COMPREHENSIVE CLIMATE ACTION PLAN

November 2025

METROPOLITAN COUNCIL

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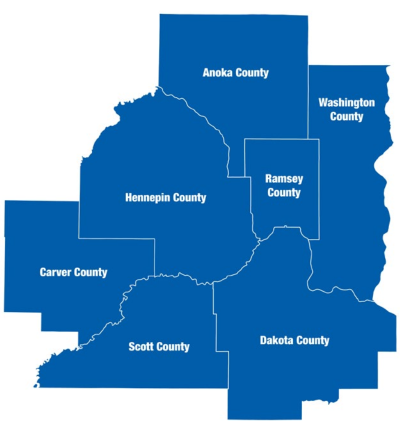

The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Met Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide housing opportunities for low- and moderate-income individuals and families. The 17-member Council board is appointed by and serves at the pleasure of the governor.

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Definitions and Acronyms

BWSR: Board of Water and Soil Resources

CO_2e: Carbon dioxide equivalent

Comprehensive Climate Action Plan (CCAP): A narrative report that provides an overview of the grantees' significant GHG sources/sinks and sectors, establishes near-term and long-term GHG emissions reduction goals, and provides strategies and identifies strategies that address the highest priority sectors to help the grantees meet those goals.

CPRG: Climate Pollution Reduction Grant programs from the Environmental Protection Agency

DEED: Minnesota Department of Employment and Economic Development

DNR: Minnesota Department of Natural Resources

DOE: United States Department of Energy

EPA: United States Environmental Protection Agency

EQB: Environmental Quality Board

GHG: Greenhouse gas

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

IPCC: United Nations Intergovernmental Panel on Climate Change

IRA: Inflation Reduction Act

LCA: Livable Communities Act

MDA: Minnesota Department of Agriculture

MHFA: Minnesota Housing Finance Agency

MPCA: Minnesota Pollution Control Agency

MMt: Million metric tons

MnDOT: Minnesota Department of Transportation

MSA: Metropolitan statistical areas as defined by the U.S. Census 2020 MSA population. A list of eligible MSAs can be found in Appendix 15.2 in EPA's CPRG: Formula Grants for Planning, Program Guidance for States, Municipalities, and Air Control Agencies.

Municipality: EPA defines municipality for the Climate Pollution Reduction Grants as "a city, town, borough, county, parish, district, or other public body created by or pursuant to State law. Consistent with section 137(d)(1) of the Clean Air Act, a group of municipalities, such as a council of governments, may also be considered an eligible entity under this program in some cases." This definition can be found in Section 4 in EPA's CPRG: Formula Grants for Planning, Program Guidance for States, Municipalities, and Air Control Agencies

NAICS: North American Industry Classification System

O*NET: Occupational Information Network

PM 2.5: Particulate matter of 2.5 micrometers and smaller

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

State: All 50 U.S. states and the District of Columbia and Puerto Rico.

SHIP: Statewide Health Improvement Partnership

SOC: Standard Occupation Classification system

USDA: United States Department of Agriculture

USEER: United States Energy and Employment Report

VMT: Vehicle miles traveled

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Executive Summary

The Comprehensive Climate Action Plan (CCAP) is a regional plan to document and guide actions that reduce climate emissions across the Twin Cities. The CCAP was developed by the Metropolitan Council and guided by an Environmental Protection Agency Climate Pollution Reduction Grant as well as existing state and regional climate goals and policies.

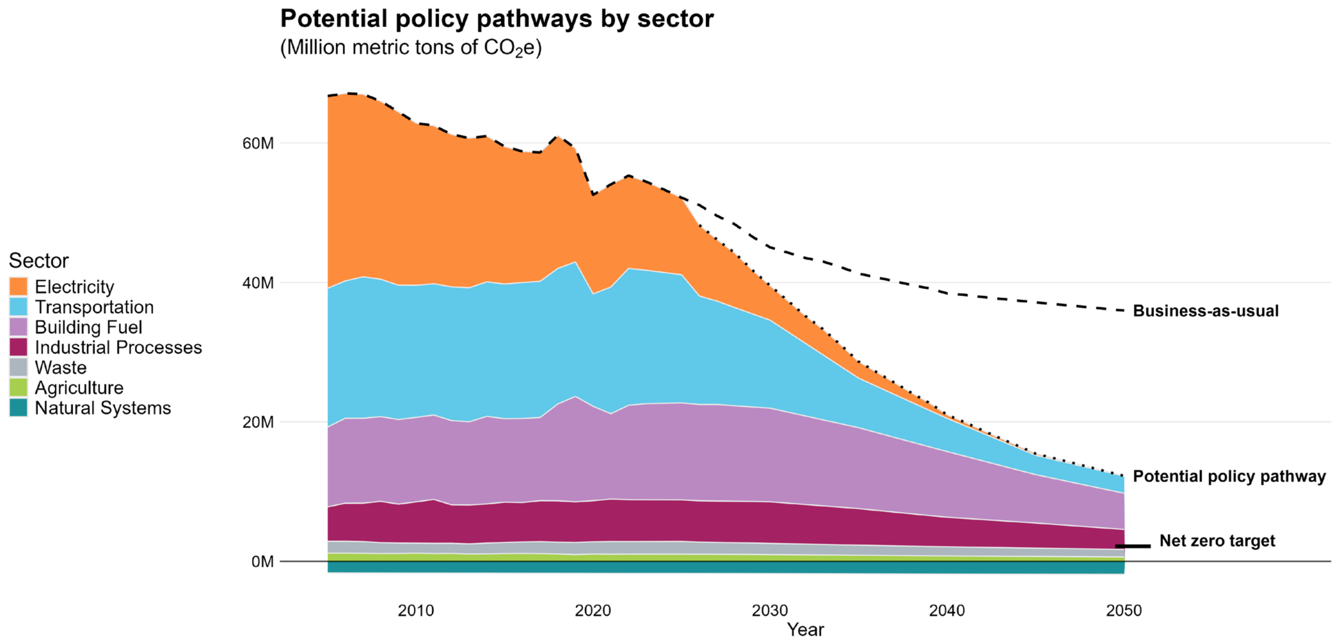
Engagement with local governments and community members was foundational to the creation of the CCAP. A steering committee of city, county, and Tribal staff provided feedback on all aspects of the plan and were especially valuable in developing the emissions reduction strategies. In-depth community engagement through eight organizations across the region included analysis of climate data and community priorities and guided the development of the plan’s community benefits analyses. Finally, a regional climate workforce work group helped ensure the workforce analysis aligned with the experience of agencies, organizations, and companies in the clean economy and workforce development sectors.

Greenhouse gas (GHG) inventory and projections are key components of the CCAP. A GHG inventory shows emissions sources and sequestration from all sectors in the region from 2005 to 2022. The inventory in Figure 1 shows the region has reduced emissions 18% since 2005.

GHG projections show how emissions will change in both the short- and long-term. Projections are shown for three scenarios:

- Business as Usual, the black dashed line, assumes emissions will continue based on past patterns and takes into account existing policies, including the state’s Clean Electricity Standard of 100% carbon-free electricity by 2040.
- Potential Policy Pathway, the wedges colored by sector, shows a scenario reflecting recent changes in federal policy and known state and local actions that would position the region substantially closer to its GHG emissions reduction goals.
- The net zero target marker shows the ambitious emissions reduction needed to achieve very low emissions offset by sequestration by 2050.

Figure 1: Potential policy pathway projections by sector



GHG reduction strategies are proposed actions for reducing GHG emissions across all sectors. Collectively, the inventory, projections, and reduction strategies outline a path for taking ambitious action to address GHG emissions in the Twin Cities region.

Introduction

CPRG Overview

The Climate Pollution Reduction Grant (CPRG) program supports states, local governments, Tribes, and territories in developing and implementing plans for reducing greenhouse gas (GHG) emissions and other harmful air pollution. This two-phase program provides $250 million for noncompetitive planning grants (of which $1 million was awarded to the Met Council) and approximately $4.6 billion for competitive implementation grants.

The two phases of the grant include two primary deliverables – the Priority Climate Action Plan (PCAP) which the Met Council submitted by March 1, 2024, and this Comprehensive Climate Action Plan (CCAP) due by December 1, 2025 – along with ongoing status reports through 2027.

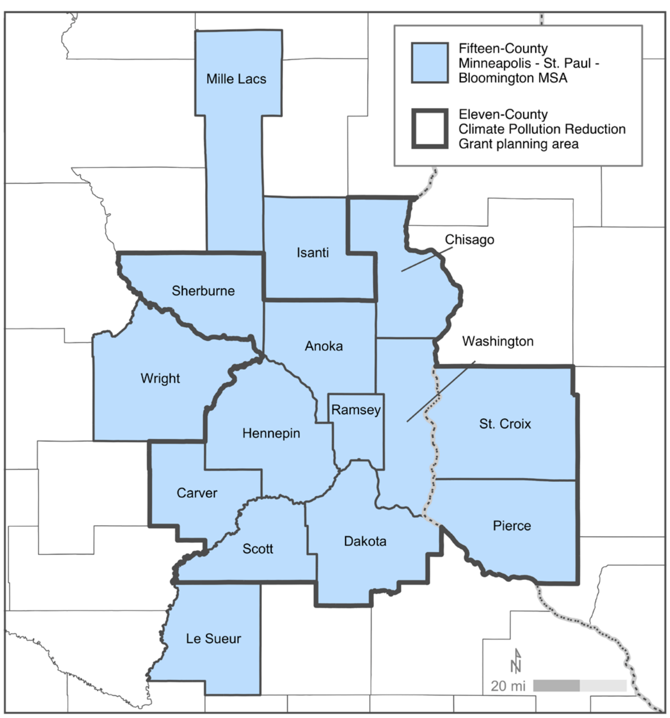
The CCAP consists of several key components including a comprehensive GHG inventory, projections for GHG emissions, specified strategies for GHG reduction, and a thorough benefits analysis covering the entire geographic scope and population addressed by the plan.

Comprehensive Climate Action Plan Purpose and Scope

Geographic scope of the CCAP

This CCAP applies to 11 of the 15 counties in the Twin Cities Metropolitan Statistical Area (MSA): Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott, Sherburne, and Washington counties in Minnesota along with Pierce and Saint Croix counties in Wisconsin.

Map 1. Map of Twin Cities Metropolitan Statistical Area and CPRG Planning Area



Source: Metropolitan Council, 2025.

The population of the 11-county region covered in the CCAP is 3,439,053 people across 278 cities and townships as of 2022.

State and regional planning context

The Met Council is the regional planning agency for the seven-county metro region, including 181 cities and townships in the counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington. It is responsible for guiding the growth and development of the region, including planning for three regional systems: the regional wastewater system, the metropolitan transportation system, and the regional parks and open space system. The Met Council adopted its most recent regional development guide, Imagine 2050, in February 2025.

As part of the planning process, the Met Council set five regional goals, one of which is: “We lead on addressing climate change: We have mitigated greenhouse gas emissions and have adapted to ensure that our communities and systems are resilient to climate impacts.”

Further, the 2023 Minnesota State Legislature passed a law requiring the regional development guide to plan for and consider climate adaptation and mitigation (Minn Stat. 473.145). The mitigation goals and strategies in the law aligned with the state’s greenhouse gas emissions goals to reduce emissions by 50% in 2030 and to become carbon-neutral by 2050.

The law also requires local governments in the seven-county metro region to consider greenhouse gas emissions reduction efforts and climate adaptation as a part of their comprehensive plans (Minn. Stat. 473.859). Local comprehensive plans are required to be completed and submitted to the Met Council for review by the end of 2028.

Purpose of the CCAP

The Comprehensive Climate Action Plan is intended to be an aspirational climate plan for the region and does not carry the regulatory weight of other Met Council plans like Imagine 2050. Communities throughout the region can reference the CCAP to understand relevant strategies for different sectors. Additionally, the analysis compiled in the CCAP supports the Met Council’s development of climate technical assistance tools. The Greenhouse Gas Emissions Reduction Tool and Climate Action Toolkit are examples of how information in the CCAP is being reformatted to support local governments in completing meaningful climate planning in their 2050 comprehensive plans.

Approach to developing the Comprehensive Climate Action Plan

The Met Council’s CPRG work expands on existing regional climate change mitigation work. The Met Council had already developed a GHG inventory and GHG strategy planning tool that quantified how a range of specific strategies may reduce future emissions at the city and township level. When it received the CPRG grant, the Met Council also was in the process of developing regional climate policy for its regional development guide, Imagine 2050. All of these efforts set the context for developing a regional comprehensive climate action plan.

Met Council staff led and largely developed the CCAP. The Minnesota Department of Employment and Economic Development conducted and compiled the workforce development analysis.

Engagement to inform the CCAP

Engagement with local governments and community members was foundational to the creation of the CCAP.

CPRG Steering Committee

The Met Council organized a CPRG Steering Committee of staff from cities, counties, and Tribes within the region. The Steering Committee's purpose included:

- Reviewing and refining the emissions inventory and reduction strategies.
- Identifying impacts of emissions reduction strategies to support the community benefit analysis.
- Advising on engagement plans for bringing city and county governments as well as community voices into climate planning.
- Providing feedback on draft plans to ensure the final plan best supports climate action in the region.

The Steering Committee met quarterly over 18 months leading up to the final Comprehensive Climate Action Plan. Committee members included representatives from the City of Bloomington, City of Carver, Chisago County, City of Coon Rapids, Dakota County, City of Eagan, Hennepin County, City of Mahtomedi, Mille Lacs Band of Ojibwe, City of Minneapolis, Saint Croix County, City of Saint Paul, and City of Savage.

Climate Action Planning Summit

In December 2024, the Met Council convened a Climate Action Planning Summit to engage with planning, natural resource, and sustainability staff from local governments in the region. The summit entailed all-day programming, including a local action panel, a session on minimum climate and natural systems planning requirements, and breakout sessions. Approximately 110 representatives from local governments across the region participated in the summit. Some key themes from the summit include:

- Interest in and need for greater collaboration within and among communities: Participants mentioned how more coordination can support the development and implementation of climate action. Participants shared specific ideas such as "peer cohorts."
- Access to data, expertise, and examples: Many participants named the importance of having access to relevant data and examples, such as case studies, strategy banks, cost-benefit analyses, and other plans, as well as access to experts and expertise in the field.
- Dynamic tensions: Discussions pointed to some inherent tensions in this work, including around the role of the Met Council to provide both flexibility and structure when creating comprehensive plan minimum requirements.

The summit also included a session that gathered feedback about the draft GHG inventory and mitigation strategies. Feedback from this session included:

- A request for per-capita as well as total GHG emissions data.
- Interest in more information in how sectors and sub-sectors are broken out and defined.

- Reflections on the importance of transportation-related actions as this sector emerges as a primary source of GHG emissions.
- A suggestion to frame reduction strategies through financial benefits.
- Questions about how to address emissions sources that are not under local control.

All the discussions throughout the Climate Action Planning Summit have helped to guide the content in the CCAP as well as the climate technical assistance tools that the Met Council creates for local governments.

Community Climate Collaboration

The Community Climate Collaboration was the Met Council's initiative to engage residents across the region in climate planning. The purpose was to obtain qualitative data to enhance regional climate policy, specifically informing the community benefit analysis included in the CCAP.

The program intentionally reached community members across the region, including those whose voices historically have been excluded in planning processes and who often bear the burden of the impacts of climate change. The engagement also focused on youth who will inherit the region and its climate. Organizations taking part in the Community Climate Collaboration included Brooklyn Bridge Alliance for Youth, COPAL, Hope for Earth, Hmong American Farmers Association, Islamic Center of Minnesota, Karen Organization of Minnesota, Minnesota 4-H, and Park Plaza Cooperative.

The engagement curriculum included 10 hours of workshop time with each organization, centered around the intersections of climate change and energy, transportation, waste, nature, environmental justice, and agriculture. Workshops focused on analyzing regional climate data, brainstorming climate strategies and their impacts, interviewing community members to better understand interest in and barriers to specific climate actions, and developing a final project to share findings with policy makers and community members.

Five key patterns emerged throughout the workshops and interviews.

Pattern 1: Recentering government accountability

> *"Ensure the program leaders, as well as government officials, honor their commitments, allowing communities to confidently collaborate with them."*

Many community members emphasized the importance of a government that shows up, listens, and follows through. Trust between government and communities is built through a proactive presence in community spaces and taking actions that reflect the priorities and lived experiences of residents. This raises the need for governments to plan and collaborate with communities to help reach common goals, and follow through with policy, tools, resources, and support.

As a piece of that accountability, participants also expressed a desire to see governments invest directly in communities, helping lower cost barriers to climate actions for individuals and households. When planning processes are transparent to and inclusive of community members, and when governments demonstrate a pattern of delivering on commitments, communities are more likely to collaborate confidently and sustain engagement over time.

Pattern 2: Empowerment within communities leads to collective action.

"One person doing something doesn't make that much of a difference, it's a collective effort. [...] How can we address this as a community?"

When residents feel agency, climate action scales naturally. Participants highlighted the importance of governments not only consulting communities but also playing a role in strategically convening and supporting the growth of local networks and leadership in ways that foster peer connection, empowerment, and shared learning. Some participants voiced that the relationships built through collective climate work often endure beyond the timeline of any single initiative, building the framework for lasting collaboration. However, peer influence can cut both ways. Public norms can either accelerate adoption of new behaviors or inhibit them. Governments can help shape these norms by amplifying community-driven climate strategies and helping cultivate climate leadership within communities.

Pattern 3: Culture-centered messaging and values shift

"Nature is a very big part of my life; I grew up in camp. The houses are made from bamboo, and we eat food straight from the ground, it's very organic. So, I would love to be a part of this."

Discussions with participants highlighted that climate strategies and their accompanying messaging are more successful when they speak to identity, heritage, and nature. Many participants spoke about climate change not simply as a technical issue, but as a challenge whose impacts are deeply personal, linked to heritage, health, spirituality, and the desire to care for future generations and beloved places. Additionally, messaging that invokes stewardship rather than personal sacrifice resonated more broadly among community members.

Participants emphasized the importance of culturally relevant climate storytelling, as well as outreach and education delivered by trusted messengers who reflect the community. Many participants also found nature to be a more tangible and effective entry point into climate action work. Shifting values around consumption, care for nature, and collective action takes culture-centered messaging, sustained connection, and recognition of the historic power dynamics that shape who gets heard and what gets prioritized.

Pattern 4: Education that leads to action

"The world is seeing the impact of climate change. People want to help but don't know how. Education drives change."

Without clear, actionable next steps, educational efforts can lead to frustration and inaction. Many participants voiced that in order for climate education to be effective, it needs to be multi-generational, language-accessible, and culturally responsive. Programs that demystify the benefits of climate strategies and offer practical steps are more likely to result in action. Community members also noted the importance of normalizing change, reframing new technologies, behaviors, or land use shifts not as disruptions, but as part of a new normal. Educational efforts to reduce stigma, whether around taking the bus or adopting nontraditional energy sources, can help shift individual behaviors and public perception.

Pattern 5: Infrastructure and mobility for low-carbon living

"Establishing more accessible and safe transportation would include more stops, meaning people wouldn't have to walk long distances to their destination."

Many communities voiced a desire for systems-level change, and a need for integrated infrastructure that supports climate-friendly living: safer streets for walking and biking, reliable transit options and multi-modal upgrades, accessible green spaces, and neighborhoods that make it easy to live without a car. Land-use changes that support walkable and bikeable, mixed-use areas were seen as investments in health, equity, affordability, and community well-being. Some participants also encouraged local governments to leverage existing infrastructure, such as installing solar panels on school roofs or parking lots or developing existing parks before building new ones. These approaches were viewed as more equitable, efficient, and responsive to the way people live.

Regional Climate Workforce Work Group

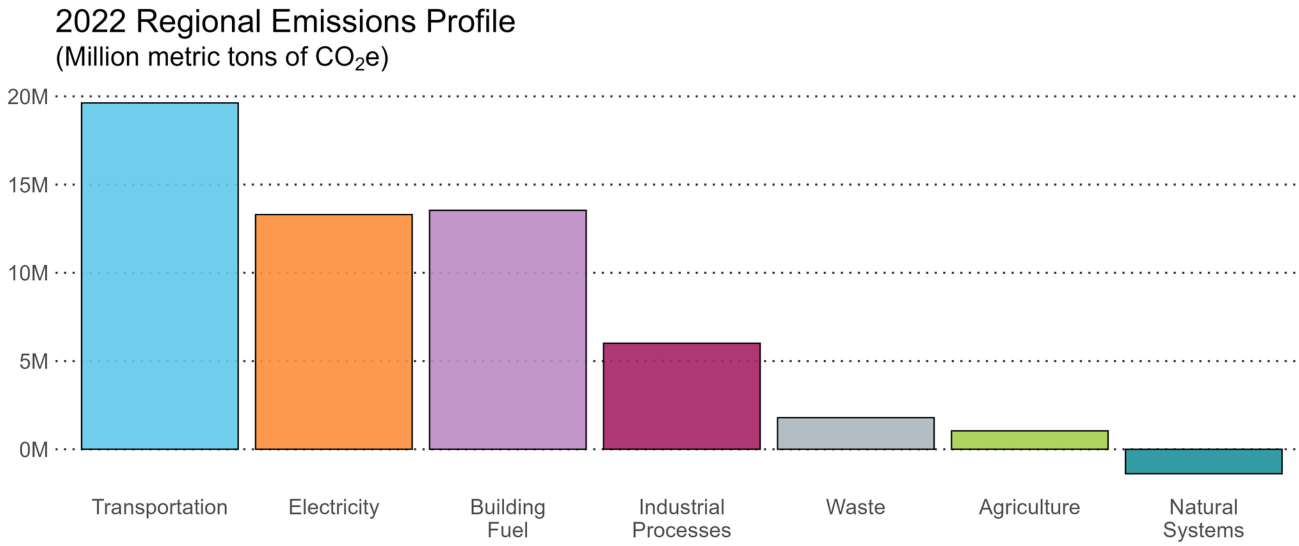
The work group focused specifically on workforce development and convened three times through the development of the Comprehensive Climate Action Plan. The purpose of the group was to advise on the workforce analysis and ensure that its conclusions and recommendations align with the experience of people doing this work day-to-day. Attendees represented state and county governments, trade organizations, and nonprofit organizations focused on workforce training and growing clean economy sectors.

Feedback from members of the Workforce Work Group highlighted both the strong growth potential of the clean economy and the workforce challenges that must be addressed to make it possible. Many participants emphasized opportunities to diversify the workforce, build awareness of green career pathways, and align training with high-demand, family-sustaining jobs, while also noting significant barriers such as lack of transportation, childcare, and training pathways, as well as gaps in data needed to target resources and track progress.

Greenhouse Gas (GHG) Inventory

In 2022, the Twin-Cities MSA generated 55.3 million metric tons of CO_2 equivalent ($MMtCO_2e$) emissions across all economic sectors. Transportation was the largest contributor to GHG emissions (35.5%), followed by building fuel use (24.5%), electricity consumption (24.0%), industrial processes (10.9%), waste (3.2%), and agriculture (1.9%). Natural systems sequestered 1.7 $MMtCO_2e$ in 2022, or 3.2% of the total amount emitted.

Figure 2. 2022 Regional Emissions Profile



Inventory Methodology

Methods used to estimate GHG emissions varied by sector. In all cases, the Global Warming Potentials from IPCC6 were used for converting all gases to CO_2 equivalency.

All data manipulation and analysis were conducted in the R programming environment and were tracked in a Metropolitan Council GitHub repository. Sectors were broken up into subtasks and assigned to researchers. As researchers completed tasks, all code and data were submitted for peer review by another team member before being merged into the main branch of the repository. Datasets and functions were regularly tested and evaluated for reproducibility and consistency. Final datasets were compared with other GHG inventories and contextual data, like population estimates, for correlation and logical consistency. Specific methodology information is listed below each sector and a detailed discussion of the GHG inventory methods are included in Appendix C.

Inventory Results

Region-wide, total GHG emissions have declined between 2005 and 2022 driven by emissions reductions in the electricity sector due to increasing use of renewable energy sources. However, only moderate reductions have been seen in other sectors with still others are increasing in emissions as shown in Table 1. The following trends and analysis section will further break down these trends.

