Baseboard heating, while electric, is a dated and inefficient heating technology. Air source heat pumps are the most efficient way to heat a building using electric power, but currently there is limited use in Ohio, as seen in Figure 12. Therefore, there are significant opportunities for

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[31] Latest year reported (2022) U.S. Energy Information Agency (EIA) data for Ohio's electricity generation. This data only represents utility-scale electricity generation along with small-scale solar

[32] LEAD Tool | Department of Energy

[33] NREL ResStock Analysis

increased adoption of efficient heating electrification technologies to reduce emissions produced by Ohio homes.

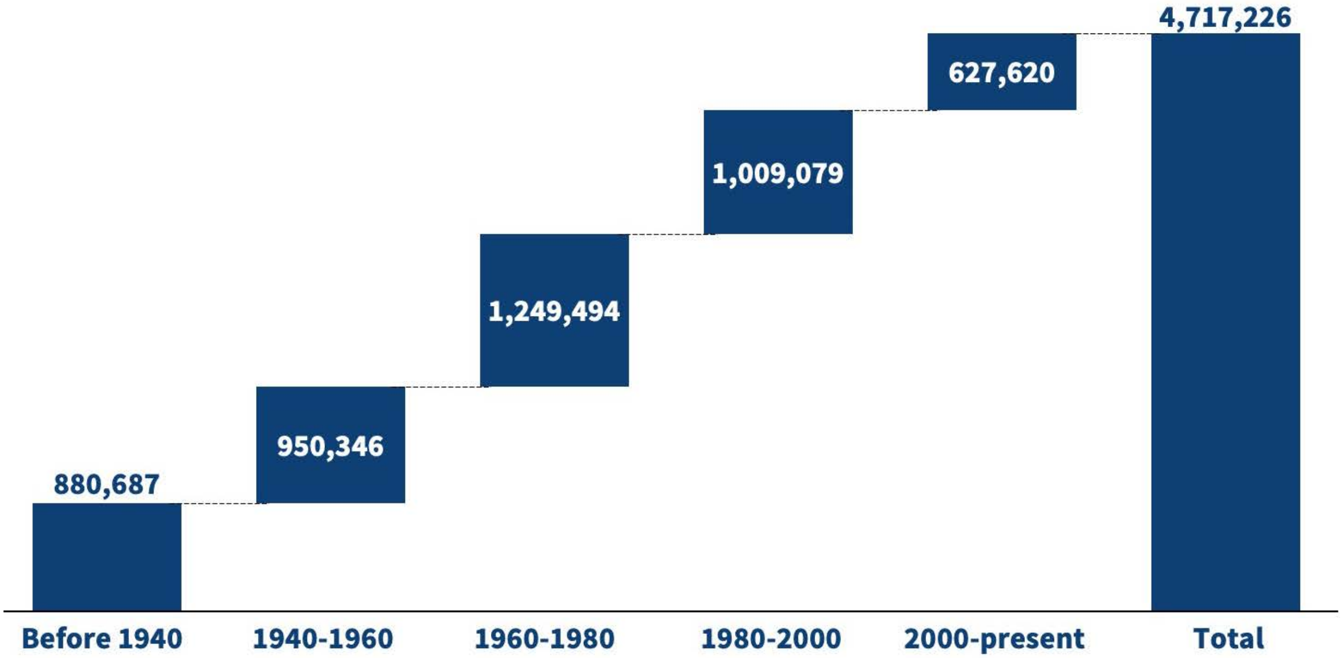
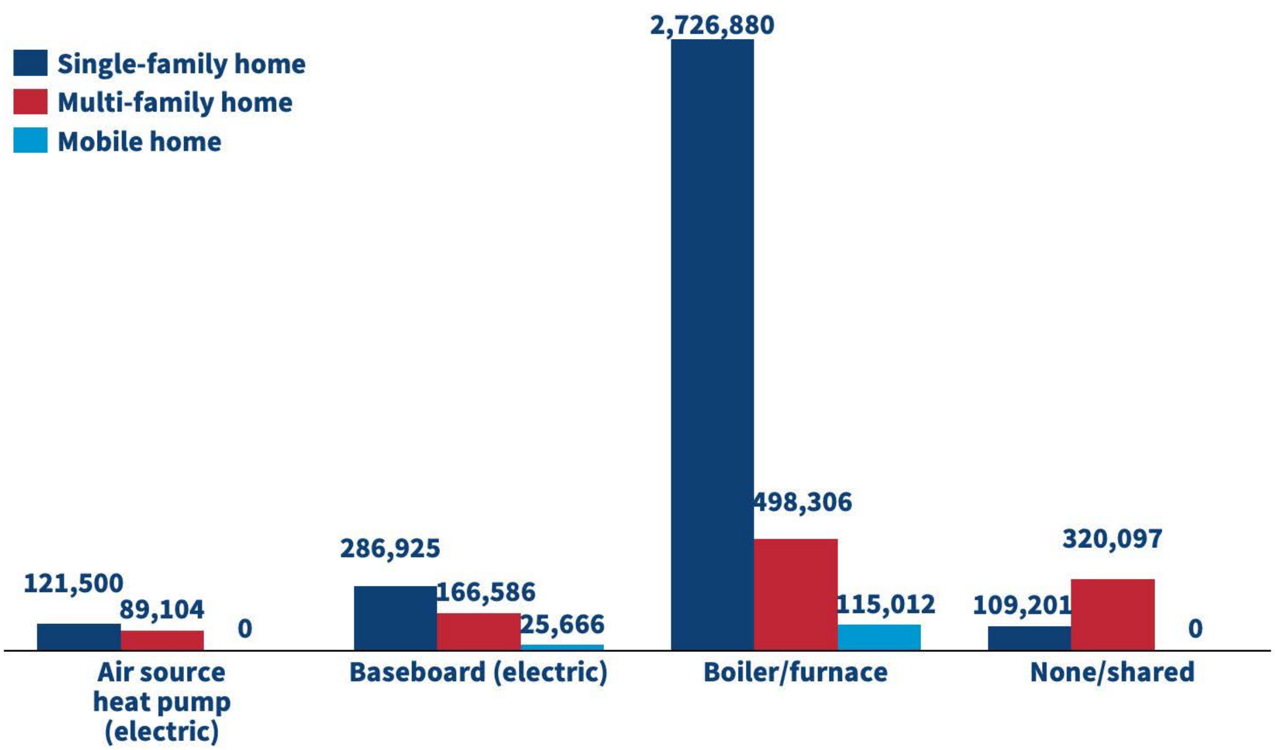


Figure 11. Residential Buildings in Ohio Based on Year Built (2023) [34]



[34] NREL ResStock Analysis

Figure 12. Heating System Types in Ohio Residential Buildings, by Type of Home (2023) [35]

Insulation of homes can also be an indicator of potential energy inefficiencies. U.S. EPA and the Department of Energy (DOE) recommend an insulation level of R10 or above for Ohio's climate zone.[36] As shown in Figure 13, over half of Ohio homes are uninsulated, and an additional 15% have insufficient insulation per the recommendation of U.S. EPA.

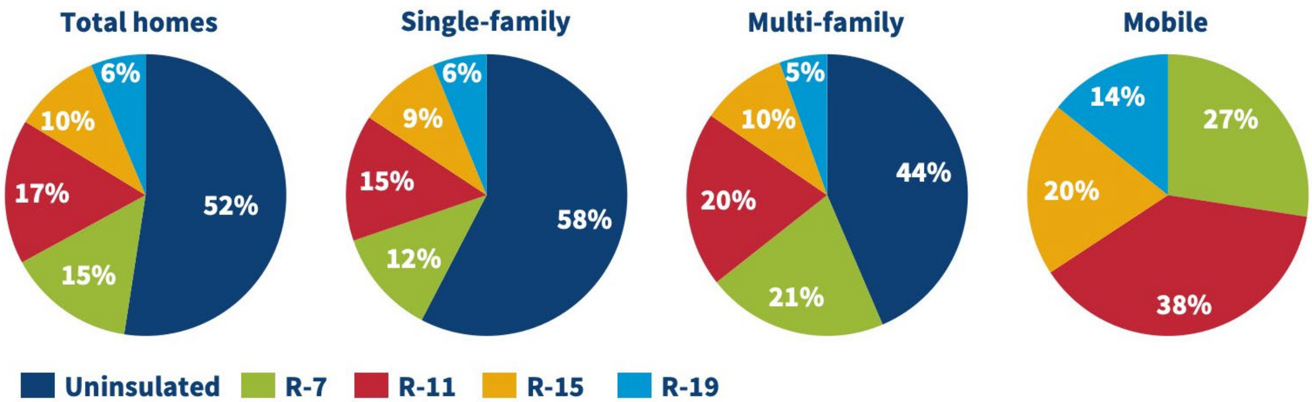


Figure 13. Insulation in Ohio Residential Buildings, By Type of Home [37]

The same principles apply to commercial and industrial buildings, where older buildings will likely require efficiency upgrades to save on energy and reduce GHG emissions.

TRANSPORTATION

The types of transport in Ohio that generate emissions includes passenger cars, light- and heavy-duty trucks, rail, boats, and aircraft. The most significant of these sources in terms of fuel combustion is transport by passenger cars and light- and heavy-duty trucks.

ON-ROAD VEHICLES

Light-duty cars – otherwise known as passenger cars – comprise most vehicle miles traveled (VMT) in Ohio (53% of total annual VMT). These passenger cars primarily burn gasoline, although this category can also include ZEVs or alternative fuel vehicles. Figure 14 shows annual VMT for GHG emitting on-road vehicles (not including ZEVs).[38] Meanwhile, buses, including public transit and school buses, represent less than 1% of total annual VMT.[39]

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[35] NREL ResStock Analysis, Heating System

[36] Recommended Home Insulation R–Values | ENERGY STAR

[37] NREL ResStock Analysis, Wall Insulation

[38] Electric and other zero emission vehicles like hydrogen or fuel-cell were not accounted for in the SIT as Ohio BMV VMT data utilized does not distinguish vehicles by fuel types; these can be integrated into the GHG Inventory for the CRP

[39] Other public transit, such as rail VMT data, was not available for this analysis.

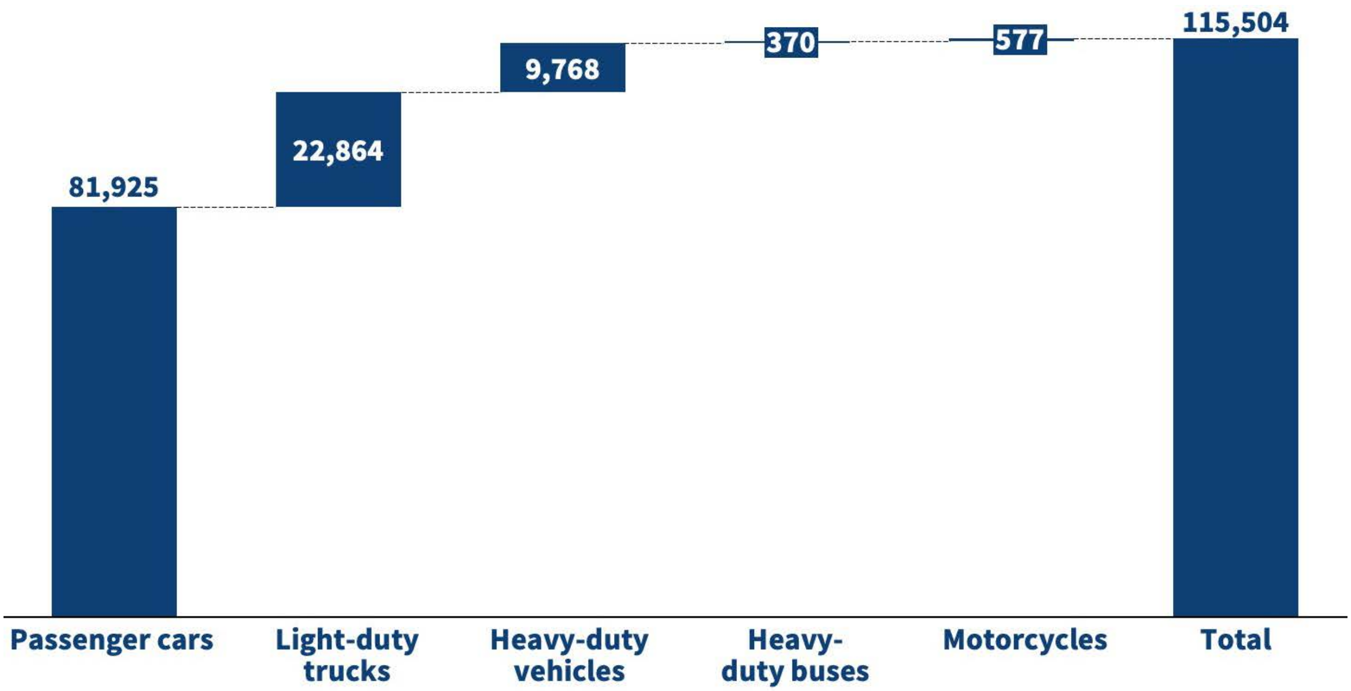

Figure 14. Annual VMT in Ohio for Emitting On-road Vehicles (Million Miles)

UPTAKE OF ELECTRIC VEHICLES IN OHIO

In 2022, the total number of fully electric vehicle registrations in Ohio was 34,100, representing less than 0.01% of total light-duty vehicle registrations in Ohio.[40] Ohio ranked 17th in the country for number of electric vehicle registrations, with California having the most at approximately 903,600 and North Dakota having the least at 600.[41] Total electric vehicle registrations in Ohio, including plug-in hybrids and hybrid electric, totaled 217,600. This number has been rising steadily since 2016.

Ohio has already begun to expand electric vehicle charging infrastructure to accommodate increasing demand. The Ohio Department of Transportation (ODOT) has a public map of all current Level 2 electric vehicle chargers (in green) shown in Figure 16, as well as planned future chargers (in blue) from the National Electric Vehicle Investment (NEVI) federal award funding Round I.

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[40] US Department of Energy Alternative Fuels Data Center, Vehicle Registration Counts by State

[41] US Department of Energy Alternative Fuels Data Center, Vehicle Registration Counts by State

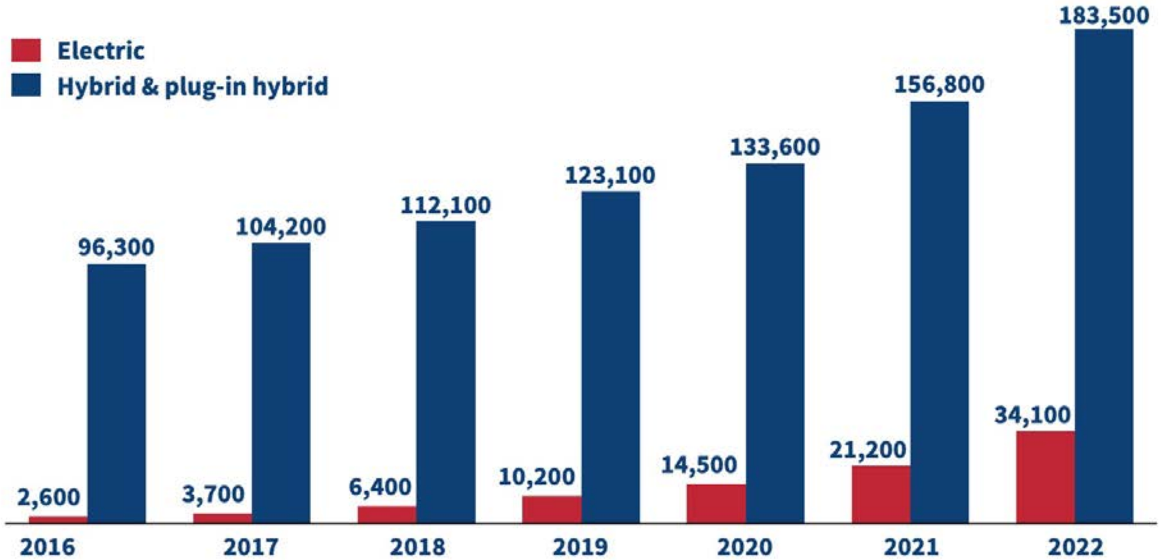

Figure 15. Electric Vehicle Registrations in Ohio 2016-2022[42]

[42] US Department of Energy Alternative Fuels Data Center, Vehicle Registration Counts by State

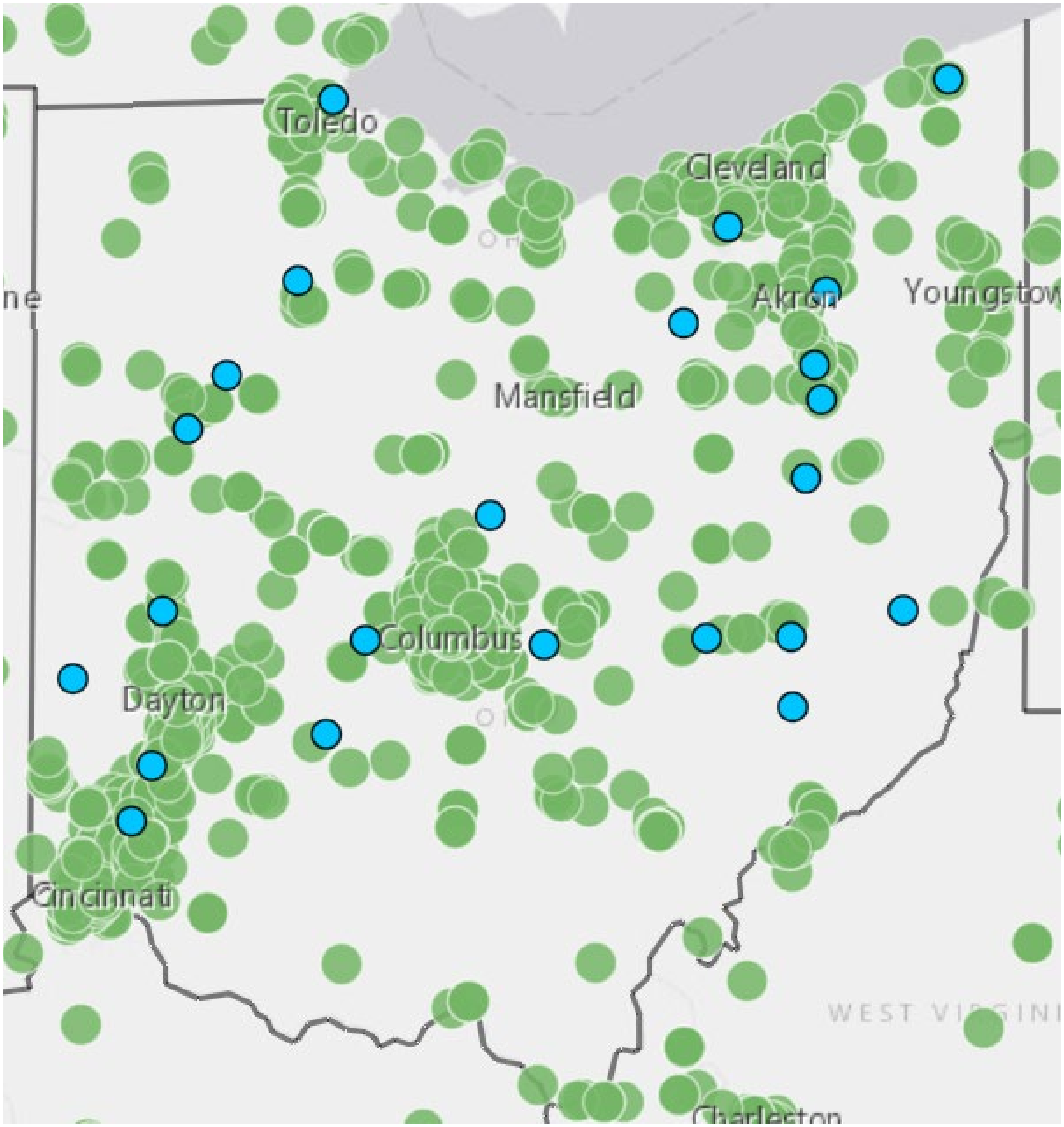

Figure 16. Ohio Level 2 EV Charging Stations (As of October 27th, 2023, and Round I Contingent NEVI Awards) [43]

[43] Ohio EV Charger Planning Map for Public (arcgis.com)

WALKING AND BICYCLING MODES OF TRANSPORT

Only 2.5% of Ohioans report walking (2.2%) or biking (0.3%) to work, according to the American Community Survey, and Ohio is ranked 28th in the country for combined walking and bicycling commute rates.[44] The state with the highest combined mode share for commuting to work is Alaska, with 8.78% of Alaskans commuting to work via bike or walking. Increasing the percentage of Ohioans who walk or bike would not only reduce GHG emissions, but also save people money and contribute to improved air quality.

Figure 17 depicts the current bike and shared lane infrastructure (both state and U.S. Bike Route System) in Ohio; it is important to acknowledge that this graphic may not be complete, as further analysis is required to understand the full system.

- Currently, the state and U.S. Bike Routes comprise more than 3,000 miles of network in more than 76 counties
- Segments of five U.S. Bike Routes are present in Ohio
- Each ODOT district has at least 150 miles of identified state or U.S. Bike Routes within their jurisdiction
- The majority of bicycle route segments are shared lanes; shared use paths are those that are separated from the roadway

[44] WBO_ExistingConditionsSummary_Final.pdf (ohio.gov)

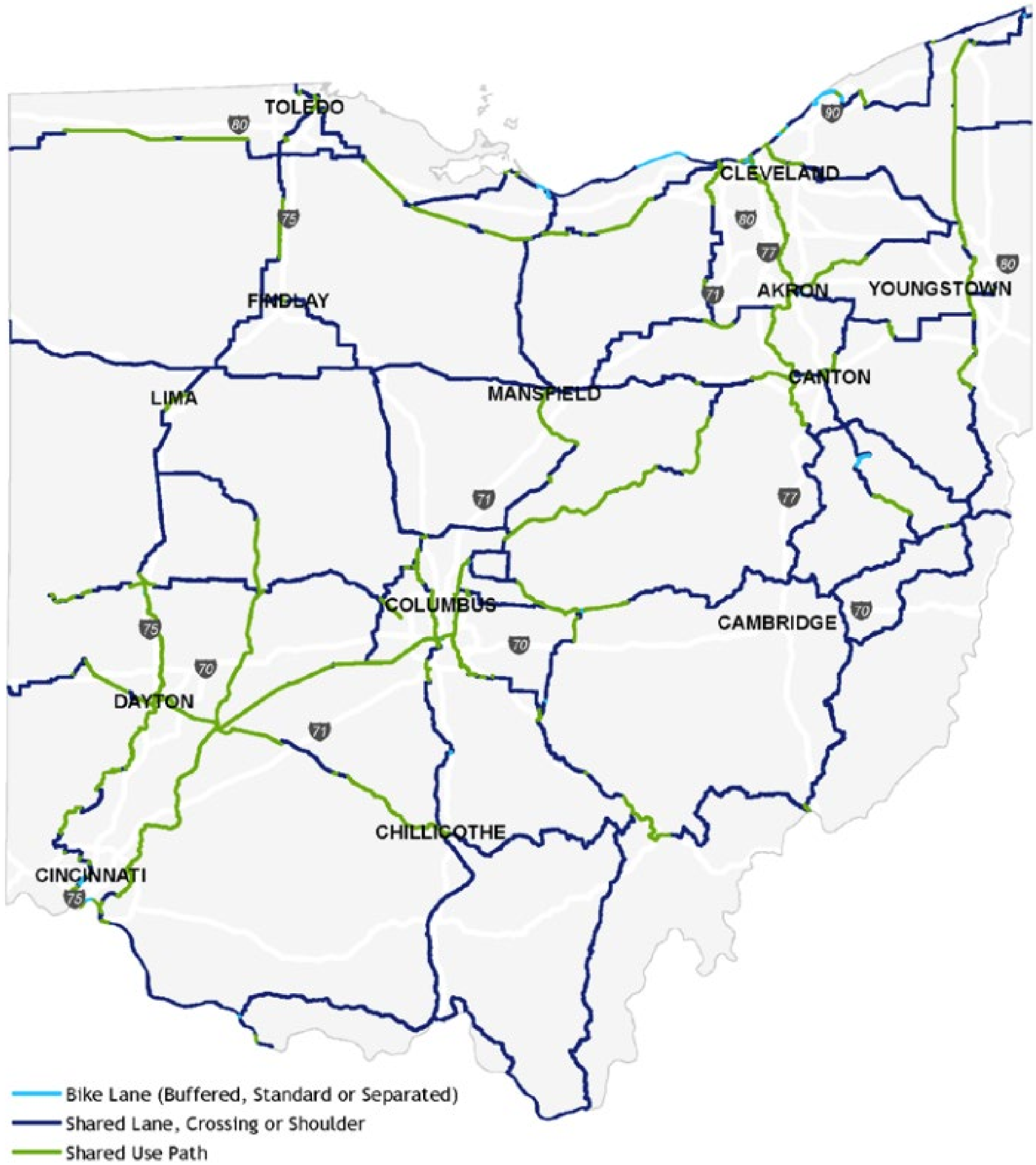

Figure 17. Current bike and shared lane infrastructure in Ohio[45]

[45] WBO ExistingConditionsSummary_Final.pdf (ohio.gov)

Priority GHG Reduction Measures

IDENTIFICATION AND PRIORITIZATION APPROACH

The GHG reduction measures in this section are identified as “priority measures.” These priority measures align with the state’s need to consider the most beneficial near-term opportunities to reduce emissions, including pursuing funding through CPRG implementation grants. This list of measures is not exhaustive of all of Ohio’s priorities.

To identify the reduction measures for inclusion in this Plan, Ohio EPA compiled a list of potential measures pertaining to different sectors and sources of emissions. Major sectors with the highest emissions identified in the statewide GHG inventory – electric power, buildings, and transportation – were of particular focus for Plan priority measures. However, the State recognizes minor sectors, such as agriculture and waste, may be the largest sources of emissions in some communities. Therefore, minor sector potential reduction measures were also accounted for, especially those that were heard as priorities during the State’s stakeholder engagement for the Plan.

Ohio EPA then conducted a screening process to identify a set of near-term, high impact priority measures. The screening framework for prioritization of reduction measures included evaluation of the following:

- **GHG emissions impact**: assessing the size of the source of emissions the measure impacted relative to the state’s total emissions.
- **Emissions reduction potential:** the potential of the measure to create emissions reductions within the specific emissions source it impacted.
- **Air emissions impact:** [e.g., criteria air pollutants (CAP) and hazardous air pollutants (HAP)], both the size of the air emissions source and the air emissions reduction potential of the measure.
- **Implementation feasibility:** the measures are readily deployable in the near term as defined by this Plan given current technical, regulatory, contractual, or other stakeholder coordination efforts.
- **Scalability:** the potential of a measure to be replicable across different geographic and demographic regions in Ohio.
- **Potential for co-benefits for other State priorities**: health impacts, economic impacts, or other environmental and social benefits beyond GHG emissions reductions especially benefiting LIDACs.

- **Intersection with other existing funding sources:** the availability of other federal, state, or municipal funding to implement the measure.

From this exercise, a reduced list of measures was identified for inclusion in the Plan. This list was then consolidated into three categories, with varying levels of analysis provided in this Plan for each measure:

1. **Priority Measures for State Implementation:** These measures were identified as those most suitable for near-term implementation by the State. This Plan includes a description of the measure and mechanisms for implementation, as well as estimates of the cumulative GHG emission reductions from 2025 through 2030 and 2050, cost estimates, impacts on LIDACs, authority to implement, and additional details, such as intersection with existing federal funding and workforce needs.[46]

2. **Priority Measures for the State of Ohio and Constituents:** These measures were identified as those most suitable for near-term implementation by other Ohio constituents, potentially in partnership with the State. Similar information to the Priority Measures for State Implementation is provided for these measures, except for long-term GHG reduction, cost estimate, intersection with existing federal funding, and workforce needs analyses.

3. **Other Measures the State of Ohio and Constituents Would Consider:** These measures were identified to be considered for near- to long-term implementation by the State and were relevant and potentially significant to Ohio constituents and other stakeholders within the state. A brief description of each of these measures is provided.

GHG REDUCTION CALCULATIONS

For each priority measure, estimated cumulative 2025 – 2030 GHG reductions were calculated based on a GHG reduction scenario. For priority measures for State Implementation, 2030 – 2050 estimated cumulative emission reductions were also calculated. Emission reduction scenarios included a combination of forecasts for future adoption based on market growth anticipated, additional growth from Plan-related activities associated with each measure, and lastly potential impact of implementation grant funding. Each priority measure aligns to a discrete sector or source of emissions for which percent reductions compare to baseline emissions.[47]

[46] Additional details can be found in Appendix IV

[47] See Appendix III for Methodology

AUTHORITY TO IMPLEMENT

Ohio EPA has reviewed existing statutory and regulatory authority to implement each priority measure contained in this Plan and has not found any State statute or regulation that would preclude these measures from being implemented in Ohio.

1. LIGHT-DUTY ZERO EMISSION VEHICLES (ZEVS) AND MODERNIZATION

What is a zero emission vehicle? [48]

Zero Emission Vehicle (ZEV): An on-road passenger car or light-duty vehicle, light-duty truck, medium-duty vehicle, or heavy-duty vehicle that produces zero exhaust emissions of all of the following pollutants: non-methane organic gases, carbon monoxide, particulate matter, formaldehyde, oxides of nitrogen, or greenhouse gas emissions including carbon dioxide, methane, and nitrous oxide, including, but not limited to, battery electric vehicles ("BEV") and fuel cell vehicles ("FCEV").

Plug-in Hybrid Electric Vehicle (PHEV): An on-road passenger car, light duty truck, medium duty vehicle, or heavy-duty vehicle that has both a battery / electric motor and an internal combustion engine (ICE) and gasoline tank. PHEVs do produce exhaust emissions when relying on the internal combustion motor but produce none when relying on electric.

Battery Electric Vehicle (BEV): All electric vehicle with electric motor. Uses battery pack to store electricity that powers the motor. BEVs do not emit any harmful tailpipe emissions.

Fuel Cell Vehicle (FCEV): FCEVs are ZEVs powered by hydrogen, which is used to generate electric power onboard. FCEVs do not emit any harmful tailpipe emissions.

DESCRIPTION

Expanding light-duty ZEVs and modernization in Ohio aims to promote environmentally friendly and efficient transportation options like BEVs and other alternative fuel vehicles to reduce GHG emissions and improve air quality.[49] Achieving this goal requires the development and expansion of robust charging infrastructure, including residential, commercial, and public charging stations.

MEASURE TYPE

Priority measure for State implementation

APPLICABLE SECTOR

Transportation

[48] Frequently Asked Questions on the Zero Emission Vehicle Investment | US EPA

[49] Defined by the Federal Highway Administration as Class 1 (<6,000lbs) or Class 2 (6,001-10,000lbs) vehicles

RELATED GHG EMISSIONS

Light-duty passenger cars and trucks represent:

- 16% of total gross emissions
- 44% of total transportation emissions

RELATED PROGRAMS AND POLICIES

The State of Ohio is engaged in/supported by numerous federal grants and programs that will facilitate the transition to light-duty ZEV, including:

- NEVI funding through the Bipartisan Infrastructure Law (BIL); Ohio has been awarded $140 million to deploy over five years, including approximately $20.7 million in funding in FY22 and is predicted to total $140 million through 2026. Ohio's NEVI Plan documents the State's approach to deploy public charging infrastructure across Federal Highway Administration (FHWA) Designated EV Alternative Fuel Corridors (AFCs).
- Federally allocated financial incentives under the Inflation Reduction Act (IRA) to encourage consumers and companies to purchase EVs / FCEVs.
  - The IRA continues the Qualified Plug-in Electric Drive Motor Vehicle Credit, also known as the Clean Vehicle Credit, which provides up to $7,500 per qualified plug-in electric vehicle or fuel cell vehicle.
  - The IRA provides a Used Clean Vehicle Credit for qualified used electric vehicle or fuel cell vehicles from licensed dealers for $25,000 or less. The credit equals 30% of the sale price up to $4,000.
  - Business and tax-exempt organizations can access the Commercial Clean Vehicle Credit. The credit provides a maximum of $7,500 for qualified vehicles with gross vehicle weight ratings of under 14,000 pounds.
- Federally allocated financial incentives under the IRA to encourage the purchase of ZEV charging infrastructure, such as Alternative Fuel Vehicle Refueling Property Credit. The credit is available for qualified fueling property (including clean burning fuel or electric) installed on qualified locations and can be leveraged by individual households and commercial entities.
  - Businesses are eligible for up to $100,000 per item
  - Consumers are eligible to receive a tax credit up to 30% of the cost, up to $1,000

The State of Ohio also facilitates or supports the following programs:

- Vehicles powered by electricity are exempt from state motor vehicle emissions inspections after a one-time verification inspection. Vehicles operating on alternative fuels require one-time visual verifications by the Ohio EPA Mobile Sources Section.

Utilities and local cities are also involved with the transition to light-duty ZEVs, and have taken the following actions:

- Cincinnati has announced plans to buy electric vehicles and eventually transition to all electric vehicle fleets.

- Cleveland is developing new charging stations within city limits.
- Utilities, including rural ones, such as the Firelands Electric Cooperative, offer rebates to support the installation of EV chargers.

