MI HEALTHY CLIMATE

Implementing the MI Healthy Climate Plan

Michigan's Comprehensive Climate Action Plan

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

December 2025

MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

This report is available digitally at Michigan.gov/EGLE

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Michigan.gov/EGLE 800-662-9278 December 2025

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DEFINITIONS

Comprehensive Climate Action Plan (CCAP): a narrative report that provides an overview of the grantees' significant greenhouse gas sources/sinks and sectors, establishes near-term and long-term greenhouse gas emission reduction goals, and provides strategies and identifies measures that address all sectors to help the grantees meet those goals.

Global Warming Potential (GWP): a greenhouse gas's ability to trap heat in the atmosphere relative to carbon dioxide.

Greenhouse Gas (GHG): atmospheric gas that absorbs radiation emitted by Earth, trapping heat and raising temperatures. The most relevant greenhouse gases to Michigan's decarbonization plan are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, chlorofluorocarbons, and sulfur hexafluoride.

Greenhouse Gas (GHG) Inventory: a list of greenhouse gas emission sources and sinks and the associated emissions quantified using standard methods.

Low Income and Disadvantaged Communities (LIDACs): communities with residents that have low incomes, limited access to resources, and disproportionate exposure to environmental or climate burdens. LIDACs can be identified by assessing indicators in categories such as air quality, climate change, energy, environmental hazards, health, housing, legacy pollution, transportation, water and wastewater, and workforce development.

Metropolitan Statistical Area (MSA): A geographic entity delineated by the Office of Management and Budget for use by federal statistical agencies. Metropolitan statistical areas consist of the county or counties (or equivalent entities) associated with at least one urban area of at least 50,000 population, plus adjacent counties having a high degree of social and economic integration with the core as measured through commuting ties. Metropolitan statistical areas are defined by the United States Census 2020 MSA population.

Priority Climate Action Plan (PCAP): a narrative report that includes a focused list of near-term, high-priority, and implementation-ready measures to reduce greenhouse gas pollution and an analysis of greenhouse gas emission reductions.

State: One of the 50 United States, the District of Columbia, and Puerto Rico.

ACRONYMS

ACEEE	American Council for an Energy-Efficient Economy
AVERT	EPA's AVoided Emissions and geneRation Tool
BAU	Business as usual
BEV	Battery electric vehicle
CCAP	Comprehensive Climate Action Plan
CCUS	Carbon capture, utilization, and sequestration
CEJST	Climate and Economic Justice Screening Tool
CH_4	Methane
CHP	Combined heat and power
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2FFC	Carbon dioxide from fossil fuel combustion
COBRA	EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool
CPRG	EPA's Climate Pollution Reduction Grant
CWETO	Michigan Community and Worker Economic Transition Office
DNR	Michigan Department of Natural Resources
DOE	United States Department of Energy
DTMB	Michigan Department of Technology, Management, and Budget
EGLE	Michigan Department of Environment, Great Lakes, and Energy
EIA	United States Energy Information Administration
EJScreen	EPA's Environmental Justice Screening and Mapping Tool
EPA	United States Environmental Protection Agency
EPS	Energy Policy Simulator
EQIP	United States Department of Agriculture's Environmental Quality Incentives Program
EV	Electric vehicle
EWR	Energy waste reduction
F-gas	Fluorinated gas
FLIGHT	EPA's Facility Level Information on GreenHouse Gases Tool
FPT	Functional Performance Testing
FTA	United States Federal Transit Administration

GHG	Greenhouse gas
GHGRP	EPA's Greenhouse Gas Reporting Program
GVMC	Grand Valley Metro Council
GW	Gigawatt
GWP	Global warming potential
H2-DRI-EAF	Hydrogen-based direct reduced iron electric arc furnace
HCFC-22	Chlorodifluoromethane
HEV	Hybrid electric vehicle
HFC	Hydrofluorocarbon
HVAC	Heating, ventilation, and air conditioning
ICEV	Internal combustion engine vehicle
IRP	Integrated Resource Plan
kW	Kilowatt
kWh	Kilowatt-hour
LEO	Michigan Department of Labor and Economic Opportunity
LIDAC	Low-income and disadvantaged community
LULUCF	Land Use, Land Use Change, and Forestry
MAC-EJ	Michigan Advisory Council on Environmental Justice
MBR	Membrane bioreactors
MDARD	Michigan Department of Agriculture and Rural Development
MDHHS	Michigan Department of Health and Human Services
MDOT	Michigan Department of Transportation
MEDC	Michigan Economic Development Corporation
MHCP	MI Healthy Climate Plan
MiEJScreen	Michigan's Environmental Justice Screening Tool
MiHER	Michigan Home Energy Rebates Program
MISO	Midcontinent Independent System Operator
$MMTCO_2e$	Million metric tons of carbon dioxide equivalent
MPSC	Michigan Public Service Commission
MRF	Material recovery facility
MSA	Metropolitan statistical area
MSHDA	Michigan State Housing Development Authority

MTRAC	Michigan Translational Research and Commercialization
MW	Megawatt
N_2O	Nitrous Oxide
NO_x	Nitrogen oxides
NREL	United States National Renewable Energy Laboratory
O&M	Operations and maintenance
ODS	Ozone depleting substance
OFME	Michigan Office of Future Mobility and Electrification
PCAP	Priority Climate Action Plan
PFC	Perfluorocarbon
PHEV	Plug-in hybrid electric vehicle
$PM_{2.5}$	Particulate matter
R&D	Research and development
REA	Michigan's Renewable Energy Academy
RESTART	Retired Engineers, Scientists, Technicians, Administrators, Researchers, and Teachers
SAF	Sustainable aviation fuel
SEMCOG	Southeast Michigan Council of Government
SF_6	Sulfur hexafluoride
SiC	Silicon carbide
SIT	EPA's State Inventory Tool
SLOPE	United States Department of Energy's State and Local Planning for Energy
SO_x	Sulfur oxides
sq ft	Square foot
T&D	Transmission and Distribution
$tCO2_e$	Metric tons of carbon dioxide equivalent
U.S.	United States
USDA	United States Department of Agriculture
VOC	Volatile organic compound
WRRF	Water Resource Recovery Facility
WWTP	Wastewater Treatment Plant
ZEV	Zero emission vehicle

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EXECUTIVE SUMMARY

This document is the State of Michigan's Comprehensive Climate Action Plan (CCAP), developed as a deliverable of the United States Environmental Protection Agency's (EPA) Climate Pollution Reduction Grant (CPRG) Program. Michigan's CCAP closely follows the framework and key strategies laid out in the MI Healthy Climate Plan (MHCP). The development of this CCAP involved statewide community engagement and the development of a greenhouse gas (GHG) inventory. Both were used to establish priority reduction measures, quantify potential GHG emission reductions, analyze benefits for low-income and disadvantaged communities (LIDACs), and provide commentary on the authority to implement the identified measures, intersection with other state programming and funding opportunities, and workforce required to realize the measures.

The key outcomes of Michigan's CCAP development include:

- **Community Engagement:** Since the development of Michigan's Priority Climate Action Plan (PCAP) in 2024, statewide community engagement efforts have included five virtual public listening sessions (November 2024 – January 2025), five in-person key partner convenings (May – October 2025), one in-person and online workshop focused on climate equity and justice (October 2024), and multiple activities throughout the 3rd Annual MI Healthy Climate Conference (April 2025). These engagements helped to identify key priorities, areas of concern, and potential solutions for each of the six main economic sectors addressed in this document (Electricity Generation, Transportation, Commercial and Residential Buildings, Industry, Waste and Wastewater, Natural and Working Lands).

- **Michigan's GHG Emissions Inventory:** As of 2021, Michigan's net GHG emissions, accounting for carbon sinks from natural and working lands, were 168.81 million metric tons of carbon dioxide equivalent ($MMTCO_2e$), a 20.66% decrease from the baseline year of 2005. The Electricity Generation sector remains the largest emitter with 29.43% of total (not accounting for carbon sinks) GHG emissions, followed by Transportation with 26.03%, Industry with 17.51%, and Commercial and Residential Buildings with 16.61%.

- **GHG Emissions Reduction Targets:** Embedded in the MHCP are goals to reduce GHG emissions in Michigan by 28% compared to 2005 levels by 2025 and 52% by 2030. It also calls for achieving economy-wide carbon neutrality by 2050 and maintaining net negative GHG emissions thereafter.

- **Reduction Measures:** GHG reduction measures were evaluated and organized using the following MHCP pillars:
    - Clean the Electric Grid
    - Electrify Vehicles and Increase Public Transit
    - Repair and Decarbonize Homes and Businesses
    - Drive Clean Innovation in Industry (includes Waste and Wastewater)
    - Protect Michigan's Land and Water (includes Agriculture)

  The Commit to Environmental Justice and Pursue a Just Transition pillar is embedded in all reduction measures across all pillars.

- **Benefits Analysis (including LIDACs):** For each reduction measure, co-pollutants and co-benefits have been identified and, where data is available, quantified. Tracking emissions by pollutant, including co-pollutants such as sulfur oxides (SO_x), nitrogen oxides (NO_x), particulate matter ($PM_{2.5}$), and volatile organic compounds (VOCs), is critical to the health and wellbeing of communities throughout the state. Different pollutants have distinct health and environmental effects, and certain populations, especially those in LIDACs, may be disproportionately exposed to higher concentrations of specific pollutants. The following metrics have been used throughout this document to measure the impact on communities, beyond just emissions reductions:
    - Avoided Deaths by Race
    - Avoided Lost Workdays
    - Avoided Respiratory Symptom Cases
    - Avoided Hospital Admissions
    - Avoided Minor Restricted Activity Days

- **Workforce Analysis:** For each sector, historical and projected growth trends have been outlined, along with any anticipated workforce shortages that might prevent the state from achieving its climate goals. Existing programs and partners at the state, regional, and/or local level that will help secure the workforce needed to achieve the goals established in the CCAP have also been identified.

The CCAP represents a significant opportunity in Michigan's efforts to address climate change and create a more sustainable future for all residents through the implementation of the MHCP. It is important to note, however, that achieving these ambitious goals will require sustained commitment, collaboration, and investment from all levels of government, businesses, and communities.

1.0 INTRODUCTION

1.1 Climate Pollution Reduction Grant Overview

The EPA issued formula grants under Phase I of the CPRG program to support interested states, metropolitan statistical areas (MSAs), Tribes, and territories in the development of plans to reduce GHG emissions and other harmful air pollutants. Through this program, EGLE was awarded $3 million to write both a PCAP and this CCAP due in 2024 and 2025, respectively.

EGLE is continuously searching for ways to bring and activate sustainable solutions to Michigan to reduce GHG emissions and improve the lives of Michiganders through economic and health benefits. The EPA's CPRG program provides another opportunity for the State of Michigan to define near-term goals and spur action in implementing the key strategies of the MHCP.

1.2 CCAP Purpose and Scope

This CCAP builds upon the PCAP, which was published in March 2024 and highlights priority actions for four of the six pillars of the MHCP: Clean the Electric Grid, Electrify Vehicles and Increase Public Transit, Repair and Decarbonize Homes and Businesses, and Drive Clean Innovation in Industry. The State of Michigan's CCAP covers all requirements stipulated by the EPA in the following structure:

- 2021 GHG inventory (economy-wide and by sector).
- Projected GHG emissions (economy-wide and by sector) under a business-as-usual scenario and full implementation scenario, whereby all emissions reduction targets are met.
- GHG emissions reduction measures for five of the six pillars of the MHCP, one additional highlighted pillar incremental to the PCAP, and their associated reduction measure descriptions, implementation timelines, GHG emissions reduction projections, co-pollutant quantifications, qualitative and quantitative community benefits analyses, overviews of authority to implement, and reviews of intersection with other funding availability.
- An overview of statewide LIDACs, incorporating the Commit to Environmental Justice and Pursue a Just Transition pillar of the MHCP.
- Workforce planning considerations for each sector, including priority occupations, historical and future trends, anticipated workforce shortages, and existing state and local programs that can support workforce growth and help prevent shortages.

1.3 Approach to Developing the CCAP

The MHCP, ordered by the State of Michigan's Executive Directive 2020-10, lays out a pathway for Michigan to reach carbon neutrality by 2050 to avert the worst impacts of the climate crisis, create good-paying jobs, and build a healthier, more prosperous, equitable, and sustainable Michigan for all Michiganders. Developed with input from hundreds of residents, including leaders and advocates in environmental justice, public transit, local food, climate action, business, labor, academia, and government, the MHCP was released in April 2022.

The PCAP and CCAP are intended to help the State build upon and continue implementation of the MHCP while keeping the EPA's strategic goals for the CPRG program top of mind. The MHCP is the state's roadmap to reaching carbon neutrality by 2050, and is centered around six pillars:

1. Commit to Environmental Justice and Pursue a Just Transition
2. Clean the Electric Grid
3. Electrify Vehicles and Increase Public Transit
4. Repair and Decarbonize Homes and Businesses
5. Drive Clean Innovation in Industry
6. Protect Michigan's Land and Water

Throughout this document, analysis is organized into six key sectors using language as suggested by the EPA. These sectors align directly with and are in order of the pillars of the MHCP. The six sectors addressed in this CCAP are: Electricity Generation, Transportation, Commercial and Residential Buildings, Industry, Waste and Wastewater, and Natural and Working Lands (includes agriculture).

CCAP Sector	Corresponding MHCP Pillar
1. Electricity Generation	Clean the Electric Grid
2. Transportation	Electrify Vehicles and Increase Public Transit
3. Commercial and Residential Buildings	Repair and Decarbonize Homes and Businesses
4. Industry; **5.** Waste and Wastewater	Drive Clean Innovation in Industry
6. Natural and Working Lands	Protect Michigan's Land and Water

Community and Partner Engagement: The geographic territory of this CCAP is the entire State of Michigan. Various methods of engaging and maintaining ongoing collaboration with communities were employed to create a holistic, inclusive CCAP influenced by residents and experts alike.

Engagement for the development of the CCAP began with a session focused on the Commit to Environmental Justice and Pursue a Just Transition pillar of the MHCP. This session was accessible in person as well as virtually and is detailed in more depth in the LIDAC Meaningful Engagement portion of this document (Section 7.2).

To ensure accessibility and meaningful engagement of all residents, a series of virtual listening sessions were held from November 2024 to January 2025 focused on the remaining MHCP pillars. To provide context about Michigan's goals and progress in climate-related initiatives, each session began with a presentation on the MHCP, including the most recent GHG inventory, an overview of relevant climate-related state programs, and other opportunities to get involved. An open-forum comment period followed the presentations, where Michiganders were invited to discuss any topic as it related to MHCP implementation and the development of CCAP reduction measures. To allow time for all willing participants to speak, comments were limited to three minutes. Across these five sessions, totaling 6.5 hours, there were 567 attendees and 114 comments.

EGLE, in partnership with the University of Michigan School for Environment and Sustainability, held five sector-specific meetings with key partners and topical experts between May and October 2025. Attendance included subject matter experts from the State of Michigan, businesses, local governments, non-governmental organizations, and academic professionals. These meetings consisted of presentations on the MHCP and relevant sector GHG emissions inventory, presentations by subject-matter experts, a discussion panel, and breakout groups which encouraged attendees to discuss barriers and opportunities to implementation of the identified reduction measures.

Additionally, multiple activities throughout the 3rd Annual MI Healthy Climate Conference (April 2025) were designed to help identify key priorities, areas of concern, and potential solutions for each of the six sectors of this CCAP. EGLE also engaged over 300 Michigan middle and high school students through the Student Sustainability Summit in May 2025. They interacted with 2021 GHG emissions inventory data and participated in a MHCP feedback exercise. At the 2025 Northern Michigan Environmental Conference & Workshops, held in March 2025 at Northern Michigan University in Marquette, EGLE hosted a workshop focused on the MHCP and key measure prioritization, opportunities to implementation, and barriers.

EGLE has longstanding collaborative relationships with several entities that broadened to incorporate CCAP-specific discussions. For instance, the Southeast Michigan Council of Governments (SEMCOG) and Grand Valley Metro Council (GVMC), two Michigan MSAs, both received funding to develop their own PCAPs and CCAPs. EGLE began meeting with SEMCOG and GVMC on a biweekly basis and continue to meet monthly to share status updates, align strategies, and foster collaboration.

Additionally, during PCAP development, EGLE engaged with the Michigan Advisory Council on Environmental Justice (MAC-EJ) and Catalyst Communities. EGLE also met monthly with the federally recognized Tribal governments in Michigan that received their own CPRG planning grants. After completing the PCAP and transitioning to the CCAP, these meetings occurred bimonthly and expanded to include all twelve of the federally recognized Tribes in Michigan.

Some other entities EGLE has ongoing relationships with that provided input on the CCAP, whether directly or indirectly, include the Council on Climate Solutions and its state department subcabinet, EGLE Climate Liaisons, MI Healthy Climate Fellows, MI Healthy Communities Accelerator, interagency groups, community members, municipalities, universities, and students, among others.

Themes from Engagement Sessions: While the following summary cannot fully capture the depth of individual perspectives or the importance of local context, several key themes emerged across engagement events. Successful climate action in Michigan will depend on continued attention to community needs, regional differences, and collaboration across sectors.

Across all pillars, the following key themes emerged:

Coordinated Planning and Infrastructure Investment: Participants emphasized the need for cohesive statewide planning that integrates land use, infrastructure, and permitting. This includes upgrading aging infrastructure, especially to support electrification and decarbonization. Engagement participants also stressed aligning infrastructure and permitting decisions with long-term climate goals to avoid duplication and improve efficiency.

Communication, Outreach, and Education: Effective communication and engagement were viewed as foundational to progress. Participants called for tailored messaging that reaches diverse audiences, spaces for dialogue, and transparent sharing of information and data. Public access to success stories, educational resources, and local examples can build trust and help residents and organizations understand complex issues and identify opportunities to align goals.

Funding and Economic Tools for Transition: Participants called for clear, accessible, and equitable funding pathways to support Michigan's climate transition. Recommendations included developing financing mechanisms to fill gaps in hard-to-decarbonize sectors, expanding incentives that improve affordability, and promoting shared investment models.

Policy, Governance, and Coordination: Participants underscored the importance of consistent policies and collaboration across state agencies, local governments, and industry. Enhanced coordination across departments and with external partners can reduce redundancy, streamline implementation, and foster shared ownership of outcomes.

Research, Innovation, and Knowledge Sharing: Expanding research and data-sharing capacity can inform decision-making. Participants encouraged partnerships with universities and research institutions to collect and analyze data, test and de-risk emerging technologies, and evaluate progress.

These themes underscore that achieving Michigan's climate goals will require ongoing partnership, innovation, and commitment across the public, private, and civic spheres.

Authority to Implement: In alignment with direction from the EPA, this CCAP prioritizes measures that have achievable, significant GHG reductions within the program period. As such, the State of Michigan retains authority to implement each of the reduction measures identified in this document. Further, many of the measures are voluntary and implementation ready, building on existing programs. The CCAP also incorporates measures that have the potential to be scaled and positively impact Michigan communities state-wide.

2.0 GHG INVENTORY

2.1 GHG Inventory Methodology

The State of Michigan completed its first-ever GHG inventory in 2005, supported by the Center for Sustainable Systems at the University of Michigan. The first inventory specifically focused on 1990 and 2002 GHG emissions across the state. In 2024, EGLE developed a new GHG inventory for the PCAP. This inventory looked at 2005 and 2019 GHG emissions and analyzed overall trends between 1990 and 2019. For this CCAP, the GHG inventory has been updated once again to reflect 2021 GHG emissions.

This statewide GHG inventory was developed using the EPA's State Inventory Tool (SIT), which provides state-specific inventory data across 11 modules. There were five modules that were not used as part of this inventory: Coal, Waste, Wastewater, Natural Gas and Oil, and Indirect Carbon Dioxide (CO_2) from Electricity. The Coal Module was not used because there are no active coal mines in Michigan and therefore no emissions from coal production. The Waste, Wastewater, and Natural Gas and Oil Modules were not used because more complete or more specific data was found via other data sources. Finally, the Indirect CO_2 from Electricity Module was not included in this inventory because the data is not mutually exclusive with other modules. Additional data sources utilized include the EPA's Greenhouse Gas Reporting Program (GHGRP) and the EPA's State-level GHG Inventory.

Each sector inventory was compiled using a combination of SIT modules and additional sources. Additional detail on inventory methodology can be found in the Appendix.

- **Electricity Generation:** This sector inventory is based on default data from the following SIT modules: Industrial Processes (Transmission and Distribution [T&D] Systems), carbon dioxide from fossil fuel combustion (CO_2FFC) (Electric Utilities), and Stationary Combustion (Electric Utilities).
- **Transportation:** This sector inventory is based on default data from the following SIT modules: CO_2FFC (Transportation), Mobile Combustion (Methane [CH_4]), and Mobile Combustion (Nitrous Oxide [N_2O]).
- **Commercial and Residential Buildings:** This sector inventory is based on default data from the following SIT modules: CO_2FFC (Residential), CO_2FFC (Commercial), Stationary Combustion (Residential), and Stationary Combustion (Commercial).
- **Industry:** This sector inventory is based on default data from the following SIT modules: Industrial Processes, CO_2FFC (Industrial), and Stationary Combustion (Industrial). Additional data from the GHGRP was incorporated because default data did not exist in the SIT for the following: Glass Production, Silicon Carbide (SiC) Consumption, Ferroalloy Production, Magnesium Production and Processing, Fluorochemical Production, Carbon Dioxide Consumption, and N_2O from Product Use. GHGRP data was also pulled in for part of the

following "all in" category: Lime. Data from the EPA's State-level GHG Inventory was also pulled in for the following: Cement, Iron and Steel, and Natural Gas and Oil.

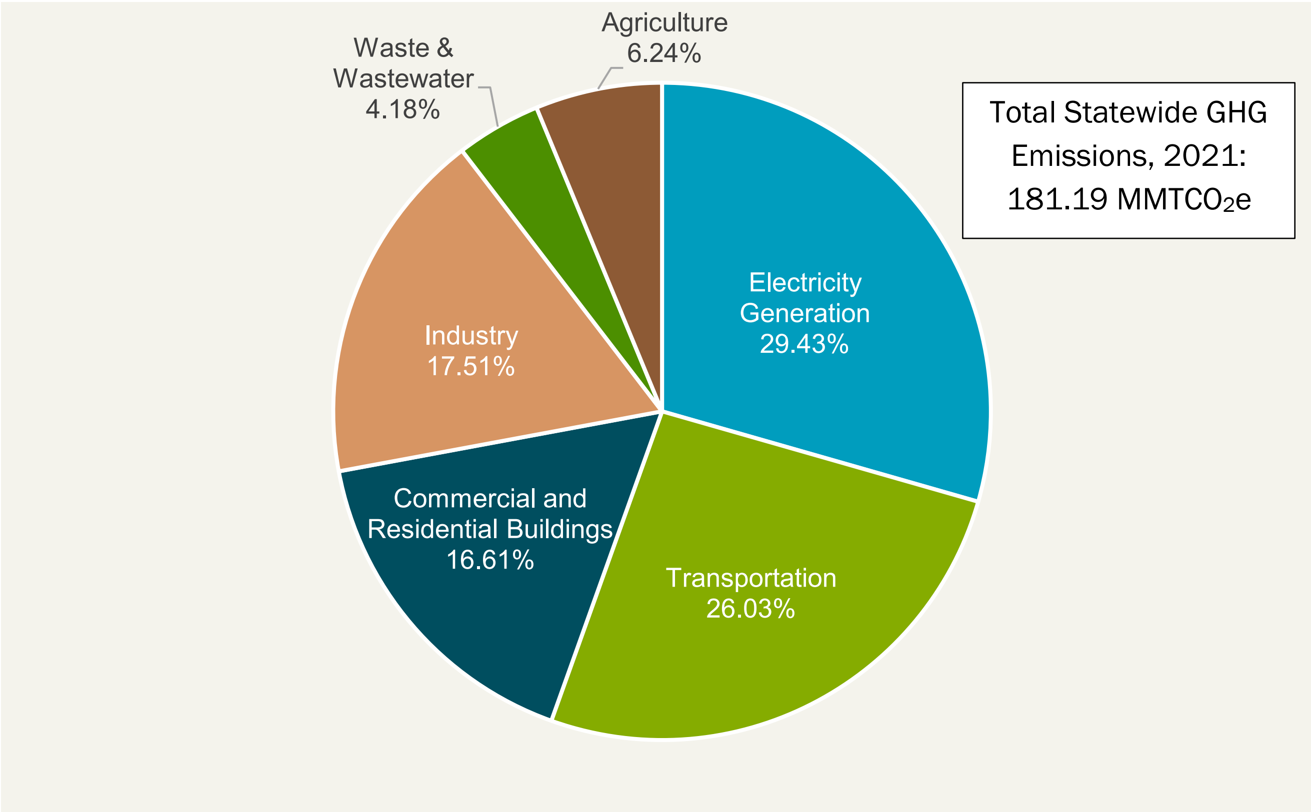
- **Waste and Wastewater:** This sector inventory is based on data from the following EPA's State-level GHG Inventory Waste Sector categories: Composting (CH_4, N_2O), Anaerobic Digestion (CH_4), Landfills (CH_4), Municipal Wastewater, and Industrial Wastewater.
- **Natural and Working Lands:** This sector inventory is based on default data from the following SIT module: Land Use, Land Use Change, and Forestry (LULUCF). Additional data was pulled in from the EPA's State-level GHG Inventory for select items that were not included in SIT: Non-CO_2 Emissions Forest Fires, Wetlands, Settlements, and Flooded Lands.
- **Agriculture:** This sector inventory is based on default data from the following SIT module: Agriculture.

2.2 Inventory Results

Table 1: GHG Emissions (MMTCO$_2$e) by Sector for Base Year of 2005 and Inventory Year of 2021, and Percent Change from 2005 to 2021

Sector	2005	2021	% Change
Electricity Generation	77.20	53.29	-30.97%
Transportation	56.56	47.13	-16.67%
Commercial and Residential Buildings	34.98	30.07	-14.04%
Industry	38.47	31.85	-17.21%
Waste and Wastewater	9.97	7.56	-24.17%
Agriculture	9.36	11.29	+20.62%
Total (Gross) Emissions	226.54	181.19	-20.02%
Natural Lands	(13.67)	(12.38)	+9.44%
Total (Net) Emissions	212.87	168.81	-20.70%

Figure 1: Proportion of Total (Gross) Emissions by Economic Sector in Michigan, 2021



Source: EPA's SIT, EPA's Inventory by State (default data); Totals do not include sinks from natural lands, which were (12.38) $MMTCO_2e$ in 2021.

According to IPCC Global Warming Potential Values, the Global Warming Potential (GWP) values for 100-year time horizon for the below gases include: CO_2 = 1 GWP; CH_4 = 28 - 30 GWP; N_2O = 265 GWP; Hydrofluorocarbon (HFC) varies widely depending on type of HFC = 4 - 12,400 GWP; Perfluorocarbon (PFC) varies widely depending on type of PFC = 6,630 - 11,100 GWP; sulfur hexafluoride (SF_6) = 23,500.

Table 2: GHG Emissions (Measured in Million Metric Tons) by Gas, by Sector for Inventory Year of 2021

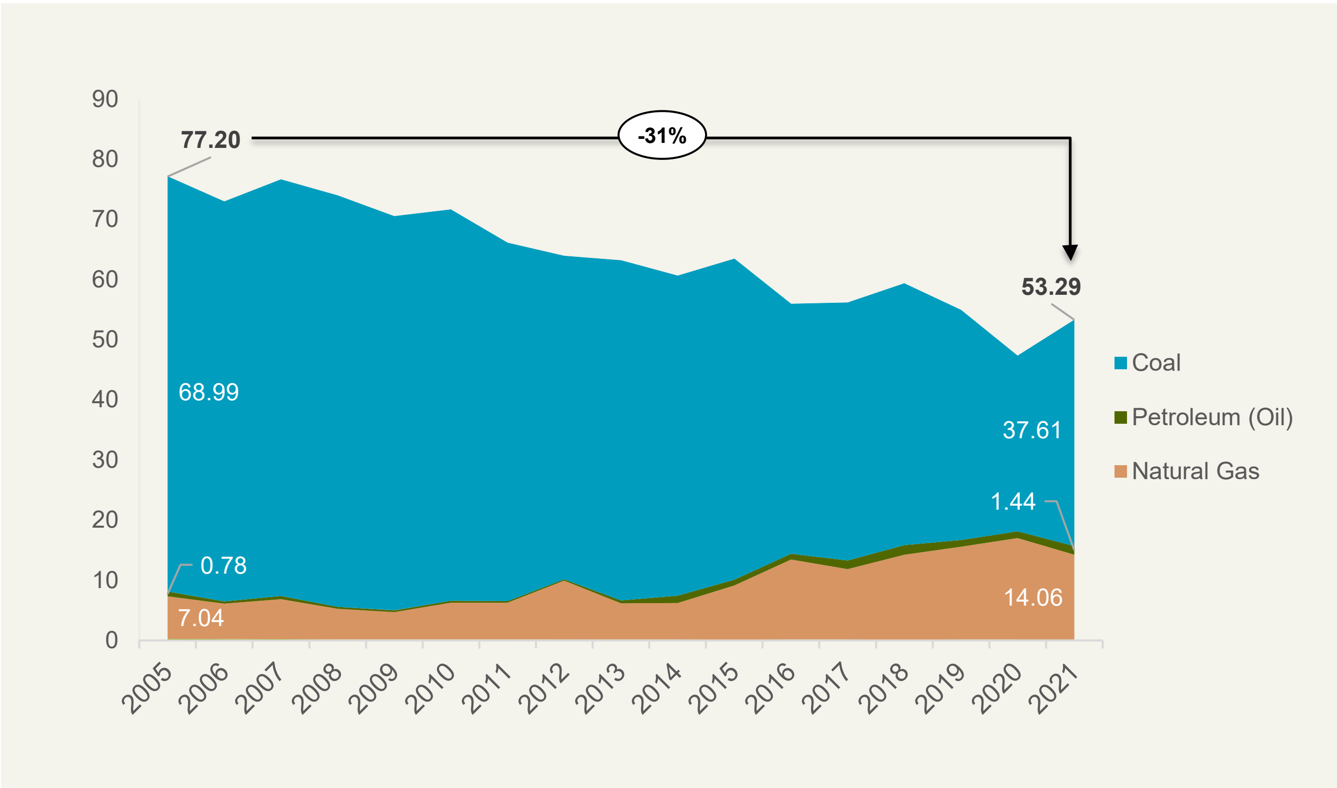
Sector	CO_2	CH_4	N_2O	HFC	PFC	SF_6
Electricity Generation	52.92	$1x10^{-3}$	$1x10^{-3}$	-	-	$1x10^{-5}$
Transportation	46.60	$3x10^{-3}$	$2x10^{-3}$	-	-	-
Commercial and Residential Buildings	29.68	$1x10^{-3}$	-	-	-	-
Industry	23.58	0.12	$1x10^{-3}$	0.48	$1x10^{-3}$	$1x10^{-5}$
Waste and Wastewater		0.25	$2x10^{-3}$	-	-	-
Natural Lands	(12.38)	-	-	-	-	-
Agriculture	0.11	0.20	0.02	-	-	-
Total Emissions	**140.51**	**0.58**	**0.03**	**0.48**	**1x10-3**	**1x10-5**

Note: The apparent SF_6 total discrepancy is a result of rounding. Despite occurring in small quantities, this GHG is important to report due to its high GWP.

2.3 Inventory Trends and Analysis

Electricity Generation

Figure 2: Electricity Generation GHG Emissions ($MMTCO_2e$) by Source and Year



Note: Totals include emissions from Wood (Biomass) and Grid Leakage, which contributed less than 0.39 $MMTCO_2e$ in 2005 and less than 0.18 $MMTCO_2e$ in 2021.

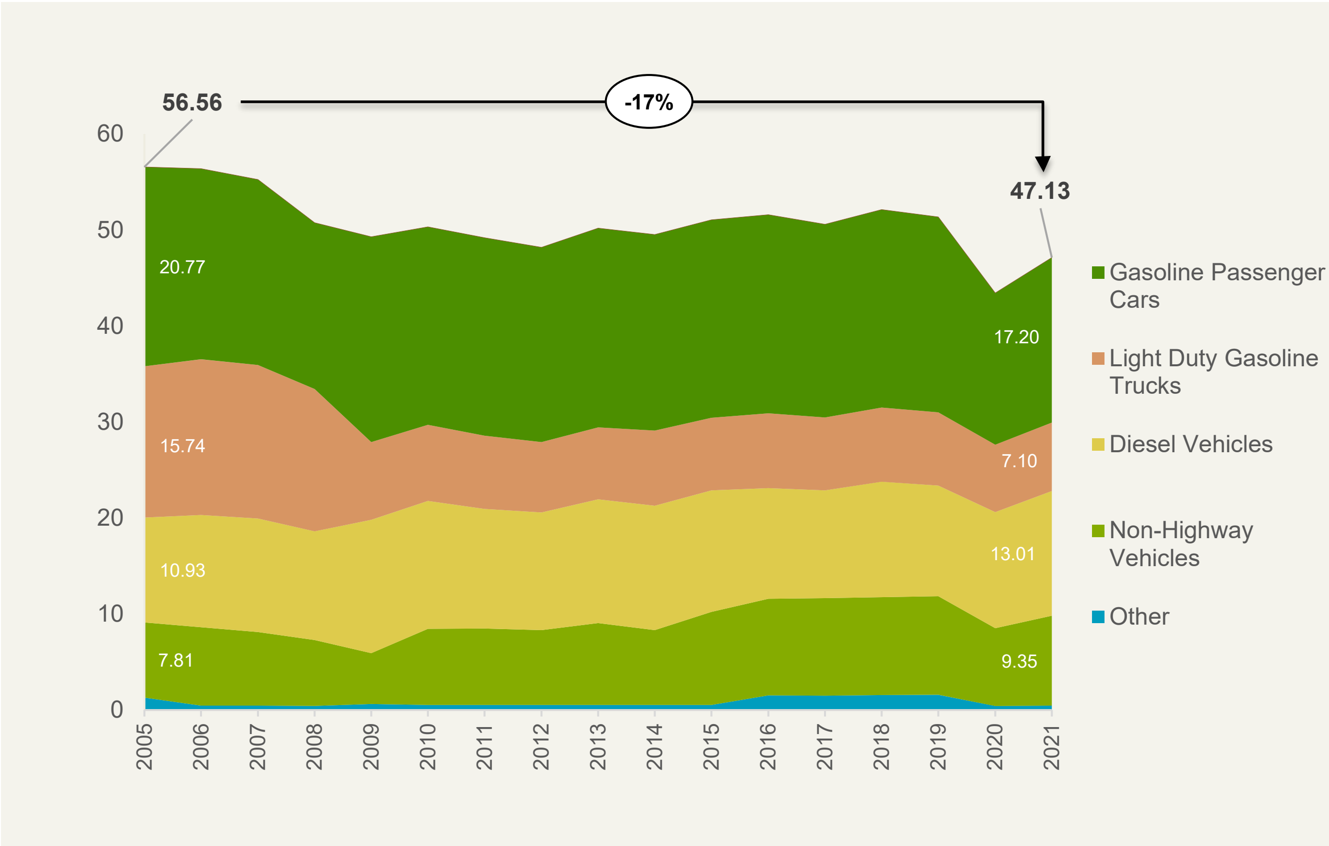
Michigan's electric power sector is undergoing significant transformation. Emissions from electricity generation declined 31% between 2005 and 2021, dropping from 77.20 $MMTCO_2e$ to 53.29 $MMTCO_2e$. This reduction is equivalent to taking roughly 5 million gasoline-powered vehicles off the road.

In this same time frame, coal use dropped by 45% and, according to Consumers Energy's and DTE's Integrated Resource Plans (IRPs), the state's three remaining coal plants are set for closure or conversion by 2032. This is a crucial step toward achieving net-zero emissions, given the carbon-intensive nature of coal.

To replace coal, Michigan's utilities have increasingly turned to natural gas. While it is a cleaner alternative, using natural gas for power generation still emits GHGs and co-pollutants, underscoring the need for continued investment in zero-emission energy sources.

Transportation

Figure 3: Transportation GHG Emissions ($MMTCO_2e$) by Vehicle Type and Year



Note: Diesel vehicles include heavy duty trucks, buses, light duty trucks, and passenger cars. Non-Highway vehicles include boats, locomotives, farm equipment, construction equipment, aircraft, and utility vehicles. Other vehicles include alternative fuel vehicles, motorcycles, and heavy duty gasoline vehicles.

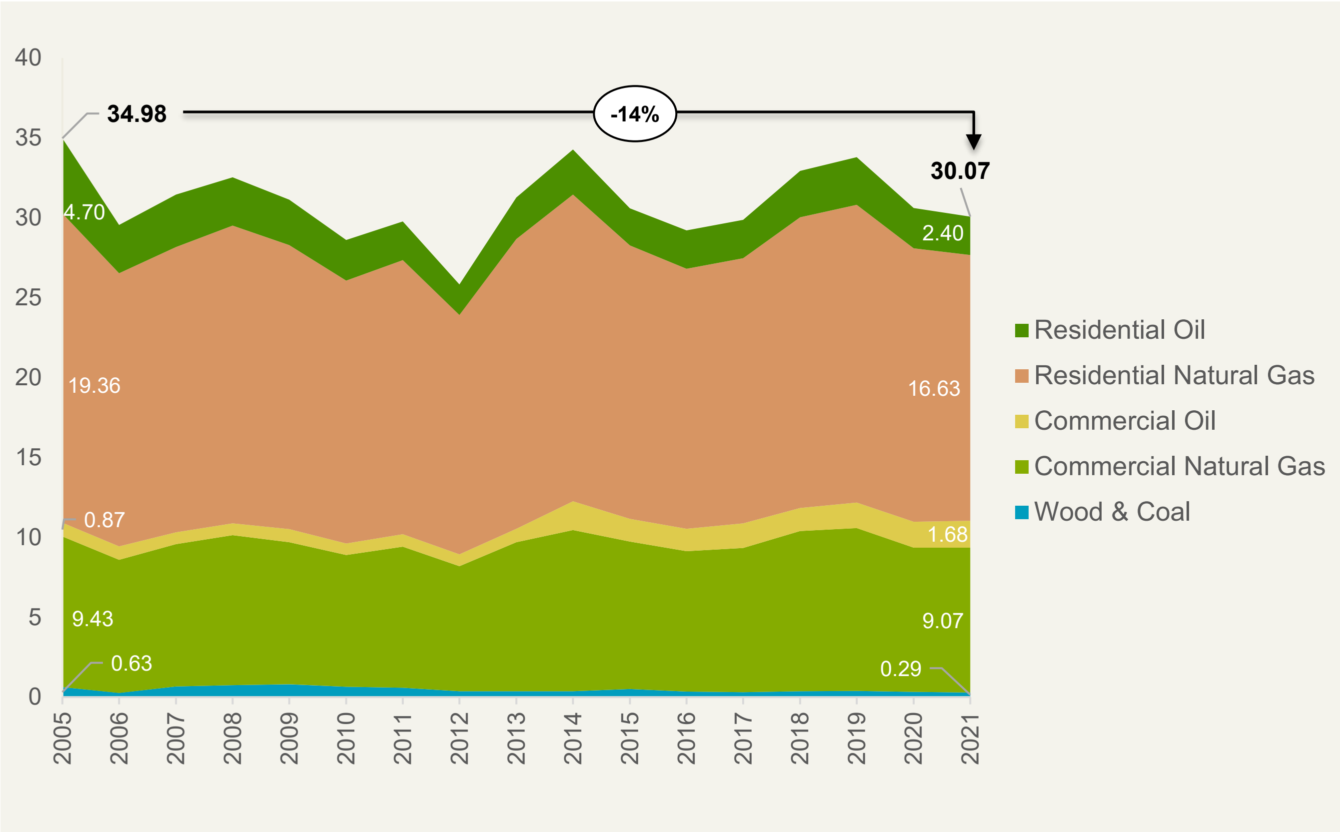
Emissions from Michigan's transportation sector decreased by 17% from 2005 to 2021, falling from 56.56 $MMTCO_2e$ to 47.13 $MMTCO_2e$. In 2005, gasoline passenger cars and light duty trucks made up almost two-thirds of emissions, but by 2021, their share dropped to around 50%.