Table 1. Region-wide GHG Emissions Inventory Results

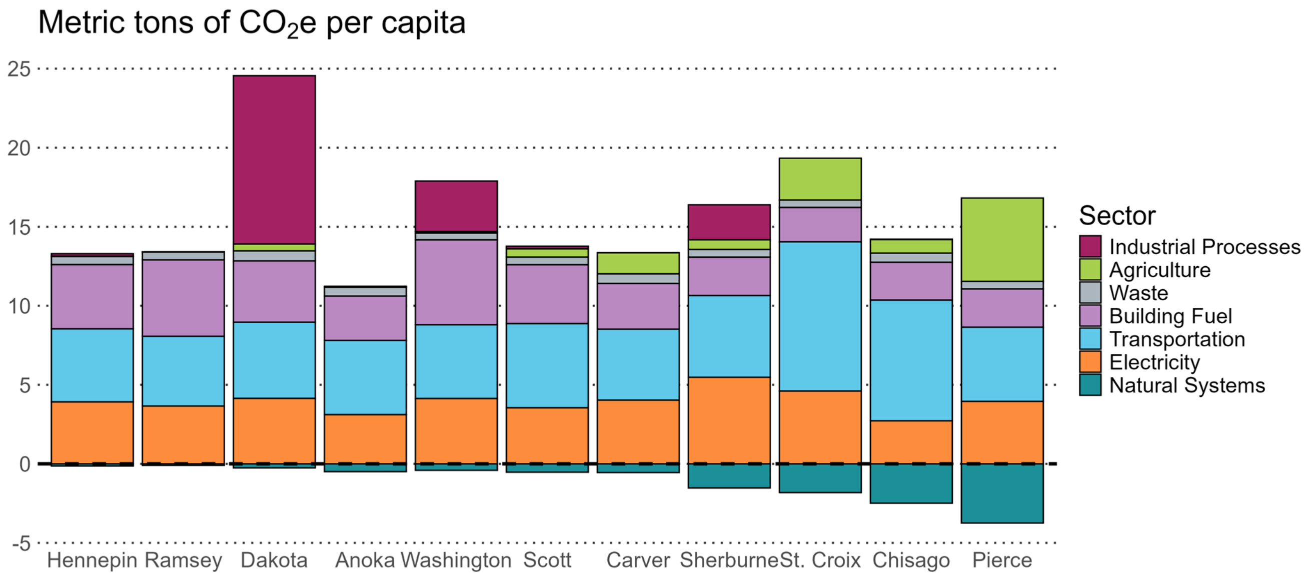
Sector	2005 Emissions (MMt CO_2e)	2022 Emissions (MMt CO_2e)	2022 emissions as a percentage of 2005
Transportation	19,900,147	19,628,892	99%
Electricity	27,564,577	13,299,448	48%
Building Fuel	11,537,468	13,538,967	117%
Industrial Processes	4,940,902	6,009,118	122%
Waste	1,695,692	1,791,994	106%
Agriculture	1,226,170	1,044,415	85%
Natural Systems	-1,316,548	-1,385,608	105%
Total Emissions	66,864,956	55,312,834	83%
Net Emissions	65,548,407	53,927,225	82%

Inventory Trends and Analysis

Geographic trends

Total emissions per county are highly correlated with county population. However, the graph below shows that per capita emissions are relatively even across the Twin-Cities MSA. The major exceptions occur due to large industrial point sources, such as an oil refinery in Dakota County, as well as rural counties having more natural systems and agricultural areas. St. Croix and Chisago counties also have large interstate systems running through them with heavy truck traffic which is not offset by their smaller population as they are in other counties.

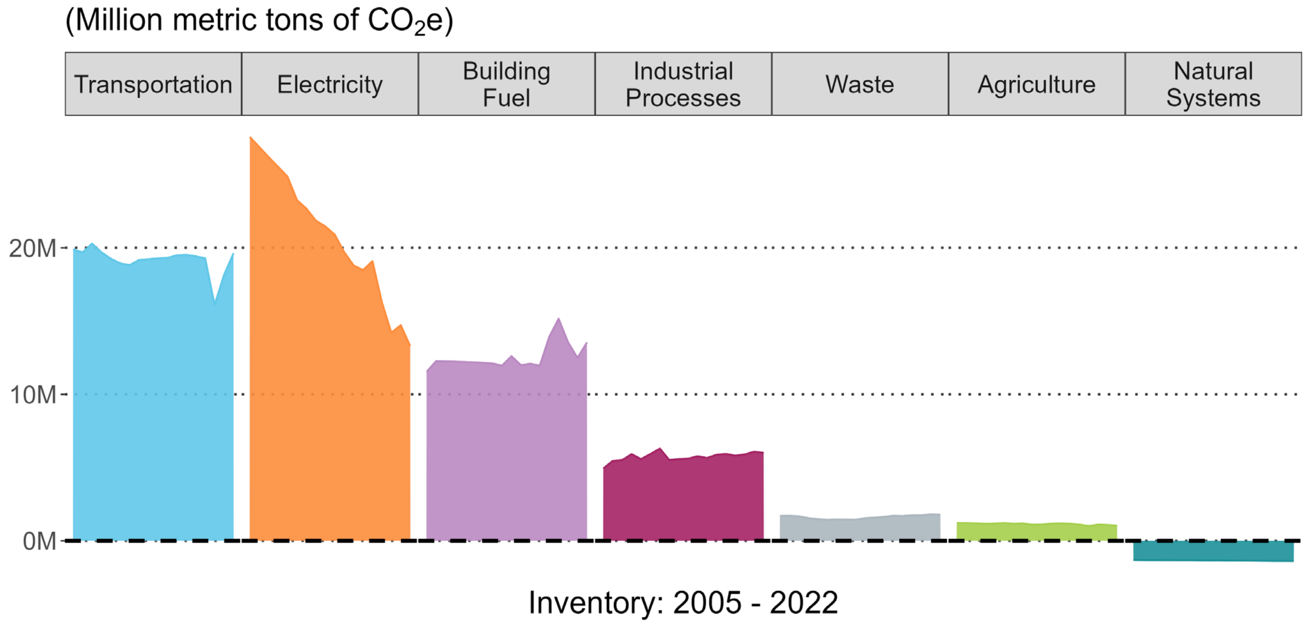
Figure 3. 2022 Per Capita GHG Emissions by County



Temporal trends

Emissions since 2005 have remained relatively flat with the notable exception of electricity, which has decreased by 51.7% due to the increasing use of renewable energy like solar and wind. The notable dip in 2020 for the transportation sector is due to the COVID-19 pandemic, though emissions have rebounded to previous levels as of 2022. There is also a notable spike in building fuel usage in 2018 which is attributed to colder than average weather that increased building heating demand. Despite the relatively stable emissions profile in most sectors, a growing population means the emissions per capita still decreased from 12.4 metric tons of CO_2e to 11.4 when omitting electricity.

Figure 4. 2005 to 2022 Regional Emissions Inventory by Sector



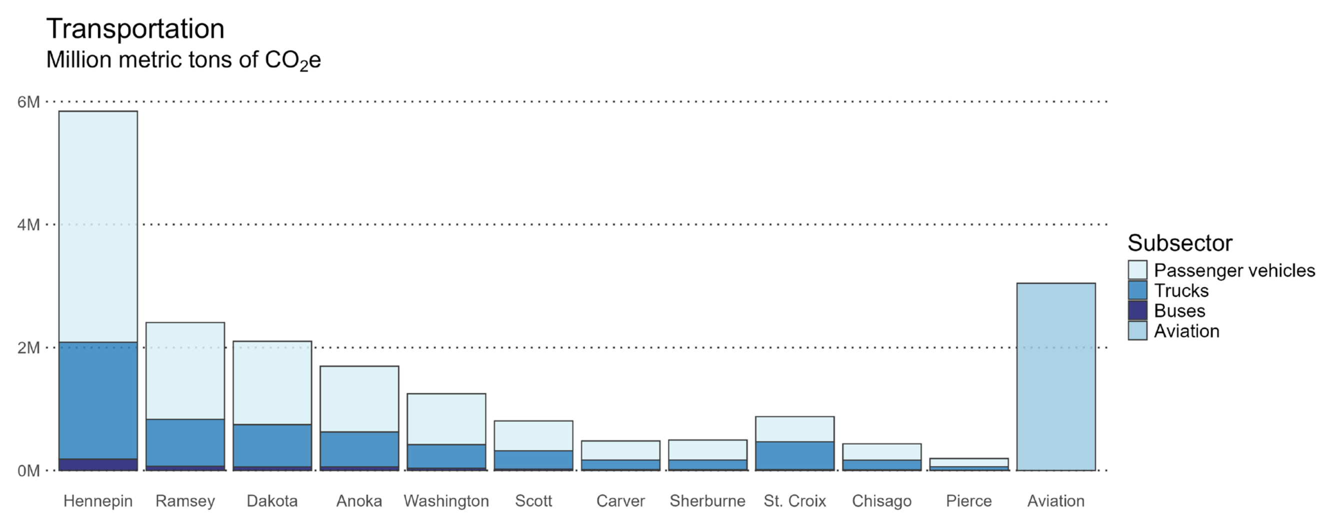
Transportation

The transportation sector generated 19.6 $MMtCO_2e$ of emissions in the Twin Cities MSA in 2022, with aviation accounting for 3.0 $MMtCO_2e$ and the rest coming from on-road emissions. Overall, transportation accounted for 35.5% of emissions in the region in 2022.

This is a county-level, geographic emissions estimate that accounts for on-road emissions that occur in each county. Modes included are motorcycles, passenger cars, intercity buses, light commercial trucks, single-unit long-haul trucks, refuse trucks, and transit buses.

Aviation emissions are attributed to the entire region and not broken out by county.

Figure 5. 2022 Transportation Emissions by County



Accounting method

County-level transportation emissions data were pulled directly from EPA data sources. Years 2002-2019 are from EPA EQUATES, year 2020 is the National Emissions Inventory (NEI), and years 2021-2022 are from recent EPA Air Emissions Modeling Platforms. For each dataset, we downloaded and compiled SMOKE FF10 tables published by the EPA and the Community Modeling and Analysis System (CMAS). Datasets were cross verified where possible.

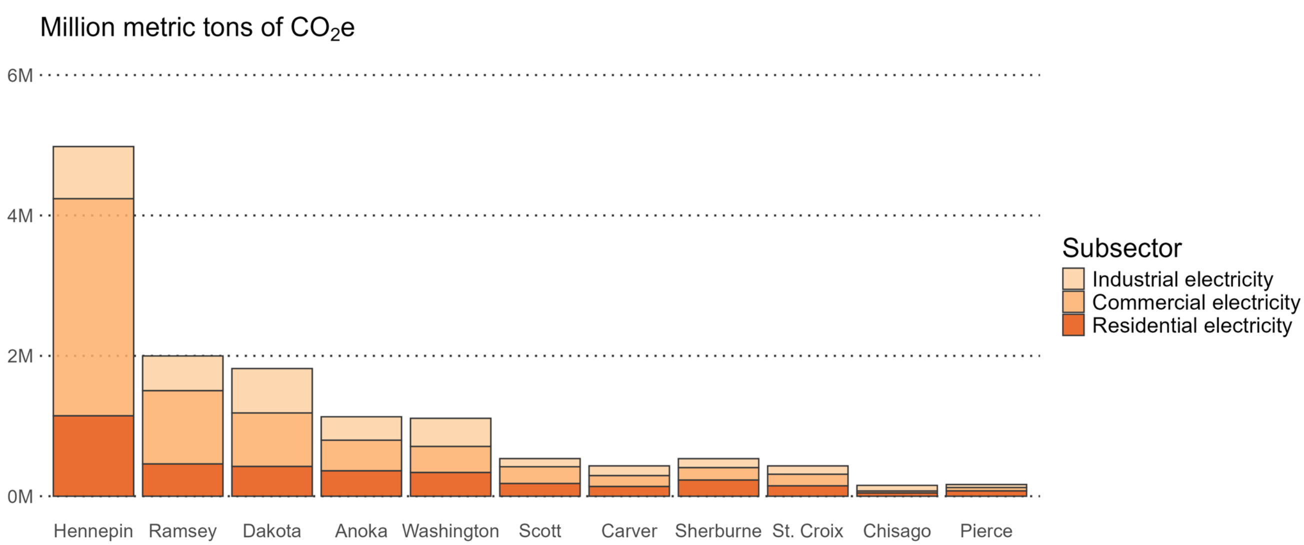
Aviation emissions are derived from fuel data from the Metropolitan Airports Commission (MAC) for the major international airport, MSP. Additional aviation emissions data from regional, reliever, and private airports was sourced from the EPA's NEI database.

Electricity

Electricity demand in the Twin Cities MSA generated 13.3 MMtCO_2e of emissions in 2022, accounting for 24% of total emissions. This represents a 51.7% decrease in emissions since the 2005 baseline, attributable to decarbonization of the electrical grid.

The county-level breakdown of electrical emissions largely follows population trends, though larger commercial electrical demand is evident in Hennepin and Ramsey counties, which have larger downtown districts.

Figure 6. 2022 Electricity Emissions by County



Accounting method

Emissions were apportioned to the county level by identifying all electric utilities in the Twin Cities MSA, collecting their reports on energy delivered to customers, and using EPA eGrid emission factors for the Midwest Reliability Organization – West to calculate estimated emissions. The inventory presented here therefore reports demand-side emissions as opposed to within-boundary emissions by the utilities themselves (Scope 2). Utilities with operations in Minnesota reported the specific amount of electricity delivered to each of the Minnesota counties in our inventory. In contrast, utilities with operations in Wisconsin counties reported statewide numbers, which were allocated to Wisconsin counties in our inventory based on either a) the proportion of customer accounts in total utility service territories within the inventory counties, or b) the proportion of population in total utility service territories within the inventory counties, subject to data availability.

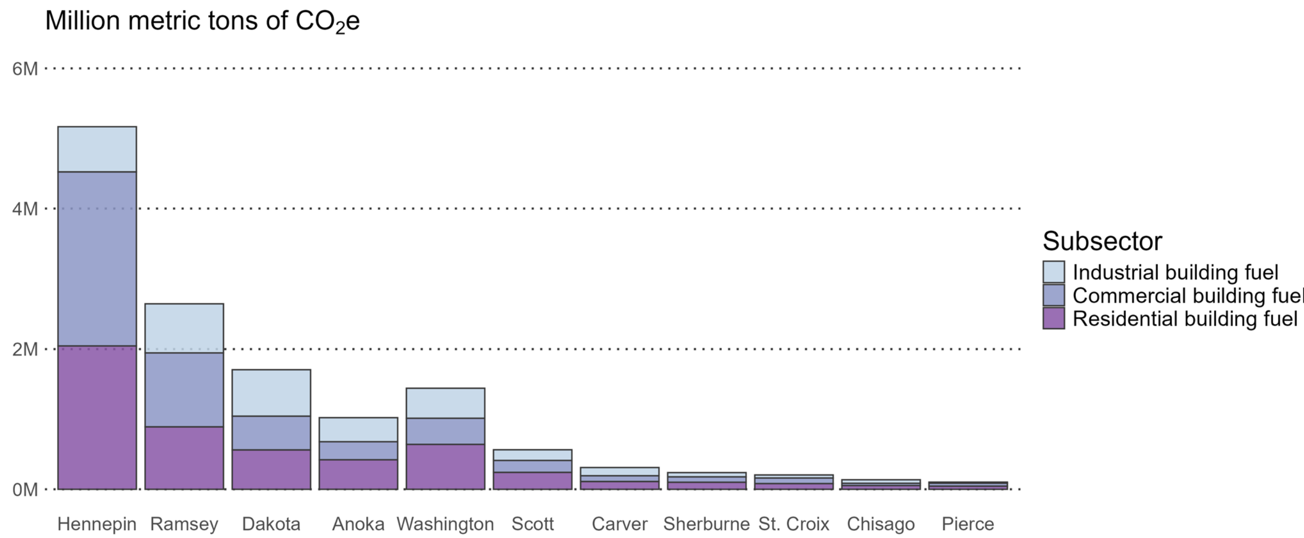
Emissions were apportioned to commercial, industrial, and residential emissions using the State and Local Planning for Energy platform curated by the National Renewable Energy Laboratory.

Building fuel

Building fuel in the Twin Cities MSA generated 13.5 $MMtCO_2e$ of emissions in 2022, accounting for 24.5% of regional emissions. Building fuel is primarily the combustion of natural gas for heating and appliances, though it does include some other fossil fuels as well. Emissions in this sector grew by 17% from 2005 to 2022.

The county-level breakdown of building fuel emissions largely follows population trends, though larger relative commercial demand is evident in Hennepin and Ramsey counties.

Figure 7. 2022 Building Fuel Emissions by County



Accounting method

Emissions were apportioned to the county level by identifying all natural gas utilities in the Twin Cities MSA, collecting their reports on energy delivered to customers, and using emission factors from the 2022 EPA Emissions Factor Hub to calculate estimated emissions. The inventory presented here therefore reports demand-side emissions as opposed to within-boundary emissions by the utilities themselves (Scope 2). Utilities with operations in Minnesota reported the specific amount of natural gas delivered to each of the Minnesota counties in our inventory. In contrast, utilities with operations in Wisconsin counties reported statewide numbers, which were allocated to Wisconsin counties in our inventory based on the proportion of customer accounts in total utility service territories within the inventory counties.

Emissions were apportioned to commercial, industrial, and residential emissions using the State and Local Planning for Energy platform curated by the National Renewable Energy Laboratory.

Industrial processes

Industrial processes include emissions from industrial facilities *excluding* electricity consumption and combustion of utility-delivered natural gas, which are accounted for in their respective sectors. Industrial process emissions in the Twin Cities MSA generated 6.0 $MMtCO_2e$ of emissions in 2022, accounting for 11% of regional emissions and a 22% increase from 2005.

The county-level breakdown reveals highly uneven geographic spread due to the nature of these point-source emissions. The largest emitters in the region are two oil refineries located in Dakota and Washington counties. Other notable emitters include an industrial waste facility in Dakota County and super conductor manufacturers in Hennepin County. St. Croix and Pierce counties had zero reported industrial emissions.

Figure 8. 2022 Industrial Processes Emissions by County

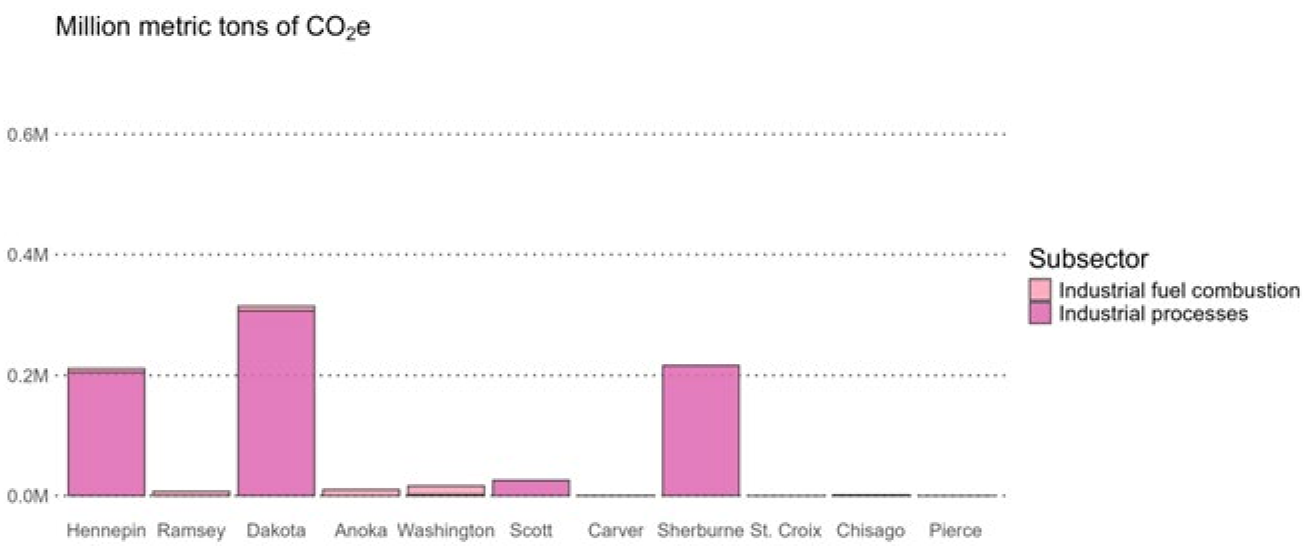
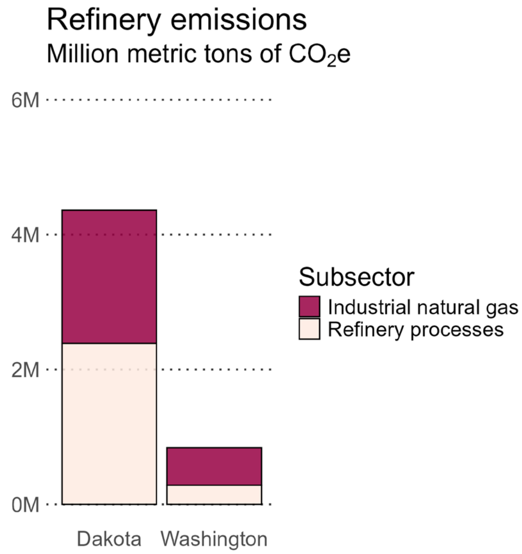


Figure 9. 2022 Refinery Emissions by County



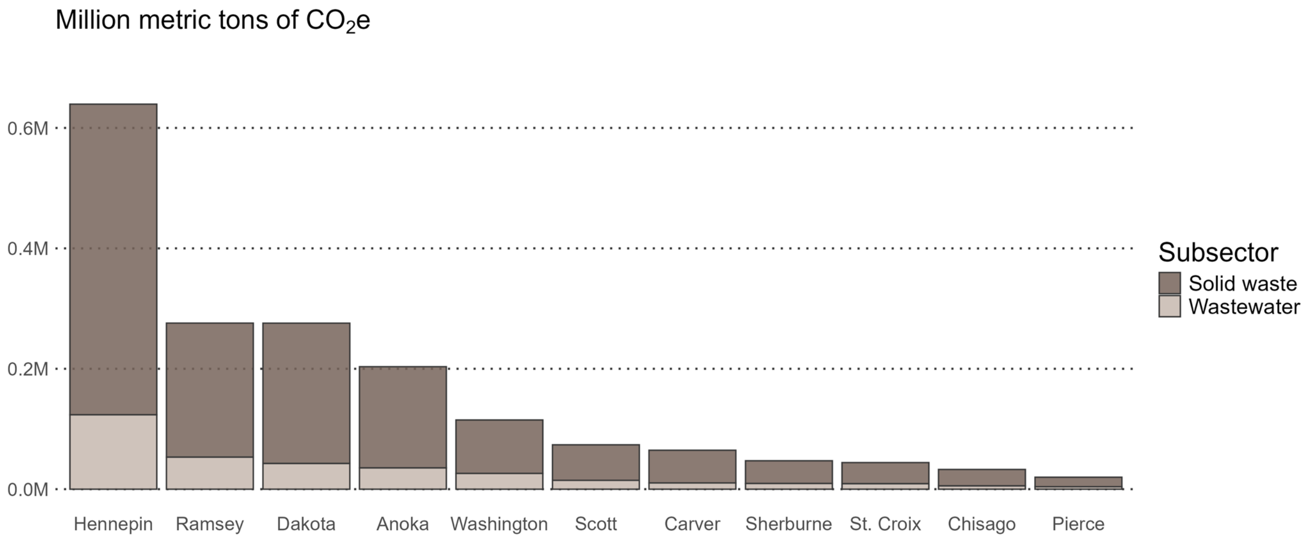
Accounting method

We compiled industrial emissions from two primary sources. First, the EPA Greenhouse Gas Reporting Program (GHGRP) provides total emissions from any point source emitting more than 25,000 metric tons of CO_2e annually, dating back to 2010. The GHGRP further provides a fuel combustion dataset that allowed us to parse out natural gas combustion from non-refinery sources, allowing us to avoid double counting with utility natural gas delivery. The second source was an MPCA data source with a broader set of industrial and commercial facilities that report on-site fuel combustion dating back to 2016. We filtered out any cities that were represented in the GHGRP program (facility-to-facility comparisons were not feasible due to different naming conventions) and used 2022 EPA Emissions Factor Hub to calculate GHG emissions from the listed fuel combustion. We used the MPCA GHG inventory dating back to 2005 to extend our emission estimates backward, anchoring our curated inventory to the appropriate subsector categories in the MPCA inventory, calculating a statewide proportion, modeling that proportion backwards, and recalculating total emissions by year.

Waste

Waste emissions include carbon dioxide, methane, and nitrous oxide from sources including landfills, incineration of municipal solid waste, and treatment of wastewater. Waste activities in the Twin Cities MSA generated 1.8 MMtCO2e of emissions in 2022, accounting for 3.2% of regional emissions and a 6% increase from 2005.