ACTIVITIES

There are several potential activities the State can use to support the transition to light-duty ZEVs and modernization. Ohio stakeholders are focusing attention on expanding electric vehicles rather than the broader group of ZEVs. Sources that supported the development of this list include the ODOT study on freight electrification, stakeholder interviews, and additional research into other state incentives and programs:

- **Expanding financial incentives**: Provide incentives such as direct rebates, tax credits, and grants for ZEV purchases or leases for the public and larger organizations, with targeted support for low/middle-income households and private charging/alternative fuel equipment purchases. This also applies to modernization technologies, such as anti-idling systems.
- **Investing in alternative fueling infrastructure**: Increase the number of alternative fueling stations (e.g., charging stations) and promote their operational maintenance through financial incentives and/or regulatory changes to reduce wait times to improve the overall ZEV driving experience.
- **Investing in public fleets:** Provide financial incentives to encourage public entities to modernize fleets, including purchasing ZEVs and other alternative fuel vehicles, adopting emissions reduction technologies, such as anti-idling technology, and performing operational maintenance to reduce inefficiencies.
- **Driving perks for electric vehicle users:** Encourage ZEV adoption by offering benefits like access to high-occupancy vehicle (HOV) lanes and toll discounts.
- **Updating building codes and zoning standards:** Promote preparation for the widespread adoption of EVs by considering updating regulations to accommodate future EV charging equipment installation.
- **Studies on electrification and pollution:** Support research on various topics, including strategies for improving low-income ZEV adoption and addressing the disproportionate impact of pollution on vulnerable communities across Ohio.
- **Financing and taxation solutions:** Leverage Ohio Air Quality Development Authority (OAQDA)'s Clean Air Improvement Program for funding clean vehicles and infrastructure, explore new financing options, and study gas tax alternatives as ZEV adoption becomes more widespread.
- **Collaboration with other states and federal systems:** Work closely with other states and federal systems to formulate cohesive resolutions for ZEV adoption and related issues.

Additional opportunities exist at the municipal and utility levels to expand ZEV adoption, including:

- Set local fleet electrification goals
- Asses public charging needs
- Support matchmaking of stakeholders involved in charging infrastructure
- Educate members, officials, and staff on fleet electrification

- Adopt ordinances and regulations for ZEV-friendly infrastructure and parking
- Review of ZEV feasibility in government fleets
- Consider innovative financing for ZEV adoption
- Collaborate with utilities to optimize ZEV integration
- Conduct demonstrations and gather regional ZEV data
- Share lessons learned from ZEV implementation projects
- Ensure ZEV rollouts generate enthusiasm and user satisfaction
- Develop programs that support / subsidize ZEV ownership in rural areas

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[50]

2025 – 2030: 3.9 up to 6.4 MMTCO_2e

- 6 – 7% reduction in tailpipe light-duty vehicle GHG emissions.
- 3 – 5% reduction in electricity generation GHG emissions (assuming increased renewables to accommodate charging demand).
- 2 – 3% reduction in total net GHG emissions.

2030 – 2050: 15.7 up to 25.7 MMTCO2e

- 25 – 29% reduction in tailpipe transportation GHG emissions.
- 10 – 20% reduction in electricity generation GHG emissions (assuming increased renewables to accommodate charging demand).
- 7 – 12% reduction in total net GHG emissions.

ESTIMATE OF CO-POLLUTANT REDUCTIONS

Co-pollutants – other air emissions – are also reduced alongside GHG emissions. The table below summarizes the annual co-pollutant reductions under the same parameters as the GHG reductions.

CO-POLLUTANT	POUNDS REDUCED ANNUALLY 2025 – 2030
Sulfur Dioxide, SO_2	503,060 to 535,200
Nitrous Oxides, NO_x	459,920 to 720,780

[50] Expanding electric vehicle adoption was the ZEV focus for GHG reduction calculations for the Plan; however, this can be expanded to cover other ZEV for the CRP. To do so, U.S. Department of Energy (DOE) Alternative Fuels Data Center (AFDC) Ohio electric vehicle registration data and 2016 – 2022 trends were analyzed to forecast market adoption emissions reductions and additional reductions with an implementation grant scenario. The U.S. EPA's Avoided Emissions and Generation Tool (AVERT) was used to calculate tailpipe emission reductions and emission impacts of increased electricity generation based on the average 2025 – 2030 annual growth projections of EVs. Energy Information Agency (EIA) Wind and Solar Energy Industries Association (SEIA) wind and solar trends and projections were considered. For 2030 – 2050, the 2025 – 2030 five-year growth in vehicles and associated emission reductions was assumed to be the same for the remaining four, five-year periods 2030 – 2050. See Appendix III for sources and additional details

Particulate Matter 2.5, $PM_{2.5}$	39,110 to 44,350
Volatile Organic Compounds (VOCs)	180,500 to 546,970
Ammonia (NH_3)	44,190 to 105,720

Co-pollutants – other air emissions – are also reduced alongside GHG emissions. The table below summarizes the annual co-pollutant reductions under the same parameters as the GHG reductions.

Note: Range based on market adoption and additional estimates.[51] Reductions are less than 1% of total Ohio co-pollutants; however, certain regions may see more significant benefits with uptake.[52]

ESTIMATE OF COSTS[53]

- Average cost of a passenger EV is nearly $34,000[54]
- Average cost of a Level 2 charger and installation is $1,990[55]
- Estimated operating savings of $579[56] pays back the costs of charging within four years, assuming average mileage
- Additional State ZEV incentives could offer an average of $2,500 per vehicle[57]

INTERSECTION WITH FEDERAL FUNDING

Please see Appendix IV for a description of the intersection with federal funding for this measure.

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[51] Outputs from U.S. EPA AVERT

[52] Based on average pounds reduced annually from 2020 National Emissions Inventory (NEI) data including CAP, HAP, PFAS (Per- and Polyfluoroalkyl Substances), and other co-pollutants not defined as GHGs

[53] For Ohio's CRP, the total cost of ownership of an internal combustion engine (ICE) fossil fuel vehicle versus ZEVs across types including upfront costs of the vehicles, operations (fuel and electricity costs), maintenance differences, and other key capital and operating variables will be assessed

[54] Average of Tesla, Chevrolet, and other brands least expensive cars and budget SUV upfront costs

[55] Alternative Fuels Data Center: Charging Infrastructure Procurement and Installation (energy.gov)

[56] Estimated based on annual average residential charging demand (kWh) from Energy Sage and EIA residential electricity prices for Ohio as of November, 2023 compared to average gallons of fuel consumed per FHWA and EIA Midwest gasoline prices as of January 2024

[57] See Appendix III for Methodology

2. MEDIUM- AND HEAVY-DUTY (MDHD) ZERO EMISSION VEHICLES (ZEV) AND MODERNIZATION

DESCRIPTION

Expanding MDHD ZEVs and modernization in Ohio aims to promote environmentally friendly and efficient transportation options such as battery electric vehicles (BEV), hydrogen fuel cell, and other alternative vehicles to reduce GHG emissions and improve air quality.[58] Broad medium- and heavy-duty vehicle electrification refers to the transition from internal combustion engines (ICE) to electric or fuel cell commercial trucks, buses, and specialized larger port and agricultural vehicles. Successful implementation relies on innovation in batteries, especially for long distance freight trucks, sophisticated charging infrastructure, improvements to hydrogen and alternative fuel technologies, and supportive policies for a cleaner, more sustainable future.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

APPLICABLE SECTOR

Transportation

RELATED GHG EMISSIONS

MDHD trucks and buses represent:

- 7% of total gross emissions
- 25% of total transportation emissions

RELATED PROGRAMS AND POLICIES

The State of Ohio is engaged in numerous federal grants and programs that support the transition for MDHD ZEVs, including:

- NEVI funding through the BIL: Ohio has been awarded $140 million to deploy over five years, which includes approximately $20.7 million in funding in FY22 and is predicted to total $140 million through 2026. Ohio's NEVI Plan documents the State's approach to deploy public charging infrastructure across FHWA Designated EV AFCs.
- The Regional Clean Hydrogen Hubs program includes up to $7 billion to establish hydrogen hubs as part of a larger $8 billion effort funded through the BIL. The program aims to scale up hydrogen production, processing, delivery, storage, and end-use of clean hydrogen. Ohio will receive funding through the Appalachian Hydrogen Hub.
- Ohio school districts benefit from the U.S. EPA's Clean School Bus Program, which, through the BIL, provides $5 billion between 2022-2026 to replace existing school buses

[58] Medium and Heavy-Duty vehicles are defined by the FHFA as vehicles greater than 10,000 lbs

with zero- and low-emission models. The program awarded 39 Clean School Bus Awards in the state of Ohio in 2022.

- The IRA allocates approximately $1 billion in funding for clean heavy-duty vehicles between now and 2031. The funding can be used to replace heavy-duty vehicles, ZEV infrastructure, workforce development and training, and planning and technical activities.
- The U.S. is signatory to the Global Memorandum of Understanding on Zero Emission Medium and Heavy Duty Vehicles, which hopes to enable 100% zero-emission new truck and bus sales by 2040.
- Diesel Emissions Reduction Grants are funded through federal Congestion Mitigation and Air Quality (CMAQ) dollars awarded by the Federal Highway Administration to the ODOT. CMAQ provides roughly $2.6 billion each through 2026 after being reauthorized and extended under the IRA.

The State of Ohio also facilities or supports the following programs:

- Ohio EPA offers grants for the replacement or repower of eligible on- and off-road vehicles and equipment, including Class 4-8 trucks, school, shuttles, public transit buses, freight-switcher locomotives, etc. The funding for these grants is sourced from Ohio's share of an Environmental Mitigation Trust Fund. The fund was developed as part of Volkswagen's settlement with U.S. EPA following allegations that they violated the Clean Air Act.
- Vehicles powered by electricity are exempt from state motor vehicle emissions inspections after a one-time verification inspection.

Additionally, ODOT implemented the DriveOhio initiative in 2018, which aims to connect all the organizations supporting Ohio's smart mobility efforts. As part of this initiative, DriveOhio produced a freight electrification report, released in 2021, detailing steps Ohio can take to support MDHD vehicle electrification.

ACTIVITIES

The State of Ohio has several potential activities through which it can support the transition from ICE MDHD vehicles to ZEVs. The ODOT study on freight electrification detailed the following areas where the state or relevant agencies can take steps to prepare for freight electrification:

- **Codes and Standards:** Promote updating building codes and zoning standards to prepare for future installation of ZEV fueling equipment (e.g., chargers, hydrogen fueling station).
- **Market Research:** Support additional studies into topics relevant to the ZEV effort, including potential strategies to address the disproportionate impact of pollution from freight / logistics operations.
- **Vehicle Incentives:** Reform and streamline Diesel Emission Reduction Grant (DERG) program, adopt voucher, and rebate best practices, and align new state initiatives with federal programs.
- **Infrastructure Incentives**: Consider state incentives for ZEV fueling infrastructure including freight electrification and combine administration with new federal sources (for applications not eligible under NEVI).
- **Education and Financing**: Utilize OAQDA financing/forgiveness tools through the Clean Air Improvement Program (CAIP) for clean vehicles and infrastructure and explore

additional financing programs. Expand education programs related to Federal and State incentives / programs.

- **Taxation**: Study solutions for gas tax replacement with ZEV adoption, collaborate with other states and federal systems for common resolutions.

Additional opportunities exist at the municipal and utility levels, including:

- Set local fleet electrification goals
- Analyze opportunities to add ZEVs to various fleets
- Conduct assessments of public charging needs
- Support matchmaking of stakeholders involved in charging infrastructure
- Educate members, officials, and staff on fleet electrification and ZEV infrastructure
- Promote adoption of ordinances and regulations for ZEV-friendly infrastructure and parking
- Promote thorough review of ZEV feasibility in government fleets
- Consider innovative financing for ZEV adoption
- Collaborate with utilities to optimize ZEV integration
- Conduct demonstrations and gather information on regional ZEV data
- Share lessons learned from ZEV implementation projects
- Ensure ZEV rollouts generate enthusiasm and user satisfaction
- Lower charging costs through battery storage technology

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[59]

2025 – 2030: 309,910 $MTCO_2e$

- 2% reduction in bus tailpipe GHG emissions
- <1% reduction in total net GHG emissions (since buses only comprise a small proportion); however, reduces numerous other co-pollutants

ESTIMATE OF CO-POLLUTANT EMISSION REDUCTIONS[60]

Co-pollutants – other air emissions – are also reduced alongside GHG emissions. The table below summarizes the annual co-pollutant reductions under the same parameters as the GHG reductions. While reductions are less than 1% of total Ohio co-pollutants, certain regions may see more significant benefits with uptake.

[59] Buses were selected as the MDHD asset of focus for GHG reduction scenario for the Plan aligned with the U.S. EPA AVERT tool's capabilities to accommodate this MDHD asset class; however, this can be expanded for the CRP to cover other MDHD asset classes. Ohio BMV Vehicle Registration data for 2022 was utilized as a proxy for 2024 to determine the total number of buses in the state. AVERT was then used to calculate tailpipe emission reductions and emission impacts of increased electricity generation based on the average 2025 – 2030 annual growth projections of electric transit and school buses. Energy Information Agency (EIA) Wind and Solar Energy Industries Association (SEIA) wind and solar trends and projections were considered. Notably, only one year's worth of emission reductions is accounted for assuming vehicles are operational by 2030; however, emissions would be even greater if vehicles were converted prior to 2030. See Appendix III for sources and additional details

[60] Outputs from U.S. EPA AVERT

CO-POLLUTANT	POUNDS REDUCED ANNUALLY 2025 – 2030
Sulfur Dioxide, SO_2	547,810
Nitrous Oxides, NO_x	374,200
Particulate Matter 2.5, $PM_{2.5}$	37,480
Volatile Organic Compounds (VOCs)	12,150
Ammonia (NH_3)	16,020

INTERSECTION WITH FEDERAL FUNDING

- Low or No Emission Grant Program: Ohio awarded $29.3 million for Zero Emission Ready Ohio
- Appalachian Hydrogen Hub: Up to $925 million awarded in 2023 the Regional Clean Hydrogen Hubs program. The DOE awarded funding for the Appalachia region, including Ohio, to support the development of low-cost clean hydrogen.

3. TRANSPORTATION EFFICIENCIES

DESCRIPTION

Expanding various strategies that can effectively implement infrastructural, asset, and behavioral changes to create a more time-efficient, environmentally friendly, and sustainable transportation system. The primary objective is to reduce travel times, lengths, and the overall carbon intensity of trips, thereby reducing emissions and enhancing mobility and connectivity in urban and suburban areas.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

APPLICABLE SECTOR

Transportation

RELATED GHG EMISSIONS

Currently transportation fossil fuel emissions represent:

- 26% of total gross emissions

RELATED PROGRAMS AND POLICIES

The State of Ohio maintains numerous programs that are dedicated to supporting changes to modal share, including:

- Ohio's Transportation Alternatives Program (TAP) offers financial support for a variety of transportation-related projects, encompassing both on- and off-road facilities for pedestrians and cyclists, infrastructure improvements aimed at facilitating non-driver access to public transportation, as well as promoting enhanced mobility. Additionally, the program covers community development initiatives, environmental mitigation efforts, recreational trail developments, and projects focused on ensuring safe routes to educational institutions.
- Ohio's Urban Transit Program supports efficient and effective use of State funds in the provision of transportation services.
- ODOT maintains a Statewide Bike and Pedestrian Plan. Called Walk.Bike.Ohio, the plan provides a roadmap for overcoming challenges related to increasing pedestrian and bike trips.
- Ohio plans to establish a network of state and U.S. bicycle routes to provide cyclists with connections between different destinations in the state.
- The Safe Routes to School program provides resources, technical assistance and project funding to encourage and enable students in K-12 to walk or ride their bike to school.
- The Ohio Active Transportation Academy provides training, workshops, and implementation programs to communities throughout Ohio.

Cities and municipalities also operate several programs that are focused on this area, including:

- Akron's Tree Canopy Program has planted thousands of trees to increase tree coverage throughout the city, which improves the pedestrian experience and reduces pollutants.
- Columbus established an E-Bike incentive pilot program which discounts E-Bikes for qualifying Columbus residents.
- Cleveland continues to invest in the development of urban bikeways.

ACTIVITIES

The State of Ohio and local municipalities have several potential activities through which both can support the broader goal of shifting modal share away from vehicles towards walking and biking. These activities include:

- **Investments in the public realm:** non-car transportation infrastructure, including bike lanes, bike and e-bike share programs, public transit, and pedestrian pathways to improve regional interconnectivity.
- **Trip subsidies:** subsidizing transit ridership (e.g., transit cards for students, low-income riders).
- **Transit prioritization:** implementing transit prioritization projects, such as transit signal priority and dedicated bus lanes.
- **Zoning:** Promoting updates to building/zoning codes to permit private developments that encourage alternative transportation methods (e.g., allowing new multifamily buildings near public transportation).
- **Incentivize alternative trips:** Public enablers to encourage transit use and decrease VMT, such as reduced street parking and demand-based metered parking.
- **Transportation investments:** Financial support for implementation of transportation infrastructure efficiencies that reduce idling and/or VMT pollutant emissions, including

roundabouts, traffic signal optimization, ramp metering, and traffic incident management, etc.
- **Intelligent traffic systems:** Financial support/regulatory streamlining for intelligent traffic system implementation.
- **Education:** Providing education programs that support alternative transportation methods (e.g., bike education programs, smart driving training, etc.).

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[61]

2025 – 2030: 1,511,556 $MTCO_2e$

- 2.6% reduction in non-public transit motor vehicle transportation emissions.
- <1% reduction in total net emissions with conservative assumption for public transportation, bike, and walking mode share adoption**.**

INTERSECTION WITH FEDERAL FUNDING

- U.S. DOT RAISE Program: $52.9 million provided under the BIL in 2022 to support projects that projects that modernize roads, bridges, transit, rail, ports, and intermodal transportation in Ohio.

4. RENEWABLE ELECTRICITY GENERATION

DEFINITIONS

Renewable Energy: Energy sourced from fuel sources that restore themselves over short periods of time and do not diminish. Examples include: the sun, wind, moving water, geothermal, etc.

Net Metering: Identified in Ohio Revised Code Section 4928.01 "as measuring the difference in an applicable billing period between the electricity supplied by an electric service provider and the electricity generated by a customer-generator that is fed back to the electric service provider."

DESCRIPTION

Solar-focused distributed energy and utility-scale solar are complementary approaches to harnessing solar power for electricity generation. Distributed solar energy involves installing small-scale photovoltaic (PV) systems, typically on rooftops or ground-mounted systems, for individual homes, businesses, or communities, leading to decentralized energy production and

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[61] Expanding public transportation, biking, and walking focuses for GHG reduction calculations for the Plan; however, this can be expanded to cover other types of transportation efficiencies for the CRP. To do so, ODOT analyses of the current proportion of VMT and commuting modes that are traveled by public transportation, biking, and walking was assessed, including growth projections and emission reduction estimates. Additional emission reductions for additional zero emission biking and walking modal share increases were also considered based on replacing 4% of annual passenger car commuting miles that are reported to be less than one mile by the FHWA with biking. See Appendix III for sources and additional details

increased grid stability. Utility-scale solar, on the other hand, refers to large-scale solar power plants that produce electricity for distribution through the grid, employing either PV panels or concentrated solar power (CSP) technology. Utility-scale wind is also prominent. These large-scale projects provide substantial amounts of clean energy while benefiting from economies of scale. Hydrogen can also be considered a renewable energy resource when it is generated from renewable sources. Combining these approaches maximizes renewable energy benefits, contributing to a more sustainable and environmentally friendly energy landscape.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

APPLICABLE SECTOR

Electric power

RELATED GHG EMISSIONS

Electric power from electricity generation represent:

- 28% of total gross emissions

RELATED PROGRAMS AND POLICIES

The federal government and relevant agencies provide funding and programs to support the development of renewable power generation, including the following programs:

- Tax credits funded by the IRA, such as the federal residential solar energy tax credit, the Business Energy Investment Tax Credit, or the federal solar tax credits for businesses, that financially support residents, commercial and industrial entities interested in purchasing their own solar arrays.
- Advantageous lending programs, such as the U.S. DOE's Section 1703 program, which has been expanded to provide loans to innovative clean energy technologies. The IRA provides an additional $40 billion of loan authority for projects through 2026 under the program.
- The Regional Clean Hydrogen Hubs program includes up to $7 billion to establish hydrogen hubs as part of a larger $8 billion effort funded through the BIL. The program aims to scale up hydrogen production, processing, delivery, storage, and end-use of clean hydrogen. Ohio benefits from this program as it will receive funding through the Appalachian Hydrogen Hub.

The State of Ohio itself administers several programs, regulations, and funding to support the deployment of renewable energy technology:

- The Ohio Net Metering program allows for billing arrangements whereby customers who produce their own electricity can receive electric utility bill credits for extra electricity products, up to 120% of the energy produced. The current program requires all electric utilities to offer a standard net metering tariff to customers providing electricity through renewable/alternative means.

- Solar Sales Tax Exemption, which exempts some properties used for solar energy projects from Ohio sales taxes.
- The Qualified Energy Project Tax Exemption exempts some properties used for solar energy projects from public utility tangible personal property tax.
- Ohio Property Assessed Cleaning Energy (PACE) Financing program which connects property owners with capital providers and contractors and offers fixed-rate PACE loans. PACE financing relies on special assessments to repay and secure upfront funding for energy efficiency or creation improvements, and can result in improved financing terms (e.g., lower interest rates).
- ECO-Link, which is designed to provide reduce rate financing for homeowners interested in weatherization and energy efficiency improvements. ECO-Link can be used on solar arrays as well.
- Ohio's Renewable Energy Portfolio Standard (RPS) mandates that 8.5% of electricity sold by Ohio's electric utilities or service companies must be generated from renewable energy sources by 2026.

Cities are actively involved in the development of renewable energy solutions:

- Cities, such as Cleveland and Cincinnati, also offer several tax exemptions and abatement programs that support the development and installation of solar panels.
- Sustainable Columbus is a program approved by voters whereby the city is allowed to aggregate the retail electric for residents and small businesses to support local clean energy generation.

ACTIVITIES

The State of Ohio and local municipalities have several potential activities through which both can support the broader goal of increasing the share of energy from renewable sources (in particular, solar). These activities include the following:

- **Financial Incentives:** Incentivize renewable energy generation on residential, industrial, public, and commercial properties (e.g., rebates, tax credits, net metering, affordable financing). Encourage developers to integrate renewable energy technologies, such as solar arrays, into new residential, industrial, commercial, and public developments through financial incentives. Incentives may also cover structural or other upgrades and remediation necessary to prepare land or buildings for renewable energy technology installation.
- **Permitting:** Provide technical and financial assistance to local governments to streamline permitting for renewable energy technology construction across all sectors.
- **Support for large projects:** Support the development of utility-scale renewable energy projects or improve grid interconnection to allow for renewable projects to come online.
- **Regulation:** Promote improvement and streamlining of permitting processes for developing transmission systems connecting renewable generation to the electrical grid.
- **Education:** Develop an education program to inform residents and municipalities how Ohio's net metering programs work, how renewable energy technologies can be financed, etc.
- **Virtual Power Plants:** Encourage cities to work with third party aggregators to design and construct renewable energy assets in their respective regions, then leverage virtual power

plant agreements to source renewable power. This activity can be expanded to the private sector, which includes commercial power purchase agreements that expand utility-scale renewable energy.

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[62]

2025 – 2030: 1,811,940 $MTCO_2e$ up to 2,307,000 $MTCO_2e$

- 3% reduction in electric power electricity generation GHG emissions.
- 1% reduction in total net GHG emissions.

INTERSECTION WITH FEDERAL FUNDING

Ohio applied for Solar for All, the $7 billion program which will provide grants to expand the number of LIDACs primed for residential solar investment. Ohio's application targets delivering a total of 310 additional MW of solar capacity.

5. BUILDING ENERGY EFFICIENCY

DEFINITION

Energy efficiency refers to the practice of using less energy to perform tasks or produce results in various settings such as homes, buildings, and manufacturing facilities. This is typically accomplished by implementing measures like weatherization, insulation, air sealing, and efficient heat pumps that reduce energy consumption and emissions.

DESCRIPTION

Efficient buildings encompass residential, industrial, and commercial structures that integrate advanced design approaches, materials, and technologies to minimize energy consumption, reduce greenhouse gas emissions, and promote sustainability. These buildings prioritize features such as high-performance insulation, energy-efficient windows, efficient HVAC systems, and smart thermostats, while often incorporating technologies such as solar panels and geothermal heating systems.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

APPLICABLE SECTOR

Buildings

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[62] Expanding wind, utility-scale solar, and small-scale distributed solar were the renewable energy focuses for GHG reduction calculations for the Plan; however, this can be expanded to cover other types of renewable energy for the CRP. To do so, Energy Information Agency (EIA) Wind and Solar Energy Industries Association (SEIA) wind and solar trends and projections were considered, and U.S. EPA's AVERT was used to calculate associated emission reductions. See Appendix III for sources and additional details

RELATED GHG EMISSIONS

Buildings fuel and electricity usage (electric power consumption) comprises:

- 53% of total gross emissions

RELATED PROGRAMS AND POLICIES

The federal government and relevant agencies provide funding and programs to support the expansion of building efficiency measures, including the following programs:

- Tax credits, such as the Federal Residential Energy Efficiency Tax Credit, the Energy Efficiency New Homes Tax Credit for Home Builders, or the energy efficient commercial buildings deduction that financially support residents, commercial and industrial entities interested in upgrading their building efficiencies.
- Grant programs to support energy efficiency improvements and other activities, such as the U.S. DOE's Energy Efficiency and Conservation Block Grant Program.
- Advantageous lending programs, such as the FHA's Energy Efficient Mortgage program, which allows additional mortgage funds to finance energy efficient upgrades for homes.
- Training and research programs, such as DOE's Building America Program, which researches the best ways to advance energy efficiency in homes, or the State and Local Energy Efficiency Action Network, which provides resources for the design and implementation of policies and programs that can drive investment in energy efficiency.
- Assistance programs, such as the DOE Weatherization Program, which works with local community agencies and governments to conduct energy assessments and improve energy efficiency for low-income households.

Ohio administers several programs, regulations, and funding to support the development of energy efficient buildings, including:

- The Ohio Community Reinvestment Area program, which provides property tax exemptions for property owners who renovate existing or construct new buildings.
- The Ohio Energy Efficiency program helps businesses, manufacturers, nonprofits and local governments identify energy use and costs and develop energy plans.
- The Ohio Building Code has provisions that support energy efficiency within new construction and for rehab of older buildings.
- ECO-Link, which is designed to provide reduce rate financing for homeowners interested in weatherization and energy efficiency improvements.
- The Ohio Housing Finance Agency Design and Architectural Standards requires that multifamily developments obtain energy efficiency and/or green building certifications.

Municipalities and other local cities, such as Cleveland and Cincinnati, also offer tax exemptions and abatement programs that support the development of energy efficient buildings.

In addition, many local utilities offer incentives such as rebates or home energy audits to support the installation of energy efficient devices and improved energy efficiency practices. For example, CenterPoint Energy offers rebates for replacing gas furnaces, insulation and home sealing, and smart thermostats.

ACTIVITIES

The State of Ohio and local municipalities have several activities through which both can support the implementation of energy efficient devices and practices in buildings across the state. These activities include:

- **Financial incentives for products:** Offer targeted financial incentives (e.g., rebates, low-interest loans) for improved efficiency measures (e.g., LED lighting, occupancy sensors, high-efficiency appliances, cooling paint) or structural and operational upgrades/remediation in old/new residential, industrial, commercial, and public construction.
- **Financial incentives for construction:** Develop financial incentives that promote the use of low carbon construction materials (e.g., cross-laminated timber, recycled steel, low-embodied-energy concrete) in new residential commercial, and public construction and rehabilitations.
- **Zoning and building codes:** Encourage changes to state/municipal zoning/building codes including energy code, reviewing, and updating them to support compact, mixed-use, transit-oriented development and require higher energy efficiency standards in new construction projects.
- **Regulatory changes:** Provide financial incentives and promote regulatory streamlining (e.g., grants, tax credits, simplified permitting processes) for adaptive reuse of industrial and commercial buildings; encourage energy benchmarking programs to measure performance of buildings and/or building performance standards.
- **Education:** Develop education programs to support individuals/organizations interested in learning more about energy efficiency measures and programs.

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[63]

2025 – 2030:

- Residential: 9,158 MTCO2e
- Commercial and Industrial: 447,286 MTCO2e
- Less than 1% reduction in total net building emissions given conservative (low-end) estimate considering high costs of capital required for deep energy efficiency retrofits.

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[63] Retrofitting existing Ohio buildings was the focus for GHG reduction calculations for the Plan; however, this can be expanded to cover new builds for the CRP. NREL's ResStock was used to calculate Ohio average residential energy efficiency emission reductions. Costs of energy efficiency retrofits to assess reasonable adoption and scale of reductions was then sourced from the American Council for an Energy-Efficient Economy. For commercial and industrial buildings, emission reduction potentials for a variety of measures such as occupancy sensors and smart programmable thermostats was sourced from the Department of Energy. Notably, only one year's worth of emission reductions are accounted for assuming buildings are retrofitted by 2030; however, emissions would be even greater if buildings were retrofitted prior to 2030. See Appendix III for sources and additional details

INTERSECTION WITH FEDERAL FUNDING

- Home Energy/Weatherization Assistance Program (HEAP and HWAP) are federally funded and provide home energy bill and energy efficiency assistance.

6. CLEAN HEATING

DESCRIPTION

This priority measure emphasizes expanding clean heating solutions to replace energy-intensive systems within buildings including residential, commercial, industrial, and public buildings. Essential strategies for clean heating include implementing high-efficiency electric heat pumps (that increase emission reductions further when paired with renewable electricity), geothermal heat pumps, deploying bioenergy-based heating systems, utilizing solar thermal collectors, and incorporating district heating powered by renewable energy sources.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

APPLICABLE SECTOR

Buildings

RELATED GHG EMISSIONS

Buildings fuel usage, including for heating applications, comprises:

- 25% of total gross emissions

RELATED PROGRAMS AND POLICIES

The federal government and relevant agencies provide funding and programs to support the installation of electric heating and cooling systems, including the following programs:

- Rebate programs, including the Home Electrification and Appliance rebate program and Home Efficiency rebates, which will come into effect this year and provide rebates on certain home energy projects.
- Tax credits, including Clean Energy Tax Credits for Consumers that cover products such as heat pumps and efficient air conditioners.
- Assistance programs, such as the DOE Weatherization Program, which works with local community agencies and governments to conduct energy assessments and improve energy efficiency for low-income households.

The State of Ohio itself administers several programs, regulations, and funding to support the development of energy efficient buildings, including:

- The Ohio Community Reinvestment Area program, which provides property tax exemptions for property owners who renovate existing or construct new buildings.
- The Ohio Energy Efficiency program helps businesses, manufacturers, nonprofits, and local governments identify energy use and costs and develop energy plans.

Ohio cities are also highly involved with the development of clean heating policies, programs, and solutions, including:

- Akron maintains a district energy system that supplies energy, heating, and cooling to buildings in downtown Akron.
- Cleveland's District Energy System, which provides steam and chilled water from a central plant eliminating the need for building owners to install and maintain expensive onsite HVAC equipment.

ACTIVITIES

The State of Ohio and local municipalities have several potential activities through which both can support electrification and heating goals. These activities include the following:

- **Financial Incentives:** Offer financial incentives and low-interest loans to make electrification more affordable by providing financial support such as tax rebates, grants, or low-interest loans.
- **Building codes:** Promote updating building codes and streamline zoning and permitting to encourage electrification adoption through building regulations that favor electric systems and simplifying zoning and permitting processes.
- **Education:** Promote education, outreach, and technical assistance for property owners and professionals by raising awareness about the benefits of electrification.
- **Certifications:** Create green certifications and collaborate with utilities to provide additional incentives by developing green building certifications to recognize and reward properties that incorporate electrification measures.
- **Partnerships:** Partnering with utilities for additional incentives and rebates.
  Procurement: Implement bulk procurement programs to lower the cost of electrification equipment.

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[64]

2025 – 2030:

- Residential: 130,962 $MTCO_2e$
- Commercial and Industrial: 2,028,952 $MTCO_2e$
- 3% reduction in total building emissions
- Less than 1% reduction in total net emissions given conservative (low-end) estimate considering high costs of capital required for clean heating retrofits

INTERSECTION WITH FEDERAL FUNDING

- No other federal funding has been awarded to Ohio for clean heating initiatives.

7. COMPOSTING

DESCRIPTION

This Plan aims to promote composting as an emissions mitigation strategy and sustainable waste management practice. Composting is the controlled, aerobic (oxygen-required) biological decomposition of organic materials by microorganisms. Organic (carbon-based) materials include grass clippings, leaves, yard and tree trimmings, food scraps, crop residues, animal manure and biosolids.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

APPLICABLE SECTOR

Waste

RELATED GHG EMISSIONS

Municipal solid waste (MSW) in landfills comprises:

- 2% of total gross emissions (5.3 net out of 245 $MMTCO_2e$)
- 64% of gross landfill methane emissions is already diverted from Ohio's total emissions.

[64] Retrofitting existing Ohio buildings was focus for GHG reduction calculations for the Plan; however, this can be expanded to cover new builds for the CRP. NREL's ResStock was used to calculate Ohio's average residential electrification emission reductions. Costs of electrification were then sourced to assess reasonable adoption and scale of reductions. Likewise, emission reduction potentials and costs were sourced for commercial and industrial buildings. Notably, only one year's worth of emission reductions is accounted for assuming buildings are retrofitted by 2030; however, emissions would be even greater if buildings were retrofitted prior to 2030. See Appendix III for sources and additional details

- Out of total diverted emissions, 6% is already oxidized in composting, 27% is flared whereby CH_4 is burned to release CO2 into the atmosphere that is already biogenic – or part of the atmospheric carbon cycle[65], and 67% is converted from waste methane to energy.

RELATED PROGRAMS AND POLICIES

The federal government and relevant agencies provide funding and programs to support the composting programs, including:

- USDA Composting and Food Waste Reduction Cooperative Agreements support waste management plans to reduce food waste and diverse waste from landfills.
- Programs/toolkits to support composting across different communities, including U.S. EPA's Sustainable and Healthy Communities Research Program and the North American Initiative on Organic Waste Diversion and Processes.

The State of Ohio has several licensed and registered facilities that facilitate composting and provides guidance to households interested in composting.