In 2005, the total automobile count in the state was approximately 8.5 million vehicles, compared to 7.2 million vehicles in 2021. The decrease in emissions is likely related to the slight decrease in registered vehicles and to better fuel efficiency. The EPA reports a 32% increase in real-world fuel economy since 2004.

In contrast, emissions from heavy duty diesel trucks rose by approximately 2 $MMTCO_2e$ during the same period, which slowed further progress in this sector.

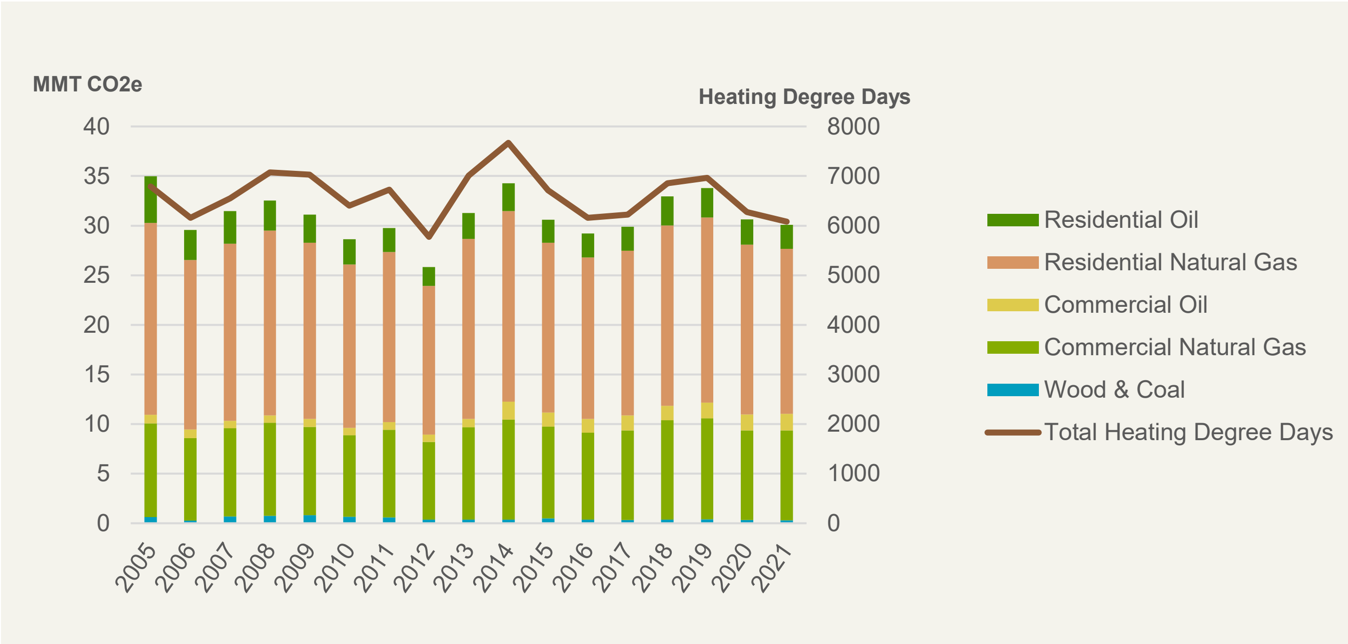
Commercial and Residential Buildings

Figure 4: Commercial and Residential Buildings GHG Emissions ($MMTCO_2e$) by Building Classification, Fuel Type, and Year



Michigan's emissions from commercial and residential buildings declined 14% between 2005 and 2021, dropping from 34.98 $MMTCO_2e$ to 30.07 $MMTCO_2e$. Building emissions are largely driven by natural gas combustion, which remains the primary energy source for space heating, water heating, and cooking. In rural and northern regions of Michigan, oil-based fuels such as heating oil and propane are commonly used in place of natural gas for heating. The reduction in emissions for this sector likely reflects improvements in energy efficiency, including changes to commercial and residential building codes.

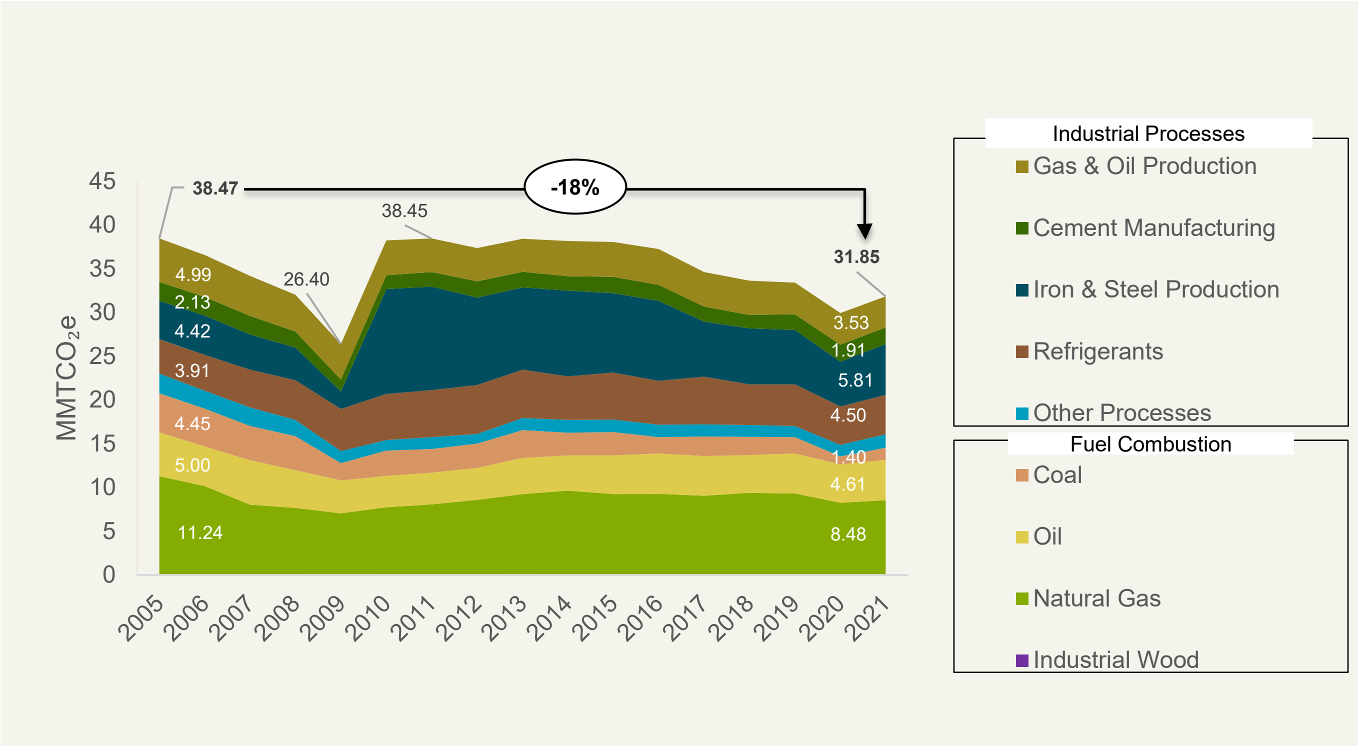
Figure 5: Commercial and Residential Buildings GHG Emissions ($MMTCO_2e$) by Building Classification and Fuel Type, Compared to Total Annual Heating Degree Days (2005-2021)



As shown by the graph above, the number of Michigan Heating Degree Days is very closely aligned to the inventory emissions data over the last three decades. A greater number of heating degree days typically means there is a greater need for space heating, and therefore, more energy usage across both commercial and residential buildings.

Industry

Figure 6: Industry GHG Emissions ($MMTCO_2e$) by Industrial Process, Fuel Type, and Year

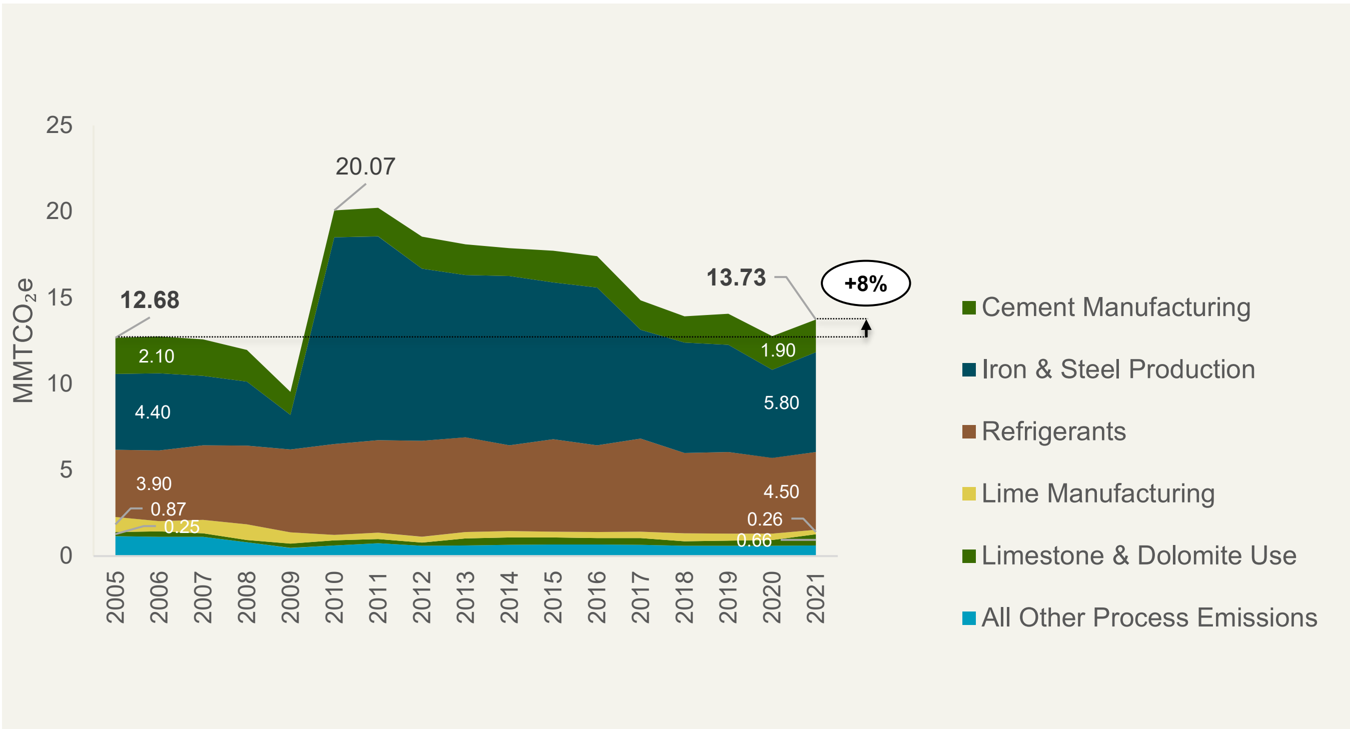


Note: Refrigerants include emissions from refrigerants, air conditioning equipment, foams, and aerosols. Other processes include lime manufacturing, limestone and dolomite use, urea consumption, magnesium production, ferroalloy production, carbide production, glass production, and semiconductor manufacturing. Industrial wood does not appear in the graph, it accounts for 0.07 $MMTCO_2e$ in 2021.

Michigan's industrial emissions declined 18% between 2005 and 2021, dropping from 38.47 $MMTCO_2e$ to 31.85 $MMTCO_2e$. A notable dip occurred in 2009, likely due to reduced industrial activity during the Great Recession. Between 2005 and 2021, emissions from industrial fuel combustion declined, but trends within specific industrial processes vary. The next two graphs provide a closer look at **industrial process emissions**, and **natural gas and oil production emissions**.

Industry: Industrial Process Emissions

Figure 7: Subsector - Industrial Process GHG Emissions ($MMTCO_2e$) by Industrial Process and Year



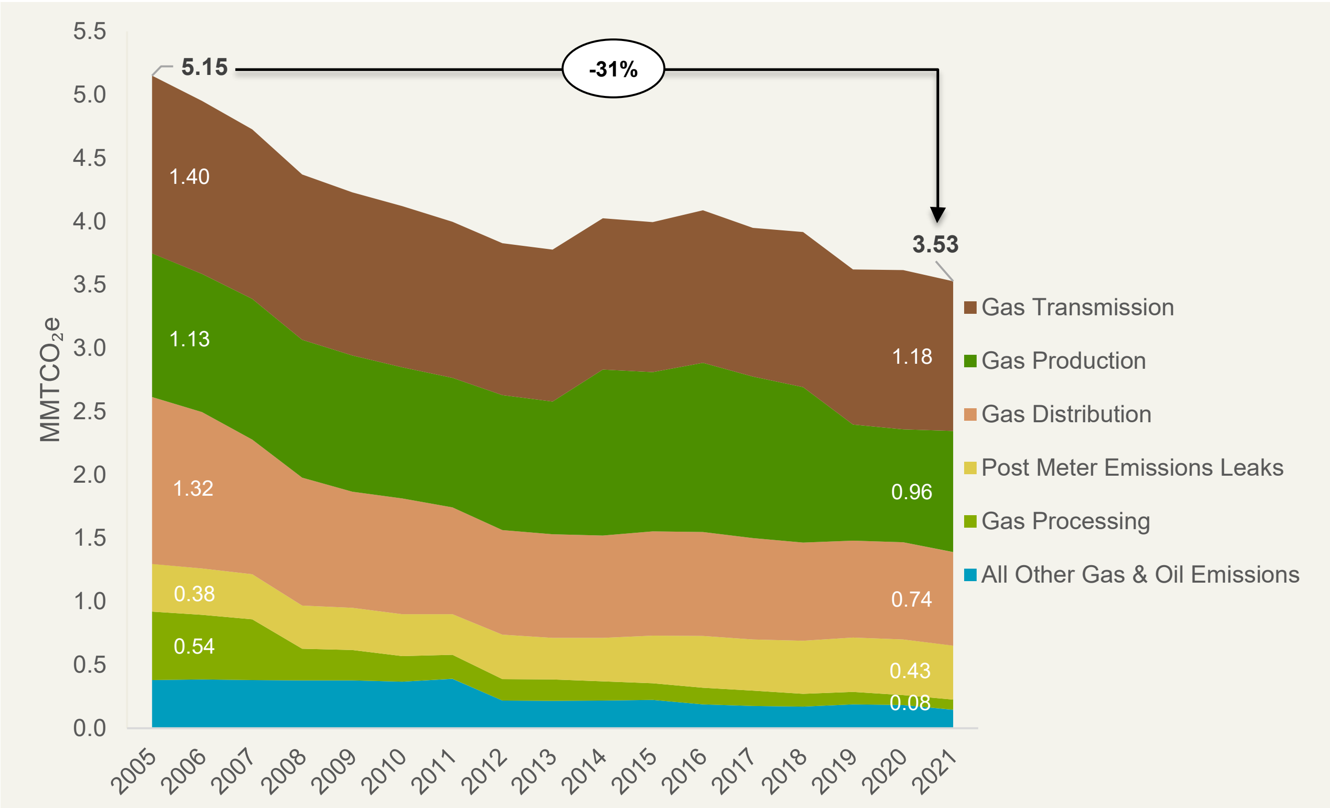
Note: Refrigerants include emissions from refrigerants, air conditioning equipment, foams, and aerosols. All Other Processes Emissions include urea consumption, magnesium production, ferroalloy production, carbide production, glass production, and semiconductor manufacturing.

Emissions from industrial processes in Michigan rose by 8% from 2005 to 2021, increasing from 12.68 $MMTCO_2e$ to 13.73 $MMTCO_2e$. These process emissions are GHGs released during chemical or physical processes, such as cement production, steelmaking, or fertilizer manufacturing, that are not directly tied to fuel combustion. The increase in these emissions is largely driven by higher emissions from iron and steel production, which spiked in 2010. Though they have since declined, they remain above 2005 levels.

Refrigerant emissions also increased from 2005 to 2021 due to the replacement of Ozone Depleting Substances (ODS) with fluorinated gas (F-gas) substitutes. These F-gas substitutes are often found in refrigeration, air-conditioning, and aerosol applications. GWP measures a gas' ability to trap heat in the atmosphere relative to CO_2. F-gases have high GWPs compared to other GHG types, so though the amount of F-gas emissions may not be large, their ability to retain heat in the atmosphere over their lifetime is significant.

Industry: Natural Gas and Oil Production

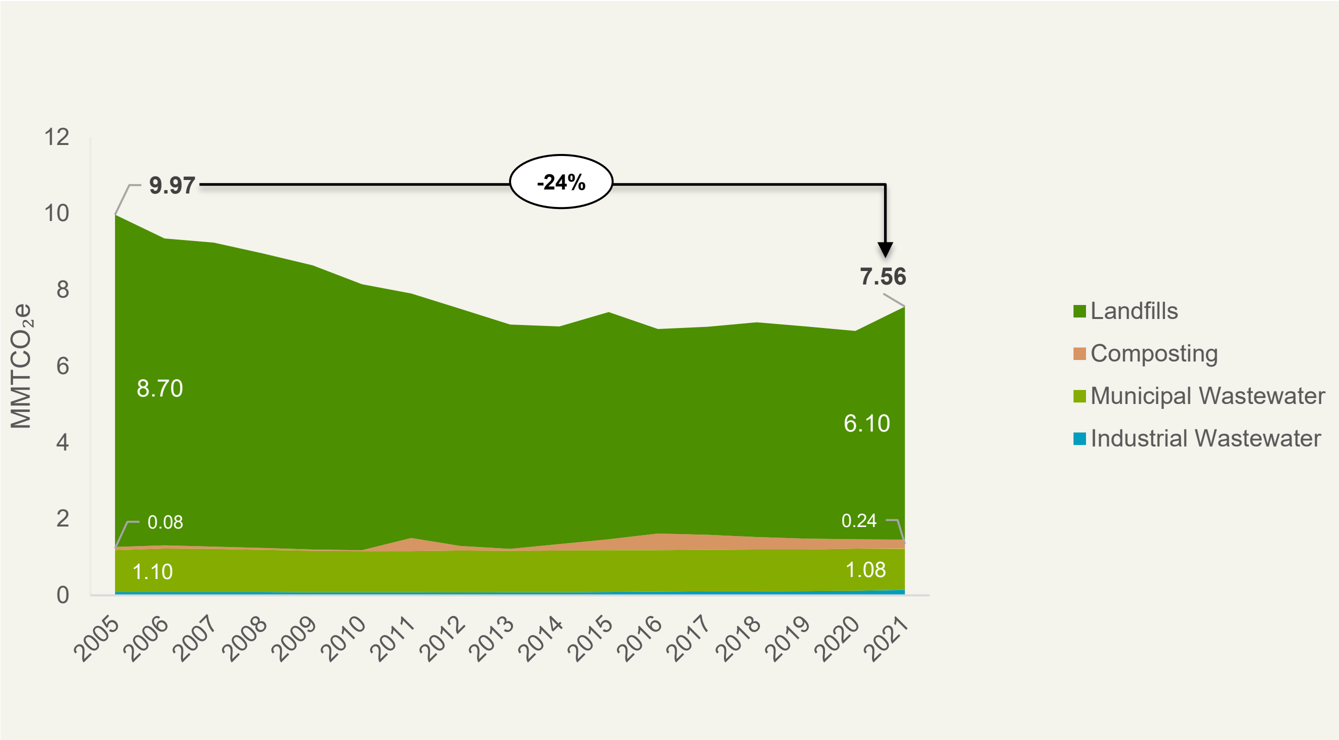
Figure 8: Subsector – Natural Gas and Oil Production GHG Emissions ($MMTCO_2e$) by Component and Year



Emissions from Michigan's gas and oil sector have declined significantly, dropping by 31% from 5.15 $MMTCO_2e$ in 2005 to 3.53 $MMTCO_2e$ in 2021. This reduction is largely driven by decreased emissions from transmission and distribution, likely due to infrastructure improvements and efforts to minimize equipment leaks. Emissions from gas production also decreased, likely due to an overall decrease in natural gas production volumes. These advancements reflect progress in modernizing the sector and reducing emission leaks, contributing to Michigan's overall emissions decline.

Waste and Wastewater

Figure 9: Waste and Wastewater GHG Emissions ($MMTCO_2e$) by Subsector and Year



Note: Emissions from anaerobic digestion are included in the total but are too small to appear on the graph. Industrial wastewater accounted for 0.09 $MMTCO_2e$ in 2005 and 0.14 $MMTCO_2e$ in 2021.

Michigan's waste sector emissions decreased 24% between 2005 and 2021, largely driven by a significant decline in emissions from landfills. Landfill emissions decreased 30% from 8.7 $MMTCO_2e$ in 2005 to 6.1 $MMTCO_2e$ in 2021. This reduction reflects improvements in methane gas management from Michigan's Public Act 451 of 1994 Part 115 amendments, which created rules requiring gas collection and control systems for the state's Municipal Solid Waste landfills of a certain size.

In contrast, emissions from municipal and industrial wastewater remained relatively stable over the same period, contributing just over 1 $MMTCO_2e$ to the sector's total annual emissions.

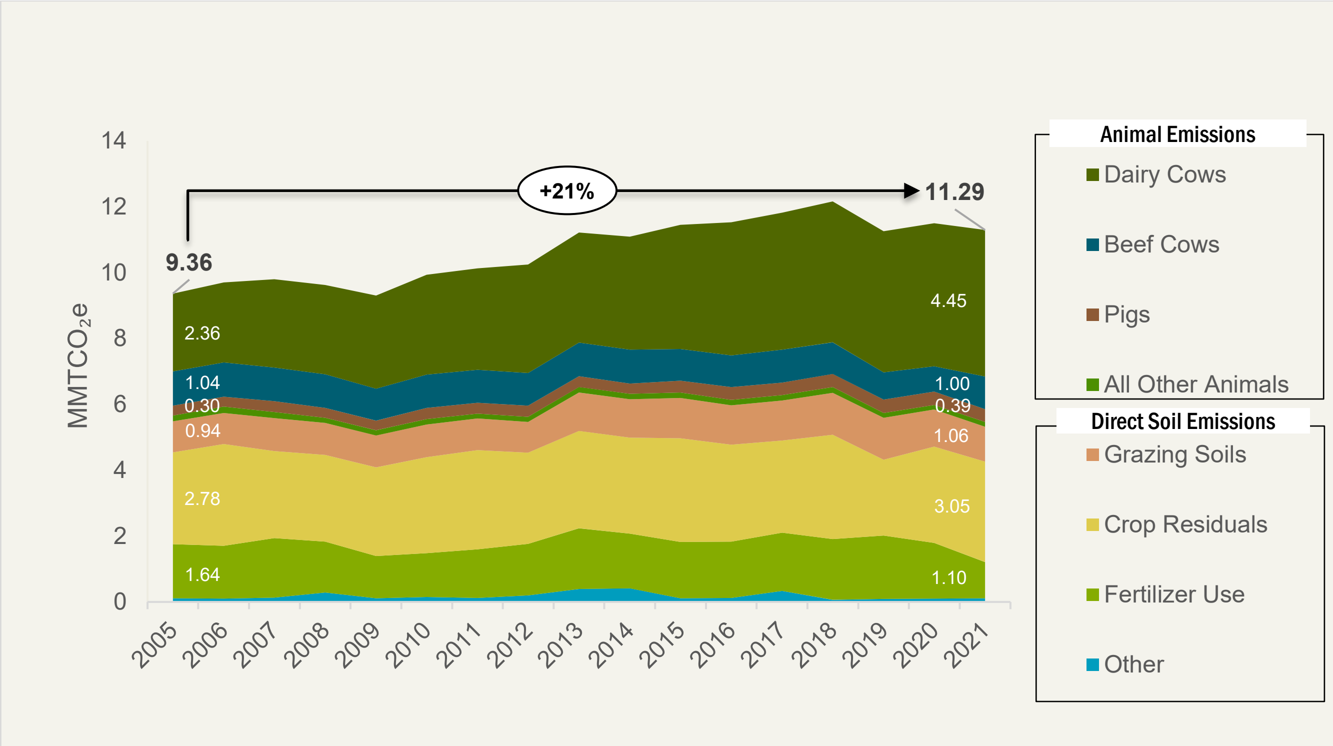
Natural and Working Lands

Figure 10: Natural and Working Lands GHG Emissions ($MMTCO_2e$) by Subsector and Year

Michigan's natural and working lands act as a net carbon sink, offsetting 12.38 $MMTCO_2e$ in 2021, a roughly 9% decrease from carbon offset in 2005. In this sector, emissions are often in flux. Forests, for example, can both release and sequester GHG emissions. Ultimately, however, agricultural soils, wetlands, and settlements contribute net emissions, while forests and harvested wood products sequester emissions. Wetlands both sequester and emit GHGs, but due to limitations in data availability, only the net emissions are reported. These landscapes all play a crucial role in balancing emissions and advancing Michigan's climate goals.

Natural and Working Lands: Agriculture Emissions

Figure 11: Agriculture GHG Emissions ($MMTCO_2e$) by Subsector and Year



Note: Other Animals include turkeys, sheep, goats, chickens, and horses. Other Emissions include those from agricultural residue burning, liming, and urea fertilization.

Agricultural emissions in Michigan increased by 21% from 2005 to 2021, from 9.36 $MMTCO_2e$ to 11.29 $MMTCO_2e$. This growth is primarily driven by animal emissions, which include CH_4 and N_2O released through manure management and enteric fermentation – processes associated with livestock digestion.

Direct soil emissions come from crop residues left in fields after harvest, fertilizer application, and animal manure and urine deposits, which release N_2O. Other emissions stem from CO_2 released through liming and urea fertilization, as well as CH_4 and N_2O emissions from the burning of crop residues. The overall increase in agricultural emissions reflects the broader challenges of managing agricultural GHG emissions, as both livestock and soil-related sources continue to contribute to Michigan's overall emissions profile.

3.0 NEAR- AND LONG-TERM TARGETS

3.1 Economy Wide GHG Reduction Targets

In February 2019, Governor Gretchen Whitmer signed Executive Directive 2019-12, which committed Michigan to pursuing a 26-28% reduction in GHG emissions from 2005 levels by 2025. This was followed up in September 2020 with Executive Directive 2020-10, which committed Michigan to achieving economy-wide carbon neutrality no later than 2050 and maintaining net-negative GHG emissions thereafter. In addition to the goals set by these directives, Michigan joined 22 other states and Puerto Rico – under the umbrella of the United States (U.S.) Climate Alliance – in committing to an interim goal of a 52% GHG emissions reduction from 2005 levels by 2030.

3.2 Sector Specific GHG Reduction Targets

The MHCP includes the following 2030 targets:

Figure 12: **MHCP Goals by Pillar**

Commit to Environmental Justice and Pursue a Just Transition	Ensure that at least 40 percent of state funding for climate-related and water infrastructure initiatives benefit Michigan's disadvantaged communities; that Justice40 is developed in partnership with leaders in disadvantaged communities; and that Michigan emphasizes a just transition for all workers through proactive engagement, job training, and workforce development.
Clean the electric grid	Generate 60 percent of the state's electricity from renewable resources and phase out remaining coal-fired power plants by 2030. Limit energy burden from powering and heating homes to not more than 6 percent of annual income for low-income households.
Electrify vehicles and increase public transit	Build the infrastructure necessary to support 2 million electric vehicles on Michigan roads by 2030. Increase access to clean transportation options – including public transit – by 15 percent each year.
Repair and decarbonize homes and businesses	Reduce emissions related to heating Michigan homes and businesses by 17 percent by 2030. Increase investments in repairing and improving buildings to reduce costs for working families and small businesses.
Drive clean innovation in industry	Encourage clean innovation hubs where private enterprises strategically co-locate and collaborate to develop and deploy new, cleaner manufacturing technologies and conduct research and development to reduce emissions from hard to decarbonize industries. Triple Michigan's recycling rate to 45 percent and cut food waste in half by 2030.
Protect Michigan's Land and Water	Protect 30 percent of Michigan's land and water by 2030 to naturally capture GHG emissions, maintain and improve access to recreational opportunities for all Michiganders, and protect biodiversity. Leverage innovative strategies to support climate-smart agriculture.

4.0 BAU GHG EMISSIONS PROJECTION

4.1 BAU GHG Emissions Projection Methodology

The RMI Energy Policy Simulator (EPS) was used for business as usual (BAU) projections, where there is no implementation of CCAP measures and state actions are not oriented towards decarbonization, and implementation of CCAP scenarios projections (included in Section 5). The EPS uses 2021 state data for projections (from various sources, including the EPA's state inventory, EPA's State-level Non-CO_2 Greenhouse Gas Mitigation Report, the United States Energy Information Administration's [EIA] state profiles, etc.). Note, the majority of modelling for this report was conducted using the April 2025 EPS version 4.0.4, which models state and federal policy as of that date.[1]

Because the EPA's SIT (as presented in Section 2) uses 2021 data and the EPS starts at 2021, comparisons were possible between the two tools. When comparing the EPS 2021 data and the SIT-based 2021 inventory, the numbers track very closely. Subtle differences are likely due to different measurements, data sources, and additional levels of specificity in the SIT. In each instance that the EPS and the SIT-based inventory are different, the SIT-based inventory was more conservative. This validates that emissions have not been underreported in the inventory.

To align both data sources and ensure a smooth transition in the data from inventory to projections, raw EPS data was used to calculate a year-over-year rate of change to adjust the SIT-based inventory. The following formula was used to do this: Rate of change = (final value - initial value) / initial value. These rates of change were used and applied to the inventory data.

4.2 BAU GHG Emissions Projection Results

Table 3: **BAU GHG Emissions Projections ($MMTCO_2e$) in 2030 and 2050, Compared to 2005 and 2021**

Sector	Base Year Emissions (2005)	Most Recent Inventory Year (2021)	Short Term BAU Projection Year (2030)	Long Term BAU Projection Year (2050)
Electricity Generation	77.20	53.29	25.84	23.75
Transportation	56.56	47.13	40.62	21.79
Commercial and Residential Buildings	34.98	30.07	30.24	30.17
Industry	38.47	31.85	30.42	28.50
Waste and Wastewater	9.97	7.56	7.88	8.49
Agriculture	9.36	11.29	11.37	11.62
Total (Gross) Emissions	**226.54**	**181.19**	**146.37**	**124.32**
Natural Lands	-13.67	-12.38	-12.38	-12.38
Total (Net) Emissions	**212.87**	**168.81**	**133.99**	**111.94**

[1] The EPS versions used for GHG emissions projections (4.0.3 and 4.0.4) do not take into account the passage of H.R.1 The 4.0.4 – April 1, 2025 version includes a "Federal Policy Repeal and Rollback" scenario, but because the modelling occurred before the passage of H.R.1, this policy scenario was not included in calculations. Federal repeals and rollbacks outside of the modeled scenarios are likely to delay emissions reductions.

Figure 13: BAU Gross GHG Emissions Projections ($MMTCO_2e$) by Sector

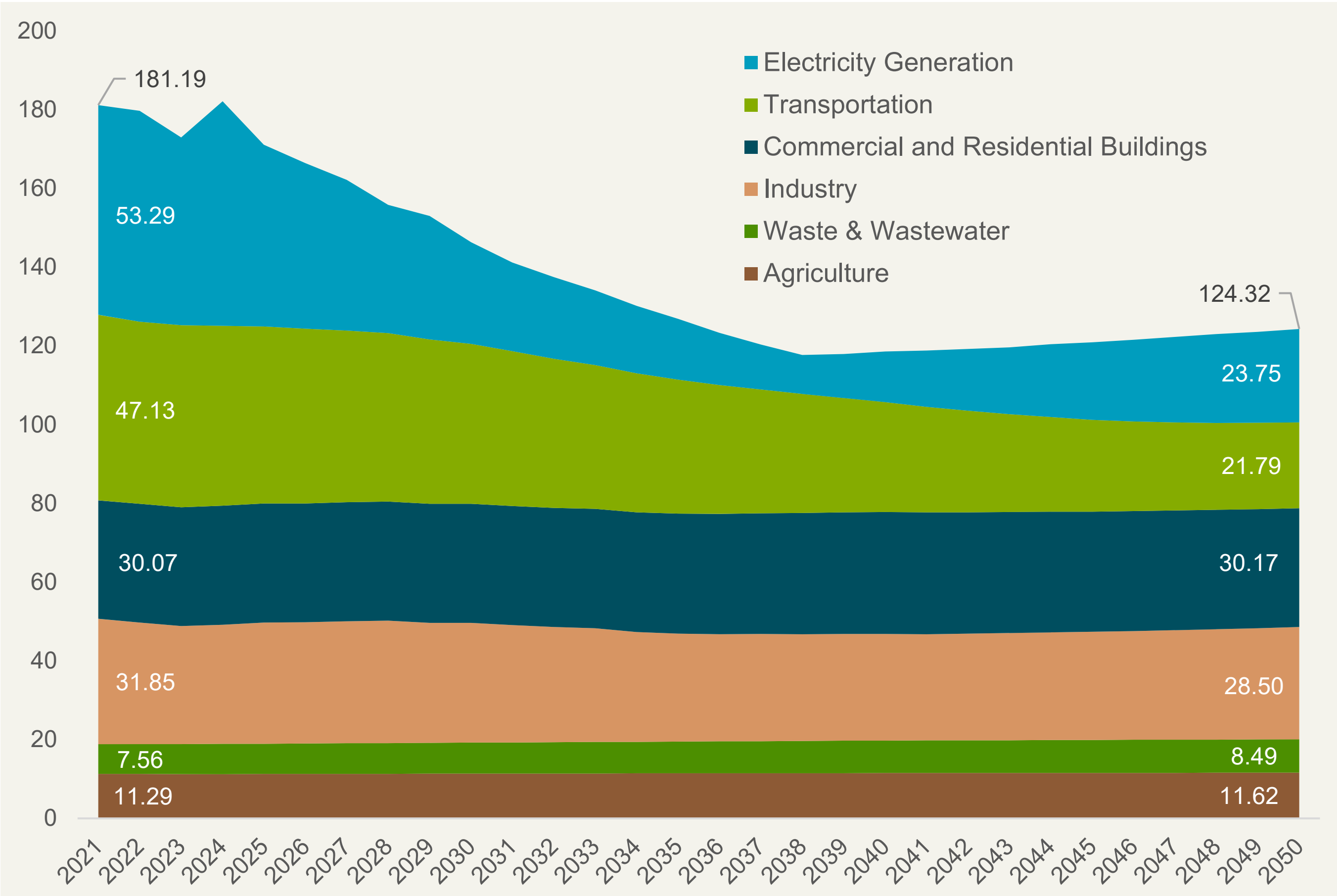


Figure 13 shows Michigan's projected GHG emissions by sector under a BAU scenario, using the EPS. All sectors except Electricity Generation are based on the April 2025 EPS version 4.0.4. In order to demonstrate the emissions impact of the 2023 Michigan Clean Energy & Climate Action package (five bills that establish a clean energy standard, increase energy waste reduction standards and reestablish the standard for municipal and cooperative utilities, create a state-level siting process for renewable energy and battery storage, and make changes to the IRP process) the Electricity Generation sector analysis uses the December 2024 EPS version 4.0.3, which predates Michigan's clean energy legislation being embedded into the model. The noticeable jump in Electricity Generation emissions in 2024 reflects anticipated post-COVID increases that were included in the earlier version of the EPS. In contrast, the implementation of the CCAP scenario for Electricity Generation, which includes Electricity Generation reduction measures and is modeled with the EPS version 4.0.4, eliminated this spike due to a revised methodology and improved real-world data.

5.0 GHG EMISSIONS REDUCTION MEASURES AND IMPLEMENTATION OF CCAP SCENARIOS PROJECTIONS

5.1 GHG Emissions Reduction Measures Summary

Priority reduction measures were previously selected for the PCAP based on alignment to the MHCP, magnitude of GHG reduction potential, replicability across the state, and alignment with other CPRG requirements as established by the EPA. The comprehensive reduction measures listed below build upon the priority reduction measures and were selected based on the most recent state GHG inventory (as detailed in Section 2) and collaborative engagement with the public and partners. For each sector, the largest sources of emissions were identified and prioritized.