Figure 10. 2022 Waste Emissions by County



Accounting method

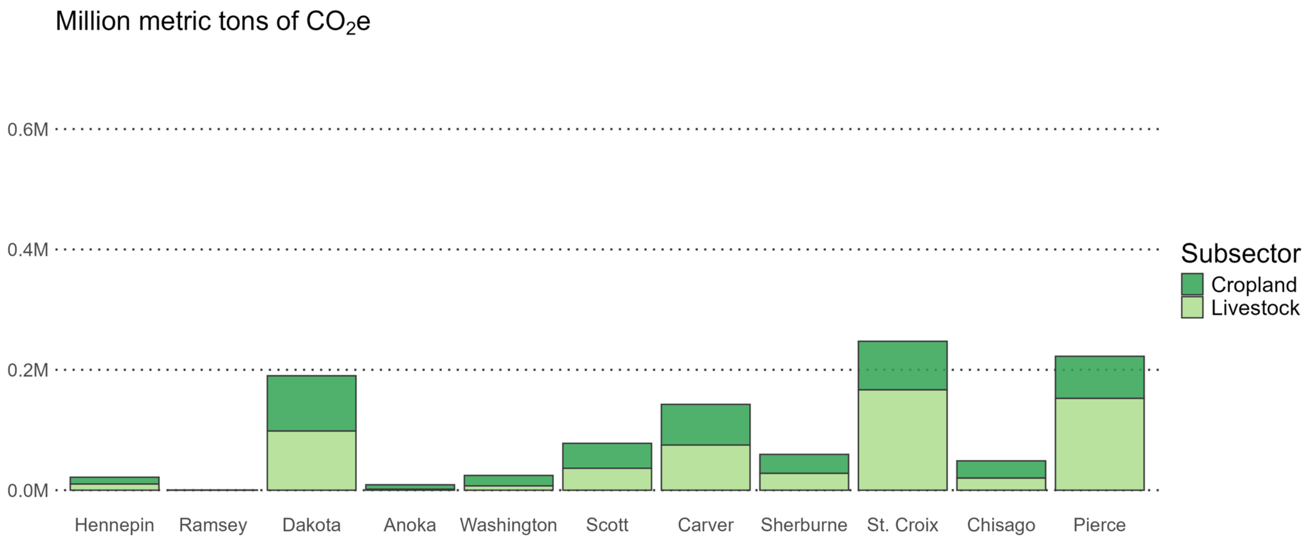
Wastewater emissions were estimated using EPA State Inventory Tool methodology to scale wastewater methane and nitrous oxide emissions based on population. We estimated solid waste emissions using the IPCC methane commitment method, which calculates landfill methane based on county-level waste totals from MPCA's SCORE report and methane generation potential. Compost emissions were estimated using IPCC default factors for aerobic composting (anaerobic digestion does not occur within the region). Incineration emissions were calculated from SCORE-reported waste-to-energy data, applying IPCC and GHG Protocol defaults for combustion efficiency, carbon content, and nitrous oxide emission factors.

Agriculture

Agricultural emissions are predominantly methane emissions from livestock and nitrous oxide emissions associated with manure and crop production. Collectively, the region produced 1.0 $MMtCO_2e$ in 2022, accounting for 1.9% of regional emissions.

County emissions from agriculture unsurprisingly occur in more rural areas, though this does not reflect consumption trends of agricultural products, which tend to occur outside of the region in which they are generated.

Figure 11. 2022 Agriculture Emissions by County



Accounting method

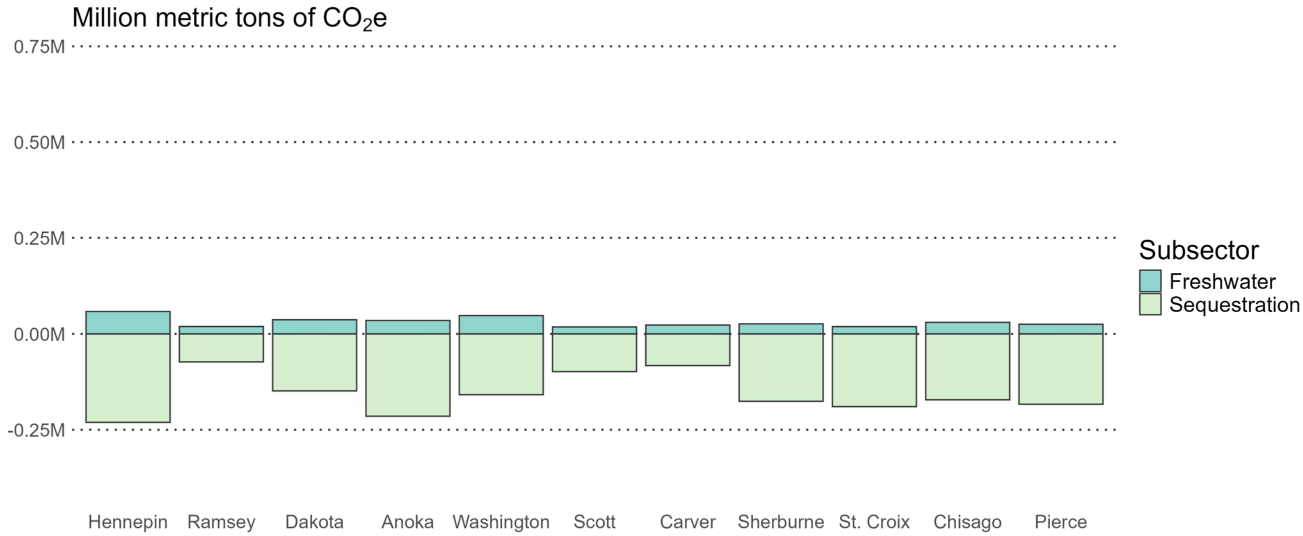
Agricultural emissions are derived from two primary sources. First, we used the USDA agricultural census to provide county-level activity data in the form of livestock head counts, crop production, and fertilizer sales. Second, we used the EPA State Inventory Tool (SIT) to calculate how Minnesota- and Wisconsin-specific activities produced GHG in form of enteric fermentation, manure storage and runoff, fertilizer volatilization, and soil residue volatilization. Fertilizer sales were calculated as a proportion of state totals, and these proportions were applied to an estimate of statewide fertilizer application found in the SIT.

The USDA census is conducted once every five years (years ending in 2 and 7). For interstitial years, we used linear interpolation to provide county-level estimates.

Natural systems

Natural systems consist of vegetated ecosystems within and beyond developed areas that sequester carbon from the atmosphere. Natural systems in the region sequestered an estimated 1.7MMtCO_2e in 2022, or 3.2% of emissions from the region. Freshwater systems emit methane naturally but do so at higher rates when disturbed by chronic nutrient input, invasive species, or eutrophication. Freshwater in the region emitted an estimated 0.34 MMtCO_2e, or 0.6% of the regional total in 2022.

Figure 12. 2022 Natural Systems Emissions by County



Accounting method

We used land cover maps from the United States Geological Survey's National Land Cover Database (NLCD) to estimate the area of five land cover types: forests, grasslands, wetlands, urban trees, and turfgrass. We used values derived from the scientific literature on sequestration per area per cover type, matched to be as Minnesota- and Wisconsin-specific as possible. For interstitial years, we interpolated changes in land cover between NLCD survey years.

For freshwater systems, we used the USGS National Hydrography Dataset to calculate areas of different freshwater systems (lake, reservoir, river, marsh) and used values determined by the MPCA for expected methane offput rate per unit area.

Emissions by gas type

Carbon dioxide is the most common greenhouse gas produced by human activity, but other gases also contribute to climate change. Each gas type has its own impact measured in global warming potential; and carbon dioxide is used as the comparison. For example, nitrous oxide has a 100-year global warming potential of 273, meaning one metric ton traps 273 times more heat than one metric ton of carbon dioxide over a 100 year period.

In the Twin Cities region, CO_2 produces 93% of greenhouse gas warming potential. Methane produces 4.7% of the region's warming potential while nitrous oxide produces 1.9%. Methane and nitrous oxide are produced predominantly in the waste and agriculture sectors. The remainder (less than 1%) of the warming potential is caused by the emission of fluorinated gases produced by industrial processes.

It should be noted that our CO_2-equivalency emissions from the gas type analysis do not precisely match our overall emission analysis due to several emissions sources in the industrial sector not being identified to a specific gas type.

Table 2. Greenhouse gas emissions by gas type

Greenhouse gas	2022 emissions by weight (MT)	2022 emissions by warming potential (MT CO_2e)	Percentage of warming potential	Global Warming Potential relative to CO_2
CO2	51,489,192	51,489,192	92.98%	1
CH4	94,035	2,623,572	4.74%	28
N2O	3,876	1,058,247	1.91%	273
HFC	91.4	15,073	0.03%	164 – 400
PFC	17.7	145,714	0.26%	7380
Other fluorinated GHG	1.86	42,843	0.08%	17,400 – 24,300

Near-Term and Long-Term GHG Reduction Targets

The Twin Cities metro region's GHG reduction targets are:

- Near-term target: Reduce emissions 50% below 2005 emissions by 2030
- Long-term target: Reach net zero emissions by 2050

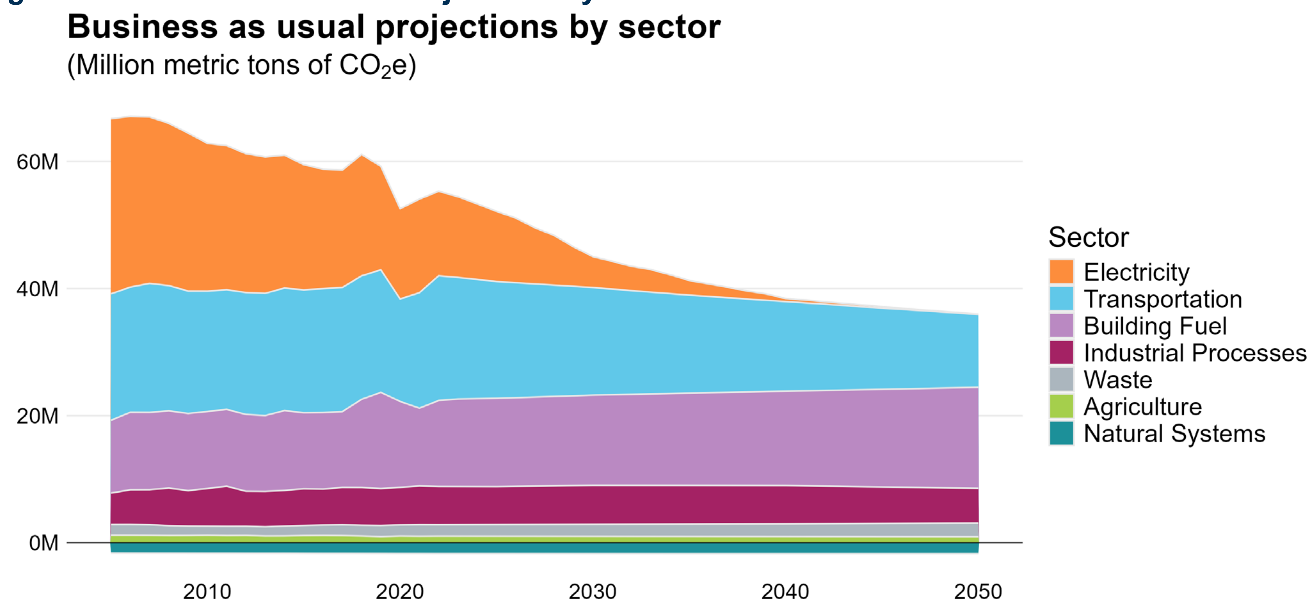
These commitments were adopted in Imagine 2050, the regional development guide for the seven-county metropolitan area, in February 2025 as part of the larger goal "We lead on addressing climate change." These targets also align the region with the goals set by the state of Minnesota. The year 2005 was selected as a baseline year because it aligns with state goals.

Business as Usual GHG Emissions Projections

Business as Usual projections assume emissions will continue based on past patterns and takes into account existing policies including the state's Clean Electricity Standard of 100% carbon-free electricity by 2040.

Business as Usual projections reveal the Twin-Cities MSA is estimated to produce a net 43.3 MMt CO_2e in 2030 and 34.2 $MMtCO_2e$ in 2050. This represents 67% and 53% of 2005 emissions, respectively. The projected declines represent the decarbonization of the electrical grid and expected increases in fuel efficiency and electrification in the transportation sector more than compensating for increased VMT projections. Nonetheless, these declines are well short of both 2030 and 2050 targets, demonstrating the need for continued aggressive policy aimed at GHG mitigation. Below we explore key mitigation strategies and associated projections across all sectors.

Figure 13. Business as Usual Projections by Sector



Business as Usual Projections Methodologies

General methods for projecting GHG emissions for each sector are included below, and detailed methodology information is in Appendix C.

Electricity

Electricity activity data was modeled based on existing and projected housing stock for residential electricity and existing and projected job growth for nonresidential electricity. Future electric grid mix was modeled using MISO projections for the region.

Transportation

Transportation activity data was modeled based on the Metropolitan Council regional travel demand model. Emission factors were based on EPA's MOVES dataset, which anticipates increased fuel efficiency and electric vehicle market share. Aviation and heavy duty vehicle projections were anchored to the MPCA's state modeling.

Building fuel

Building fuel activity data was modeled based on existing and projected housing stock for residential electricity and existing and projected job growth for nonresidential electricity. Natural gas emission factors were held constant.

Industrial processes

Industrial process emissions were matched as best as possible to appropriate subsectors in the MPCA's state model and anchored to their projections.

Waste

Solid waste and wastewater activity data was modeled based on existing and projected population in the region. Emission factors were held constant for both.

Agriculture

Agricultural emissions decrease proportionally with expected loss of agricultural land to development in the region but are otherwise held constant..

Natural systems

Natural systems land cover areas and sequestration values were held constant in projections.

Business as Usual Projections Results

Table 3. Business as Usual Projections by Sector

Sector	2005 Emissions ($MT\ CO_2e$)	2022 Emissions ($MT\ CO_2e$)	2030 BAU Projection Year ($MT\ CO_2e$)	2050 BAU Projection Year ($MT\ CO_2e$)
Building Fuel	11,447,556	13,538,967	14,194,305	15,896,248
Electricity	27,564,577	13,299,448	4,871,174	37,372
Transportation	19,900,147	19,628,892	16,931,908	11,464,539
Industrial processes	4,940,902	6,009,118	6,126,005	5,477,543
Agriculture	1,226,170	1,040,587	1,041,356	955,717
Natural Systems	-1,657,926	-1,726,986	-1,731,780	-1,736,573
Waste	1,695,692	1,791,994	1,882,676	2,130,962
Total Emissions	66,726,073	55,309,775	45,022,956	35,962,381
Net Emissions	65,068,147	53,582,789	43,291,176	34,225,807

GHG Emissions Reduction Strategies and Implementation Scenario Projections

GHG Emissions Reduction Strategies Summary

The regional CCAP includes 18 GHG emissions reduction strategies that address each of the sectors.

Table 4. GHG Emissions Reduction Strategies Summary

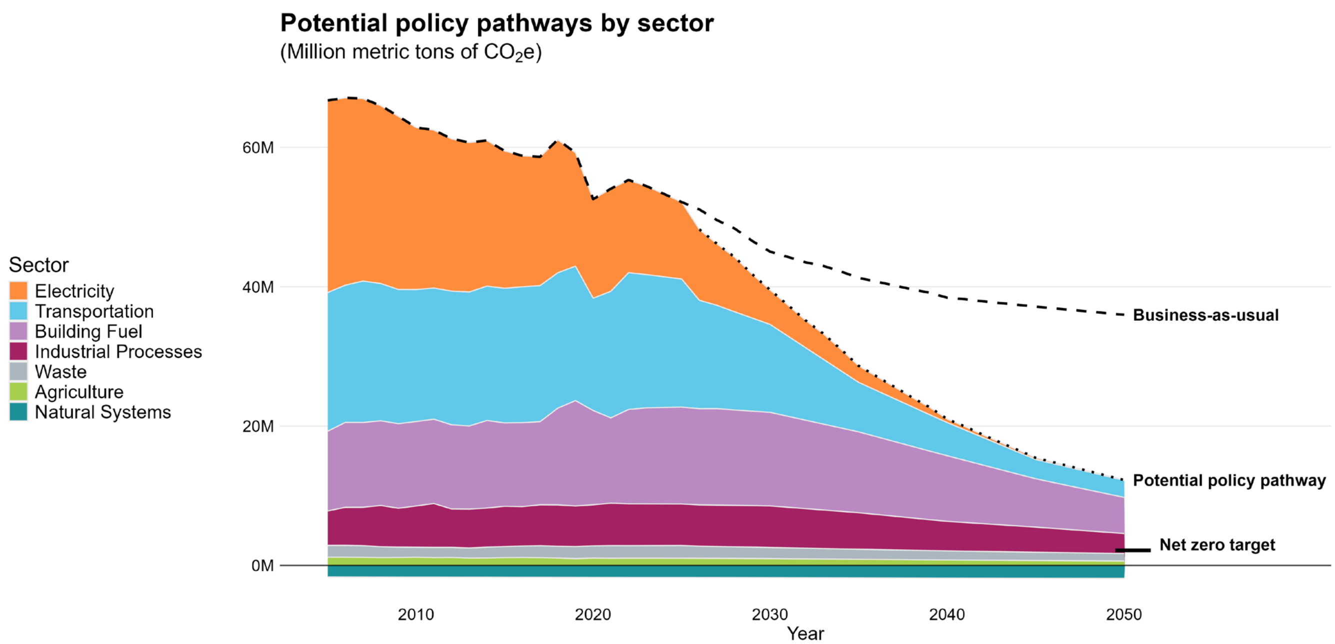
Sector	GHG Emissions Reduction Strategies
Transportation	1. Implement land use policies that support compact and multimodal-oriented development
	2. Increase public transit
	3. Increase infrastructure for walking, rolling, and biking
	4. Accelerate the transition to low- and no-carbon fuels in vehicles and equipment
	5. Reduce the impact of highway expansion on emissions
Electricity	6. Encourage energy infrastructure investments aligned with the Minnesota 2040 Clean Electricity Standard
Building Energy	7. Improve residential building energy efficiency
	8. Electrify homes
	9. Improve non-residential building energy efficiency
	10. Electrify non-residential buildings
Industrial Processes	11. Encourage industrial adoption of energy efficiency and low-carbon technologies
Waste	12. Promote waste prevention, waste reduction, and recycling
	13. Manage wastewater efficiently
Agriculture	14. Encourage climate-smart agriculture practices that improve soil health and soil organic content
	15. Manage fertilizer and manure to reduce emissions
	16. Invest in local and urban agriculture
Natural Systems	17. Invest in a robust, resilient tree canopy
	18. Protect and restore natural systems

Implementation Scenario Projections

The implementation scenario projections help show the impact of potential GHG emissions reductions strategies. The primary implementation scenario in this plan is the Potential Policy Pathway scenario. The scenario is based on modeling from the state of Minnesota to support the ongoing update of the Minnesota Climate Action Framework and Met Council analyses. It reflects recent changes in federal policy and known state and local actions that would position the region substantially closer to its GHG emissions reduction goals.

In addition to modeling the Potential Policy Pathway scenario, projections include a 2050 net zero marker that shows the ambitious emissions reduction needed to achieve very low emissions offset by sequestration in the region by 2050.

Figure 14. Potential Policy Pathway Projections by Sector



The Path to Net Zero

As shown in the projections, reaching net zero is an ambitious goal. In the economy-wide projections, as well as in projections for each sector, net zero in 2050 is significantly below the Potential Policy Pathway scenario. The difference between these projections reflects the fact that implementation strategies will have to extend beyond those scoped in this plan.

As the regional government, the Met Council starts by looking at community design. The way communities are built embeds certain GHG emissions: it informs the way we travel, the types of buildings we live in, and how far we need to go to reach our daily destinations. If communities are designed without any daily destinations within walking distance, without well-insulated buildings, or without recycling and composting access, residents can be locked into choices that require high fuel and energy use.

Communities can be designed with sustainability in mind, and examples of projects exist in the region and beyond. Community design is largely within local and regional control, and the best practices for reducing emissions are known and provide cross-sector benefits for climate and beyond. However, we recognize that the built environment of 2050 is largely already built today. In addition to strategies for new development, local and regional governments will need to focus on incremental and targeted approaches in community design to retrofit our existing landscape.

Reaching net zero will also take innovation. Beyond community design, advancements in methods and technology exist across all sectors, from new fuels to feed additives to industrial processes. New technology and methods require research and are often higher cost as they develop. However, they will also play a role in reaching a regional net zero target.

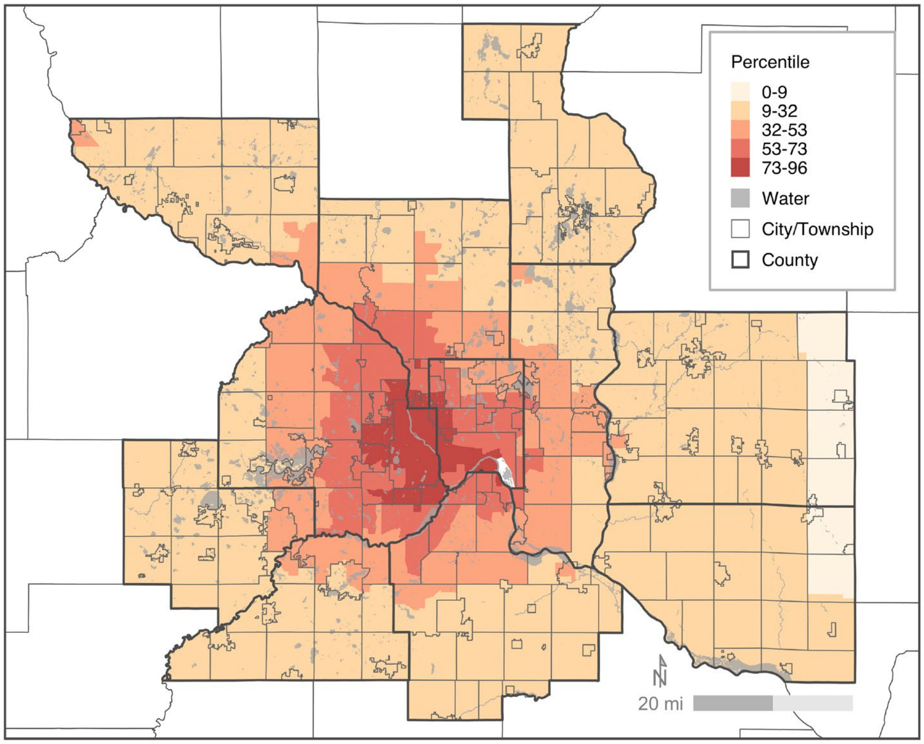
GHG Emissions Reduction Strategies

The strategies in the CCAP address the many sources of GHG emissions and potential sequestration. For each strategy, the plan includes information about the community impact, implementation authorities, timelines, metrics for tracking progress, costs, and potential funding sources. Potential funding sources were compiled in summer and fall 2025 and may not reflect recent federal policy changes.

Transportation sector

The transportation sector represents 35.5% of regional emissions as of 2022. This sector includes strategies that address increasing modes of travel that are less GHG-intensive and designing cities to support those modes. The strategies for the sector align with the seven-county metro region's goal of reducing vehicle miles traveled (VMT) 20% per capita by 2050. They will also help improve public health outcomes by improving air quality in the region; transportation-related pollution has been linked to respiratory issues including asthma, pneumonia, lung cancer, and other health hazards. Transportation pollution is significantly worse in urban centers. Map 2 (below) displays the prevalence of pollution caused by diesel fuel use across the region and shows how this pollution is highest in the urban core and along major transportation routes.