Local municipalities and nonprofits are also highly involved with the development of composting programs and solutions. Some example programs include the following:

- Rust Belt Riders is a worker-owned cooperative that provides composting services across Northeast Ohio.
- Cuyahoga County Solid Waste District provides guidance on sites that support composting across the county.

ACTIVITIES

The State of Ohio and local municipalities have several potential activities through which both can support the broader goal of increasing composting. Key measures can include public education campaigns, offering incentives for adopting composting practices, and supporting community composting sites to reduce waste, lower emissions, and benefit local agriculture and the environment. These activities include:

- **Community goals:** Set waste reduction goal for community; create and implement a plan to achieve it.
- **Community engagement:** Support home composting by reviewing ordinances and hosting a composting workshop.
- **Develop programs:** Establish a community-wide composting program to manage food and organic waste.
- **Partnerships:** Partner with private sector composting companies at the regional level.
- **Zoning:** Promote use of Ohio EPA's model zoning code to encourage organic waste composting and urban agriculture.

[65] DOE Flaring and Venting R&D: Reducing Emissions and Developing Valuable Low-Carbon Products | Department of Energy

- **Financial incentives:** Facilitate composting grants at local levels.
- **Education:** Join and support efforts to establish food waste composting on a regional scale via education programs.

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[66]

2025 – 2030: 1,669,197 $MTCO_2e$

- 26% reduction in net waste emissions
- 1% reduction in total net emissions

INTERSECTION WITH FEDERAL FUNDING

USDA Composting and Food Waste Reduction (CFWR) cooperative agreements provide funding to expand composting locations, increase waste diverse, and subsidize composting subscriptions to low-income households. In Ohio, Cleveland will access some of this funding to expand drop-off residential composting locations.

8. CLEAN WASTE-TO-ENERGY

DESCRIPTION

Waste-to-energy (WtE) is a solution that transforms waste materials, typically non-recyclable municipal solid waste (MSW) or agricultural waste, into various forms of energy such as electricity, heat, or fuel. The primary WtE technologies considered in the Plan include clean, organic gasification, anaerobic digestion, and landfill methane capture. Anaerobic digestion involves a process where bacteria decompose organic materials (e.g., animal waste, wastewater biosolids, and food waste) without the presence of oxygen. Landfill gas – a mixture of methane, carbon dioxide, and trace organic compounds – is the natural byproduct of decomposing organic material in landfills. Both produce valuable outputs that can be used to produce energy or replace products for other applications.

MEASURE TYPE

Priority Measures for the State of Ohio and Constituents

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[66] To estimate the potential for composting, the total tons of organic waste disposed in the state of Ohio annually was sourced from Ohio EPA. Based on the total avoided emissions, the current volume of organic waste remaining in landfills was calculated. Then the cost of a commercial composting operation processing 1,000 ton of organic waste annually was determined to assess reasonable adoption rates. Emission reductions were calculated based on estimated additional tonnage of organic waste diverted from landfills for composting. Notably, only one year's worth of emission reductions is accounted for assuming facilities are operational by 2030; however, emissions would be even greater if facilities are operational prior to 2030. See Appendix III for sources and additional details

APPLICABLE SECTOR

Waste and agriculture

RELATED GHG EMISSIONS

Municipal solid waste (MSW) in landfills comprises:

- 2% of total gross emissions (5.3 net out of 245 MMTCO2e)
- 64% of gross landfill methane emissions is already diverted from Ohio's total emissions.
- Out of total diverted emissions, 6% is already oxidized in composting, 27% is flared whereby CH4 is burned to release CO2 into the atmosphere that is already biogenic – or part of the atmospheric carbon cycle[67], and 67% is converted from waste methane to energy.

Agriculture comprises:

- 5% of total gross emissions
- 81% (9.4 out of the 11.5 $MMTCO_2e$) of agriculture emissions stem from methane from livestock manure management. Livestock manure is a feedstock for anaerobic digestion.

RELATED PROGRAMS AND POLICIES

The federal government and relevant agencies provide funding and programs to support WtE, including:

- WTE Technical Assistance for Local Governments, which supports local communities to efficiently recover energy and resources from municipal organic waste.

Several organizations provide WtE services in Ohio:

- Ohio is home to multiple gas-to-energy facilities, which burn landfill gas, providing energy to local communities and fuel for vehicles.

ACTIVITIES

The State of Ohio and local municipalities have a number of potential activities through which both can support the broader goal of increasing composting. These activities include:

- **Incentivize WtE:** Increase the costs associated with landfill dumping to incentivize WtE facilities.
- **Financial Incentives:** Offer subsidies and other financial incentives to encourage the development of WtE facilities.
- **Education:** Establish stronger outreach and education programs to encourage organizations and utilities to explore WtE opportunities.

[67] DOE Flaring and Venting R&D: Reducing Emissions and Developing Valuable Low-Carbon Products | Department of Energy

ESTIMATE OF CUMULATIVE GHG EMISSION REDUCTIONS[68]

2025 – 2030: 4,704,986MTCO$_2$e

- 50% reduction in net waste emissions (3,221,115 MTCO$_2$e)
- 13% reduction in agriculture emissions (1,483,871 MTCO$_2$e)
- 2% reduction in total net emissions

INTERSECTION WITH FEDERAL FUNDING

No other federal funding has been awarded to Ohio for clean WtE initiatives.

OTHER POTENTIAL MEASURES

The Plan captures near-term emission reduction measures for priority sectors; however, there are additional measures that may be considered by the State or other constituents in Ohio for implementation in either the near-term or long-term.

MEASURE	SECTORS APPLICABLE	DESCRIPTION
Transportation Demand Management	Transportation	Strategies for management transportation demands, such as strategic land use planning and transit signal priority.
Sustainable Construction Vehicles	Transportation	Use of ZEVs in the construction process. Can include vehicles used in construction, agriculture, etc., such as retail forklifts, propane mowers, and alternative fuel specialty vehicles.

[68] Landfill WtE as well as anaerobic digestion of agricultural livestock manure was considered for GHG reduction calculations for the Plan; however, this can be expanded to cover other types of waste to energy for the CRP. To estimate the potential for landfill WtE, the total tons of organic waste disposed in the state of Ohio annually was sourced from Ohio EPA. Based on the total avoided emissions, the current volume of organic waste remaining in landfills was calculated. Then the cost of a landfill waste to energy operation was determined to assess reasonable adoption rates. Emission reductions were calculated based on estimated additional tonnage of organic waste diverted from landfills for waste to energy. Electricity generation emissions assuming landfill waste to energy provided electricity were also calculated based on estimated kilowatt hours production – these emission reductions were < 1% of total electric power emissions and considered negligible. The Environmental and Energy Study Institute estimates 70% of landfill waste to energy provides electricity versus biogas for fuel. Then to estimate the potential for anaerobic digestion from agriculture operations, the average volume of manure required per anaerobic digestor operation was sourced alongside costs. The proportion of Ohio's total livestock targeted for anerobic digestion then served as an estimate for the emission reduction potential. Electricity generation or heating emissions from anaerobic digestion were also assumed to be negligible. Notably, only one year's worth of emission reductions is accounted for assuming facilities are operational by 2030; however, emissions would be even greater if facilities are operational prior to 2030. See Appendix III for sources and additional details

Carbon Reduction Planning and Management for Transportation Infrastructure	Transportation	Regular maintenance of and sustainable design for transportation infrastructure.
Driver Education Programs	Transportation	Develop education programs on operational fuel-saving driving techniques.
Improve Alternative Transportation Infrastructure	Transportation	Expansion and development of rail to encourage travel by less carbon-intensive modes of transport. Encourage zero- or low-emission rail development projects, including the replacement of old, inefficient motors with new, more fuel-efficient motors. Can include development of, upgrades to, and research and development for low- to zero-emission fuels and maintenance of rail and other non-motor vehicle transit, such as marine travel, aviation, etc.
Port, Freight, Rail, and Airport Emission Standards	Transportation	Developing financial incentives for alignment with external emission standards, including federal standards. Potentially include a reduction in carbon emissions as part of the review of applications for Diesel Emission Reduction Grant funding.
Industrial Efficiency Upgrades	Electric Power; Buildings; Industrial Processes	Implement measures to reduce emissions from industrial buildings and processes, including but not limited to deploying carbon capture and storage technologies, increasing industrial building energy efficiency, and upgrading industrial equipment and systems.
Carbon Capture, Utilization, and Storage (CCUS)[69]	Electric Power; Buildings; Industrial Processes	Carbon dioxide is captured from industrial processes and/or fossil fuel combustion (e.g., power plant operations) instead of being released to the atmosphere. ODNR entered the Midwest Region Carbon Initiative (MRCI) in 2020 with the goal to accelerate CCUS)
Energy Storage	Electric Power; Buildings	Energy storage infrastructure such as hydroelectric storage or battery storage that allows renewable energy to be stored for use when renewable energy is not available.
Demand Response	Electric Power; Buildings	Electricity power load management and aggregation practices and programs to ensure demand for electricity aligns with availability of lower-carbon intensive and/or renewable energy.

[69] Carbon Capture, Utilization, & Storage | Ohio Department of Natural Resources (ohiodnr.gov)

Fuel Switching and/or Upgrades for Efficiencies	Buildings (including Industrial)	Switching to fuels and technologies that are more efficient and less emissions intensive, such as switching from furnace and boilers to gas heat pumps for residential building heating, or use of waste fuels in manufacturing; could also upgrade technologies to consume the same fuels in a more efficient system (e.g., a cogeneration system burning natural gas instead of a traditional natural gas boiler).
Pre-development	Buildings; Industrial Processes	Addressing structural deficiencies, hazards, or other construction necessities required prior to any weatherization, energy efficiency retrofits, or renewable energy installations.
Sustainable Construction in Materials	Industrial Processes	Use of low-carbon, recycled or reclaimed construction or maintenance materials. Can include activities associated with maintenance, such as use of low-carbon fuels for road maintenance equipment. In doing so, the embodied carbon of the asset built with these materials is lowered and/or GHG emissions associated with fuel consumption decrease.
Methane Leak Detection and Repair	Natural Gas and Oil Systems	Reducing fugitive emissions from methane leaks in natural gas pipelines, and abandoned gas and oil wells, through use of advanced leak detection technologies and repairs.
Sustainable Power for Wastewater Treatment	Electric Power; Waste	Evaluate localized zero emission energy sources for wastewater treatment plants.
Zero Waste / Waste Reduction	Waste	Reducing municipal solid and industrial waste through education and reuse programs (e.g., reducing food waste through local food banks, food waste diversion, and education on practices to reduce food waste).
Recycling	Waste	Increasing the recycling rate of materials such as plastics, metals, and paper, reducing the new for production of new materials.
Carbon Sequestration	Agriculture, LULUCF	Sequestering carbon through community land trusts, increasing tree canopy cover, increasing urban greenspace, sustainable forestry management, and undertaking sustainability agriculture practices such as soil health improvements, increasing urban agriculture, or other methods.
Feasibility Studies	All	Addressing knowledge gaps to understand the viability of reduction measure implementation (e.g., transmission planning for electric power).

Low-Income and Disadvantaged Community Analysis

The implementation of the measures included in this Plan are anticipated to provide benefits to LIDACs. These communities are identified as LIDACs based on the definitions, thresholds and methodology employed in the Climate and Economic Justice Screening Tool (CEJST). A census tract is identified as a LIDAC if it above the threshold of one or more environmental, climate, or other burdens, as well as also being above the threshold for an associate socioeconomic burden. In addition, a census tract that is surrounded by other disadvantaged communities that meet the burden threshold and is at or above the 50th percentile for low income, is also considered disadvantaged. The indicators of these burdens are outlined by Executive Order 14008,[70] and are further defined by the Office of Management and Budget (OMB).[71] This section identifies each LIDAC within the jurisdiction covered by this Plan, how Ohio EPA meaningfully engaged with LIDACs in the development of this Plan, and how Ohio EPA will continue to engage into the future.

Ohio's LIDACs have historically borne a disproportionate burden of environmental impacts, including poor air quality, extreme weather conditions, and natural disasters. Cities like Cleveland and Toledo were instrumental in the industrialization of the Midwest during the late 19th and 20th centuries. Changing macroeconomic conditions lead to a reduction of manufacturing jobs, resulting in economic hardship in the urban centers of several Ohio cities. For example, in Cleveland there are only four census tracts in the downtown area that are not considered low income and disadvantaged.[72] Columbus had a rise in manufacturing in the south side of the city.[73] The effects of this industrialization can be seen today throughout the whole city, which is almost completely made up of LIDAC census tracts, the majority being south of Broad Street, which runs east to west through the center of the city.[74] The industrialization resulted in higher levels of environmental air pollutants which have resulted in long-term health issues, such as asthma, for the LIDAC residents.

Ohio has also suffered from several environmental disasters expressly caused by industrialization. Perhaps the most infamous example was Cleveland's Cuyahoga River experienced a horrific fire in the late 1960s.[75] Many of the communities impacted by this environmental disaster remain LIDACs to this day. The vulnerability of these communities is exacerbated by socioeconomic factors such as poverty, lack of access to healthcare, and

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70 Section 219, Executive Order 14008, Tackling the Climate Crisis at Home and Abroad (January 27, 2001)

71 OMB Memorandum M-21-28, Interim Implementation Guidance for the Justice40 Initiative (July 20, 2021)

72 Explore the map - Climate & Economic Justice Screening Tool (geoplatform.gov)

73 Industrialization - Columbus Neighborhoods

74 Explore the map - Climate & Economic Justice Screening Tool (geoplatform.gov)

75 Marking 50 years since the Cuyahoga River fire, which sparked US environmental action (acs.org)

inadequate housing, which limit the ability to adapt to and recover from these environmental impacts.

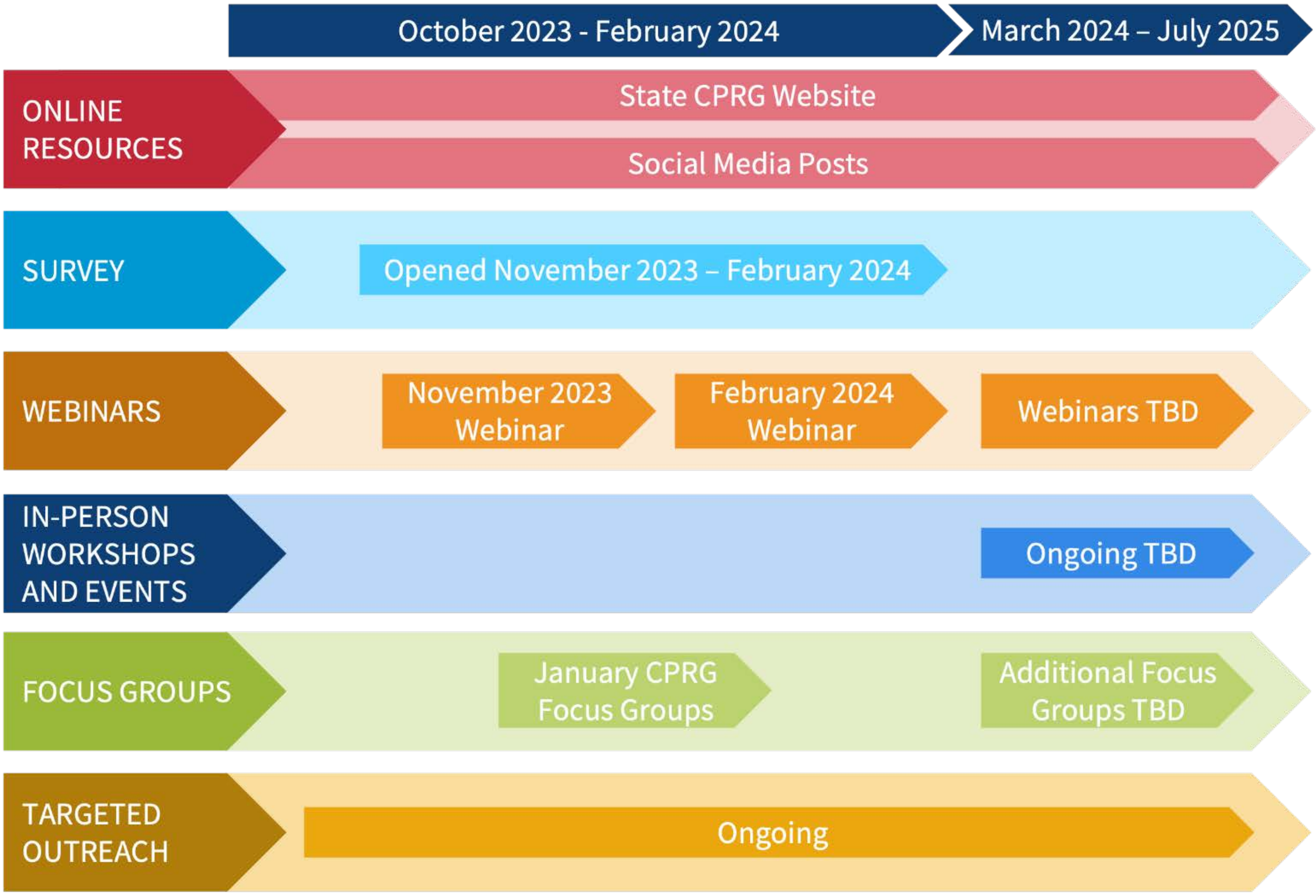
ENGAGEMENT WITH LIDACS

Ohio EPA created an engagement plan for seeking feedback on community priorities during development of this Plan. Receiving community inputs are invaluable to the success of this Plan as they provide insights on learnings from past successes and current initiatives, as well as strategies to overcome barriers and provide meaningful benefits. These inputs have been considered for the GHG reduction measures and LIDAC considerations in this Plan and will continue to be a key strategic component for the CRP. See Appendix I: Coordination and Outreach Log. Strategies for engagement with LIDACs are summarized below:

- Online resources:
  - State CPRG webpage;
  - Social media;
  - Community survey;
- Community meetings with stakeholders across the state with options for virtual participation and playback videos following the session can be found on Ohio EPA's CPRG webpage;
- Targeted outreach to known community-based organizations; and
- Attendance at known community events to disseminate information about how to provide input.

During the focus group, participants had the opportunity to share their perspectives on LIDAC impact, specifically what measures are being implemented today, what existing initiatives target LIDACs, how LIDACs are involved in decision making for reduction measures, how the financial cost of reduction measures are being distributed across LIDACs, and general challenges that have been identified in implementing reduction measures in LIDACs. Participants highlighted examples of successful reduction measure implementation in their communities such as weatherization, programs they would like to see such as general GHG reduction measure education opportunities, and funding being a primary barrier to implementation.

This focus group allowed community members an active role in shaping Ohio's statewide Plan, and their insights and concerns have been considered to create a more effective, inclusive, and responsive plan that supports LIDACs. A key output of this session was a list of additional organizations to engage for the LIDAC perspective. As Ohio EPA develops a stakeholder outreach plan for the CRP efforts, the recommendations shared will guide the way LIDAC groups are engaged in future.



OVERVIEW OF DISADVANTAGED COMMUNITIES

This section identifies the LIDACs across the state of Ohio. For the purposes of this analysis, we utilize the definitions and data from CEJST.

In Ohio there are 2,952 total census tracts, 1,088 of which are considered LIDACs, comprising almost 37% of the census tracts in the state. A total of 3.3 million people live in these LIDACs, with approximately 442,000 children under the age of 10 and 474,000 over the age of 64. Twenty-nine percent (29%) of the total population of the state reside in these LIDACs. A summary of the most relevant demographic characteristics is presented in Table 2 below, and the five regions of Ohio will be discussed in the subsequent section:

Table 2. LIDAC Demographic Information

	TOTAL POPULATION	POPULATION UNDER 10	POPULATION 10 TO 64	POPULATION OVER 64	BLACK	HISPANIC	WHITE
Percent Residing in LIDACs	29%	33%	29%	25%	64%	47%	22%
Central Ohio LIDAC Census Tracts	14%	15%	72%	11%	34%	6%	51%
Northeast Ohio LIDAC Census Tracts	35%	13%	71%	15%	35%	7%	51%
Northwest Ohio LIDAC Census Tracts	14%	13%	72%	13%	20%	7%	67%
Southeast Ohio LIDAC Census Tracts	15%	11%	70%	17%	3%	1%	92%
Southwest Ohio LIDAC Census Tracts	22%	14%	71%	14%	31%	4%	58%

Black and Hispanic people, as well as children under the age of 10 are disproportionally present in LIDACs and may be at particular risk to the various environmental challenges these communities face outlined in the following sections. To identify the specific challenges facing a LIDAC, a host of environmental and socioeconomic indicators are considered. A summary and set of definitions for the most relevant indicators to the priority reduction measures presented in this Plan are noted in Table 3 below: [76]

[76] The Climate and Economic Justice Screening Tool Technical Support Document

Table 3. Key LIDAC Indicators

Category	Type of Burden	Description
Energy	Energy Burden	Average household annual energy cost in dollars divided by the average household income.
Air Quality	Diesel Particulate Matter	Mixture of particles in diesel exhaust in the air, measured as micrograms per cubic meter.
	$PM_{2.5}$ in the Air	Fine inhalable particles with diameters that are generally 2.5 micrometers and smaller, compiled from the Office of Air and Radiation (OAR) fusion of model and monitor data from 2017 as compiled by U.S. EPA's EJScreen, sourced from NATA and DOT traffic data. Common sources of $PM_{2.5}$ emissions include power plants and industrial facilities.
Transportation	Traffic Proximity and Volume	Daily average of vehicles at major roads within 500 meters, divided by distance in meters. This is compiled from U.S. DOT traffic data from 2017.
Water and Wastewater	Underground Storage Tanks and Releases	Weighted formula of the density of leaking underground storage tanks and the number of all active underground storage tanks within 1,500 feet of the census tract boundaries.
	Wastewater Discharge	Modeled toxic concentrations at stream segments within 600 meters, divided by distance in kilometers. This is compiled from the Risk-Screening Environmental Indicators (RSEI) model from 2020.
Legacy Pollution	Proximity to Hazardous Waste Facilities	Count of hazardous waste facilities (Treatment, Storage, and Disposal facilities, and Large Quantity Generators) within 5 kilometers (or nearest one beyond 5 kilometers), divided by distance in kilometers, compiled from Treatment, Storage, and Disposal Facilities (TSDF) data calculated from U.S. EPA's Resource Conservation and Recovery Act (RCRA) Info Database from 2020.

Geographical Distribution of LIDACs

LIDACs can be found across the state of Ohio in various concentrations, often exhibiting different demographic characteristics and facing varied challenges from each other. To consider the state as a whole, we will look at each region, as defined by Ohio EPA in Figure 18, separately. In the following sections, CEJST images are presented for each area, where the shaded census tracts are identified as LIDACs.

Figure 18. Regions of Ohio[77]

[77] District Offices | Ohio Environmental Protection Agency

CENTRAL OHIO

Central Ohio is comprised of Franklin County and nine other counties that directly border it. The city of Columbus, the state capital, is home to five Fortune 500 companies and The Ohio State University, which has a student population of approximately 61,000.

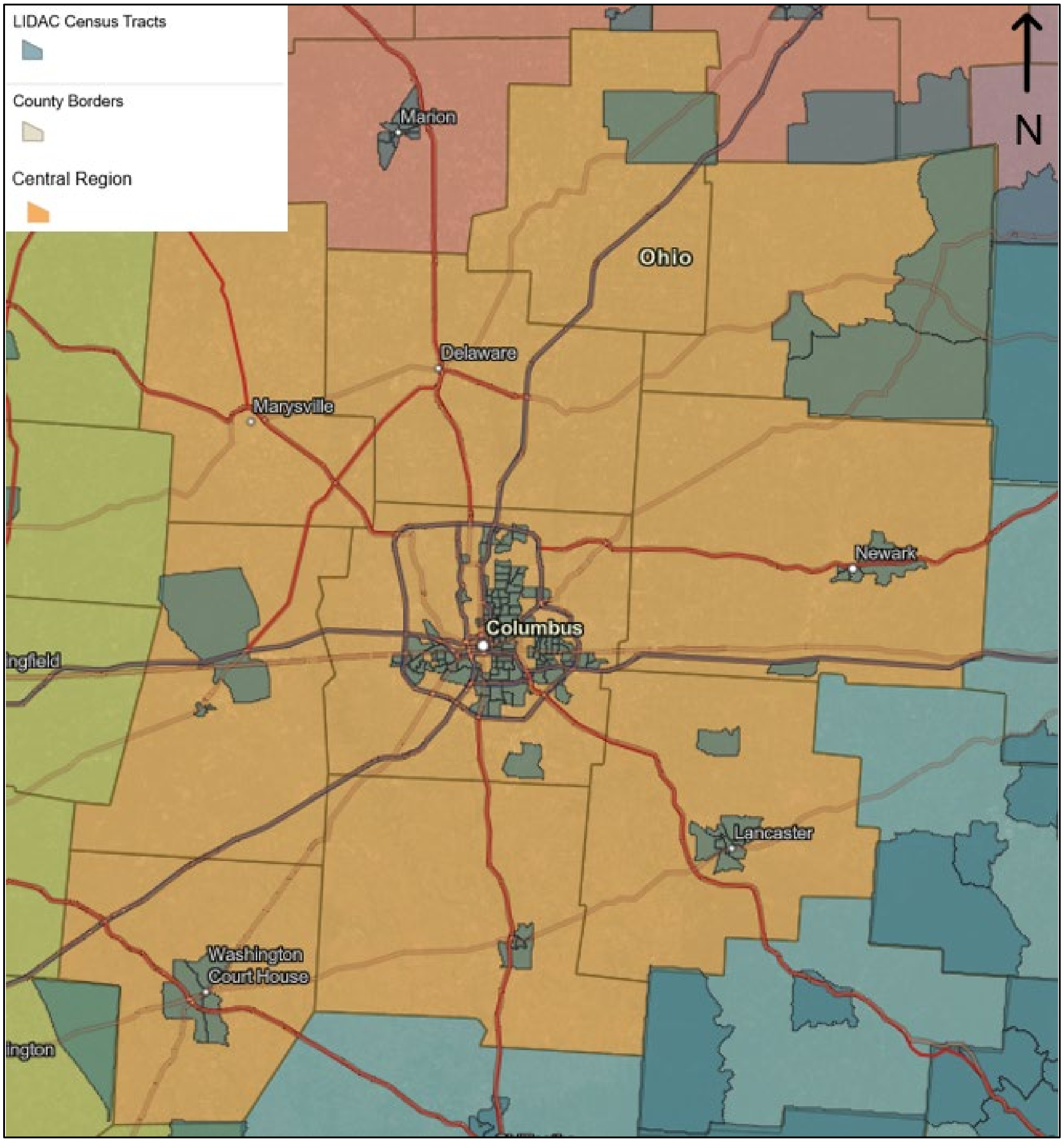


Figure 19. Central Ohio LIDAC Census Tracts

Figure 19 highlights the LIDAC census tracts in Central Ohio. While there are several in rural areas, the majority are in and around Columbus, located along the major highways that run through the city and within the Interstate 270 Beltway. As shown in Figure 19, Central Ohio LIDAC Census Tracts, the LIDACs in this area compared to the entire state have disproportionate exposure to six of the seven main environmental pollutants, with diesel particulate matter exposure being particularly prevalent. This heightened exposure, commonly found in urban areas, correlated with the higher average percentile of traffic proximity in these communities.

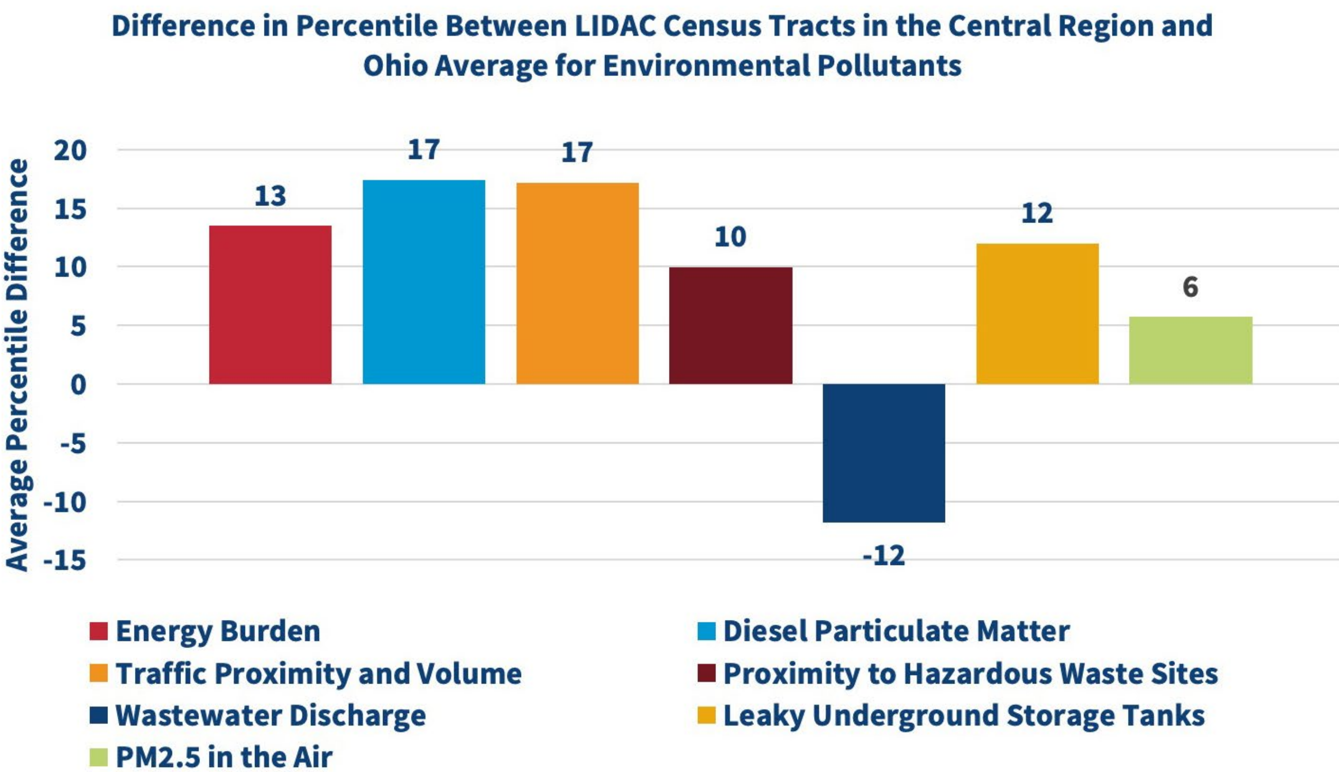


Figure 20. Environmental Pollutant Average Percentile Between the Central Region of Ohio's LIDAC Census Tracts vs. Ohio Census Tracts

Figure 20 displays the environmental pollutant average percentiles of the LIDAC census tracts in the central region of Ohio versus all the census tracts in the state. The chart shows that six out of seven environmental pollutant variables in Central Ohio are greater than the state average, the largest gaps being energy burden, diesel particulate matter, and traffic proximity and volume.

NORTHWEST OHIO

Northwest Ohio is a mix of urban and rural, with Toledo and Lima combined with rural areas and the coast of Lake Erie.

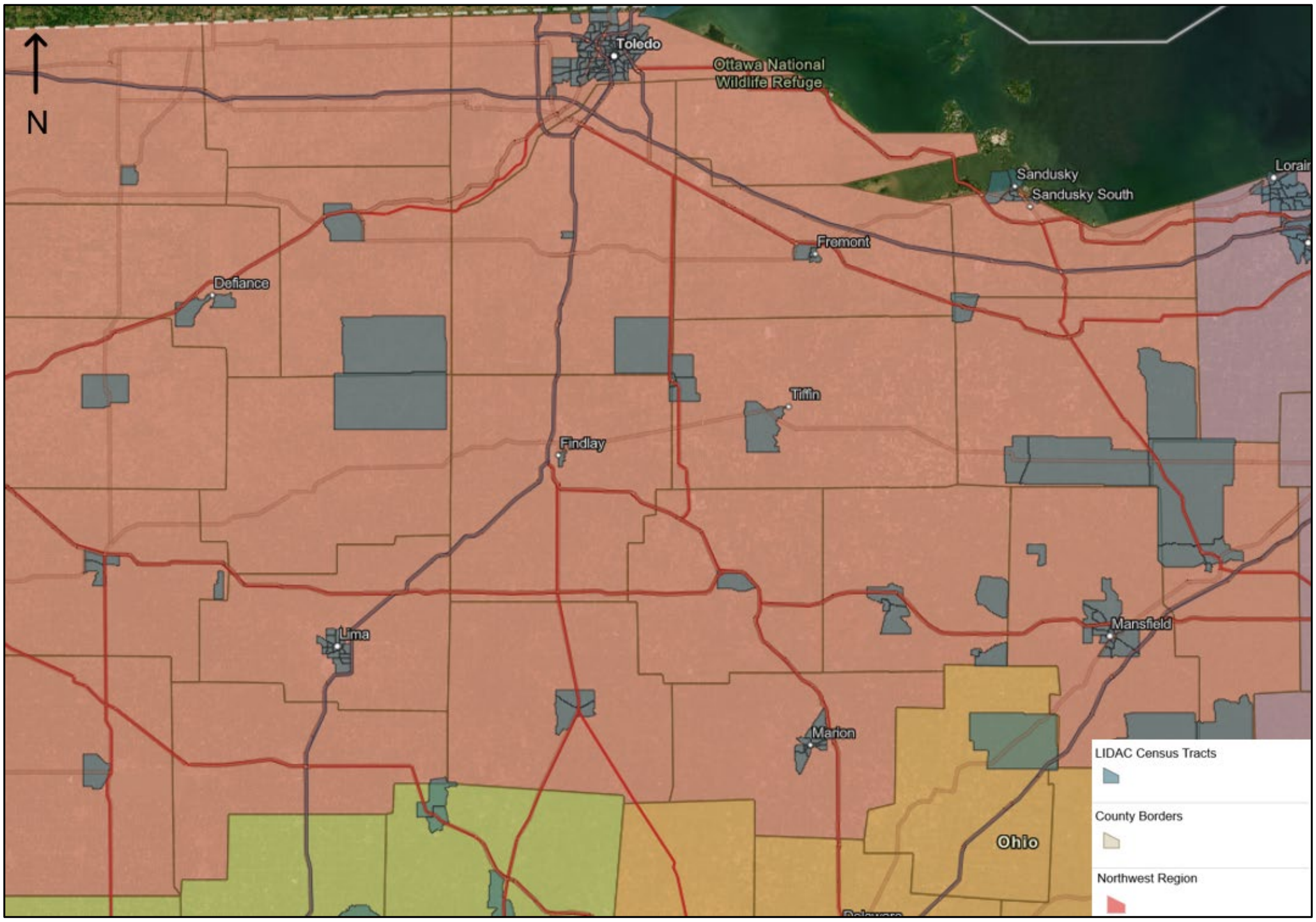


Figure 21. Northwest Ohio LIDAC Census Tracts

Figure 21 shows the LIDAC census tracts in the Northwest Ohio. There are a few scattered throughout the area, but they mainly cluster around the city of Toledo, located in Lucas County. Energy burden appears to be the biggest factor affecting the LIDACs in this area, with the average percentile being 26 points over that of the state's average (Figure 22). An important observation is that 55% of the census tracts in Lucas County have a low-income population, which exceeds the state average by 16%.