CCAP Sector	Reduction Measures
Electricity Generation	1. Support clean energy deployment, including siting for renewable energy and increased investments in customer-driven renewable energy 2. Invest in energy storage to better integrate renewable energy into the electric grid 3. Support holistic grid planning, infrastructure investments, and flexible demand programs to enhance grid resilience
Transportation	1. Encourage adoption of Electric Vehicles (EVs) by increasing EV charging infrastructure and vehicles 2. Increase access to public transportation and non-motorized transportation options 3. Support research and development to expand technologies available to reduce emissions from maritime, aviation, and heavy duty vehicles, including electrification, fleet optimization, and sustainable aviation fuel 4. Electrify state government, municipal, Tribal, and other public fleets 5. Support land use and transportation planning that will enable high-density, mixed-use development
Commercial and Residential Buildings	1. Support electrification in residential buildings, including an emphasis on households that rely on delivered fuels such as propane and home heating oil 2. Support household energy use reduction through home repairs, weatherization, and other energy waste reduction investments 3. Encourage energy efficiency enhancements, electrification, sustainable design, and retrofitting to reduce emissions from commercial buildings 4. Support electrification and energy waste reduction efforts for state government, municipal, Tribal, and nonprofit facilities

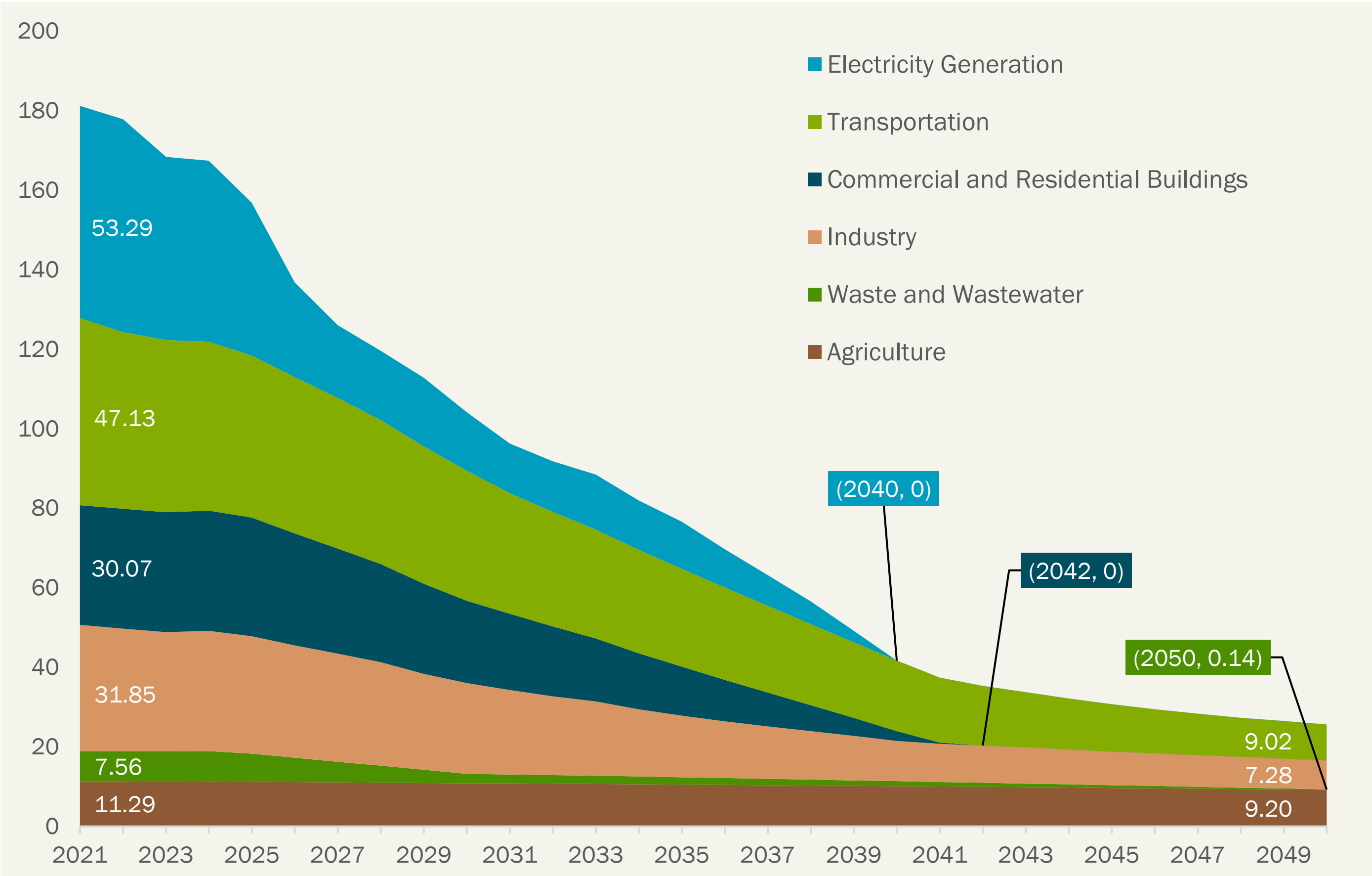
CCAP Sector	Reduction Measures
Industry	1. Promote and incentivize energy efficiency, waste heat recovery, and electrification across low to medium temperature industrial processes 2. Encourage emission reduction strategies from lime and cement manufacturing, including energy and material efficiency improvements, electrification, fuel switching, and clinker substitution 3. Encourage emission reduction strategies from iron and steel including electrification, material efficiency, energy efficiency, lower-temperature alternative production methods, and fuel switching 4. Encourage emission reduction strategies in gas and oil production, like methane capture and energy efficiency
Waste and Wastewater	1. Increase recycling and composting to send less waste to landfills 2. Continue enhancement of landfill management technologies and methods 3. Encourage process optimization, energy efficiency enhancements, and biogas-fueled generation at water treatment plants
Natural and Working Lands	1. Conserve, connect, and restore Michigan's lands and waters, advancing the Michigan the Beautiful initiative 2. Support climate-smart forestry practices 3. Support climate-smart agricultural practices

5.2 Implementation of CCAP Scenario Projections

Table 4: Implementation of CCAP Scenario GHG Emissions Projections ($MMTCO_2e$) in 2030 and 2050, Compared to 2005 and 2021

Sector	Base Year Emissions (2005)	Most Recent Inventory Year (2021)	Short Term Implementation Projection Year (2030)	Long Term Implementation Projection Year (2050)
Electricity Generation	77.20	53.29	14.69	0.00
Transportation	56.56	47.13	32.70	9.02
Commercial and Residential Buildings	34.98	30.07	20.69	0.00
Industry	38.47	31.85	22.82	7.28
Waste and Wastewater	9.97	7.56	2.38	0.14
Agriculture	9.36	11.29	10.87	9.20
Total (Gross) Emissions	**226.54**	**181.19**	**104.15**	**25.64**
Natural Lands	-13.67	-12.38	-13.39	-18.32
Total (Net) Emissions	**212.87**	**168.81**	**90.76**	**7.32**

Figure 14: Implementation of CCAP Scenario Gross GHG Emissions Projections ($MMTCO_2e$) by Sector



Note that according to the Implementation of CCAP Scenario projections, net emissions of 7.32 $MMTCO_2e$ remain in 2050. These emissions are primarily from the transportation, industrial, and agricultural sectors and are difficult to abate. The impacts of climate-smart agricultural practices (Natural and Working Lands Reduction Measure 3), however, were not included in the model. It is estimated that cover cropping and conservation tillage alone has the potential to mitigate up to 6.6 $MMTCO_2e$ per year. Further, additional efforts to reduce emissions are provided for the transportation and industry sectors in Section 5.3. While not included in the quantification, these efforts can help further reduce annual emissions. Additionally, advancements in clean energy technology over the next 25 years will likely spur emission reductions that are not technologically possible at present. It is assumed these combined efforts will help achieve the estimated net 7.32 $MMTCO_2e$ reduction needed to reach carbon neutrality.

5.3 GHG Emissions Reduction Measures

Electricity Generation

Electricity Generation Reduction Measures
Support clean energy deployment, including siting for renewable energy and increased investments in customer-driven renewable energy
Invest in energy storage to better integrate renewable energy into the electric grid
Support holistic grid planning, infrastructure investments, and flexible demand programs to enhance grid resilience

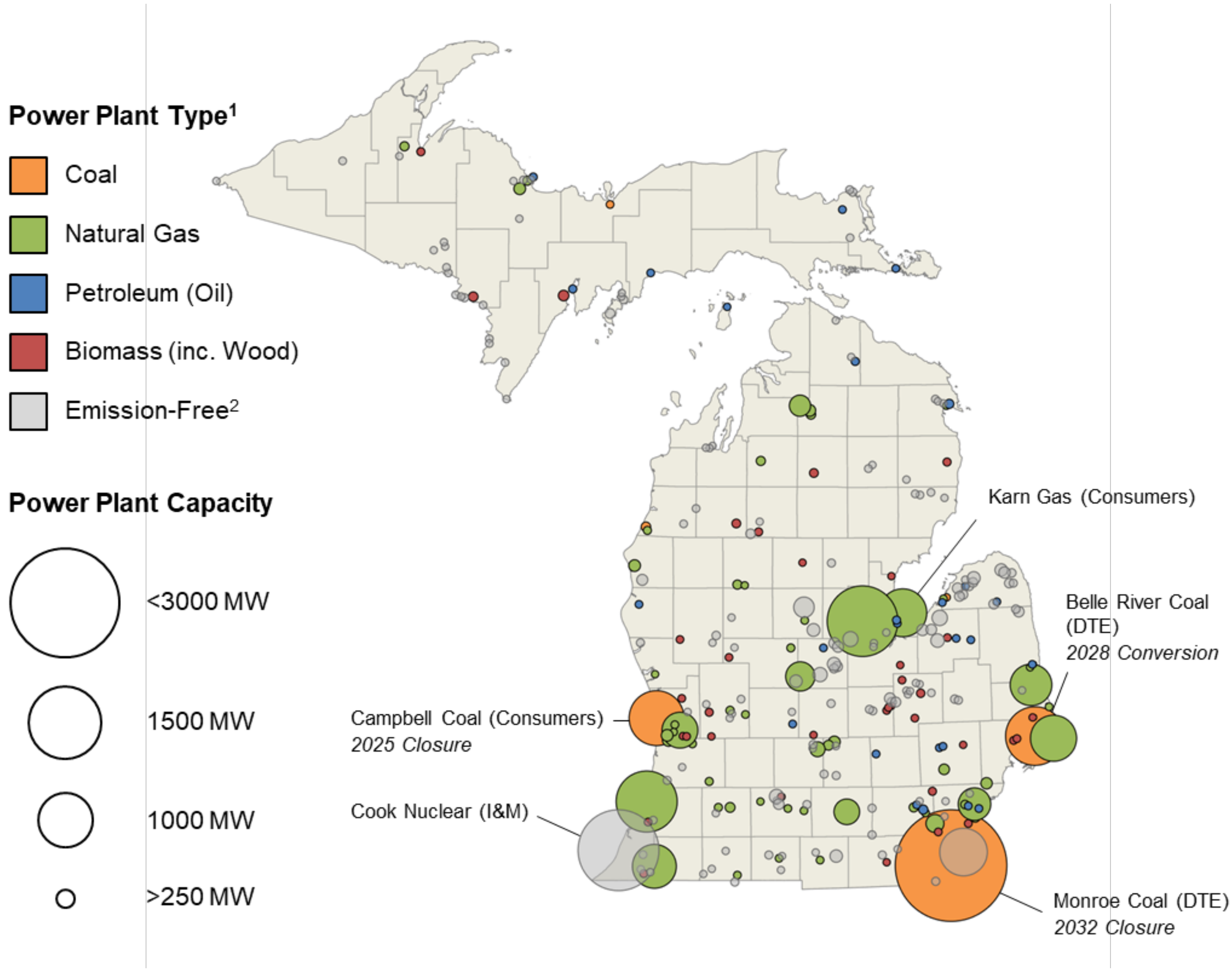
About the Sector

In 2023, roughly 65% of Michigan's electricity was generated from fossil fuels, according to data collected by the EIA from electricity generators across the state. Coal accounted for 19% of the electricity generated in Michigan in 2023. Since 2020, approximately 2,700 megawatt (MW) of coal generation has been retired, and no new coal generators have come online since 1990. Nearly all electricity sector coal emissions come from just three power plants (Consumers Energy's J.H. Campbell Complex and DTE's Belle River and Monroe Power Plants), all of which are scheduled for closure or conversion by 2032 according to Consumers Energy and DTE's IRPs.

With the ongoing retirement of coal generators, natural gas has surpassed coal in the share of electricity generated every year since 2020. In 2023, natural gas accounted for 46% of Michigan's electricity generation. Four of the top ten generating capacities in the state in 2023 were attributed to natural gas plants.

Behind fossil fuels, nuclear energy was the next top contributor, generating 23% of Michigan's electricity in 2023. Meanwhile, 11% of Michigan's electricity was generated from renewable resources: 7% from wind, 2% from biomass, 1% from hydro, and 1% from solar.

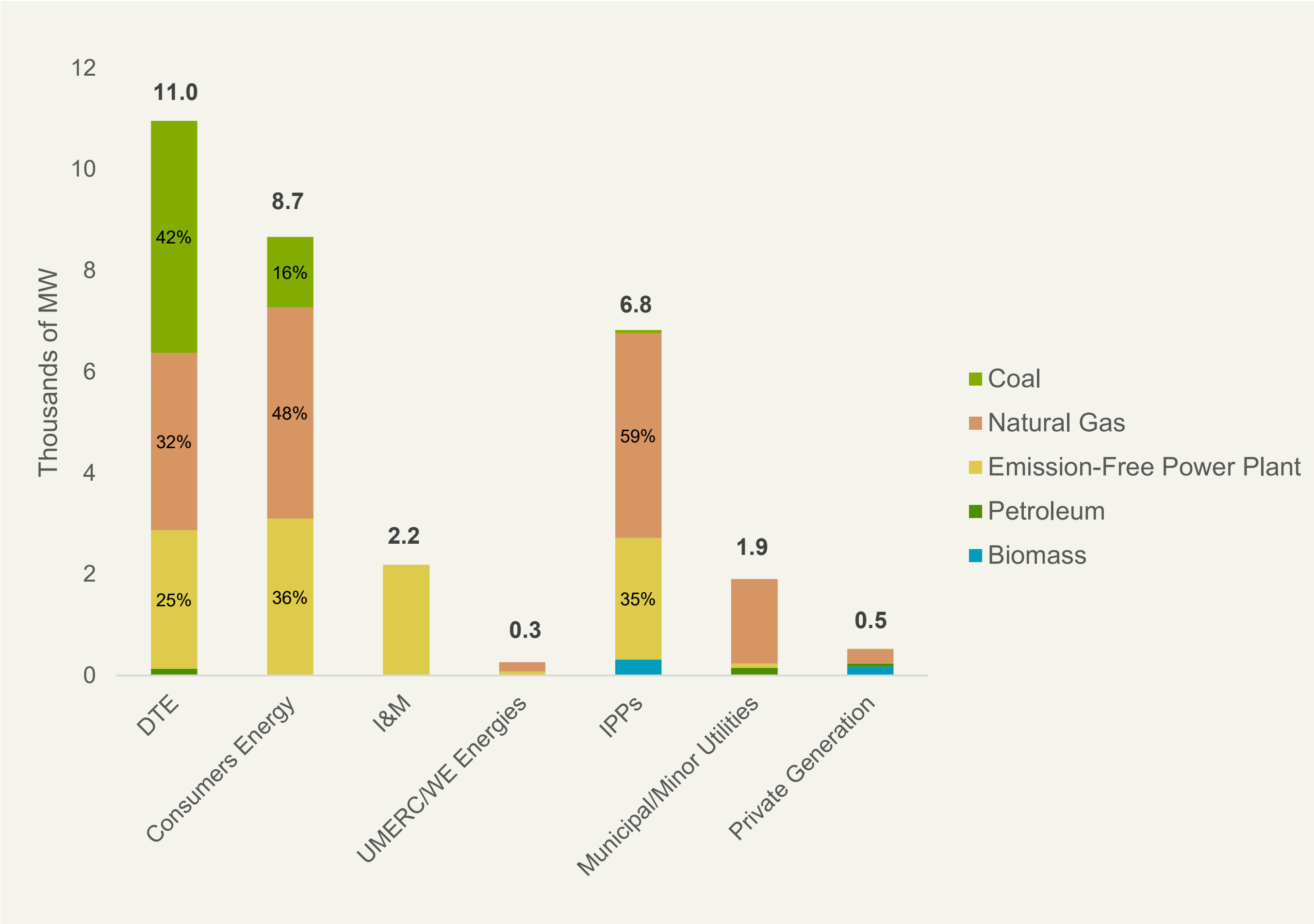
Figure 15: Electricity Generation Sites in Michigan by Energy Source and Capacity, 2023



Source: EPA's Facility Level Information on GreenHouse Gases Tool (FLIGHT); [1]Reflects primary generation source; [2]Emission-Free power plants include nuclear, hydro, solar, and wind.

In Michigan, there are seven investor-owned electric utilities, 11 electric cooperatives, and 40 municipally owned electric utilities. Michigan's two largest utilities, Consumers Energy and DTE Energy, provide electricity to 1.8 million and 2.3 million Michiganders, respectively. Together, they account for about 80% of all electricity generation in the state.

Figure 16: Renewable vs. Non-Renewable Generative Capacity by Utility, 2023



Source(s): EIA-860, EIA-860M, EIA-923; IPP = Independent Power Producer; Private Generation = Generation for Private Commercial or Industrial Use.

Decarbonizing the electric power sector is a vital step to decarbonizing Michigan's entire economy. As other sectors deploy electrification technologies such as EVs and heat pumps, carbon neutrality can only be reached if the electricity used is itself emissions free. Further, increased electrification will drive higher electricity demand overall. Thus, it's important to not only decarbonize existing electricity generation but to ensure future generation is also carbon free. To achieve this goal, the MHCP has recommended generating 60% of the state's electricity from renewable sources and phasing out all coal plants by 2030. In addition, it calls for improving energy system planning, limiting the energy burden of LIDACs to 6% of annual income, siting solar on state-owned lands, and deploying 4,000 MW of grid scale storage by 2040.

GHG Emissions Reduction Measures across the Electricity Generation Sector

Electricity Generation Reduction Measure 1:
Support clean energy deployment, including siting for renewable energy and increased investments in customer-driven renewable energy

Measure Description: Electricity generation is Michigan's greatest source of emissions, largely due to the continued use of coal and natural gas. To address this, the state is pursuing a multi-faceted strategy to accelerate renewable energy deployment and diversify its energy mix. Furthermore, deploying clean energy to Michigan's electric grid is essential to reducing emissions economy wide. As other sectors, such as transportation and commercial and residential buildings, increasingly electrify, a decarbonized grid will play a transformational role in meeting Michigan's goal of carbon neutrality.

This strategy includes ramping up utility-scale solar and wind development, deploying renewable energy on brownfields, streamlining siting and permitting processes to ensure projects are deployed in a timely and community-aligned manner, and investing in infrastructure and policy to accommodate distributed generation and energy storage. It also involves increasing generation targets for renewables, as highlighted by state law and utility IRPs, and expanding access to customer-driven renewable energy, including in underserved and rural areas. Initiatives that allow customers to directly drive demand for renewable power include community solar, voluntary green power purchasing, onsite generation, and renewable energy credits.

The clean energy legislation signed by Governor Whitmer in 2023 included five bills that align with and, in many cases, exceed these recommendations including calls to site clean and renewable energy resources across the state, expand energy efficiency offerings, address energy affordability, support workforce development and job training, evaluate potential impacts on environmental justice communities, codify just transition efforts, and more.

Consumers Energy and DTE Energy have each outlined ambitious IRPs to accelerate the state's transition to clean energy and reduce carbon emissions. Consumers Energy's IRP positions it to achieve a 90% reduction in carbon emissions from 2005 levels by 2040, including the retirement of all coal plants by 2025[2] and the addition of 8,000 MW of solar capacity. Similarly, DTE Energy's IRP sets a goal of achieving 85% carbon emission reductions from 2005 levels by 2032 and 100% by 2050. DTE plans to retire all coal-fired units by 2032, including the Monroe Power Plant, one of the nation's largest coal plants, while adding over 15,000 MW of renewable energy. Together, the two IRPs mark a significant statewide shift toward decarbonization, with a strong focus on clean energy buildout and workforce development.

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[2] Following a November 2025 order from the United States Department of Energy (DOE), Consumers Energy's last remaining coal plant, the J.H. Campbell Complex, will remain operating through February 17, 2026.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action. Further, Public Act 3 of 1939, as amended most recently in 2023, provides the authority for the Michigan Public Service Commission (MPSC) to regulate investor-owned utilities in the state. The 2023 clean energy legislation also provides the MPSC with the authority to approve renewable energy developments across the state.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MPSC, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from the 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

More specific milestones were introduced by the 2023 clean energy legislation which:

- Requires 80% clean energy by 2035 and 100% by 2040,
- Commits to 50% renewable energy by 2030 and 60% by 2035, and
- Increases the cap on distributed generation resources like rooftop solar from 1% to 10%.

These goals will necessitate the rapid build out of renewable energy systems, which will require improvements in siting and permitting to enable an additional 5-6% renewable generation coming online each year between 2024 and 2030. Another major milestone in achieving this measure is phasing out remaining coal-fired power plants by 2030, a key recommendation in the MHCP.

Metrics that may be used to track this reduction measure include the amount of renewable energy generated in the state, the number and size of renewable energy projects approved by the MPSC or local zoning/permitting authorities, the number of brownfield and other industrial sites with renewable energy or energy storage development, and other metrics as identified.

Costs: Expanding renewable energy in Michigan requires significant upfront capital investment, with utility-scale solar photovoltaic installations costing approximately $1327/kiloWatt (kW) and onshore wind projects around $1718/kW. These figures account for equipment, construction, and initial connection to the grid. While the capital costs can be high, renewable energy systems generally have lower ongoing operations and maintenance (O&M) costs compared to fossil fuel power plants. Globally, 81% of new renewable projects in 2023 were cheaper than fossil fuel alternatives. This includes fewer fuel expenses and less intensive maintenance, since wind and solar systems have no combustion-related wear and tear. Over time, this can help offset the higher installation costs, especially as technologies mature and economies of scale continue to drive prices down.

Integrating a growing share of renewables into the grid also comes with system-level costs that extend beyond generation. Because wind and solar energy are variable, dependent on weather conditions and time of day, additional infrastructure is needed to ensure a stable and reliable power supply. This includes building new transmission lines to connect renewable-rich areas to demand centers, modernizing distribution systems to accommodate two-way power flows, and deploying energy storage solutions to balance supply with demand. Additional details on grid resiliency strategies are outlined in Electricity Generation Reduction Measure 3.

Intersection with Other Funding: The MPSC and EGLE offer a range of financial and technical assistance programs, which help local governments and developers reduce upfront costs and accelerate clean energy deployment. In 2023, Governor Whitmer's budget allowed for state funds to incentivize renewable energy adopters in the state through the Renewables Ready Communities Awards. Through this program, EGLE provided $5,000/MW to permitters and hosts of eligible utility-scale renewable energy projects that underwent the local permitting processes, with $2,500/MW granted to each awardee in cases when the host and permitter differed. In 2024, EGLE was awarded an EPA Climate Pollution Reduction Grant to expand the Renewables Ready Communities Awards and develop a brownfield renewable energy pilot program.

In 2024, EGLE launched the Renewable Energy Academy (REA) in partnership with the University of Michigan's Graham Sustainability Institute, Michigan State University Extension, 5 Lakes Energy, and the Michigan Association of Planning. Funded by a $1.9 million federal award from the DOE Renewable Energy Siting through Technical Assistance program, the REA supports local renewable energy planning and deployment, prioritizing local participation and capacity building, to help local and Tribal governments navigate the complexities and harness the benefits of hosting renewable energy facilities.

Since 2023, the MPSC has awarded annual grants through their Renewable Energy and Electrification Infrastructure Enhancement and Development Grant program. These funds are designed to help businesses, nonprofits, municipalities, and Tribal governments plan, develop, design, acquire, or construct renewable energy and electrification infrastructure projects. The MPSC also set up a Clean Energy Standard workgroup, Statewide Energy Storage Target workgroup, Renewable Energy Standards and Plans workgroup, and Distributed Generation and Interconnection workgroup to implement Public Act 235 of 2023, part of the 2023 clean energy legislation.

Quantification Methodology: To quantify the impact of Michigan's clean energy legislation on electric sector emissions, the EPS tool was used to model emissions under both a BAU scenario and a scenario where this reduction measure is fully implemented with the clean energy legislation in effect. The BAU scenario is based on EPS data extracted in January 2025 (4.0.3), prior to the inclusion of Michigan's 2023 clean energy legislation. This version of the EPS reflects a continuation of pre-legislation trends and policies. The implementation of the CCAP scenario uses the updated EPS dataset released in April 2025 (4.0.4), which incorporates Michigan's clean energy legislation, including the 100% clean electricity standard, showing emissions from electricity generation declining to zero by 2040. Both versions account for the reopening of the Palisades Nuclear Generating Station, expected in 2025. Comparing emissions outputs between the January and April EPS versions results in the projected emissions reductions attributable to the state's new clean energy laws.

To further isolate the impact of individual clean energy technologies specific to this reduction measure on renewable energy as well as the next reduction measure on battery storage, the implementation of the CCAP scenario applies the updated April 2025 EPS scenario and notes the modeled capacity additions for solar, onshore wind, and battery storage. These capacity benchmarks allow for the allocation of the total emissions reductions to the expansion of renewable energy generation and energy storage systems.

The **AV**oided **E**missions and gene**R**ation **T**ool (AVERT) was used to further quantify how much of the reductions can be attributed to renewables versus storage. It is estimated that approximately 90% of the impact in the short term (2030) can be attributed to achieving the 50% renewable energy standard. In the longer term (2040), approximately 70% of the reductions listed below may be attributed to achieving the 100% clean energy standard. Additional context and strategies for increasing battery storage are highlighted under Electricity Generation Reduction Measure 2.

Quantified Emissions Reduction:

Table 5: Electricity Generation Reduction Measures 1 and 2: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measures 2030	Difference between BAU and Implementation of Measures 2050
-10.57	-23.47

Table 6: Electricity Generation Reduction Measure 1: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-1,663.47	-3,777.85
NO_x	-1,601.84	-3,642.31
$PM_{2.5}$	-144.61	-328.71
VOC	-68.06	-154.84

Electricity Generation Reduction Measure 2:
Invest in energy storage to better integrate renewable energy into the electric grid

Measure Description: Investing in energy storage is a critical step toward decarbonizing Michigan's electric grid and ensuring long-term energy reliability. As more renewable sources like wind and solar are added to the grid, energy storage provides a flexible solution to balance supply and demand, storing excess energy when production is high and releasing it when demand peaks or renewable output is low. This reduces dependence on peak demand fossil fuel plants and helps lower overall system emissions. Grid-scale storage systems also support voltage regulation and frequency control, helping utilities maintain grid stability as the energy mix becomes more variable. Additional details on grid stability and reliability are listed in the Electricity Generation Reduction Measure 3.

The clean energy legislation passed in 2023 establishes new energy storage targets of 2,500 MW by 2030, making Michigan one of just a few states with an energy storage standard. The MHCP sets an additional target of 4,000 MW by 2040. The legislation also directed the MPSC to study the potential for long-duration and multi-day energy storage, which are essential for managing seasonal shifts in renewable generation. These policies signal Michigan's commitment to accelerating clean energy deployment and modernizing its grid infrastructure.

Michigan's largest utilities are also committed to establishing energy storage systems. Consumers Energy's IRP includes 550 MW of battery storage by 2040, with procurement expected to focus on systems that support peak demand reduction and grid support services. DTE Energy's IRP is even more aggressive, calling for 1,800 MW of battery storage by 2042. When battery storage deployment is combined with policy and regulatory support, like the clean energy legislation, Michigan is positioned to continue leading on clean energy.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action. Further, Public Act 3 of 1939, as amended most recently in 2023, provides the authority for the MPSC to regulate investor-owned utilities in the state. The 2023 clean energy legislation also provides the MPSC the authority to approve energy storage developments across the state.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MPSC, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually. More specifically, the 2023 clean energy legislation established an energy storage target of 2,500 MW by 2030. The MHCP further establishes a statewide storage target of 4,000 MW by 2040.

The main metric that will be used to track this reduction measure is MW of utility-scale storage across the state, along with other metrics as identified.

Costs: To achieve Michigan's 2030 energy storage target, significant investment in battery energy storage systems will be needed. While prices vary depending on location, project size, and battery technology, national studies like those from the United States National Renewable Energy Laboratory (NREL) show promising trends. Battery storage prices are expected to fall by 16% to 49% by 2030, and up to 67% by 2050, thanks to technology improvements and economies of scale.

For a typical 4-hour battery setup, enough to store energy during the day and use at night, total capital costs are expected to range from $245 to $403/kilowatt-hour (kWh) in 2030, and are projected to drop to $159 to $348/kWh by 2050. These costs include not only the equipment itself but also construction, grid connection, and other infrastructure. Ultimately, these investments in storage are critical to ensuring a clean and reliable electric grid.

Intersection with Other Funding: In 2023, Governor Whitmer's budget allowed for state funds to reward energy storage adopters in the state through the Renewables Ready Communities Awards. Through this program, EGLE provides $5,000/MW to permitters and hosts of eligible utility-scale storage projects that underwent local permitting processes, with $2,500/MW granted to each awardee in cases when host and permitter differ. In 2024, EGLE was awarded an EPA Climate Pollution Reduction Grant to expand the Renewables Ready Communities Awards and develop a brownfield renewable energy pilot program.

In 2024, EGLE launched the REA in partnership with the University of Michigan's Graham Sustainability Institute, Michigan State University Extension, 5 Lakes Energy, and the Michigan Association of Planning. Funded by a $1.9 million federal award from the DOE's Renewable Energy Siting through Technical Assistance program, the REA supports local energy storage planning and deployment, prioritizing local participation and capacity building, to help local and Tribal governments navigate the complexities and harness the benefits of hosting energy storage facilities.

Quantification Methodology: The GHG emissions reduction impact of the 2023 clean energy legislation is listed in Table 5 of Electricity Generation Reduction Measure 1. This landmark legislation includes goals and targets for both increasing renewables and energy storage, thus encompassing Electricity Generation Reduction Measures 1 and 2.

EPA's AVERT was used to further quantify how much of the reductions can be attributed to storage versus renewables. It is estimated that approximately 10% of the impact in the short term (2030), as shown in Table 5, can be attributed to achieving the 2,500 MW of storage goal. In the longer term (2040), approximately 30% of the reductions listed in Table 5 may be attributed to achieving the 4,000 MW of storage target.

Quantified Emissions Reduction:

Table 7: Electricity Generation Reduction Measure 2: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SOx	-193.20	-1,459.43
NOx	-206.16	-1,487.94
PM2.5	-18.64	-137.20
VOC	-9.00	-66.36

Electricity Generation Reduction Measure 3:
Support holistic grid planning, infrastructure investments, and flexible demand programs to enhance grid resilience

Measure Description: This strategy focuses on advancing comprehensive grid planning that helps integrate renewable energy resources, distributed energy, and battery storage, as noted in Electricity Generation Reduction Measures 1 and 2. By prioritizing infrastructure investments, such as modernizing transmission lines, upgrading substations, and deploying smart grid technologies, Michigan's grid will be able to more readily support the growth of electric vehicles, accommodate increasing renewable generation, and strengthen energy equity and affordability across communities.

Flexible demand programs, including demand response, time-of-use pricing, and energy efficiency initiatives, further empower consumers to shift energy use away from peak periods, reducing strain on the grid and lowering GHG emissions. Demand response can be load-shedding (demand is reduced during peak periods without adding demand to other periods) or load-shifting (demand is reduced during peak periods and shifted to other periods).

Though Michigan already leads the nation in utility energy efficiency program performance, according to the American Council for an Energy-Efficient Economy (ACEEE), strengthening support for organizations like the Michigan Utility Consumer Participation Board ensures that the voices of low-income communities are included in utility decision-making processes. Committing to equitable utility investments in LIDACs will also help reach the MHCP goal of limiting the energy burden for low-income households to no more than 6% of income.

The MPSC, as of early 2025, established a "Reliability-Plus" approach in establishing financial incentives and penalties for electric utilities as part of the MPSC's efforts to improve the reliability of Michigan's power grid. This framework will incentivize speedier improvements to the distribution system and enhance reliability for customers. These efforts are especially critical given Michigan's weather variability, manufacturing-based economy, and transition away from fossil fuels. "Reliability-Plus" acknowledges the need to accommodate and leverage the rise in adoption of distributed generation, EVs, and other distributed energy resources to drive improvement in grid reliability.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action. Further, Public Act 3 of 1939, as amended most recently in 2023, provides authority to the MPSC to regulate investor-owned utilities in the state. The 2023 clean energy legislation also grants the MPSC authority to implement this measure.

The vast majority of Michigan's transmission grid is monitored by the Midcontinent Independent System Operator (MISO). MISO's Long Range Transmission Planning process will help maintain reliability while enabling significant renewable energy deployment. Tranche 1, approved in December 2022, is projected to unlock 53 Gigawatts (GW) of renewable energy capacity. Tranche 2.1, approved in Fall 2024, is expected to enable 116 GW of additional renewable energy capacity. These projects are expected to go into service between 2032 and 2034.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MPSC, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

This measure will continue to be a guiding principle through 2050 and beyond. The approval of Tranches 1 and 2.1 by MISO were major milestones. The approval and then construction of these transmission upgrades within the state will be major milestones as well.

Costs: Upfront costs for advanced metering infrastructure can range from $50–$120 per unit. This technology enables two-way communication, allowing for time-based pricing and demand response. Additional grid modernization efforts include sensors, automated switches, and distributed energy resource management systems to monitor and control system reliability. While initial investments can be significant, advanced metering infrastructure deployed in concert with other cost savings and grid reliability improvement technologies can be more cost-effective than building out additional fossil-based plants.

A report from the Advanced Energy Institute details how Michigan could offset a projected 2,000 MW of summer demand increase in the Lower Peninsula across a 9-year period, just through demand response programs. In addition to avoiding or limiting the need for new power plants, it could also save ratepayers up to $1.2 billion.

Intersection with Other Funding: Michigan was recently granted federal awards from three separate programs related to grid resilience and reliability. Recipients for these programs include the state, municipalities, and utilities and total over $100 million dollars.

- Grid Resilience and Innovation Partnerships: $119.9 million awarded to Consumers Energy and $22.9 million awarded to DTE.
- Powering Affordable Clean Energy: Awarded over $20 million to multiple municipalities.
- Preventing Outages and Enhancing the Resilience of the Electric Grid Grants: Roughly $38 million awarded to EGLE.

DOE's Energy Dominance Financing program can also be leveraged for projects that maintain, enhance, or replace electric grid and transmission infrastructure. Additionally, the MPSC's MI Power Grid initiative provided a series of technical workshops to support grid enhancement through initiatives such as demand response, innovative rate offerings, voluntary green pricing programs, and technology innovations. Though the workshops have been completed, the legacy of this program continues to guide current proceedings.

Quantification Methodology: To quantify emissions reductions from grid resilience strategies in Michigan, the EPS was used, applying recommended settings to reflect improvements in grid efficiency and demand flexibility. Specifically, a 100% adoption level for load-shedding demand response programs was modeled, which is the more common type of demand response that exists today, and set the "Reduce Transmission and Distribution Losses" policy lever to 33%. This level aligns with international benchmarks, as the U.S. currently experiences approximately 6% T&D

losses, whereas countries such as Germany, Japan, Finland, and the Netherlands maintain losses around 4%. A 33% reduction would bring U.S. losses in line with these more efficient systems by 2050. The EPS outputs were used to quantify both CO_2 and co-pollutant reductions resulting from these measures.

Quantified Emissions Reduction:

Table 8: Electricity Generation Reduction Measure 3: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.57	-6.23

Table 9: Electricity Generation Reduction Measure 3: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SOx	15.06*	-0.86
NOx	-74.13	87.55*
PM2.5	-13.44	-4.50
VOC	-5,860.00	-1,890.00

*Note: These values show an increase in co-pollutant emissions compared to the BAU. As a result of this reduction measure, the SO_x levels are greater than the BAU in 2030 and the NO_x levels are greater than the BAU in 2050. Research suggests this is because of greater reliance on generators and because nighttime fossil-based generation is typically more reliant on coal and oil, leading to more SO_x and NO_x emissions. These forecasted increases in co-pollutant emissions further necessitate Electricity Generation Reduction Measures 1 and 2. Indeed, the eventual decline of SO_x emissions compared to the BAU in 2050 may be attributable to further advancements in cleaning the electric grid. With additional or more quickly deployed renewable energy and storage capacity, this reduction measure would likely see lower numbers for SO_x and NOx and could even lower the SO_x emissions below the BAU in 2030 and the NO_x emissions below the BAU in 2050.

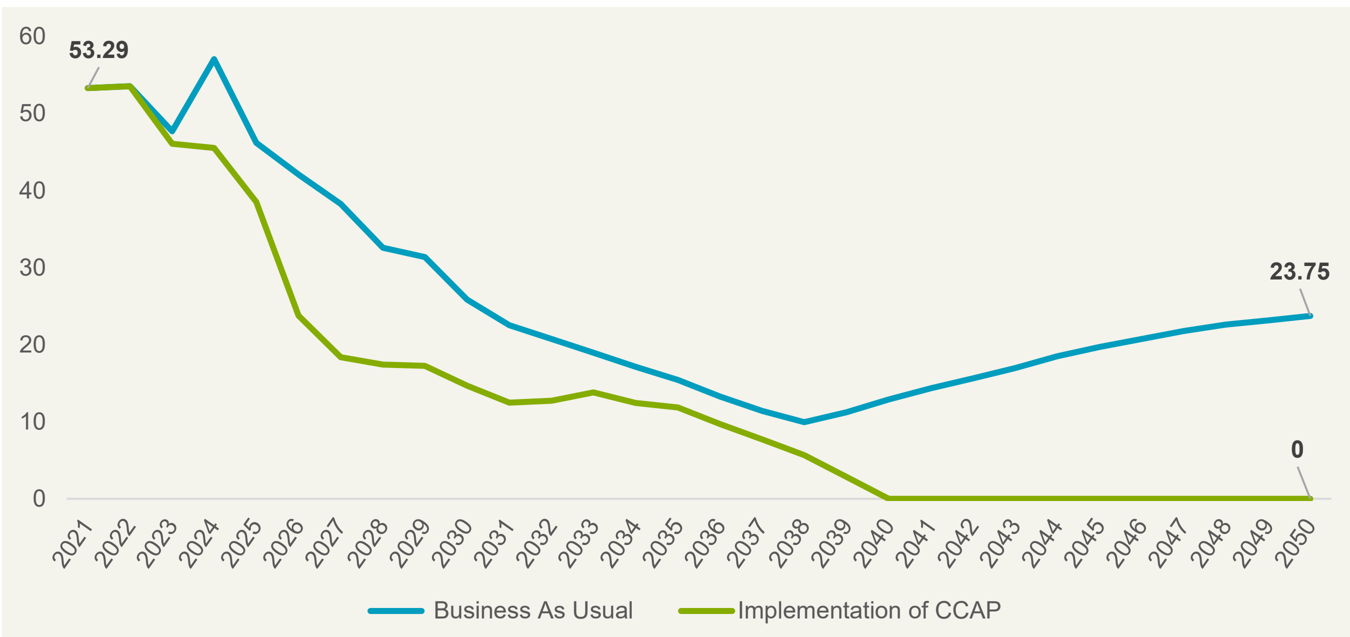
Electricity Generation Sector Summary

The data below, along with benefits and workforce considerations, is derived from aggregating the impact of all reduction measures listed in this sector.

Table 10: Electricity Generation Sector: Quantified GHG Emissions Reductions across All Electricity Generation Measures (Measured in $MMTCO_2e$)

Scenario	2021	2030	2050
BAU	53.29	25.84	23.75
Implementation of the CCAP	-	14.69	0
Difference between BAU and Implementation of CCAP	-	-11.15	-23.75

Figure 17: Electricity Generation Sector: Annual Quantified GHG Emissions Reductions across All Electricity Generation Measures (Measured in $MMTCO_2e$)



Qualitative and Quantitative Benefits Analysis across the Electricity Generation Sector

Expanding renewable energy, energy storage, and grid resilience in Michigan brings significant health, economic, and social benefits to residents statewide. Evergreen Action reports that transforming Michigan's energy sector could prevent nearly 1,000 premature deaths and save $8.3 billion in public health costs. Moving away from natural gas to clean energy will also stabilize Michigan's power grid and increase affordability, saving residents an estimated net $5.5 billion in energy costs by 2035. These benefits are especially important in historically overburdened and under-resourced communities. Further, energy efficiency and workforce training initiatives help reduce overall household energy costs and ensure long-term job creation. Enhanced grid reliability through microgrids and storage also improves resilience during power outages, while reduced reliance on fossil fuels improves public health and environmental quality.

The suite of reduction measures presented for the Electricity Generation sector bring about statewide emissions reductions beyond GHGs. Below, emissions of select co-pollutants are shown for the base year of 2021, along with anticipated reductions from the BAU scenario in the year 2030 and 2050.

Table 11: Electricity Generation Sector: Quantified Co-Pollutant Emissions Reductions across All Electricity Generation Measures (Measured in Metric Tons)

Co-Pollutant	Base Year (2021)	Difference between BAU and Implementation of all Electricity Generation Measures 2030	Difference between BAU and Implementation of all Electricity Generation Measures 2050
SOx	39,334.60	-1,841.61	-5,238.14
NOx	33,515.40	-1,882.13	-5,042.70
PM2.5	3,071.63	-176.70	-470.41
VOC	842,080.80	-5,937.06	-2,111.20

Quantifying emissions reductions allows for the calculation of quantifiable community benefits, which are detailed below. These co-benefit estimates were provided by the EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), after inputting the co-pollutant emissions reductions listed in Table 11. Additional detail on the selection of community benefits is available in Benefits of GHG Emission Reduction Measures to LIDACs (Section 7.3).