Map 2. Distribution of exposure to inhalable diesel particulate matter by percentiles

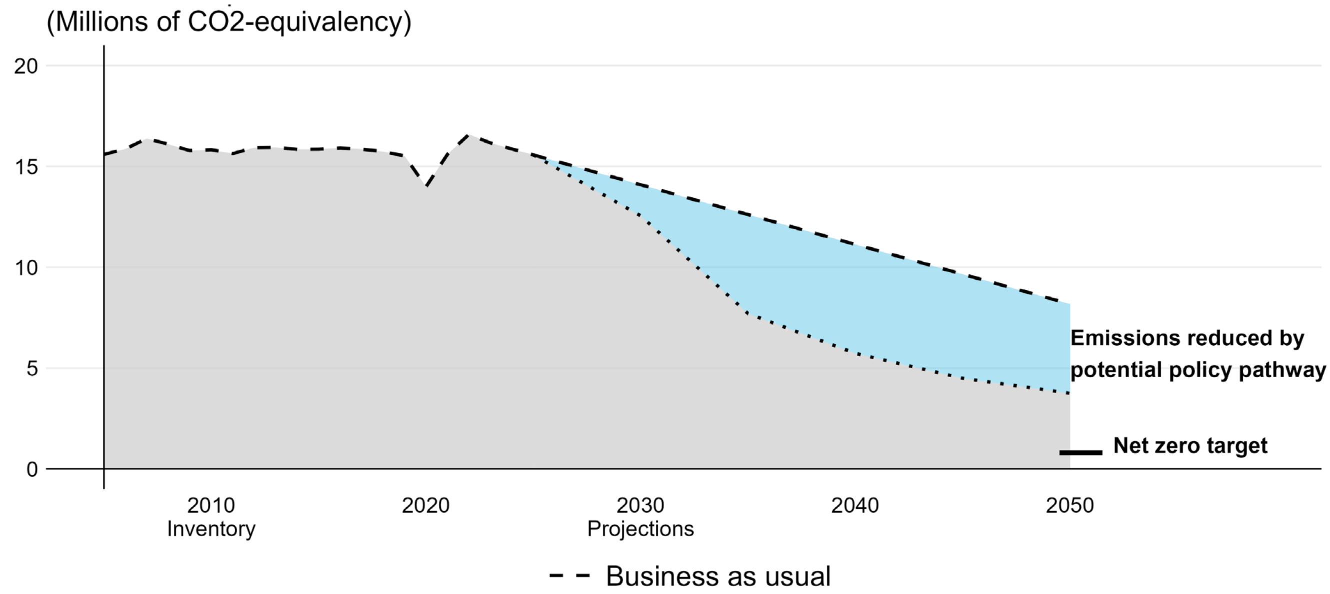


Source: Metropolitan Council analysis of Council on Environmental Quality Climate and Economic Justice Screening Tool (v2.0, Dec 2024) and Environmental Protection Agency EJScreen Data.

Table 5. Transportation Sector Strategies Summary

Transportation Sector Strategy Summary	GHG Emissions Reduction in 2030 Compared to the BAU ($MTCO_2e$)	GHG Emissions Reduction in 2050 Compared to the BAU ($MTCO_2e$)
Strategy 1-5: Implement land use policies that support compact and multimodal-oriented development, increase public transit, accelerate the transition to low- and no-carbon fuels in vehicles, and reduce the impact of highway expansion on emissions		
Potential Policy Scenario	- 3,288,296 (-23.3%)	- 5,739,189 (-70.3%)
Net Zero Scenario		- 7,286,190 (-89.2%)

Figure 15. On-road transportation emission projections



Strategy 1: Implement land use policies that support compact and multimodal-oriented development

Description

Land use and transportation are closely interrelated, and changes in land use affect which transportation modes are available and viable for residents across the region. Communities that are well connected with uses and services close to an individual's daily needs provides opportunities for choices in travel options beyond a personal vehicle. Land use and planning can encourage additional density around activity centers and along transit corridors, a greater mix of uses, and interconnected street and pedestrian networks. These land use choices are foundational to providing cost-effective new transit service or higher levels of transit service as well as bicycle and pedestrian infrastructure that connect people to destinations.

Community benefits analysis

> *"We want more walkable cities and communities; places can be too far to walk or bike to."*

Decades of planning practices have systematically produced neighborhoods burdened by inconvenient and under-resourced transportation options and fewer jobs and daily destinations. Compact, transit-oriented development reduces vehicle miles traveled, lowers transportation costs, and improves access to everyday services and amenities. For low-income households, it can mean shorter commutes, better access to jobs, and reduced dependence on costly car ownership. Equitable land use planning should incorporate affordable housing, anti-displacement measures, and meaningful community engagement to ensure that changes benefit existing residents.

Implementation authority and responsibilities

- State government: State agencies do not have direct authority over local land use. While the state does not have a large role in this area, it does influence local land use through avenues like environmental regulation.
- Regional government: Within the seven-county region, the Met Council sets regional planning policy including residential density requirements and guidance for compact growth that fits with communities' unique characteristics. The Met Council also defines and identifies transit market areas in the region which describe how much demand for transit service there is in each neighborhood or community and what kinds of transit service can be expected to meet that demand successfully and efficiently. Land use and urban design factors heavily into transit market areas analysis. The Met Council also provides technical assistance to local governments to implement policies aligned with regional goals.
- Local government: Local governments have land use authority and are therefore key actors in setting policies that support multimodal-oriented development. Counties and regional parks implementing agencies can support multimodal oriented development through design of the county roadways and trail facilities that they are respectively responsible for developing and operating.
- Other actors: Transit agencies can work with local governments to support land use planning that is conducive to new or increased transit service.

Implementation timelines and milestones

This is a long-term strategy that relies on designing and redesigning the way communities across the region are built.

Metrics for tracking progress

- Net change in residential land use intensity (household per acre)
- Net change in economic land use intensity (jobs per acre)
- Net change in land guided from lower to higher densities for residential development
- Average transportation accessibility (by mode) to neighborhood amenities
- Average housing units per acre near LRT and BRT transit stations
- Average job accessibility by car and transit

Strategy costs

Cost is expected to be medium to high depending on implementation approach. Costs are often embedded in community development projects and costs of multimodal-oriented development are not necessarily higher than costs of development generally. Multimodal-oriented development also often generates a higher return for local governments by creating a higher tax base and higher land value per acre.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Department of Health Statewide Health Improvement Partnership
- Met Council Livable Communities Act grants

Strategy 2: Increase public transit

Description

Public transit is an essential part of lowering greenhouse gas emissions from the regional transportation system. Public transit moves more people where they need to go with fewer vehicles miles traveled. It also has many additional benefits, including reducing wear on roads, managing congestion, reducing air pollutants, and supporting the mobility of those who cannot drive for any reason. Increasing public transit options includes increasing service on existing lines and adding bus rabid transit, arterial bus rapid transit, and light rail. In more rural areas, this may look like coordinating transit for commuting to job centers or smaller-scale transit options between towns.

Community benefits analysis

> *"Implementing more accessible and safe transit would help our community feel more comfortable taking the public transit. This would include more stops so that people wouldn't have to walk long distances to their destination."*

Expanding and improving public transit increases access to jobs, education, health care, and other essential services, particularly for those without reliable access to a private vehicle. Affordable, frequent, and accessible service can reduce transportation costs and travel times for low-income households, while also cutting greenhouse gas emissions and lowering pollution in communities near major highways and roads. Implementation should include prioritizing high-need routes, improving accessibility, and addressing gaps in existing transit service. Additionally, increasing widespread use of public transit – especially for young women – depends on improving passenger safety.

Implementation authority and responsibilities

- State government: MnDOT is responsible for planning intercity passenger rail and coordinating with local agencies such as Ramsey County Regional Rail Authority, which owns Union Depot in Saint Paul. MnDOT also coordinates with intercity bus companies in Minnesota, including for areas covered in the CCAP and outside the seven-county metro area.
- Regional government: As the metropolitan planning organization for the seven-county Twin Cities region, the Met Council is responsible for coordinating transportation planning and policy - including for public transit - in a continuous, cooperative, and comprehensive process. The Met Council works with cities, counties, transit providers, and other partners like Tribal governments and the state of Minnesota to plan and implement projects, strategies, and services. Metro Transit, the region's largest transit provider, is a service of the Met Council and is governed by it.
- Local government: Cities and counties work with transit providers on service levels and infrastructure like bus lanes and signal priority. Additionally, local governments with land use and zoning authority play an important role in transit feasibility across the region.
- Other actors: Metro Transit is the largest but not the only transit provider in the region. Other providers include Minnesota Valley Transit Authority, SouthWest Transit, Maple Grove Transit, Plymouth MetroLink, the University of Minnesota, Hudson Public Transit Program, and Rivers Falls Transit. Additionally, employers can encourage employees to use public transit through providing subsidized passes.

Implementation timelines and milestones

This is a medium-term strategy as efforts to expand and increase transit service throughout the region are ongoing and have some existing funding sources. Widespread adoption and implementation will also be dependent on resident use.

Metrics for tracking progress

- Total transit ridership
- Proportion of miles traveled from transit ridership
- Transit service miles
- Average housing units per acre near LRT and BRT transit stations
- Average job accessibility by transit
- Total crimes recorded by Metro Transit Police department per 100,000 riders

Strategy costs

Cost is expected to be medium to high depending on implementation approach including the need for new infrastructure.

Intersection with other funding availability

Complementary funding sources:

- Met Council Regional Solicitation
- Metro Area Transportation Sales and Use Tax
- Wisconsin Department of Administration Transit Capital Assistance Grant Program
- U.S. Federal Transit Administration RAISE program
- U.S. Federal Transit Administration

Strategy 3: Increase infrastructure for walking, rolling, and biking

Description

Active transportation modes, including walking, rolling and biking, reduce overall greenhouse gas emissions by replacing trips – especially shorter trips – taken in cars. Additionally, increasing infrastructure for active transportation can help improve connections to other modes of travel like public transit. The Twin Cities region has a bike network composed of almost 4,000 miles of existing bikeways and almost 3,000 miles of additional planned bikeways. Pedestrian infrastructure in the region includes state trails, regional trails, local multiuse paths, sidewalks, skyways, and pedestrian or multiuse bridges or underpasses. Often the most dangerous part of walking or rolling is crossing streets, so street-crossing treatments are critical infrastructure for safe travel by people walking and rolling. Active transportation modes have additional advantages beyond lowering greenhouse gas emissions including overall affordability and physical and mental health benefits.

Community benefits analysis

"I like to walk because, well, walking is fun. Plus it's a nice way to get somewhere and feel like I'm being healthy."

"There are no sidewalks, so I'm just walking on the road hoping the car doesn't hit me."

Investments in safe, connected pedestrian and bicycle infrastructure promote physical health, reduce reliance on motor vehicles, and improve neighborhood livability. Residents across the region expressed that walking is a preferred mode of travel when it could get them to their destination. In many underinvested communities, sidewalks, crossings, and bike lanes are inadequate or absent, creating safety and mobility barriers. Prioritizing projects in these areas can enhance access to jobs, schools, parks, and transit while reducing transportation costs and emissions. Inclusive design is also critical to ensure infrastructure is usable for people of all ages and abilities.

Implementation authority and responsibilities

- State government: MnDOT oversees the statewide transportation system, which includes planning and research responsibilities related to biking, walking, rolling, and ADA compliance. Additionally, MnDOT develops and maintains some trails and bikeways in the region. They also fund active transportation projects, both directly for the highway system and indirectly through grants to local agencies.
- Regional government: Within the seven-county region, the Met Council supports the planning for the development of regional trails, local bikeways, multiuse trails, and the Regional Bicycle Transportation Network (RBTN) which integrates elements of all bicycle trail and on-road facilities. The Met Council provides funding for regional trails and develops investment prioritization tools to guide regional investments in the RBTN

through the biennial Regional Solicitation process for distributing federal transportation funds. The Council also provides guidance and regional funding for implementing safe pedestrian infrastructure.

- Local government: Local governments are key drivers in building out bikeways and pedestrian infrastructure including paths, sidewalks, and street-crossings. Regional Parks Implementing Agencies are also important partners in developing and maintaining trails throughout the region.
- Other actors: Nonprofit organizations, neighborhood associations, and employers all play roles in encouraging the use of walking, biking, and rolling through actions like incentive programs, infrastructure installation and maintenance, and education campaigns.

Implementation timelines and milestones

This is a short- to medium-term strategy as efforts to expand and improve bicycle and pedestrian infrastructure throughout the region are ongoing and have existing funding sources.

Metrics for tracking progress

- Miles of regional trails
- Miles of regional bikeways
- Proportion of all trips that are walked or bicycled

Strategy costs

Cost is expected to be low to medium depending on implementation approach including the need for new infrastructure.

Intersection with other funding availability

Complementary funding sources:

- U.S. Department of Transportation Safe Streets and Roads for All grant program
- U.S. Department of Transportation Reconnecting Communities Pilot Program
- U.S. Department of Transportation Neighborhood Access and Equity Program
- Minnesota Department of Transportation Active Transportation Program
- Minnesota Department of Transportation Safe Routes to School
- Minnesota Department of Health Statewide Health Improvement Partnership

Strategy 4: Accelerate the transition to low- and no-carbon fuels in vehicles and equipment

Description

Increasing the use of low- and no-carbon vehicles is important to reducing emissions from the transportation sector. While land use and infrastructure may change over the coming decades, personal vehicles will still be integral in many parts of the region for getting around. Transitioning passenger vehicles to technologies including hybrid and battery electric is required to reduce GHG emissions. This strategy includes developing electric charging infrastructure and shared electric vehicle programs.

It is also necessary to transition fossil-fueled medium-duty, heavy-duty, and off-road vehicles and engines to low- and no-carbon-fueled alternatives. Vehicles and equipment in this category include transit and school buses, heavy-duty and medium-duty trucks, aircraft, terminal tractors, construction equipment, agricultural equipment, short-haul locomotives, and ground and maritime freight equipment. Technology has begun to provide and will continue to increase options for low- and no-carbon fuels, including electrification and other alternative carbon neutral fuel sources for these types of vehicles. This strategy applies to the whole region.

Community benefits analysis

"[Electric cars] are more expensive. We want to make the earth better but how are we supposed to access them if they're expensive? It's hard for us. ¿Como podemos mejorar si las cosas están caras?" [How can we make things better if things are expensive?]

Switching to low- and zero-emission vehicles reduces harmful exhaust pollutants, improving air quality and public health in communities near major roads, freight, and industrial zones. Decarbonizing municipal fleets, heavy-duty trucks, school buses, equipment, and more, can yield benefits especially for residents in high-exposure areas. Equitable implementation requires prioritizing communities most affected by transportation emissions, ensuring accessible charging infrastructure for underserved communities, offering technical assistance, and addressing cost barriers by providing incentives.

Implementation authority and responsibilities

- State government: State agencies including the Department of Transportation, Pollution Control Agency, Department of Administration, and Department of Agriculture have authority and/or influence over the adoption of low- and no-carbon vehicles and equipment. The Department of Transportation also influences its own construction program and fleet.
- Regional government: The Met Council has several roles related to the availability, visibility and accessibility of electric vehicles including:
    - Planning for regional private and shared electric vehicle charging needs, including supporting local agencies with up to date, comprehensive and unbiased information to make strategic and investment decisions.
    - Identifying methods and processes to prioritize targeted charging and fueling infrastructure funding with a focus on historically disadvantaged and rural communities
    - Funding, researching, developing, and sharing resources with local agencies to engage and educate residents on vehicle electrification and charging.
    - Developing and implementing low/zero-emission fleet transition plans, including service and support vehicles.
- Local government: Cities, counties, Tribal nations, and port authorities play an important role in strategies such as providing public charging options, planning, regulation, education, internal fleets, and shared mobility.
- Other actors: Transit providers, school districts, and other heavy- and medium-duty fleet owners have roles in transitioning their fleets to low- and no-carbon vehicles.

Implementation timelines and milestones

This is a short- to medium-term strategy as the technology exists and implementation efforts are ongoing but are limited by scope and funding availability.

Metrics for tracking progress

- Percent of light-duty vehicles registered that are electric or zero-emission vehicles
- Percent of light-duty vehicles sold that are electric or zero-emission vehicles
- GHG emissions from the transportation sector

Strategy costs

Cost is expected to be low to medium depending on factors including cost of technology and implementation approach.

Intersection with other funding availability

Complementary funding sources:

- Volkswagen settlement grants – available in Minnesota to fund vehicle replacements and invest in electric vehicle charging stations
- Wisconsin Electric Vehicle Infrastructure grants
- Wisconsin Department of Natural Resources Clean Diesel Grant Programs
- U.S. and Minnesota Diesel Emissions Reduction Act grants
- U.S. Federal Highway Administration Congestion Mitigation and Air Quality Improvement Program
- U.S. Federal Highway Administration Charging and Fueling Infrastructure Discretionary Grant
- U.S. Federal Highway Administration National Electric Vehicle Infrastructure Program
- U.S. Alternative Fuel Vehicle Refueling Property Credit Direct Pay

Strategy 5: Reduce the impact of highway expansion on emissions

Description

In 2023, the Minnesota legislature passed a series of statute updates to align transportation planning and new roadway projects with the state goal to reach net zero emissions by 2050. Beginning in 2025, before a major capacity expansion project may be added to the regional Transportation Improvement Program, an impact assessment must be performed to determine conformance with the greenhouse gas and vehicle miles traveled goals. If a project is not in conformance, it needs to be rescoped, interlinked with sufficient offsetting mitigation, or halted.

Community benefits analysis

"Oftentimes being close to roads or highways really affects air pollution and asthma. So both in rural and in urban areas, that can be a big factor. Often highways are built in these very low-income communities."

Highway expansion can increase vehicle traffic and pollution, with disproportionate health, safety, and economic impacts on nearby communities, particularly low-income residents and communities of color who often live closest to major roadways. Community members emphasized the need to address the impacts of emissions, traffic, and land use changes that accompany highway projects.

Implementation should prioritize strategies that attempt to limit additional car travel, such as investments in public transit, biking, and walking infrastructure alongside any expansion projects. Planning processes should also include opportunities for residents to influence decisions before projects are finalized. Emissions mitigation measures should be located where communities identify the greatest need. In addition, workforce development tied to transportation infrastructure can provide jobs but should be paired with measures that prevent displacement and ensure benefits reach the neighborhoods most impacted by expansion.

Implementation authority and responsibilities

- State government: The Minnesota Department of Transportation is responsible for implementing the new statute including setting targets, identifying methods, and assuring compliance.
- Regional government: The Council is responsible for performing impact assessments for projects or portfolios of projects within its jurisdiction and assuring that the regional Transportation Improvement Plan is in conformance with this legislation. This Council also participates in the state GHG Emissions Impact Assessment Technical Advisory Committee to review the statewide assessments and methods.
- Local government: Counties and cities are active participants in project development for major capacity expansion projects. They are often the sponsors and implementers of potential interlinked mitigation projects or other actions, which will need to be developed and managed in close cooperation with local partners.
- Other actors: This action is primarily implemented through state, regional, and local government.

Implementation timelines and milestones

This is a short- to long-term strategy. Implementation begins in 2025 with changes to project programming requirements, and the impacts of this strategy will continue to influence transportation planning for as long as the requirement is in effect.

Metrics for tracking progress

- Number of offset projects by category
- GHG emissions offset through offset projects
- Regional vehicle miles travelled
- Average particulate matter and diesel particulate matter levels
- Overall regional transportation GHG emissions

Strategy costs

Cost is expected to be medium depending the offsets needed and the scope and type of offset project.

Intersection with other funding availability

Complementary funding sources:

- U.S. Department of Transportation Safe Streets and Roads for All grant program
- U.S. Federal Transit Administration

- Minnesota Department of Transportation Active Transportation Program
- Met Council Regional Solicitation
- Regional Transportation Sale and Use Tax for Active Transportation

Electricity Sector

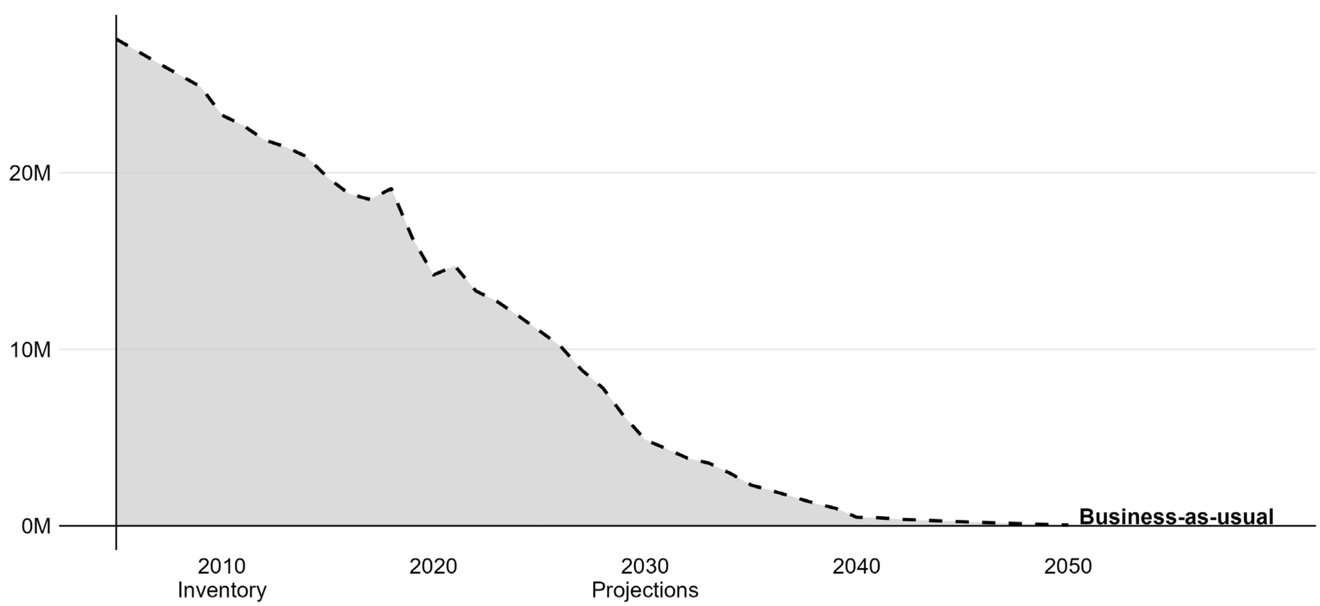
The electricity sector represents 24.8% of regional emissions in 2022. The electricity strategy is important for addressing emissions from all electricity use across the region. This includes everything from turning on lights in homes to powering water treatment plants around the region. Emissions decrease in this sector due to the decarbonization of the electric grid. However, increasing efficiency through actions like using LED lightbulbs and conserving water use are still critical for near-term GHG reductions and reducing long-term demand for electricity.

The state of Minnesota has a [2040 Clean Electricity Standard] that became state law in 2023 and requires that electric utilities to provide carbon-free electricity in Minnesota by 2040. Due to this statutory requirement, there is only one policy scenario, Business as Usual, for this sector, as demonstrated in the table and figure below.

Table 6. Electricity Sector Strategy Summary

Electricity Sector Strategy Summary	GHG Emissions Reduction in 2030 Compared to the BAU ($MTCO_2e$)	GHG Emissions Reduction in 2050 Compared to the BAU ($MTCO_2e$)
Strategy 6: Encourage energy infrastructure investments aligned with Minnesota's 2040 Clean Electricity Standard		
Current Policy Scenario	0	0

Figure 16. Electricity emission projections



Strategy 6: Encourage energy infrastructure investments aligned with Minnesota's 2040 Clean Electricity Standard

Description

The Twin Cities region has a role in supporting Minnesota's 2040 Clean Electricity Standard, including increasing renewable energy generation and storage capacity and supporting electrical grid and transmission infrastructure. This strategy includes actions like developing and supporting new renewable energy infrastructure (solar, wind, geothermal, hydropower, etc.) in and beyond the region that provides residents and businesses with carbon-free electricity. Additional relevant actions should focus on simultaneously easing demand on the grid by encouraging energy efficiency through programs like retrofitting inefficient buildings and replacing appliances and water conservation to ease demand on water treatment and pumps. The region will work to align its efforts with the state.

Community benefits analysis

"I think we should have more policy and incentives for businesses to save energy and use renewable energy."

Investments in clean energy infrastructure can advance climate goals while providing health, economic, and resilience benefits for communities. Expanding renewable energy generation and modernizing the grid reduces reliance on fossil fuels, lowering air pollution that disproportionately impacts low-income areas and communities of color. Implementation should prioritize investments and technical support in historically underserved communities, while creating pathways for community ownership, leadership, or benefit-sharing from clean energy projects.

Involving communities in planning and implementation processes of energy infrastructure projects is also an important step to minimize harm and build trust between governments and communities. Additionally, workforce development tied to new infrastructure can also provide high-quality jobs and training opportunities, ensuring that the clean energy transition supports both environmental justice and economic equity.