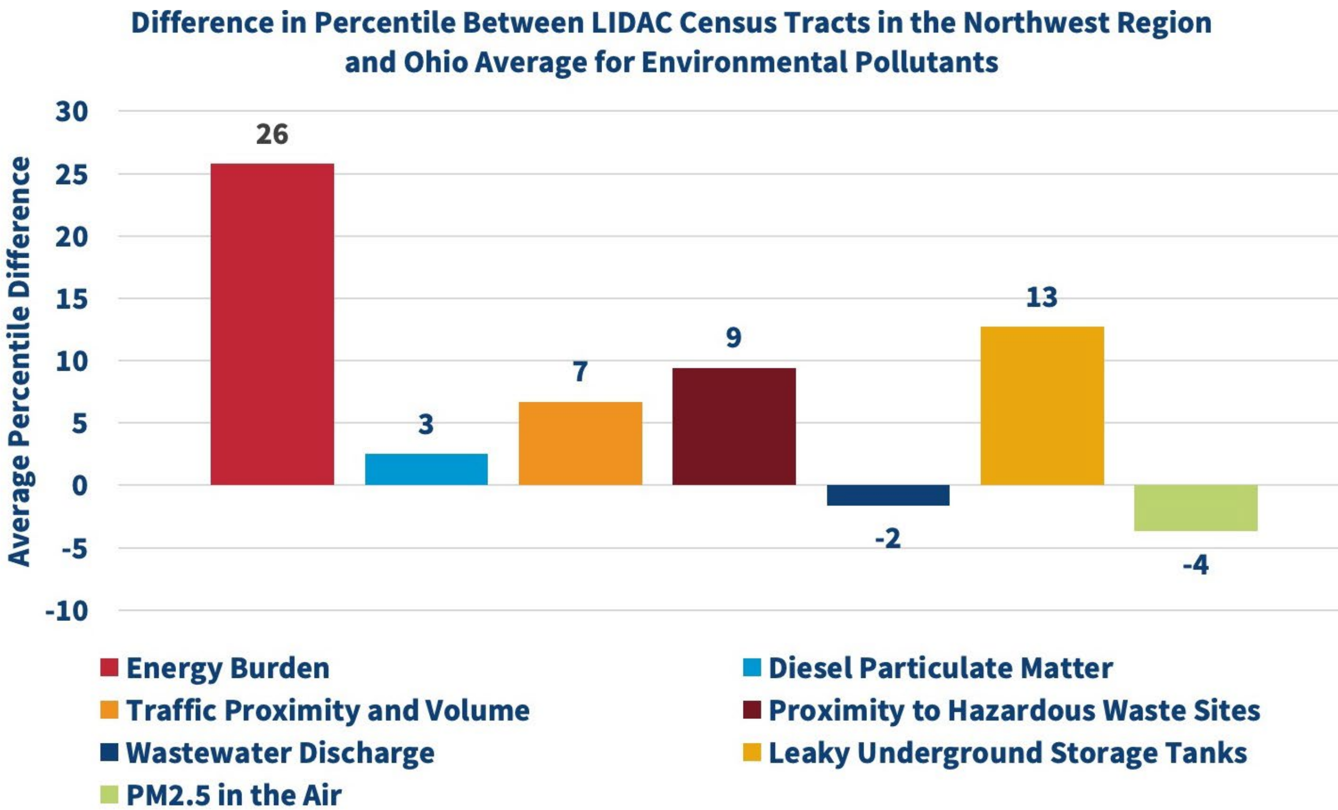


Figure 22. Environmental Pollutant Average Percentile Difference Between the Northwest Region of Ohio's LIDAC Census Tracts vs. Ohio Census Tracts

Figure 22 displays the environmental pollutant average percentiles of the LIDAC census tracts in Northwest Ohio versus all the census tracts across the state. The chart shows five of the seven environmental pollutants in the northwest region being higher than the state's averages; energy burden has the largest gap of 26 points while the rest of the variables are within 15 points of the state average.

NORTHEAST OHIO

Figure 23 depicts the LIDAC census tracts in the Northeast Ohio. This area features more clusters of disadvantaged tracts than the other regions, excluding Southeast Ohio, due to it having multiple cities, which have larger populations but don't have the economy to sustain a living wage for many of the residents.

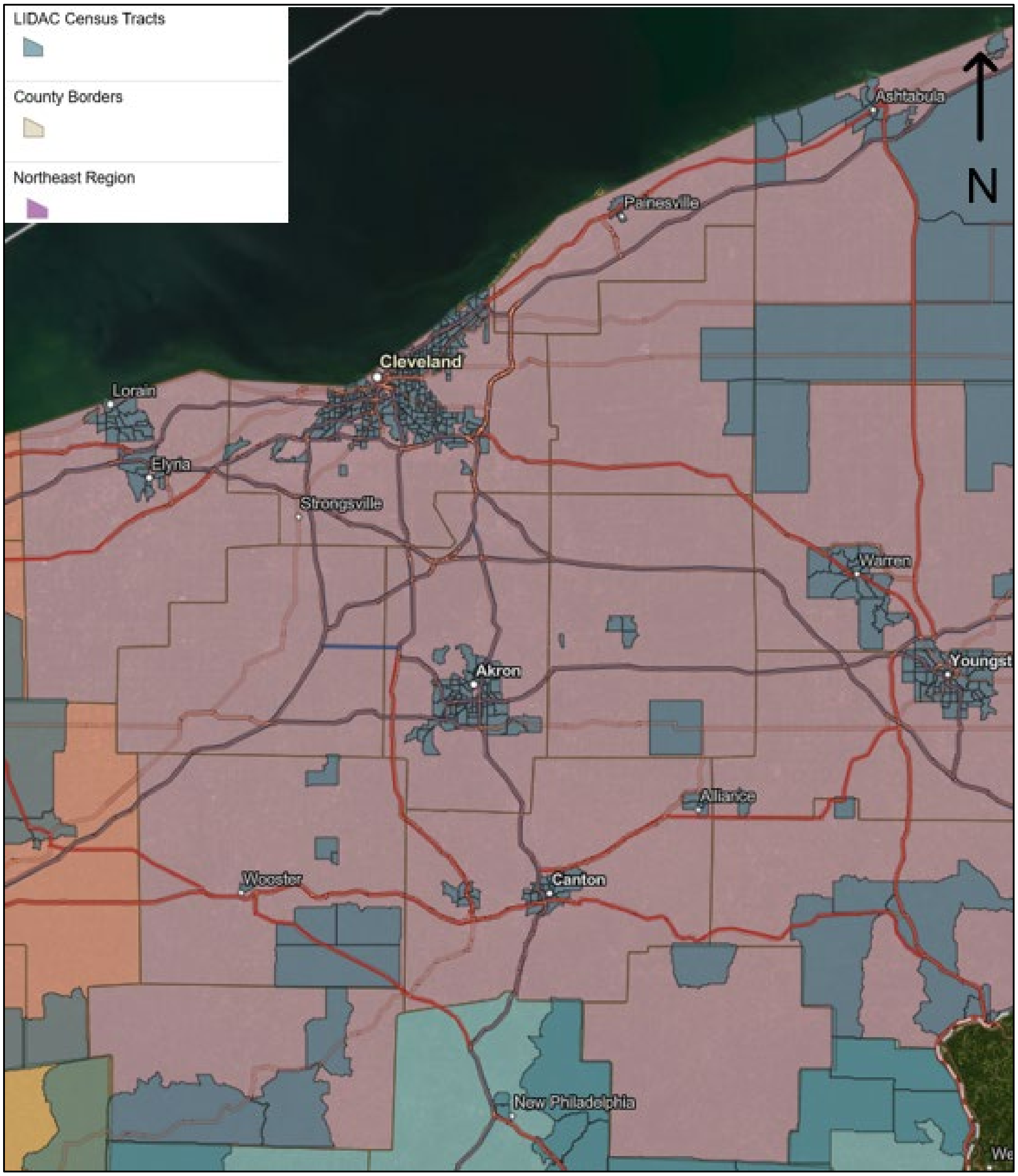


Figure 23. Northeast Ohio LIDAC Census Tracts

Cleveland in Cuyahoga County, Akron in Summit County, Youngstown in Mahoning County, and Canton in Stark County all have clusters of LIDAC census tracts surrounding them and have environmental pollutants, on average, higher than the state's averages. Youngstown is in a partially rural county[78] and has the highest energy burden among the four largest cities in the region, 29 points higher than the state average.

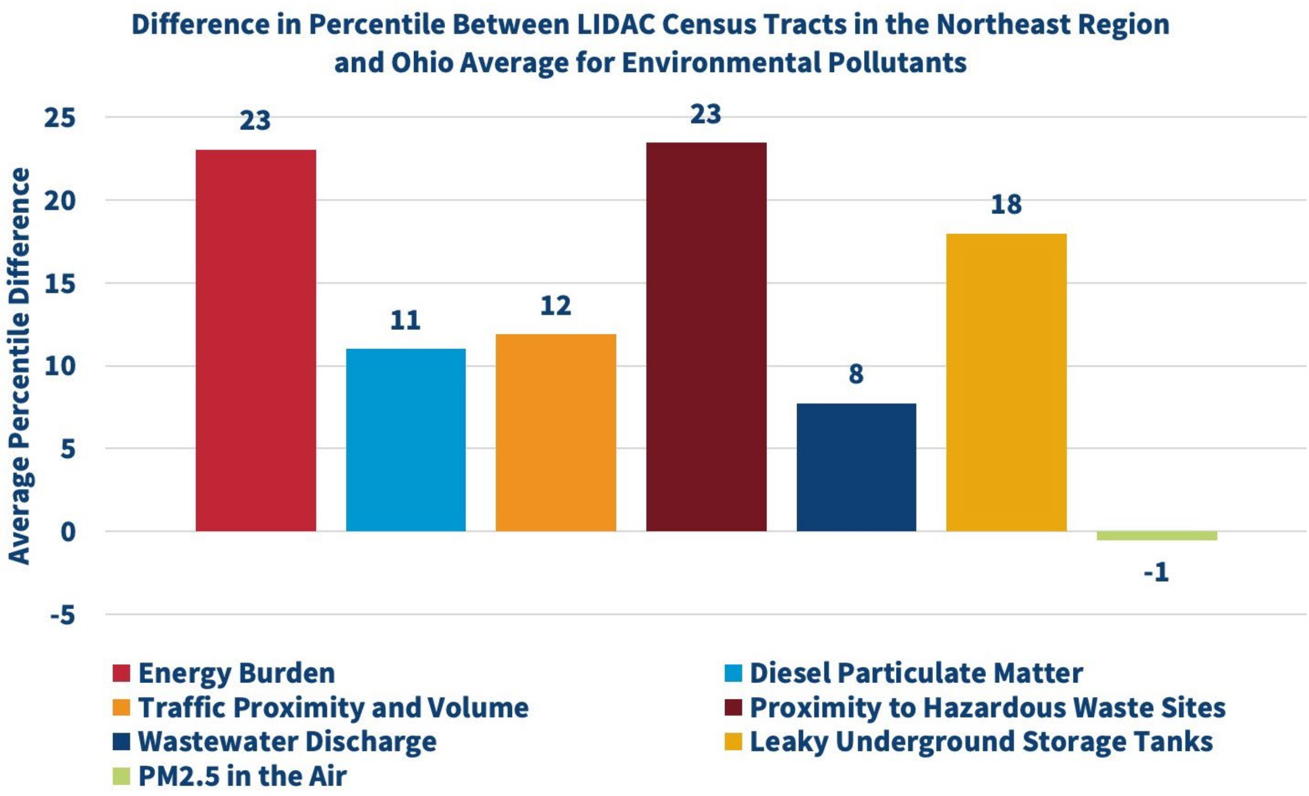
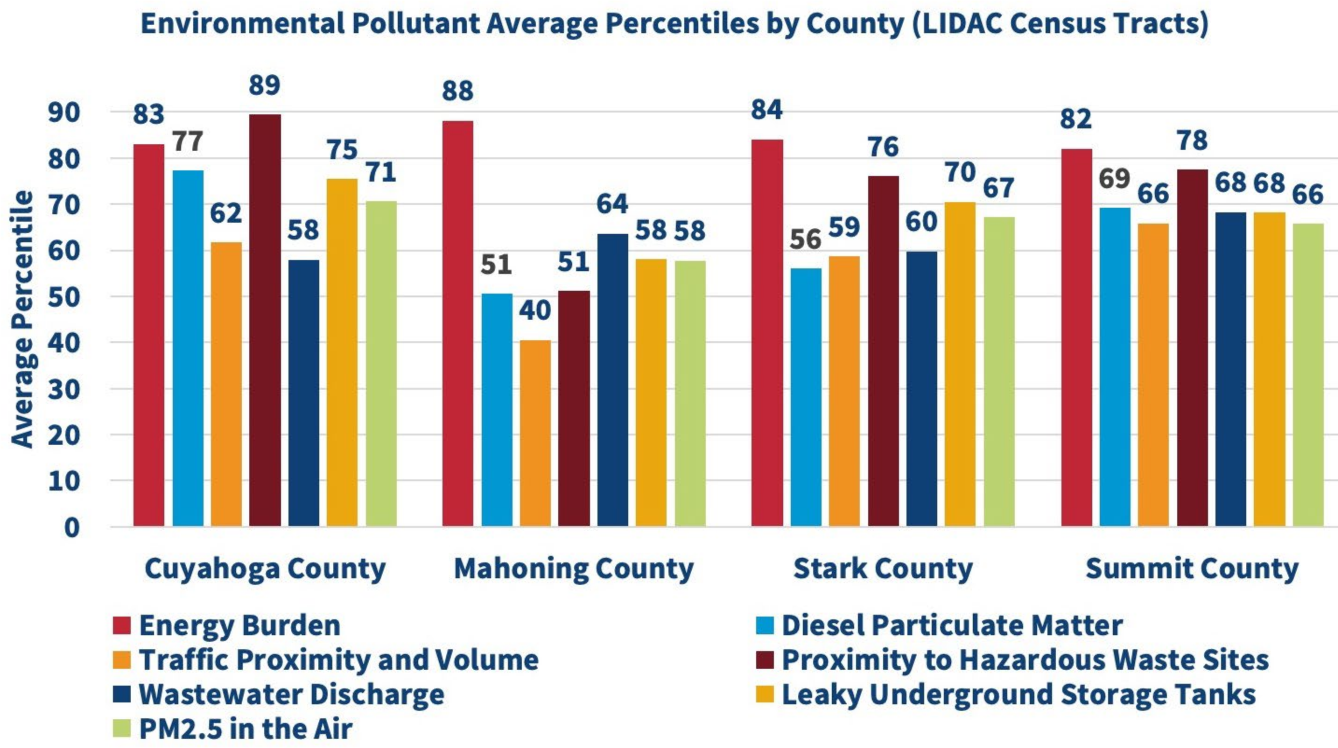


Figure 24. Environmental Pollutant Average Percentile Difference Between the Northeast Region of Ohio's LIDAC Census Tracts vs. Ohio Census Tracts

Figure 24 features the gaps between the average percentiles of environmental pollutants, the largest being energy burden and proximity to hazardous waste sites, of the LIDAC census tracts in Northeast Ohio versus the rest of the state. We choose to highlight the different counties of the region because we observe significant differences in the environmental pollutants and issues that the LIDACs in Northeast Ohio face.

[78] Urban and Rural counties are defined using the Ohio Department of Health's 2020 classifications. 2020_rural_and_urban_counties.pdf (ohioruralhealth.org)



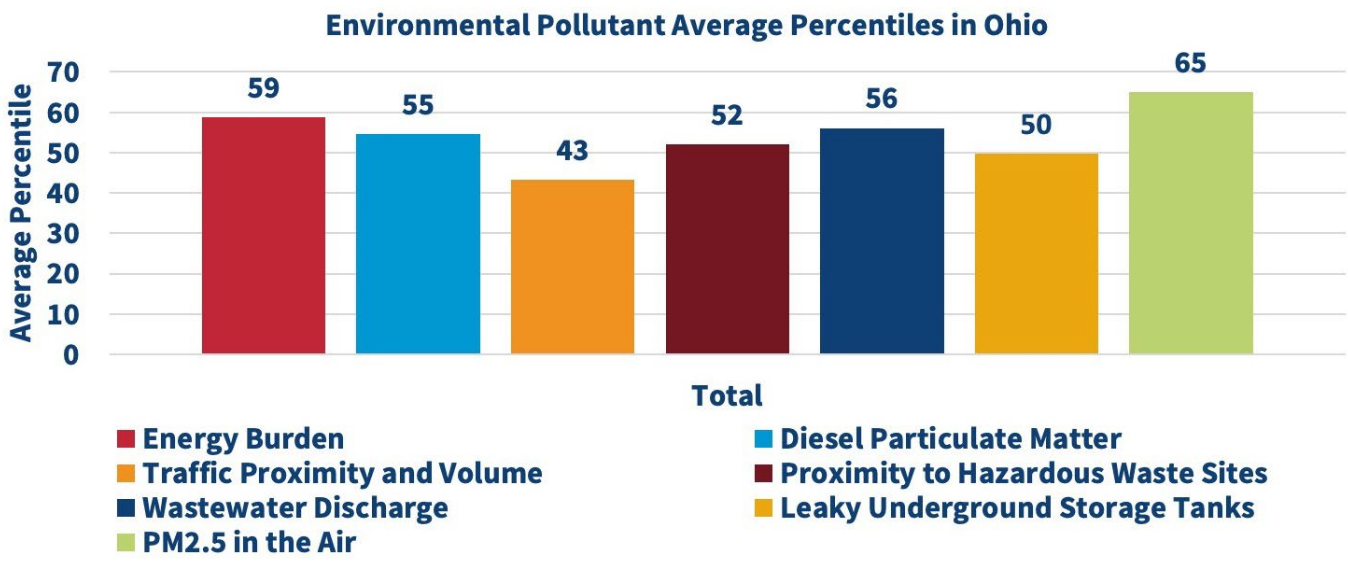


Figure 25. Environmental Pollutant Average Percentiles by County in Northeast Ohio vs. all of Ohio

Figure 25 displays the environmental pollutant average percentiles for the LIDAC census tracts in the counties that have the four largest cities in the northeast region of Ohio, compared to the average percentiles in the state. Proximity to hazardous waste sites is a concern for three of the four counties, which ranges from 24 to 37 points higher than the state's average. Energy burden is also a concern across the counties, between 23 and 29 points higher than the state.

SOUTHWEST OHIO

Figure 26 shows Southwest Ohio's LIDAC census tracts. There are many LIDAC communities in partially and fully rural counties, such as Brown County where Georgetown is located. The largest clusters can be seen around the metropolitan cities of Cincinnati, Dayton, and Springfield.

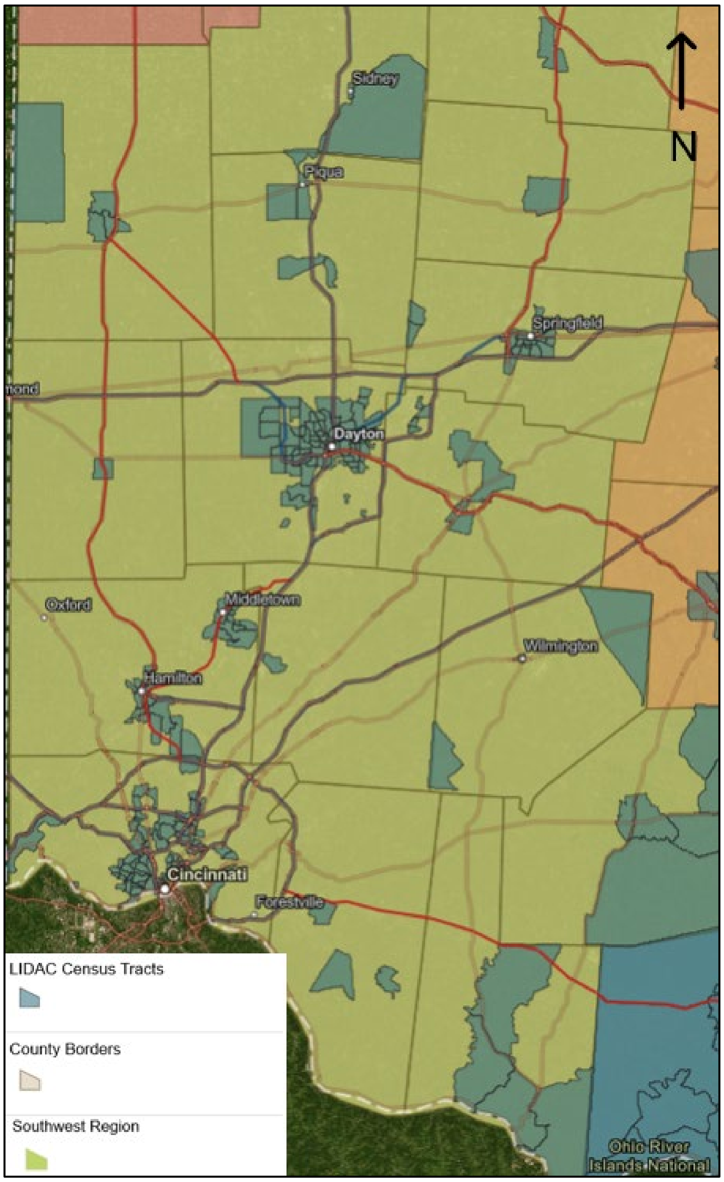


Figure 26. Southwest Ohio LIDAC Census Tracts

Cincinnati is Ohio's largest metropolitan area, with an estimated population of 2.1 million people.[79] The Cincinnati Metro Area includes five counties: Brown, Butler, Clermont, Hamilton, and Warren. The average percentile of $PM_{2.5}$ in the air for these counties' LIDAC census tracts is 85, which is 20 points higher than the state's average. Brown County experiences a significantly higher energy burden compared to the state (Figure 27), which has been common throughout many of the rural and partially rural counties. Hamilton County, home to downtown Cincinnati, features high levels of $PM_{2.5}$ in the air as well as diesel particulate matter, 23 and 29 points higher than those of Ohio, respectively (Figure 27).

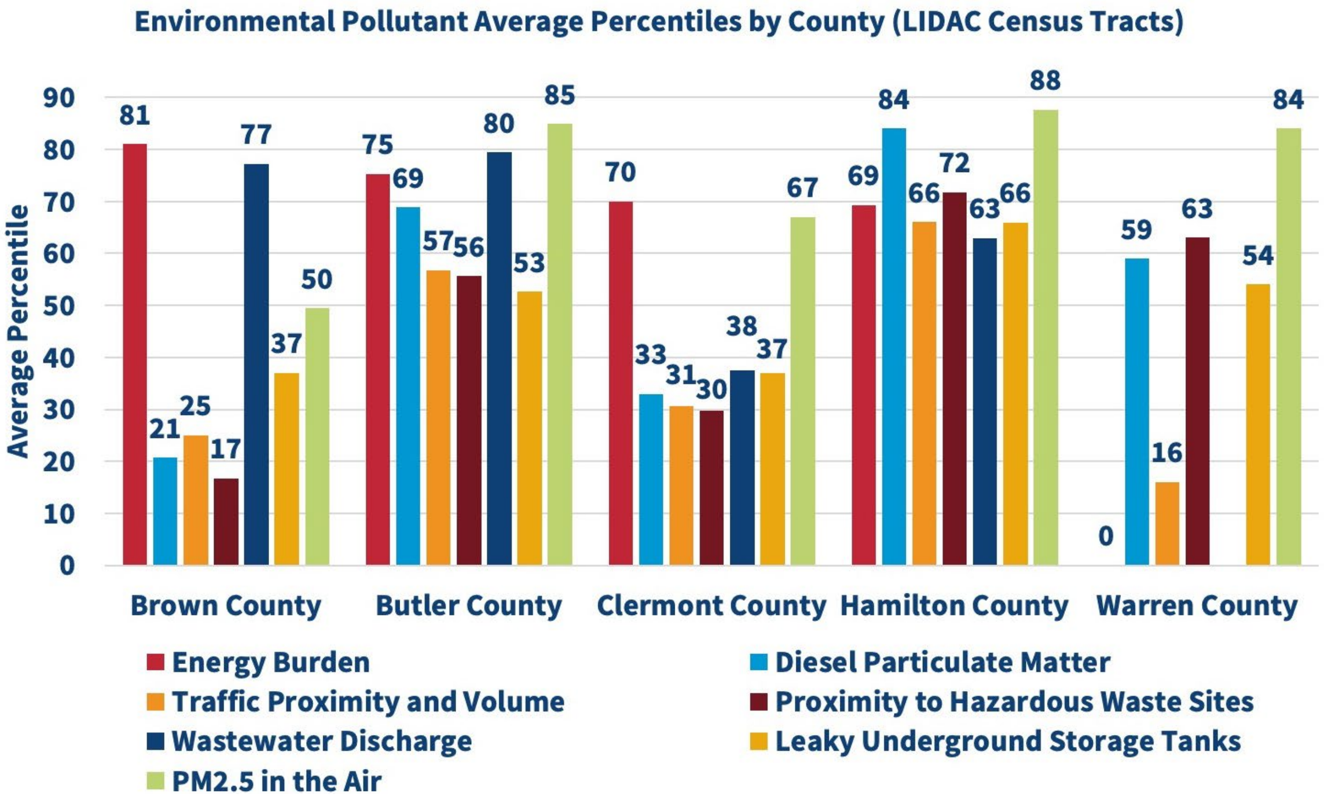


Figure 27. Environmental Pollutant Average Percentile in the Cincinnati Metro Area County's LIDAC Census Tracts

Figure 27 shows the environmental pollutant average percentiles in the Cincinnati Metropolitan Area's counties' LIDAC census tracts. All the counties, except for Brown, have a higher than state average percentile of $PM_{2.5}$ in the air. Hamilton County also features a higher than state average percentile for diesel particulate matter, traffic proximity, and volume.

[79] The Demographic Statistical Atlas of the United States – Statistical Atlas

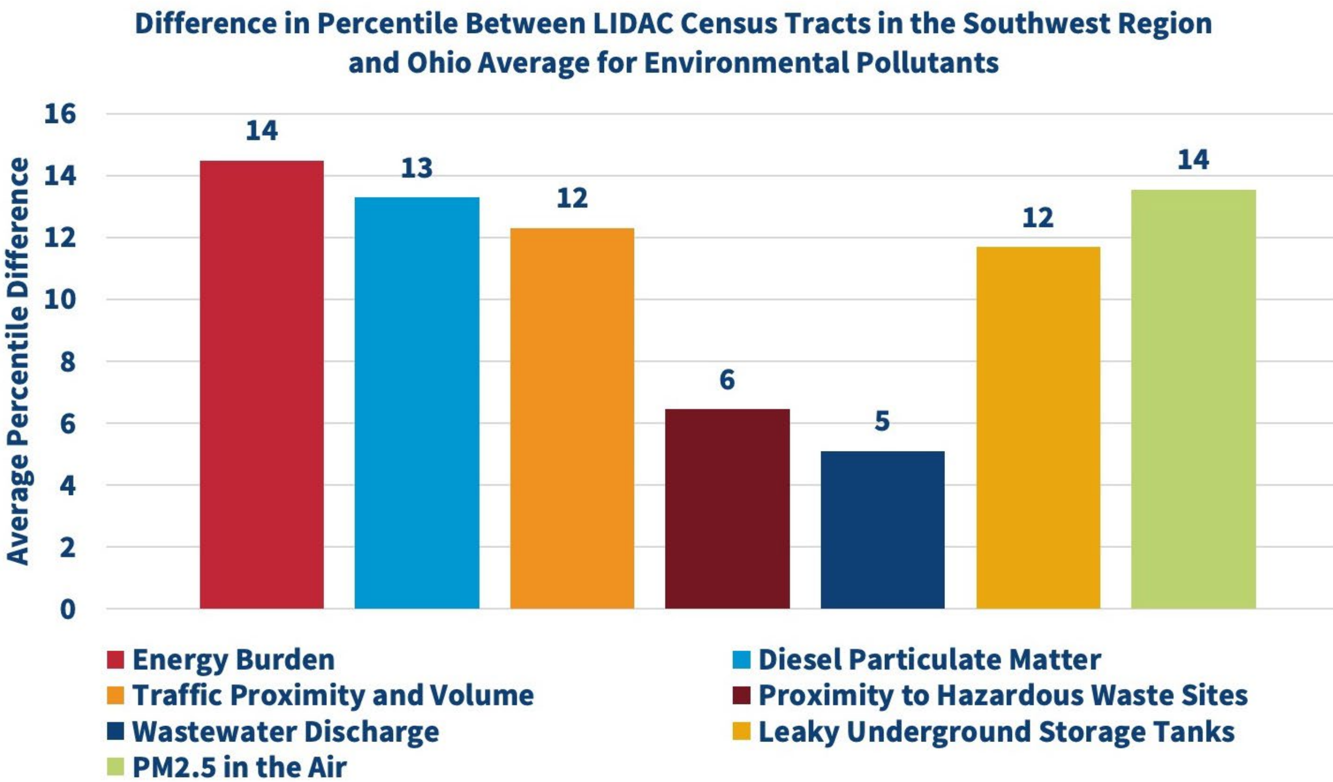


Figure 28. Environmental Pollutant Average Percentile Difference Between the Southwest Region of Ohio's LIDAC Census Tracts vs. Ohio Census Tracts

Figure 28 highlights the difference between Southwest Ohio's LIDAC census tract average environmental pollutants and Ohio's. The seven environmental pollutants are, on average, between 5 and 14 points higher than the state. Energy burden, diesel particulate matter, traffic proximity and volume, and $PM_{2.5}$ show the largest differences, signaling that the LIDACs are most affected by their proximity to roads and highways.

SOUTHEAST OHIO

Figure 29 shows the northern half of Southeast Ohio, and Figure 30 shows the southern half of the region. The map is split due to the large area of this region.

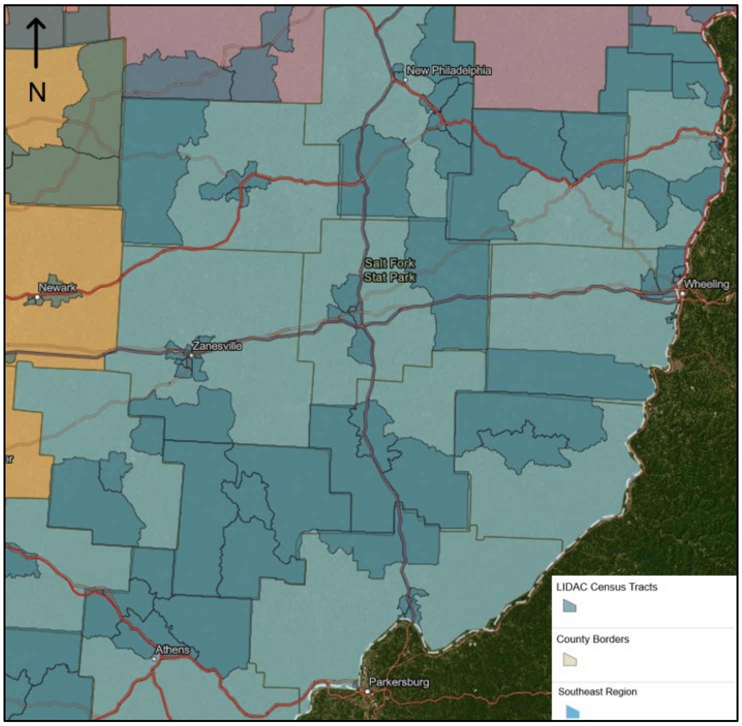


Figure 29. Northern half of Southeast Ohio LIDAC Census Tracts

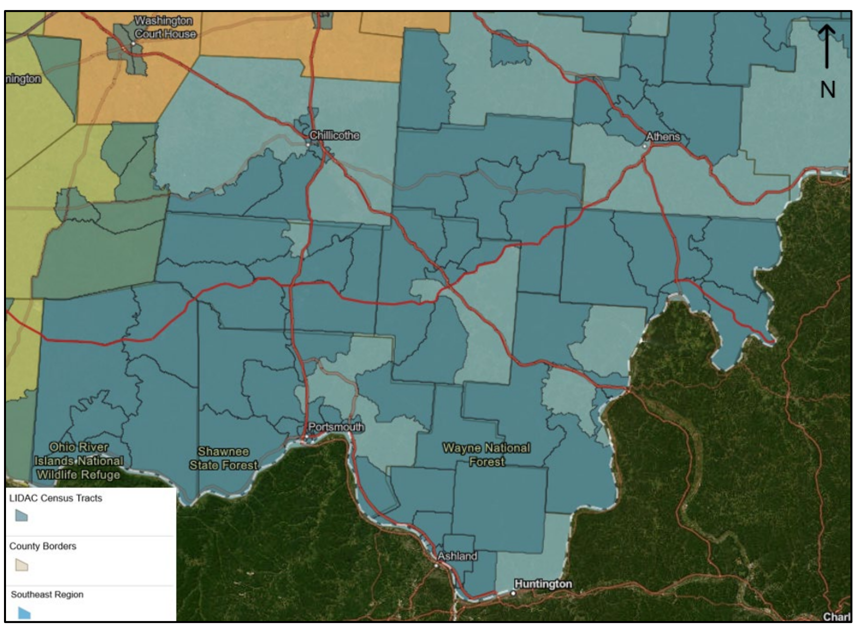


Figure 30. Southern half of Southeast Ohio LIDAC Census Tracts

This area has the relatively largest concentration of rural counties,[80] with the region's biggest challenge being low-income. This is consistent with energy burden having an average percentile 28 points higher than that of the state (Figure 31).