Table 12: Estimated Community Benefits in the Near-Term and Long-Term across the Electricity Generation Measures

Benefit	Cumulative Impact, 2025 through 2030	Cumulative Impact, 2025 through 2050
Avoided Lost Workdays	2,150	30,000
Avoided Respiratory Symptom Cases	22,000	275,000
Avoided Hospital Admissions	3.4	45
Avoided Minor Restricted Activity Days	13,000	175,000

Note: Avoided Deaths by Race is not reported for the Electricity Generation Sector because data is not available.

Workforce Considerations across the Electricity Generation Sector

Michigan's electric power sector is undergoing significant transformation as the state retires coal-fired power plants and expands renewable energy capacity. This shift is driving rapid growth in clean energy jobs, particularly in solar, wind, battery storage, and grid modernization, but the demand for skilled workers may outpace the available labor supply.

According to the 2024 Clean Jobs America Report, clean energy businesses in Michigan added more than 5,200 workers in 2024, bringing the total to 127,690 clean energy jobs statewide. Michigan was ranked number one in the Midwest for clean energy jobs, with the clean energy sector growing twice as fast as the overall economy. Clean energy now employs over six times as many Michiganders as the combined number of lawyers, web developers, and real estate agents. In 2022, solar jobs grew by 7%, wind by 2%, battery storage by 6%, and grid modernization by a notable 14%. While major metro areas like Detroit, Grand Rapids, and Lansing are hubs for clean energy employment, nearly 16,000 jobs are located in rural areas, demonstrating the statewide reach of Michigan's clean energy economy.

Key occupations within the sector fall within the following subclusters: Utilities, Wholesale, and Electric Manufacturing. The occupations with the highest projected growth rates through 2030 are Millwrights (18.1%), Electricians (13.1%), Electrical, Electronic and Electromechanical Assemblers (12.9%), Helpers - Installation, Maintenance, and Repair Workers (10.8%), and Construction Managers (9.4%).

Anticipated Workforce Shortages: Potential workforce gaps may be in areas such as linework, solar panel installation, wind turbine maintenance, battery storage system management, and utility-scale engineering. Grid modernization also requires new roles in information technology, data management, and cybersecurity to support smart grid infrastructure. Compounding these challenges is the pending retirement of a significant portion of Michigan's existing utility workforce, creating an urgent need for succession planning and rapid workforce development. The occupations with the most projected annual openings through 2030 are Construction Laborers (3,555), Electricians (2,655), Supervisors of Construction Trades and Extraction Workers (1,615), Plumbers, Pipefitters, and Steamfitters (1,420), and Supervisors of Mechanics, Installers, and Repairers (1,340).

Solutions to Address Workforce Shortages: There are a variety of programs to address these anticipated workforce shortages across the Michigan Department of Labor and Economic Opportunity (LEO) and Michigan Department of Treasury. Registered Apprenticeships play a crucial role in developing and preparing Michigan’s future workforce. Training helps apprentices develop the skills needed for an in-demand career while helping employers build critical talent pipelines. The Treasury’s Energy Transition Impact Project helps to address challenges associated with the state’s changing energy sources and brings local, state, and federal resources to the table to plan for future adjustments and changes.

The Going PRO Talent Fund, administered by LEO, provides grants to employers for training, developing, and retaining current and newly hired employees in high-demand, high-skill positions. In 2023, Public Act 232 established the Community and Worker Economic Transition Office (CWETO) within LEO to provide further assistance to transitioning workers in the auto and utility sectors and to communities impacted by these transitions, helping to ensure a just transition in Michigan.

Transportation

Transportation Reduction Measures
Encourage adoption of EVs by increasing EV charging infrastructure and vehicles
Increase access to public transportation and non-motorized transportation options
Support research and development to expand technologies available to reduce emissions from maritime, aviation, and heavy duty vehicles, including electrification, fleet optimization, and sustainable aviation fuel
Electrify state government, municipal, Tribal, and other public fleets
Support land use and transportation planning that will enable high-density, mixed-use development

About the Sector

The transportation sector is Michigan's second largest source of GHG emissions, accounting for 29% of total emissions in 2021. This sector encompasses a wide range of modes: from personal vehicles to freight trucks, public transit systems, aviation, and maritime operations. As the demand for mobility and commerce continues to grow, so does the importance of addressing emissions from this sector in a comprehensive way.

According to the Michigan Department of Transportation (MDOT), over 98.3 billion vehicle miles were traveled in 2023. As of 2025, the state has over 9.25 million registered vehicles, 8.59 million of which are passenger vehicles. Gasoline remains the predominant fuel source, powering 83% of all light duty vehicles in 2023. These vehicles alone are responsible for 24.3 $MMTCO_2e$, about half of the transportation sector's total emissions as of the 2021 inventory.

Beyond private vehicles, 79 public transit agencies across the state operate more than 3,000 transit vehicles. Passenger trips are back on the rise following the pandemic with 47 million rides taken by Michiganders in 2022. Additionally, there are 214 airports operating in the state, 18 of which are commercial, including Detroit Metropolitan and Grand Rapids' Gerald R. Ford International. Airports statewide facilitated transport of 38.8 million passengers in 2024 and drive a $22 billion aviation economy annually.

Beyond passenger travel, Michigan's transportation infrastructure supports the movement of freight and the functioning of local economies. The state is home to approximately 190,000 heavy duty trucks, including semis, farming/logging vehicles, dump trucks, and flatbeds, which moved 74% of all freight tonnage in the state in 2022. Freight demand is expected to rise, with truck tonnage projected to increase by 15% by 2045, primarily from pass-through traffic.

Maritime shipping also plays a key role in the state's transportation industry. Michigan's 3,200 miles of shoreline along four of the five Great Lakes contain 33 active cargo ports that ship or receive cargo. Michigan's ports handle approximately 51.7 million tons of cargo each year.

In 2024, the U.S. Federal Highway Administration approved MDOT's Carbon Reduction Strategy, which calls for reduction case scenarios such as encouraging modal shift from personal vehicle usage to shared mobility and public transit, deploying charging infrastructure for EVs, and prioritizing transportation infrastructure efficiencies.

The MHCP provides a set of key strategies to reduce the emissions of this complex, multimodal system while supporting connectivity, economic growth, and equitable access across the state. They include building the infrastructure needed to support 2 million EVs on Michigan roads by 2030, increasing access to clean and public transportation options by 15% annually, transitioning the State fleet to 100% Zero Emission Vehicles (ZEVs), and adopting a Clean Fuels Standard.

GHG Emissions Reduction Measures across the Transportation Sector

Transportation Reduction Measure 1:
Encourage adoption of EVs by increasing EV charging infrastructure and vehicles

Measure Description: The MHCP sets the goal of building the infrastructure necessary to support 2 million EVs on Michigan roads by 2030. As of July 2025, Michigan had 85,311 Battery Electric Vehicles (BEVs) and 18,013 Plug-In Hybrid Electric Vehicles (PHEVs), supported by just over 5,333 charging ports at over 1,987 station locations.[3] The Michigan Office of Future Mobility and Electrification developed the MI Future Mobility Plan and released the latest version, MI Future Mobility Plan 2.0, in August 2025. The 2.0 Plan calls for a focus on data and energy infrastructure, with examples such as modernizing to enable "real-time data flows, charging access, and grid resilience at scale." Increasing the access, reliability, and security of chargers is imperative to increasing the uptake of ZEVs.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with MDOT and the Office of Future Mobility and Electrification (OFME), will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

A more specific milestone introduced by the MHCP is to build the infrastructure necessary to support 2 million EVs on Michigan's roads by 2030. OFME estimates that at least 27,000 EV chargers will be needed to support 10% of this market share. The MI Future Mobility Plan 1.0 also sets goals of improving access to hydrogen infrastructure and maintaining at least 80% of EV charging off peak.

[3] EV registration data is sourced from a partnership between the Michigan Secretary of State and SEMCOG.

The primary metrics for this reduction measure will be the cumulative number of charging ports, the number of charging ports added each year, and other metrics as identified.

Costs: According to an analysis conducted by Atlas Public Policy, EVs typically have a total cost of ownership lower than internal combustion engine vehicles (ICEV) of the same vehicle type. This is because higher purchase prices and insurance costs are offset by lower fuel and maintenance costs. One study by Consumer Reports shows that EV owners can save $4,700 or more over the first seven years, just in fuel savings. DOE research shows that maintenance costs for a light duty BEV are 6.1 cents per mile, compared to a conventional ICEV at 10.1 cents per mile.

Beyond the price of the EVs themselves, investments in charging infrastructure must be made. Most EVs come with Level 1 charging equipment, which can make use of standard 120-volt outlets, but non-home use charging stations can be costly to set up. According to an EV Charging Infrastructure Study conducted by Michigan State University, the average cost of a Level 2 charger is roughly $3,555.78 while installation costs average an additional $4,311.80. A direct current fast charger costs an average of $71,407.63 and installation costs average $69,032.74. It is important to note, however, that costs can vary widely depending on location, number of charging ports, and what kind of upgrades are needed to incorporate the chargers into the grid.

Intersection with Other Funding: Charge Up Michigan offers grants to fund DC fast charging stations across the state of Michigan, ensuring the feasibility of all long-distance trips for EV users. Additionally, Michigan, Wisconsin, Illinois, and Indiana are working together to create a scenic route with reliable charging stations along Lake Michigan's 1,100 miles of drivable coastline through the Lake Michigan Circuit. The charging stations will be installed at recreational areas, hospitality businesses, and entertainment attractions to provide EV drivers with a long-distance vacation opportunity free from range anxiety.

The State of Michigan has also made available $30 million for the Clean Fuel and Charging Infrastructure program. This program will provide grants for the deployment of EV and hydrogen fueling stations for fleets, public transit systems, multifamily housing units, and within designated alternative fuel corridors. In addition, $4.5 million was appropriated for an inductive charging pilot project and $116 million was authorized to Consumers Energy and DTE for EV infrastructure.

Significant federal funding has been brought to Michigan to support EV charging infrastructure, including approximately $1.5 million to the City of Grand Rapids, $8 million to the City of Lansing, $2.8 million to the City of Ann Arbor, and $38.5 million to the City of Detroit through the Charging and Fueling Infrastructure Grant program. Roughly $110 million was also awarded to the State of Michigan through the National Electric Vehicle Infrastructure Formula program to deploy EV charging infrastructure along designated alternative fuel corridors.

Quantification Methodology: To quantify emissions reductions from increasing EV adoption in Michigan, a hybrid methodology was used, combining current vehicle registration data from the DOE's Alternative Fuels Data Center for 2023 and projected growth rates from the DOE's State and Local Planning for Energy (SLOPE) tool. The 2023 baseline includes 50,300 BEVs, 29,100 PHEVs, 148,100 hybrid electric vehicles (HEVs), and 7.13 million ICEVs. Using SLOPE-derived growth rates, vehicle numbers through 2030 and 2050 were projected. EPA's AVERT inputs were calculated to reflect achievement of the MHCP goal of 2 million EVs by 2030 and complete electrification of light duty vehicles in the state by 2050. These projections are a conservative estimate of the GHG reductions and co-benefits associated with Michigan's transition to electric transportation because EPA's AVERT doesn't allow for the quantification of emission reductions from transition to HEVs from ICEVs. Additionally, EPA's AVERT models impacts on a year-by-year basis and does not account for the cumulative emissions savings of EVs remaining on the road over time.

Quantified Emissions Reduction:

Table 13: Transportation Reduction Measure 1: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.93	-1.93

Table 14: Transportation Reduction Measure 1: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SOx	-4.90	-10.14
NOx	-622.31	-935.09
PM2.5	-14.61	-26.16
VOC	-677.49	-1,099.67

Transportation Reduction Measure 2:
Increase access to public transportation and non-motorized transportation options

Measure Description: Michigan's current public transit system comprises 79 public transit agencies with a total of 3,069 transit vehicles statewide. Together, they transported over 47 million passengers across the state in 2023. The MHCP established a goal of increasing transit access 15% each year through 2030. To accomplish the expansion of Michigan's public transit network, upgrades and improvements to existing infrastructure are necessary. By improving and upgrading infrastructure, Michigan can increase routes, frequency, and reliability among public transit services for the Michigan public. Incentivizing the use of public transit can reduce emissions, commute time, and traffic congestion.

While an increase in public transit ridership and use of non-motorized transportation solutions will reduce emissions by displacing use of ICEVs, increased access to public transit could increase emissions if transit buses do not use cleaner fuels. Thus, this measure also relies on electrification of transit buses across the state.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with MDOT, OFME, regional transit authorities, and local transit providers, will follow an implementation schedule aligned with the MHCP's goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

A more specific milestone put forth by the MHCP is to increase access to transit by 15% each year through 2030.

Metrics for this measure include the number of transit buses, the percentage of the transit system that is made up of electric transit buses, the number of new routes added to the system, ridership increases, any reductions in the number of vehicles on the road, and other metrics as identified.

Costs: A battery electric bus can range from $750,000 to $887,000, while diesel buses range from only $425,000 to $480,000. Battery electric buses have a higher upfront cost than their diesel equivalents, but base battery electric bus prices have already decreased by 25% over the last five years, according to the Center for Transportation and the Environment. Electric transit buses will also require charging stations to be set up at bus depots. These can cost $50,000 per charger, along with $17,000 per charger in installation costs.

However, just as with light duty EVs, electric transit buses have lower fuel and maintenance costs. At $2.60 per gallon, the annual fuel costs of a diesel bus add up to over $29,000, while a battery electric bus would cost under $11,000 in electricity. Maintenance costs for a battery electric bus will also be lower than diesel, with only $0.64/mile compared to $0.88/mile.

Over the full lifecycle, battery electric buses offer significant cost advantages despite their higher initial purchase price. When accounting for fuel, maintenance, and longer operational lifespans, total cost of ownership for electric buses can be comparable to or lower than diesel buses over a 12–15 year period. These lifecycle savings, combined with reduced emissions and improved air quality, make battery electric buses a cost-effective and sustainable investment for Michigan's transit systems, especially as the state works to increase the number of transit buses on the road each year.

Intersection with Other Funding: According to MDOT's Michigan Mobility 2045 Plan, state funding for transportation is projected to equal $90 billion over the next 25 years. Of this, $9.6 billion is expected to flow towards public transportation expansion and improvement, with an additional $3.4 billion in federal funding. In 2024, 12.4% ($818.8 million) of the total transportation budget was appropriated for public transportation programs, including capital and operating assistance to local public transit agencies, capital and operating assistance for passenger rail services, and other targeted public transportation programs (Detroit/Wayne County Port Authority, rail freight, commuter rail, and specialized services for the elderly and persons with disabilities).

Programs like the MDOT Office of Passenger Transportation and Michigan Mobility Funding Platform incentivize companies to bring pilot projects and field offices to Michigan to address urban and rural transit challenges. MDOT received $480,000 for Rural Electrification Vehicles and Charging Stations for Non-Emergency Medical Rides To Wellness. This funding is provided by the U.S. Federal Transit Administration's (FTA) Innovative Coordinated Access and Mobility Pilot Program. Additionally, four transit agencies across the state received FTA grants through the Buses and Bus Facilities and No-Emission Vehicle Programs, which support the purchase, rehabilitation, and construction of electric buses, vans, and related facilities.

Quantification Methodology: Starting with the 2023 baseline of 3,069 transit vehicles statewide, and assuming a 15% annual increase in access to transit through 2030, the MHCP projects a fleet size of approximately 8,164 vehicles by 2030. In this modelling, it was assumed that all new transit buses added between 2023 and 2030 are electric, and that all remaining buses are electrified by 2050.[4] These figures were input into EPA's AVERT, which calculates the avoided emissions from switching diesel-powered transit to electric, based on the emissions profile of the regional electric grid.

In addition, mode shift impacts were modeled using the EPS. For light duty vehicles, the EPS suggests 26% of car and SUV trips can be shifted to other modes (including transit) by 2050. An intermediate goal of 15% trip displacement by 2030 was also added. This allows for the estimation of additional emissions reductions through increased transit access and use, even before full electrification. Thus, this combined approach captures both direct benefits of replacing diesel buses with electric buses and indirect benefits from reduced demand for personal vehicle travel.

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[4] As of the finalization of this report in 2025, not all buses added to transit fleets since 2023 have been electric. Reduction estimates for this measure are thus likely overestimates.

Quantified Emissions Reduction:

Table 15: Transportation Reduction Measure 2: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-3.21	-2.22

Table 16: Transportation Reduction Measure 2: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-26.27	-18.62
NO_x	-2,222.72	-1,218.34
$PM_{2.5}$	-89.00	-56.50
VOC	-2,905.79	-2,157.28

Transportation Reduction Measure 3:
Support research and development to expand technologies available to reduce emissions from maritime, aviation, and heavy duty vehicles, including electrification, fleet optimization, and sustainable aviation fuel

Measure Description: Beyond light duty vehicles, Michigan has an estimated 116,000 diesel trucks on the road today that contributed 12.04 $MMTCO_2e$ in 2021. That's 25% of all transportation sector emissions that year. Further, the number of these heavy duty vehicles is expected to increase 15% by 2045.

As of 2025, electric heavy duty trucks make up just 4% of all ZEV trucks in the U.S. While the technology for long-haul electric semi-trucks is not yet ready for scale, a portion of these heavy duty trucks can be readily electrified. Over 40% of heavy duty trucks drive short distances (less than 250 miles), which makes them ideal candidates for electrification since battery electric trucks can travel more than 200 miles on a full charge.

Additional research and development (R&D) efforts to address current battery limitations and overcome charging infrastructure challenges will be needed to reliably switch longer range trucks to electric. For example, one solution is a network of leased batteries that are exchanged at battery swapping stations at truck stops along major routes. This would address concerns of long refueling times and some of the cost barriers to electric adoption, but this solution is relatively untested in the U.S. Ultimately, cost reductions and improved infrastructure, supported by R&D policy, are needed for electric trucks to be an economic choice for commercial transportation.

Beyond land transportation, maritime and aircraft emissions contributed just over 2 $MMTCO_2e$ in 2021. Maritime transportation emissions can be reduced through a combination of electrification and cleaner fuel alternatives, such as biofuels and hydrogen. Research predicts the global market for electric boats and ships will grow by 10.4% a year through 2033. While full electrification of large vessel propulsion remains challenging due to current battery technology limitations, significant emissions reductions can still be achieved by electrifying non-propulsion energy uses (like lighting, refrigeration, and onboard systems) and by providing "cold ironing" at ports. Cold ironing, also known as shore-to-ship power, is the process of supplying electrical power to a ship from the shore while it is docked, allowing it to shut down its onboard diesel engines. Large vessels will likely require continued use of bunker fuel, but emissions reductions could be achieved by replacing diesel with biodiesel, ammonia, or other less carbon-intensive fuels. The forthcoming Michigan Maritime Strategy will inform strategies to ensure Michigan's maritime industry reduces carbon emissions, as will the Port of Detroit Decarbonization and Air Quality Improvement plan.

For aircraft, there are a variety of strategies available to reduce emissions across the state, including increases in fuel efficiency, route optimization, and alternative fuels. Sustainable aviation fuel (SAF) is a biofuel used to power aircraft that has similar properties to conventional jet fuel but with a smaller carbon footprint. High certification standards and upgraded infrastructure needs make the transition challenging, however. Recently proposed legislation could establish an income tax credit for the producers and blenders of SAF, which would be purchased and used for flights departing Michigan.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with MDOT and OFME, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

Costs:

Heavy Duty Trucks

A Class 8 tractor truck with battery electric technology and a range of 750 miles retails for $423,000, compared to $175,000 for a comparable diesel truck. While the upfront costs of truck replacement are high, the 2024 Fleet Fuel Study showed that 75,000 electrified trucks saved a combined $512 million in 2023 compared to the average trucks on the road. This was largely due to fuel and maintenance cost savings, along with improvements in efficiency and route optimization.

A significant amount of R&D is necessary to develop technology for widespread electrification of heavy duty trucks, but battery costs fell by an average of 19% each year between 2010 and

2015. This is promising for making heavy duty truck electrification cost effective because the larger the vehicle battery, the faster the overall vehicle cost will decrease over time, since a larger portion of the capital cost is attributed to batteries.

Battery swapping solutions can reduce the upfront cost of a heavy duty EV by up to 50%. However, the capital expenses for establishing a battery swapping station can be significant, between $1 million and $1.5 million, with 30%-50% of that being the cost of the batteries themselves.

Maritime

Electric boats, like electric vehicles, have a higher upfront cost, ranging from $14,000 for two seaters to $500,000 for high-end yachts. The high costs are largely due to the high costs of batteries, which are expected to continue to decline over the next 25 years. As with vehicles, however, electric boats see O&M cost savings. Charging an electric boat can cost as little as $5 or $6 per day, compared to $200 per day to fuel a boat with fossil fuels.

Aviation

The key driver for increased adoption of SAF will likely be oil price fluctuations, while the major constraint is cost. As of 2024, SAF costs two to seven times more than traditional jet fuel, but this difference in cost can be managed by diversifying the types of feedstocks used. There are a variety of early-stage technologies to drive down the cost and support the adoption of SAFs, which will likely be expanded in the next 25 years due to R&D investments.

Intersection with Other Funding: This reduction measure requires a considerable amount of R&D spending. Michigan is well positioned to conduct this research, since the state leads the country in automotive investment (both public and private), with $41.5 billion invested between 2009 and 2019. The state's Make It in Michigan Mobility Prototyping Grant program is also strengthening the state's leadership in mobility, electrification, autonomous systems, and advanced manufacturing innovation. Led by the OFME and the Michigan Office of Defense and Aerospace Innovation, in partnership with Centrepolis Accelerator at Lawrence Technological University, the program offers grant awards of up to $100,000 per company, with a total funding pool of $2 million available for product development of innovative mobility technology. Additionally, the Michigan Economic Development Corporation (MEDC) offers many opportunities for early stage funding for startups and entrepreneurs and the Michigan Treasury administers an R&D tax credit.

MEDC's Michigan Translational Research and Commercialization (MTRAC) program helps bridge the gap between R&D at Michigan's institutions of higher education and the commercial market. The University of Michigan is home to the Advanced Transportation Innovation Hub. Other relevant MTRAC hubs include Michigan Technological University's Advanced Materials Innovation Hub and Wayne State University's Advanced Computing Innovation Hub.

Heavy Duty Trucks

Through the Michigan Clean Diesel Program, EGLE is offering grants for projects that will reduce diesel emissions by replacing old vehicles, engines, and equipment, with all-electric vehicles and equipment, focusing on local government fleets, recycling vehicles, compost and food waste recovery vehicles, agriculture, and irrigation equipment.

The Fuel Transformation Program, also administered by EGLE, supports the replacement of qualifying diesel vehicles, vessels, and equipment with new, cleaner versions that have low to no emissions. Over approximately three years, $30 million in grants is being made available to support the transition to cleaner fuels.

In fiscal year 2023, LEO was awarded $8.5 million through the Better Utilizing Investments to Leverage Development program to build the Mobility Charging Hub. This "truck stop of the future" will provide charging infrastructure for passenger vehicles and commercial fleets alike, while providing a testing grounds for future innovations in technology and business.

Maritime

Grants totaling $16.63 million from the U.S. Department of Transportation's Federal Ferry Service Rural Communities program, along with a $14 million state investment, will enable MDOT to purchase a new, more efficient, and environmentally friendly ferry for the 32-mile run from Charlevoix to Beaver Island. Additionally, the Detroit/Wayne County Port Authority received nearly $22 million through the EPA's Clean Ports Program to install zero-emission equipment. The Detroit/Wayne County Port Authority and EGLE each received a $3 million Climate and Air Quality Planning grant through the same program to further efforts to decarbonize the maritime industry.

In 2023, Governor Whitmer announced the Fresh Coast Maritime Challenge, designed to offer commercial enterprises of all sizes a sustainable, cost-effective, and efficient means of transitioning watercraft from diesel to electric power. While this was a one-time grant funding opportunity, six companies received $506,000 to establish what will become an evolving network of shore-side charging facilities for clean-fueled marine vessels and electric passenger vehicles operating on the Great Lakes.

Aviation

The Advanced Aerial Mobility Activation Fund was launched to accelerate the development and deployment of Advanced Aerial Mobility technologies and infrastructure that have the potential to drive measurable benefits for all Michiganders and strengthen the state's economy.

Recently proposed legislation would provide a $1.50/gallon tax credit for those who purchase, produce, or blend SAF within the state of Michigan. The credit is designed to directly support farmers and businesses that develop and supply cleaner-burning, ethanol-derived aviation fuels. There is a maximum incentive cap of $4.5 million in the first year, and $9 million annually thereafter for the next nine years. If greater emissions reductions are reached, additional incentives are available.

Quantification Methodology: To estimate emissions reductions from electrifying heavy duty trucks, EPA's AVERT was used, applying assumptions based on current and projected vehicle counts. Michigan has an estimated 116,000 diesel trucks today. This number is expected to increase 15% by 2045. It is estimated that 43% of today's trucks could be electrified by 2040, with the remaining heavy duty vehicles electrifying by 2050.

For aviation and maritime sectors, as well as additional truck-related strategies, the EPS was used. Fuel economy improvements were applied across sectors, including 50% for maritime freight, 17% for passenger aviation, and 50% for freight aviation. Heavy duty trucks were projected to experience a 56% improvement in fuel economy. Mode shifting assumptions were also added, shifting 30% of passenger air travel and 25% of truck freight to other, lower-emission modes by 2050. Lastly, the EPS "R&D: Fuel Use Reduction" setting was applied, reducing diesel engine fuel consumption by 40% through technology advances. All EPS strategies were modeled for 100% implementation by 2050, allowing for the capture of cumulative emissions reductions from efficiency, electrification, mode shift, and innovation across the heavy duty and long distance transport sectors.

Quantified Emissions Reduction:

Table 17: Transportation Reduction Measure 3: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-2.38	-4.82

Table 18: Transportation Reduction Measure 3: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-12.31	-106.05
NO_x	-1,521.13	-3,404.32
$PM_{2.5}$	-44.51	-186.27
VOC	-176.22	-408.33

Transportation Reduction Measure 4:
Electrify state government, municipal, Tribal, and other public fleets

Measure Description: As a step towards decarbonizing the transportation sector, Governor Whitmer issued Executive Directive 2023-5, calling for a transition of the state government fleet to ZEVs by 2033 for light duty vehicles and by 2040 for medium and heavy duty vehicles. The state government fleet has nearly 15,000 vehicles, about 68% (approximately 10,045) of which are light duty. Since 2020, the total state fleet increased by an average of 1.68% each year.

This reduction measure aims to expand the opportunity for fleet electrification to other organizations, including municipal fleets, Tribal fleets, school buses, and other public fleets. As of the 2023-2024 school year, there were 15,871 school buses across Michigan. With this large fleet operating daily for most of the year, school bus transportation offers a substantial opportunity for emissions reductions. Electric school buses can have up to 61% lower lifecycle emissions than their gasoline and diesel powered counterparts.

Beyond school buses, there are an estimated 56,000 total vehicles in municipal fleets across the state, which are owned by over 1,500 cities and townships.[5] Additionally, as reported in the Intertribal Council of Michigan Combined PCAP, fleet electrification and additional charging infrastructure are goals for Tribal governments. The Grand Traverse Band of Ottawa and Chippewa Indians, for example, estimates a reduction of 33.6 metric tons of carbon dioxide equivalent (tCO_2e) each year from the replacement of eight vehicles with EVs and the installation of 33 additional EV charging stations. The Nottawaseppi Huron Band of the Potawatomi estimates a reduction of 103 tCO_2e each year from the replacement of their entire vehicle fleet with EVs and the installation of solar EV charging stations. Independent PCAPs from the Gun Lake Tribe and Keweenaw Bay Indian Community estimate additional reductions from fleet conversion of 130.7 tCO_2e and 44.9 tCO_2e, respectively.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MDOT and the OFME, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

The State's Zero Emission Fleet Plan provides a broad implementation schedule. Approximately 1,500 light duty vehicles per year need to be transitioned in order to achieve a fleet of light duty ZEVs by 2033.

Metrics that may be used to track this reduction measure include the number of electrified vehicles owned or leased by state government and other applicable entities, the number of EV chargers

[5] This rough estimate is based on a municipal vehicle per resident ratio, which was averaged from a sample of five cities and townships, and previously included in Michigan's PCAP.

installed on government and publicly owned property, the number of entities engaging in bulk-buy programs, and other metrics as identified.

Costs: The same lifetime cost savings described in Transportation Reduction Measure 1 of owning an EV versus an ICEV apply here. Transitioning to EVs in the state fleet will thus yield taxpayer benefits, as EVs have a lower total cost of ownership. When Florida was considering implementing a total cost of ownership analysis for the procurement of new state vehicles, a study found that the state could save nearly $280 million in taxpayer dollars by transitioning its fleet to EVs. Additional cost information on heavy duty vehicle electrification is detailed in Transportation Reduction Measure 3.

Electric school buses cost around $400,000 per bus, which is higher than some diesel alternatives. However, the cost of these buses has declined 35% over the last decade and will continue to decline as the costs of batteries decline. These buses also have lower overall O&M costs, with an average annual cost savings between $5,000 and $10,000 per bus. The transition to electric buses can save school districts up to $100,000 over 10 years.

Intersection with Other Funding: As of October 2024, a total of $2 million had been appropriated towards the electrification of the state fleet. So far, the funding has been used for assessment costs and could support the purchase of EVs.

The Bipartisan Infrastructure Law's Clean School Bus Program is already helping the state transition school buses to ZEVs. In 2024, Detroit, Lansing, and Pontiac public school systems each received $5,925,000 in federal funding to buy 15 clean-powered school buses each. An additional 27 school districts have also received funding to add an additional 104 electric school buses to their fleets, collectively.

The Michigan Department of Education has also partnered with EGLE to provide $125 million in grants to help school districts replace aging diesel buses with cleaner alternatives through the Clean Bus Energy Grant program.

For municipal fleet electrification, the Charge Up Michigan Program information, detailed in Transportation Reduction Measure 1, is also applicable. Additionally, the MDOT received Innovative Coordinated Access and Mobility funding from the U.S. Department of Transportation in the amount of $480,000 for Vehicles and Charging Stations for Non-Emergency Medical Rides To Wellness for rural communities. Technical assistance and information about the most recent funding opportunities are available via the State of Michigan Community EV Toolkit, which provides local communities and partners access to key data and background information, the current status of infrastructure and deployment, community zoning and planning ordinances, community fleet electrification, funding opportunities, local case studies, and best practices.

Quantification Methodology: To estimate emissions reductions from electrifying Michigan's state, municipal, and school vehicle fleets, EPA'S AVERT was used. Projections of 2035, 2045, and 2050 fleet sizes were calculated based on the current vehicle totals of 10,045 light duty and 4,656 medium and heavy duty, as well as the average historical growth rate of 1.68%. Municipal fleet estimates were derived using vehicle per citizen ratios from five sample jurisdictions (Detroit, Grand Rapids, Waterford, Bay City, and Huntington Woods), projecting a total state-wide fleet of nearly 90,000 by 2050 and using the assumption that these are all electrified by 2050. For school buses, all are assumed to be electrified by 2050, at a rate of approximately 623 per year. Tribal fleet data was not included in quantification because of the small numbers of vehicles and to balance any potential overestimations across the municipal fleet estimations.

Quantified Emissions Reduction:

Table 19: Transportation Reduction Measure 4: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.04	-0.02

Table 20: Transportation Reduction Measure 4: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-0.41	-0.32
NO_x	-132.94	-101.55
$PM_{2.5}$	-1.65	-1.35
VOC	-34.65	-25.00

Transportation Reduction Measure 5:
Support land use and transportation planning that will enable high-density, mixed-use development

Measure Description: To reduce GHG emissions and foster more sustainable communities, Michigan can align transportation and land use planning to support high-density, mixed-use development. By concentrating housing, jobs, services, and transit in to compact, walkable or bikeable areas, the state can lower transportation-related emissions in urban areas and reduce development pressure on natural and agricultural lands.

Smart growth strategies that promote infill development, transit-oriented design, and zoning reform can help Michigan communities become more vibrant, affordable, and resilient. Coordinated planning efforts could prioritize expanding access to public transit, bike and pedestrian infrastructure, and affordable housing near major employment hubs. These efforts are especially important in areas facing economic transition, population growth, or infrastructure strain. By investing in dense, mixed-use neighborhoods, Michigan can enhance quality of life, reduce energy consumption, and make meaningful progress toward climate and equity goals. A study from the University of Utah shows that a 10% increase in compactness reduced fatal crashes by 13.8%, increased public transit mode share by 11.5%, and reduced transportation costs by 3.5%

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MDOT and the OFME, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 levels by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually. A more specific milestone developed by the MHCP is to increase access to public transit by 15% each year through 2030.

Metrics that may be used to track this reduction measure include increase in infill mixed-use development, reduction in traffic crash rates, and other metrics as identified.

Costs: Housing and transportation costs are the first and second largest expenditures for consumers in the U.S. respectively. Expanding modes of transportation such as walking and cycling allows these consumers to spend less on fuel and car maintenance.

Beyond transportation cost savings, an increase in housing supply drives down overall housing costs. However, denser housing types can have a higher cost per square foot (sq ft) due to different construction techniques, such as high-rise vertical concrete construction compared to low- and mid-rise wood frame construction.

Intersection with Other Funding: Programs and funding allocations outlined in Transportation Reduction Measure 2 also apply to this reduction measure.

The MDOT, in partnership with the OFME, awarded $6.5 million in funding to 27 municipalities and eight transit agencies as part of the Shared Streets and Spaces Program. The program supports quick-build projects led by incorporated cities and transit agencies that improve plazas, sidewalks, curbs, streets, bus stops, parking areas, and other public spaces in support of public health, safe mobility, and strengthened commerce.

Additionally, the Redevelopment Ready Communities program is a voluntary technical assistance initiative offered through the MEDC to empower communities to shape their future by building a strong foundation of planning, zoning, and economic development best practices.

In 2024 the OFME, with support from the Community Economic Development Association of Michigan and Wayne State University, launched the MI Mobility Fellows Program. The Fellows program will support mobility tech startups and founders who work with transit and economic development agencies throughout Michigan to address mobility and transportation planning challenges.

Quantification Methodology: To estimate emissions reductions from land use strategies, historical data from the MDOT's Roadway Statewide Statistics Reports and the Michigan State Police Criminal Justice Information Center's Crash Reports was compiled. The implementation of this CCAP scenario assumes, in line with other states' PCAPs, a 5% reduction in vehicle miles traveled by 2030 and a 15% reduction by 2050. The emissions impact of this reduction was calculated by applying a per-mile CO_2 emission factor of 296 grams, based on data from the Bureau of Transportation Statistics.

Quantified Emissions Reduction:

Table 21: Transportation Reduction Measure 5: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-1.36	-3.78

Note: EPA's AVERT co-pollutants calculations were not available for this measure, though it will likely result in similar benefits as previous reduction measures, such as improved air quality and a healthier environment for communities.

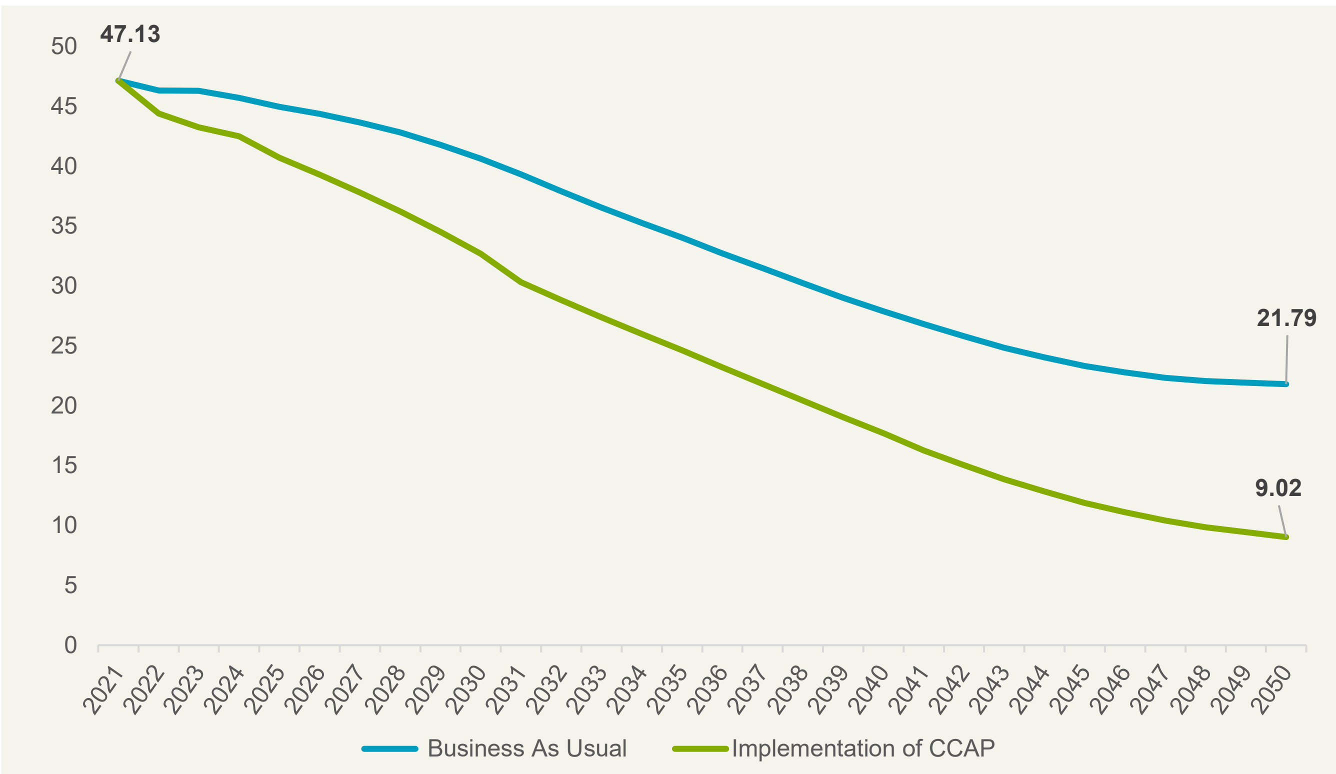
Transportation Sector Summary

The following data, along with benefits and workforce considerations, is derived from aggregating the impact of all reduction measures listed in this sector.

Table 22: Transportation Sector: Quantified GHG Emissions Reductions across All Transportation Measures (Measured in $MMTCO_2e$)

Scenario	2021	2030	2050
BAU	47.13	40.62	21.79
Implementation of the CCAP	-	32.70	9.02
Difference between BAU and Implementation of CCAP	**-**	**-7.92**	**-12.77**

Figure 18: Transportation Sector: Annual Quantified GHG Emissions Reductions across All Transportation Measures (Measured in $MMTCO_2e$)



Additional Efforts to Reduce Emissions across the Transportation Sector

Beyond these measures, an estimated 9.02 $MMTCO_2e$ will still need to be abated by 2050. Some additional efforts to reduce emissions in this sector include:

- **Rail:** Rail contributes 0.72 $MMTCO_2e$ to transportation sector emissions. Expanding passenger rail options can reduce reliance on personal vehicles and short-haul flights. Investments in rail also support dense, transit-oriented development that complements land use strategies. Rail transit was not included in emissions reduction calculations in Transportation Reduction Measure 2 due to difficulty isolating emissions specific to Michigan. Beyond passenger rail, increasing rail freight can help to reduce reliance on long-haul freight via heavy duty trucks.

- **Utility and Recreation Vehicles:** In 2021, according to Michigan Department of State data, there were 999,056 watercraft, snowmobiles, and mopeds registered in the state. These vehicles contribute 1.99 $MMTCO_2e$ to transportation sector emissions. Electrifying utility vehicles (e.g., maintenance fleets) and recreational vehicles (e.g., ATVs, snowmobiles) can reduce fossil fuel consumption in these smaller subsectors.