Implementation authority and responsibilities

- State government: The state has existing authority under Minnesota law (Minn. Stat. 216B.1691). State agencies led by the Department of Commerce have responsibility for implementation of the Clean Electricity Standard.
- Regional government: The Met Council does not have authority over electric utilities. The Met Council does have some existing renewable energy generation at its facilities and continues to look at ways to increase renewable energy generation and use across its services. The Met Council also supports local governments in technical assistance for solar planning.
- Local government: Local governments do not have authority over electric utilities but they do have roles in planning, zoning, and permitting renewable energy projects.
- Other actors: Electric utilities have a primary role in developing and deploying renewable and carbon-free electricity to comply with the state's Clean Electricity Standard. Nonprofit organizations also play roles in developing community energy projects and connecting residents to opportunities like community solar gardens.

Implementation timelines and milestones

This is a medium-term strategy as technology exists and the milestones are set by the Clean Electricity Standard.

Metrics for tracking progress

- Percentage of electrical capacity from carbon-free sources
- Utility generation capacity
- Energy storage capacity
- Electricity demand
- Share of region's households experiencing energy cost-burden

Strategy costs

Cost is expected to be medium. Costs will depend on the available technology, implementation approaches, and success of reducing overall electrical load through energy efficiency measures.

Intersection with other funding availability

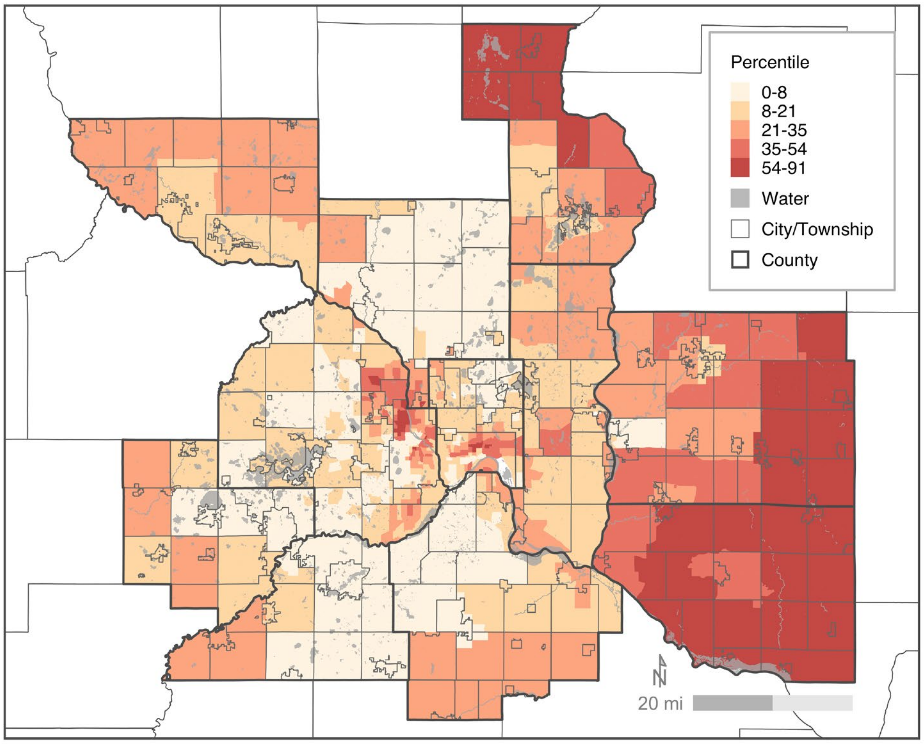
Complementary funding sources:

- Minnesota Climate Innovation Finance Authority
- Wisconsin Grid Resilience Program
- U.S. Department of Agriculture Electrical Infrastructure Loan and Loan Guarantee program
- U.S. Department of Energy Grid Resilience and Innovation Partnerships

Building Energy Sector

The building energy sector accounts for 24.5% of 2022 regional emissions. Building energy strategies reduce building energy use and transition buildings to using renewable energy sources through electrification. For residents across the region, energy efficiency strategies can help reduce energy costs while electrification can improve health outcomes by reducing exposure to air pollutants in the home. These strategies are especially impactful for energy-cost-burdened households, households that spend a disproportionate amount of their income on energy costs. Those households are especially prevalent in the urban center and rural parts of the region, as shown in Map 3.

Map 3. Distribution of energy-cost-burdened households by percentiles



Source: Metropolitan Council analysis of Council on Environmental Quality Climate and Economic Justice Screening Tool (v2.0, Dec 2024) and Environmental Protection Agency EJScreen Data.

Table 7. Building Energy Sector Strategies Summary

Building Energy Sector Strategy Summary	GHG Emissions Reduction in 2030 Compared to the BAU ($MTCO_2e$)	GHG Emissions Reduction in 2050 Compared to the BAU ($MTCO_2e$)
Strategies 7 & 8: Electrify and improve residential building energy efficiency		
Potential Policy Scenario	-453,078 (-6.5%)	-3,557,716 (-59.1%)
Net Zero Scenario		-5,745,471(-95.4%)
Strategy 9 & 10: Electrify and improve non-residential building energy efficiency		
Potential Policy Scenario	-235,349 (-1.9%)	-7,148,251 (-72.1%)
Net Zero Scenario		-9,467,502 (-95.5%)

Figure 17. Residential building energy projections

This includes electricity demand and on-site fuel combustion emissions.

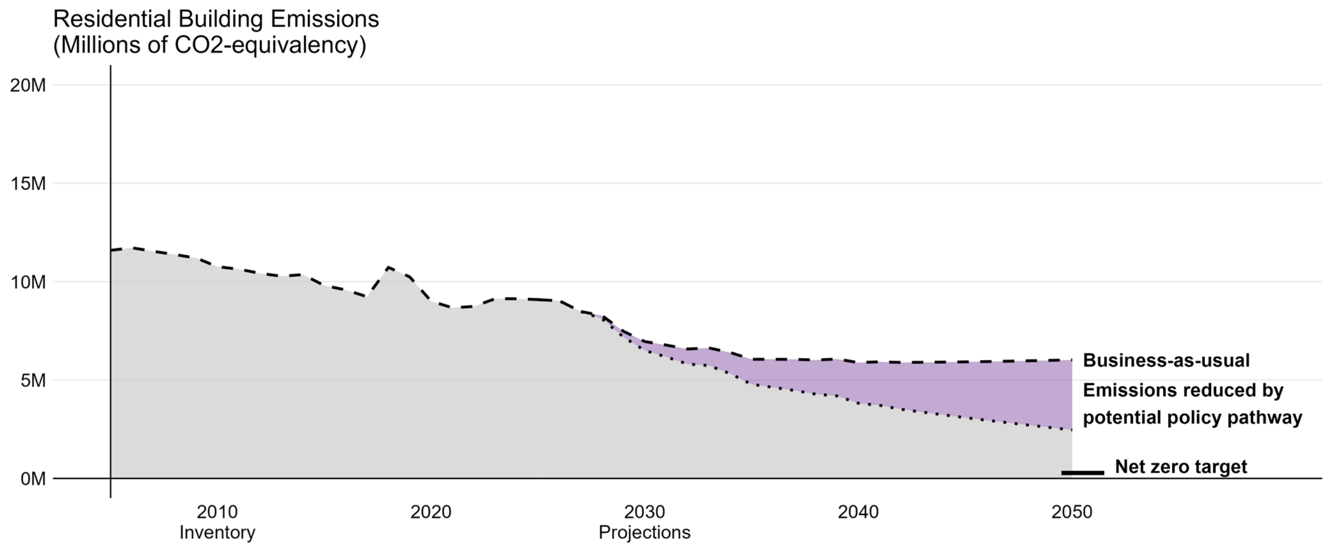
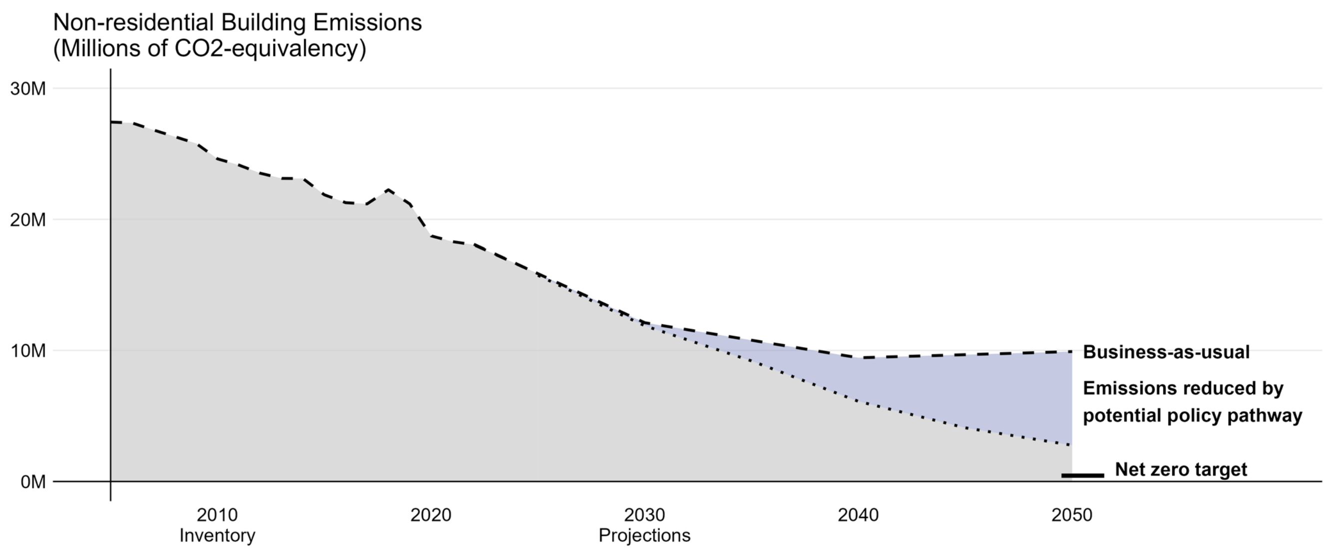


Figure 18. Non-residential building energy projections.

This includes electricity demand and on-site fuel combustion emissions.



Strategy 7: Improve residential building energy efficiency

Description

Improving the energy efficiency of residential buildings can considerably reduce the energy consumption of single and multifamily homes across the Twin Cities region. Energy efficiency improvements include enhancing insulation, installing energy-efficient windows, upgrading HVAC systems, and incorporating smart technologies. Retrofitting and weatherizing existing housing units is more difficult and costly than building new homes to be efficient. Cities can adopt policies or programs encouraging new single-family homes to achieve energy efficiency standards similar to LEED Gold and other green building standards. Retrofitting and building new energy-efficient housing can be accelerated by educating residents and providing incentives, designs, and navigation support. This strategy is relevant to the whole region. When prioritizing homes for this strategy, factors like age of the building, rental or ownership status, and previous energy efficiency upgrades could highlight buildings of highest need and guide the implementation approach.

Community benefits analysis

"People are interested in taking action on efficiency and renewable energy if cost wasn't an issue."

Improving the energy efficiency of residential buildings can result in reduced utility costs and increased climate resilience, which can be especially impactful for low-income households. Targeted retrofits can reduce indoor and outdoor air pollution, enhance comfort during extreme weather, and address energy insecurity. Energy efficiency programs should be structured to address barriers faced by low-income households including prohibitive upfront costs for improvements that have long-term payback. Implementation should also consider how to design programs to include renters, multi-family housing, and manufactured home communities. Additionally, programs should incorporate energy education and outreach through community partners to overcome access, language, and trust barriers.

Implementation authority and responsibilities

- State government: State agencies have statutory authority to increase efficiency in new construction and provide weatherization programs, primarily through the Department of Commerce and Department of Administration. State agencies also support residents in navigating resources and rebates and provides funding opportunities.
- Regional government: The Met Council has authority over houses it owns through the Housing and Redevelopment Authority and seasonally conducts home energy audits on both vacant and occupied residences. The Met Council also plays a role in supporting local governments through providing climate planning technical assistance.
- Local government: Local governments connect residents with energy efficiency programs and can hire or designate staff to serve as experts and prioritize outreach. Local governments can also offer financial assistance through direct funding, utility and nonprofit partnerships, or rebate programs.
- Other actors: Utilities fund programs that support residential energy efficiency and offer rebates for appliance upgrades. Nonprofit organizations provide services to households like home energy audits and connections to rebate programs. Housing authorities can ensure homes within their portfolio receive timely energy efficiency improvements.

Implementation timelines and milestones

This is a medium-term strategy as the technology exists and some implementation is ongoing. The timeline for widespread implementation will be impacted by the availability of funding.

Metrics for tracking progress

- Number of homes weatherized
- Number of homes retrofitted with energy-efficient HVAC systems
- GHG emissions in the residential building sector

Strategy costs

Costs are expected to be low to medium, depending on building type, technology, and scale of implementation. Energy efficiency improvements are significantly more costly in existing buildings while new buildings can be built to meet energy efficiency standards with moderate impacts on the overall costs. Across building types, energy efficiency improvements can have significant upfront costs but then provide a return on investment through lower electricity, heating, and gas utility costs.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Pre-weatherization Program
- Minnesota Department of Commerce Conservation Improvement Program
- Minnesota Housing Finance Authority Impact Fund
- Minnesota Housing Finance Authority Fix Up Home Improvement Loan Program
- Minnesota Housing Finance Authority Energy Loan Plus Program
- Minnesota Housing Finance Authority Consolidated Request for Proposals
- Minnesota Housing Finance Authority Rental Rehabilitation Deferred Loan
- Minnesota Housing Finance Authority Community Stabilization Program
- Minnesota Department of Commerce Weatherization Assistance Program
- Wisconsin Energy Innovation Grant Program
- Wisconsin Home Energy Assistance Program
- Rebate programs from energy utilities
- U.S. Department of Energy Buildings Upgrade Prize
- U.S. Environment Protection Agency Collaborative Problem Solving Cooperative Agreement Program
- U.S. rebates and credits for home energy upgrades

Strategy 8: Electrify Homes

Description

Electrifying homes supports decarbonization by switching appliances and systems from energy sources like natural gas to power that can be carbon neutral. Residential electrification efforts exist at the individual household scale, like heat pump or solar panel installation, and also exist at a community scale, like district energy networks. The benefits of electrification can include improved indoor air quality and more resilient cooling systems during extreme heat. This strategy is relevant to the whole region. When prioritizing homes for this strategy, factors like age of the building, rental or ownership status, and grid mix of electricity could highlight buildings of highest need or potential and guide implementation approach.

Community benefits analysis

"Switching from gas to electricity can bring high startup costs, fear, and can be hard to navigate on a busy schedule."

Home electrification reduces indoor air pollution and enhances public health in communities disproportionately exposed to combustion-based emissions. Replacing gas appliances with electric alternatives improves air quality, reduces greenhouse gas emissions, and can stabilize energy costs over time. To ensure equity, programs should consider providing financial assistance for low-income households to address cost barriers and technical assistance such as including trusted community guides to increase participation and comfort. Local workforce training can deliver additional economic benefits through installation and maintenance jobs.

Implementation authority and responsibilities

- State government: State agencies already have authority to pursue incentive-based programming, including fuel-switching under Minnesota's utility conservation program. Legislative action would be required for a regulatory approach.
- Regional government: The Met Council does not have direct authority over residential electrification. The Met Council plays a role in supporting local governments through providing climate planning technical assistance.
- Local government: Cities and counties can directly connect residents with programs that may support new technology adoption and hire or designate staff to serve as experts and prioritize outreach.
- Other actors: Nonprofit organizations provide services to households like connections to rebate programs. Utilities may provide rebate programs for some technologies and access to renewable energy resources.

Implementation timelines and milestones

This is a medium- to long-term strategy as the technology exists but is costly for households and not widely adopted. The timeline will be impacted by the availability of funding.

Metrics for tracking progress

- Number of homes electrified
- GHG emissions from the residential building sector

Strategy costs

Cost is expected to be medium for this strategy and ranges significantly based on building type and technology.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Climate Innovation Finance Authority
- Minnesota Housing Finance Authority Energy Loan Plus Program
- Wisconsin Energy Innovation Grant Program
- Rebate and rewards programs from energy utilities

Strategy 9: Improve non-residential building energy efficiency

Description

Retrofitting existing non-residential buildings – primarily commercial and public buildings – can considerably reduce their energy consumption. Energy efficiency improvements include enhancing insulation, upgrading heating and cooling systems, and replacing lighting systems with energy-efficient alternatives. Once facilities are retrofitted, it is critical that technicians have the skills to operate and maintain technologies correctly and efficiently. This ensures that new equipment will operate as intended for its expected lifetime. This strategy is relevant to the whole region. When prioritizing buildings for this strategy, factors like age of the building, building energy use, and previous energy efficiency upgrades could highlight buildings of highest need and guide implementation approach.

Community benefits analysis

"We should incentivize or require new construction and buildings to be energy efficient and have cleaner energy."

Energy efficiency upgrades in commercial and public buildings can reduce utility costs and improve indoor conditions, particularly in underserved areas and for small and BIPOC-owned businesses. Equitable implementation should prioritize under-resourced neighborhoods, and address education and cost barriers by including incentives and guidance for property owners.

Implementation authority and responsibilities

- State government: State agencies, including the Department of Administration and Department of Commerce, have some existing statutory authority and responsibility to increase efficiency in new construction and weatherization, including through the B3 program. State agencies also offer funding opportunities and support navigation of resources and rebates. Additionally, state agencies have direct control over state-owned public buildings.
- Regional government: The Met Council has direct control over Met Council-owned public buildings and infrastructure. The Met Council continually works to improve the efficiency of its buildings, particularly large buildings and infrastructure that serve the regional wastewater and transit systems.
- Local government: Local governments have direct control over the energy efficiency of their municipal buildings. Many local governments in the Twin Cities region have initiated or completed energy efficiency projects on their buildings. They also can provide financial or technical assistance to commercial property owners.
- Other actors: Utilities fund programs that support commercial energy efficiency offer rebates for energy efficiency projects and equipment upgrades. Nonprofit organizations provide services to businesses like energy efficiency consultations and connections to rebate programs.

Implementation timelines and milestones

This is a medium-term strategy as technology exists and can provide a return on investment but needs to be implemented at a broad scale. The timeline will be impacted by the availability of funding.

Metrics for tracking progress

- Number of public buildings weatherized
- Number of public buildings retrofitted with energy-efficient HVAC systems
- Number of public buildings retrofitted with LEDs
- GHG emissions from commercial building sector.

Strategy costs

Costs are expected to be low to medium, depending on building type, technology, and scale of implementation. Energy efficiency improvements can have significant upfront costs but then provide a return on investment through lower electricity, heating, and gas utility costs.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Climate Innovation Finance Authority
- Minnesota Department of Commerce Air Ventilation Pilot Grants
- Minnesota Department of Commerce Conservation Improvement Program and Energy Conservation and Optimization Programs
- Wisconsin Energy Innovation Grant Program
- Utility energy efficiency equipment rebates
- U.S. 179D Commercial Building Energy-Efficiency Tax Deduction
- U.S. Department of Agriculture Small Community Facilities Grant
- U.S. Department of Agriculture Rural Development Energy Programs

Strategy 10: Electrify non-residential buildings

Description

Electrifying non-residential buildings like commercial and public buildings supports decarbonization by transitioning appliances and systems from energy sources like natural gas to power that can be carbon neutral. Similar to the residential sector, commercial and public building electrification efforts exist at the individual building scale like heat pump or solar panel installation and also exist at a community scale like district energy networks. The benefits of electrification can include improved indoor air quality and more resilient cooling systems during extreme heat. This strategy is relevant to the whole region. When prioritizing buildings for this strategy, factors like age of the building, building purpose and required systems, and grid mix of electricity could highlight buildings of highest need or potential and guide implementation approach.

Community benefits analysis

“Huge [temperature] fluctuations impact older buildings management of heating systems. It will put more strain on whatever systems we have in place, especially the older ones. You just have to power through a whole day where it’s either really hot or really cold. Could electrification help with that?”

Electrifying commercial and public buildings improves air quality by reducing GHG emissions. In public facilities such as schools and community centers, electrification creates safer, healthier spaces and demonstrates visible leadership in the clean energy transition. Focusing investments in overburdened neighborhoods ensures these health and resilience benefits reach the communities most in need and addresses cost barriers to participation. Offering guidance programs for property owners may aid in addressing gaps in education and understanding.

Implementation authority and responsibilities

- State government: State agencies, including the Department of Commerce, have authority to pursue incentive-based programming, including fuel-switching under Minnesota's utility conservation program. Legislative action would be required for a regulatory approach. State agencies also have direct control over state-owned public buildings.
- Regional government: The Met Council has direct control over Met Council-owned public buildings and infrastructure. The Met Council has installed solar panels at some facilities and continues to explore opportunities to further electrify and decarbonize its buildings.
- Local government: Local governments have direct control over municipal buildings. Many local governments in the Twin Cities region have initiated or completed projects to electrify municipal buildings including installing solar panels and purchasing renewable energy. They also can provide financial or technical assistance to commercial property owners.
- Other actors: Utilities may offer rebates for new equipment and programs to allow commercial customers access renewable energy.

Implementation timelines and milestones

This is a medium- to long-term strategy as the technology exists but is costly and not widely adopted. The timeline will be impacted by the availability of funding.

Metrics for tracking progress

- Number of public buildings with on-site renewable energy generation
- Square footage of commercial/industrial space decarbonized
- GHG emissions from commercial building sector

Strategy costs

Cost is expected to be medium for this Strategy and ranges significantly based on building type and technology.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Climate Innovation Finance Authority
- Minnesota Department of Commerce Solar for Schools program
- Minnesota Department of Commerce Solar on Public Buildings grant program
- Wisconsin Energy Innovation Grant Program
- Wisconsin Department of Natural Resources Green Tier Program
- Proposed Xcel Energy Community Ground Source Heat Pump demonstration project

Industrial Processes Sector

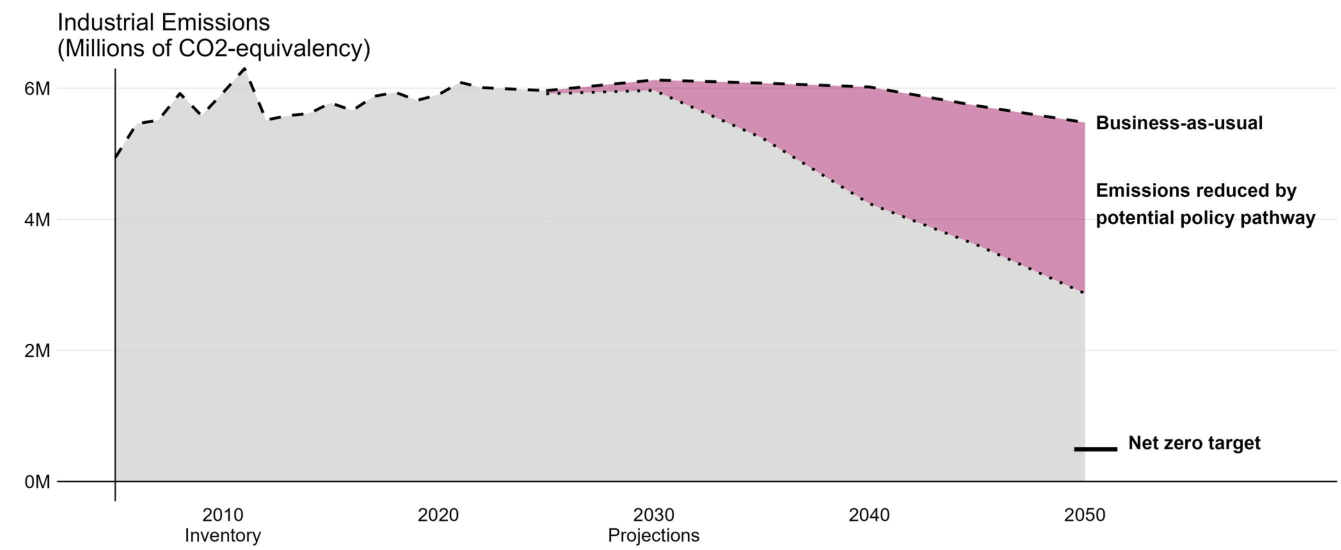
The industrial processes sector represents 11% of regional emissions. The industrial reduction strategy is important for addressing these emissions while recognizing that the feasibility of transitioning to low-carbon technology varies by industry and use. Transitioning to low-carbon technologies often can have public health benefits by improving air quality both for workers and residents who live near industrial areas.

Table 8. Industrial Sector Strategy Summary

Industrial Sector Strategy Summary	GHG Emissions Reduction in 2030 Compared to the BAU ($MTCO_2e$)	GHG Emissions Reduction in 2050 Compared to the BAU ($MTCO_2e$)
Strategy 11: Encourage industrial adoption of energy efficiency and low-carbon technologies		
Potential Policy Scenario	-158,384 (-2.6%)	-2,608,052 (-47.6%)
Net Zero Scenario		-4,986,546 (-91.0%)

Figure 19. Industrial process emission projections

This includes on site fuel combustion, natural gas flaring, and process emissions not accounted for in the nonresidential building sector.