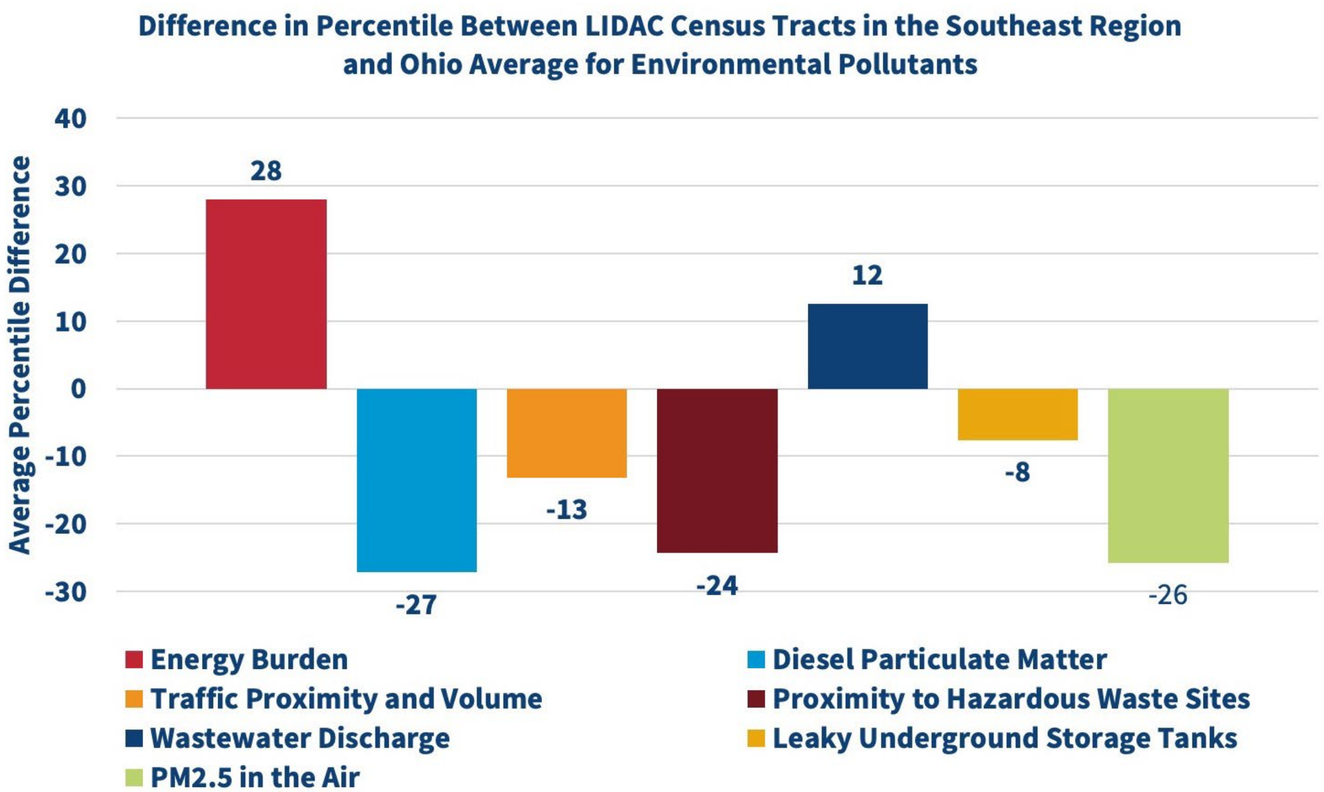


Figure 31. Environmental Pollutant Average Percentile Difference Between the Southeast Region of Ohio LIDAC Census Tracts vs. Ohio Census Tracts

Figure 31 shows the environmental pollutant average percentiles for Southeast Ohio's LIDAC census tracts compared to Ohio's census tracts. Energy burden and wastewater discharge are 28 and 12 points higher than Ohio's averages, respectfully.

OVERVIEW OF CO-POLLUTANTS

In addition to the direct benefits of GHG reduction measures, there are also often additional harmful co-pollutants that can also be mitigated that have damaging health effects. While many factors play a role in health outcomes, LIDAC census tracts in Ohio exhibit markedly worse health outcomes for several key metrics often associated with various co-pollutants.

Table 4. Average Percentiles of Health Variables in LIDAC census tracts vs. all census tracts in Ohio

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[80] Urban and Rural counties are defined using the Ohio Department of Health's 2020 classifications. Available at: 2020_rural_and_urban_counties.pdf (ohioruralhealth.org)

Average Percentile

	ADULTS WITH ASTHMA	ADULTS WITH CORONARY HEART DISEASE	ADULTS WITH DIAGNOSED DIABETES	AVERAGE LIFE EXPECTANCY (YEARS)
Disadvantaged Census Tracts in Ohio	90	82	83	73
All Census Tracts in Ohio	69	66	62	77

Below is a brief description of each of the co-pollutant's sources and the side effects of being exposed to them.

SULFUR DIOXIDE (SO2)

The present of SO_2 in the atmosphere primarily stems from the combustion of fossil fuels in power plants, petroleum refining, and steel making operations.

Short-term exposures to SO_2 can significantly harm the human respiratory system, causing breathing difficulties, particularly for individuals with asthma, especially children. Emissions of SO_2, resulting in elevated concentrations of this compound in the air, often prompt the formation of additional sulfur oxides (SO_X). These SO_X can undergo reactions with other compounds in the atmosphere, forming fine particles that contribute to particulate matter (PM) pollution. In significant quantities, these particles are capable of deeply penetrating the lungs and contributing to health problems.[81]

NITROGEN OXIDES (NOX)

NO_x refers to both nitric oxide (NO) and nitrogen dioxide (NO_2). Under ambient conditions, NO is rapidly oxidized to form NO_2; hence, NO_2 is usually considered a primary pollutant. The reaction of NO_2 with water produces nitrous acid (HONO), a strong oxidant and common indoor pollutant. Indoor levels of NO_2 are a function of both outdoor and indoor sources; therefore, indoor levels can be influenced by high outdoor levels originating from combustion or local traffic. It was reported that the distance between buildings and roadways has a significant influence on indoor NO_2 levels.[82] Additionally, major indoor sources include smoking and wood-, gas-, oil-,

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[81] https://www.epa.gov/so2-pollution/sulfur-dioxide-basics

[82] Kodama Y., Arashidani K., Tokui N., Kawamoto T., Matsuno K., Kunugita N., Minakawa N. *Environmental NO2 concentration and exposure in daily life along main roads in tokyo.* Environ. Res. 2002;89:236–244.

coal-, and kerosene-burning appliances, such as stoves, space, ovens, and water heaters and fireplaces.[83]

Breathing air with a high concentration of NO_2 can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), hospital admissions and visits to emergency rooms. Longer exposures to elevated concentrations of NO_2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly, are generally at greater risk for the health effects of NO_2.[84]

PARTICULATE MATTER (PM2.5)

Some $PM_{2.5}$ particles are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks, or fires. Most particles form in the atmosphere because of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries, and automobiles.

Particulate matter may contain microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems. Some particles less than 10 micrometers in diameter can get deep into your lungs and some may even get into your bloodstream. Of these, particles less than 2.5 micrometers in diameter, also known as fine particles or $PM_{2.5}$, pose the greatest risk to health. Fine particles are also the main cause of reduced visibility (haze) in parts of the United States.[85]

VOLATILE ORGANIC COMPOUNDS (VOCS)

Organic chemical compounds are in both indoor and outdoor environments because they have become essential ingredients in many products and materials. Outdoors, VOCs are released into the air mostly during manufacturing activities or use of everyday products and materials. Indoors, VOCs are mostly released into the air from the use of products and materials containing VOCs, such as paints, pesticides, building materials, household cleaners, carpeting, and automotive products.

The ability of organic chemicals to cause health effects varies greatly. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed. Some of the mild effects are eye, nose and throat irritation, headaches, loss of coordination and nausea. The more serious effects can be damage to liver, kidney, and central nervous system, along with cancer in some animals and humans.[86]

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[83] Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality – PMC (nih.gov)

[84] Basic Information about NO2 | US EPA

[85] Particulate Matter (PM) Basics | US EPA

[86] Volatile Organic Compounds' Impact on Indoor Air Quality | US EPA

AMMONIA (NH3)

NH_3 is found throughout the environment in the air, soil, and water, and in plants and animals, including humans. Ammonia is also found in many household and industrial cleaners.

High levels of ammonia can irritate and burn the skin, mouth, throat, lungs, and eyes. Very high levels of NH_3 can damage the lungs or cause death. The level of exposure depends upon dose, duration, and work being done.[87]

ANTICIPATED BENEFITS AND IMPACTS OF PRIORITY MEASURES

This section discusses the potential benefits and impacts of the priority measures outlined in this Plan to the various LIDACs across the state. A more in-depth case study is performed for the first priority measure in Franklin County as an illustrative example.

1. LIGHT-DUTY ZERO EMISSION VEHICLES (ZEV)

FRANKLIN COUNTY – ILLUSTRATIVE EXAMPLE

Given the typically higher levels of pollutants in LIDACs, it is expected that reducing emissions could have the greatest benefit in these areas. To illustrate this, we conducted a high-level analysis of the county. Franklin County has a population of approximately 1.3 million people, making it the most populous county in the state. The county is characterized by its monocentric layout, with the capital of the state, Columbus, at its center. The county has a population density of 2,186 people per square mile, while Columbus' population density is 4,295 people per square mile. Columbus' downtown area features a mix of high-rise office buildings, apartment complexes, and retail outlets, while its suburbs are more residential. The infrastructure of the county features an extensive network of highways, railroads, and airports, including the John Glenn Columbus International Airport. However, Franklin County's extensive road network, while largely beneficial, also presents certain challenges. The county's heavy reliance on road transportation has led to a rapid increase of roads, highways, and freeways. The infrastructure, while necessary for the county's transportation needs, has also contributed to issues such as urban sprawl, traffic congestion, and environmental pollution. The city is surrounded by the Interstate 270 beltway, intersected by Interstate 70, 71, innerbelt Interstate 670, and significant State Roads 315, 161, 62, and 40, among others.

Despite its urban character, Franklin County also contains several more suburban and rural areas, particularly in its outer regions. These areas are characterized by their lower population densities and more agricultural landscapes.

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[87] Ammonia | NIOSH | CDC

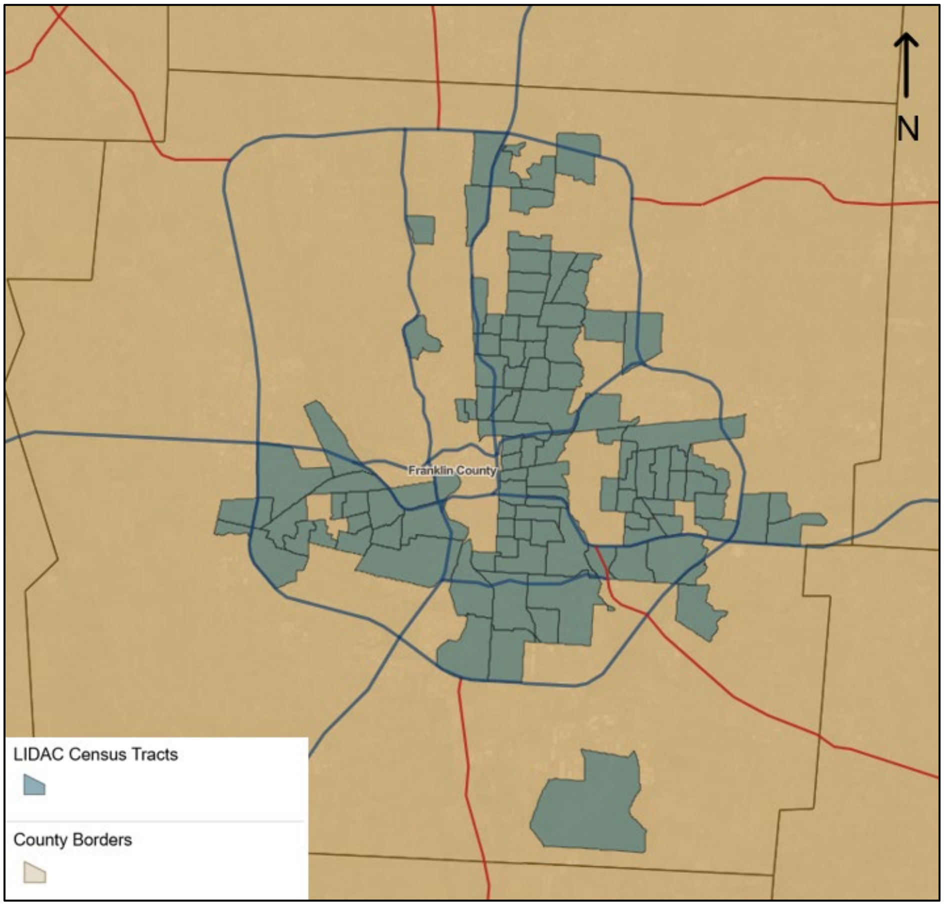
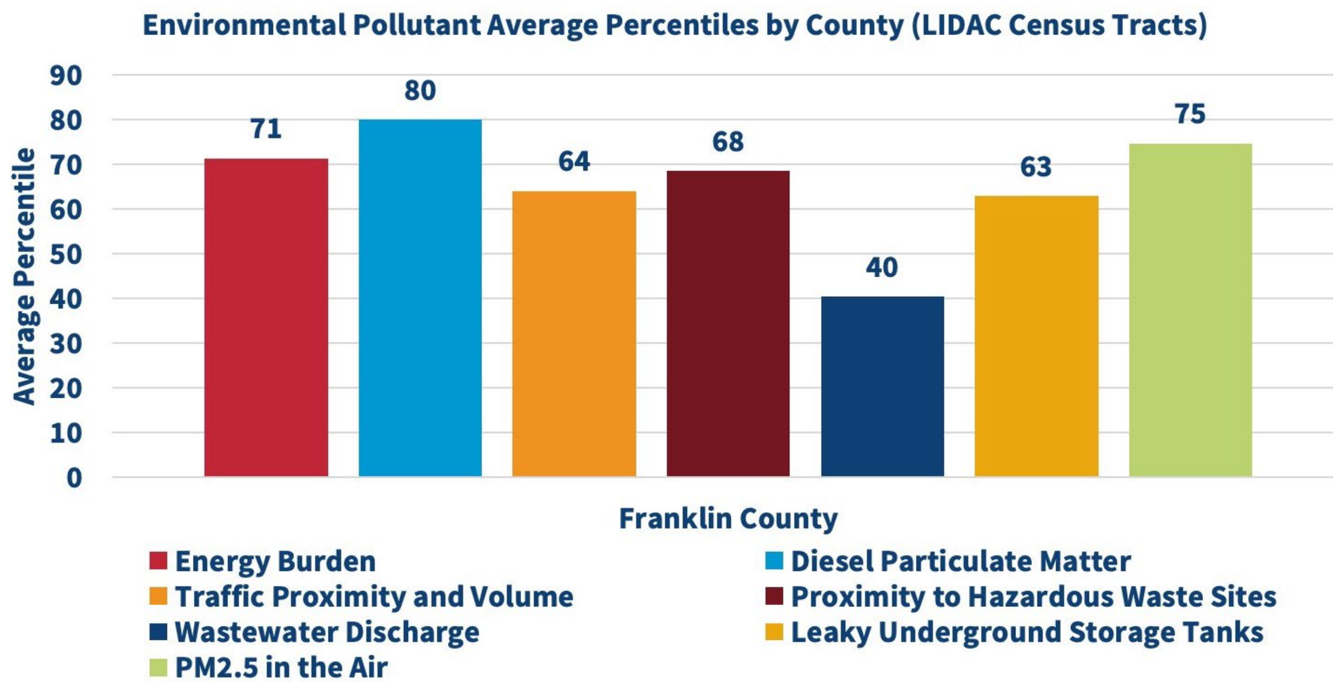
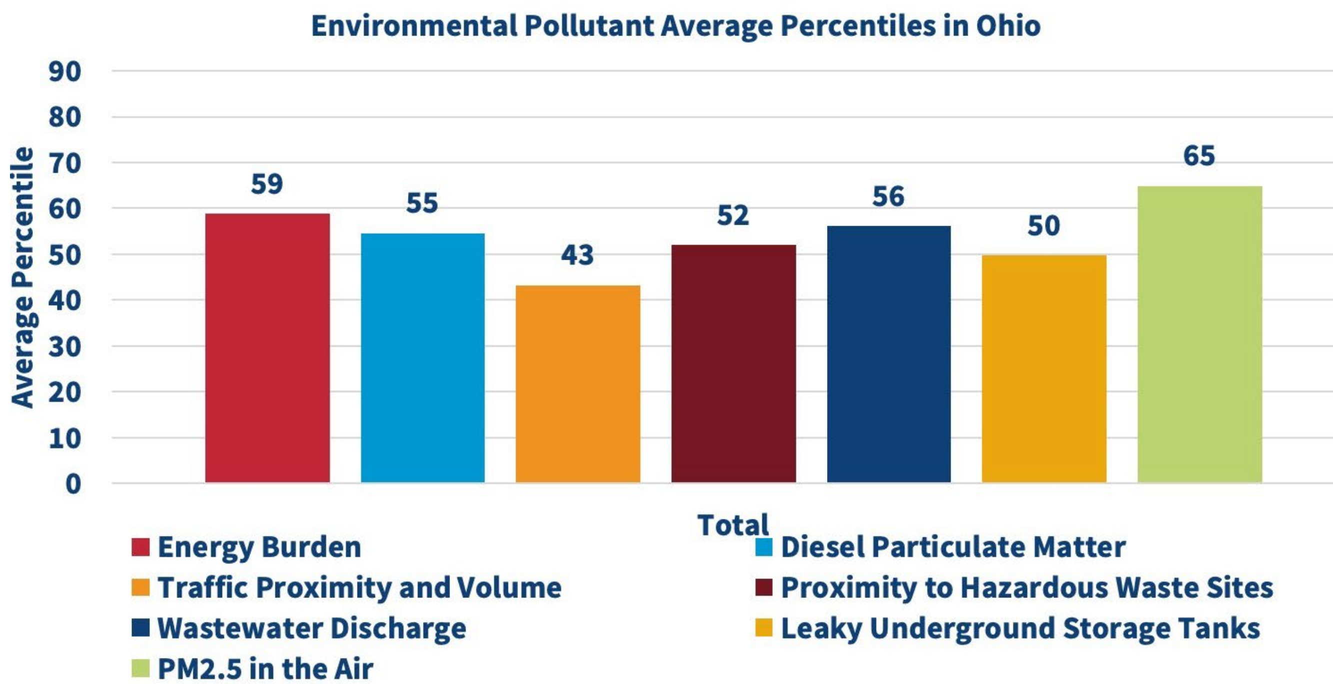


Figure 32. Franklin County LIDAC Census Tracts

One immediate observation of the distribution of LIDAC communities in Franklin County is that nearly every LIDAC community is neighboring a major highway or thoroughfare (Figure 32). In fact, the traffic proximity and volume for Franklin County's LIDACs is 987 (64th percentile), significantly larger than the statewide overall average of 436 (43rd percentile) and state LIDAC average of 638 (52nd percentile, Figure 33).


Environmental Pollutant Average Percentiles by County (LIDAC Census Tracts)
Average Percentile
90
80
70
60
50
40
30
20
10
0
71
80
64
68
40
63
75
Franklin County
Energy Burden
Diesel Particulate Matter
Traffic Proximity and Volume
Proximity to Hazardous Waste Sites
Wastewater Discharge
Leaky Underground Storage Tanks
PM2.5 in the Air


Environmental Pollutant Average Percentiles in Ohio
Average Percentile
90
80
70
60
50
40
30
20
10
0
59
55
43
52
56
50
65
Total
Energy Burden
Diesel Particulate Matter
Traffic Proximity and Volume
Proximity to Hazardous Waste Sites
Wastewater Discharge
Leaky Underground Storage Tanks
PM2.5 in the Air

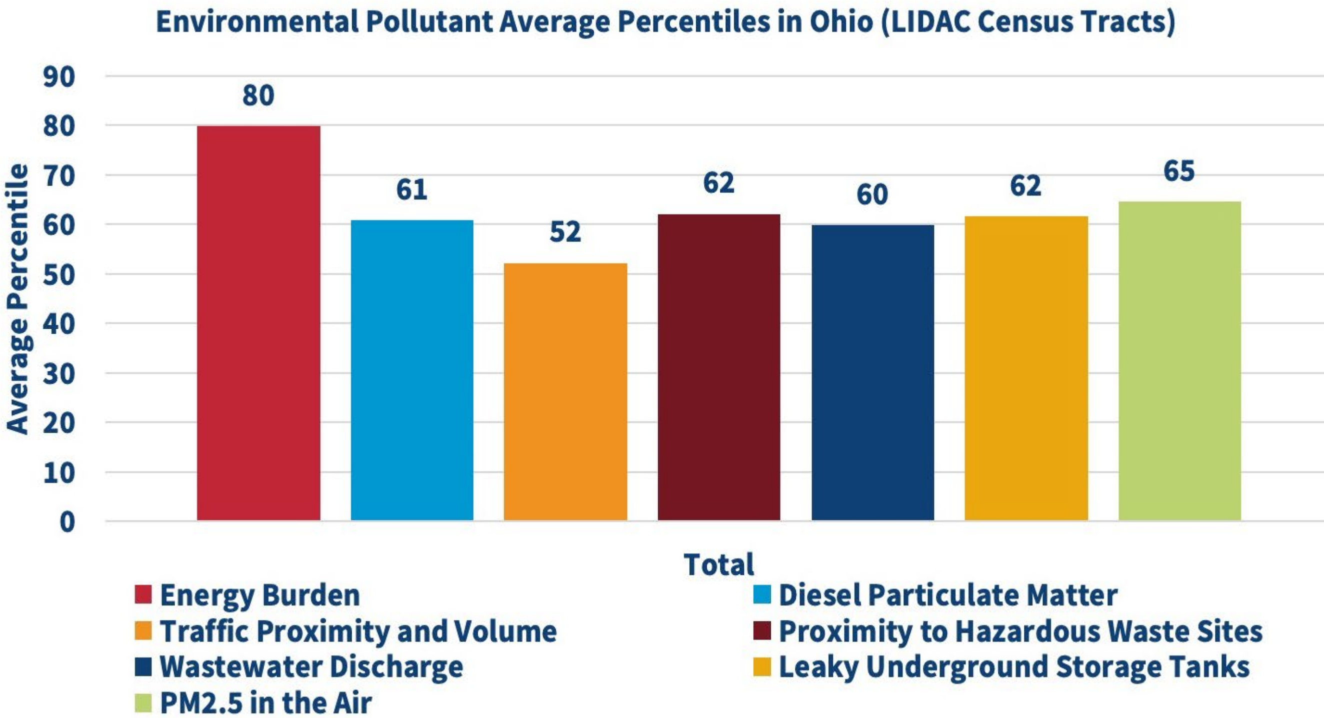


Figure 33. LIDAC Environmental Pollutant Average Percentiles Franklin County vs. all of Ohio vs Ohio LIDAC Census Tracts

Figure 33 features three charts comparing the environmental pollutant averages: the top is Franklin County LIDAC census tracts, the middle chart is all census tracts in Ohio, and the bottom chart is LIDAC census tracts in Ohio. Franklin County features average percentiles higher than both latter charts in diesel particulate matter, traffic proximity and volume, proximity to hazardous waste sites, leaky underground storage tanks, and $PM_{2.5}$ in the air.

Figure 34 shows the average traffic proximity and volume in Franklin County census tracts (left), Ohio census tracts (middle), and Ohio's LIDAC census tracts (right). Franklin County's average traffic proximity and volume is 226% more than that of all census tracts in Ohio, and 154% more than the LIDAC census tracts in Ohio.

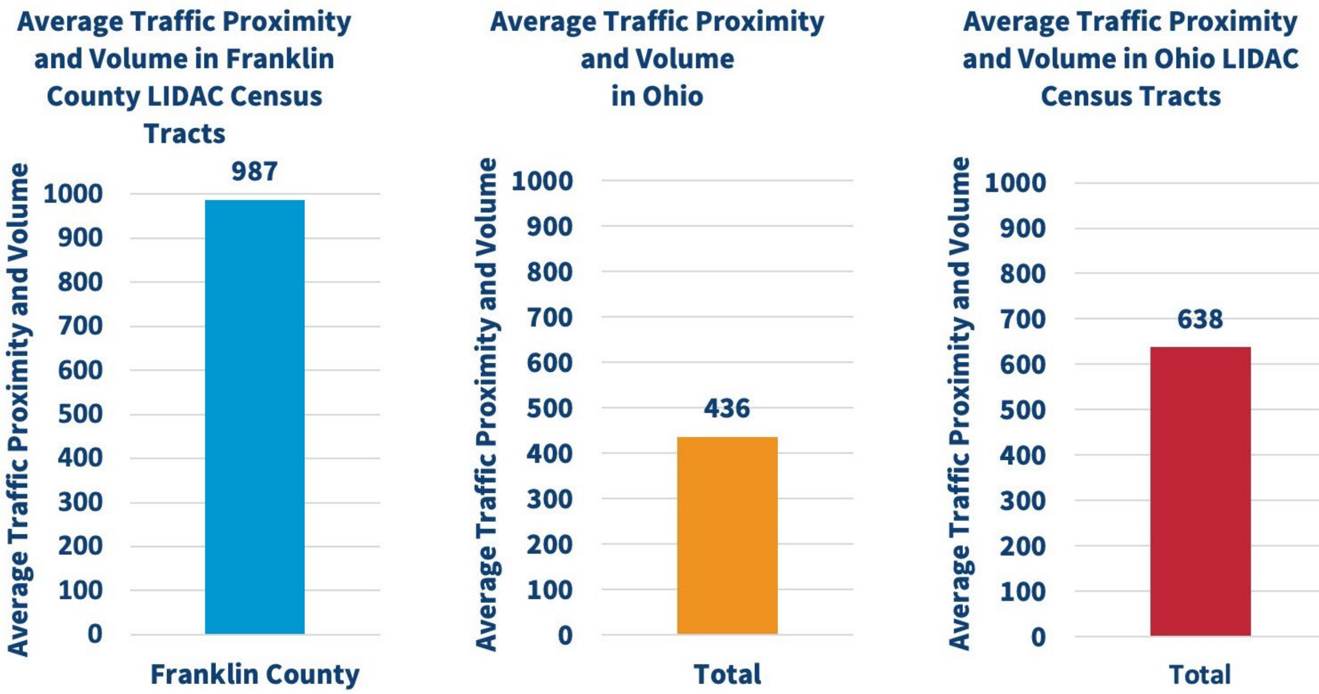


Figure 34. Average Traffic Proximity and Volume in Franklin County LIDAC Census Tracts vs. all of Ohio vs. Ohio LIDAC Census Tracts

Driving is extremely prevalent in Franklin County, with a total daily VMT of 30.6 million miles. The breakdown of these VMT by road type as provided by the ODOT are in Table 5 below.[88]

Table 5. Adjusted Franklin County Daily VMT (In Thousands) 2019

	INTER – STATE	PRINCIPAL ARTERIAL – OTHER FREEWAYS/ EXPRESS-WAYS	PRINCIPAL ARTERIAL – OTHER	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL	TOTAL
Rural	154.92	0.00	18.47	16.11	83.58	4.50	27.99	305.57
Urban	12,747.98	2,679.07	4,881.59	5,139.5	2,378.51	495.27	1,994.6	30,316.60

Of all daily VMT, 99% are urban and 42% are interstate urban. As previously indicated, the arterial highways in Franklin County run through almost every community and are adjacent to nearly every LIDAC census tract.

[88] Archived DVMT Reports by Year. Available at: 2019 Kdvmt.xlsx (state.oh.us)

PRELIMINARY LIGHT-DUTY ZERO EMISSION VEHICLES (ZEV) ANALYSIS

Employing U.S. EPA's Motor Vehicle Emission Simulator Version 4, in 2019 the total harmful pollutants in Franklin County from passenger vehicles is presented in the table below (in tons).

Table 6. Harmful Annual Emissions due to Passenger Vehicles in Franklin County in 2019 (in tons)

PM2.5	SO2	NOX	NH3	VOC
24	17	1,386	286	1,628

For this preliminary analysis, we employ 2019 VMT and emissions assuming all else equal. Including projected changes in VMT as well as existing organic adoption of alternative fuel and zero-emission vehicles is beyond the scope of this exercise but will be considered in the subsequent CRP.

In order to provide a high-level estimate for the potential quantitative benefits of emissions reductions from further adoption of light-duty zero emissions vehicles, we employ estimates of the total dollar value (mortality and morbidity) per ton of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursor reduced associated with Internal Combustion Engines in the table below:[89] These health impacts and the economic value of these impacts were derived by U.S. EPA using the Environmental Benefits Mapping and Analysis Program-Community Edition (BenMAP-CE v1.5).[90]

Table 7. Summary of the total dollar value (mortality and morbidity) per ton of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursor reduced with Internal Combustion Engines 2030 (in 2019 dollars)

	DIRECT				OZONE	
Discount Rate	$PM_{2.5}$	SO_2	NO_X	NH_3	NO_X	VOC
3%	$179,000	$41,600	$11,400	$81,500	$64,400	$10,000
7%	$160,000	$37,300	$10,200	$73,200	$57,700	$8,990

These costs are borne both by individual residents as well as the community, from loss of productivity, additional medications, treatment, hospital visits, and even death.

[89] U.S. Environmental Protection Agency. *Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors and Ozone Precursors from 21 Sectors.* September 2023. Available at: source-apportionment-tsd-oct-2021_0.pdf (epa.gov)

[90] Sacks, J. D.; Lloyd, J. M.; Zhu, Y.; Anderton, J.; Jang, C. J.; Hubbell, B.; Fann, N. *The Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP–CE): A Tool to Estimate the Health and Economic Benefits of Reducing Air Pollution.* Environmental Modelling and Software 2018, 104. https://doi.org/10.1016/j.envsoft.2018.02.009.

To calculate the total costs associated with these emissions for the year 2030 in 2019 dollars, we multiply the quantities of each of the harmful emissions by their corresponding price.

While it is difficult to know the exact impact of electric vehicle incentives on adoption in a specific region, we can consider the hypothetical impact of electrifying a percentage of existing VMT that are currently internal combustion. This reduction in combustion VMT may be achieved by the adoption of zero electric vehicles, plug-in hybrids, or a combination of the two. To illustrate the potential benefits, we project a range for a given percentage of combustion VMT reduced for 2030 in 2019 dollars, summarized in Table 7.

Table 8. Potential Annual (2030) Financial Impact of Vehicle Electrification in Franklin County December 2023 dollars)

	PERCENTAGE OF 2019 VMT REMOVED VIA ELECTRIFICATION		
Discount Rate	5%	7%	10%
3%	$8,979,060	$12,570,684	$17,958,120
7%	$8,049,265	$11,268,971	$16,098,530

These benefits due to reductions in mortality and morbidity equate to between $6.24 cents to $13.92 per resident of Franklin County, per year.

While this analysis has been conducted at the county level, given the makeup and distribution of LIDAC census tracts within Franklin County, it is evident that a large share of these annual benefits would accrue to LIDACs.

It should be noted that the estimates above represent the potential benefits for a single county for a single year. Of course, considering the potential impact over a longer time (and discounting to derive the net present value) would result in significantly larger benefits. Expanding this analysis to the state level would generate correspondingly higher benefits than reported in this illustrative exercise. However, such a quantification is beyond the intention of this illustrative exercise discussing potential benefits to LIDACs.

While these annual potential benefits are significant, we also should note that ZEVs generally require less maintenance and so mechanics and other internal combustion related jobs, such as gas stations, may see reduced employment. Additionally, it is likely that LIDACs will adopt ZEV at lower rates than more wealthy communities, so additional outreach or economic incentives may be required. However, even if LIDACs themselves adopt EVs at a lower rate than non-LIDACs, the benefits from overall VMT, given commuting patterns, may still benefit LIDACs even if they are not themselves driving the ZEVs. For example, Yu et al (2023) found that in California, despite disadvantaged communities adopting zero emission vehicles at a rate 3.8 times less than non-disadvantaged communities, disadvantaged communities receive 40% more benefits from emissions reductions than non-disadvantaged communities given the location of VMT relative to the placement of disadvantaged communities.[91]

The benefits to such an emissions reduction measure are likely most impactful where traffic proximity and airborne co-pollutants are at the highest concentration. Thus, the potential benefits are likely higher in urban areas and less beneficial in rural areas.

2. MEDIUM- AND HEAVY-DUTY ZERO EMISSION VEHICLES (ZEV)

Expanding medium- and heavy-duty ZEVs would have similar benefits and co-benefits to the LIDAC residents of Ohio, including local reductions in $PM_{2.5}$ resulting from combustion in trucks, reduced exposure to diesel particulate emissions, ozone, and noise.[92]

The introduction of additional Medium- and Heavy-Duty Zero Emission Vehicles ZEV's, just like for Light-Duty ZEVs, also leads to capacity building in terms of ZEV maintenance personnel and facilities. Infrastructure construction for EV charging stations will create new or improved local jobs and build capacity through training; new jobs will be created in ZEV manufacturing and other technology sectors.[93]

However, ZEVs generally require less maintenance, so mechanics and other truck maintenance jobs may be negatively impacted.