Qualitative and Quantitative Benefits Analysis across the Transportation Sector

Implementing a suite of transportation emission reduction strategies in Michigan, including public transit expansion, vehicle electrification, and land use planning, provides significant co-benefits for communities across the state. As shown in Table 23, reducing fossil fuel use through electrification of vehicles and transportation not only reduces CO_2 emissions but also emissions of co-pollutants such as $PM_{2.5}$ and SO_x. These air pollutants harm the human respiratory system and make breathing difficult for people with asthma, especially children. They also contribute to haze and reduced visibility. The benefits of reduced co-pollutant emissions are especially impactful in overburdened communities, where air pollution disproportionately harms public health.

Enhanced transit and non-motorized transportation also improve community health and safety by fostering greater interaction, reducing isolation, and increasing accessibility. Transit is also cost-effective, making mobility access more affordable for low-income residents.

These strategies offer strong economic returns as well. Improved transit systems support job access, connect residents to education and government services, and stimulate economic growth, especially near transit hubs. However, realizing these benefits requires addressing infrastructure gaps, funding challenges, and the need for better integration across transportation modes and regions. A comprehensive approach that links housing, governance, and transit planning can help build cohesive systems that serve all communities equitably.

The suite of reduction measures presented for the Transportation sector bring about statewide emissions reductions beyond GHGs. Below, emissions of select co-pollutants are shown for the base year of 2021, along with anticipated reductions from the BAU scenario in the year 2030 and 2050.

Table 23: Transportation Sector: Quantified Co-Pollutant Emissions Reductions across All Transportation Measures (Measured in Metric Tons)

Co-Pollutant	Base Year (2021)	Difference between BAU and Implementation of all Transportation Measures 2030	Difference between BAU and Implementation of all Transportation Measures 2050
SOx	481.72	-43.90	-135.13
NOx	77,697.60	-4,499.10	-5,659.30
PM2.5	2,896.72	-149.77	-270.28
VOC	34,324.80	-3,794.15	-3,690.28

Quantifying emissions reductions allows for the calculation of quantifiable community benefits, which are detailed below. These co-benefit estimates were provided by the EPA's COBRA, after inputting the co-pollutant emissions reductions listed in Table 23. Additional detail on the selection of community benefits is available in Benefits of GHG Emission Reduction Measures to LIDACs (Section 7.3).

Table 24: Estimated Community Benefits in the Near-Term and Long-Term across the Transportation Measures

Benefit	Cumulative Impact, 2025 through 2030	Cumulative Impact, 2025 through 2050
Avoided Lost Workdays	940	1,400
Avoided Respiratory Symptom Cases	12,000	16,000
Avoided Hospital Admissions	1.8	2.4
Avoided Minor Restricted Activity Days	5,600	8,500

Figure 19: Avoided Deaths by Race across the Transportation Measures, 2025-2030

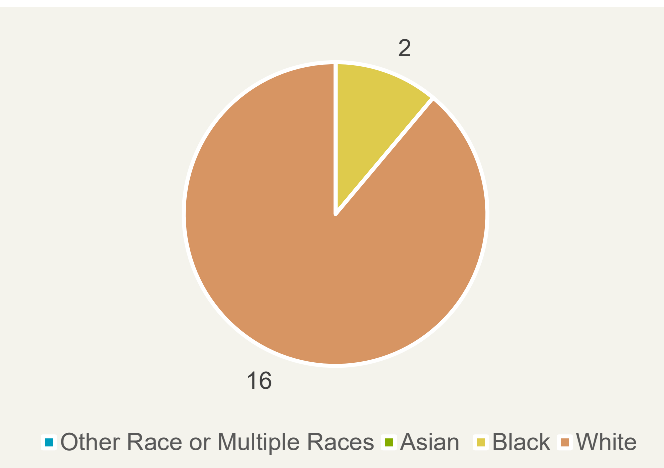
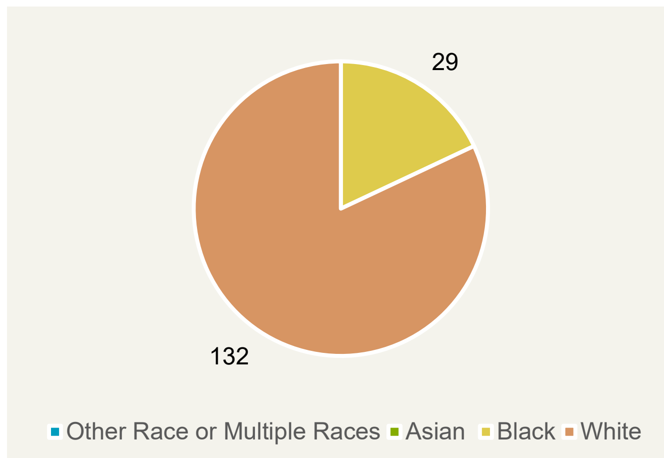


Figure 20: Avoided Deaths by Race across the Transportation Measures, 2025-2050



Note: Avoided Deaths by Race data was collected from the EPS, based on portions of the quantified co-benefits listed above. Emission reductions from Transportation Reduction Measure 5, which were calculated manually, were not included in Figures 19 and 20 above. Where races are not present in Figures 19 and 20 above, avoided deaths were estimated to be zero.

Workforce Considerations across the Transportation Sector

Transportation has always been a critical sector in Michigan, where automobile manufacturing dominates. With changing technology and innovation around mobility, the definition of the sector has evolved and will continue to change. To support transportation decarbonization, it is important to ensure that the workforce adapts and grows alongside these changes.

Current mobility-related employment, which includes manufacturing, service, and transportation, supports 433,000 jobs, accounting for 10.5% of Michigan's total employment. The clean transportation subsector, focused on alternative fuels and emerging technologies to reduce emissions from transportation, employs nearly 35,000 workers. Between 2015 and 2021, clean transportation jobs in Michigan grew by 5.4%, even as overall statewide employment declined 0.7%. In 2022 alone, the sector added over 4,000 new jobs, largely driven by the automotive industry's shift toward EVs.

According to the 2024 Clean Jobs America report, Michigan ranks second nationally for clean vehicle employment, with 33,953 clean vehicle jobs, including: 15,376 in HEVs, 6,950 in PHEVs, 9,850 in BEVs, and 1,778 in hydrogen/fuel cell vehicles. Michigan also ranks sixth in the U.S. for EV battery manufacturing employment with 1,500 workers. As automakers and suppliers accelerate electrification and Michigan works towards 2 million electric vehicles by 2030, clean transportation jobs are expected to continue growing across the state.

Beyond electric vehicle manufacturing and clean transportation jobs, the largest occupations for mobility-related employment in Michigan are Cutting, Punching, and Press Machine Operators, Heavy and Tractor Trailer Truck Drivers, and Automotive Service Technicians/Mechanics, respectively. The occupations with the most projected growth through 2030 are Industrial Machinery Mechanics (28.2%), Flight Attendants (21.5%), Industrial Engineers (20.4%), Passenger Vehicle Drivers (18.2%), and Millwrights (18.1%).

Anticipated Workforce Shortages: There are projected to be over 32,400 average annual openings among the 25 key occupations in the transportation sector. These openings are due to the significant growth of the sector and to labor force exits, retirements, and occupational transfers. The occupations with the most projected annual openings through 2030 are Laborers and Freight, Stock, and Material Movers (12,540), Miscellaneous Assemblers and Fabricators (10,255), Heavy and Tractor Trailer Truck Drivers (7,635), Light Truck Drivers (3,465), and Supervisors or Production and Operating Workers (3,190).

A projected shortage of truck drivers could pose a significant challenge to Michigan's transition to electric heavy-duty vehicles by 2050, as workforce gaps may slow the adoption, operation, and maintenance of new vehicle technologies across the freight and logistics sectors.

Solutions to Address Workforce Shortages: There are a variety of programs across LEO, including the crucial work of the CWETO, and the Michigan Department of Treasury to address these anticipated workforce shortages.

Michigan is investing in transportation workforce development through partnerships like the Federation for Advanced Manufacturing Education and the Michigan Alliance for Greater Mobility Advancement. The MI Auto Workforce Hub convenes Michigan automotive workforce partners to identify shared problems and develop stakeholder-informed, consensus-based solutions that build and sustain a robust automotive workforce in Michigan. The MI Mobility Fellows Program offers real-world experience in transportation planning and mobility innovation for individuals looking to start careers in the transportation sector. The Build Michigan Infrastructure Workforce Program and the $25 million Mobility Futures Initiative further support workforce growth in EV manufacturing workforce, infrastructure, and mobility innovation, with 84 in-demand occupations identified across 11 infrastructure sectors, many of which are automotive and transportation related.

Registered Apprenticeships are vital to ensuring a skilled workforce is in place to build, service, and innovate next-generation transportation technologies. The number of registered apprentices in the transportation and warehousing industry has been on the rise over the last decade, from 133 active registered apprentices in 2015, to 283 active registered apprentices in 2024, and 251 active registered apprentices so far in 2025.

Evidence of Michigan's commitment to addressing the transportation workforce transition can be found by looking at the goals established by the MI Future Mobility Plan 1.0, Pillar 1: Transition and Grow Our Mobility Industry and Workforce. The goal to create 20,000 new jobs in the mobility and automotive sector by 2026 has already been surpassed, with 26,745 jobs added. The goal to add 7,000 workers with mobility credentials by 2030 has been far surpassed with over 23,000 workers with mobility credentials added. The goal to support 170,000 automotive manufacturing jobs by 2030 has also been surpassed with 197,382 jobs supported.

There is still work to be done as Michigan advances toward a decarbonized transportation system. A key priority is upskilling current workers in fossil fuel dependent occupations, so they can transition into roles that support EVs and public transit. Ensuring equity and accessibility in workforce development is also essential and programs must continue to be designed to reach underrepresented communities, remove barriers to participation, and provide pathways to quality jobs in clean transportation for all Michiganders. Meeting these challenges will be critical to building a workforce that can support the state's climate goals.

Commercial and Residential Buildings

Commercial and Residential Buildings Reduction Measures
Support electrification in residential buildings, including an emphasis on households that rely on delivered fuels such as propane and home heating oil
Support household energy use reduction through home repairs, weatherization, and other energy waste reduction investments
Encourage energy efficiency enhancements, electrification, sustainable design, and retrofitting to reduce emissions from commercial buildings
Support electrification and energy waste reduction efforts for state government, municipal, Tribal, and nonprofit facilities

About the Sector

Buildings account for 16.6% of Michigan's total GHG emissions, driven largely by fossil fuel use for space and water heating as well as cooking in both residential and commercial sectors. Over 60% of Michigan's single-family homes were built before 1980, predating modern building energy codes and often lacking basic insulation or efficient heating, ventilation, and air conditioning (HVAC) systems. Some of the building stock relies on delivered fuels, such as propane and fuel oil, for heating, predominantly in the rural northern Lower Peninsula and the Upper Peninsula. For example, over 50% of households in northern counties heat with propane. As of 2023, 77% of Michigan homes used natural gas for heating. Electric resistance heating is still common in older multifamily housing. Overall, the opportunity for carbon and cost savings through electrification and improved energy waste reduction is substantial.

Strategies for upgrading homes will differ across building types and ownership structures. According to the State of Michigan Housing Data Portal, approximately 72.9% of households are homeowner occupied, with 27.1% renter occupied. Approximately 82% of the 3.3 million single family homes in Michigan are owner-occupied. A little over 36% of renters live in single family homes, and close to 60% live in apartment buildings (28.3% in 2-9 unit apartments, 19.9% in 10-49 unit apartments, and 11.5% in 50+ unit apartments).

On the commercial side, Michigan's building stock spans 2 billion sq ft, with NREL's ComStock dataset showing that warehouse, storage, and retail spaces make up the largest share, together consuming over 17 billion kWh annually. However, energy-intensive uses such as Food Service and Healthcare facilities, which account for the state's highest natural gas and district heating loads respectively, represent potential electrification targets. Meanwhile, public buildings are uniquely positioned for deep retrofits due to long-term ownership and access to public funding, allowing them to reap the long-term cost-saving benefits of upfront energy efficiency investments.

Together, these strategies support the MHCP goals of reducing residential and commercial heating emissions 17% by 2030, achieving 2% electric efficiency savings annually, adopting the 2021 Model Energy Code, and exploring financing opportunities to help families, small businesses, and schools invest in clean energy projects.

GHG Emissions Reduction Measures across the Commercial and Residential Buildings Sector

Commercial and Residential Buildings Reduction Measure 1:
Support electrification in residential buildings, including an emphasis on households that rely on delivered fuels such as propane and home heating oil

Measure Description: On average, 70% of annual residential energy use goes toward space and water heating. Most homes still rely on fossil fuels, especially in rural areas, where delivered fuels like propane and heating oil are prevalent. According to the EIA, Michigan uses more propane in the residential sector than any other state in the country. An estimated 320,000 Michigan households use propane as their primary heating fuel, with over half of those homes in low- or moderate-income communities.

Air-source heat pumps and heat pump water heaters only use about 25% of the energy of traditional delivered fuel systems. Recommendations from RMI and ACEEE note that targeted electrification of delivered fuels in cold-climate states is one of the most cost-effective and high-impact decarbonization levers available.

Beyond electrification, residential buildings can also utilize direct use and district heating geothermal systems. Rather than combusting fuels onsite or using electricity, these systems rely on the latent temperature of the Earth to provide heat to buildings.

This measure does not cover weatherization or energy efficiency improvements (see Commercial and Residential Buildings Reduction Measure 2).

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the Michigan State Housing Development Authority (MSHDA), Michigan Department of Health and Human Services (MDHHS), and the MPSC will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

A more specific milestone, presented in the MHCP, is to reduce emissions related to heating homes and businesses by 17% by 2030. This goal equates to reducing heating emissions in buildings by at least 3% each year between 2025 and 2030.

Metrics that may be used to track this reduction measure include the number of homes converted from delivered fuels to electric heating systems, the number of heat pumps installed, the average cost savings per converted home, the average BTU savings per converted home, emissions from heating and cooling in residential buildings, and other metrics as identified.

Costs: Transitioning homes to residential heat pumps, specifically in cold-weather climates, can cost $5,000 - $10,000, plus installation costs. There may also be additional panel or ductwork upgrades that are needed. An analysis by Rewiring America however, shows that roughly 1.4 million Michigan households could save a collective $710 million annually by switching from current systems to modern, electric furnaces and water heaters, with an average savings of $513 per household.

Notably, savings are not guaranteed for all natural gas customers who exclusively transition to heat pumps. Without weatherization and energy waste reduction fixes around the home, transitioning to a heat pump could increase utility bills by $1,100 annually for these customers.

Intersection with Other Funding: Rewiring America launched a Michigan Home Energy Incentives Calculator to help residents identify available federal and state-specific tax credits, incentives, and rebates. The Michigan Home Energy Rebates program (MiHER) is funding electrification upgrades for approximately 15,000 Michigan homes, helping to reduce monthly utility costs, reduce energy use, and enhance comfort and indoor air quality.

Quantification Methodology: Emissions reductions from building electrification and fuel-switching were quantified using the EPS. A 75% reduction in energy use by 2050 for all major building systems (heating, cooling, ventilation, envelope, appliances, etc.) was used to reflect improvement in energy efficiency. In addition, it was assumed that 100% of sales of traditionally non-electric components (heating, cooling, ventilation, appliances, etc.) would be electric by 2050. The model assumes prioritization of rural households using propane and heating oil in the near term and expands to natural gas users over time.

Quantified Emissions Reduction:

Table 25: Commercial and Residential Buildings Reduction Measure 1: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-1.65	-16.41

Table 26: Commercial and Residential Buildings Reduction Measure 1: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-34.56	-408.15
NO_x	-1,328.80	-13,462.80
$PM_{2.5}$	-1,441.80	-17,002.60
VOC	-1,022.40	-12,603.80

Commercial and Residential Buildings Reduction Measure 2:
Support household energy use reduction through home repairs, weatherization, and other energy waste reduction investments

Measure Description: More than half of all Michigan homes were built before 1980, predating modern state building energy codes and thus lacking proper insulation and air sealing. Upgrading this pre-1980 housing stock, therefore, provides an opportunity for significant emissions reductions. These upgrades, meant to improve building envelopes and enhance efficiency, may include insulation, window sealing, and roof treatments. This measure also calls for energy efficient technology to be installed in all new construction.

The poor efficiency of Michigan's aging housing stock also presents equity concerns. According to a University of Michigan 2024 study, the lowest-income households in a Southeast Michigan sample had the least energy-efficient homes. Energy costs in some rural and urban census tracts exceed 10% of household income – far above the MHCP goal of capping energy burden at 6%.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MSHDA, the MDHHS, and the MPSC, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

A more specific milestone, presented in the MHCP, is to reduce emissions related to heating homes and businesses by 17% by 2030. This goal equates to reducing heating emissions in buildings by at least 3% each year between 2025 and 2030. Additional goals have been outlined in the MHCP for achieving these emissions reductions, including achieving at least 2% annual electric energy efficiency savings.

Metrics that may be used to track this reduction measure include the number of homes retrofitted (specifically pre-1980 homes), average improvement in energy intensity per retrofitted home, cost savings from energy efficiency and weatherization programs, emissions from heating and cooling in residential buildings, and other metrics as identified.

Costs: Weatherization costs are influenced by things like the size and condition of the home, the type of insulation used, the age and efficiency of the HVAC system, etc., with the average U.S. cost around $2,500. Key components include air sealing ($500–$1,500), which involves sealing leaks around doors, windows, pipes, and wiring; insulation ($1,000–$3,000), which helps regulate indoor temperature year-round; and HVAC upgrades ($1,000–$5,000), which improve heating and cooling efficiency. Older or poorly maintained homes typically require more extensive and costly interventions, but weatherization efforts can lead to long-term energy savings and improved home comfort. These weatherization improvements and upgrades can save households an average of $372 every year.

Under Michigan law, electricity providers must achieve an energy waste reduction (EWR) target of 1.5% of total retail sales each year and natural gas providers must hit 0.875%. The MPSC's latest Annual Report on the Implementation of Public Act 295 found that Michigan's electric and natural gas utilities spent more than $551 million on EWR programs in 2023, which is estimated to save customers $1.4 billion over 12 years. For every dollar spent on EWR programs, customers realized savings of $2.54.

Intersection with Other Funding: The State of Michigan has several existing initiatives related to energy waste reduction. EGLE's MiHER helps households save on energy expenses through home energy improvements and new, more efficient appliances. The Weatherization Assistance Program, administered by the MDHHS, helps to make homes more energy efficient with services like Home Energy Audits; sealing; attic, foundation, wall, or sill box insulation; programmable thermostat installation; furnace or water heater tune-up or replacement; refrigerator replacement; and lightbulb replacement. Additionally, $7.4 million has been awarded in grants to organizations across the state as part of the MSHDA's Michigan Housing Opportunities Promoting Energy Efficiency program. MSHDA's MI Neighborhood program, which is currently slated to run three rounds of funding at $60 million each, can also be used for energy efficiency improvements. Finally, the Michigan Energy Assistance Program, administered by the MPSC, awarded $54.5 million in grants to provide energy assistance payments and self-sufficiency services to approximately 54,028 low-income households. The MPSC also oversees EWR programs, which are implemented directly by utilities or by Efficiency United.

Quantification Methodology: Emission reductions from residential retrofits and contractor training were modeled using the EPS. The model accounts for energy savings from upgraded heating, cooling, and envelope systems, particularly in pre-1980 housing stock. Urban retrofits prioritize multifamily units with high energy burden, while rural retrofits emphasize weatherization and heating upgrades. In addition, it was assumed that 100% of urban and rural residential buildings would be retrofitted by 2050. A "Contract Training" option was selected to reflect improved installation quality.

Quantified Emissions Reduction:

Table 27: Commercial and Residential Buildings Reduction Measure 2: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-1.46	-7.16

Table 28: Commercial and Residential Buildings Reduction Measure 2: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-53.68	-259.89
NO_x	-1,282.40	-6,242.00
$PM_{2.5}$	-2,096.10	-10,313.30
VOC	-1,675.20	-8,255.50

Commercial and Residential Buildings Reduction Measure 3:
Encourage energy efficiency enhancements, electrification, sustainable design, and retrofitting to reduce emissions from commercial buildings

Measure Description: Michigan's commercial sector spans about 2 billion sq ft and consumes roughly 44.67 billion kWh each year. Most commercial square footage comes from warehouse, storage, and retail facilities, which consume energy at moderate intensities of roughly 13–30 kWh/sq ft. Education and office buildings operate near 25 kWh per sq ft. Food-service facilities, by contrast, average 133 kWh per sq ft due to the energy intensive needs of cooking, ventilation, and refrigeration. Healthcare facilities have the state's highest district-heating load at 1.2 kWh/sq ft and sizable natural-gas intensity at 12.8 kWh per sq ft.

Decarbonizing Michigan's commercial buildings will require both deep retrofits that slash plug, lighting, and envelope loads across the state's vast commercial floor area as well as targeted electrification of high-intensity end uses, such as those in food-service facilities, space-heating, and process loads. Michigan's commercial buildings can also benefit from the use of geothermal systems to provide heat. Paired with the updated commercial building energy code for new construction, this approach positions Michigan's businesses to cut operating costs, reduce emissions, and capture the air-quality benefits of advanced electric HVAC and cooking systems.

As of April 2025, Michigan's updated commercial building energy code includes Functional Performance Testing (FPT) for all new construction, additions, and renovations. FPT aims to verify that building systems such as HVAC, lighting, water heating, and building envelope features are operating as designed and are maximizing energy efficiency, occupant comfort, and system longevity. Though not included in the 2025 energy code update, new construction can further its emissions reduction impact by utilizing sustainable materials such as mass timber.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MSHDA, MDHHS, and MPSC will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

A more specific milestone, presented in the MHCP, is to reduce emissions related to heating homes and businesses by 17% by 2030. This goal equates to reducing heating emissions in buildings by at least 3% each year between 2025 and 2030. Additional goals have been outlined in the MHCP for achieving these emissions reductions, including achieving at least 2% annual electric energy efficiency savings.

Metrics that may be used to track this reduction measure include the number of businesses retrofitted, commercial energy use intensity, cost savings from energy efficiency and electrification programs, emissions from heating and cooling in commercial buildings, and other metrics as identified.

Costs: While there are significant upfront costs of new electric and heating and cooling systems in commercial buildings, the annual energy savings often outweigh those costs over the lifetime of the equipment. Heat pumps can range in cost from $12 to $24 per sq ft, depending on building type. However, energy cost reductions average out to $2.58 - $4 per sq ft each year. Additionally, costs will likely continue to decrease as more equipment comes onto the market and prices become more competitive.

The new building code and accompanying improvements in energy efficiency are expected to save Michigan businesses approximately $0.073 per sq ft in operating costs. The cost of construction however, may increase due to additional commissioning, extra wiring, new metering requirements, and upgrades to meet envelope and equipment performance standards.

Intersection with Other Funding: In 2024, EGLE launched the Michigan Climate Investment Accelerator, which aims to attract hundreds of millions of dollars to finance the development of clean energy and energy efficiency projects for consumers, businesses, nonprofits, and local governments throughout Michigan. Additionally, Section 179D of the Internal Revenue Code offers federal tax deductions of up to $5.81 per sq ft for businesses investing in energy efficiency improvements in commercial buildings.

Through its Qualified Allocation Plan, the MSHDA requires applicants to the Low Income Housing Tax Credit to obtain a green building certification through Enterprise Green Communities, National Green Building Standard, or U.S. Green Building Council LEED. Many of the applicants also pursue zero energy certifications through these third-party certifiers.

The state is also committed to private-public partnerships, like the 2030 Districts Network, which provides leadership and resources to reduce emissions in the built environment. Ann Arbor/Washtenaw County, Detroit, Grand Rapids, and Lansing make up four of the 26 districts across North America.

The state also supports partners like the Michigan State University Industrial Training and Assessment Center, which works to increase efficiency and productivity and reduce environmental impacts of small- to medium-sized commercial buildings across Michigan. Lawrence Technological University's Retired Engineers, Scientists, Technicians, Administrators, Researchers, and Teachers (RESTART) program also provides energy waste reduction and sustainability services to businesses, ensuring competitiveness and creating and retaining jobs.

At the federal level, the DOE's Commercial Buildings Integration program helps identify and develop strategies to reduce commercial building energy consumption, with a focus on innovative, cost-effective, energy-saving measures. Additionally, while not a source of funding, the Better Buildings Challenge presents an opportunity for commercial buildings across the country to share solutions, report on progress, and learn from each other.

Quantification Methodology: Emissions reductions from commercial building decarbonization were quantified using the EPS. This scenario assumes 100% electrification of new commercial heating systems, appliances, and other components by 2050. Additionally, the scenario assumes 100% of existing commercial buildings are retrofitted by 2050, and aggressive energy efficiency standards are applied, amounting to a 75% reduction in energy use across all major building systems. These inputs reflect a transition to net-zero-ready construction and advanced energy controls.

Quantified Emissions Reduction:

Table 29: Commercial and Residential Buildings Reduction Measure 3: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.87	-9.65

Table 30: Commercial and Residential Buildings Reduction Measure 3: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-14.95	-189.85
NO_x	-699.20	-7,848.00
$PM_{2.5}$	-505.90	-7,021.60
VOC	-286.00	-4,402.50

Commercial and Residential Buildings Reduction Measure 4:
Support electrification and energy waste reduction efforts for state government, municipal, Tribal, and nonprofit facilities

Measure Description: Decarbonizing government owned and nonprofit institutions, including schools, provides a critical opportunity for Michigan to lead by example. These facilities represent a significant portion of the state's building stock and energy use, and unlike private sector buildings, their public mission and long ownership timelines make them uniquely positioned to invest in deep energy retrofits, electrification, and renewable energy.

In 2020, Governor Whitmer announced that all State-owned buildings would be powered by 100% renewable energy by 2040 and set a goal to lower the energy intensity in state buildings by 40% by 2040. In 2022, the State announced a 59% reduction in building energy consumption for state-owned buildings since 2005 levels, and in 2025, it procured 100% renewable energy for state-owned buildings through the purchase of renewable energy credits. New facility and major renovation projects are rare, but most of the State's new facilities are managed by the Michigan Department of Technology, Management, and Budget (DTMB) and are designed to incorporate sustainability and achieve the State's climate goals. When other agencies have project needs, DTMB's Design and Construction Division works with them to develop a project that meets their needs and budget while supporting the goal of carbon neutrality.

Many local governments in Michigan that have climate action plans also include "lead by example" measures that focus on addressing municipal building-related emissions. Additionally, many PCAPs for Tribes in Michigan included energy efficiency and electrification measures for government buildings. The Little Traverse Bay Band of Odawa Indians, for example, estimates an annual reduction of 18.8 tCO_2e from the installation of a heat pump and LED lighting in Tribal owned housing. Within the Intertribal Council of Michigan Combined PCAP, the Nottawaseppi Huron Band of the Potawatomi estimates an annual reduction of 10 tCO_2e from the installation of LEDs at the Tribal greenhouse and the Bay Mills Indian Community estimates an annual reduction of 0.31 tCO2e from various efficiency improvements across Tribal facilities.

Meanwhile, nonprofit institutions, such as college buildings and hospitals, are often overlooked in commercial energy programs, despite providing key community services. Supporting deep energy efficiency upgrades, electrification, and deployment of renewable energy systems in these buildings can reduce emissions, lower utility costs, and improve resilience.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with DTMB, municipalities, and Tribal governments, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

More specific milestones introduced by the MHCP include reducing emissions related to heating homes and businesses by 17% by 2030 and achieving at least 2% energy efficiency savings annually. Executive Directive 2020-10 also ordered DTMB to develop policies to ensure all new State-owned buildings and all major renovations of such buildings are carbon neutral by 2040 and to ensure all existing State-owned buildings reduce energy usage by 40% by 2040. Metrics that may be used to track this reduction measure include the number of state buildings electrified and powered by clean energy; the number of energy efficiency upgrades made across local and Tribal governments; percentage of state, local, and Tribal government buildings electrified; the number of weatherization upgrades made in schools; the number of waste reduction projects across the state; and other metrics as identified.

Costs: Depending on the size and specific needs, upgrading buildings across Michigan's public sector involves similar costs and incentives as those mentioned in Commercial and Residential Buildings Reduction Measures 1-3.

For schools specifically, nearly $23 billion and 10 years are needed to carry out essential infrastructure improvements. Notably, incurring this cost addresses several aspects of student health, safety, and wellbeing needs beyond the scope of this reduction measure. The largest portion of this total cost however, is for HVAC repairs and upgrades, which is estimated to be $7.5 billion.

Beyond schools, investing in energy efficiency and electrification offers both economic and environmental benefits for nonprofits and other tax-exempt organizations, as well as the communities they support. Since energy costs are often the second-largest operational expense for nonprofits, conducting an energy audit and embedding energy efficiency can significantly help reduce costs. These savings not only enhance sustainability but also free up resources to better advance their core missions.

Intersection with Other Funding: Through a $2.7 million formula grant from the DOE's Energy Efficiency and Conservation Block Grant Program, EGLE provides financial assistance for communities to improve energy management and accelerate the implementation of energy efficiency through the Community Energy Management Program. Additionally, the Sacred Spaces Clean Energy Grants provide funding to make low-income places of worship more energy efficient. Three Tribes in Michigan – Lac Vieux Desert Band of Lake Superior Chippewa, Nottawaseppi Huron Band of Potawatomi, and Pokagon Band of Potawatomi Indians – received EPA CPRG Implementation grants to fund efforts related to energy efficiency and to install heat pumps in Tribal buildings.

Quantification Methodology: This measure quantifies emissions reductions from a combined total of approximately 195 million sq ft of Michigan government buildings (state, local, and federal), and 1.24 billion sq ft of nonprofit facilities, as derived from MiCPR, Commercial Buildings Energy Consumption Survey, and Michigan nonprofit census data. Baseline emissions for government and nonprofit buildings were estimated from the energy use intensities utilized in NREL's ComStock Analysis Tool. A 30% reduction in emissions from energy efficiency and a 15% reduction from electrification by 2030 were assumed. Emission reductions were assumed to be 35% and 60%, respectively, from 2030-2050. Tribal facility data was not included in quantification because of data limitations and to balance any potential overestimations across the other facility categories included in this measure.

Quantified Emissions Reduction:

Table 31: Commercial and Residential Buildings Reduction Measure 4: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-5.57	-11.77

Note: EPA's AVERT co-pollutants calculations were not available for this measure, though it will likely result in similar benefits as previous reduction measures, such as improved air quality and a healthier environment for communities.

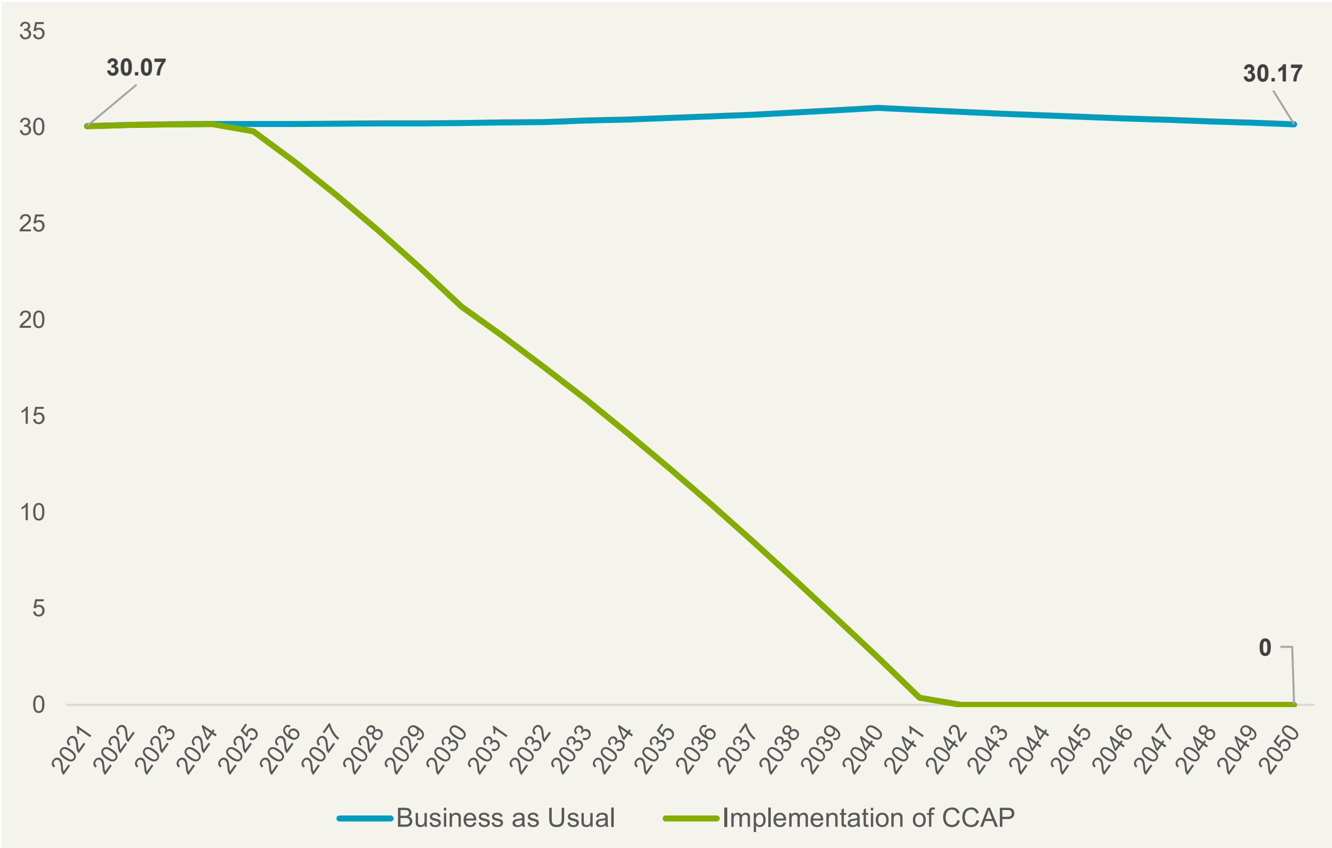
Commercial and Residential Buildings Sector Summary

The data below, along with benefits and workforce considerations, is derived from aggregating the impact of all reduction measures listed in this sector.

Table 32: Commercial and Residential Buildings Sector: Quantified GHG Emissions Reductions across All Commercial and Residential Buildings Measures (Measured in MMTCO$_2$e)

Scenario	2021	2030	2050
BAU	30.07	30.24	30.17
Implementation of the CCAP	-	20.69	0
Difference between BAU and Implementation of CCAP	-	**-9.55**	**-30.17**

Figure 21: Commercial and Residential Buildings Sector: Annual Quantified GHG Emissions Reductions across All Commercial and Residential Buildings Measures (Measured in $MMTCO_2e$)



Qualitative and Quantitative Benefits Analysis across the Commercial and Residential Buildings Sector

Reducing emissions in Michigan's Commercial and Residential Buildings offers significant public health, economic, and social co-benefits. Poorly maintained fuel-burning systems can degrade indoor air quality, introducing dangerous toxins like carbon monoxide (CO) and VOCs. Homes that rely on delivered fuels may be further exposed to harmful air pollutants such as $PM_{2.5}$, NO_x, and SO_x, which can contribute to respiratory illness, cardiovascular problems, smog, and acid rain. Building electrification reduces these direct emissions, improving indoor air quality, moderating humidity, and reducing carbon pollution. These changes directly enhance comfort, safety, and health for Michigan residents, especially in low-income and vulnerable communities.

Energy waste reduction measures, such as insulation, weatherization, and efficiency upgrades, reduce utility costs, improve thermal comfort, and lower overall energy demand. Building upgrades across local and state facilities can yield operational savings that benefit taxpayers while demonstrating best practices that businesses and residents can replicate. Moreover, the shift toward electrification and efficiency fosters green job creation, strengthens local contractor networks, and builds capacity in the state's energy workforce. Ensuring that residents have access to education, training, and decision-making opportunities further empowers communities and drives equitable benefits from the clean energy transition.

Across the state, the suite of reduction measures presented for the Commercial and Residential Buildings sector brings about reductions beyond GHGs. Below, emissions of select co-pollutants are shown for the base year of 2021, along with anticipated reductions from the BAU scenario in the years 2030 and 2050.

Table 33: Commercial and Residential Buildings Sector: Quantified Co-Pollutant Emissions Reductions across All Commercial and Residential Buildings Measures (Measured in Metric Tons)

Co-Pollutant	Base Year (2021)	Difference between BAU and Implementation of all Commercial and Residential Buildings Measures 2030	Difference between BAU and Implementation of all Commercial and Residential Buildings Measures 2050
SOx	820.95	-103.20	-857.89
NOx	25,292.90	-3,310.40	-27,552.80
PM2.5	31,431.60	-4,043.80	-34,337.50
VOC	23,088.30	-2,983.60	-25,261.80

Quantifying emissions reductions allows for the calculation of quantifiable community benefits, which are detailed below. These co-benefit estimates were provided by the EPA's COBRA, after inputting the co-pollutant emissions reductions listed in Table 33. Additional detail on the selection of community benefits is available in Benefits of GHG Emission Reduction Measures to LIDACs (Section 7.3).

Table 34: Estimated Community Benefits in the Near-Term and Long-Term across the Commercial and Residential Buildings Measures

Benefit	Cumulative Impact, 2025 through 2030	Cumulative Impact, 2025 through 2050
Avoided Lost Workdays	34,000 – 48,780	775,000 – 2,066,600
Avoided Respiratory Symptom Cases	27,315 – 155,000	1,158,450 – 4,000,000
Avoided Hospital Admissions	30 – 140	750 – 6,400
Avoided Minor Restricted Activity Days	200,000 – 1,289,200	4,500,000 – 12,250,050

Note: Ranges are reported for the Commercial and Residential Sector because this community benefit data was available via multiple data sources.

Figure 22: Avoided Deaths by Race across the Commercial and Residential Buildings Measures, 2025-2030

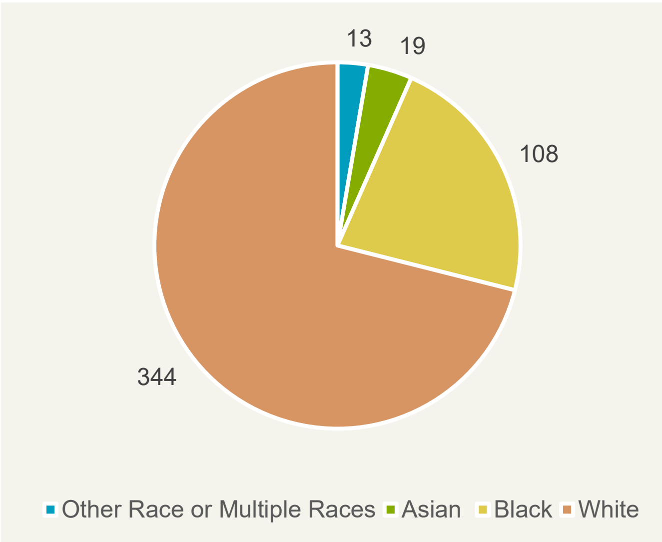
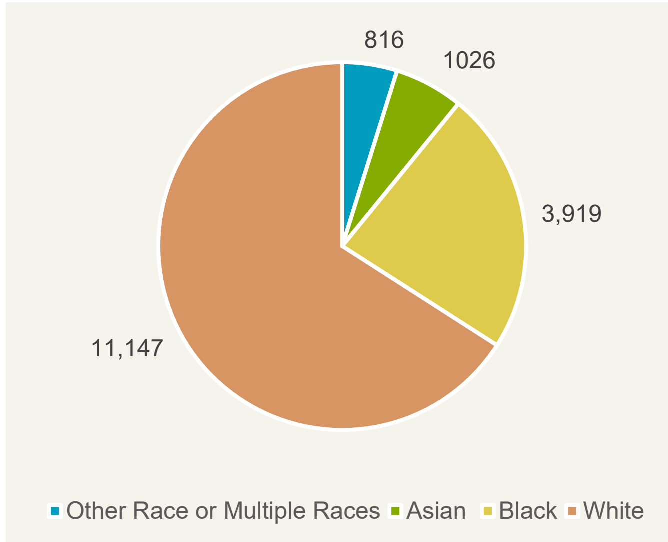


Figure 23: Avoided Deaths by Race across the Commercial and Residential Buildings Measures, 2025-2050



Note: Avoided Deaths by Race data was collected from the EPS, based on portions of the quantified co-benefits listed above. Emissions reductions from Commercial and Residential Buildings Reduction Measure 4, which were calculated manually, were not included in Figures 22 and 23 above.