Strategy 11: Encourage industrial adoption of energy efficiency and low-carbon technologies

Description

Reducing emissions from the industrial sector involves increasing energy efficiency and material efficiency and adopting low-carbon technologies where possible and as technology evolves. Energy efficiency actions including implementing ISO 50001 standard for energy management systems and can reduce overall energy costs. Low- and no-carbon energy sources like the direct use of renewable energy or hydrogen are feasible by varying degrees for different industrial uses. Increasing adoption of those technologies will also be an important part of reducing emissions in the sector.

Community benefits analysis

"I want my future to be cleaner neighborhoods. When you're in neighborhoods here, you see more industrial buildings that could be used for reducing carbon. The more we use these spaces for things that are ruining our ecosystem, it reverses every part - less housing, fewer jobs, health issues. A lot of people get asthma because they're in such industrialized environments."

Industrial decarbonization reduces air pollution and associated health risks in nearby communities. Many industrial facilities are located near low-income neighborhoods and communities of color, who bear a disproportionate burden of pollution and its accompanying impacts. Implementation of low-carbon technologies should involve frontline communities in planning and execution, while creating opportunities for workforce transition.

Implementation authority and responsibilities

- State government: State agencies including the Pollution Control Agency already have some authority to implement this strategy, but full implementation may require legislative action.
- Regional government: The Met Council does not have authority over or a significant role in the industrial sector processes and emissions.
- Local government: Local governments do not have authority over or a significant role in the industrial sector processes and emissions.
- Other actors: Federal programs like Energy Star provide support and technical assistance to industrial manufacturers.

Implementation timelines and milestones

This is a medium- to long-term strategy as existing technology and funding does not meet the implementation need.

Metrics for tracking progress

- GHG emissions from the industrial sector
- Participation in ISO 50001 standards
- Number and capacity of carbon capture and storage projects

Strategy costs

Cost is expected to be medium to high. Costs will depend on the available technology and type of operation. Costs of energy efficiency improvements will be offset by lower energy costs.

Intersection with other funding availability

Complementary funding sources:

- Public-private cost share
- Department of Energy (DOE) Industrial Research and Assessment Center Implementation Grants
- DOE Industrial Research and Assessment Centers
- DOE Manufacturing Leadership

- DOE Energy Efficient Transformer Rebates
- DOE Extended Product System Rebates
- DOE Critical Material Innovation, Efficiency, and Alternatives
- DOE Rare Earth Security Activities
- Environmental Protection Agency (EPA) Implementation of the American Innovation and Manufacturing Act
- EPA Environmental Product Declaration Assistance
- EPA Methane Emissions Reduction Program

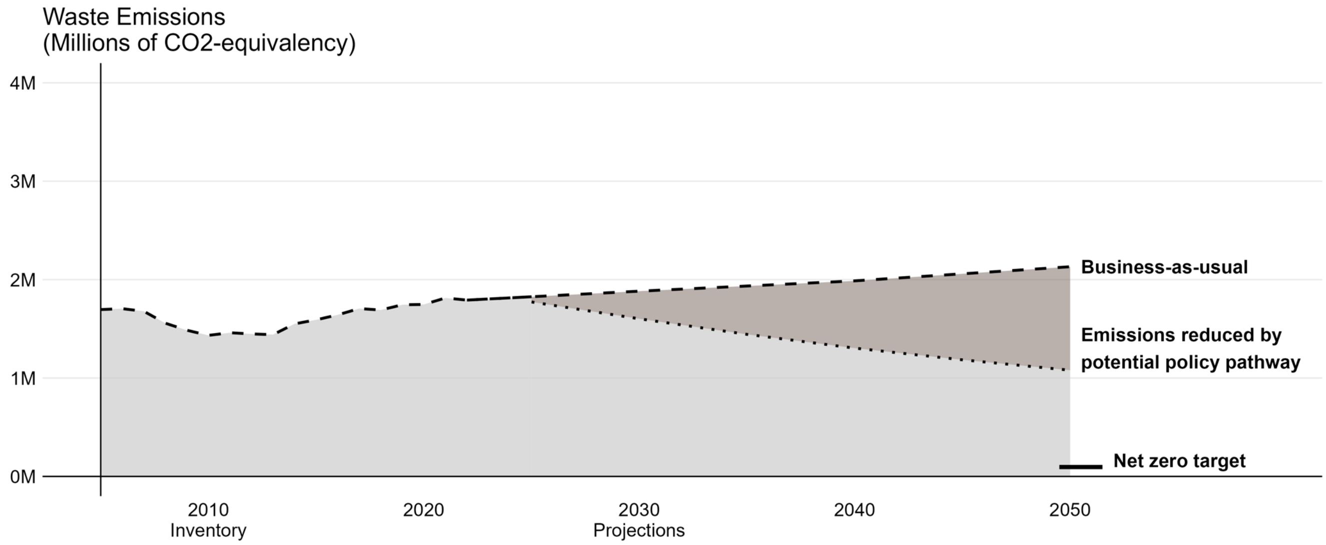
Waste Sector

The waste sector accounts for 3.3% of regional emissions as of 2022 and includes solid waste reduction and wastewater management. While a small percentage of overall emissions, the waste sector is important as many people connect with waste reduction as a mechanism for reducing emissions from material production.

Table 9. Waste Sector Strategies Summary

Waste Sector Strategy Summary	GHG Emissions Reduction in 2030 Compared to the BAU ($MTCO_2e$)	GHG Emissions Reduction in 2050 Compared to the BAU ($MTCO_2e$)
Strategy 12 & 13: Promote waste prevention, waste reduction, and recycling; manage wastewater efficiently		
Potential Policy Scenario	-201,570 (-11.2%)	-1,051,560 (-43.0%)
Net Zero Scenario		-2,035,579 (-95.5%)

Figure 20. Waste emission projections from solid waste and wastewater



Strategy 12: Promote waste prevention, waste reduction, and recycling

Description

Minnesota Statute 115A.02 establishes a hierarchy of practices to achieve the state's waste management goal of protecting land, air, water, natural resources, and public health. Focusing on the preferred practices in this hierarchy – reduce, reuse, and recycle – also achieves the greatest reductions in greenhouse gas emissions from waste. Reducing emissions takes many forms including by preventing waste, increasing opportunities for reuse and recycling, diverting and managing organics, effectively managing solid waste, promoting alternative packaging methods, improving methane capture at landfills, and promoting zero waste practices and a circular economy. Promoting biochar for environmental and economic benefits including landfill methane mitigation and soil contamination remediation also supports overall emissions reductions.

For the seven-county metro region, the Minnesota Pollution Control Agency (MPCA) leads the development and implementation of the Metropolitan Solid Waste Management Policy Plan. The most recent plan for the 2022-2042 timeframe was released in January of 2024 and includes the following related goals:

- Reduce waste production in the metro area by 15% compared to current projections.
- Establish curbside organics collection in all cities with a population greater than 5,000 by 2030.
- Each of the seven counties in the metro area must recycle a minimum of 75% (by weight) of total municipal solid waste they generate by 2030.

This strategy is region-wide, though the most appropriate waste prevention and reduction efforts may vary by community.

Community benefits analysis

"The biggest dream is composting food waste and containers. We don't have any options in River Falls, and it's too expensive to haul it to Eau Claire."

Waste prevention and recycling reduce environmental burdens from landfills and incinerators, which are disproportionately located near low-income communities and communities of color. Expanding access to recycling, composting, and reuse programs can cut greenhouse gas emissions, lower disposal costs, and create green jobs. Implementation should address barriers faced by renters and residents in multi-unit buildings and include culturally relevant outreach and education.

Implementation authority and responsibilities

- State government: The MPCA is the main agency responsible for waste planning and management, including developing the Metropolitan Solid Waste Management Policy Plan.
- Regional government: The Met Council does not have direct authority or responsibilities in solid waste management. The Met Council plays a role in supporting local governments through providing climate planning guidance and technical assistance including related to waste reduction.
- Local government: Counties are responsible for developing and implementing solid waste management plans aligned with the MPCA regional plan. City, township, and tribal governments also play roles in solid waste management including providing recycling and organics recycling services to residents and businesses.
- Other actors: Nonprofit organizations and commercial and industrial businesses all have roles in supporting waste prevention and reduction efforts.

Implementation timelines and milestones

This is a short- to medium-term strategy as implementation efforts are ongoing and have some existing funding sources.

Metrics for Tracking Progress

- County recycling rates
- County reuse rates
- County organic diversion rates
- Tons of waste diverted from landfill
- Greenhouse gas emissions reduction

Strategy costs

Cost is expected to be low to medium depending on implementation approach.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Pollution Control Agency Prevention of Wasted Food and Food Rescue Grants
- Minnesota SCORE funds
- Minnesota Department of Health Statewide Health Improvement Partnership
- Wisconsin Department of Natural Resources Basic Recycling Grant
- Wisconsin Department of Natural Resources Recycling Consolidation Grant

Strategy 13: Manage wastewater efficiently

Description

Wastewater management emits methane and nitrous oxide and can pollute waterways, while technology can mitigate its environmental harm and recapture clean water, nutrients, and energy. The Met Council serves most of the urbanized extent of the region, providing wastewater services to 111 communities, home to more than 2.8 million residents. Smaller plants serve communities beyond the urbanized metro region, including the counties outside of the Met Council's seven-county jurisdiction.

The Met Council has been working to reduce emissions in its operations across its nine water resource recovery facilities by pursuing energy efficiency and electrification opportunities, increasing purchases and generation of renewable energy, and maximizing energy and resource recovery. In addition to emissions from wastewater treatment, there is an opportunity to recover thermal energy from wastewater and biosolids incineration to produce clean, thermal energy for integration into existing hot water district energy heating systems, further reducing reliance on fossil fuels. The strategy is regionwide.

Community benefits analysis

> *"Wastewater or gray water systems, and rain barrels are a good way to recycle and reuse."*

Upgrading wastewater systems improves water quality, reduces energy use, and protects public health in communities with aging or undersized infrastructure. Overflow events and untreated discharges can expose residents to harmful pathogens and degrade aquatic ecosystems. The Met Council has worked with partners to avoid untreated discharges from its infrastructure, but smaller plants may not have had resources to make these investments. Prioritizing investments in vulnerable neighborhoods, combined with local hiring and workforce training, ensures that both environmental and economic benefits are shared equitably.

Implementation authority and responsibilities

- State government: The MPCA issues permits for water and air pollution which regulate all wastewater treatment facilities in the region.
- Regional government: Metropolitan Council Environmental Services manage nine water resource recovery facilities that serve the majority of residents in the region. The Met Council continues to implement improvements to reduce operational emissions.
- Local government: Municipal and wastewater operators beyond the Met Council also have a role in the wastewater they manage.
- Other actors: Additional partners include district energy operators to capture thermal energy.

Implementation timelines and milestones

This is a medium-term strategy as implementation efforts are ongoing and have some existing funding sources, but reaching the full potential of this strategy require technology innovations and additional funding.

Metrics for tracking progress

Greenhouse gas emissions from wastewater, renewable energy produced or purchased for Met Council-owned water resource recovery facilities.

Strategy costs

Cost is expected to be medium to high depending on implementation approach, though some approaches provide a long-term return on investment.

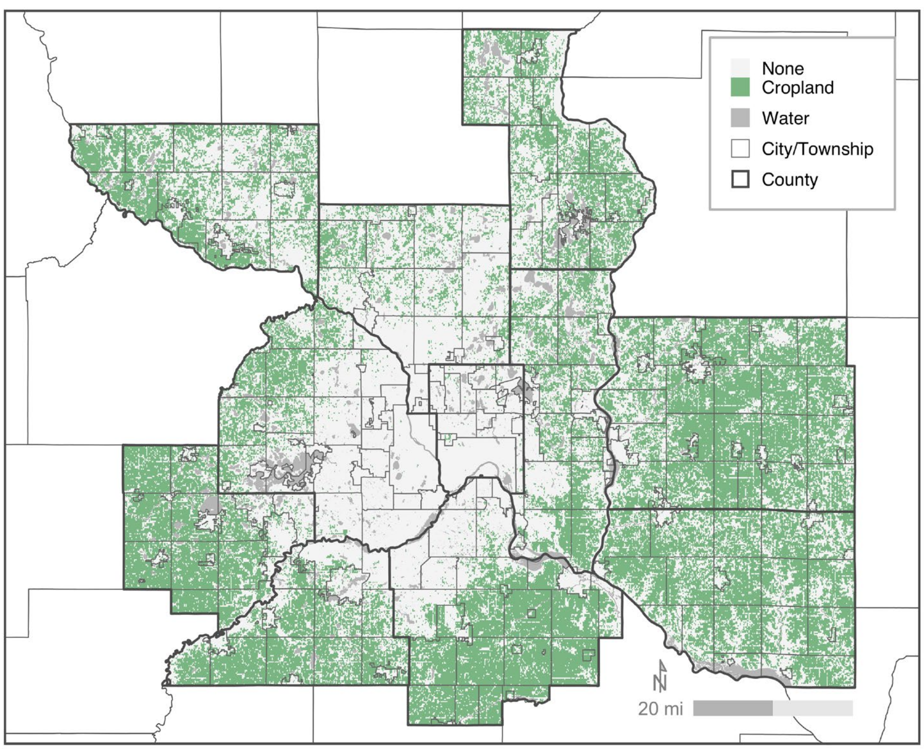
Intersection with other funding availability

Complementary funding sources include utility conservation improvement programs.

Agriculture Sector

The agriculture sector accounts for 1.9% of regional emissions as of 2022. Emissions in this sector are expected to decrease in the region owing to projected increases in agricultural abandonment and development. Agriculture sector strategies focus on reducing emissions from large-scale agriculture in the region through practice changes and supporting small-scale and urban agriculture efforts. These strategies also lead to increased sequestration in agricultural soils, which we bundle with associated emission decreases graphically in this sector.

Map 4. Agricultural lands throughout the 11-county MSA



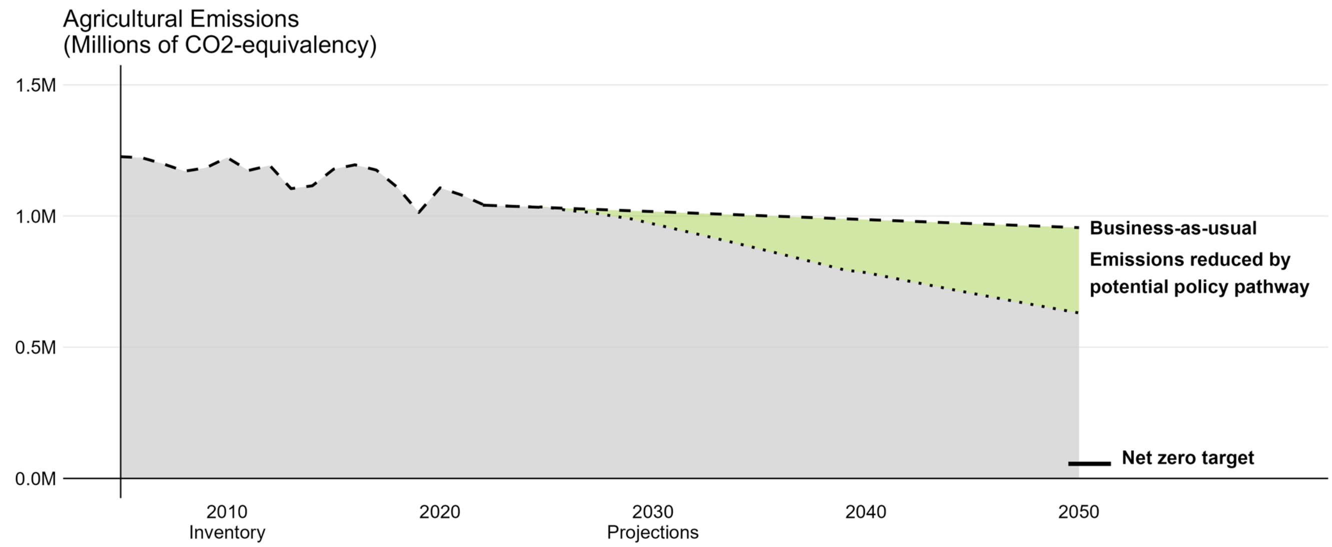
Source: Metropolitan Council analysis of USGS National Land Cover Database data

Table 10. Agriculture Sector Strategies Summary

Agriculture Sector Strategies Summary	GHG Emissions Reduction in 2030 Compared to the BAU ($MTCO_2e$)	GHG Emissions Reduction in 2050 Compared to the BAU ($MTCO_2e$)

Strategy 14 - 16: Encourage climate-smart agriculture, better manage fertilizer and manure, and invest in local and urban agriculture		
Potential Policy Scenario	-46,783 (-4.6%)	-325,125 (-34.0%)
Net Zero Scenario		-900,125 (-94.2%)

Figure 21. Agricultural emission projections from livestock and crop production



Strategy 14: Encourage climate-smart agriculture practices that improve soil health and soil organic content

Description

Climate-smart agriculture practices improve soil health and soil organic carbon content while providing additional benefits including increasing nutrient-use efficiency, reducing erosion, and improving water quality. Climate-smart practices include cover crops, conservation tillage, diverse crop rotations, forest farming, silvipasture, perennial crops, and winter annual crops. These measures can be supported through developing and expanding relevant markets, increasing access to specialized equipment, and providing education on and incentives for specific practice adoption. This strategy is most relevant to rural and agricultural parts of the region.

Community benefits analysis

"How do we build microbiomes here, improve soil, and sequester more carbon through our practices? How do we incorporate cover crops, reduce soil erosion, create economic opportunities for us, while keeping it vibrant here? As farmers, we're not just thinking about this year, but we're thinking about next year and the years to come. How do we rejuvenate and make sure we have longevity? Agriculture is something that's necessary to feed all of us, feed the world."

"There is willingness from farmers [to try cover cropping], but there's a huge gap of knowledge of how to get here. The key is to lowering that barrier of knowledge as much as possible."

Climate-smart agricultural practices strengthen farm resilience, protect local waterways and improve water quality, and store carbon in soils, providing both environmental and economic benefits to rural communities. While many practices provide a long-term return on investment, farmers, and especially underserved farmers, need financial support and technical assistance to learn about and decide to test new methods. Additionally, implementation should consider developing markets for end-products from diverse and alternative crops to make these practices financially viable.

Implementation authority and responsibilities

- State government: State agencies including the Department of Agriculture, Pollution Control Agency, and Board of Water and Soil Resources have authority and/or influence over the adoption of climate smart agricultural practices.
- Regional government: The Met Council helps implement the Metropolitan Agricultural Preserves program in partnership with property owners and local authorities in the seven-county region. The program establishes a local planning process to designate agricultural areas as a long-term land use and provides benefits to maintain viable, productive farm operations. This program supports agriculture viability in the region generally and does not specifically address climate-smart practices.
- Local government: Local governments including soil and water conservation districts play an important role in providing programs that support producers in adopting climate-smart practices and connecting farmers to additional resources including federal funding programs.
- Other actors: The University of Minnesota Extension program plays an important role in providing resources on climate-smart practices and connecting producers to research on best practices. There are also many nonprofit organizations working to support producers in adopting best practices and developing markets for climate-smart crops.

Implementation timelines and milestones

This is a short- to medium-term strategy as implementation efforts are ongoing and have existing funding sources.

Metrics for tracking progress

- Number of acres with climate-smart agriculture practices
- Number of acres newly enrolled in conservation programs
- GHG emissions and sequestration data from cropland

Strategy costs

Costs are expected to be low to medium depending on implementation approach. Different practices have varying upfront costs, and some provide a return on investment over time.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Board of Water and Soil Resources Soil Health Cost-Share Program

- Minnesota Department of Agriculture Continuous Living Cover Grant
- Minnesota Department of Agriculture Minnesota Agricultural Water Quality Certificate Program
- Minnesota Department of Agriculture Down Payment Assistance Grant
- Minnesota Department of Agriculture Emerging Farmer Technical Assistance Grant
- Minnesota Clean Water, Land and Legacy Amendment Funds
- Wisconsin Department of Agriculture, Trade, and Consumer Protections Organic Cost Share Certification Rebate Program
- Wisconsin Department of Agriculture, Trade, and Consumer Protections Soil and Water Resource Management Grants
- Wisconsin Department of Agriculture, Trade, and Consumer Protections Producer-led Watershed Protection Grants
- U.S. Department of Agriculture Regional Conservation Partnership Program funds
- U.S. Department of Agriculture Environmental Quality Incentives Program
- U.S. Department of Agriculture Conservation Stewardship Program
- U.S. Department of Agriculture Conservation Reserve Program and Conservation Reserve Enhancement Program

Strategy 15: Manage fertilizer and manure to reduce emissions

Description

Fertilizer and manure are two agriculture materials that can be managed to reduce greenhouse gas emissions from the agriculture sector. Slow-release or controlled-release fertilizers and stabilizers can increase the nitrogen efficiency of fertilizers, lowering nitrous oxide emissions while ensuring crops still receive the benefits. Manure management techniques like solid-liquid separation, diet adjustments, and anaerobic digestion can reduce the greenhouse gas emissions from livestock. These practices are particularly relevant for rural and agricultural parts of the region, especially Carver, Dakota, Pierce, and St. Croix counties.

Community benefits analysis

"We need more affordable natural fertilizers. To match cover crops to environment and reduce synthetic fertilizer, education is required."

Improved fertilizer and manure management protects public health by reducing nutrient runoff into waterways and lowering harmful emissions. Rural, low-income communities often bear the brunt of these impacts, facing contaminated drinking water and degraded air quality. Equitable implementation should ensure low-income, rural, and historically underserved farmers have access to funding and technical assistance to make these practices financially viable. Supporting reduced emission fertilizer and manure best-practices can safeguard environmental health while improving operational efficiency for farmers.

Implementation authority and responsibilities

- State government: State agencies including the Department of Agriculture and Pollution Control Agency, and Board of Water and Soil Resources have authority and/or influence over this strategy.

- Regional government: The Met Council does not have direct authority over agriculture practices including fertilizer licensing and manure management plans. The Met Council does have a role in water quality in the region, partnering with agencies and organizations for watershed planning and water quality monitoring.
- Local government: Local governments including counties and soil and water conservation districts play an important role in providing programs that educating and providing support to producers interested in adopting new practices like transitioning to enhanced efficiency nitrogen fertilizers.
- Other actors: The University of Minnesota Extension program plays an important role in providing resources and training on nitrogen and manure management and connecting producers to research on best practices.

Implementation timelines and milestones

This is a short- to medium-term strategy as implementation efforts are ongoing and have some existing funding sources. Timelines will depend on funding, product, and technology availability.

Metrics for tracking progress

- Amount of enhanced efficiency nitrogen fertilizers sold
- Feedlot permit and registration data
- GHG emissions from the agriculture sector

Strategy costs

Costs are expected to range from low to high depending on implementation approach. Enhanced efficiency nitrogen fertilizers can cost more than traditional fertilizers but provide a return on investment by reducing overall input costs and increasing yield, making it a relatively low-cost strategy. Manure management practices can be more costly as they may require infrastructure investments.

Intersection with other funding availability

Complementary funding sources:

- Minnesota Department of Agriculture Minnesota Agricultural Water Quality Certificate Program
- Minnesota Clean Water, Land and Legacy Amendment Funds
- Minnesota Department of Agriculture Nitrogen Management Financial Assistance Pilot Program
- Wisconsin Department of Agriculture, Trade, and Consumer Protections Soil and Water Resource Management Grants
- Wisconsin Department of Natural Resources Targeted Runoff Management Grants
- U.S. Department and Agriculture Environmental Quality Incentives Program

Strategy 16: Invest in local and urban agriculture

Description

While greenhouse gas emissions from agriculture largely come from more industrial-scale production, it is also important to support the distributed, smaller-scale agriculture that continues to expand in more residential areas. Local food production has many benefits including reducing emissions from transporting food to people. Local and urban food systems emerge in many forms from front yard and community gardens to year-round indoor greenhouses to food recovery projects. Supporting these efforts can include providing resources and workforce development opportunities, expanding the Local Food Purchase Assistance Program, providing financial and technical assistance to local food producers. It can also look like developing markets for long-lived wood products that store carbon, incentivizing beneficial uses for waste wood such as millwork and mulch, and encouraging production and use of biochar. This work is important across the region and particularly impactful in areas with food deserts.