The benefits to such an emissions reduction measure are likely most impactful where traffic proximity and airborne co-pollutants are at the highest concentration. Thus, the potential benefits are likely higher in urban areas and less beneficial in rural areas.

3. TRANSPORTATION EFFICIENCIES

Expanding transportation efficiency would reduce time spent in transit, reduction in vehicles with combustion engines, reduced air pollution emissions (specifically $PM_{2.5}$) and other electrification co-benefits such as reduction of noise in streets previously from car engines. The expansion of public transit routes will reduce barriers to travel for low-income households that depend on public transit and improve connectivity to the rest of the city including access to services,

[91] Yu, Q., He, B. Y., Ma, J., & Zhu, Y. (2023). California's zero-emission vehicle adoption brings air quality benefits yet equity gaps persist. Nature communications, 14(1), 7798. https://doi.org/10.1038/s41467-023-43309-9

[92]Congressional Research Service (2023). Heavy-Duty Vehicles, Air Pollution, and Climate Change. https://crsreports.congress.gov/product/pdf/IF/IF12043

[93] Building Charging for Electric Vehicles Can Create Good Jobs (nrdc.org)

education, jobs, parks, and green spaces. In addition, improvements in access to public transit may reduce poverty burdens due to reduced transportation costs.[94]

Increasing service times, routes, and transit vehicle trip frequencies will result in the creation of new jobs, (e.g., transit drivers and maintenance operators), however, there would be declines in some other jobs such as taxis and private sharing vehicles.[95]

The benefits to such an emissions reduction measure are likely most impactful where traffic proximity and airborne co-pollutants are at the highest concentration. Thus, the potential benefits are likely higher in urban areas and less beneficial in rural areas.

4. RENEWABLE ELECTRICITY GENERATION

Renewable electricity generation can provide household energy savings that reduce high energy burdens[96] and provide other meaningful co-benefits such as pollution abatement (both GHG and air pollutants), improved grid reliability through energy storage, improved economic outcomes for LIDAC households, investment in local businesses and an increase in high-quality local workforce development opportunities.

Expanding renewable electricity generation will lead to several tangible benefits to LIDACs, potentially reducing the electricity costs, and thus energy burdens when LIDACs utility costs are directly reduced. There also may be improvements in air quality depending on the location of existing fossil-fuel based power generation. The manufacture, installation, and maintenance of renewable energy generation could also translate the creation of new jobs. However, this could potentially lead to a decline in jobs such as mining and extraction.[97] It could also contribute to land use conflict for residents and farmers concerned about land value, land available for cultivation, and other ecological concerns. Multiple solar projects in the state of Ohio have received such pushback.[98]

The benefits to such an emissions reduction measure are likely most impactful where energy burden is a prevalent factor. From the prior overview of LIDACs in Ohio, this occurs across the state in both urban and rural communities, in particular Northeast and Southwest Ohio.

[94] Public Transportation | MIT Climate Portal

[95] How can investing in public transport benefit our cities? | World Economic Forum (weforum.org)

[96] Energy Justice and the Energy Transition (ncsl.org)

[97] Ohio U.S. Energy and Employment Report – 2023 USEER23-OH-v2.pdf (energy.gov)

[98] Farmers concerned over potential solar farm in Greene County (daytondailynews.com)

5. BUILDING ENERGY EFFICIENCY

Expanding building energy efficiency can significantly reduce energy costs for households. By using less power for heating, cooling, and lighting families will have more available money for food, healthcare, and other necessities. Additionally, energy-efficient buildings often provide healthier and more comfortable living environments because they are designed to ensure good air quality, healthy temperatures, and humidity levels to prevent mold, and reduce noise levels, improving overall health. [99] Enacting energy efficiency measures can create local jobs and stimulate economic growth because they often involve retrofitting existing buildings or constructing new, energy-efficient ones.[100]

However, the upfront costs of implementing energy efficiency measures can be high, which may be prohibitive for low-income households and communities and older properties. While these costs can often be recouped over time through energy savings, the initial investment may still be out of reach for many. Additionally, as buildings become more energy-efficient and desirable, property values may rise, potentially pushing out existing residents who can no longer afford to live there.

The benefits to such an emissions reduction measure are likely most Impactful where energy burden is a prevalent factor. From the prior overview of LIDACs in Ohio, this occurs across the state in both urban and rural communities, in particular Northeast and Southwest Ohio.

6. CLEAN HEATING

Expanding clean heating can significantly decrease the cost of heating, which is often a substantial portion of a household's energy bill. High-efficiency electric heat pumps are more energy-efficient than traditional heating systems, cutting electricity use by 50% when compared with electric resistance heating, leading to lower energy consumption and cost savings according to the DOE.[101] Energy burden is a significant issue in many LIDACs in Ohio, so any efforts to reduce the cost of energy can greatly ameliorate this challenge. Clean heating systems can improve indoor air quality by reducing the emissions of $PM_{2.5}$.[102] These pollutants are often produced by traditional heating systems and can cause or exacerbate health problems like asthma, heart disease, and other respiratory conditions. This is particularly important in low-income communities, which often bear a disproportionate burden of air pollution.[103] Additionally,

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[99] Health and Safety Benefits of Clean Energy | Department of Energy

[100] Here's how clean energy will change the global jobs market | World Economic Forum (weforum.org)

[101] Electric Resistance Heating | Department of Energy

[102] Significant but Inequitable Cost-Effective Benefits of a Clean Heating Campaign in Northern China | Environmental Science & Technology (acs.org)

[103] Currit, Elisabeth. "Disproportionate Exposure to Air Pollution for Low-Income Communities in the United States." Ballard Brief. May 2022. www.ballardbrief.byu.edu.

the installation and maintenance of clean heating systems can create local jobs and stimulate economic development, providing a much-needed boost to these communities.

However, there are also potential impacts to consider. The initial cost of installing clean heating systems can be high, which may be a significant barrier for low-income households. While these costs can often be offset over time through energy savings, the upfront investment may still be unaffordable for many, and may require direct assistance, subsidies, or tax incentives. The transition to clean heating may require significant changes to existing infrastructure, which can be disruptive and costly. Like clean heating, the desirability of an energy-efficient area could lead to gentrification and the displacement of the current residents.

The benefits to such an emissions reduction measure are likely most impactful where energy burden is a prevalent factor. From the prior overview of LIDACs in Ohio, this occurs across the state in both urban and rural communities, in particular Northeast and Southwest Ohio.

7. COMPOSTING

Expanding composting in low-income and disadvantaged communities can bring several benefits. Composting can help reduce the amount of municipal waste that households produce, therefore lowering total waste needing to be collected by municipalities and lowering costs. Additionally, composting provides a way to recycle organic waste into nutrient-rich compost, which can be used to improve soil health in community gardens or urban and rural farms, potentially increasing access to fresh produce. Composting can also have environmental benefits by reducing the amount of organic waste that ends up in landfills, where it can produce methane, a potent greenhouse gas.

While composting can reduce waste disposal costs, the initial costs of setting up a composting system or program may be prohibitive for some low-income households or communities. Composting also requires space, which is limited in densely populated urban areas where many low-income and disadvantaged communities are located.

8. CLEAN WASTE-TO-ENERGY

Expanding clean waste-to-energy (WtE) initiatives in low-income and disadvantaged communities can offer several benefits by providing a sustainable solution for waste management. WtE facilities reduce the amount of waste that ends up in landfills or reduces agricultural waste emissions by converting it to energy, and therefore reduces the need for fossil fuel energy. Therefore, there will be fewer greenhouse gas emissions and co-pollutants in the air.[104] WtE also has the potential to reduce energy costs, leading to lower energy burdens for many households in LIDACs where WtE is installed. WtE facilities additionally create jobs

[104] Trash to treasure: The benefits of waste-to-energy technologies | Argonne National Laboratory (anl.gov)

through the construction and operation phases, but they can be expensive to operate and could potentially discourage waste reduction and recycling efforts.

The benefits to such an emissions reduction measure are likely most impactful where energy burden is a prevalent factor. From the prior overview of LIDACs in Ohio, this occurs across the state in both urban and rural communities, in particular Northeast and Southwest Ohio.

Coordination and Outreach

Public outreach and participation are essential to this Plan, and Ohio EPA is committed to centering equity and respect for all community members. Throughout the development of this Plan, we conducted extensive intergovernmental coordination and outreach alongside community outreach. This section describes the framework used to support robust and meaningful engagement, ensuring comprehensive stakeholder representation and overcoming obstacles to engagement, including linguistic, cultural, institutional, geographic, and other barriers.

When developing a stakeholder outreach plan, we took a mindful approach to formulate a strategy, all while actively capturing lessons learned and opportunities for future engagement. Our strategy focuses on learning about communities' priorities and values, building capacity and interest in sustainable development, and increasing the community buy-in and awareness of Ohio EPA's vision. As we learned of highly interested stakeholders or additional groups to engage, these insights were taken into consideration for future engagement opportunities relating to either this Plan or CRP discussions.

IDENTIFICATION OF STAKEHOLDERS

Ohio EPA identified stakeholder representatives who may be impacted by implementation of this Plan. Stakeholders included, without limitation:

INTERAGENCY GROUPS	PRIVATE ORGANIZATIONS	LOCAL ORGANIZATIONS	COMMUNITY-BASED ORGANIZATIONS AND NON-PROFITS
• Transportation Agencies • Energy Agencies • Agricultural agencies • Housing Authorities • Air Quality Authorities	• Ohio Businesses and Corporations • Agricultural Organizations • Utilities	• Metropolitan Planning Organizations • Local elected officials • Community Action Organization	• Faith-based Organizations • Labor Organizations • Underserved and Disadvantaged Community Representatives

To identify stakeholders, Ohio EPA contacted municipalities, interagency organizations, community organizations, regional planning groups, and advocacy organizations known to be interested in climate resiliency and environmental planning. The list of identified stakeholders as of the publication of this Plan is included in Appendix I: Coordination and Outreach Log. The selected group of stakeholders engaged were chosen based on the key knowledge and perspective they hold and the values in which they uphold for their communities and neighboring communities. This was essential criteria for our initial outreach plan to help ensure we were effective in our planning efforts and prioritization.

In addition to our tailored engagement approach, Ohio EPA also provided public events and engagement opportunities which encouraged Ohioans to increase their awareness of our CPRG program and contribute to our planning efforts with their perspectives.

INTERAGENCY AND INTERGOVERNMENTAL COORDINATION

Ohio EPA took a strategic and intentional approach to interagency and intergovernmental coordination. The approach was rooted in both awareness of the planning efforts and the need for collaboration and data sharing.

To begin, we assessed how much state agencies knew about the CPRG program and Plan initiatives being carried out based on previous discussions and informative sessions. We wanted to ensure that every interaction with these groups supported the understanding of this project and the goals of our Plan. In addition, Ohio EPA used this opportunity to inform groups that were not directly related to the Plan's emission sectors about the CPRG program and how they could remain involved during Plan development. For groups that could support the Plan by providing emissions data and collaborating on reduction measures (such as the ODOT and OHFA), the Ohio EPA saw engagement as a collaborative effort to share sector-specific data and examine the feasibility of proposed reduction measures.

A critical driver of our interagency engagement was the idea of creating a strong foundational knowledge regarding the CPRG program. This alignment is what allowed Ohio EPA to establish partnerships with other state agencies that will prove beneficial as we continue to collaborate across the state for CRP planning efforts.

OUTREACH APPROACH AND PLAN

Ohio EPA's outreach plan was grouped into three main categorizations of stakeholder groups and outreach objectives:

- Engaging MSAs that received CPRG funding, to ensure collaboration and knowledge sharing across recipients,
- Engaging with utilities, manufactures, environmental groups, regional planning groups, and more, to identify priorities, reduction measures, and opportunities for a coordinated PRP that benefits the state,
- And engaging with community groups and advocates to understand the priorities of and environmental impact to LIDAC and historically underrepresented regions.

Taking a segmented approach allowed Ohio EPA to formulate an engagement strategy to connect with audiences around their priorities and concerns, contributing to an inclusive and representative Plan. Many of our initial conversations were geared towards awareness of the CPRG program – introducing the funding award and the first deliverable, that being the Plan. We leveraged the initial discussions as a way solicit input as to what other communities and organizations to engage for individual discussions. As Ohio EPA began documenting our GHG inventory and potential GHG emissions reduction measures, we capitalized on these small group meetings to gather initial feedback of our findings to date. Being able to review these findings throughout our stakeholder engagement process allows our team to continually fine tune our Plan strategy to better fit the broader goals of the state and its key counterparts.

Ohio EPA acknowledges that individuals and organizations will vary in their understanding and perception of climate resiliency actions and their level of involvement. Consequently, public engagement events and tools were designed to target key stakeholders. To reach a broad stakeholder base of interested organizations wanting to partake in Plan related discussions, Ohio EPA conducted large-style virtual forums to encourage public participation:

VIRTUAL PUBLIC WEBINAR

Ohio EPA hosted a virtual public webinar which was open to all organizations and individuals across the state of Ohio. The webinar, attended by over 100 individuals and over 20 Ohio organizations, provided attendees with a detailed overview of Ohio EPA's CPRG program, details of the objectives and requirements of the Plan, and a forum to ask questions and submit feedback for consideration as Ohio EPA develops their Plan. All materials from the webinar, including a recording, were made public on Ohio EPA's website to drive awareness and education for those who were unable to attend the session live.

To further promote transparency, Ohio EPA hosted an additional virtual public webinar to report on the findings of this Plan. This forum served to inform stakeholders about the findings in the Plan – specifically the proposed GHG emissions reduction measures. Stakeholders were given the opportunity to ask questions and offer their insights to inform Ohio's ongoing climate resiliency planning.

CPRG SURVEY INPUT AND OUTREACH DOCUMENTATION

To gather input from a wide range of stakeholders, Ohio EPA made an online survey available where respondents could submit feedback, considerations, and opportunities for coordination as the Plan was developed. Our survey received 96 responses including, but not limited to, Ohio local governments, grassroot organizations, and local planning councils. This survey allowed stakeholders to indicate what type of support – financial, technical, or legislative – they would require to further sustainability goals. Questions included:

- Does your organization currently have a program(s) or project(s) in place that drives GHG emissions reductions?
- What Ohio organization(s) do you recommend be engaged to provide insights and considerations as Ohio EPA continues to develop their Resiliency Plans? Organizations may include those who already are progressing (or planning) GHG reduction measures, or community-based organizations active in community programs and outreach.
- Do you have any suggestions for priority GHG reduction measures?
- Would your organization like to participate in additional engagement opportunities with Ohio EPA's CPRG Program to support the Comprehensive Resiliency Plan that will be completed mid-2025?

Not only did the responses allow for direct considerations for this Plan, but also allowed for stakeholders to raise their hand to be involved in future engagement opportunities. This provides Ohio EPA with further detail to build out our engagement strategies for the CRP development. Figure 35 provides an illustrative example of what types of Ohio organizations responded to this survey:

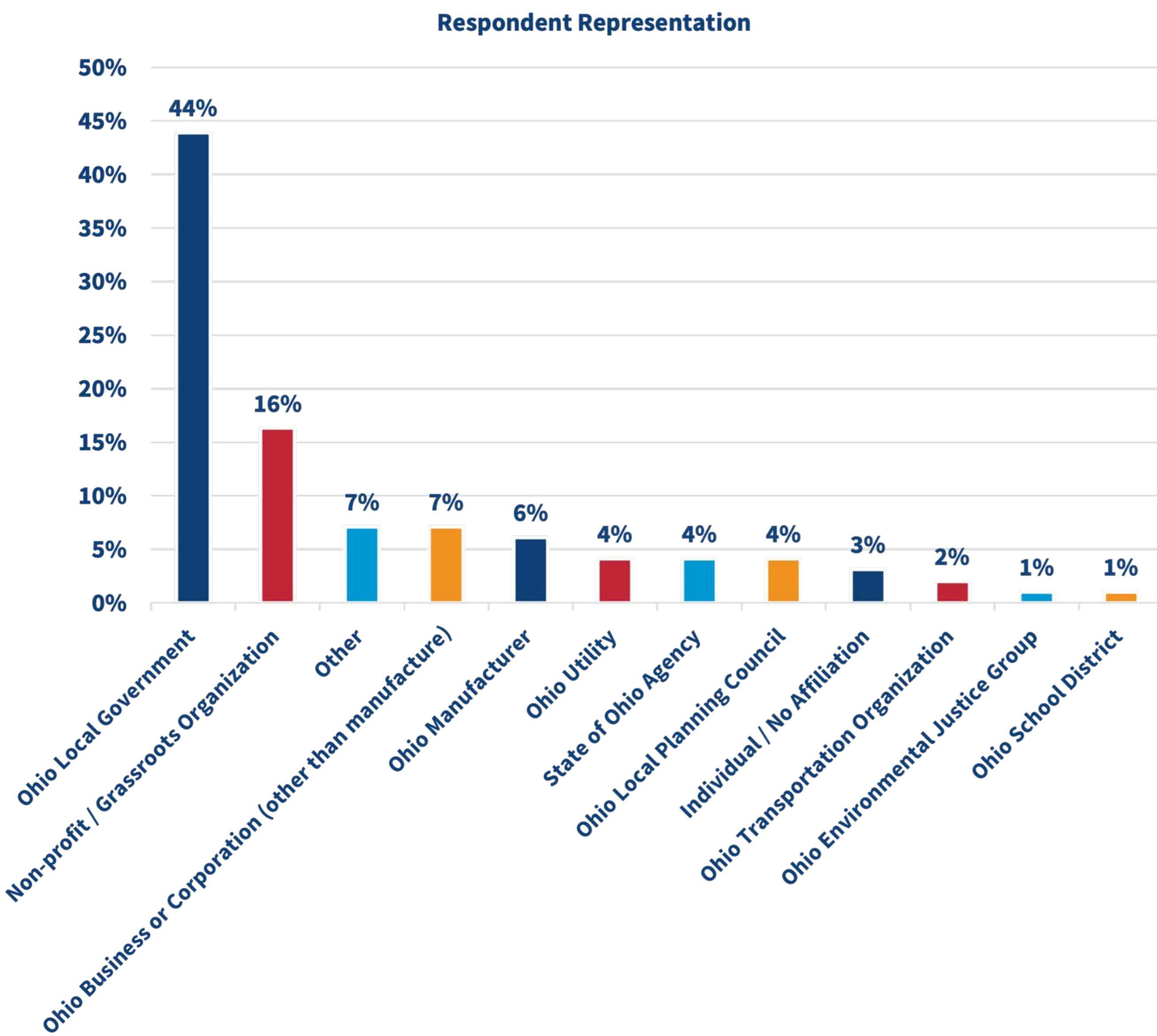

Figure 35. Survey Respondents Organization Representation

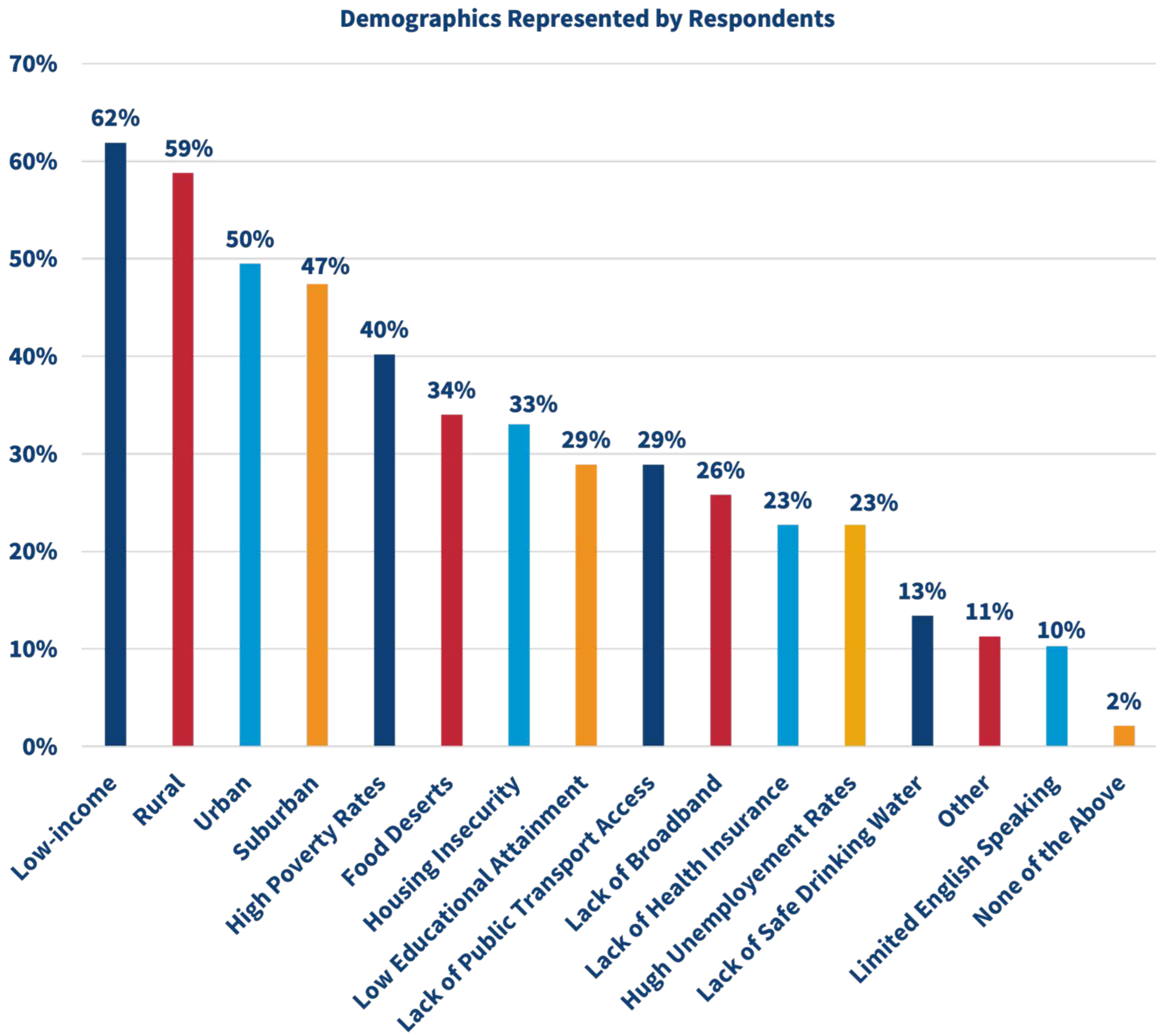

Figure 36. Demographics Represented by Respondents

Nearly two-thirds of respondents identify as low-income and there was nearly even representation of rural, urban, and suburban respondents. The representation of low-income and rural communities helps to validate that the needs and values of those often-underrepresented communities are considered as part of Ohio's Plan.

Respondents that selected "other" indicated they serve communities categorized by the following demographics:

- Amish communities
- Communities facing financial stressors
- Industrial areas

- Communities facing a lack of direct access to resources
- Communities with sewer / water infrastructure challenges

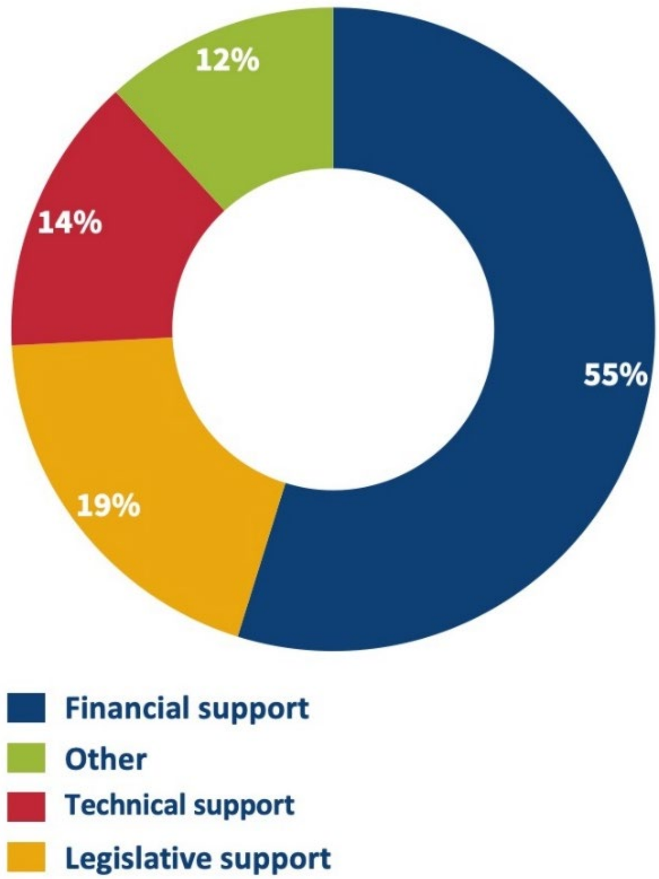

Figure 37. Support Needed to Implement GHG Reduction Measures

Financial support was requested most (55%), followed by legislative support (19%), then technical support (14%), and other (12%). Seeing that financial support is the most common request amongst respondents reinforces the need for Ohio EPA to remain collaborative when discussing funding opportunities across the state. A coordinated funding plan will ensure constituents across the state are receiving the most financial benefit as possible.

Respondents that selected "other" indicated they would benefit from support in the forms of:

- Workforce opportunities to support Ohio EPA initiatives across 32 Appalachian counties
- Collaboration and sharing of resources to address challenges
- The consolidation of a central vendor list for electrification of fleet

Collaborating on existing GHG emission reduction measures is an important step in developing both this Plan and the CRP. Through forums such as this survey, Ohio EPA captures details around what emission reduction measures are currently being designed and implemented on local levels. This sharing of information will allow us to learn from other communities and organizations, ultimately driving successful strategies to include in the CRP.

This survey also allowed Ohio EPA to capture contact information, both for LIDAC representatives and other organizations, that will be critical as the outreach and engagement plans evolve for the CRP. With the expanded emission reduction scope in the CRP, Ohio EPA will leverage the recommendations shared to help ensure those underrepresented communities and organizations looking for a seat at the table are brought into additional planning effort.

TACTICS FOR AN INCLUSIVE ENGAGEMENT APPROACH

Over the Plan development period, engagement opportunities (webinars, small group discussions and one-on-one discussions) have been primarily virtual to capitalize on the number of discussions conducted in a short period of time. This shift to online platforms has allowed Ohio EPA to reach a wider audience and has enabled individuals from all over Ohio to participate in the sessions. When promoting forums such as public webinars, Ohio EPA would leverage social media and the CPRG webpage to socialize the registration and value of participating in these feedback opportunities.

In line with this virtual format, Ohio EPA has made materials and recordings of webinars available to attendees, allowing individuals who were unable to attend the live session to view and hear the content at their own convenience.

To ensure that Ohio EPA meets the evolving needs of stakeholders, a series of questions in a public survey were created to document the preferences of how to engage. Among the various questions asked, Ohio EPA specifically inquired into the importance of having informative materials available in languages other than English. This was an important component, as Ohio EPA recognizes the need to cater to the diverse needs of the state, many of whom speak languages other than English.

Comprehensive Resiliency Plan

Beyond this Plan, the next step of this program will be to develop a Comprehensive Resiliency Plan (CRP), to be published no later than fall 2025. While the Plan has focused on priority sectors that represent significant emissions sources to the state, the CRP will cover all GHG emissions sources and sinks. The CRP will establish both near-term and long-term targets for GHG emissions reductions in each of these sectors and provide strategies and plans to achieve these goals.

The CRP will include:

1. **A GHG inventory** – This GHG inventory will build on the initial inventory included in this Plan, providing additional detail and granularity on the sources of emissions in Ohio;

2. **GHG emissions projections** – A projection of Ohio's emissions to 2050;

3. **GHG reduction targets**, covering all significant GHG emissions sources in the state;

4. **Quantified GHG reduction measures** – Quantified emissions reductions to achieve the GHG emissions targets laid out in the CRP, including a description of the targeted geographic area, implementation schedule and milestones, key implementing agencies, and identification of funding sources. These measures will cover each of the main GHG emitting sectors:
    a. Electricity generation and use
    b. Commercial, public, industrial, and residential buildings
    c. Transportation
    d. Industrial processes
    e. Agriculture
    f. Natural and working lands
    g. Waste and materials management;

5. A **benefits analysis** for the full geographic scope and population covered by the plan – this analysis will include a base year analysis of co-pollutants and quantified estimates of anticipated co-pollutant reductions associated with the GHG reduction measures, as well as a potential broader assessment of impacts, such as public health outcomes;

6. **LIDAC benefits analysis** – The extent to which the GHG reduction measures proposed in the CRP will reduce co-pollutants and provide other benefits for LIDACs;

7. A review of **authority to implement**;

8. A plan to **leverage other federal funding**; and,

9. A **workforce planning analysis**.

To inform the CRP, Ohio EPA will refresh the stakeholder engagement approach to better support the expanded scope of the comprehensive plan. Ohio EPA will continue to engage with constituents across the state of Ohio that were instrumental in developing the Plan, especially those representing underrepresented demographics. Ohio EPA will leverage the stakeholder recommendations captured during Plan planning discussions and the public survey, including, but not limited to:

- Soil and Water Conservation Districts
- Ohio Agriculture Conservation Initiative
- Ohio Weatherization Programs
- Appalachian Regional Commission
- Rural County Commissions
- Ohio Environmental Councils
- Ohio Organics Council
- Environmental Consultants
- Electrification Coalitions

As the scope of GHG emission sources expands for the CRP, Ohio EPA will identify where new partnerships need to be established to drive collaboration on GHG emissions data and potential reduction measures. Similar to the engagement for this Plan, Ohio EPA will continue to promote in-person and virtual meetings, provide web-based information, and engage in public forums, allowing for widely accessible information and participation from organizations and constituents across Ohio.

Acronyms and Abbreviations

ACRONYM	FULL FORM
AFC	Alternative Fuel Corridor
AFDC	Alternative Fuels Data Center
AVERT	Avoided Emissions and Generation Tool
BAU	Business-as-usual
BEV	Battery Electric Vehicle
BIL	Bipartisan Infrastructure Law
BMV	Bureau of Motor Vehicles
BPD	DOE’s Building Performance Database
CAGR	Compound Annual Growth Rate
CAIP	Clean Air Improvement Program
CAP	Criteria Air Pollutant
CCUS	Carbon Capture, Utilization, and Storage
CEJST	Climate and Economic Justice Screening Tool
CFWR	Composting and Food Waste Reduction
CH4	Methane
CMAQ	Congestion Mitigation and Air Quality
CNG	Compressed Natural Gas
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalents
Coops	Cooperative Electric Utilities
CPRG	Climate Pollution Reduction Grant
CRP	Comprehensive Resiliency Plan
CSP	Concentrated Solar Power
DERG	Diesel Emission Reduction Grant
DOE	Department of Energy
DOT	United States Department of Transportation
ECO-Link	Energy Conservation for Ohioans- Link
EIA	Energy Information Administration
EE	Energy Efficiency
EDA	Economic Development Administration
EPA	United States Environmental Protection Agency
EV	Electric Vehicle
EVITP	Electric Vehicle Infrastructure Training Program
EVSE	Electric Vehicle Supply and Equipment
FCEV	Fuel Cell Electric Vehicle
F-gases	Fluorinated Gases
FHA	Federal Housing Administration
FHWA	Federal Highway Administration

GHG	Greenhouse Gas
GLCAP	Great Lakes Community Action Partnership
GNA	GNA Clean Transportation & Energy Consultants
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant
HEV	Hybrid Electric Vehicles
HFCs	Hydrofluorocarbons
HOV	High Occupancy Vehicle
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine
IMAP	Individual Microcredential Assistance Program
IOUs	Investor-Owned Utilities
IRA	Inflation Reduction Act
LADCO	Lake Michigan Air Directors Consortium
LIDAC	Low-Income and Disadvantaged Communities
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
LULUCF	Land Use, Land-Use Change, and Forestry
MDHD	Medium- and Heavy-Duty
MMT	Million Metric Tons
MMTCO2	Million Metric Tons of Carbon Dioxide
MMTCO2e	Million Metric Tons of Carbon Dioxide Equivalents
MORPC	Mid-Ohio Regional Planning Commission
MPOs	Metropolitan Planning Organizations
MRCI	Midwest Region Carbon Initiative
MSA	Metropolitan Statistical Area
MSW	Municipal Solid Waste
MTCO2e	Metric Tons of Carbon Dioxide Equivalent
MVRPC	Miami Valley Regional Planning Commission
MWh	Megawatt- Hours
N2O	Nitrous Oxide
NATA	United States EPA National Air Toxics Assessment (NATA)
NEI	National Emission Inventory
NEVI	National Electric Vehicle Investment
NF3	Nitrogen Trifluoride
NH3	Ammonia
NO2	Nitrogen Dioxide
NOACA	Northwest Ohio Areawide Coordinating Agency
NOX	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
OAQDA	Ohio Air Quality Development Authority
OAR	Office of Air and Radiation
OARC	Ohio Association of Regional Councils
ODNR	Ohio Department of Natural Resources

ODOD	Ohio Department of Development
ODOT	Ohio Department of Transportation
OEM	Original Equipment Manufacturer
OEPA	Ohio Environmental Protection Agency
OKI	Ohio-Kentucky-Indiana
OMB	Office of Management and Budget
OWT	Ohio Office of Workforce Transformation
PACE	Property Assessed Clean Energy
PFAs	Per-and Polyfluoroalkyl Substances
PFCs	Perfluorocarbons
PHEV	Plug-in Hybrid Electric Vehicle
PM2.5	Particulate Matter 2.5 micrometers
PRP	Priority Resiliency Plan
PUCO	Public Utilities Commission of Ohio
PV	Photovoltaic
R10	R-Value of 10 (insulation value)
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
RCRA	Resource Conservation and Recovery Act
ResStock	Residential Stock
RNG	Renewable Natural Gas
RPS	Renewable Portfolio Standard
RSEI	Risk-Screening Environmental Indicators
S&P	Standard & Poor's
SEIA	Solar Energy Industries Association
SF6	Sulfur Hexafluoride
SIT	State Inventory Tool
SO2	Sulfur Dioxide
SOC	Standard Occupational Classification
SOPEC	Sustainable Ohio Public Energy Council
SOx	Sulfur Oxides
TAP	Transportation Alternatives Program
TMACOG	Toledo Metropolitan Area Council of Governments
TSDF	Treatment, Storage, and Disposal Facilities
U.S.	United States
U.S. Bike Route	United States Bike Route
U.S. EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds
WtE	Waste-to-Energy
ZEV	Zero Emission Vehicle

Appendix I: Coordination and Outreach Log

The following Table 10 showcases Ohio EPA's log of stakeholder engagement including one-on-one discussions, small group discussions, focus groups, and public webinars.