Workforce Considerations across the Commercial and Residential Buildings Sector

Over 60% of the state's clean energy workforce is in the energy efficiency sector. These employees manufacture ENERGY STAR-rated appliances, install efficient lighting, and work on HVAC systems. Michigan has the fastest growing high efficiency HVAC and renewable heating and cooling workforce in the country, growing 9.6% between 2022 and 2024. Michigan also led the country in total number of advanced materials jobs and ranks sixth in overall clean energy employment.

The occupations with the most projected growth through 2030 are Millwrights (18.1%), Mobile Heavy Equipment Mechanics (14.5%), Electricians (13.1%), Civil Engineers (12.3%), and Woodworking Machine Operators (12%). While Michigan has momentum across these occupations, targeted programs and investments are needed to scale workforce capacity and fill growing gaps.

Anticipated Workforce Shortages: Between 2020 and 2030, it is projected there will be over 34,700 average annual openings across the 25 key occupations in the construction industry. The occupations with the most projected annual openings through 2030 are Landscaping and Groundskeeping Workers (4,725), Project Management Specialists (3,770), Construction Laborers (3,555), Sales Representatives of Services (3,010), and Mechanical Engineers (2,920). HVAC and Refrigeration Mechanics and Installers, critical roles for decarbonizing buildings, are expected to have 970 annual openings.

Solutions to Address Workforce Shortages: There are a variety of programs across LEO and the Michigan Department of Treasury that can help address these anticipated workforce shortages. Initiatives like EGLE's Clean Energy Workforce Development Program, address gaps in Michigan's public and private advanced energy workforce development training, for both participants and employers, increase access to wrap around services for training participants, and continue to build and maintain relationships with educational institutions at all levels. To accelerate workforce readiness, Michigan has invested in career and technical education programs and apprenticeship pipelines for construction and building trades. EGLE also has partnerships with the Building Operator Certification program, MI Energy Efficiency Contractors Association, Michigan Works, MI Energy Workforce Development Consortium, and MI Energy Innovation Business Council. The state's EWR programs, administered by utilities, also create demand for contractors who understand advanced efficiency practices.

Registered Apprenticeships are vital to ensuring a skilled workforce is in place to build, retrofit, and improve Michigan's commercial and residential buildings. The number of new registered apprentices in the construction industry has been on the rise over the last decade, from approximately 1,421 new registered apprentices in 2010, to a record 5,042 new registered apprentices in 2024.

Industry

Industry Reduction Measures
Promote and incentivize energy efficiency, waste heat recovery, and electrification across low to medium temperature industrial processes
Encourage emission reduction strategies from lime and cement manufacturing, including energy and material efficiency improvements, electrification, fuel switching, and clinker substitution
Encourage emission reduction strategies from iron and steel including electrification, material efficiency, energy efficiency, lower-temperature alternative production methods, and fuel switching
Encourage emission reduction strategies in gas and oil production, like methane capture and energy efficiency

About the Sector

Michigan's industrial sector is comprised of over 11,000 manufacturing companies spanning a range of industries, including Automotive, Metals, Chemical Products, Machinery, Food and Beverage, Natural Resources, Computer and Electronic Products, Furniture, Printing, and Medical Equipment and Supplies. Michigan is home to nearly 19% of all U.S. auto production, more than any other state in the nation, with over 1,000 independent automotive suppliers. Of the top 100 automotive suppliers in North America, 96 have a presence in Michigan and 60 are headquartered in the state.

Industrial sector emissions included here are “scope 1” emissions, or those that come from direct, onsite fossil fuel combustion and industrial processes. Emissions from the consumption of electricity that is produced off-site and supplied by utilities are captured in the Electricity Generation sector. Fuel combustion is relatively easy to decarbonize compared to process emissions because it primarily relies on changing energy feedstocks from fossil fuels to electricity.

Process emissions can be hard to decarbonize because they come from various chemical reactions that occur in some materials manufacturing. Several factors make these chemical reactions difficult to modify, such as their inherent need for high-temperature heat or the emerging nature of alternatives. According to the statewide GHG Inventory, these process emissions have risen by over 8% since 2005, from 12.68 $MMTCO_2e$ to 13.73 $MMTCO_2e$ in 2021. The iron and steel and refrigerants-related process emissions contribute the largest share of these emissions.

Given the diversity of operations across this sector, decarbonization solutions must be tailored to the specific needs of individual facilities. Even among Michigan’s approximately 100 largest industrial sites, heat demand and equipment complexity vary significantly. Some industries are particularly hard to decarbonize due to technological, economic, and logistical complexities, such as cement and steel.

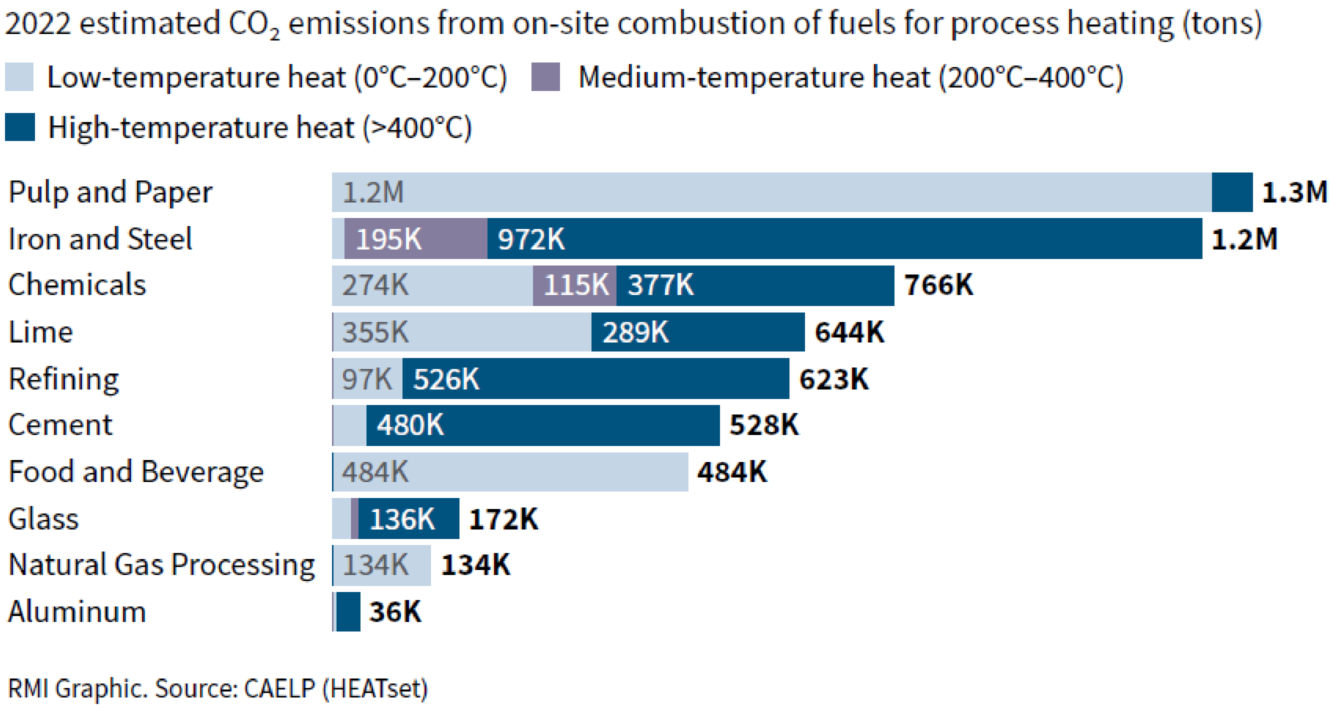
To address these diverse needs, the MHCP has outlined a set of strategies and goals for the industrial sector. These include establishing clean innovation hubs; strengthening procurement programs across public and private sectors to favor low-carbon and circular-economy products; offering incentives and technical assistance for energy efficiency; deploying combined heat and power in new facilities; transitioning existing facilities to renewable or lower-carbon fuels such as biogas, renewable natural gas or biomethane, and clean hydrogen; and exploring carbon capture, utilization, and sequestration (CCUS) in industrial applications where eliminating the use of fossil fuels is impossible or cost-prohibitive.

GHG Emissions Reduction Measures across the Industry Sector

Industry Reduction Measure 1:
Promote and incentivize energy efficiency, waste heat recovery, and electrification across low to medium temperature industrial processes

Measure Description: Nearly one third of Michigan’s industrial emissions come from industrial processes with a high demand for low (0-200°C) and medium (200-500°C) temperatures. The industries corresponding to these processes include: food and beverage, pharmaceuticals, chemicals, automotive, pulp and paper, and wood products. According to a 2025 report from RMI, approximately 40% of low- and medium-heat emissions are from the pulp and paper subsector, approximately 16% from food and beverage, 13% from chemicals, and 12% from lime manufacturing.

Figure 24: Annual Emissions by Industrial Subsector (2022)



While smaller manufacturing facilities represent a small fraction of fuel-based industrial emissions, these facilities will be the easiest to abate through existing programs like energy waste reduction, electrification, retooling grant programs, etc.

Support for electrification and energy efficiency is critical for eliminating emissions across these low-to-medium temperature industries. Significant fractions of the low- and medium-heat needs and process activities may be ideal candidates for electrification. Energy efficiency, as well as waste heat to power systems and fuel-switching to lower-carbon fuels, are other tools to reduce GHG emissions at these facilities.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the LEO and the MEDC, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

Metrics that may be used to track this reduction measure include the number of manufacturing facilities replacing existing equipment (e.g. furnaces, boilers, and process heaters) with electric alternatives, percentage of equipment replaced by 2030, number of industrial heat pump installations, number of facilities leveraging technical assistance from the Michigan State University Industrial Training and Assessment Center and the DOE Onsite Energy Technical Assistance Partnership at the University of Illinois at Chicago, and other metrics as identified.

Costs: This reduction measure requires a transition to electrified, low-to-medium temperature industrial heating equipment, including technology such as industrial heat pumps, electric resistance, induction, dielectric heating (with radio waves or microwaves), infrared heating, and lasers. The vast majority of heat-producing units that rely on combusted fuels cannot simply switch to electricity. Entirely new units must be purchased and installed to fully electrify a facility. The costs scale roughly with facility size, from $50,000 - $100,000 for smaller units, up to $500 million or greater for larger units.[6] These costs typically hold manufacturers back from electrifying until a heat-producing unit fails and must be replaced.

Intersection with Other Funding: Since Michigan's industrial sector is diverse and complex, decarbonization plans and projects may be customized for each facility. The Michigan State University Industrial Training and Assessment Center offers site assessments for small and medium industrial facilities across the state to begin thinking about what they can do to decarbonize their operations. Utilities also offer a variety of energy waste reduction programs and incentives for industrial customers, as required by law. RESTART@LTU is a partnership between EGLE and Lawrence Technological University that connects retired engineers, scientists, technicians, administrators, researchers, and teachers to businesses and public institutions to provide energy efficiency, sustainability, and waste reduction assessments and services. Small- and medium-sized manufacturers may also be eligible for a DOE Industrial Training & Assessment Centers Implementation Grant to implement findings from these assessments. The DOE has also established a regional network of Onsite Energy Technical Assistance Partnerships to help industrial facilities and other large energy users increase the adoption of the latest onsite energy technologies. The U.S. Department of Commerce, through the National Institute of Standards and Technology, has also created a network of Manufacturing Extension Partnerships to provide technical assistance in several facets of the manufacturing industry, included sustainability and energy. Michigan manufacturers can access this technical assistance through the Michigan Manufacturing Technology Center.

At the state level, EGLE's Retooling Program offers matching grants to accelerate the implementation of manufacturing process improvements that reduce energy use and cost per unit produced. Additionally, the Michigan Hub for Manufacturers helps manufacturers grow and adapt to industry shifts by providing access to business advising, responsible funding, events and courses, and a wide range of partner resources and programs.

In 2024, Michigan was awarded $18 million from DOE to specifically help small- and medium-sized automotive companies modernize their capabilities to manufacture EVs. In addition, with a $9.1 million award from the U.S. Department of Treasury and a $500,000 matching grant from the Make It in Michigan Competitiveness Fund, Michigan will soon launch the Michigan Auto Supplier Transition Program to support the critical steps the state is taking to help communities, businesses, and workers benefit from a clean energy future.

[6] Cost estimates and other industry sector research came from the Institute for Energy Innovation and 5 Lakes Energy.

Quantification Methodology: The EPS was used to project emissions reductions from electrification of low-to-medium temperature processes by selecting industries with significant low-temperature heat demand, including Construction, Other Manufacturing, Chemicals, Food and Beverage, Textiles, Pulp and Paper, and other industries as identified in Energy Innovation's Decarbonizing Low-Temperature Industrial Heat in the U.S. It was assumed that low temperature processes will be fully electrified by 2040 and high temperature processes, under the most optimistic scenario, will be fully electrified by 2050. Energy efficiency was set to a 17% improvement by 2050, based on DOE analyses suggesting this is the upper bound of an accelerated action scenario.

Quantified Emissions Reduction:

Table 35: Industry Reduction Measure 1: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-4.87	-13.29

Table 36: Industry Reduction Measure 1: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-574.84	-1,476.93
NO_x	-3,896.80	-10,832.80
$PM_{2.5}$	-253.85	-600.64
VOC	-1,335.10	-3,848.10

Industry Reduction Measure 2:
Encourage emission reduction strategies from lime and cement manufacturing, including energy and material efficiency improvements, electrification, fuel switching, and clinker substitution

Measure Description: The lime and cement industries in Michigan are made up of just eight large facilities. According to EPA's FLIGHT, most emissions from these facilities are process emissions, with a majority of total emissions coming from the chemical processes of manufacturing lime and cement. As of 2023, the facilities are Carmeuse Lime, Amrize (formerly Holcim) (cement), Port Inland Plant (lime), St Marys Cement, four Michigan Sugar Company plants, and two Billerud paper mills. The sugar facilities are included here because lime plays an important role in sugar production and these sugar plants operate their own lime kilns, as do the two paper mills. Reducing emissions in this industry will require energy and material efficiency improvements, electrification, cement clinker substitution, fuel switching, and carbon capture and storage, among other solutions.

Cement clinker is one of the key ingredients in cement manufacturing, created by heating limestone and other materials to high temperatures. Clinker production is responsible for about 90% of CO_2 emissions in cement manufacturing, so replacing cement clinker with industrial byproducts like fly ash and slag or other supplementary cementitious materials, like calcined clay, is one of the most direct and scalable levers for cutting emissions. However, the long-term viability of this approach is limited, as the availability of these substitutes will decline with the phaseout of coal and blast furnace-based ironmaking. Improving material efficiency is also an important component to decarbonize these industries.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the LEO and the MEDC, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

While there are no specific milestones outlined by the MHCP for the lime and cement industries to align with the state's carbon neutrality goal, facilities will likely pursue energy efficiency measures, among others.

The primary metrics for this reduction measure could be the number of manufacturing facilities replacing existing equipment with electric alternatives where feasible, clinker substitution rates, energy efficiency rates, material use optimization, fuel switching to low-carbon fuels, the carbon intensity of the product, and other metrics as identified.

Costs: For cement production, there are a variety of retrofit options to increase thermal efficiency, increase production capacity, and save $0.10/ton of clinker in O&M costs. Further, replacing existing motors with more energy efficient alternatives (up to 95% efficiency motors are available), can save up to $168,000 per year in energy costs and $30,000 per year in maintenance costs.

Using supplementary materials in cement and reducing the amount of clinker used in the manufacturing process may also require new equipment or equipment upgrades to allow for receiving, storing, and blending the materials. These investment costs are estimated to be $4.10 per ton of clinker, but these costs can be offset by savings from using less clinker overall and reducing energy costs.

Intersection with Other Funding: One of the MHCP strategies for the industrial sector is encouraging clean innovation hubs to foster collaboration on the development and deployment of new, cleaner manufacturing technologies to reduce emissions from hard to decarbonize industries. Michigan communities impacted by industrial development and operations should be meaningfully engaged in the siting, construction, and operation of these clean innovation hubs. The DOE has a regional network of Technical Assistance Partnerships to help industrial facilities and other large energy users increase the adoption of the latest onsite energy technologies.

Quantification Methodology: The EPS was used to estimate emissions reductions from lime and cement manufacturing by targeting the Cement and Other Non-Metallic Minerals industries. A 60% clinker substitution rate was assumed, aligned with the International Energy Agency Net Zero Scenario and supported by the EPS documentation. Electrification was set to 100%, with lower temperature processes reaching this by 2040 and higher-temperature processes by 2050. Material Efficiency, Longevity, and Reuse was set to a 70% reduction in cement demand, based on feasible reductions from optimized design, reuse, and extended building lifespans. Energy efficiency improvements were set to 17%, consistent with international benchmarks for technological upgrades and process optimization.

Quantified Emissions Reduction:

Table 37: Industry Reduction Measure 2: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.85	-1.79

Table 38: Industry Reduction Measure 2: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-236.00	-506.70
NO_x	-867.00	-1,955.20
$PM_{2.5}$	-83.54	-210.60
VOC	-148.70	-526.40

Industry Reduction Measure 3:
Encourage emission reduction strategies from iron and steel including electrification, material efficiency, energy efficiency, lower-temperature alternative production methods, and fuel switching

Measure Description: The iron and steel industry in Michigan includes one iron ore mine and pelleting plant (Tilden Mine), one operating integrated/primary steel mill (Dearborn Works), the EES Coke Battery which supplies the primary steel mill among other smaller customers, two Gerdau steel mills, and other iron casting and steel mill operations. Emissions across this industry represent a significant portion of emissions from Michigan's industrial sector. Reducing emissions in this sector will require the deployment of a combination of strategies. Roughly 95% of heat demand across the iron and steel industry is above 500°C, making it hard to electrify. Full electrification of the iron and steel industry will likely require the replacement of basic oxygen blast furnaces with hydrogen-based direct reduced iron paired with electric arc furnaces (H2-DRI-EAF). Other solutions may include using lower carbon intensive fuels to reduce its carbon footprint.

Improvements in material and energy efficiency are also necessary to decarbonize this industry. Improved material efficiency includes using higher shares of recycled steel and steel manufacturing residuals. Further, energy efficiency enhancements across the iron and steel industry could lead to a 24% reduction in energy consumption.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the LEO and the MEDC, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

At least 5% of iron and steel industry processes occur at low-to-medium temperatures and can be electrified in the short-term under Industry Reduction Measure 1.

The primary metrics for this reduction measure may be the energy and/or carbon intensity per ton of steel, scrap utilization and reuse rates, number of hydrogen-based steel projects, capital investments in clean manufacturing technologies, and other metrics as identified.

Costs: This reduction measure may require electrification of high temperature processes, which includes replacing basic oxygen furnaces with more efficient equipment such as H2-DRI-EAFs. One case study found an estimated cost of at least $1.57 billion to upgrade Dearborn Works, Michigan's sole remaining integrated/primary steel mill to H2-DRI-EAF technology, with additional expenses to support hydrogen production. Despite upfront equipment costs to replace existing equipment with H2-DRI-EAFs, competitive hydrogen prices could make this solution more cost-effective than conventionally-made, blast furnace-based primary steel. High hydrogen prices, however, could create a 20-30% cost premium on Michigan steel made from the H2-DRI-EAF production pathway, compared with conventionally-made primary steel. Both existing and new systems that are modified to increase efficiency and optimize heat supply will likely experience decreased production costs.

Intersection with Other Funding: The State of Michigan has received funding through the Regional Clean Hydrogen Hubs program as part of the Midwest Hydrogen Hub to expand the production, processing, delivery, storage, and end-use of hydrogen. Over $70 million has been made available to Nel Hydrogen for its planned electrolyzer manufacturing expansion in Michigan as part of the Qualifying Advanced Energy Project Tax Credit program.

One of the MHCP strategies for the industrial sector is encouraging clean innovation hubs to foster collaboration on the development and deployment of new, cleaner manufacturing technologies to reduce emissions from hard to decarbonize industries. Michigan communities impacted by industrial development and operations should be meaningfully engaged in the siting, construction, and operation of these clean innovation hubs. The DOE has established a regional network of Technical Assistance Partnerships to help industrial facilities and other large energy users increase the adoption of the latest onsite energy technologies.

Quantification Methodology: The EPS was used to estimate emissions reductions from the iron and steel industry by applying a combination of electrification, material efficiency, and energy efficiency assumptions. Electrification was set to 100%, with lower temperature processes reaching this by 2040 and higher-temperature processes by 2050. Material efficiency was, somewhat optimistically, modeled as a 65% reduction in steel demand, assuming increased material efficiency in building construction, encouraging re-use and re-purpose of buildings, and extended product lifespans, among other actions, as outlined in Sustainable Materials Without the Hot Air. Energy efficiency improvements were set to 17% by 2050, consistent with international benchmarks for technological upgrades and process optimization.

Quantified Emissions Reduction:

Table 39: Industry Reduction Measure 3: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-1.39	-3.04

Table 40: Industry Reduction Measure 3: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-712.60	-1,973.29
NO_x	-1,632.60	-4,559.40
$PM_{2.5}$	-325.02	-1,146.54
VOC	-396.20	-1,264.80

Industry Reduction Measure 4:
Encourage emission reduction strategies in gas and oil production, like methane capture and energy efficiency

Measure Description: While acknowledging the need to transition away from fossil fuels in the long-term, reducing emissions from the interim production of gas and oil is a critical strategy for meeting Michigan's climate goals given that methane is over 80 times more potent than CO_2 over a 20 year period. According to the GHG inventory, natural gas and oil emissions decreased by 31% since 2005, dropping from 5.2 $MMTCO_2e$ to 3.5 $MMTCO_2e$ in 2021. This decline may be partially due to an overall decrease in natural gas production volumes, but is also likely due in part to equipment improvements and better leak detection technology. The three largest sources of emissions in this industry, in order of decreasing emissions as of 2021, are gas transmission, gas production, and gas distribution.

Within gas production, pneumatic controllers and gas engines are the primary sources of methane emissions. Reciprocating compressors and gas engines are the largest sources of methane emissions during the process of moving gas and oil from fields to processing facilities and then onto distribution or storage facilities. Gas distribution involves moving gas and oil via mains, service lines, and meters to end customers. The largest source of methane emissions here is leakage during meter installation.

Mitigating methane leaks across the gas and oil industry first requires identification of the methane leakage point. Deploying advanced detection technologies, such as aerial surveys, continuous monitoring systems, and satellite-based observations, allows operators to quickly identify leaks and prioritize repairs. Other methane mitigation options at these leakage points include capture or re-routing of vented gas.

Energy efficiency upgrades in gas and oil facilities can also substantially reduce emissions and operating costs. These improvements include optimizing process heat systems and pump and compressor configurations, upgrading motors and drives, and deploying waste heat recovery where feasible. Many of these technologies are already commercially available.

Beyond the production, transmission, and distribution of gas and oil, orphaned wells are a significant source of methane emissions. These wells have no known owner or operator responsible for plugging them. Through EGLE's Orphaned Wells Program, approximately 400 wells have been plugged and 3,700 grams per hour of leaking methane has been eliminated to date.

There are also not-yet-commercialized technologies that aim to remove methane already in the air. These technologies require additional research and development to be deployed at scale.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the LEO and the MEDC, will follow an implementation schedule aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

The primary metrics for this reduction measure may be the energy intensity of facilities, methane intensity, rate of methane capture, leak detection-to-repair rates, number of orphaned wells plugged, percentage of pipelines with continuous monitoring, and other metrics as identified.

Costs: Leak detection and repair programs in the gas and oil sector, particularly those utilizing infrared cameras, offer a highly cost-effective method for reducing methane emissions. Most leaks identified can be repaired with a payback period of less than one year, and survey and monitoring costs are relatively low. Additionally, upgrading equipment, like reciprocating compressor rod packing systems ($6,000) and electric pumps ($10,000), will require upfront capital expenditures, but will likely lower O&M costs in the years following.

Electrification requires careful planning, including the selection of optimal technologies, assessment of total costs, and development of strategies to ensure a continuous energy supply, particularly in remote locations with limited grid access.

Intersection with Other Funding: In 2023, the MPSC approved $50 million in state funds for low-carbon Energy Infrastructure Enhancement and Development projects across the state, including natural gas to areas now reliant on propane. Michigan received a $5.8 million award from the Department of the Interior in 2024 to continue EGLE's Orphan Wells Program. Additionally, the EPA's Methane Emissions Reduction Program provides financial and technical assistance to reduce methane emissions from the petroleum and natural gas sectors.

Quantification Methodology: The EPS was used to estimate emissions reduction from the Oil and Gas Extraction and Energy Pipelines and Gas Processing industries by applying a combination of electrification, energy efficiency, and methane capture. Electrification was set to 100%, with lower temperature processes reaching this by 2040 and higher-temperature processes by 2050. Energy efficiency improvements were set to 17% by 2050, consistent with the DOE analyses. Methane capture from oil and gas extraction, pipelines, and processing was set at 85% to represent aggressive leak mitigation.

Quantified Emissions Reduction:

Table 41: Industry Reduction Measure 4: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.49	-3.10

Table 42: Industry Reduction Measure 4: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SO_x	-9.70	-42.20
NO_x	-421.80	-1,014.80
$PM_{2.5}$	-16.11	-49.85
VOC	-66.80	-423.20

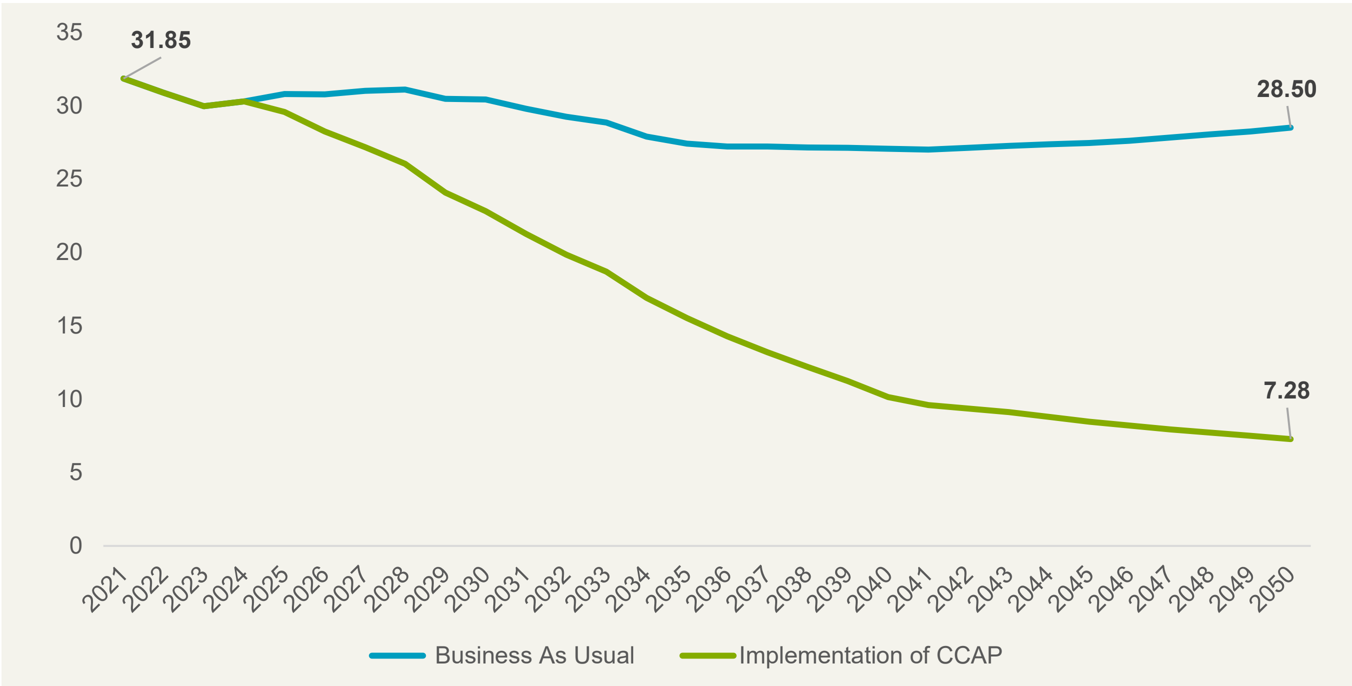
Industry Sector Summary

The data below, along with benefits and workforce considerations, is derived from aggregating the impact of all reduction measures listed in this sector.

Table 43: Industry Sector: Quantified GHG Emissions Reductions across All Industry Measures (Measured in $MMTCO_2e$)

Scenario	2021	2030	2050
BAU	31.85	30.42	28.50
Implementation of the CCAP	-	22.82	7.28
Difference between BAU and Implementation of CCAP	-	-7.60	-21.22

Figure 25: Industry Sector: Annual Quantified GHG Emissions Reductions across All Industry Measures (Measured in MMTCO$_2$e)



Additional Efforts to Reduce Emissions across the Industry Sector

Beyond these measures, an estimated 7.28 MMTCO$_2$e will still need to be abated by 2050. Some additional efforts to reduce emissions in this sector include:

- **Refrigerants:** Refrigerant emissions, particularly from HFCs, are potent GHGs often released during the manufacturing, servicing, and disposal of cooling and refrigeration systems. Replacing HFCs with low-GWP alternatives is one way to reduce emissions in this sector. Improved leak detection and repair practices, enhancing refrigeration equipment system efficiency, as well as robust recovery and recycling programs, are also strategies for reducing refrigerant-related emissions.

- **Chemicals:** In Michigan, the chemical industry plays a major role in the state's manufacturing economy, with facilities producing plastics, industrial gases, adhesives, and agricultural chemicals. The chemical manufacturing sector presents opportunities for emissions reductions through process electrification, feedstock substitution, and energy efficiency upgrades. Switching to bio-based or recycled inputs can also significantly cut industrial GHG emissions while maintaining productivity.

- **Combined Heat and Power:** Combined heat and power (CHP) is a system of onsite fuel combustion for the provision of both heat and electricity. According to the DOE, cogeneration can operate at 65-75% efficiency, compared to an average of 50% efficiency when both services are provided separately. Deploying CHP in new facilities or converting existing facilities to CHP can thus be an effective strategy for reducing emissions in hard-to-decarbonize industries.

- **Lower-Carbon Fuels:** Lower-carbon fuels such as biogas, renewable natural gas or biomethane, and clean hydrogen can be an effective strategy for reducing emissions in hard-to-decarbonize industries. Low-carbon hydrogen, particularly green hydrogen produced via electrolysis powered by renewable energy, can serve as a key decarbonization tool in hard-to-electrify industrial processes. In sectors like refining, ammonia production, and high-temperature heat applications, replacing fossil-based hydrogen with clean hydrogen can help reduce carbon intensity and support the broader industrial energy transition.
- **CCUS:** The MHCP outlined a goal of exploring the use of CCUS in industrial applications where eliminating the use of fossil fuels is impossible or cost prohibitive.

Qualitative and Quantitative Benefits Analysis across the Industry Sector

Reducing emissions across Michigan's industrial sector brings a range of qualitative benefits that extend well beyond climate change mitigation. Cleaner manufacturing technologies and fuel switching significantly reduces harmful co-pollutants such as NO_x, SO_x, and CO. Improvements in local air quality can lead to better health outcomes, lower healthcare costs, and offer a higher quality of life for residents. This is particularly important to LIDACs who are often located near industrial zones and thus exposed to more harmful air pollutants.

As industries begin adopting more energy efficient equipment and cleaner processes, they are also likely to incorporate broader strategies to enhance efficiency and reduce waste throughout their supply chains. This may include streamlined manufacturing practices, greater transparency in sourcing, and improved logistics planning to reduce emissions across production and distribution. These shifts can make Michigan's industrial sector more competitive in a global market increasingly focused on sustainability. Furthermore, the transition to cleaner industrial operations has the potential to generate high quality local jobs in equipment installation, maintenance, and energy systems management, supporting economic development while advancing environmental goals. At the same time, electrifying industrial processes reduces reliance on volatile fossil fuel markets, improving both operational stability and long-term energy security.

Across the state, the suite of reduction measures presented for the industry sector brings about reductions beyond GHGs. Below, emissions of select co-pollutants are shown for the base year of 2021, along with anticipated reductions from the BAU scenario in the years 2030 and 2050.

Table 44: Industry Sector: Quantified Co-Pollutant Emissions Reductions across All Industry Measures (Measured in Metric Tons)

Co-Pollutant	Base Year (2021)	Difference between BAU and Implementation of all Industry Measures 2030	Difference between BAU and Implementation of all Industry Measures 2050
SOx	10,148.50	-1,533.14	-3,999.12
NOx	29,206.00	-6,818.20	-18,362.20
PM2.5	8,469.90	-678.52	-2,007.63
VOC	28,791.10	-1,946.80	-6,062.50

Quantifying emissions reductions allows for the calculation of quantifiable community benefits, which are detailed below. These co-benefit estimates were provided by the EPA's COBRA, after inputting the co-pollutant emissions reductions listed in Table 44, and by the EPS. Additional detail on the selection of community benefits is available in Benefits of GHG Emission Reduction Measures to LIDACs (Section 7.3).

Table 45: Estimated Community Benefits in the Near-Term and Long-Term across the Industry Measures

Benefit	Cumulative Impact, 2025 through 2030	Cumulative Impact, 2025 through 2050
Avoided Lost Workdays	9,185 – 10,000	128,375 – 142,500
Avoided Respiratory Symptom Cases	5,140 – 75,000	77,150 – 1,050,000
Avoided Hospital Admissions	12.5 - 15	177.5 – 350
Avoided Minor Restricted Activity Days	54,000 – 60,000	761,250 – 850,000

Note: Ranges are reported for the Industry Sector because this community benefit data was available via multiple data sources.

Figure 26: Avoided Deaths by Race across the Industry Measures, 2025-2030

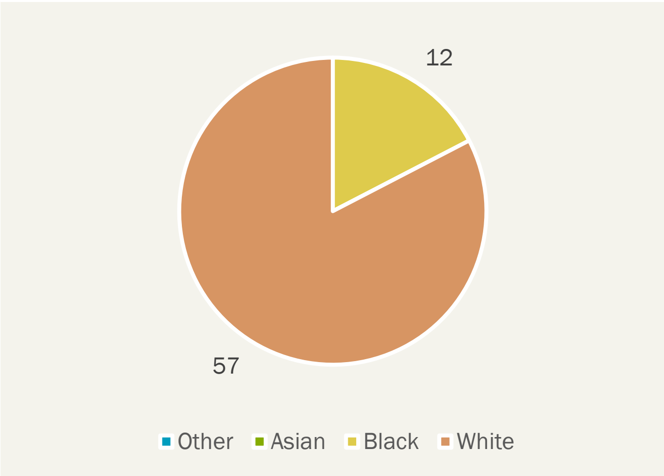
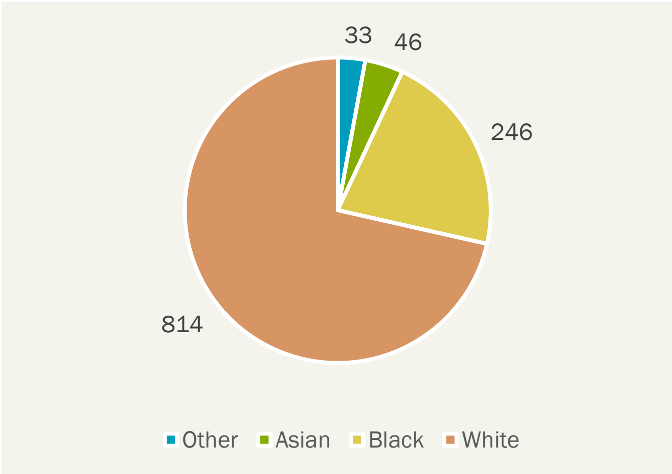


Figure 27: Avoided Deaths by Race across the Industry Measures, 2025-2050



Note: Avoided Deaths by Race data was collected from the EPS, based on portions of the quantified co-benefits listed above. Where races are not present in Figure 26 above, avoided deaths were estimated to be zero.

Workforce Considerations across the Industry Sector

Since 2011, manufacturing employment has grown 14.9%, which is double the statewide employment growth rate over the same period. Michigan's industry workforce analysis consists of 11 sectors: Automotive (29.8%), Metals (15%), Chemical Products (11.6%), Machinery (11.6%), Food and Beverage (8.1%), Natural Resources (5.8%), Computers and Electronic Products (5.8%), Other (5%), Furniture (3.4%), Printing and Related (2%), and Medical Equipment (1.9%).

The occupations with the most projected growth through 2030 are Computer Numerical Control Tool Programmers (33%), Medical Appliance Technicians (31.2%), Molders, Shapers, and Casters, except Metal and Plastic (30.1%), and Logisticians (29.7%). The anticipated growth in tool programmers and molders, and shapers and casters is especially important since these are the occupations that will be supporting the industrial transition to electric equipment and more efficient manufacturing processes. Logisticians also play a direct role in decarbonization by optimizing supply chains, reducing fuel consumption, and supporting the integration of electric systems. Transitioning to cleaner industrial processes will also generate demand for new skills and expertise that can create new workforce opportunities in areas like conducting energy audits and implementing energy saving strategies. It will also be important to update the skills and expertise of the existing workforce to adapt to these new technologies.

Anticipated Workforce Shortages: There are a projected 51,200 average annual openings among these key occupations through 2030. Annual openings are due to a variety of reasons such as labor force exits and retirements, occupational transfers, and growth in the occupation. The key occupations with the most projected annual openings through 2030 are Miscellaneous Assemblers and Fabricators (10,255), Sales Representatives, except Tech and Scientific Products (5,230), Supervisors of Production and Operating Workers (3,190), Inspectors, Testers, Sorters, Samplers, and Weighers (3,130), and Mechanical Engineers (2,920). Ensuring there are enough assemblers, operators, inspectors, and engineers, along with many other occupations, to install, inspect, and scale up new electric equipment and processes will be essential to achieving this reduction measure.

Solutions to Address Workforce Shortages: There are a variety of programs to address these anticipated workforce shortages across the LEO, and the Michigan Department of Treasury. The Treasury's Energy Transition Impact Project helps to address challenges associated with the state's changing energy sources, and bring local, state, and federal resources to the table to plan for future adjustments and changes. Additionally, through the Clean Energy Workforce Development program and Going PRO Talent Fund, Michigan is directing resources toward developing the workforce required for a clean energy future within industrial operations. The LEO's Michigan Industry Cluster Approach further encourages employers to partner with training providers to develop industry-responsive programs.