Community benefits analysis

> *"Supporting community gardens and diversity of green spaces at schools can help with better nutrition, saving money, and less reliance on the corporate food system."*

Increased investment in local and urban agriculture can improve food security, affordability, access, and quality in communities, especially underserved areas. By increasing access to fresh, culturally relevant foods, these actions can address diet-related health disparities and foster community connections. Additional benefits may include increased civic engagement, strengthened cultural identity, improved mental health, decreased stress, increased physical activity, healthy nutrition knowledge, improved community safety, and increased access to greenspace. Equitable implementation approaches should ensure secure land tenure, supportive zoning, technical assistance, and targeted funding for marginalized and low-income communities.

Implementation authority and responsibilities

- State government: State agencies including the Department of Natural Resources, Pollution Control Agency, and Department of Agriculture have authority and roles related to this strategy.
- Regional government: The Met Council plays a role in supporting local governments through providing climate planning guidance and technical assistance including related to local food systems resilience.
- Local government: Local governments have roles in workforce development, zoning and permitting, and program development that can support local and urban agriculture practices.
- Other actors: Nonprofit organizations in the region play many important roles in implementing this strategy from organizing farmers markets to owning and managing community gardens.

Implementation timelines and milestones

This is a short- to medium-term strategy as implementation efforts are ongoing and have some existing funding sources.

Metrics for tracking progress

- Number and geographic distribution of community gardens
- Number and geographic distribution of local farmers markets
- Rate of people experiencing food insecurity

Strategy costs

Cost is expected to be low to medium depending on implementation approach.

Intersection with other funding availability

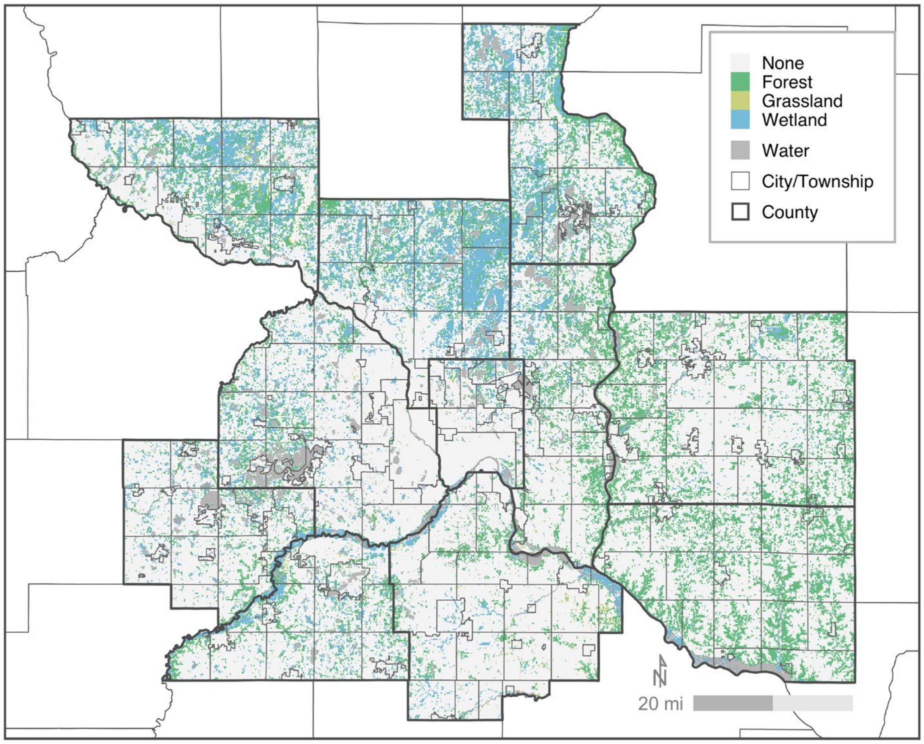
Complementary funding sources:

- The Good Acre's Local Economic Accelerator for Farmers (LEAFF)
- Minnesota Department of Agriculture Local Food Purchase Assistance Program
- Minnesota Forestry Association Call Before You Cut Program
- Minnesota Department of Natural Resources forest stewardship cost share programs
- Wisconsin Department of Agriculture, Trade, and Consumer Protections Resilient Food Infrastructure Program
- Wisconsin Department of Agriculture, Trade, and Consumer Protections Local Food Purchase Assistance Program
- U.S. Department of Agriculture Environmental Quality Incentives Program (EQIP)
- U.S. Department of Agriculture Conservation Stewardship Program
- U.S. Department of Agriculture Urban Agriculture and Innovative Production Grants
- Federal funding for woodland owners

Natural Systems Sector

The natural systems sector primarily sequesters greenhouse gases, reducing regional emissions 3.2% in 2022. Natural systems strategies focus on increasing sequestration while improving the quality of natural systems accessible to residents throughout the region. Healthy natural systems have many benefits to the region including building the region's resilience to the impacts of climate change through improving public health and mitigating flooding and extreme heat. Land cover in the region, shown in Map 5, is primarily developed or agricultural. Protecting or restoring natural systems where possible and improving tree canopy throughout the region can significantly improve quality of life while sequestering greenhouse gases.

Map 5. Natural systems throughout the 11-county MSA (excluding built-up environments)

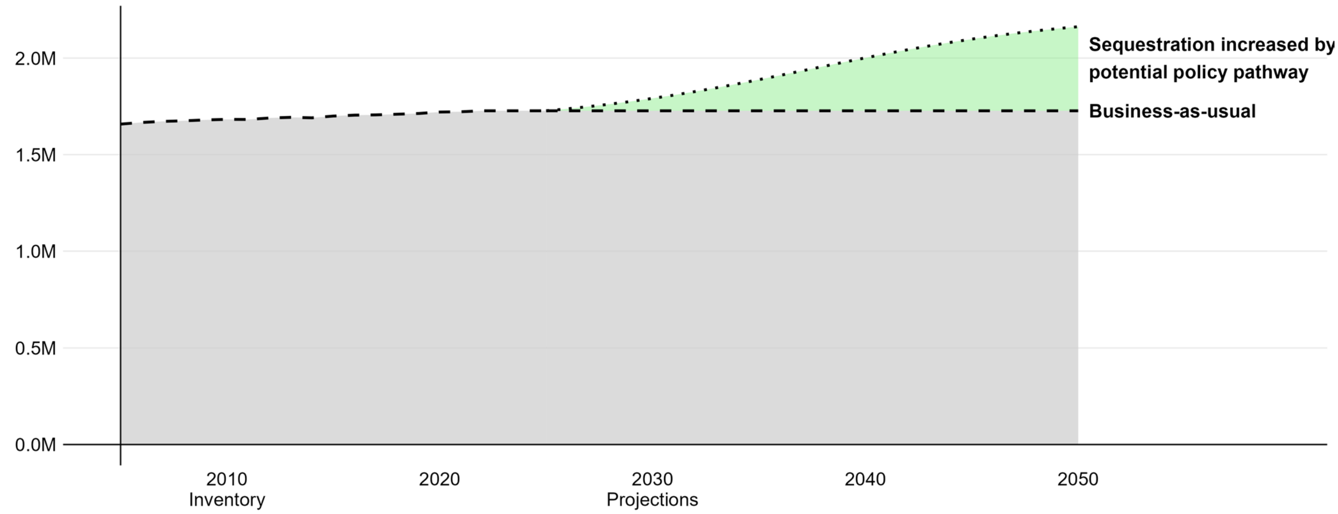


Source: Metropolitan Council analysis of USGS National Land Cover Database data.

Table 11. Natural Systems Sector Strategies Summary

Natural Systems Sector Strategy Summary	GHG Sequestration Gains in 2030 Compared to the BAU ($MTCO_2e$)	GHG Sequestration Gains in 2050 Compared to the BAU ($MTCO_2e$)
Strategy 17 & 18: Invest in a robust, resilient tree canopy; Protect and restore natural systems		
Potential Policy Scenario	+64205 (+3.7%)	+435532 (+25.2%)

Figure 22. Natural systems sequestration projections



Strategy 17: Invest in a robust, resilient tree canopy

Description

Trees act as natural carbon sinks by absorbing carbon dioxide from the atmosphere and storing it in their trunks, branches, leaves, and roots. Increased tree planting can also provide additional benefits, such as reducing urban heat island effects, improving air quality, promoting biodiversity, and enhancing aesthetic appeal. Tree planting and maintenance is relevant regionwide, with priority areas being those with less tree canopy as identified through the Council's Growing Shade tool.

Community benefits analysis

"Trees are one of the most important parts of our natural world."

"We don't have that many trees. My big things are developing more cropland, and green spaces. There are not enough trees. If I had a wish, I would wish that these developed areas would be a mixture of trees and development."

Due to residential segregation through explicit codification in laws, institutional practices, and historic disinvestment in segregated areas, some communities in the region have less tree coverage. Trees can reduce the urban heat island effect, increase natural cooling, improve air quality and aesthetics, help manage stormwater runoff, increase property value, and improve mental health. Equitable tree planting programs should prioritize underserved areas and involve community members in planning and stewardship. Long-term maintenance planning is essential to ensure the benefits are sustained.

Implementation authority and responsibilities

- State government: State agencies including the Departments of Natural Resources, Agriculture, and Transportation, the Pollution Control Agency, and the Board of Soil and Water Resources play a role in supporting the Twin Cities' regional tree canopy.

- Regional government: The Met Council manages technical assistance tools to inform tree canopy enhancement and preservation in the region. The Met Council also runs a Community Tree Planting Grant program that funds local governments to complete tree canopy improvement projects.
- Local government: Cities, counties, townships, and Tribal nations have relevant authorities in managing the tree canopy in public spaces and along transportation corridors. Local governments can also support private property canopy programs to increase tree canopy across their jurisdictions.
- Other actors: Nonprofit organizations, such as Tree Trust and The Nature Conservancy, support local government efforts to increase and manage tree canopy.

Implementation timelines and milestones

This strategy is a short- to medium-term strategy as tree planting and maintenance efforts are ongoing and have regional and state funding sources. However, the impact of emerald ash borer and other pests and diseases will necessitate tree canopy health and resilience investment and action for the foreseeable future.

Metrics for tracking progress

- Percent canopy coverage by community
- Regional average of tree canopy coverage
- Percent canopy coverage increase in census block groups prioritized for the Community Tree Planting Grant
- Number of trees planted funded by the Community Tree Planting Grant in total and in census block groups prioritized

Strategy costs

Cost is expected to be low to medium depending on the scope of future canopy impacts from disease, pests, and disasters. Met Council data from the Community Tree Planting Grant program indicates that costs including materials, labor, and maintenance average $500 per tree planted while tree removal due to pest or disease averages around $1,000.

Intersection with other funding availability

Complementary funding sources:

- Met Council Community Tree Planting Grants
- Minnesota Department of Natural Resources ReLeaf Community Forestry Grants Program
- Minnesota Department of Natural Resources Shade Tree Program Bonding Grants
- Minnesota Department of Natural Resources Community Tree Planting Grants Program
- Wisconsin Department of Natural Resources Urban Forestry Grants

Strategy 18: Protect and restore natural systems

Description

Grasslands, forests, and wetlands are effective natural carbon sequestration and storage options and offer a multitude of co-benefits including protecting biodiversity, improving water quality, mitigating flooding, and providing public recreation opportunities. Restoring, maintaining, and protecting these natural systems ensures that they are healthy and can provide environmental benefits, including carbon sequestration. Restoration can happen at a variety of scales on public and private land, ranging from transitioning large abandoned agricultural areas to grassland to converting urban lawns to pollinator habitats. While this strategy will look different depending on the context, restoration and protection has a role across all areas in the metro region. It is especially important in areas along the suburban edge of the region where new development pressures existing natural systems. Some higher priority areas include:

- Areas with limited natural areas.
- Ecologically significant areas: areas with high-functioning ecological systems that support biodiversity, habitat, connectivity, and rare and endangered species.
- Ecologically sensitive areas: ecosystems that are vulnerable to disturbances such as human activities, climate change, and invasive species.

Community benefits analysis

"Nature preserves and local parks are part of what makes and builds a community."

"We should integrate nature in all spaces, maintain existing parks, and look at proximity to parks for all developments."

Restoration and protection of natural lands enhance biodiversity, improve air and water quality, and provide recreational and cultural benefits. Natural areas also offer critical climate resilience by managing stormwater and buffering against flooding. Equitable strategies should focus on increasing access to green space in communities with limited resources and integrating Indigenous and local ecological knowledge into restoration practices. Job creation in land management can provide additional local benefits.

Implementation authority and responsibilities

- State government: Agencies including the Departments of Natural Resources and Agriculture, the Board of Water and Soil Resources, and the Pollution Control Agency support this strategy.
- Regional government: The Met Council plays a role in supporting local governments through providing planning guidance and technical assistance for restoring and protecting natural systems. The Met Council also works with partners across the region to improve impacted waters and protect unimpaired waters including: reviewing local comprehensive plans, local water plans, and watershed management plans; providing technical and financial assistance to local governments and other partners on water issues and water management activities; and facilitating discussions on regional water issues that transcend community or watershed organization boundaries. The Met Council also conducts water quality management studies for water bodies in the seven-county region and maintains a regional water quality database for information collected.
- Local government: Cities, townships, and counties all play a role in conserving and restoring natural areas in their communities. Watershed and conservation districts also support the restoration and protection of natural land through implementing and funding projects protect or restore terrestrial and aquatic systems.

- Other actors: Nonprofit conservation partners also play an important role across the spectrum of land acquisition, management, and educational programs.

Implementation timelines and milestones

This is a medium- to long-term strategy. Land restoration and protection takes time, and existing funding does not meet the implementation need.

Metrics for tracking progress

- Regional acreage under conservation easement
- Proportion of regionwide open space acreage to population
- GHG sequestration in natural systems

Strategy costs

Costs are expected to range from low to medium. Restoration efforts are relatively low cost, but land protection and restoration will increasingly face pressure from development.

Intersection with other funding availability

Complementary funding sources:

Minnesota Board of Water and Soil Resources Lawns to Legumes
Minnesota Board of Water and Soil Resources Habitat Friendly Utilities program
Minnesota Department of Health Statewide Health Improvement Partnership (SHIP) initiatives

- Minnesota Department of Natural Resources Natural and Scenic Areas Grant Program
- Minnesota Department of Natural Resources Outdoor Recreation Grant Program
- Wisconsin Department of Natural Resources Knowles-Nelson Stewardship Grants
- Wisconsin Department of Natural Resources Land and Water Conservation Fund
- Natural Resources Foundation of Wisconsin
- U.S. Department of Agriculture Wetland Reserve Enhancement Partnerships
- U.S. Department of Agriculture Conservation Reserve Program

Co-pollutant Benefits Analysis

Greenhouse gas mitigation is often associated with reduced co-pollutants that pose public health hazards. The EPA CO-Benefits Risk Assessment (COBRA) tool was used to compare the MPCA's Current Policies Scenario (Business as Usual) to the Potential Policy Pathway scenario and quantify expected changes in two co-pollutants, PM 2.5 and ozone, and this associated health benefits.

Table 12. Projected reduction in Particulate Matter 2.5 under Potential Policy Pathway Scenario compared to Current Policies Scenario, measured in micrograms per cubic meter (µg/m3)

County	Current Policies Scenario PM 2.5	Potential Policy Pathway Scenario PM 2.5	Difference between Scenarios PM 2.5
Anoka	6.54	5.86	0.68
Carver	4.82	4.59	0.23
Chisago	5.41	5.09	0.33
Dakota	5.54	5.21	0.33
Hennepin	5.84	5.30	0.54
Ramsey	6.80	6.05	0.76
Scott	5.06	4.82	0.24
Sherburne	4.89	4.63	0.26
Washington	6.38	5.86	0.52
Pierce	5.21	4.99	0.22
St. Croix	5.64	5.39	0.25

Table 13. Projected reduction in ozone under Potential Policy Pathway Scenario compared to Current Policies Scenario, parts per billion

County	Current Policies Scenario Ozone	Potential Policy Pathway Scenario Ozone	Difference between Scenarios Ozone
Anoka	9.81	8.97	0.83
Carver	9.10	8.60	0.51
Chisago	9.03	8.37	0.66
Dakota	9.55	8.99	0.56
Hennepin	8.21	7.64	0.57
Ramsey	9.53	8.78	0.75
Scott	8.58	8.14	0.45
Sherburne	8.75	8.15	0.59
Washington	9.79	9.06	0.73
Pierce	9.41	8.94	0.47
St Croix	9.27	8.75	0.52

Table 14. Total health benefits in 11-county region from Potential Policy Pathway Scenario compared to Current Policies Scenario

Year	Total Annual Health Benefits ($, low estimate)	Total Annual Health Benefits ($, high estimate)
2030	54,445,601	110,676,962
2050	917,010,680	1,841,955,777

Workforce Planning Analysis

Achieving the climate goals outlined in the Twin Cities region's Comprehensive Climate Action Plan (CCAP) will require a robust and ready workforce. As local governments and communities implement climate strategies across transportation, energy, industry, waste, agriculture, and natural systems sectors, a coordinated workforce strategy will help ensure these efforts support high-quality jobs and open pathways for all residents to participate in and benefit from the ongoing economic transition. This analysis explores a broad set of industries and occupations connected to the region's Comprehensive Climate Action Plan (CCAP). Rather than focusing on one technology or sector it examines a wide range of industries that either directly support or are impacted by climate action. The goal is to establish an understanding of the current workforce and anticipate challenges that may grow as CCAP measures are implemented.

An in-depth workforce planning analysis is included as Appendix B.

Overview of Workforce Demand

While there is no single dataset that tracks "green jobs" in Minnesota, this analysis identifies industries and occupations that have the potential to contribute to climate action. These include both direct climate sectors, such as clean energy production and building retrofits, and supporting industries such as supply chains and professional services.

In 2024, clean energy jobs in the 11 participating counties totaled 39,100, with the majority in energy efficiency work. Looking more broadly, about 182,000 workers, roughly one in ten jobs in the region, are in industries connected to climate action. Construction and manufacturing dominate, though other sectors like transportation, utilities, and professional services also play key roles. Looking ahead, climate-relevant industries are projected to grow by about 5.6% by 2032, compared to 3.5% in other sectors which is still faster than the broader metro and state averages. However, growth in climate-relevant industries may be more volatile. Some subsectors are poised for rapid expansion, while others may decline as technologies, policies, and markets evolve. This uncertainty reinforces the need for flexible workforce strategies.

Priority Occupations

A total of 174 occupations were identified as especially relevant to CCAP implementation, ranging from hands-on technical trades to specialized professional roles. Together, these occupations employ over 500,000 metro residents. These jobs span industries that both directly advance climate action and support it indirectly through energy efficiency, repair and maintenance, planning, and smarter resource use. They show consistent projected growth, and many are experiencing elevated vacancy rates, a sign of current hiring challenges. Occupations that currently struggle to meet demand and for which demand will continue to increase have been identified as priority occupations.

Many priority occupations require specialized technical training, certifications, or apprenticeships, underscoring the importance of training pipelines and recruitment strategies to ensure a steady workforce. Median wages for priority occupations consistently fall above the metro area's cost-of-living benchmark, including for occupations that do not require a bachelor's degree.

For more information about how occupations were prioritized and job quality in priority occupations, please reference the appendix.

Current Training Landscape

The Twin Cities metropolitan region has a robust network of training programs that align with many priority occupations, particularly those requiring less than a bachelor's degree. These programs provide practical, skills-based pathways into climate-relevant jobs and often prepare workers for multiple related roles, such as HVAC, industrial machinery repair, and general maintenance.

For higher-degree roles, academic programs in business, computer science, and engineering form the backbone of professional workforce pipelines. While these programs are strong, aligning curricula with emerging climate priorities will ensure graduates are ready to meet regional needs.

Community Impacts

As clean economy sectors grow, it is important to ensure equitable access to these opportunities. The Regional Workforce Work Group identified several common barriers such as access to transportation, especially in construction and trades which often require travel to sites not accessible by public transit. Finding childcare can also be a challenge for parents who work non-traditional hours, especially single parents and women entering the workforce. Many clean economy jobs require credentials such as post-secondary education, or specific licenses and training which may be inaccessible for individuals without targeted support. Additionally, there is a need for greater awareness or career opportunities and pathways, especially for younger generations, as well as resources to allow workers to view these positions not just as jobs but as long-term careers. Intentional action to address these barriers such as diversified training pipelines, support services, and outreach to non-traditional talent pools are important steps in supporting the success, equity, and growth of the clean economy workforce.

Next Steps

This workforce analysis has raised ideas about how to make the information actionable for those working in climate and workforce development. Most immediately, the Met Council is putting together technical assistance tools for local governments in the seven-county region as they begin 2050 comprehensive planning and exploring how to integrate workforce data. The Workforce Work Group has recommended developing clear, accessible resources to show training and advancement routes for clean economy jobs, such as career pathway profiles. The improvement of data collection, such as conducting a targeted survey to better understand how much current work is directly tied to climate action, would reduce gaps in understanding the extent workers in any given occupation are working on green or clean projects. Lastly, focusing on regional approaches to workforce development, and strengthening partnerships among workforce development organizations to align training programs, grant applications, and support services is an important step.

Appendix A: Detailed Community Engagement Results

The engagement summaries in Appendix A detail results from each organizational cohort. Engagement results are divided into patterns and insights. Engagement data patterns are themes that came up repeatedly during workshops and interviews. Engagement data insights are powerful ideas and reflections that came out of workshops or interviews that are important to capture even if they were not mentioned repeatedly.

4H Engagement Summary

Organizational summary

Minnesota 4-H is the largest youth development program in the state, offering out-of-school, hands-on learning programs for youth to explore a variety of interests.

Participant description

The cohort participating in this workshop series was comprised of 13 students aged 13 to 18 years old. Participants represented a variety of racial and ethnic backgrounds and came from Anoka, Carver, Chisago, Hennepin, Ramsey, Scott, and Washington counties. Workshop curriculum focused on energy, waste, agriculture, nature, and environmental justice sectors, with the cohort interviewing community members from across the region on energy, agriculture, and nature actions.

Engagement data patterns

Pattern 1: Climate actions are rooted in community culture.

"Climate change can feel overwhelming, so when there's a social value as well as a climate benefit, I think that's nice."

"It's harder to make a difference as one person versus a whole community."

This cohort expressed a preference for participating in climate actions that center collective behaviors or events rather than individual choices. The youth were motivated by what others around them were doing, and many expressed a desire for more awareness and shared responsibility within their communities. At the same time, stigma and fear of judgment from peers played a role in participants' willingness to pursue certain climate actions. This social lens shaped how people viewed their own ability to act and made clear that any change effort must be built from community culture, not just increased access to information.

Pattern 2: Strong connections to nature.

"The strain on the plants with the thawing but also the freezing often is probably very stressful."

"I feel like we need bigger areas of nature versus small, because animals can't thrive in one acre of land."

Participants displayed strong connections to nature, describing it as something they not only wanted to enjoy but protect, whether through caring for plants and animals or simply having access to green space. Some youth also voiced requests for natural spaces closer to where they live. These connections were a motivator for climate action especially when participants considered how climate change may impact the wildlife and natural areas they care about.

Pattern 3: Cultural norms, habits, and convenience are barriers to change.

"People don't want to change their lifestyle for convenience. My friends all use plastic water bottles and don't drink it all and then throw it out."

While many youth and community members showed interest in participating in climate actions, cultural norms, habits, and convenience often posed challenges. Many participants noted that they are conditioned to expect certain foods in their meals, products in stores, and routines in daily life, and breaking those patterns is difficult. There was a preference towards climate actions that didn't require lifestyle changes and fit into familiar routines. Within these discussions youth emphasized the importance of making sustainable choices feel easy and integrated into daily life.

Engagement data insights

Insight 1: Economic concerns limit focus on climate.

"People don't have resources or the choices to be environmentally friendly."

"It would be easier to do for most families if it cost less."

Some participants shared that climate change and the environmental impact of certain actions are hard to focus on when finances and cost-savings are a priority. When people are focused on saving money and paying bills, environmental concerns fall lower on their list of priorities. Climate actions that are affordable, save money, or directly improve daily life are preferred.

Insight 2: Lack of walkable and bikeable infrastructure limits sustainable transportation.

"I don't like to bike or walk as much even though the things that I want are in walking distance because I don't want to cross the highways/busy roads."

This cohort displayed interest in modes of sustainable transportation such as walking and biking yet expressed frustration over gaps in infrastructure. Several participants noted wanting sidewalks, trails, and safe routes, as well as having more amenities closer to their homes to allow for travel without a car. In many cases, youth were not opposed to changing their mode of transportation, but they require a built environment to support that change.