Table 9. Outreach and Coordination Log

DATE	MEETING / TOPIC(S) DISCUSSED	ORGANIZATIONS INVOLVED (IN ADDITION TO OHIO EPA)
6/14/2023	Ohio CPRG Managers Meeting	• Ohio MPOs
6/20/2023	CPRG Interagency Assistance	• Public Utilities Commission of Ohio (PUCO) • Department of Agriculture • Ohio Department of Transportation (ODOT) • Ohio Department of Natural Resources (ODNR) • Ohio Air Quality Development Authority (OAQDA)
7/14/2023	Ohio CPRG Managers Meeting	• Ohio MPOs
7/24/2023	ODOT Resilience Improvement Plan	• ODOT
8/1/2023	Ohio CPRG Managers Meeting	• Ohio MPOs
9/6/2023	Ohio CPRG Managers Meeting	• Ohio MPOs
9/6/2023	Conveners Network Meeting	• Conveners Network • Additional State Governments
9/26/2023	Conveners Network Meeting	• Conveners Network • Additional State Governments
9/27/2023	Lake Michigan Air Directors Consortium (LADCO) CPRG Meeting	• LADCO

10/5/2023	Overview of Ohio EPA's CPRG Program and Discussion of Points of Collaboration	• Sustainable Ohio Public Energy Council (SOPEC)
10/24/2023	Overview of Ohio EPA's CPRG Program and Discussion of Points of Collaboration	• Duke Energy
10/24/2023	Overview of Ohio EPA's CRPG Program	• Ohio Governor's Office
10/30/2023	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• NiSource • Columbia Gas
10/31/2023	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• Rural Action
11/9/2023	Ohio CPRG Managers Meeting	• City of Dayton • City of Cleveland • City of Columbus • MVRPC • OKI • NOACA • Green Umbrella
11/16/2023	Ohio EPA's CPRG Program Public Webinar (recording may be accessed here: https://youtu.be/f47yRf59phE)	• Organizations spanning the state, including Ohio Agencies, businesses, manufacturers, utilities, local governments, local planning councils, non-profits, and grassroot organizations
11/21/2023	Overview of Ohio EPA's CPRG, Initial Review of Emissions Data, and Discussion Regarding Dayton's Current Plan and Sustainability Planning	• City of Dayton, • Miami Valley Regional Planning Commission (MVRPC)
11/27/2023	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• Public Utilities Commission of Ohio (PUCO)

11/28/2023	Overview of Ohio EPA's CPRG, Initial Review of Emissions Data, and Discussion Regarding Columbus's Current PCAP and Sustainability Planning	• City of Columbus • Mid-Ohio Regional Planning Commission (MORPC)
11/29/2023	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• Ohio Association of Regional Councils (OARC)
12/5/2023	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• Toledo Metropolitan Area Council of Governments (TMACOG)
12/8/2023	Overview of Ohio EPA's CPRG, Initial Review of Emissions Data, and Discussion Regarding Cincinnati's Current Plan and Sustainability Planning	• City of Cincinnati • Ohio-Kentucky-Indiana (OKI) Regional Council of Governments
12/14/2023	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• Department of Agriculture
1/3/2024	Virtual Power Plan	• OAQDA • SOPEC • City of Dayton • MVRPC
1/4/2024	Overview of Ohio EPA's CPRG, Initial Review of Emissions Data, and Discussion Regarding Cleveland's Current Plan and Sustainability Planning	• City of Cleveland • Northwest Ohio Areawide Coordinating Agency
1/5/2024	CPRG Implementation Project	• OAQDA
1/8/2024	Battery Storage Projects in Appalachian Ohio	• OAQDA • Hecate Energy

1/10/2024	CPRG Program Focus Group to Review Priority Resiliency Plan Reduction Measures and LIDAC Considerations	• City of Athens • City of Toledo • City of Akron • City of Canton • Lucas County • SOPEC • Time to Recycle • Great Lakes Community Action Partnership (GLCAP)
1/11/2024	Educational Discussion of the CPRG Program and Plan Objectives	• ICANDO • Ohio State University
1/11/2024	Review of Initial Electric Power Reduction Measures	• Ohio Air Quality Development Authority (OAQDA)
1/12/2024	Review of Initial Building Reduction Measures	• Ohio Homes
1/12/2024	CPRG and Vehicle Electrification	• City of Cleveland • OAQDA
1/16/2024	Follow-up Discussion Regarding Initial Review of Emissions Data, and Discussion Regarding Cleveland’s Current Plan and Sustainability Planning	• City of Cleveland • NOACA
1/17/2024	Overview of Ohio EPA’s CPRG and Discussion of Points of Collaboration	• Holcim
1/18/2024	Overview of Ohio EPA’s CPRG and Discussion of Points of Collaboration	• GNA Clean Transportation & Energy Consultants

1/19/2024	Review of Initial Transportation Reduction Measures	• Ohio Department of Transportation (ODOT)
1/25/2025	Follow-up Discussion of the City of Akron's Sustainability Initiatives and Opportunities for Alignment	• City of Akron
1/30/2024	Overview of Ohio EPA's CPRG and Discussion of Points of Collaboration	• Buckeye Hills Regional Council
2/21/2024	CPRG Plan Review and Q&A Public Webinar (recording may be accessed here: https://youtu.be/4AAnfE8vpro)	• Organizations spanning the state, including Ohio Agencies, businesses, manufacturers, utilities, local governments, local planning councils, non-profits, and grassroot organizations

Appendix II: GHG Inventory Supporting Documentation

In calculating the State of Ohio's Greenhouse Gas inventory, U.S. EPA's SIT was utilized. Default values from this tool were used to calculate emissions from all relevant sectors to Ohio, save for two sectors (transportation and electric power). To customize the outputs of the tool, data on total vehicle miles traveled (VMT) for Ohio vehicles in 2019 from the Ohio Bureau of Motor Vehicles was substituted to calculate the CO_2 emissions from mobile combustion. Data on Ohio's electric power generation, sourced for the 2019 Form EIA-923, was also used to customize the electric power data in the SIT.[105] Use of this custom data did not create significant variances between the default tool outputs.

Below, comparisons between both the SIT customized and default inventories, as well as U.S. EPA state-level GHG Inventory, can be found (see Table 1 for the state-level data breakdown).[106] Results from the SIT customized inventory largely aligned with the U.S. EPA data apart from three categories:

- **International Bunker Fuels:** This category is not included within the U.S. EPA State Level GHG Inventory
- **Stationary Combustion:** The sectors that contribute to U.S. EPA's Stationary Combustion module emissions are Commercial, Residential, Industry, and most significantly the Electric Power Industry. While the SIT does calculate stationary combustion in each of these areas, emissions are only included for N_2O and CH_4. CO_2 emissions are calculated within the "CO_2 from Fossil Fuel Combustion" section, and not broken out separately for Stationary Combustion. This results in a lower shown value within the Stationary Combustion module of the SIT.
- **Natural Gas and Oil Systems:** The U.S. EPA State Level GHG Inventory has three categories contributing to the Natural Gas and Oil Systems Category (MMTCO2e): Natural Gas Systems (8.5), Petroleum Systems (2.2), and Abandoned Oil and Gas Wells (1.1). Likewise to Stationary Combustion, the SIT only calculates CH_4 emissions associated with Natural Gas and Oil Systems emissions, lowering the SIT's count relative to the U.S. EPA state-level data.

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[105] Form EIA-923 detailed data with previous form data (EIA-906/920) – U.S. Energy Information Administration (EIA)

[106] https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals

Table 10. Comparison of Ohio GHG emissions

2019 EMISSIONS SUMMARY BY SECTOR

	SIT CUSTOM		SIT DEFAULT			U.S. EPA STATE GHG		
Emissions (MMTCO2E)	**Emissions**	**% of Total**	**Emissions**	**% of Total**	**% Difference from Custom**	**Emissions**	**% of Total**	**% Difference from Custom**
Energy	198.72	90%	193.92	90%	-2%	198.03	89%	0%
CO2 from Fossil Fuel Combustion	192.81	87%	188.01	87%	-3%	183.39	83%	-5%
Residential	18.36	8%	18.36	8%	0%	18.23	8%	-1%
Commercial	12.28	6%	12.28	6%	0%	13.13	6%	7%
Industrial	29.08	13%	29.08	13%	0%	24.64	11%	-15%
Transportation	63.21	29%	60.07	28%	-5%	59.98	27%	-5%
Electric Utilities	69.11	31%	67.46	31%	-2%	67.42	30%	-2%
International Bunker Fuels	0.77	0%	0.77	0%	0%	0.00	0%	-100%
Stationary Combustion	0.72	0%	0.72	0%	0%	1.29	1%	80%
Mobile Combustion	0.61	0%	0.62	0%	1%	0.65	0%	7%
Coal Mining	0.89	0%	0.89	0%	0%	0.89	0%	0%
Natural Gas and Oil Systems	3.68	2%	3.68	2%	0%	11.80	5%	221%
Industrial Processes	15.10	7%	15.10	7%	0%	15.13	7%	0%

Agriculture	11.54	5%	11.54	5%	0%	12.63	6%	9%
LULUCF	(10.95)	-5%	(10.95)	-5%	0%	(10.34)	-5%	-6%
Waste	6.44	3%	6.44	3%	0%	6.58	3%	2%
Municipal Solid Waste	5.30	2%	5.30	2%	0%	5.29	2%	0%
Wastewater	1.15	1%	1.15	1%	0%	1.29	1%	13%
Indirect CO2 from Electricity Consumption*	88.20	-	88.20	-	0%	-	-	-
Gross Emissions by SIT Sector Totals	231.80	100%	227.01	100%	-2%	232.37	100%	0%
Sinks	(10.95)	-	(10.95)	-	-	(10.34)	-	-
Net Emissions	220.86	100%	216.06	100%	-2%	222.03	100%	-1%

Table 11. U.S. EPA Ohio GHG emissions in $MMTCO_2e$ by Sector[107]

SIT TOOL CATEGORY MAPPING	SECTOR/SOURCE	2019	2021
	Transportation	62.0	56.5
Transportation	CO_2 from Fossil Fuel Combustion	60.0	54.7
Industrial Processes	Substitution of Ozone Depleting Substances	1.3	1.1
Mobile Combustion	Mobile Combustion	0.5	0.4
Industrial Processes	Non-Energy Use of Fuels	0.3	0.3
	Electric Power Industry	68.5	68.2
Electric Utilities	CO_2 from Fossil Fuel Combustion	67.4	66.9
Stationary Combustion	Stationary Combustion	0.9	0.9
N/A	Incineration of Waste	NO	NO
Industrial Processes	Electrical Equipment	0.1	0.1
Industrial Processes	Other Process Uses of Carbonates	0.1	0.1
	Industry	48.4	46.7

[107] Data were obtained from U.S. EPA's State-level GHG inventories file State-GHG_Trends_Emissions__Sinks_Economic_Sector_08312023.xlsx, which was accessed on 1/29/24. This data set is available at <https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals>.

NO = Not occurring

Symbols:

"-" indicates that the value has not be estimated at this time or is not applicable to the State

"+" indicates that the value does not exceed 0.005 MMT CO_2E

Industrial Processes	CO_2 from Fossil Fuel Combustion	24.6	23.3
Natural Gas and Oil Systems	Natural Gas Systems	8.5	7.9
Industrial Processes	Non-Energy Use of Fuels	3.1	2.3
Natural Gas and Oil Systems	Petroleum Systems	2.2	4.0
Coal Mining	Coal Mining	0.8	0.5
Industrial Processes	Iron and Steel Production	1.4	1.2
Industrial Processes	Cement Production	0.5	0.6
Industrial Processes	Substitution of Ozone Depleting Substances	1.2	1.1
Industrial Processes	Petrochemical Production	0.3	0.2
Industrial Processes	Lime Production	1.2	1.1
Industrial Processes	Ammonia Production	0.5	0.4
Industrial Processes	Nitric Acid Production	0.2	0.3
Natural Gas and Oil Systems	Abandoned Oil and Gas Wells	1.1	1.1
Wastewater	Wastewater Treatment	0.1	0.1
Industrial Processes	Urea Consumption for Non-Agricultural Purposes	0.2	0.2
Mobile Combustion	Mobile Combustion	0.2	0.2
Coal Mining	Abandoned Underground Coal Mines	0.1	0.1
N/A	Adipic Acid Production	NO	NO
Industrial Processes	Carbon Dioxide Consumption	0.2	0.2
N/A	Electronics Industry	NO	NO
Industrial Processes	N_2O from Product Uses	0.1	0.1

Stationary Combustion	Stationary Combustion	0.1	0.1
Industrial Processes	Other Process Uses of Carbonates	0.1	0.1
N/A	Fluorochemical Production	NO	NO
N/A	Aluminum Production	NO	NO
N/A	Soda Ash Production	NO	NO
Industrial Processes	Ferroalloy Production	0.7	0.7
Industrial Processes	Titanium Dioxide Production	0.3	0.2
N/A	Caprolactam, Glyoxal, and Glyoxylic Acid Production	NO	NO
Industrial Processes	Glass Production	0.1	0.1
Industrial Processes	Magnesium Production and Processing	0.1	0.1
N/A	Zinc Production	NO	NO
N/A	Phosphoric Acid Production	NO	NO
N/A	Lead Production	NO	NO
Municipal Solid Waste	Landfills (Industrial)	0.5	0.5
Industrial Processes	Carbide Production and Consumption	+	+
	Agriculture	13.6	13.4
Agriculture	N_2O from Agricultural Soil Management[1,2]	7.5	7.0
Agriculture	Enteric Fermentation	2.8	2.8
Agriculture	Manure Management	2.2	2.1
Commercial	CO_2 from Fossil Fuel Combustion	1.0	1.3
Agriculture	Rice Cultivation	NO	NO
Agriculture	Urea Fertilization	0.1	0.1
Agriculture	Liming	NO	NO

Mobile Combustion	Mobile Combustion	0.0	0.0
Agriculture	Field Burning of Agricultural Residues[1,2]	0.0	0.0
Stationary Combustion	Stationary Combustion	+	+
	Commercial	20.2	19.9
Commercial	CO_2 from Fossil Fuel Combustion	12.1	11.3
Municipal Solid Waste	Landfills (Municipal)	4.8	5.4
Industrial Processes	Substitution of Ozone Depleting Substances	2.0	1.9
Wastewater	Wastewater Treatment	1.2	1.2
Agriculture	Composting	0.0	0.0
Stationary Combustion	Stationary Combustion	0.1	0.1
Stationary Combustion	Anaerobic Digestion at Biogas Facilities	0.0	0.0
	Residential	19.5	18.2
Residential	CO_2 from Fossil Fuel Combustion	18.2	17.0
Industrial Processes	Substitution of Ozone Depleting Substances	1.0	1.0
Stationary Combustion	Stationary Combustion	0.3	0.2
	Total Emissions (Sources)	232.4	222.8
LULUCF	Land-Use, Land-Use Change, and Forestry (LULUCF) Sector Net Total	(10.3)	(10.6)
Net Emissions (Sources and Sinks)		**222.0**	**212.2**

Table 12. Fossil Fuel Types Captured in Emissions Inventory for Electric Power, Buildings, and Other Energy Sectors[108]

RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	ELECTRIC POWER	OTHER ENERGY[109]
• Coal • Natural Gas • Distillate Fuel • Kerosene • Hydrocarbon • Gas • Liquids	• Coal • Natural Gas • Distillate Fuel • Kerosene • Hydrocarbon • Gas • Liquids • Motor • Gasoline • Residual Fuel	• Coking/other coal • Natural Gas • Distillate Fuel • Kerosene • LPG • Motor Gasoline • Residual Fuel • Lubricants • Asphalt/Road Oil • Crude Oil • Feedstocks • Misc. Petroleum Products • Petroleum Coke • Pentanes Plus • Still Gas • Special Naphthas • Unfinished Oils • Waxes • Aviation Gasoline Blending Components • Motor Gasoline Blending Components	• Coal • Natural Gas • Distillate Fuel • Hydrocarbon Gas Liquids • Motor Gasoline • Residual Fuel • Lubricants, • Aviation Gasoline • Jet Fuel, Kerosene • Jet Fuel, Naphtha	• Coal • Natural Gas • Distillate Fuel • Residual Fuel • Petroleum Coke	• Jet Fuel, Kerosene • Distillate Fuel • Residual Fuel

[108] Fuel types are listed as per the SIT user guide for the CO2FFC module.

[109] International bunker fuels only.

Appendix III: GHG Reduction Measures Supporting Documentation

GHG reduction calculation methodology is documented within this Appendix for each priority measure alongside key assumptions and considerations for enhancement for Ohio's CRP. While each measure has unique assumptions and CRP considerations, the following apply to all priority measures:

KEY ASSUMPTIONS:

- Baseline business-as-usual (BAU) emissions remain level 2025 – 2050 to Ohio's 2019 GHG inventory, where 2019 is the latest year available that is not a year impacted by COVID-19.

- 2019 or otherwise, the latest year available for data, is assumed to be a proxy for 2024 GHG emissions or trends.

- Adoption rates based on historical trends are assumed to apply to future projections.

- Structure of potential Implementation Grants is illustrative for GHG reduction modeling, and subject to change for any potential Implementation Grant applications, as is the requested award value and receipt of award subject to change.

OPPORTUNITIES TO REFINE FOR OHIO'S CRP:

- For each priority measure in the Plan, one or two emission reduction scenarios were considered based on activities and assets impacted. For the CRP, GHG reduction measures will be expanded to be inclusive of all activities with direct emission reduction potentials.

- Data for the CRP related to customizing the GHG inventory, calculating GHG projections, and modeling GHG reductions will begin to be inventoried following submission of the Plan. GHG projections will be calculated for:

Table 13. Projection Data and Calculation Considerations for CRP

PROJECTION TYPE	DATA AND CALCULATION CONSIDERATIONS
BAU	Integrate annual growth factors such as population growth, vehicle registration growth, net change in buildings square footage including demolition and new construction, etc. to the respective sectors and sources of emissions impacted.
Modified BAU – State Implementation actions	Integrate growth factors based on impacts of existing State policies that impact future years (such as Ohio's Renewable Portfolio Standard (RPS)) or planned State policies and State administered programs such as NEVI public charger expansion and expected expansion of ZEV adoption. 110
Modified BAU – Statewide actions	Integrate growth factors based on impacts of existing Municipal and Metropolitan Statistical Area (MSA) policies that impact future years (such as Ohio's Renewable Portfolio Standard (RPS)) or planned Municipal/MSA policies and programs such as those included in other Ohio MSA Priority Climate Action Plans.
Select Decarbonization Measure	Calculate the near-term (2025 – 2030) and long-term (2030 – 2050) GHG emission reductions for each reduction measure included in this Plan and any additional measures included in the CRP, including the impacts of each direct implementation activity. Any measures awarded to Ohio via the Implementation Grants application will be included (to the State among other organizations including Municipalities and MSAs). Additionally, geographic-specific analyses at the county level will be considered where relevant to the measure.
Decarbonization Pathway	Calculate cumulative GHG emission reductions near- and long-term for the combined impact of decarbonization measures aligned to GHG reduction targets to be set by the State during the CRP planning period
Sector Decarbonization Pathway	Calculate cumulative GHG emission reductions near- and long-term for the combined impact of decarbonization measures for a specific sector aligned to any sector-specific GHG reduction targets to be set by the State during the CRP planning period

[110] Ohio Electric Vehicle Infrastructure Deployment Plan

MEASURE	METHODOLOGY	POTENTIAL IMPLEMENTING AGENCIES
#1 Zero Emission Light-Duty Vehicles	**Identifying the current market and growth** Ohio light-duty vehicle registration data from the Alternative Fuels Data Center (AFDC) was analyzed for the time-period available 2016 – 2022.[111] Annual growth rates for battery electric vehicles (BEV) and plug-in / hybrid electric vehicles (PHEV/HEV) were evaluated and the compound annual growth rate (CAGR) for the six-year period calculated to serve as an estimated adoption rate for future BEV and PHEV growth. CAGRS for Ohio were compared to U.S. trends and were largely consistent: (see table below) **Forecasting 2025 – 2030 adoption** These CAGRS were then applied annually to the year prior to estimate 2025 – 2030 number of PHEVs and BEVs, respectively that are new to the market, converting from ICE vehicles (e.g., 2025 estimated based on the CAGR multiplied by the latest year reported AFDC vehicle registration data). **Calculating GHG emission reductions** U.S. EPA's Avoided Emissions and Generation Tool (AVERT) v4.2 was then used to calculate CO_2 and co-pollutant emission reductions based on the number of additional BEV and PHEV vehicle registrations respectively, taking the average new vehicle registrations from 2025 – 2030. Registrations were assumed to replace existing vehicles with the marginal (0.31%) growth in net new vehicles.	• Ohio Department of Transportation • Ohio Environmental Protection Agency

VEHICLE CATEGORY	OH CAGR (%) 2016 – 2022	U.S. CAGR (%) 2016 – 2022
PHEV/HEV	11%	11%
BEV	54%	43%
Total Vehicles	0.31%	1%

[111] Alternative Fuels Data Center: Vehicle Registration Counts by State (energy.gov)

Considering additional GHG emission reductions

Next, an estimate was made for how many additional BEVs, and PHEVs, would be adopted for every $500 of grant, subsidy, and or tax credit provided to purchasers of light-duty passenger vehicles. Literature reviews and peer-reviewed journal articles that report an average 2% adoption rate for every $500 in financial assistance.[112,113]

Recognizing there is already a $7,500 federal EV incentive, it was assumed for this estimate of additional GHG reductions that on average that the State would provide:

TYPE OF VEHICLE	MODELED POTENTIAL INCENTIVE
BEV	$3,500
PHEV	$1,500
Average	$2,500

If the State of Ohio were to win a $200,000,000 low-end Tier A implementation grant award, this would equate to a maximum of 80,000 new BEVs/PHEVs in Ohio with expected annual growth rates of 2% per every $500 across BEVs and PHEVs, respectively. *(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).*

TYPE OF VEHICLE	ANNUAL GROWTH IF 2% INCREASE PER $500 INCENTIVE
BEV	15%
PHEV	6%

[112] Evaluating Electric Vehicle Policy Effectiveness and Equity | Annual Review of Resource Economics (annualreviews.org)

[113] Subsidizing low- and middle-income adoption of electric vehicles: Quasi-experimental evidence from California - ScienceDirect

BEV and PHEV additional growth rates were applied to existing registrations to determine 2025 converted BEVs and PHEVs and beyond to estimate 2026 – 2030 converted BEVs and PHEVs. This results in approximately 60,000 new BEVs and PHEVs in Ohio by 2030. Thus, remaining potential funds could support additional vehicles, private charging infrastructure, outreach, education, workforce development, and other technical assistance.

The average of the additional expected BEVs and PHEVs from 2025 – 2030 were then entered in AVERT to calculate additional avoided CO_2 and co-pollutant emissions per year, which were summed to calculate cumulative 2025 – 2030 estimated emission reductions.

For 2030 – 2050 emission reductions, the CAGR was not considered, but rather additional BEVs/PHEVs converted across the 20 years was assumed to be four times the anticipated adoption 2030 – 2050.[114]

MEASURE-SPECIFIC ASSUMPTIONS

While electric vehicles were the focus on this calculation for this Plan, other zero emission vehicle (ZEV) types can be considered for the CRP such as green hydrogen fuel cell, or partially clean other alternative fuels like renewable natural gas (RNG) and biodiesel. Ohio may decide to define ZEV and what types of vehicles are included differently as well especially in terms of eligibility for any future policies, programs, or projects including any Implementation Grants.

[114] Projections for the proportion of renewables on the grid 2030 – 2050 and proportion of vehicles that are ZEV expected on the road 2030 – 2050 with CAGRs applied annually surpasses penetration rates considered feasible for a long-term emission reduction estimate; feasibility for long-term adoption rates and emission reductions will be further assessed in the CRP.

When calculating in AVERT, expected MW of solar and wind was including in the ZEV expansion reduction calculation (see Renewable Electricity Generation methodology below)
The following are AVERT specific assumptions (full methodology can be found here):
Considers additional electricity generation emissions required to charge ZEVs as well as reductions in tailpipe exhaust emissions.
EVs get more efficient with newer model years (2025 model year replacing existing vehicles was the setting utilized.
Uses Ohio's regional electricity grid's carbon intensity (with input renewable modifications).
EVs get more efficient with newer model years (2025 model year replacing existing vehicles was the setting utilized).
Default time of day and days of the week charging demand and the ratio of light-duty passenger cars versus trucks
Nationwide average vehicle miles traveled (VMT) of 11,543 miles in each year per light-duty vehicle.
PHEVs run 54% on electricity and 46% from fossil fuel.
CH_4 and N_2O emissions are negligible compared to the magnitude of CO_2, which is the only GHG for which AVERT accounts.
Measure-Specific Opportunities to Refine for Ohio's CRP
Estimate CH_4 and N_2O emission reductions outside of AVERT
Adjust BEV and PHEV growth assumptions alongside renewable electricity assumptions based on GHG Projections (including having multiple scenarios)
Calculate cumulative emissions based on precise estimated vehicles adopted each year rather than a 5-year average adoption rates

#2 Zero Emission Medium/Heavy-Duty Vehicles	**Identifying the current market and growth** Buses were selected as the medium/heavy-duty (MHD) asset of focus for GHG reduction calculations for this Plan aligned with the U.S. EPA AVERT tool's capabilities; however, this will be expanded to cover other MHD asset classes for the CRP. Ohio BMV Vehicle Registration data for 2022 was utilized as a proxy for 2024 to determine the total number of buses.[115] **Calculating GHG emission reductions** Next, indicative prices for diesel and electric transit and school buses were collected;[116] $500,000 for a diesel transit and $750,000 for an electric transit bus $110,000 for a diesel transit and $250,000 for an electric transit bus With an average financial assistance of $500,000 per bus, if the State of Ohio were to win a $200,000,000 low-end Tier A implementation grant award, this would equate to 400 new electric buses *(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).* Electric transit buses and electric school buses were then entered in AVERT v4.2 to calculate additional avoided CO_2 and co-pollutant emissions. The number of vehicles selected by type, 40 transit buses and 360 electric school buses, each reflect a reported 4% of the annual vehicle sales in the Mid-Atlantic Ohio region from AVERT (with there being a smaller number of new transit buses or conversion of existing buses being required each year). **MEASURE-SPECIFIC ASSUMPTIONS**	• Ohio Department of Transportation • Ohio Environmental Protection Agency

[115] Ohio BMV

[116] Electric buses for mass transit seen as cost effective | American Public Power Association

While electric vehicles were the focus on this calculation for this Plan, other zero emission vehicle (ZEV) types can be considered for the CRP such as green hydrogen fuel cell, or partially clean fuels like renewable natural gas (RNG) and biodiesel. Ohio may decide to define ZEV and what types of vehicles are included differently as well especially in terms of eligibility for any future policies, programs, or projects including any Implementation Grants.
When calculating in AVERT, expected MW of solar and wind was including in the ZEV expansion reduction calculation (see Renewable Electricity Generation methodology below))
The following are AVERT specific assumptions (full methodology can be found here):
Considers additional electricity generation emissions required to charge ZEVs as well as reductions in tailpipe exhaust emissions.
EVs get more efficient with newer model years (2025 model year replacing existing vehicles was the setting utilized.
Uses Ohio's regional electricity grid's carbon intensity (with input renewable modifications).
EVs get more efficient with newer model years (2025 model year replacing existing vehicles was the setting utilized).
Default time of day and days of the week charging demand left unchanged.
Nationwide average vehicle miles traveled (VMT) of 12,000 miles in each year per bus and 43,647 miles in each per transit bus
CH_4 and N_2O emissions are negligible compared to the magnitude of CO_2, which is the only GHG for which AVERT accounts.
Measure-Specific Opportunities to Refine for Ohio's CRP
Estimate CH_4 and N_2O emission reductions outside of AVERT.

Adjust electric transit and school bus growth assumptions alongside renewable electricity assumptions based on GHG Projections (including having multiple scenarios).

Calculate cumulative emissions based on precise estimated vehicles adopted each year.

#3 Transportation Efficiency

Identifying the current market and growth

Modal transportation shifts away from fossil fuel vehicles to less carbon intensive public transit, biking, and walking mode shares was the focus of the Transportation Efficiencies GHG reduction calculations for the Plan; however, this will be expanded to cover other transportation efficiencies for the CRP.

ODOT's Walk.Bike.Ohio Existing Conditions Summary Report (2020) definitions the current share of commuting in Ohio that's by walking and biking.[117]

TRANSPORTATION TYPE	PROPORTION OF OHIO COMMUTING MILES (%)
Bike	0.3%
Walk	2.2%
Bike + Walk	2.5%

Forecasting adoption and GHG emission reductions

ODOT reports that if the current share of commuting miles by biking and walking were to increase by 1.1% total, then 340,000 $MTCO_2e$ would be mitigated annually. While a 1.1% increase is a target, the Northeast Ohio Areawide Coordinating Agency (NOACA) reports that combined public-transit, biking, and walking VMT is expected to increase from 6.3%

- Ohio Department of Transportation
- Municipal / Regional Transit Agencies
- Municipal / Regional Planning Agencies

[117] WBO_ExistingConditionsSummary_Final.pdf (ohio.gov)

to 7% by 2030, totaling a 0.7% increase.[118] Comparing a 0.7% to a 1.1% increase (0.7% / 1.1%) and ODOT's GHG mitigation potential of 340,000 $MTCO_2e$, there would still be a 216,364 MTCO2e reduction by 2030.

Considering additional GHG emission reductions

Scenario: Bike expansion was the focus of the Transportation Efficiencies additional GHG reductions scenario for the Plan; however, this will be expanded to cover other transportation efficiencies for the CRP. Bikes and specifically e-bikes represent are a zero-carbon mode of travel shift, with electricity consumption emissions from e-bikes considered negligible. 119 A shift from motor vehicles such as cars to public transit is another mode shift, for example, that will be evaluated further for the CRP.

This additional GHG reduction scenario considers if the State of Ohio were to win a $200,000,000 low-end Tier A implementation grant award. (Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).

Costs: Median e-bike prices are reportedly $1,305.50 and there have been multiple government directed incentive programs across the nation that have subsidized costs to expand this low-carbon transit option. Average incentive provided across programs analyzed in this peer-reviewed study was nearly $500, which covers one-third to one-half of an e-bikes cost.120 Therefore, assuming a 50% cost share incentive program with median e-bike costs of $1,305.50, the State could supply approximately 306,396 Ohioans e-bikes, assumed to be deployed in 2025.

Relevant Vehicle Miles Traveled and Trips: To calculate associated carbon reductions, e-bikes were assumed to be only used for commuting twice a day for trips less than one

[118] 9911f1_93e865ff216d4aadad50005dc0fc3cfb.pdf (filesusr.com)

[119] Impacts of e-bike ownership on travel behavior: Evidence from three northern California rebate programs - ScienceDirect

[120] Impacts of e-bike ownership on travel behavior: Evidence from three northern California rebate programs - ScienceDirect

mile (recognizing the limitations of e-bikes for longer mileage travel). FHWA data was used to determine the total numbers of annual miles traveled and annual trips in the U.S. under one mile.121 To then calculate the proportion of these miles attributable the Ohioans commuting population, the total Ohio Employed (5,591,400) from the U.S. Bureau of Labor Statistics122 was divided by the total U.S. Population from the Census Bureau123 (11,759,697) to estimate Ohio's proportional share of 4% for annual miles and trips traveled that are less than one mile (< 1) .

Next, studies on commuter habits have shown that those with e-bikes will displace anywhere from 20% to 86% of their car trips.124 Taking the low-end of this range, assuming 20% of Ohio's 4% share of commuting miles on < 1-mile trips are replaced by e-bikes, 71 million vehicle millions would be converted from assumedly gasoline passenger car to "zero" emission e-bikes.

Emission Reduction Calculations: To calculate the emissions associated with this reduction in gasoline passenger car vehicle miles, average miles per gallon for a U.S. passenger car from the U.S. EPA of 25.4 mpg was applied,125 and then multiplied by the U.S. EPA GHG Emission Factors Hub, Table 2 Mobile Combustion CO2 factor for motor gasoline of 8.78 kgCO2 per gallon consumed. This output represents the total potential for e-bike emission reductions if 20% of all miles traveled in trips < 1 mile were to be switched to e-bike.