Apprenticeship expansion grants, partnerships with community colleges, and the Michigan Reconnect Program, which offers free tuition to residents over 25, are also helping workers access training in high-demand industrial occupations. Registered Apprenticeships are vital to ensuring a skilled industrial workforce in Michigan. In 2010 there were less than 200 newly registered apprentices in manufacturing. By 2024, that number had increased to roughly 1,133 newly registered apprentices.

Waste and Wastewater

Waste and Wastewater Reduction Measures
Increase recycling and composting to send less waste to landfills
Continue enhancement of landfill management technologies and methods
Encourage process optimization, energy efficiency enhancements, and biogas-fueled generation at water treatment plants

About the Sector

Michigan's waste and wastewater sector is composed of a comprehensive network of landfills, recycling facilities, composting programs, and wastewater treatment plants that collectively manage the state's diverse waste streams. In fiscal year 2024, Michigan's 67 reporting landfills disposed of over 24.1 million tons of waste – an increase of approximately 1.24 million tons, or 5.43%, from the previous year. Imported waste from Canada and 12 U.S. states accounts for 18.97% of all waste disposed of in Michigan landfills. Canada is by far the largest contributor of imported waste, accounting for 14.35% of all waste disposed of in Michigan landfills.

Based on current disposal rates, Michigan has approximately 21 years of landfill capacity remaining. In fiscal year 2024, the facilities with the highest volume of waste received were Pine Tree Acres in Lenox, Michigan (3.6 million cubic yards) and Woodland Meadows in Wayne, Michigan (2.9 million cubic yards). While recycling and composting efforts are ongoing, only nine of the 116 registered composting sites in Michigan currently accept food waste, indicating room for growth in organic waste diversion and sustainable waste management practices.

Although methane emissions from the waste and wastewater sector represent a relatively small share of Michigan's total GHG emissions, their impact is significant due to methane's high GWP. Landfills and wastewater treatment processes are key sources of methane, making them important targets for mitigation strategies. Expanding composting programs, improving landfill gas capture, diverting more combustible construction materials and other biomass residuals from industrial landfill, and optimizing wastewater treatment operations are essential steps to reduce methane emissions and support Michigan's broader climate goals. Reducing the amount of waste that ends up in the state's landfills in the first place will also play a key role in reducing emissions in this sector. As such, the MHCP recommends achieving a recycling rate of 45% and cutting food waste in half from the 2005 baseline year by 2030.

GHG Emissions Reduction Measures across the Waste and Wastewater Sector

Waste and Wastewater Reduction Measure 1:
Increase recycling and composting to send less waste to landfills

Measure Description: In fiscal year 2024, Michigan generated 19.7 million tons of waste, an increase of 7.05% from the previous year. The single largest source of waste material is food, with as much as 1.5 million tons of food waste disposed through Michigan's municipal and commercial waste streams each year. Recycling, composting, and diverting construction materials from landfill can reduce the volume of waste going to landfills and thereby reduce the GHG emissions stemming from decomposition or incineration of organic material.

Michiganders recycled a record-breaking 703,369 tons of materials in 2023, including more than 330,000 tons of paper, 237,000 tons of metals, 67,000 tons of glass, and 58,000 tons of plastics. Michigan's recycling rate has steadily improved from 14.25% before 2019 to over 23% in 2023.

To reach a 45% recycling rate by 2030, EGLE plans to continue and scale up proven strategies and grow the state's circular economy. This includes expanding curbside and drop-off access statewide, particularly in underserved rural and urban areas; standardizing materials accepted across jurisdictions to reduce confusion; and strengthening market development for recycled materials. Education and outreach, like the "Know It Before You Throw It" campaign, continue to improve participation and reduce contamination. Long-term success will also require integrating recycling goals into local and regional materials management plans.

Beyond recycling, increasing the statewide compost rate will require a reduction in the amount of food waste generated and the diversion of food waste from the landfill. The state has outlined strategies in the Michigan Food Waste Roadmap to reduce the amount of food waste sent to Michigan landfills and waste-to-energy facilities by diverting 600,000 tons of additional material per year to compost, anaerobic digestion, or animal feed and by preventing 600,000 tons of total food waste through prevention and rescue strategies. These strategies include promoting secondary markets and educational campaigns.

Additionally, under Michigan's recently amended solid waste law, counties and regions have embarked on a process to develop comprehensive Materials Management Plans. Where waste planning efforts historically focused on landfill capacity, these plans will focus instead on more sustainable approaches such as recycling and composting.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the LEO, MEDC, and local and municipal partners, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

More specific milestones have been developed by the MHCP and Michigan Food Waste Roadmap to reach a 45% recycling rate by 2030 and a 50% composting rate by 2030. Michigan is on track to achieve these goals, having increased the recycling rate by over 75% between 2019 and 2024.

Metrics that may be used to track this reduction measure include quantity of waste to landfills, recycling rate, composting rate, tons of food waste sent to landfills, tons of food wasted, tons of food saved via prevention and rescue strategies, and other metrics as identified.

Costs: Achieving higher recycling and composting rates will require infrastructure and operational investments, including expanded curbside collection, upgraded facilities, and improved transportation and sorting systems.

Material recovery facilities (MRFs) are complex operations with significant ongoing costs, and their income is highly dependent on fluctuating factors such as material volume, quality, and volatile commodity prices. To ensure long-term financial stability, strong and adaptable relationships between MRF owners, operators, suppliers, and buyers are essential to navigate the dynamic nature of recycling markets. Michigan Recycles shows a current average revenue of $73-$80 per ton for such facilities across all materials in a single-stream system. Expanding recycling programs across the state would increase the quantity going to these MRFs and thus increase the total revenue of these facilities.

Construction of a new composting facility costs between $3.5 million and $5.4 million, depending on size, facility capacity, and location. However, the vast majority of Michigan's existing composting facilities do not accept food waste. Expanding the services of these facilities may be a more cost-effective method of decreasing food waste and thus emissions. Developing and expanding home/backyard composting programs is also a great strategy that can save a municipality $23 per ton, compared to municipal composting.

Intersection with Other Funding: To help offset these expenses and to accelerate progress, EGLE has distributed more than $11.8 million in grants in 2025, including $4.6 million in municipal Recycling Infrastructure Grants, $1.6 million in Organics Infrastructure Grants, and $5.6 million in NextCycle Michigan Circular Economy Grants. EGLE also awarded over $14 million in 2024 to local governments and organizations for improved recycling infrastructure and increased recycling accessibility.

Beyond state funding, the U.S. Department of Agriculture's (USDA) Composting and Food Waste Reduction program assists local and municipal governments with planning and implementing compost and food waste reduction plans. The civic organization Keep America Beautiful also works to bring together municipal, school, business, and community leaders to advance recycling.

Finally, Michigan's 10-cent Beverage Container Deposit Law requires a refundable $0.10 deposit, higher than most other states, on eligible beverages to encourage recycling and reduce litter. Recent data shows the redemption rate is 70.4% in 2024.

Quantification Methodology: To model the impact of increased recycling and composting on emissions, the EPS was used. Material Efficiency, Longevity, and Re-Use was set at 47.5% by 2030, reflecting the MHCP recycling and food waste reduction goals of 45% and 50% respectively. A target of 75% by 2050 was also applied, reflecting an aggressive scenario. While not highlighted in this reduction measure, the Material Efficiency EPS setting used for quantifying these reduction measures also includes the impact of reducing wastewater.

Quantified Emissions Reduction:

Table 46: Waste and Wastewater Reduction Measure 1: Quantified GHG Emissions Reductions (Measured in MMTCO$_2$e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-3.80	-6.40

Note: EPA's AVERT co-pollutants calculations were not available for this measure, though it will likely result in similar benefits as previous reduction measures, such as improved air quality and a healthier environment for communities.

Waste and Wastewater Reduction Measure 2:
Continue enhancement of landfill management technologies and methods

Measure Description: Michigan ranks among the top ten states for highest landfill methane emissions. Methane is a potent GHG with 80 times more short-term warming power than CO_2 and is produced when organic waste decomposes anaerobically in landfills. Enhancing landfill management technologies in Michigan is thus pivotal for reducing GHG emissions, particularly methane.

To address this, Michigan has implemented regulatory measures such as the updated Part 115 of the state's solid waste law, mandating all landfills to develop Landfill Surface Emission Monitoring Plans. These plans require landfills to monitor methane emissions and take corrective actions if emissions exceed specified thresholds. Complimentary field investigations, utilizing specialized equipment to identify and address methane leaks, have been deployed. Technological advancements, including satellite mapping and drones, are being utilized for more precise detection of methane leaks.

These initiatives not only mitigate environmental impacts but can also contribute to the state's renewable energy portfolio. The 2023 clean energy legislation considers a landfill gas recovery and electricity generation facility a "renewable energy system" if it is located in a landfill that employs best practices for methane gas collection as well as control and emissions monitoring. Captured gas can be used to produce renewable natural gas, generate electricity onsite, or provide direct heat for a variety of applications. However, utilizing landfill gas for energy should not encourage an increase in the amount of waste sent to landfills. This CCAP, through the previous measure, thus emphasizes the need to reduce waste overall as a crucial step towards a more sustainable waste management system.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with municipal partners, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

While there are no specific milestones outlined by the MHCP to align with the state's carbon neutrality goal, these facilities could aim to achieve a landfill gas collection efficiency of at least 75% and a flaring destruction efficiency of 98%.

Metrics that may be used to track this reduction measure include landfill gas collection efficiency, flaring destruction efficiency, and other metrics as identified.

Costs: A typical landfill gas energy project has high upfront costs exceeding $5 million. However, these costs vary based on the size of facility, size of engines, flow volume, and types of controls. Once the system is up and running however, there can be significant economic benefits. It is expected to add $11.93 million to $13.50 million in economic output from increased employment and local gas sales.

Intersection with Other Funding: The Landfill Methane Outreach Program is a voluntary EPA initiative that partners with communities, landfill operators, and other partners to reduce methane emissions by promoting the capture and use of landfill gas as a renewable energy source. There are over 70 projects through this program in Michigan that are candidates, planned or operational.

Quantification Methodology: To estimate emission reductions from improved landfill gas management, Michigan used the EPS and the EPA's Non-CO_2 Greenhouse Gas Mitigation Tool, focusing specifically on methane mitigation strategies that do not involve electricity generation. This approach includes actions such as flaring and gas recovery, which reduce landfill methane emissions without overlapping with the electric power sector—ensuring emissions reductions are not double-counted. Key modeling parameters include a landfill gas collection efficiency of 75 - 85%, a flaring destruction efficiency of 98%, and assumed technical lifetimes of 15 years for equipment and infrastructure.

Quantified Emissions Reduction:

Table 47: Waste and Wastewater Reduction Measure 2: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.32	-0.46

Note: EPA's AVERT co-pollutants calculations were not available for this measure, though it will likely result in similar benefits as previous reduction measures, such as improved air quality and a healthier environment for communities.

Waste and Wastewater Reduction Measure 3:
Encourage process optimization, energy efficiency enhancements, and biogas-fueled generation at water treatment plants

Measure Description: Across the country, municipal wastewater treatment plants (WWTPs) consume over 30 terawatt hours of electricity annually. Innovation in equipment technology, however, can bring about higher energy efficiency. Real time sensors and other monitoring equipment are becoming more prevalent, aiding in process optimization, which can result in decreased chemical usage, reduced costs to run these facilities, and lowered emissions.

The Global Methane Initiative identifies several key strategies for mitigating methane emissions from wastewater, including improving wastewater collection and treatment infrastructure, installing anaerobic digesters to capture and use methane as biogas, and enhancing sludge management practices. EGLE supports the Utility of the Future and Water Resource Recovery Facility (WRRF) concepts that view WWTPs as not just waste receiving and treatment facilities, but also as facilities with opportunities for resource recovery and reuse, such as capturing biogas for electricity generation or sequestering nutrients in the wastewater for use as fertilizers. These concepts also support improved efficiency and reduced costs through process optimization, operational efficiency, etc.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the Michigan Department of Agriculture and Rural Development (MDARD) and local and municipal partners, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

While there are no specific milestones outlined by the MHCP for the waste and wastewater industry, to align with the state's carbon neutrality goal, these facilities could aim to achieve an improvement of 10% methane collection efficiency each year, as recommended by the EPA's Non-CO_2 Greenhouse Gas Mitigation Tool.

Metrics that may be used to track this reduction measure include WWTP methane collection efficiency and other metrics as identified.

Costs: WWTPs allocate between 25% and 40% of their operating budget to electricity costs, totaling about $2 billion across the country annually. Energy efficiency improvements and upgraded equipment can help to reduce energy costs, however. One facility in Massachusetts is saving $1.5 million per year by cutting energy intensity in half.

Anaerobic digesters require significant upfront investment, with capital costs between $400 and $1,500 per ton of material processed. Further, operating costs typically range from $18 to $100 per ton. Upgrades in existing wastewater treatment technology, particularly the adoption of membrane bioreactors (MBRs), which help to indirectly reduce the amount of methane emissions, can significantly reduce operating costs by producing 30–50% less sludge, cutting chemical use, lowering labor needs through automation, and requiring up to 75% less space.

Intersection with Other Funding: In 2016, EGLE provided grant funding to the Michigan Water Environment Association to develop a Michigan specific WRRF initiative. They continue to promote these efforts at WWTPs in Michigan today. The MDARD's Wastewater Infrastructure Fund Grant is also assisting the food and agriculture industries to ensure compliance with the wastewater regulations.

The Clean Water State Revolving Fund is a federal and state partnership program providing low interest financing for wastewater and stormwater projects in municipalities working to improve water quality, environmental quality, and public health. Since 1999, nearly $7.3 billion has been provided to Michigan municipalities for wastewater infrastructure projects.

Quantification Methodology: The EPA's Non-CO_2 Greenhouse Gas Mitigation Tool was used to estimate emissions reductions from improved wastewater management, focusing exclusively on methane reductions through targeted infrastructure improvements. This tool assumes initial methane collection efficiency of 60%, 10% annual improvement in methane collection efficiency, and technical lifetimes of up to 50 years for infrastructure upgrades.

Strategies modeled include the construction of wastewater collection systems and the development of aerobic treatment facilities, which reduce methane emissions by limiting anaerobic conditions in wastewater processing. Nitrous oxide mitigation was not included, as its reduction is more dependent on operational practices and process optimization than on engineered capital interventions.

Quantified Emissions Reduction:

Table 48: Waste and Wastewater Reduction Measure 3: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-1.38	-1.48

Note: EPA's AVERT co-pollutants calculations were not available for this measure, though it will likely result in similar benefits as previous reduction measures, such as improved air quality and a healthier environment for communities.

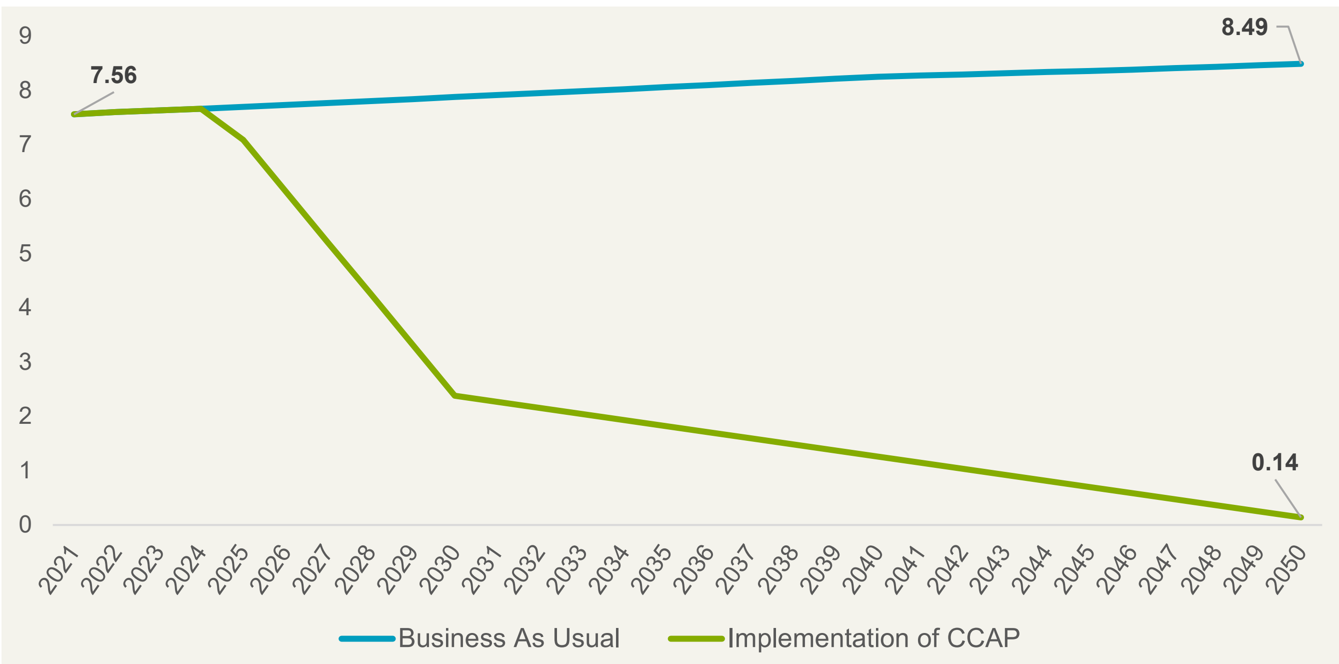
Waste and Wastewater Sector Summary

The following data, along with benefits and workforce considerations, is derived from aggregating the impact of all reduction measures listed in this sector.

Table 49: Waste and Wastewater Sector: Quantified GHG Emissions Reductions across All Waste and Wastewater Measures (Measured in $MMTCO_2e$)

Scenario	2021	2030	2050
BAU	7.56	7.88	8.49
Implementation of the CCAP	-	2.38	0.14
Difference between BAU and Implementation of CCAP	-	**-5.50**	**-8.35**

Figure 28: Waste and Wastewater Sector: Annual Quantified GHG Emissions Reductions Across All Waste and Wastewater Measures (Measured in $MMTCO_2e$)



Qualitative and Quantitative Benefits Analysis across the Waste and Wastewater Sector

Reducing emissions in the waste and wastewater sector offers a wide range of co-benefits for public health, environmental quality, and community well-being. One major advantage is the improvement in air quality through the reduction of methane and other hazardous air pollutants released from landfills and WWTPs. Methane is not only a potent GHG but is also often accompanied by VOCs and odorous gases that can worsen respiratory issues and degrade quality of life, especially for LIDACs and communities located near waste infrastructure. Modernizing wastewater facilities through methane mitigation strategies and advanced treatment technologies like MBRs also enhances water quality and supports water reuse.

Increased recycling and composting efforts further benefit communities by conserving natural resources, reducing the need for energy-intensive raw material production, creating local jobs in materials recovery, and reducing the volume of waste sent to landfills. Across the sector, these improvements also help municipalities comply with stricter environmental regulations, lower long-term operational costs, and build more sustainable, circular waste systems.

Note: Co-pollutant data is not reported for the Waste and Wastewater Sector because data is not available.

While co-pollutants were not quantified for the waste and wastewater sector, quantifiable community benefits data was available via the EPS. Additional detail on the selection of community benefits is available in Benefits of GHG Emission Reduction Measures to LIDACs (Section 7.3).

Table 50: Estimated Community Benefits in the Near-Term and Long-Term across the Waste and Wastewater Measures

Benefit	Cumulative Impact, 2025 through 2030	Cumulative Impact, 2025 through 2050
Avoided Lost Workdays	910	15,725
Avoided Respiratory Symptom Cases	2,040	8,750
Avoided Hospital Admissions	0	25
Avoided Minor Restricted Activity Days	5,410	93,425

Note: The EPA's Non-CO_2 Greenhouse Gas Mitigation Tool does not provide numbers for co-pollutants and thus was not used to calculate these co-benefits. Instead, an aggregated EPS scenario for both landfill and wastewater facilities was used to calculate these co-benefits.

Figure 29: Avoided Deaths by Race across the Waste and Wastewater Measures, 2025-2030

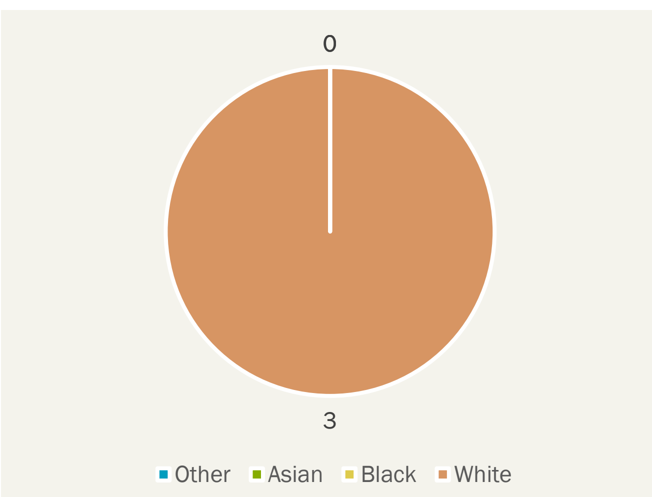
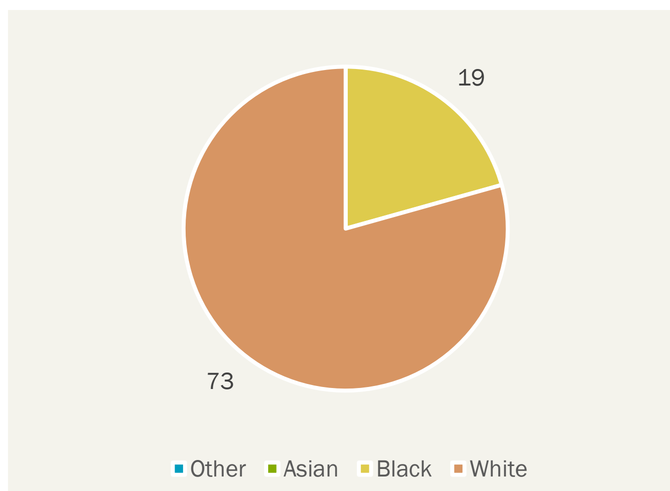


Figure 30: Avoided Deaths by Race across the Waste and Wastewater Measures, 2025-2050



Note: The number of Avoided Deaths by Race is likely an underestimation due to limited data availability. Only the impact of Waste and Wastewater Reduction Measures #2 and #3 are included as data is not available via the EPS for Waste and Wastewater Reduction Measure #1. Where races are not present in Figures 29 and 30 above, avoided deaths were estimated to be zero.

Workforce Considerations across the Waste and Wastewater Sector

Recycling, reuse, and remanufacturing industries in Michigan provide 72,500 jobs and contribute more than $17 billion a year to the state's total economic output. While more specific data for the water and wastewater workforce in Michigan is not available, 2016 nationwide statistics for the largest occupations across this workforce are: Plumbers, Pipefitters, and Steamfitters (19.3%), Construction Laborers (8.9%), Water and Wastewater Treatment Plant and System Operators (6.9%), and Operating Engineers and Other Construction Equipment Operators (4.8%).

Anticipated Workforce Shortages: The following wastewater occupations are projected to see growth rates above the average growth rate of all occupations through 2026: Software Developers, Applications; Information Security Analysts; Market Research Analysts and Marketing Specialists; Pipelayers; and Plumbers, Pipefitters, and Steamfitters. The growth of digital roles, like developers and data analysts, represents the growing need for methane monitoring and leak detection, along with support roles for the transition to new electric equipment.

As Michigan aims for a 45% recycling and 50% composting rate by 2030, the need for trained personnel across collection, sorting, processing, and composting will also likely grow. In addition, continued innovation in landfill methane capture and waste-to-energy conversion systems will demand technicians with experience in both mechanical operations and environmental compliance.

Solutions to Address Workforce Shortages: There are a variety of programs in the state to address these anticipated workforce shortages. EGLE supports capacity-building through its Recycling Infrastructure and Education Grants, which not only fund infrastructure improvements but also help train workers in best practices for waste reduction and materials management. NextCycle Michigan, EGLE's initiative to accelerate the circular economy, offers technical assistance and business support that also indirectly contributes to workforce development by helping entrepreneurs and local governments launch or expand diversion-related programs.

Registered Apprenticeships are vital to ensuring a skilled workforce in Michigan. In 2010 there were 207 newly registered apprentices in Administrative and Support and Waste Management and Remediation Services. By 2024, that number had increased to 314 newly registered apprentices.

Natural and Working Lands

Natural and Working Lands Reduction Measures
Conserve, connect, and restore Michigan's lands and waters, advancing the Michigan the Beautiful initiative
Support climate-smart forestry practices
Support climate-smart agricultural practices

About the Sector

Michigan's natural and working lands, including forests, wetlands, croplands, pastures, and rangelands, are a cornerstone of the state's climate mitigation and resilience strategy. These landscapes store vast amounts of carbon in vegetation and soils and offer significant opportunities for additional carbon sequestration through nature-based solutions, such as reforestation and grassland restoration, cover and alley cropping, and improved manure and cropland nutrient management. According to Nature4Climate's Natural Climate Solutions Mapper, Michigan could sequester up to 19 $MMTCO_2e$ per year if it implemented additional nature-based solutions.

The Great Lakes State is well known for its natural lands and agricultural industry. The Michigan Department of Natural Resources (DNR) developed the Michigan the Beautiful initiative to conserve, connect, and restore at least 30% of Michigan's lands and waters by 2030. According to the most recent GHG inventory, the amount of carbon sequestered by natural lands decreased 9% between 2005 and 2021. This downward trend emphasizes the need for a strong commitment to conserving Michigan's existing carbon sinks. The "Michigan the Beautiful: Pathways" report is expected in 2026. The six proposed pathways for achieving the Michigan the Beautiful goals are presented below.

Proposed Michigan the Beautiful Pathways

1. Making room for more people to be involved in conservation planning and action
2. Planning conservation collaboratively and at a landscape level
3. Creating more community-led green spaces
4. Restoring degraded areas to natural habitats
5. Embracing sustainable use and management practices
6. Protecting high-quality natural areas

Michigan's 20.3 million acres of forestland provide an immense carbon sink for the state. According to the Forest Resources Association, Michigan's forest carbon stocks rose by 8% between 1990 and 2019, and today average 74.4 tCO_2e per acre. Models indicate Michigan's forests are projected to decline from 20.3 million acres to a range of 19.2 to 18.7 million acres by 2060 due to anticipated population growth, climate change, and invasive species, pointing to the need to conserve existing forestlands. Existing funding programs that conserve forests include the Michigan Natural Resources

Trust Fund and the Forestry Legacy Program. In addition, carbon sequestration by forests could be increased by an additional 7 $MMTCO_2e$ per year through interventions such as reforestation, urban tree planting, and the implementation of climate-smart forestry practices.

Michigan has 9.4 million acres of farmland, 1.11 million cattle (including 440,000 dairy cows), 1.7 million hogs, 84,000 sheep, and over 3 million poultry. Agriculture generates over $104.7 billion annually in the state and Michigan is among the top ten states nationally for the production of more than 20 commodities. This industry contributes 11.3 $MMTCO_2e$ annually, largely driven by livestock emissions, fertilizer use, and soil degradation.

The MHCP has outlined several recommendations for decarbonizing Michigan's natural and working lands. These include supporting the Michigan the Beautiful Initiative in conserving 30% of Michigan's lands and waters by 2030, maintaining and improving access to recreational opportunities, preserving biodiversity, restoring wetlands, expanding the use of sustainable materials such as mass timber, and leveraging innovative farming strategies to improve soil health, store carbon, and protect water quality.

GHG Emissions Reduction Measures across the Natural and Working Lands Sector

Natural and Working Lands Reduction Measure 1:
Conserve, connect, and restore Michigan's lands and waters, advancing the Michigan the Beautiful initiative

Measure Description: The DNR's Michigan the Beautiful initiative aims to conserve, connect, and restore at least 30% of Michigan's lands and waters by 2030. These efforts are vital to maintaining the state's carbon sequestration capacity, particularly in forests, wetlands, grasslands, and agricultural soils. Intact wetlands and peatlands play a particularly important role in the state's natural carbon sink infrastructure and avoided conversion or degradation of these systems protects the carbon benefits of these systems. By preserving existing high-quality natural areas through strategies like identification and study of rare natural communities, voluntary acquisitions and easements, protection of key areas for biodiversity and wildlife movement, and strategic public lands acquisition, Michigan can maintain and, ultimately, increase the amount of carbon removed from the atmosphere each year while simultaneously protecting biodiversity and supporting climate resilience. By restoring and improving the management of degraded natural systems through strategies like preventing and managing invasive species, implementing prescribed fire, restoring native plant communities, and restoring connectivity and hydrology in Michigan's waterways, the state can further maximize carbon sequestration as well as environmental and social co-benefits. It is also vital that efforts include supporting more community-led green spaces, especially in urban areas and disadvantaged communities. These types of spaces increase carbon sequestration while improving climate resilience through co-benefits like heat mitigation, stormwater management, and public health benefits.

Success of this measure relies on maintaining Michigan's existing carbon sink, which has diminished from -14.5 $MMTCO_2e$ since the 2005 baseline year to -12.4 $MMTCO_2e$ in 2021.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

As stated in the MHCP, state conservation efforts must respect the exercise of treaty rights. The state will not interfere with treaty rights, treaty resources, or Tribal cultural resources and will consult with Tribal Nations in the implementation of this measure.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the DNR will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

A more specific milestone, embedded in the Michigan the Beautiful initiative and included in the MHCP, is to conserve 30% of Michigan's lands and waters by 2030.

Metrics that may be used to track this reduction measure include the percentage of Michigan's lands and waters considered "conserved" and other metrics as identified.

Costs: Conservation costs vary based on whether the land needs to be acquired and what type of intervention is needed. Intervention may require significant investment due to comprehensive planning needs, the actual solution implementation, and the ongoing management needs afterwards.

The Alliance for the Great Lakes Ohio Environmental Council reports that Michigan would need to spend an additional $40 million to $65 million annually to meet water quality objectives in the Western Basin of Lake Erie. Given the scale and ambition of conserving 30% of Michigan's lands and waters, including the Great Lakes shoreline which spans hundreds of miles, similar annual conservation investments may be necessary.

Intersection with Other Funding: The U.S. Forest Service's Landscape Scale Restoration grants support cross-jurisdictional restoration of priority forest areas and through the Forest Legacy Program, they partner with state agencies to conserve privately owned forests through conservation easements or land purchase. The Agricultural Conservation Easement Program helps landowners conserve agricultural lands by providing financial and technical assistance to purchase conservation easements that limit development, support working farms and ranches, and improve environmental quality. The North American Wetlands Conservation Act provides matching grants for projects that involve the long-term protection, restoration, or enhancement of wetlands and associated habitats.

The Michigan Natural Resources Trust Fund supports projects that protect natural resources and promote outdoor recreation. The Michigan Land and Water Conservation Fund provides matching grants to units of government for the acquisition of land and development of public recreation areas. The 2025 Michigan Urban Conservation Community Grants, offered by The Conservation Fund and the DNR, support community-based conservation projects that enhance natural resources and access to green spaces in urban and underserved areas. Grants up to $50,000 are available for initiatives like tree planting, habitat restoration, green infrastructure, and community engagement.

Additionally, $600,000 in Watershed Council grants were awarded across the state to support watershed organizations with conservation and educational efforts. The Students to Stewards program, which helps teach K-12 students about the Great Lakes, watersheds throughout the state, and the importance of water resource conservation, invested $240,000 over the first two phases. A third phase will soon provide funding to facilitate field trips to Great Lakes freshwater ecosystems and for student led problem-, project-, and place-based learning opportunities around local water challenges. The federal Great Lakes Restoration Initiative has also provided $3.8 billion to help transform polluted waterfronts into places of recreation.

Quantification Methodology/Quantified Emissions Reduction: This measure was not quantified beyond the assumption that it maintains the existing -12.38 $MMTCO_2e$ considered a "sink", as of the 2021 inventory. Additional modelling for reforestation, afforestation, and wetland restoration is included in Measure 2 below.

Note: EPA's AVERT co-pollutants calculations were not available for this measure.

Natural and Working Lands Reduction Measure 2: Support climate-smart forestry practices

Measure Description: Michigan possesses one of the largest forest-based carbon removal opportunities in the Midwest, offering an estimated 11.38 $MMTCO_2e$ per year in mitigation potential through reforestation and urban tree planting. Approximately 3.43 million acres in Michigan are identified as suitable for reforestation, spanning pastures, marginal croplands, grassy areas, urban open spaces, and riparian corridors. Nearly 90% of this opportunity lies on private land, underscoring the importance of designing inclusive policies and incentive programs that encourage voluntary participation by landowners.

Climate-smart forestry practices such as extended harvest rotations, selective thinning, and enhanced stocking can significantly increase carbon sequestration of Michigan's forestland. Michigan's forests can further support economy wide decarbonization by providing sustainable building material such as mass timber. By implementing these climate-smart forestry practices, Michigan can advance a high-impact, science-based strategy for reducing emissions, conserving forests, and improving resilience.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action. Notably, the DNR directly manages nearly 4 million acres of state forestland.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the DNR and the MDARD, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

The MHCP also set a goal of protecting 30% of Michigan's lands and waters by the year 2030.

Metrics that may be used to track this reduction measure include the number of trees planted, urban canopy coverage, acres reforested, the number of landowners enrolled in forestry programs, climate-smart forestry acreage, acres of forest certified by the Sustainable Forestry Initiative or Forest Stewardship Council, the number of trees planted in underserved communities, and other metrics as identified.

Costs: Reforestation costs between $5.02 and $6.17 per seedling. These costs cover the supply and planting efforts, but do not account for transport, pest control, or fencing. Overall, costs can amount to $20 per ton of CO_2 sequestered.

Intersection with Other Funding: Michigan's forest landscape is supported by a robust network of public and private programs that promote sustainable forest management, conservation, and education. The Michigan Forest Stewardship Program, in partnership with the USDA Forest Service and other agencies, equips 250 foresters and 1,000 loggers with tools and resources to assist the state's 400,000 family forest owners in managing more than 9 million acres of private forestland. In 2023, the program invested nearly $58,000 in partnerships across the state, including $16,000 to the Michigan Tree Farm Committee to support landowner outreach, administration, and audits for independently managed forestry groups. The program is also spearheading Forest to Mi Faucet, a new initiative with 20 conservation partners, to educate the public about how Michigan's forests protect drinking water sources.

Complementing these efforts, the Qualified Forest Program and Commercial Forest Program administered by the MDARD offer tax incentives to landowners who manage their forests for sustainable timber harvests, wildlife habitat, and ecological health. The MDARD's Forestry Assistance Program works with local conservation districts to provide technical assistance to private forest owners on how to manage their forestland sustainably. Additional support comes from the Sustainable Forestry Initiative, whose program participants manage over five million acres of forest in Michigan.

The U.S. Forest Service's Landscape Scale Restoration grants support cross-jurisdictional restoration of priority forest areas, while the USDA's Environmental Quality Incentives Program (EQIP) offers technical and financial assistance to improve soil health, water quality, wildlife habitat, and climate resilience. The Northern Institute of Applied Climate Science also contributes through climate adaptation guidance, carbon management strategies, and science-based decision support tools, helping Michigan's forests remain a vital environmental and economic resource for generations to come.

The state included $10 million in its fiscal year 2025 budget for the Water Infrastructure Initiative – Green Infrastructure Project, which provides funding to encourage local governments to restore and conserve wetlands. The budget also includes $3 million for the DNR to acquire and conserve wetlands throughout the state. The Voluntary Wetland Restoration program facilitates coordination with state, federal, Tribal, and nongovernmental agencies and organizations specializing in wetland restoration and conservation.

Quantification Methodology: The EPS was used to model net GHG emissions from land use under different policy interventions, accounting for state-specific forest growth rates, land competition, and delayed biomass accumulation. For both reforestation and improved forest management, 100% implementation scenarios were modeled, reflecting full deployment of feasible opportunities over time.

For simplicity of quantification, emissions from avoided conversion of peatlands, wetland restoration, and improved management of wetlands were included in this measure as well. The Naturebase Principles of Natural Climate Solutions dataset (2024) was used to estimate per-acre emissions reductions for peatland areas identified through expert-reviewed opportunity assessments as restorable and at-risk.

Quantified Emissions Reduction:

Table 51: Natural and Working Lands Reduction Measure 2: Quantified GHG Emissions Reductions (Measured in MMTCO_2e)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-1.01	-5.94

Note: EPA'S AVERT co-pollutants calculations were not available for this measure, though it will likely result in similar benefits as previous reduction measures, such as improved air quality and a healthier environment for communities.

Natural and Working Lands Reduction Measure 3:
Support climate-smart agricultural practices

Measure Description: Michigan's agriculture sector contributes approximately 11.3 MMTCO_2e annually, with projections showing minimal change through 2050 in the absence of new interventions. Two of the most promising strategies to reduce these emissions are (1) improved manure management and methane capture technologies and (2) cover cropping and conservation tillage (such as zero tillage).

Livestock methane emissions, primarily from enteric fermentation and manure management, can be abated through the adoption of feed additives and methane digesters. The national technical potential for livestock methane reduction is about 55 MMTCO_2e by 2050. When scaled to Michigan's livestock emissions profile, this translates to approximately 2.4 MMTCO_2e reduction potential by 2050.

Cover cropping and conservation tillage alone have a combined technical mitigation potential of approximately 6.6 MMTCO_2e per year if implemented across all suitable cropland. Michigan already has 672,000 acres utilizing cover crops and 3.8 million acres under conservation tillage. Together, these are mitigating 1.2-1.4 MMTCO_2e in annual emissions. However significant remaining potential exists; approximately 5.5 million acres of row cropland remain available for cover crop adoption, and 4.6 million acres could transition to reduced-till or no-till practices. Cover crops, nutrient management, crop diversification, and other regenerative approaches also lower the need for synthetic fertilizer, which is itself a contributor of emissions in the agriculture sector. These practices provide economic benefits to farmers, with returns on investment ranging from 7% to 343% through improved yields, reduced input costs, and enhanced resilience to extreme weather. Though famers face several barriers to adoption of these practices, such as high upfront costs, secure land tenure concerns, and knowledge gaps, the MDARD's Regenerative Agriculture program exists to support farmers and promote these and other climate-smart agricultural practices.

Implementation Authority: As stated in Section 1.3, the State of Michigan has existing legislative and regulatory authority to implement this measure without additional action.

Implementation Timelines, Milestones, and Metrics: This statewide action, implemented by EGLE in collaboration with the MDARD, will follow a timeline aligned with the MHCP goals of reducing GHG emissions by 52% from 2005 baselines by 2030 and reaching 100% carbon neutrality by 2050. EGLE will track progress towards these emissions targets annually.

While there are no specific milestones for agriculture outlined in the MHCP, the MHCP acknowledges that Michigan should maximize potential climate-smart agricultural practices in order to achieve net zero goals.

Metrics that may be used to track this reduction measure include acres under cover cropping, acres under conservation tillage, input savings (fertilizer, herbicide, etc.), soil organic carbon improvements, number of methane digesters installed, number of agricultural producers enrolled in conservation programs, and other metrics as identified.

Costs: Improved manure management systems require high upfront capital investment, including land acquisition, site development, equipment, installation costs, permitting fees, developer costs, etc. Of all the contracts provided by the USDA's EQIP, anaerobic methane digesters represent the most expensive practice at an average of over $400,000 per contract. Improvements in combustion systems, waste facility covers, waste storage facility development and water conservation systems range from an average contract cost of $50,000 to $75,000.

Based on the EQIP, contracts allocated to cover crops cost an average of just over $9,000, with seeds costing approximately $14.86 plus $9.12 per acre. Meanwhile, average net returns for conservation tillage were $377 per acre for corn, while averages for conventionally tilled fields were $324 per acre for corn. While cover crops tend to have higher short-term costs than reduced tillage, these costs do decline over time as farmers gain experience managing the cover crops. These strategies can ultimately lead to cost savings through reduced fertilizer use, reduced need for herbicides and pesticides, improved yields, and soil erosion prevention.

Intersection with Other Funding: Over $48 million in Food and Agriculture Investment Fund Grants, which provide financial support for food and agriculture projects and enable growth in the industry, have been awarded to the MDARD. Further, the MDARD's 2024 budget provided $6 million to bolster soil health and regenerative agriculture initiatives, including soil cover maintenance, crop diversity, and livestock integration. Additionally, $7 million was allocated for research grants to Michigan State University to promote climate-smart agricultural methods and innovative technologies. These research efforts will help enhance soil and plant health, carbon sequestration, water efficiency, and conservation efforts. The Michigan Agriculture Environmental Assurance Program is a voluntary, confidential program helping farmers adopt environmentally sound practices and demonstrate their commitment to protecting natural resources.

The state is also committed to supporting programs like the 'Buy Michigan Agriculture Campaign' to encourage the purchase of Michigan grown and raised products, address food insecurity challenges, and counter supply chain issues. The Food Hubs and Farm Stops Grant Program from the MDARD supports the development and expansion of food hubs and farm stops that connect local farmers with consumers.

At the federal level, the EQIP provides technical and financial assistance to agricultural producers to start addressing water and air quality concerns, water conservation, soil health, soil erosion, improved wildlife habitat, and drought mitigation. The Conservation Stewardship Program, which is also administered by the USDA, provides longer term support to help farmers, ranchers, and forest landowners maintain and improve existing conservation efforts on their land. The Agricultural Conservation Easement Program, which helps landowners conserve agricultural lands, provides financial and technical assistance to purchase conservation easements that limit development, support working farms and ranches, and improve environmental quality.

Additionally, organizations such as Sustainable Agriculture Research and Education offer grants towards projects that advance research and education of sustainable agricultural practices. Michigan Agriculture Advancement also supports long-term farm resilience, environmental health, and food system diversity by uplifting innovative farmers across Michigan and offering farmers and other partners opportunities to learn from one another.

Quantification Methodology: The quantification methodology draws on modeling results from the EPS and bottom-up estimates from American Farmland Trust and the EPA sources. For livestock methane, the EPS modeling assumes full adoption by 2050, reaching a reduction of 2.4 $MMTCO_2e$ per year, with 0.5 $MMTCO_2e$ achieved by 2030.

While not included in the quantification due to modeling constraints, and therefore not included in the results presented below, climate-smart agricultural practices have the potential to mitigate up to an additional 6.6 $MMTCO_2e$.

Quantified Emissions Reduction:

Table 52: Natural and Working Lands Reduction Measure 3: Quantified GHG Emissions Reductions (Measured in $MMTCO_2e$)

Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
-0.50	-2.42

Table 53: Natural and Working Lands Reduction Measure 3: Quantified Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Base Year (2021)	Difference between BAU and Implementation of Measure 2030	Difference between BAU and Implementation of Measure 2050
SOx	178.70	1.08*	1.71*
NOx	502.13	2.67*	4.27*
PM2.5	163.25	0.84*	1.40*
VOC	3,360.37	16.76*	25.74*

*Note: These values show an increase in co-pollutant emissions. While feed additives and methane digesters are valuable tools for reducing livestock methane emissions, they can lead to increases, rather than decreases, in $PM_{2.5}$, NO_x, SO_x, and VOCs due to changes in manure chemistry, combustion byproducts, and nitrogen cycling.

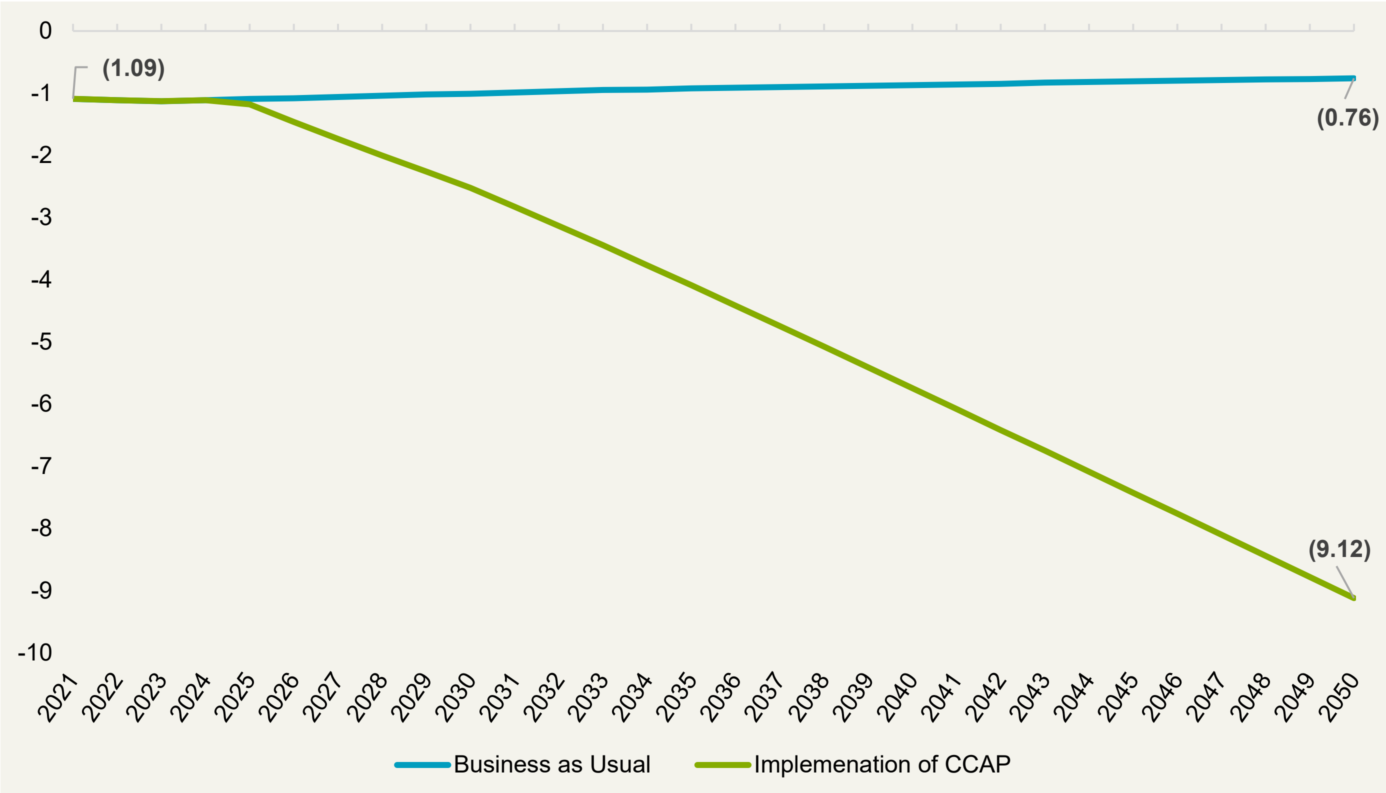
Natural and Working Lands Sector Summary

The data here, along with benefits and workforce considerations, is derived from aggregating the impact of all reduction measures listed in this sector.

Table 54: Natural and Working Lands Sector: Quantified GHG Emissions Reductions across All Natural and Working Lands Measures (Measured in $MMTCO_2e$)

Scenario	Agriculture 2030	Land Sink 2030	Net Total 2030	Agriculture 2050	Land Sink 2050	Net Total 2050
BAU	11.37	-12.38	-1.01	11.62	-12.38	-0.76
Implementation of the CCAP	10.87	-13.39	-2.52	9.20	-18.32	-9.12
Difference between BAU and Implementation of CCAP	-0.50	-1.01	**-1.51**	-2.42	-5.94	**-8.36**

Figure 31: Natural and Working Lands Sector: Annual Quantified GHG Emissions Reductions across All Natural and Working Lands Measures (Measured in $MMTCO_2e$)



Qualitative and Quantitative Benefits Analysis across the Natural and Working Lands Sector

The reduction measures across the Natural and Working Lands sector have a variety of benefits beyond GHG emissions reductions. These strategies contribute to healthier ecosystems and communities by restoring ecological functions, improving air and water quality, and enhancing local resilience. Reforestation projects support biodiversity, protect watersheds, and reduce the risk of flooding and erosion. Climate-smart forestry practices further reinforce these benefits by ensuring that forests are managed for long-term ecological health, supporting habitat conservation while sustaining jobs and timber production.

Conservation-focused strategies such as wetland restoration and habitat protection bring direct benefits to communities, including expanded recreational opportunities, flood mitigation, and improved drinking water quality. These strategies also create pathways for public engagement and environmental education, especially when paired with community-based initiatives.

Sustainable agriculture practices like reduced fertilizer use, improved manure management, and soil health enhancements promote both climate mitigation and public health. These practices limit nutrient runoff that can degrade water quality and contribute to harmful algal blooms, while also boosting the fertility and resilience of farmland. Supporting small and family-owned farms through climate-smart practices can also strengthen local food systems, improve food security, and create tourism and economic opportunities in rural areas.

Conserving, restoring, and connecting Michigan's natural heritage not only reduces emissions and enhances carbon storage, but it also fosters healthier, more connected communities and landscapes. Integrating these approaches holistically ensures that climate action in agriculture and natural lands also supports health, resilience, and local economies, particularly for historically overburdened communities.

Note: Natural and Working Lands Reduction Measure 3 was the only reduction measure with co-pollutant data available for this sector, so no aggregate co-benefit estimates were calculated for this sector. Estimated Community Benefits and Avoided Deaths by Race are not reported for the Natural and Working Lands Sector because data is not available.

Workforce Considerations across the Natural and Working Lands Sector

Employment in the state's agriculture sector has grown since 2011, with several subsectors projected to grow at a rate higher than the statewide employment growth rate of 8.8%. Agriculture in Michigan consists of the following subsectors: Food Processing (48%), Farming (30.1%), Agriculture Wholesale and Retail (19.3%), Input Supplies to Agriculture (1.4%), and Other (1.2%). The occupations with the most projected growth through 2030 are Farm Equipment Mechanics and Service Technicians (13.5%), Separating and Filtering Machine Operators (12.7%), Bakers (9.6%), Mixing and Blending Machine Operators (9.6%), and Conveyor Operators and Tenders (9.4%).

As Michigan expands implementation of strategies such as forest restoration, cover cropping, and methane digesters, new jobs are also expected in areas such as forestry equipment operation, land surveying and mapping, soil and water conservation, and digester system maintenance. The forestry sector also supports roles in nursery operations, tree planting crews, fire management, invasive species control, and forest inventory.

Anticipated Workforce Shortages: Annual openings for an occupation can occur for a variety of reasons, such as retirement and labor force exits, career transfers, or expansion within the occupation. The key occupations in Agriculture are expected to offer just under 70,000 average annual openings through 2030. The occupations with the most projected annual openings through 2030 are Hand Packers and Packagers (2,225), Farmworkers, Crop, Nursery, and Greenhouse workers (1,540), Packaging and Filling Machine Operators (1,370), Bakers (830), and Butchers and Meat Cutters (540).

Solutions to Address Workforce Shortages: There are a variety of programs in the state to address these anticipated workforce shortages across the LEO. The Michigan Agriculture Environmental Assurance Program also promotes sustainable practices and offers training to producers on how to reduce runoff and emissions. The DNR and Conservation Districts also provide job training and internship opportunities in environmental stewardship, habitat restoration, and wildfire prevention. The growth of the regenerative agriculture movement in the state is creating new green job pathways, especially for beginning farmers and food entrepreneurs focused on climate-smart practices.

Registered Apprenticeships are vital to ensuring a skilled workforce in Michigan. There are currently 11 active apprentices in the Agriculture, Forestry, Fishing and Hunting industry.

6.0 BENEFITS ANALYSIS

This section focuses on the benefits of GHG reduction measures on co-pollutant emission reductions. However, beyond what is included here, there are many co-benefits of climate action that include improved public health outcomes, economic benefits, increased climate resilience, and other environmental benefits.

Tracking emissions, including co-pollutants such as SO_x, NO_x, $PM_{2.5}$, and VOCs, evaluates the impact to health and wellbeing of Michiganders across the state. Different pollutants have distinct health and environmental effects, and certain populations, especially those in LIDACs, may be disproportionately exposed to higher concentrations of specific pollutants. For example, $PM_{2.5}$ and VOCs can trigger asthma and other respiratory issues. Meanwhile NO_x and SO_x contribute to acid rain and respiratory problems and often disproportionately impact communities living near industrial facilities.

Quantified estimates of co-pollutant reductions across the state associated with the proposed suite of measures.

Table 55: Economy-wide Co-Pollutant Emissions Reductions (Measured in Metric Tons)

Co-Pollutant	Base Year (2021)	Difference between BAU and Implementation of CCAP 2030	Difference between BAU and Implementation of CCAP 2050
SOx	50,964.46	-3,520.77	-10,228.58
NOx	166,214.00	-16,507.15	-56,612.73
PM2.5	46,033.10	-5,047.95	-37,084.40
VOC	931,645.40	-14,644.90	-37,100.00

7.0 LIDAC BENEFITS ANALYSIS

The tools used in this LIDAC analysis include the Climate and Economic Justice Screening Tool (CEJST), the EPA's Environmental Justice Screening and Mapping Tool (EJScreen), and Michigan's Environmental Justice Screening Tool (MiEJScreen). A list of all identified census tracts can be found in the Appendix of the PCAP.

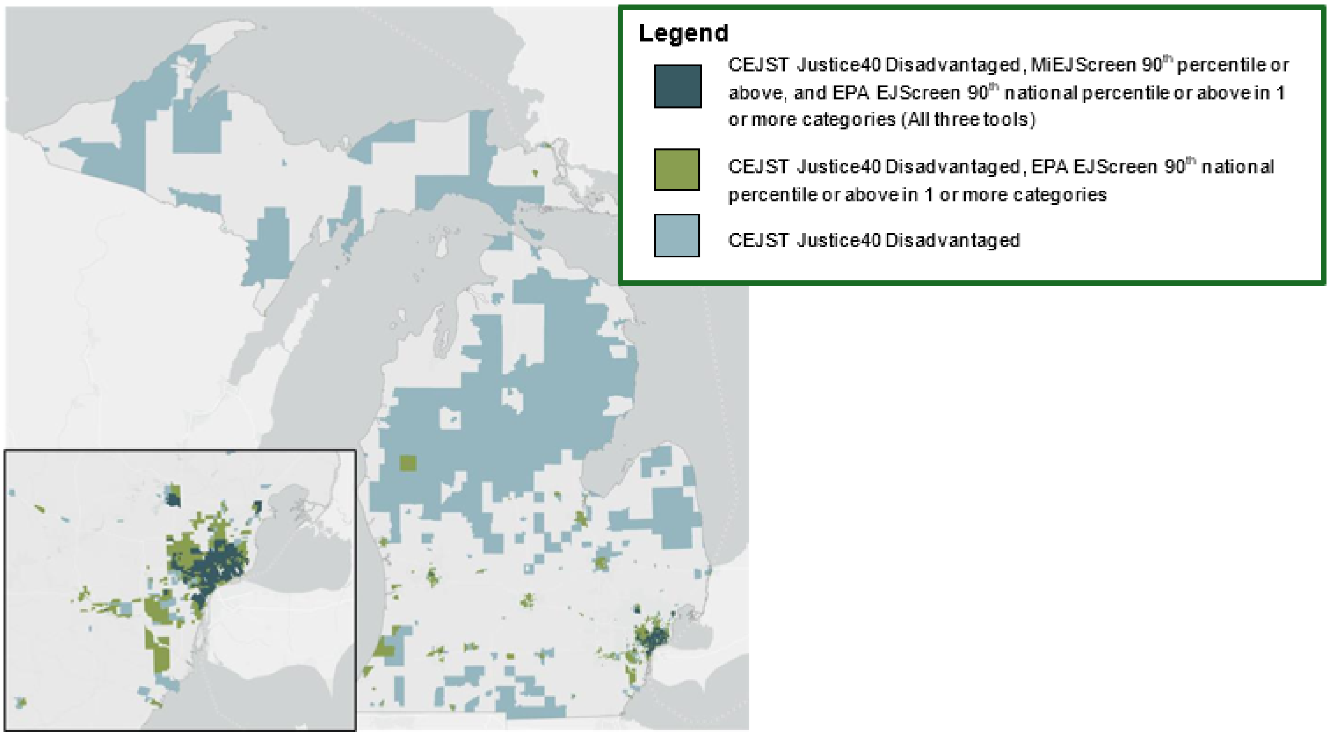
LIDAC Definition:

1. Any census tract that is included as disadvantaged in the CEJST
2. Any census block group that is at or above the 90th percentile for any of EJScreen's Supplemental Indexes when compared to the nation or state
3. Any geographic area within Tribal lands as included in the EJScreen

7.1 LIDAC Identification

The State of Michigan has many areas that are identified as LIDACs. Many of these communities are also disproportionally impacted by injustices in categories including climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. The CEJST methodology considers a census tract to be disadvantaged if it meets one of two requirements: (1) they are in census tracts that meet the thresholds for at least one of the tool's categories of burden or, (2) they are on land within the boundaries of Federally Recognized Tribes.

Figure 32: Map of Michigan State Showing the LIDACs among Three Different Tools



Based on the CEJST screening tool, the State of Michigan has 996 census tracts that are identified as disadvantaged, making 35% of Michigan communities considered LIDACs. The map shown above provides an illustration of how widespread the identified disadvantaged communities are throughout the State of Michigan. Within the 996 census tracts identified as disadvantaged, four of the tracts located in Isabella County are considered so due to 99% of the tract being within Federally Recognized Tribal areas.

In addition to the CEJST screening tool, the 996 identified disadvantaged census tracts were also analyzed using the MiEJScreen and the EJScreen. Both tools include additional information on supplemental indexes, which provides a combination of environmental and socioeconomic information based on thirteen specific environmental indicators, including: $PM_{2.5}$, Ozone, Diesel Particulate Matter, Air Toxics Cancer Risk, Air Toxics Respiratory Hazard Index, Toxic Releases to Air, Traffic Proximity, Lead Paint, Risk Management Program Facility Proximity, Hazardous Waste Proximity, Superfund Proximity, Underground Storage Tanks, and Wastewater Discharge. Based on the EJScreen tool, many of the 996 identified disadvantaged census tracts within the State of Michigan were ranked in the 90th percentile nationally for seven out of the thirteen specific environmental indicators as described in the Appendix of the PCAP.

7.2 LIDAC Meaningful Engagement

As explained in Section 1.3, the State of Michigan engaged with community members and leaders throughout many of the identified LIDACs, utilizing several different engagement methodologies, including in-person and virtual forums, to ensure that the concerns and desired outcomes for LIDACs throughout the state were identified.

To launch engagement for the development of the CCAP, EGLE, in partnership with the University of Michigan School for Environment and Sustainability, hosted a hybrid session titled "Collaborative Planning for Equitable and Just Climate Action" in Detroit and virtually in October 2024. The session aimed to identify key environmental justice considerations to inform the development of GHG reduction measures. Insights gathered during this event were shared at subsequent engagement sessions and helped establish a framework for more detailed discussions on environmental justice across other pillars of the MHCP. Over 270 individuals registered for the virtual option, with an additional 63 attending the session in person. Across both the virtual and in person options, over 700 comments were collected on all 6 pillars of the MHCP, the overarching themes are captured below.

Themes from the Engagement Session:

Engagement & Education

- Importance of education and outreach to raise awareness and build trust within communities.
- Encouraging grassroots initiatives and local buy-in of sustainability efforts.
- Use of storytelling and clear messaging to effectively communicate benefits and encourage participation.

Resilience & Sustainability

- Emphasis on building community resilience to climate impacts and disasters.
- Integrating sustainability into broader community development and planning efforts.
- Recognition of the interconnectedness of environmental, social, and economic factors.

Economic Opportunity

- Creation of jobs through energy efficiency programs, building upgrades, and renewable energy initiatives.
- Support for small businesses and workforce development in the green economy.
- Economic benefits from reduced utility costs and increased property values.

Infrastructure & Technology

- Need for upgrades to outdated infrastructure (e.g., electrical systems, housing).
- Promotion of energy-efficient technologies and renewable energy sources (e.g., solar, battery storage).
- Streamlining access to utility data and smart technologies for better energy management.

Policy & Regulation

- Calls for stronger policies that prioritize community health and the environment.
- Advocacy for transparency and accountability in utility and corporate practices.
- Recommendations to support community-driven renewable energy projects.

Meaningful engagement with Michigan's LIDACs is essential to ensure the CCAP reflects community priorities, lived experiences, and local expertise. Continued collaboration with LIDACs will guide implementation in ways that are equitable, transparent, and grounded in the realities of Michigan's communities.

7.3 Benefits of GHG Emissions Reduction Measures to LIDACs

The implementation of these reduction measures will provide crucial co-benefits to LIDACs in areas including air quality, public health, energy burden, workforce, and climate resilience. The following measures of community benefits were chosen due to their tangible benefits on the health, economic wellbeing, and overall quality of life of individuals within these communities.

All reduction measures in Section 5 aimed to quantify each of these areas, but due to the variety of tools used in emissions reduction quantification, this was not always possible. The estimates provided for each reduction measure, where data is available, are from either the EPA's COBRA or the EPS, or where a range of values are listed, both. The COBRA tool inputs co-pollutant emissions reductions (SO_x, NO_x, $PM_{2.5}$, and VOCs) and provides a value for the reduction in the metrics listed below. The EPS provides this data as well, based on settings selected for each reduction measure. Additional methodology for the COBRA and the EPS can be found on their respective websites.

Due to the statewide scope of this CCAP, these benefits can be reasonably expected to affect all census tracts listed in the Appendix of the PCAP.

Avoided Deaths by Race: Avoidable deaths by race sheds light on the unequal environmental burdens faced by different communities. Different racial groups can have varying degrees of vulnerability to environmental hazards due to factors like housing quality and access to healthcare. By minimizing air pollution and improving overall air quality, the risk of respiratory diseases and cardiovascular issues decreases. By looking at preventable deaths linked to harmful pollution, communities that bear a disproportionate burden can be pinpointed. This approach allows policymakers to develop targeted interventions that address specific community needs.

Avoided Lost Workdays: Lower-income communities often bear the brunt of health-related challenges, leading to increased absenteeism from work. Lost workdays capture the immediate and ongoing economic harm caused by environmental issues, which is crucial for communities often dealing with financial insecurity. This metric captures the short-term health issues, respiratory problems, and mental health impacts that significantly disrupt lives and cause an economic toll on LIDACs. Implementation of GHG reduction measures should reduce the occurrences of respiratory illnesses, resulting in fewer lost workdays, improving the economic wellbeing of individuals in these communities, and fostering greater productivity and financial stability.

Avoided Respiratory Symptom Cases: GHG reduction measures that reduce fossil fuel combustion play a pivotal role in reducing air pollution. Co-pollutants from fossil fuel combustion such as $PM_{2.5}$ or NO_x are a major contributor to respiratory issues, including bronchitis and asthma. Respiratory issues such as coughing, wheezing, and shortness of breath are often early indicators of exposure to environmental pollutants. Tracking avoided cases of these symptoms provides an early warning system for potential long-term health problems like chronic respiratory diseases or asthma. Tracking avoided respiratory symptoms also captures the day-to-day burdens faced by communities living in polluted environments. Additionally, reducing the prevalence of respiratory symptoms not only enhances the overall health of individuals in LIDACs but also alleviates the burden on healthcare systems, leading to a more equitable distribution of health resources.

Avoided Hospital Admissions: This metric highlights the significant burden of illness caused by environmental factors and encompasses a wide range of health problems from acute respiratory infections to chronic conditions exacerbated by pollution. Avoided hospital admissions provides a more comprehensive picture of environmental health impacts. In addition, hospital admissions are expensive, both for individuals and healthcare providers. Tracking avoided admissions reveals the substantial economic burden placed on communities disproportionately exposed to environmental hazards.

Avoided Minor Restricted Activity Days: Unlike more severe outcomes such as deaths and hospital admissions, this metric captures the subtler, everyday impacts of environmental hazards on people's lives. This includes days when individuals experience symptoms like headaches, fatigue, or mild respiratory issues that restrict their usual activities like exercise or outdoor time. Access to clean air promotes a healthier lifestyle and enhances the overall quality of life for community members. Tracking minor restricted activity days can highlight the cumulative burden of exposure to pollution. A single day of feeling unwell might seem minor, but repeated occurrences can significantly impact mental wellbeing and quality of life, particularly for children and vulnerable populations.

8.0 WORKFORCE PLANNING ANALYSIS

As stated in the MHCP, as Michigan transitions away from fossil fuels and traditional carbon heavy industries, it is critical to prepare the workforce for the new opportunities of a carbon neutral economy and ensure all Michigan families have access to those opportunities, particularly those who have not enjoyed equitable access in the past.

Each sector in Section 5 includes a subsection detailing historical and projected growth of the workforce within that sector. Key occupations are listed, including those with the most anticipated growth over the next 5 years and those with the largest number of openings. The state and local programs that can help address the current and changing workforce metrics are also outlined in each section.

While not all sections above include workforce demographics, the cited reports from the LEO do provide more information on demographics such as gender, age, education, and race or ethnicity in order to identify trends and disparities in workforce representation.

- Workforce Considerations across the Electricity Generation Sector
- Workforce Considerations across the Transportation Sector
- Workforce Considerations across the Commercial and Residential Buildings Sector
- Workforce Considerations across the Industry Sector
- Workforce Considerations across the Waste and Wastewater Sector
- Workforce Considerations across the Natural and Working Lands Sector

APPENDIX

BAU and Implementation of CCAP Scenarios Projections Methodology

Why was the EPS used instead of the SIT Projection Tool for projections? The EPS was used for BAU projections and many of the implementation of the CCAP scenario projections. The decision was made to use the EPS for projections, instead of the EPA SIT Projection tool because EPA's Projection Tool uses national (or regional) projections and 2021 state percentages for the projections. The EPS uses 2021 state data for projections (including the EPA's state inventory, EPA's State-level Non-CO_2 Greenhouse Gas Mitigation Report, EIA's state profiles, modelling of Michigan's 2023 clean energy legislation, etc.). With the exception of Electricity Generation, all BAU scenario projections are based off of the EPS Version 4.0.4. (April 2025).

How were the BAU projections done? The EPS does not have historical data, it is solely a projection tool. The EPS projections were mapped to the economic sector inventory developed for the year 2021. Because the developed 2021 inventory ends at 2021 and the EPS starts at 2021, comparisons can be made between the data and 2021 can be used for alignment. When comparing the two data points for 2021 (EPS vs. inventory), there are subtle differences, which are likely due to different measurements and data sources. Overall, the numbers in the EPS model track very closely to what was calculated in the 2021 inventory. Any differences are likely because the 2021 inventory added more specificity. Each time the EPS and the 2021 inventory are different, the 2021 inventory is more conservative in the estimates.

To align both data sources and ensure a smooth transition from inventory to projections, the raw data from the EPS was adjusted slightly to map onto the 2021 inventory. The following formula was used to do this: Projected Emissions for 2022 = 2021 inventory data point * rate of change for 2022.

Rate of change = (final value - initial value) / initial value

Rate of change for 2022 = (EPS data point for 2022 - EPS data point for 2021) / EPS data point for 2021

Rate of change for 2023 = (EPS data point for 2023 - EPS data point for 2022) / EPS data point for 2022

This same method was used to calculate a rate of change through 2050.

GHG INVENTORY METHODOLOGY

Figure 33: EPA Inventory Categories mapped to MI EGLE Economic Sectors

EPA Inventory Category (SIT Modules)	MI EGLE Economic Sectors						
	Agriculture	Waste & Wastewater	Commercial and Residential Buildings	Industry	Electric Power	Natural Lands	Transportation
Agriculture	Module mapped 1-to-1						
Waste (Not Used)							
Wastewater (Not Used)							
Industrial Processes				All Emissions (minus T&D Systems)	Transmission & Distribution (T&D) Systems		
LULUCF						Module mapped 1-to-1	
Indirect CO_2 from Electricity (Not Used)							
CO_2FFC			Residential & Commercial Emissions	Industrial Emissions	Electric Utilities Emissions		Transportation Emissions
Coal (Not Used)							
Stationary Combustion			Residential & Commercial Emissions	Industrial Emissions	Electric Utilities Emissions		
Natural Gas & Oil (Not Used)							
Mobile Combustion							Methane and Nitrous Oxide Emissions
Additional Data Sources Used	N/A	State GHG Inventory	N/A	State GHG Inventory and GHGRP	N/A	State GHG Inventory	N/A

Electricity Generation Economic Sector GHG Emissions: Electricity Generation is all default data from the EPA's SIT, including the default data modules: Industrial Processes (T&D Systems), CO_2FFC (Electric Utilities), and Stationary Combustion (Electric Utilities).

Transportation Economic Sector GHG Emissions: This sector includes SIT default data modules: CO_2FFC (Transportation), Mobile Combustion (Methane), and Mobile Combustion (Nitrous Oxide). CO_2 emissions are calculated using the high-reliability CO_2FFC Transportation module based on fuel consumption data. The Mobile Combustion module, which estimates emissions based on miles traveled by vehicle type, has a lower degree of confidence for CO_2 calculations and was therefore used only to derive vehicle type percentages. These percentages were then applied to the CO_2FFC total to provide a reliable breakdown by vehicle type.

Commercial and Residential Economic Sector GHG Emissions: This sector includes SIT default data modules: CO_2FFC (Residential), CO_2FFC (Commercial), Stationary Combustion (Residential), and Stationary Combustion (Commercial)

Industry Economic Sector GHG Emissions: This sector encompasses emissions from industrial processes, fossil fuel combustion for industrial use, stationary combustion, and natural gas and oil systems. The inventory was developed using three SIT workbooks as the primary foundation: CO_2FFC, Stationary Combustion, and Industrial Processes. For certain categories, the EPA's State GHG Inventory data and facility-level GHGRP data were used to ensure accuracy and address data gaps or quality concerns, as recommended by the EPA "Crosswalk between the Inventory U.S. Gas

Emissions and Sinks by U.S. State: 1990-2021 and the State Inventory Tool (SIT, January 2024 edition)."

The majority of industrial sector emissions were estimated directly using the EPA's SIT default data. The CO_2FFC workbook provided emissions estimates (CO_2) for industrial fossil fuel combustion by fuel type (coal, petroleum, natural gas, and other fuels). The Stationary Combustion workbook similarly estimated emissions (CH_4 and N_2O) from stationary industrial sources across multiple fuel types (coal, petroleum, natural gas, wood, and other fuels). The Industrial Processes workbook supplied default data for limestone and dolomite use, soda ash, ODS substitutes, urea consumption, and semiconductor manufacturing.

For the following categories, comprehensive state-level estimates from the EPA's 2024 State GHG Inventory[7] were used instead of the SIT default data:

- Aluminum Production (CO_2 and PFCs)
- Iron and Steel Production[8]
- Ammonia Production
- Magnesium Production and Processing
- Ferroalloy Production
- SiC Production and Consumption
- Glass Production
- Carbon Dioxide Consumption
- Nitrous Oxide from Product Uses
- Fluorochemical Production[9]: Emissions data were adopted directly from the State Inventory. In Michigan, chlorodifluoromethane (HCFC-22) production emissions are driven entirely by HCFC-22 manufacturing, as other HCFC-22 production shows no activity in the state.
- **Natural Gas and Oil Systems[10]**
  - Natural Gas - Transmission and Storage
  - Natural Gas - Production
  - Natural Gas - Distribution
  - Natural Gas - Post-Meter
  - Petroleum - Production
  - Natural Gas - Processing

[7] **EPA's State GHG Inventory:** EPA's 2024 All State GHG Inventory Data Workbook provides comprehensive state-level GHG emissions estimates from 1990-2022, consistent with the national GHG Inventory as documented in the Methodology Report: Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990-2022 (EPA-430-R-24-006). The State Inventory follows IPCC/UNFCCC methodology and represents economy-wide estimates across all emission sources.

[8] **Iron and Steel Production:** EPA's State Inventory data were used because the SIT default data was unavailable for all years and flagged as potentially inaccurate.

[9] **Fluorochemical Production:** In the EPA's State Inventory data structure, "Fluorochemical Production" is broken down into HCFC-22 Production and Production of Fluorochemicals Other Than HCFC-22. For Michigan, only HCFC-22 Production shows non-zero emission values. HCFC-22 is highlighted as a separate subcategory because its production generates significant HFC-23 emissions as a byproduct, which is a potent GHG.

[10] **Natural Gas and Oil Systems:** Since data provided by EGLE's Oil, Gas, and Minerals Division did not resolve all data gaps, the EPA's State Inventory estimates were used for all natural gas and oil emissions instead of relying on the SIT default data from the Natural Gas & Oil Module.

- Petroleum - Crude Oil Refining
- Petroleum - Crude Oil Transportation
- Abandoned Oil and Gas Wells

The following categories used a temporal hybrid approach, combining the EPA's State Inventory data for earlier years with facility-level GHGRP data accessed through the EPA's FLIGHT for recent years:

Cement Manufacturing:

- 1990-2009: EPA's State Inventory
- 2010-2021: EPA's FLIGHT (GHGRP facility-level data)

FLIGHT data includes both fuel combustion and process emissions that cannot be separated due to industry reporting practices.

Lime Manufacturing:

- 1990-2009: EPA's State Inventory
- 2010-2022: EPA's FLIGHT (GHGRP facility-level data)

This category does not include emissions from sugar facilities in Michigan, as CO_2 emissions are reabsorbed during the sugar production process.

Waste and Wastewater Economic Sector GHG Emissions: For industrial CH_4 wastewater, data was not available for a few line items in the EPA's SIT modules. Waste and wastewater data was not available via state sources, so the entire dataset was brought in from the EPA's SIT. The SIT data was pulled from the following: Composting (CH_4, N_2O), Anaerobic digestion (CH_4), Landfills (CH_4), Municipal Wastewater, and Industrial Wastewater.

Agriculture Economic Sector GHG Emissions: This economic sector is mapped one-to-one with the agriculture EPA's SIT module. Beyond the data shown in the SIT module, additional data manipulation (multiplying original gas emissions times GWP to get totals) allowed for agriculture soils to be broken down for additional data granularity. In order to see the breakdown by animal type, a formula was created which takes all the references to dairy cows and sums it up. For example, throughout the SIT module, dairy cow is mentioned in a few different places: NO_2 from Manure Management, CH_4 from Manure Management, and CH_4 from Enteric Fermentation. The formula combined these for a total for dairy cows. Similar computations were done for poultry and all other animal types. It strings together all of the values for each animal to arrive a total amount of emissions by animal for each process. While this approach was able to detail the emissions by animal, the same was not possible for crop type because of how the module outlines crop type.

Natural Lands Economic Sector GHG Emissions: This sector is based off the EPA's SIT default LULUCF data module*.* Additional State GHG Inventory data from the EPA was brought in for select items that were not included in the EPA's SIT, including: Non-CO_2 Emissions Forest fires, Wetlands, Settlements, and Flooded lands

Reduction Measures Quantification Data Sources

Sector	Measures	CO_2 Quantification	Co-Pollutant Quantification	Co-Benefit Quantification
Electricity Generation	Support clean energy deployment, including siting for renewable energy and increased investments in customer-driven renewable energy	EPS, impact measured jointly with energy storage reduction measure listed below	EPA's AVERT	EPA's COBRA, using EPA's AVERT outputs
Electricity Generation	Invest in energy storage to better integrate renewable energy into the electric grid	See above	EPA's AVERT	EPA's COBRA, using EPA's AVERT outputs
Electricity Generation	Support holistic grid planning, infrastructure investments, and flexible demand programs to enhance grid resilience	EPS	EPS	EPA's COBRA, using EPS outputs
Transportation	Encourage adoption of EVs by increasing EV charging infrastructure and vehicles	EPA's AVERT	EPA's AVERT	EPA's COBRA, using EPA's AVERT outputs
Transportation	Increase access to public transportation and non-motorized transportation options	EPA's AVERT and EPS	EPA's AVERT and EPS	EPA's COBRA, using EPA's AVERT and EPS outputs
Transportation	Support research and development to expand technologies available to reduce emissions from maritime, aviation, and heavy duty vehicles, including electrification, fleet optimization, and sustainable aviation fuel	EPA's AVERT and EPS	EPA's AVERT and EPS	EPA's COBRA, using EPA's AVERT and EPS outputs

Sector	Measures	CO_2 Quantification	Co-Pollutant Quantification	Co-Benefit Quantification
Transportation	Electrify state government, municipal, Tribal, and other public fleets	EPA's AVERT	EPA's AVERT	EPA's COBRA using EPA's AVERT outputs
Transportation	Support land use and transportation planning that will enable high-density, mixed-use development	Manually (see page 66)	Data not available	Data not available
Commercial and Residential Buildings	Support electrification in residential buildings, including an emphasis on households that rely on delivered fuels such as propane and home heating oil	EPS	EPS	EPA's COBRA and EPS, reported as range
Commercial and Residential Buildings	Support household energy use reduction through home repairs, weatherization, and other energy waste reduction investments	EPS	EPS	EPA's COBRA and EPS, reported as range
Commercial and Residential Buildings	Encourage energy efficiency enhancements, electrification, sustainable design, and retrofitting to reduce emissions from commercial buildings	EPS	EPS	EPA's COBRA and EPS, reported as range
Commercial and Residential Buildings	Support electrification and energy waste reduction efforts for state government, municipal, Tribal, and nonprofit facilities	Manually (see page 81)	Data not available	Data not available

Sector	Measures	CO_2 Quantification	Co-Pollutant Quantification	Co-Benefit Quantification
Industry	Promote and incentivize energy efficiency, waste heat recovery, and electrification across low to medium temperature industrial processes	EPS	EPS	EPA's COBRA and EPS, reported as range
Industry	Encourage emission reduction strategies from lime and cement manufacturing, including energy and material efficiency improvements, electrification, fuel switching, and clinker substitution	EPS	EPS	EPA's COBRA and EPS, reported as range
Industry	Encourage emission reduction strategies from iron and steel including electrification, material efficiency, energy efficiency, lower-temperature alternative production methods, and fuel switching	EPS	EPS	EPA's COBRA and EPS, reported as range
Industry	Encourage emission reduction strategies in gas and oil production, like methane capture and energy efficiency	EPS	EPS	EPA's COBRA and EPS, reported as range
Waste and Wastewater	Increase recycling and composting to send less waste to landfills	EPS	Data not available in EPS	EPS
Waste and Wastewater	Continue enhancement of landfill management technologies and methods	EPA's Non CO_2 GHG Tool	Data not available in EPS	EPS, with results reported jointly with the reduction measure below

Sector	Measures	CO_2 Quantification	Co-Pollutant Quantification	Co-Benefit Quantification
Waste and Wastewater	Encourage process optimization, energy efficiency enhancements, and biogas-fueled generation at water treatment plants	EPA's Non CO_2 GHG Tool	Data not available in EPS	See above
Agriculture and Natural Lands	Conserve, connect, and restore Michigan's lands and waters, advancing the Michigan the Beautiful initiative	Data not available	Data not available	Data not available
Agriculture and Natural Lands	Support climate-smart forestry practices	EPS, Manually (see page 117)	Data not available	Data not available
Agriculture and Natural Lands	Support climate-smart agricultural practices	EPS, Manually (see page 120)	EPS	Data not available