To assess reasonable adoption, the number of new e-bikes (306,396) that could be delivered by a potential implementation grant was assumed to be the total number of reasonable new users. Assuming commuters travel twice a day, every day on trips < 1 mile, there would be approximately 1,057,579 total potential e-bike candidates in the

[121] NHTS Data Extraction Tool (ornl.gov)

[122] Ohio Economy at a Glance (bls.gov)

[123] U.S. Census Bureau QuickFacts: Ohio

[124] The impact of e-cycling on travel behaviour: A scoping review - PMC (nih.gov)

[125] EPA Report: U.S. Cars Achieve Record High Fuel Economy and Low Emission Levels as Companies Fully Comply with Standards | US EPA

	State. The total 306,396, new e-bikes purchased by users would then equate to 29% of users. Thus, 29% of the < 1 mile trip commuting miles by car would be reduced to "zero" emissions. **MEASURE-SPECIFIC ASSUMPTIONS** ODOT's carbon reduction calculation reflects a blended biking, walking, and public transit emission reduction potential **MEASURE-SPECIFIC OPPORTUNITIES TO REFINE FOR OHIO'S CRP** Estimate CH_4 and N_2O emission reductions alongside CO_2 in addition to calculating the marginal electricity consumption emissions attributable to e-bikes	
#4 Renewable Electricity Generation	**Identifying the current market and growth** Solar Energy Industries Association (SEIA) Ohio state data was utilized to evaluate current megawatts (MW) of solar installed and five-year growth projections. These projections were then used to calculate an annual growth rate of 24% based on current MW installed.[126] To evaluate the proportion of utility-scale versus distributed rooftop, Project Sunroof reported Ohio rooftop installations were subtracted from total SEIA reported installations.[127] To then estimate MW of utility-scale solar versus distributed rooftop, the average size of a rooftop system was calculated based on EIA reported annual electricity consumption in kilowatt hours (kWh)[128] and Ohio peak sunlight hours of 4.15 whereby kWh per year is divided by 365 days in a year multiplied by peak sunlight hours.[129] The average Ohio rooftop system size of 6.79kW was then multiplied by total rooftop systems to calculate an estimated 19 MW of rooftop solar in Ohio, which was subtracted from total SEIA reported MW installed in the state (for which the remainder was assumed to be utility-scale).	• Ohio Environmental Protection Agency • Ohio Air Quality and Development Authority • Utilities • Municipal / Regional Planning Agencies

[126] Ohio Solar | SEIA

[127] Project Sunroof - Data Explorer | Ohio

[128] Residential Energy Consumption Survey Dashboard (arcgis.com)

[129] Sunlight Hours Rank | TurbineGenerator

	Forecasting 2025 – 2030 Adoption SEIA reported annual growth rate of 24% was assumed to apply the same to both utility and rooftop systems. For wind, where there were no growth projections, U.S. Energy Information Agency (EIA), Ohio state wind MW hours (MWh) generation data was analyzed to calculate a 2016 – 2022 six-year CAGR growth trend of 17% akin to the CAGR used for the light-duty ZEV analysis.[130] Annual growth rates for wind, utility-scale solar, and distributed rooftop solar, were then applied to current MWs to estimate annual additional MWs 2025 – 2030. **Calculating GHG emission reduction** U.S. EPA's AVERT v4.2 was then used to calculate CO_2 and co-pollutant emission reductions based on the average number of new MWs across wind and solar 2025 – 2030 where solar was divided into utility-scale and distributed rooftop solar. **Considering additional GHG reductions** Next, an estimate was made for how many additional renewable MW could be deployed; for the Plan a utility-scale solar scenario was evaluated whereby if the State were to win a $200,000,000 low-end Tier A implementation grant award, this would equate to 300 MW additional utility-scale solar assuming 50% matching upfront costs with utility-solar capital development costs from the U.S. Department of Energy (DOE) National Renewable Energy Laboratory (NREL). [131]*(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).*	• Ohio Public Utilities Commission

[130] Electricity data browser - Net generation for all sectors (eia.gov)

[131] Index \| Electricity \| 2022 \| ATB \| NREL

	MEASURE-SPECIFIC ASSUMPTIONS AVERT Assumptions (full methodology can be found here) **MEASURE-SPECIFIC OPPORTUNITIES TO REFINE FOR OHIO'S CRP** Estimate CH_4 and N_2O emission reductions alongside CO_2 While utility-scale solar was the technology focus for the emission reduction calculation, other types of solar and renewable energy sources could be considered for expansion (utility-scale solar does not duplicate potential residential federal solar funding through Solar for All)	
#5 Building Energy Efficiency	**Identifying the current market** Both residential and then commercial and industrial (C&I) building markets were assessed for potential energy efficiency (EE) emission reductions. For residential buildings, NREL's State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis (ResStock)[132] was used to assess the number of residential households in Ohio (4.5 million) and their characteristics, meanwhile for commercial buildings, the DOE's Building Performance Database (BPD) was used to assess C&I building characteristics and a conservative estimated for total number of reported C&I buildings (< 1 million) in lieu of state-specific data for the Plan (something which will be sought out for the CRP analyses). **Calculating GHG emission reductions – Residential Buildings** For residential buildings, ResStock was used to calculate the average emission savings for an Ohio household (a weighted average across single-family, multi-family, and mobile housing stick) to implement basic and enhanced energy efficiency as well as minimum and high efficiency electric heat pumps (see #6 Clean Heating). Basic / minimum efficiency options were averaged with the enhanced / high efficiency options to calculate the average median emission savings for EE and electrification, respectively. ResStock considers many building aspects to calculate savings including building age and geographic location (e.g., Ohio's Climate Zone).	• Ohio Environmental Protection Agency • Municipal / Regional Planning Agencies • Department of Development • Utilities

[132] State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis | Tableau Public

RESIDENTIAL UPGRADE	MEDIAN EMISSION SAVINGS (%)	ESTIMATED CAPITAL COSTS ($) PER RESIDENTIAL HOUSEHOLD
EE	21%	$44,175[133]
Electrification	37%	$5,500[134]

Next, an estimate was made for how many Ohio households could be targeted for EE and electrification, respectively; if the State were to win a $200,000,000 low-end Tier A implementation grant award for both EE and electrification, this would equate to 4,527 homes enhanced with EE and 36,364 homes receiving electrification assuming 100% of capital costs are covered (e.g., such as a targeted program for LIDAC familiar). *(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).*

The median emission savings for each were then multiplied by the percent of total Ohio households targeted for EE and electrification to calculate the emission reduction potential against Ohio's 2019 baseline residential building emissions.

Calculating GHG emission reductions – C&I Buildings

For C&I buildings, similar emission reduction potentials from EE and electrification were sourced alongside costs. Where costs were supplied per square foot, the BPD reported average C&I square footage of 58,937 was assumed to be the building size to calculate estimated capital costs per C&I buildings.

[133] Report: Deep Retrofits Can Halve Homes' Energy Use and Emissions | ACEEE

[134] How Much Does Heat Pump Installation Cost? (2023 Guide) (homeinspector.org)

C&I UPGRADE	MEDIAN EMISSION SAVINGS (%)	ESTIMATED CAPITAL COSTS ($) PER C&I BUILDING
EE	45%[135]	$9.9 million[136]
Electrification	37%[137]	$1.2 million[138]

Next, an estimate was made for how many Ohio C&I buildings could be targeted for EE and electrification, respectively; if the State were to win a $200,000,000 low-end Tier A implementation grant award for both EE and electrification, this would equate to 40 C&I buildings receiving enhanced with EE and 323 C&I buildings receiving electrification assuming a 50% capital cost share. *(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).*

The median emission savings for each were then multiplied by the percent of total Ohio C&I buildings targeted for EE and electrification to calculate the emission reduction potential against Ohio's 2019 baseline combined C&I building emissions.

MEASURE-SPECIFIC ASSUMPTIONS
Costs and emission savings specific to commercial buildings such as commercial office buildings are also applicable to industrial buildings.

[135] Average energy and emission reduction potentials from three common DOE reported C&I EE measures 1) Occupancy Sensors Wireless Occupancy Sensors for Lighting Controls: An Applications Guide for Federal Facility Managers (energy.gov); 2) LED Lighting LED Lighting | Department of Energy and 3) Programmable Smart Thermostats Programmable Thermostats | Department of Energy

[136] In lieu of C&I specific EE costs, the difference in cost of a residential compared to C&I electrification was applied to the residential EE costs

[137] Restock savings was used as a proxy in lieu of C&I specific emission reduction potentials

[138] The Building Electrification Technology Roadmap - New Buildings Institute

	Only one year's worth of emission reductions is accounted for assuming buildings are retrofitted by 2030; however, emissions would be even greater if buildings were retrofitted prior to 2030. **MEASURE-SPECIFIC OPPORTUNITIES TO REFINE FOR OHIO'S CRP** Collect Ohio specific labor and installation costs from contractors to tailor EE and electrification costs.	
#6 Clean Heating	See #5 for calculation steps. Building electrification was selected as the clean heating GHG reduction scenario for the Plan; however, for the CRP this can be expanded to include other clean heating options such as ground-source geothermal heat pumps.	• See # 5
#7 Composting	**Identifying the current market** Ohio EPA's Economic Impact Potential of Recycling in Ohio Final Report from 2019 was used to assess the different waste streams in the state, in order to determine the volume of organic waste that would be subject to potential composting.[139] Organic waste includes food and yard waste. **ANNUAL ORGANIC WASTE DISPOSED IN OHIO (TONS)**: 2,291,521 **PROPORTION OF TOTAL WASTE DISPOSED IN OHIO (%)**: 23.9% Out of this total tonnage of organic waste, the GHG Inventory results revealed that 64% is already being diverted from producing emissions through composting oxidation, flaring and waste to energy; therefore, only 36% or nearly 800,000 tons of this waste remain to target for composting, whereby they would be diverted from landfills producing methane emissions. **Calculating GHG emission reductions**	• Ohio Environmental Protection Agency • Local waste operators • Municipal / Regional Planning Agencies

[139] Ohio Report Final021119

	Next, an estimate was made for how many commercial composting facilities could be installed if the State were to win a $200,000,000 low-end Tier A implementation grant award. Based on capital costs of $800,000 per facility that processes 1,000 tons annually, the State would be able to support 250 new facilities covering 100% of costs.[140] *(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).* With 250 facilities each processing 1,000 tons annually, this yields another 250,000 tons of organic waste that avoids landfills, which is an 11% decrease from baseline tons of organic waste disposed. This percent decrease was then multiplied by total gross landfill emissions (15 MMTCO2e) to estimate the additional avoided emissions from more composting. **MEASURE-SPECIFIC ASSUMPTIONS** Only one year's worth of emission reductions is accounted for assuming facilities are operational by 2030; however, emissions would be even greater if facilities are operational prior to 2030 **MEASURE-SPECIFIC OPPORTUNITIES TO REFINE FOR OHIO'S CRP** Assess specific landfill operations to target	
#8 Clean Waste-to-energy	**Identifying the current market** Ohio EPA's Economic Impact Potential of Recycling in Ohio Final Report from 2019 was used to assess the different waste streams in the State, to determine the volume of organic waste that would be subject to potential WtE.[141] Organic waste includes food and yard waste. **ANNUAL ORGANIC WASTE DISPOSED IN OHIO (TONS)** | **PROPORTION OF TOTAL WASTE DISPOSED IN OHIO (%)**	• Ohio Environmental Protection Agency • Local waste operators • Municipalities • Municipal / Regional

[140] PROOF ACC SolidWaste-CompostFacility-Brochure (accgov.com)

[141] Ohio Report Final021119

	2,291,521	23.9%	Planning Agencies

Out of this total tonnage of organic waste, the GHG Inventory results revealed that 64% is already being diverted from producing emissions through composting oxidation, flaring and waste to energy; therefore, only 36% or nearly 800,000 tons of this waste remain to target for WtE, whereby they would be diverted from landfills producing methane emissions. Another source of WtE could be agriculture livestock manure.

Calculating GHG emission reductions

Next, an estimate was made for how many landfill WtE as well as agriculture anaerobic digestor facilities could be installed if the State were to win a $200,000,000 low-end Tier A implementation grant award. This award was assumed to be split across the two WtE modalities with one fifth the funding going to landfill WtE (since this sector is already being targeted by composting) and four firths the funding going to agriculture WtE operations. *(Note: this is not representative of a precise Implementation Grant project, but a scenario for which to calculate additional GHG emission reduction potential).*

Landfill WtE

Based on capital costs of $23 million per 10MW landfill WtE facility that processes 28 tons of waste per kW amounting to 227,400 tons of landfill waste avoided annually per 10MW facility.[142] With one fifth of the $200,000,000 low-end Tier A implementation grant award, Ohio could cover all funding for 2 landfill WtE facilities. In total, this would avoid over 600,000 tons of organic waste landfilled annually which is a 26% reduction in total tons landfilled and consequently estimated to be a 26% reduction in gross waste emissions. Only annual emissions are accounted for assuming these projects are installed and operational by 2030; however, emissions would be even greater if projects were completed prior to 2030.

[142] Fact Sheet | Landfill Methane | White Papers | EESI

It is also estimated that 70% of all current landfill WtE operations today produce electricity versus utilizing WtE for heating or fuel[143] with 300 kWh of electricity production per 1 ton waste.[144] With an annual production capacity factor of 0.95 for landfill WtE operations, there would be 8,322 kWh of production annually per kW.[145] Therefore, alongside calculation emission reductions from avoided organic waste in landfills, emission reductions from kWh of additional biogas for electricity generation were also estimated. Total annual kWh was multiplied by Ohio's regional grid emission factor; however, emission reductions to electric power are negligible < 1% compared to the waste sector emission reductions.

Agricultural WtE

The approximate volume of manure per an average anaerobic digestor operation was sourced alongside costs.[146] Based on capital costs of $250,000 per WtE facility, the state could fund 640 facilities with four fifths the $200,000,000 award. This amounts to approximately 13% of state's total livestock manure.[147] This proportion then served as an estimate for the emission reduction potential. Like the landfill WtE, electricity generation or heating emissions from anaerobic digestion were also assumed to be negligible.

MEASURE-SPECIFIC ASSUMPTIONS
Only one year's worth of emission reductions is accounted for assuming facilities are operational by 2030; however, emissions would be even greater if facilities are operational prior to 2030
MEASURE-SPECIFIC OPPORTUNITIES TO REFINE FOR OHIO'S CRP
Assess specific landfill and agricultural operations to target

[143] Fact Sheet | Landfill Methane | White Papers | EESI

[144] FAQs | Anaerobic Digestion (biogas-info.co.uk)

[145] Microsoft Word - CLL Feasibility Report-FINAL 21 Jun 13.docx (az.gov)

[146] Anaerobic Digestion Cost – Plus Gate Fees and Other Rules of Thumb (anaerobic-digestion.com)

Appendix IV: Additional Analysis for Light-Duty ZEV Reduction Measure

INTERSECTION WITH OTHER FUNDING AVAILABILITY

Many of the priority measures included in this Plan expand upon or complement existing programs. Ohio EPA has explored federal and non-federal funding sources to determine whether these sources could fund each priority measure and whether such funding is sufficient to fully implement the measure. This section describes the results of this analysis for the priority measure to expand light-duty ZEVs that the State is considering for implementation.

CURRENT PROGRAMS

- **NEVI:** The federal government allocated $140 million in NEVI formula funds to Ohio under the BIL. [148] The program, which is overseen and administered by ODOT, will be used to fill charging gaps alongside Ohio's interstate highway system, with the goal of providing a charger at least every 50 miles and ensuring that 90% of Ohioans live within 25 miles of NEVI compliant chargers.[149]
  - **Relationship to priority measure:** The NEVI program is designed to increase access to publicly available fast chargers, which remains a key strategy for increasing EV range and lowering barriers to purchasing EVs. An S&P survey from 2023 identified charging concerns as the second most important concern for respondents against buying an electric vehicle. Termed "range anxiety" – concerns over EV charger range and length of time to charge top consumer concerns regarding EV purchases and are considered a major barrier to purchasing EVs.[150]
  - **Current state:** Thus far, the program has distributed two rounds of funding, which will support the installation of approximately 51 publicly available fast chargers. Additional funding is expected to commence once charging stations on federally required corridors are complete. The future funds, which ODOT expects will be distributed in two rounds, will commence once Ohio is certified as Fully Built out by the Joint Office of Energy and Transportation.
  - **Future state and ability to support the priority measure:** As identified in the Ohio Electric Vehicle Infrastructure Deployment Plan.
    - ODOT's goals for NEVI, in accordance with FHWA guidance, will focus on building out FHWA Designated AFCs, then seek to expand to regional and local routes of significance, equity-based destination charging, and freight charging locations. Maintaining consistency with the prior fiscal year, there have been no changes to the strategic direction, goals, or milestones.
    - The State's NEVI plan has been identified by key stakeholders as a vital part of this priority measure, as the ability to access publicly available chargers across the State is likely to assuage "range anxiety" for many would-be purchasers of

[148] National Electric Vehicle Infrastructure Formula Program (NEVI) (ohio.gov)

[149] DriveOhio_NEVI_Plan_2023-07_28_Round7_removed.pdf

[150] Affordability tops charging and range concerns in slowing EV demand | S&P Global (spglobal.com)

EVs. Importantly, research shows that availability of charging infrastructure largely increases preference for EVs.[151]

  - The current NEVI plan is focused on several AFCs, which may not include the most helpful charging locations to commuters in Ohio. Notably, NEVI do not cover private residential, commercial and other public non-AFC charger locations, which may need additional funding support to gain widespread adoption.

- **IRA EV and FCEV Tax Credits:** Although not technically a program to be administered by the state of Ohio, IRA tax credits are an important part of the funding support provided by the U.S. government. The various financial incentives are designed to boost the adoption of ZEVs and the expansion of charging/alternative fuels infrastructure. Consumers can benefit from tax credits up to $7,500 for new and $4,000 for used EV or FCEV purchases, as well as a 30% credit (up to $1,000) for home charging / alternative fuels installations. Businesses can receive up to $7,500 in tax credits for purchasing commercial EVs / FCEVs and up to $100,000 for installing alternative fuels refueling / charging stations. These incentives aim to reduce upfront costs, increase EV adoption, and expand charging infrastructure.
  - Relationship with priority measure: Stakeholders have consistently identified electric vehicles as the priority zero emission vehicle type for adoption across the state. In the context of Ohio's ongoing efforts to increase electric vehicle adoption, the IRA funding provides significant financial support to both consumers and businesses. By making EVs more affordable and competitive with traditional gasoline vehicles and promoting the development of accessible charging infrastructure, this federal funding aligns with Ohio's electrification initiatives and encourages residents and organizations to transition to zero emission transportation options. Importantly, the funding aims to significantly reduce EV costs, addressing a major concern among potential buyers. According to the S&P survey, nearly half of the respondents believe that the current prices of electric vehicles are too high.152
  - Current state: as of the beginning of 2024, all aforementioned tax credits are currently available and funded.
  - Future state and ability to support the priority measure: Financial incentives have been identified by stakeholders as a key approach to increasing EV adoption. However, as EVs remain highly priced relative to ICE vehicles, it is unclear if the federal funding is sufficient for widespread EV adoption in Ohio. Ohio offers inspection exemptions to ZEV drivers and does not offer other financial incentives at the State level to drive down the price of EVs, which may make it difficult to make the price competitive enough with ICE vehicles. As of 2023, EVs only represent 0.33% of Ohio registrations.153 To meet the modelled GHG emission reductions, the State may need to consider additional subsidies/incentives.

[151] Transportation Research Record (TRR) 2020

[152] Affordability tops charging and range concerns in slowing EV demand | S&P Global (spglobal.com)

[153] Alternative Fuels Data Center: Vehicle Registration Counts by State (energy.gov)

[159] Bureau of Labor Statistics September 2023 Quarterly Census of Employment and Wages (QCEW)

[160] Bureau of Labor Statistics National Industry-Occupation Employment Matrix

FUNDING GAPS

- **Charging Infrastructure:** Charging infrastructure has received funding through NEVI and IRA tax grants. Additional funding may need to be considered to offset the high upfront costs associated with developing charging infrastructure.
- **Vehicle Purchases:** The IRA provides funding for EV/FCEV tax credits through 2032. Current federal tax incentives vary depending upon vehicles purchased and price. However, additional funding may need to be considered to offset the high upfront costs associated with purchasing electric vehicles.
- **Education and Workforce Planning:** The IRA does not allocate specific funding for education related to light-duty electric vehicles. IIJA funding has been used to support education and training plans. Under the NEVI plan, ODOT identified specific career pathways that are critical to the EV ecosystem. However, additional funding may be needed to support the development of robust education and training programs. Additional information on workforce planning is described herein.
- **Customer Acquisition:** No specific federal funding streams were identified to support the customer acquisition process or to improve messaging around electric vehicles.

WORKFORCE PLANNING ANALYSIS

WORKFORCE PLANNING

The priority measures included in this Plan will result in the creation of high-quality jobs for Ohioans. This section details Ohio's strategies and commitments to ensure job quality, strong labor standards, and a diverse, highly skilled workforce for implementation of the priority measures.

WORKFORCE OVERVIEW

As of September 2023, the Ohio Labor Force comprised approximately 5.8 million individuals, of which 96.5% were employed and 3.5% were unemployed. While the state's population increased 1.0% from 2018 to 2023, the growth in employment was only 0.4%, which lagged the U.S. national average employment growth of 4.4% in the same period.[159] However, the Bureau of Labor Statistics predicts that employment in Ohio is expected to increase by 1.9% from 2023 to 2027[160].

Demographically, Ohio is in line with national averages for age diversity with approximately 4% fewer millennials and approximately 5% more retirement and pre-retirement age individuals. Ohio's demographic concentration of racial diversity is significantly lower than the national average with less than half the racially diverse population expected for an area of its size.[154]

WORKFORCE PARTNERSHIPS & MESSAGING OPPORTUNITIES

State Commerce & Labor Agencies: Ohio EPA can explore partnering with the ODOT via their Drive Ohio initiative. Drive Ohio's Electric Vehicle Infrastructure Deployment Plan for the NEVI Formula Program plans to create an EV charging framework and network across the state of Ohio. As the goals of Drive Ohio's plan complement the Ohio EPA's priority measure of

[154] Bureau of Labor Statistics Current Employment Statistics (CES)

expanding light-duty ZEVs in Ohio, so too do the workforce considerations, commitment to good job creation (as defined in the U.S. Economic and Development Administration's (EDA) Good Jobs Challenge), upskilling and training requirements considerations. Drive Ohio has already secured $140 million over five years in funding for their implementation plan in the amount of $140 million over five years and is in phase two of implementation.[155] Ohio EPA may also partner with ODOT to increase the impact of their program and scale the best practices as they relate to labor, safety, training, and installation standards.

Additionally, Ohio EPA can evaluate partnering with JobsOhio, and by extension the Ohio Department of Development (ODOD), OhioMeansJobs, and the Ohio Department of Commerce to effectively communicate and advertise newly created good jobs anticipated from the priority measure, disseminate training program details, and facilitate education and outreach to underserved communities.

Educational Institutions & Training Programs: There are over 120 schools in Ohio that offer degrees or certificates related to the anticipated roles needed to implement light-duty ZEV expansion across the state.[156] Ohio EPA may work with institutions to supplement automotive-related programs and curricula with ZEV-specific training and education resources and support outreach for participation in local areas, especially within underserved communities.

Labor Unions: Ohio EPA will consider working with ODOT to leverage the Electrical Industry Training Centers and International Brotherhood of Electrical Workers to prioritize training in electric vehicle supply and equipment (EVSE) installation, provide additional EVSE certifications for electricians via NEVI's Electric Vehicle Infrastructure Training Program (EVITP) national curriculum, and reimburse those certifications via the Ohio TechCred program for employers of electrical contractors in Ohio.

Ohio Governor's Office of Workforce Transformation (OWT): Ohio EPA may partner with the Ohio Governor's OWT to execute on and utilize their many existing workforce-specific initiatives to further the impact of Ohio EPA's priority measures, including Individual Microcredential Assistance Program (IMAP), Industry Sector Partnership Grants, State Approved Industry Recognized Credentials, High School Tech Internship Pilot Program, TechCred, Top Jobs, Ohio to Work, Choose Ohio First, Career Pathways Resource, Career Resource Navigator, Innovative Workforce Incentive Program and ApprenticeOhio.

ANTICIPATED LABOR CHANGES, STRENGTHS, RISKS & OPPORTUNITIES

Increasing light-duty electric vehicles in Ohio requires additional vehicle and parts manufacturing to meet expected demand, specialized repair and maintenance, and expansion of the electric vehicle charging infrastructure. While many career pathways will be affected by the expansion of light-duty electric vehicle expansion, the main occupations impacted (defined by Standard

[155] DriveOhio_NEVI_Plan_2023-07_28_Round7_removed.pdf

[156] National Center for Education Statistics, Integrated Postsecondary Education System (IPEDS); National Center for Education Statistics, Office of Educational Research and Improvement for the CIP – SOC crosswalk, Classification of Instructional Programs Crosswalk to Standard Occupational Classification

Occupational Classification (SOC) code) will be Production occupations (SOC 51), Installation, Maintenance, and Repair occupations (SOC 49), and Construction and Extraction occupations (SOC 47).[157]

Because of Ohio's significant footprint in the automotive industry (internal combustion engines (ICE), parts manufacturing, maintenance, etc.), the shift to EV will decrease the demand for ICEs and therefore displace workers who are producing ICE-specific products and services.[158] However, it simultaneously creates a substantial opportunity to shift the existing ICE workforce into similar roles for EVs, allowing them to leverage their existing skillsets in addition to upskilling or reskilling to meet the requirements of EV production and maintenance. Additionally, there is an opportunity to transition workers who are not currently working in the industry but who have skillsets like those required for EV production/maintenance and EV infrastructure installation.

- **EV & EVSE Manufacturing and Production:** Automakers (original equipment manufacturers (OEMs), suppliers, etc.) across the world are investing over $860 billion (over $200 billion in the U.S.) by 2030 in the transition to EVs.[159] Simultaneously, numerous federal grants and programs have been rolled out to facilitate the transition by providing financial incentives to consumers and companies to purchase electric vehicles (e.g., IRA incentives, state and federal tax credits).

- The increased demand for EVs prompts manufacturers to increase production and expand their capabilities. Ohio's place as a major player in automotive manufacturing in not only the Midwest but considering the entire country, Ohio positions itself well to see the workforce and economic development impacts of the transition. Ohio has the second largest workforce in the nation for motor vehicle and parts manufacturing and is home to major automotive suppliers, OEMs, and assembly facilities including Honda, Ford, GM, and Fiat Chrysler. Recent EV investments by automakers in the state are creating new jobs, for example:[160]
    - LG and Honda's battery plant in Columbus (~2,500 jobs)[161]
    - Hyperion's fuel cell facility in Columbus (~700 jobs)[162]
    - Forsee Power's North American headquarters in Columbus (~150 jobs)[163]
    - SEMCORP's lithium-ion battery component facility in Sidney (~1,200 jobs)[164]
    - Mobis North America's battery assembly plant in Toledo (~185 jobs)[165] and

[157] Bureau of Labor Statistics National Industry-Occupation Employment Matrix

[158] https://www.jobsohio.com/ohio-leads-in-electric-vehicles

[159] Automakers electric vehicle investment plans (reuters.com)

[160] https://www.jobsohio.com/industries/automotive

[161] Honda to Invest in Ohio for Electric Vehicle Production (jobsohio.com)

[162] https://www.dispatch.com/story/business/2022/02/01/hyperion-add-700-jobs-far-west-side-hydrogen-fuel-cell-facility/9296467002/#:~:text=A%20California%20company%20plans%20to,.%2C%20which%20closed%20in%202020

[163] https://www.forseepower.com/press-release/forsee-power-to-establish-north-american-headquarters-and-battery-systems-gigafactory-in-the-columbus-ohio-27-06-2022/#:~:text=A%20scalable%203%2DGWh%20manufacturing,North%20American%20headquarters%20and%20Gigafa

[164] https://www.jobsohio.com/news-press/semcorp-to-produce-critical-lithium-ion-battery-component-in-sidney

[165] https://www.jobsohio.com/news-press/mobis-north-america-chooses-toledo-for-electric-battery-assembly-plant

- Ford's EV manufacturing plant in Sidney (~1,800 jobs).[166]

- **EV Charging Infrastructure Expansion and Maintenance:** As organizations like Drive Ohio continue to implement their NEVI Formula programs, the EV landscape will expand via the installation of standalone accessible EV charging stations, installation of EVSE-compatible wiring in new buildings, upgrades to such wiring in existing buildings, and continued maintenance of charging stations. This need presents an opportunity for electrical workers and service technicians in the installation, maintenance, and repair occupations (SOC 49) and well as the construction and extraction occupations (SOC 47).

As not all workers currently in these occupations may possess the EV-specific specialized skills required to transition into the needed roles, there is an opportunity for integration with the automotive sector for the purposes of training, upskilling, and certifying technicians. As several occupations have overlapping skillsets, there is further opportunity to recruit, upskill and certify talent from adjacent occupations and industries. In the long term, this creates additional employment opportunities and career pathways for workers in the automotive, manufacturing, construction, and utilities industries.

For electrical workers and other transitioning workers to work on commercial projects in the state of Ohio, they are required to be licensed. In accordance with the minimum standards set forth by NEVI, all electricians installing, operating, or maintaining EVSE must have: (i) certification from EVITP, (ii) graduation or a continuing education certificate from a registered apprenticeship program for electricians that includes charger-specific training and is developed as a part of a national guideline standard approved by the Department of Labor in consultation with the Department of Transportation, or (iii) for projects requiring more than one electrician, at least one electrician must meet the requirements above, and at least one electrician must be enrolled in an electrical registered apprenticeship program.[167]

- **EV Repair & Maintenance:** In addition to a skilled workforce for erecting, retrofitting, and maintaining EV charging stations, the influx of EVs among individuals and companies will be followed by an increased need for maintenance and repairs. This creates an opportunity for workforce development among vehicle service technicians, mechanics, and similar roles. In 2023, there were more than 10,200 job postings for automotive service technicians and mechanics in Ohio, indicating a high demand for talent and an opportunity for workforce development in this area.[168] Additionally, the complexity of EVs will require additional training and continuing education on proper maintenance techniques, component parts, and software. Technicians and mechanics can take advantage of the existing suite of technical training programs and continuing education resources available to them in the state of Ohio, including online instructional resources, post-secondary vocational programs, community colleges, and courses to supplement current automotive training and continuing education curricula with EV-specific content. There is also opportunity for automakers and

[166] https://governor.ohio.gov/media/news-and-media/Governor-DeWine-Ford-Motor-Company-Announce-1800-New-Jobs-to-Assemble-New-Commercial-Electric-Vehicle-06022022

[167] Federal Register :: National Electric Vehicle Infrastructure Standards and Requirements

[168] Lightcast, 2023

automotive industry employers to incentivize hiring by subsidizing these EV training and continuing education programs.

EQUITY AND UNDERSERVED COMMUNITIES

While there are many opportunities for workforce development due to the expansion of light-duty ZEVs in Ohio in the form of job creation, upskilling and training, there are also barriers to those in underserved communities. Upskilling, training programs, and continuing education courses for electricians and automotive technicians and service workers can be costly and time-consuming, with EVIT certification requiring 8,000 hours of electrical field experience and continuing upskilling courses at community colleges costing thousands of dollars.[169] Workers may also lose out on wages due to the time commitment and availability of relevant courses required to pursue certifications.

Ohio's Governor's Office of Workforce Transformation has programs and initiatives in place to alleviate the cost burden of programs for underserved communities. Programs include the Individual Microcredential Assistance Program (IMAP) which helps Ohioans who are low income, partially unemployed, or totally unemployed participate in a training program to receive a credential at no cost; OhioMeansJobs.com which is Ohio's free online career counseling center that connects businesses to job seekers and provides career services to all Ohioans; and the Ohio to Work initiative which consists of career service professionals who provide job-seekers with free guidance and resources to get them on the path to finding a stable career.

WORKFORCE FUNDING NEEDS

Ohio has significant infrastructure and support for workforce planning and development. To drive Plan implementation, it will be most efficient to leverage this robust network of partners across the state. Therefore, potential resources would be incremental to amplify and scale these programs. We expect that additional funding will be necessary to support:

- **Additional instructional support:** Ohio's network of educational institutions offering this training are often constricted in their offerings by the availability of qualified instructors and one innovative approach is to partner with agencies to share resources into programs on a part time basis through grants and incentives.
- **Additional advertising:** To drive participation, Ohio EPA can consider leveraging the Jobs Ohio communication channels with focus on underserved communities and those in roles which are expected to have significant skills overlap with new roles and/or may be in lower demand in future.
- Ohio EPA may also consider some unique programs that address barriers to work, such as lost wages during training time, transportation, and other matters. We can work with the Governor's OWT to pilot and channel funding towards these areas to drive adoption and participation, particularly in underserved communities.

As mentioned above, Ohio has several organizations actively working on workforce related matters that are aligned to the workforce needs discussed previously. Ohio EPA can partner

[169] https://evitp.org/

with these organizations to support the need for upskilling, training, hiring, and outreach to underserved communities. Specific examples include:

- Drive Ohio's initiatives to create good jobs through upskilling and training is already funded and into the implementation period. Ohio EPA can work to increase its impact and scale it with the additional need associated with Plan implementation.
- Jobs Ohio and the associated regional organizations have channels to effectively communicate the opportunities and drive awareness and participation in training and certification programs.
- Ohio's educational institution network and training programs already are embedded within their communities and are offering the degrees, certificates, designations, and microcertificates/microcredentials required for EV-related jobs.
- Ohio's labor unions and manufacturing associations have programs to develop skills for their membership (e.g., EVSE certifications)
- Governor's OWT provides a number of programs that support the overall development of the state's workforce, including addressing rapid upskilling and on-the-job training

Ohio has several coordination points to ensure collaboration across the state's workforce development programs. The Office of Workforce Transformation already coordinates activities across the state through OhioMeansJobs county offices in partnership with regional and local stakeholders.

Specific collaboration opportunities are noted above. Further to add that sector-based strategies may include partnering with trade organizations like the Ohio Manufacturers' Association (OMA) to scale programs through their membership, as well.

Much of the curricula exists to support the identified training and certifications, but not at the scale required. Across the state, educational institutions and training programs are interested to offer such programs and scale existing programs. Additionally, while new curricula are likely not required, there may be opportunities to rethink the structure of such programs to accelerate paths to certification, offer more programs that accommodate alternate schedules, or partner with employers to create on-the-job training opportunities.