Insight 3: People want to act, yet don't always know how or where they have influence.

"People want to make change but don't know where or who to go to, [...] or what actions would be most effective."

Participants expressed a strong interest in taking action to address climate change, especially at a local level. However, many were uncertain which actions were most impactful, how to take action, or whether their individual efforts could even make a difference. In general, participants and interviewees gravitated towards actions that were tangible and within reach such as changing personal habits or partaking in individual actions rather than larger-scale efforts that may require clear direction and shared effort.

Insight 4: Desire for broader community understanding of climate change.

"Many people lack proper education on these topics. As a result, they often feel uncertain about how to address or navigate these conflicts due to their limited understanding."

Underlying cohort discussions was a sense that participants wished their communities understood more about climate change and climate actions. Several participants mentioned the desire to build this awareness through community events, offering an opportunity to build community relationships around climate action efforts.

Brooklyn Bridge Alliance for Youth Engagement Summary

Organizational summary

The Brooklyn Bridge Alliance for Youth (BBAY) is an organization in the northwest suburbs of the Twin Cities region that focuses on increasing high school graduation rates, as well as creating pathways to college and careers, and youth safety and well-being.

Participant description

This cohort group consisted of 15 youth of color aged 14 to 18 years old from Hennepin County. Workshop curriculum focused on energy, transportation, waste, and environmental justice sectors, with the cohort interviewing community members from across the region on energy and transportation actions.

Engagement data patterns

Pattern 1: Climate change in the broader context of caring for the environment.

"Pollution from our cars, factories, trash, and more all factor into why our environment is in danger. Putting an effort towards our planet would save our climate as well as improve the quality and sustainability in our own lives."

Participants tended to view climate change not as an isolated issue but as part of a broader concern for caring for the environment and protecting community health. Many connected climate impacts to concepts they had experienced or already understood such as local pollution, air quality, or extreme weather. This lens of connection and motivation provides a more accessible entry point for building awareness around climate actions especially when climate education is linked to tangible and local examples.

Pattern 2: Desire for climate education and actionable steps.

"The issue is not having enough information or not enough people to caring about climate change. Education matters because if others are well informed, they'll take actions towards bettering our community and world - they'd put a more active role in helping."

There was a strong desire among the cohort for actionable and accessible climate education. Many participants cited misconceptions and a lack of data literacy and knowledge as community barriers to climate action. The youth were interested in learning practical tips that made change feel possible, such as information on home energy, sustainable transportation, and reducing waste.

Pattern 3: Expanding and improving transit systems.

"Implementing more accessible and safe transit for the people of the Brooklyns would help our community feel more comfortable taking the public transit."

Participants shared a wide range of ideas and concerns surrounding public transit. Stigma, safety, efficiency, and unreliable schedules came up as barriers to regular public transit usage.

Improving information access, route availability in the suburbs, ease of use, and overall safety could help normalize transit use and build trust in the system. There was also strong enthusiasm for micro-transit options, including on-demand vans and community shuttles.

Pattern 4: Prioritize short trips and walkability in local climate strategies.

“There are no sidewalks, so I'm just walking on the road hoping the car doesn't hit me.”

There was notable interest in shifting more short trips to biking or walking yet also recognition that infrastructure needs to improve for that to be an effective long-term change. Missing or unsafe sidewalks and trails, lack of destinations in walking distance, and the cost of transit were all seen as barriers to low-carbon travel. Participants expressed that the suburban landscape makes a car feel like a necessity, but infrastructure scaled accordingly would be met with community interest.

Engagement data insights

Insight 1: Framing walking and biking as a right, not a privilege.

“Invest in better infrastructure to support safe, sustainable well-designed streets and pathways to make communities stronger, healthier, and more connected.”

“Everyone who lives in the Brooklyn area deserves the right to be able to walk or bike in their own city.”

Many participants believed public infrastructure like sidewalks, bike lanes, and safe crossings should be treated as basic rights not extras. Framing walking and biking as part of a shared public good rather than an individual lifestyle choice may be more successful messaging for this cohort. Participants used this framing to connect personal mobility to broader goals like equity, safety, and environmental justice.

Insight 2: Interest in immediate, accessible actions.

“I love learning hacks to make life easier.”

This cohort displayed strong interest in “tips” and climate actions people could take immediately such as driving less, avoiding fast fashion, reducing waste at home, and home energy saving mechanisms. This highlights how community members reach for climate actions that feel tangible, understandable, and accessible. Making more climate actions visible, simple, and concrete could lead to stronger community involvement.

Insight 3: Support for government funding in solar energy.

“If price was not such a determining factor, citizens in Brooklyn Park and Brooklyn Center would be more likely to install solar panels.”

Many participants and interviewed community members voiced interest in solar panels as both a cost-saving and climate-friendly energy source; however, financial barriers are preventing many households from accessing them. There was widespread support for public government funding and incentive programs to make solar energy more accessible, affordable, and equitable.

Insight 4: More community recycling and composting programs.

“More communities should offer recycling and composting.”

For many participants, recycling and composting were seen as accessible entry points into climate action. However, many communities lack infrastructure and visibility around these waste-reduction programs. Whether through neighborhood drop-off points, city-wide waste pickup systems, or public education, there was a strong sense that local governments could do more to support recycling and composting efforts.

Insight 5: Important to discuss fast-fashion and thrifting.

"We should avoid fast fashion, buy quality clothes, and thrift."

Some participants, mainly young women, expressed an interest in education and discussion surrounding the environmental impacts of fast fashion. Thrifting, an action many youth already participate in, was viewed not just as a trend, but as a climate action tied to creativity, affordability, and reducing waste. Including this topic in outreach or education efforts could help make climate conversations more personal and relevant, especially for young people.

COPAL Engagement Summary

Organizational summary

COPAL is a Minnesota member-based organization whose mission is to lead social impact initiatives to improve the quality of life for Latine families.

Participant description

This workshop series was attended by nine Latine individuals of all ages. Participants lived in Minneapolis, Saint Paul, and inner ring suburbs. Workshop curriculum focused on energy, transportation, waste, nature, and environmental justice sectors, with the cohort interviewing community members from across the region on energy, and transportation actions.

Engagement data patterns

Pattern 1: Low-income families are disproportionately affected by climate change.

"La gente con menos recursos contribuyen menos [al cambio climático]. Tenemos que hablar del mundo, y la gente pobre que resulta más afectados porque sus casas se pueden inundar o incendiar." (People with fewer resources contribute less [to climate change]. We have to talk about the whole world, and poor people end up more affected because their houses can flood or burn down.)

"I used to work for 211. One of the most common calls was families with children struggling to pay their light bills and not getting light. I think about the increasing costs, especially in the winter. We have the cold weather rule where they can't shut off the heat, but families still have to pay it."

Participants expressed awareness of how climate change deepens existing inequities. Low-income families, people with disabilities, and historically marginalized communities were seen as bearing the brunt of the impacts of climate change while having the fewest resources to respond. The high cost of energy, unaffordable solar programs, and inaccessible electric vehicles left many community members and participants feeling that climate solutions are inaccessible for low-income communities. Some highlighted that climate action efforts must be designed with a focus on equity, recognizing both financial and structural barriers to participation.

Pattern 2: Desire for stronger government action, regulation, and incentives.

"Hay que tener una regla del gobierno que las compañías de alquilar hacen [estrategias de ahorro de energía]." (There needs to be a governmental rule that the rental companies [use energy-saving strategies.])

"The government has to be involved in making big industries and companies to [design products sustainably]. They only care about profit, and they are damaging the planet. That primarily affects low-income people. The government has to change."

Some participants called for the government to make more climate progress through stronger action, regulations, and incentives. There was strong support for public investment in tree planting and community gardens and for regulations on landlords, delivery services, businesses, and industry polluters. Participants saw the government as an important actor in ensuring that private entities are not taking advantage of individuals, especially low-income residents and undocumented residents.

Pattern 3: Trusted messengers and culturally relevant framing are important.

"Para los cristianos en la biblia dice no se debe dañar la creación de dios." (For Christians, the bible says we shouldn't harm God's creation.)

Through cohort discussions, it was expressed that climate messaging will resonate more with communities when it connects to cultural and spiritual values. For Christian participants, framing caring for the earth as an act of faith resonated. Similarly, for others, Indigenous cultural belief systems provided a meaningful framing for climate action. Messaging that focuses on addressing the benefits and interests of different groups such as youth and elderly, while using accessible language and emphasizing cost savings (especially framing as more money to care for your family) was also seen as effective.

Pattern 4: Lack of trust in government acts as a barrier to engagement.

"[Escucho sobre un programa.] Pero recuerda, soy Latina." ([I hear about a program.] But remember, I'm Latina.)

Participants, especially immigrants and non-English speakers, expressed significant distrust in government institutions. Some doubted their eligibility for programs because of immigration status or cultural background, while others shared that immigration concerns shaped decisions such as avoiding public transit systems. Some highlighted that climate programs need to work through community leaders and trusted organizations to reach those left out of traditional outreach.

Engagement data insights

Insight 1: Car sharing is a frequently used and more realistic climate-friendly transportation action.

"I usually share a car with someone; I don't have a car of my own. I used to take more public transit when I lived in California, but I feel like the transit system here is not super great."

Some community members shared that carsharing and carpooling is a climate-friendly action that already feels practical and accessible. For those juggling financial constraints and infrastructure challenges, sharing a vehicle through informal community arrangements is a realistic solution.

Insight 2: Prioritize nature when making choices.

"Deseo que podamos tener la obligación que tenemos para cuidar y dar a los que todavía ni han nacido." (I wish we could fulfill the obligation we have to care for and give to those who still haven't been born.)

Participants framed protection of nature as the ethical and practical priority when asked to weigh trade-offs of everyday choices and various climate actions. Whether developing new infrastructure or making choices at the grocery store, many emphasized that actions benefiting ecosystems, trees, wildlife, and natural landscapes should come first.

Insight 3: Climate solutions must address disability-specific needs and impacts.

"For me, thinking about disability and transportation, I've only seen two vehicles that are hybrids that are accessible or adaptable. Other than that, there's vans which use more fuel. What would make it easier would be to have things be less expensive, accessible transportation like access to own an electric vehicle."

Participants highlighted that people with disabilities experience unique barriers both from climate impacts and from solutions that aren't designed with accessibility in mind. Some cohort members called for incentives, programs, and infrastructure adaptations that included and addressed the needs of disabled community members, so that climate action doesn't reinforce exclusionary practices.

Insight 4: Solar panels represent freedom from corporations and foreign energy, yet renters face accessibility issues.

"Solar panels sometimes come up. I wish I could have some solar panels to create my own energy, see if that reduces the bill."

For many community members, solar energy represents freedom from corporate utilities, high energy costs, and instability in global supply chains. However, participants who rent their homes voiced frustration that they're unable to benefit from most solar programs, reinforcing the sense that clean energy is designed for homeowners, excluding many low-income households.

Insight 5: Inadequate HVAC systems lead to space heater use, leading to unaffordable energy bills.

"Sometimes my kids have a heater in the room because one is colder than the other, and the bill goes up. It's more money in the electric bill. But it's cold, so you have to keep it on sometimes."

Some participants described struggling with inadequate HVAC systems, which leads many to rely on electric space heaters in winter, which is both an expensive and inefficient solution. This cycle drives up already high energy bills, leaving some community members feeling trapped to balance comfort and financial strain. Weatherization and energy efficiency improvements were seen as immediate, basic needs.

Insight 6: Electric vehicles (EVs) are not a priority – too expensive and unrealistic for many people.

""Teslas and EVs are really expensive. How can they expect a low-income person to buy one?"

While the use of electric vehicles can be an impactful climate strategy, some participants expressed little interest in them as a realistic solution. High upfront costs, limited charging infrastructure, and daily financial pressures made EVs feel inaccessible and impractical for most families, especially those renting or living on lower incomes.

GrowUs Engagement Summary

Organizational summary

GrowUs, a North Minneapolis non-profit, strives to create a more resilient community through workforce training, green construction, and sustainable agriculture opportunities.

Participant description

This one-off workshop was attended by about 30 participants, all ages, from across the region. Workshop curriculum focused on discussing actions within energy, transportation, agriculture, waste, environmental justice, and nature sectors.

Engagement data patterns

Pattern 1: Systemic Analysis

"I think most of vulnerable populations, BIPOC youth and seniors are disproportionately impacted. They have the fewest resources to recover. Poor housing, underfunded health care, and lack of policies and power make it even harder to fight back or get the help they need."

Community members emphasized that climate change is deeply interconnected with wider systemic challenges they face surrounding transportation, housing, racism, workforce development, financial burdens, and food justice. Some participants pointed a historical lack of investment and collaboration in North Minneapolis that has left gaps in infrastructure, community exclusion from benefits and planning processes, as well as a lack of trust in government. Effective climate policy and implementation must respond to all of these interconnections and direct benefits towards the North Minneapolis community. Additionally, many highlighted that implementation must be transparent and accountable, with follow-through that demonstrates government's commitment to reversing historic inequities rather than repeating them.

Pattern 1 Sub-theme: Interconnectedness of Health and Climate Change

"Communities who are breathing where these industries are pay the cost in poor health."

Throughout cohort discussions, health emerged as the most pressing and tangible dimension of climate justice, touching every aspect of daily life. Many community members highlighted the health impacts of industrial pollution, highways, plastics, and poor air quality, all of which are disproportionately concentrated in their community. These exposures can lead to higher rates of asthma, chronic illness, and healthcare costs, reinforcing cycles of inequality, and impacting quality of life. Participants called for climate solutions that prioritize health improvements, from cleaner air to safer transportation infrastructure. Community members emphasized that centering health is both a justice imperative and a strategy for ensuring that policies resonate with and serve the people most impacted.

Pattern 2: Community-Driven Education and Action

"We should have more education and awareness campaigns that provide easy low-cost energy tips and partner with trusted local voices to lead the message."

Cohort members highlighted the importance of education and action led by communities and trusted local leaders. They expressed a desire for practical resources such as workshops, "Climate 101s," and actionable tips that give residents clear entry points for direct action in their daily lives. Awareness campaigns, when rooted in community values and delivered by familiar voices, were seen as more likely to inspire sustained engagement. Participants also stressed that government's role should be to resource and amplify these efforts rather than dictate them, allowing for increased community sovereignty. This approach was linked to broader goals of community building and environmental justice, with many community members noting that education and action are most powerful when paired with trust-building and reparative investments that acknowledge past harms. In this vision, climate action is not only about reducing emissions but about strengthening the community's capacity to lead its own future.

Hmong American Farmers Association Engagement Summary

Organizational summary

The Hmong American Farmers Association (HAFA) is a West Saint Paul-based organization aiming to advance the prosperity of Hmong farmers through cooperative endeavors, capacity building and advocacy.

Participant description

This workshop series was attended by 15 Hmong individuals of all ages from across the region, many of whom are farmers or connected to Minnesota food systems. Workshop curriculum focused on energy, transportation, agriculture, and nature sectors, with the cohort interviewing community members from across the region on agriculture and nature actions.

Engagement data patterns

Pattern 1: Interconnectedness of climate change, economics, community, and health.

"Everything boils down to money. If we don't have the money, we can't take care of ourselves and others."

Participants described climate change as not simply a stand-alone issue, but as an issue deeply connected to community, family well-being, personal health, and financial stability. Cohort discussions reflected a holistic worldview, viewing nature's health and humanity's health as interconnected. Furthermore, some expressed concerns over the economic impact of climate change on the ability of people to care for each other. While caring for the environment and climate is valued, economic stress directly impacts participants' ability to take action.

Pattern 2: Time as a primary constraint.

"By the time I'm done with work there's not a lot of time to do anything."

"Convenience drives what we do. [...] People preach about saving the environment but there is a disconnect between their everyday life."

Many community and cohort members discussed the difficulty of balancing and prioritizing where their time and funds go. Cost of living and life and work demands impact people's ability to engage with climate solutions, pushing people to choose between taking climate-friendly actions and day-to-day survival. Many participants shared that climate actions that aren't time consuming and can fit into their current routines are preferable.

Pattern 3: Emphasis on collective action rooted in culture and community education.

"One person doing something doesn't make that much of a difference, it's a collective effort."

"How can we address this as a community?"

Across cohort discussion, collective action was viewed as more powerful and more culturally aligned than isolated individual efforts. There was strong support for community education, yet participants noted that for education to be most effective, it must be culturally relevant - in their native language(s), addressing generational differences, publicly accessible, and shared through familiar community spaces or trusted leaders. Participants discussed the need for a broader culture shift, not just changing behaviors, but reshaping norms and expectations across generations. Elders were seen as holders of knowledge and values, and youth as critical to carrying those values forward.

Pattern 4: Desire for meaningful government investments.

"Investments now for future success. Making sure resources are available for the next generations."

Participants voiced the desire for more significant government investment of time and money in climate actions that benefit both current and future generations. Some key priorities included building out transportation systems that work for suburban communities, supporting farmers and land stewards through incentives for sustainable practices (like cover cropping, polyculture, and green technology), and investing in infrastructure to manage pollution and runoff.

Engagement data insights

Insight 1: Connection to global indigenous practices.

"Learning from indigenous communities here is key to learning the land."

"[Farming] has been an indigenous practice of ours and when we found refuge here, a way to connect back to our roots from a home that we will never return back to. This is what we consider home – protecting the land that we live on and that we live off of, making sure that we don't take all of it, that we have enough for our future generations."

Some participants expressed a desire to learn from local indigenous stewardship practices while maintaining their own indigenous and cultural practices. Among the cohort, there was a recognition of the importance of understanding global indigenous practices when learning how to care for the environment. It creates an opportunity for cross-cultural learning and solidarity, especially when framed as returning to principles many communities have long held.

Insight 2: Growing food can support health and community connection but faces barriers.

"People need greenspace in the urban matrix to come together as community to create their own food."

“Allowing people to own small pieces of land to make their own food would help with health issues. It feels like we are chained to this way of life of mass production… We need to take a step back and educate people to do it for themselves.”

Participants shared a vision of more people growing their own food as a way to support health and community building. They also identified existing challenges including access to land and a lack of education around how to grow food. They saw a role for government to lower these barriers and support farmers in accessing markets.

Insight 3: Farmers interested in sustainable practices but need incentives and training

With things like cover crops, there is a willingness from farmers, but a huge gap of knowledge of how to get here. The key is lowering that barrier of knowledge as much as possible.”

Participants and interviewees expressed that among Hmong farmers, there is a broad interest in sustainable practices, but cost and knowledge limit adoption. Farmers default to crops they know how to grow and know they can sell without outside help. At the HAFA farm, many farmers use cover cropping because the organization provides seeds and technical guidance.

Hope for Earth Engagement Summary

Organizational summary

Hope for Earth is an organization based in River Falls, Wisconsin, that focuses on creating a hopeful, ecologically sustainable future through collaboration, education, partnerships, advocacy, and action.

Participant description

The Hope for Earth cohort consisted of 18 participants of all ages. A majority of participants were white, and they represented River Falls from both Pierce and St. Croix counties. Workshop curriculum focused on energy, waste, transportation, and agriculture sectors, with the cohort interviewing River Falls community members on energy and waste actions.

Engagement data patterns

Pattern 1: Education to correct misconceptions and shift culture.

“People just don’t know this information and aren’t seeing the connection between this and real-life impacts.”

Participants highlighted the need for more widespread climate education to target misinformation and lack of understanding surrounding climate change causes, impacts, and strategies. Some noticed a gap in their communities’ understanding about how climate change impacts them, and more education is required to clarify how climate change manifests locally. Misconceptions and a culture that prioritized consumerism and convenience were highlighted as barriers to community participation in climate actions, barriers that could be remedied through effective climate education.

Pattern 2: Reluctance to act publicly, but openness to act individually.

“There’s a small town factor; it discourages advocacy in the community.”

Participants and interviewed community members expressed concerns about taking public action in their community to support climate strategies. The climate change actions that were most popular among participants and interviewed community members were those that individuals could implement within their own households, such as using smart thermostats, composting, recycling, and thrifting. The interest in strategies targeting individual households stemmed from potential economic savings but also a reluctance to publicly engage in climate conversations due to lack of community support and a lack of structural support from local and state governments. As participants reflected on their interview data, they identified this dynamic as a sign of living in a small community and saw an opportunity to use their platforms to build a sense of broad support for community-scale climate action.

Pattern 3: Strong commuter connection to Twin Cities, struggles with sustainable transportation as a rural city.

"I would love to be able to take public transit back to where I live but there are no direct options. I wish I didn't have to use a car, but I don't really have an option. It's either that or I don't go home."

The River Falls community's strong commuting relationship to the Twin Cities, paired with its rural character, positions sustainable transportation as both a challenge and area for growth. Participants emphasized the city's lack of public transit and bike-ability as limitations to reducing climate impacts from transportation. Participants expressed strong interest in commuter vanpools, shuttles, or regional buses to nearby hubs and safer biking infrastructure.

Pattern 4: Community leaders drive climate action, but structural change is needed.

"[One participant] started a powerful choices program that got people from various businesses together to talk about these sort of energy issues. Having awareness to think about where you can make the changes is important too."

Due to a lack of structural and institutional support, committed individuals, community leaders, and volunteers are the drivers of climate action progress in River Falls. They shared examples of building informal or semi-formal networks around specific efforts often without ample funding or policy backing. Many participants emphasized the difficulty of promoting or maintaining climate-friendly behaviors without system-level changes that make sustainable choices easier. This cohort noted the challenge of shifting society and their community away from consumeristic mindsets, which they felt hindered the advancement of long-term cultural shifts towards more sustainable lifestyle practices.

Engagement data insights

Insight 1: Strong connections to and value in natural areas.

"Lack of snowfall impacts the river levels, which could impact the trout populations and other parts of the river ecosystem. The Kinnikinic is a big draw to the area which would experience a big impact from a lack of rainfall."

This cohort displayed strong connections to local ecology and natural areas, including the Kinnikinnic River. The local ecology not only shapes the identity of the area, frequently identified as places of community pride, but also serves as a motivating force for environmental protection. Participant discussions illustrated how stewardship of natural areas could be a unifying entry point for climate action work.

Insight 2: Barriers to access for recycling and composting.

"We don't have any [composting facility] options in River Falls, and it's too expensive to haul it to Eau Claire but there it is in Washington County. [...] There's not enough options in Northern WI, nowhere to go with it."

Many participants noted a lack of access to official recycling and composting systems due to infrastructure gaps. The lack of nearby composting facilities makes it logistically and economically challenging for many River Falls residents to participate, limiting access to community-level waste reduction strategies.

Insight 3: Many interview respondents had already done climate actions.

"We purposefully bought a house in the middle of town, because we have a lot of kids that could then walk. 4 years ago, I bought an electric car. How do we make doing that affordable to everybody? Payback on our solar is probably 15 years."

Many cohort participants and interviewees expressed eagerness to participate in climate actions, with numerous individuals having already completed certain actions including home energy audits, solar panel installation, smart thermostat use, and moving to walkable locations. These examples suggest a relatively high level of baseline knowledge and enthusiasm among participants and interviewees that can be organized to support systemic or collective climate action.

Islamic Center of Minnesota

Organizational summary

The Islamic Center of Minnesota (ICM) is a Fridley-based organization that provides community-members with avenues for spiritual, social, and civic engagement. In addition, ICM hosts a full time Islamic school, a monthly food shelf, a health clinic, and provides programs on topics such as education, religion, mental health, and convert support.

Participant description

This cohort group was comprised of 10 Muslim high school and college students, a majority from Anoka County. Workshop curriculum focused on energy, waste, transportation, nature, and environmental justice sectors, with the cohort interviewing mostly Anoka County community members on energy and transportation actions.

Engagement data patterns

Pattern 1: Climate action woven into cultural and lifestyle practices.

"In the Quran, Allah refers to the Earth and its resources as a trust given to humanity. Muslims are instructed to protect and preserve what has been given to them. The environment, including air, water, and land, is considered a divine gift that should not be wasted or harmed."

Participants described how climate actions and the concept of caring for the environment are not separate from their everyday life but are already woven into their cultural and religious practices. For example, carpooling was viewed by many participants as an extension of attending community events or religious services. In addition, discussions surrounding the intersections of sustainability and access to culturally relevant and halal foods highlighted the importance of food systems that are both culturally appropriate and climate friendly. Participants also reflected on the Earth as a trust or responsibility from Allah, reiterating the concept of environmental stewardship as a spiritual practice. These discussions raised how planning efforts need to make space for the cultural, religious, and gender identities of communities.

Pattern 2: Home energy actions are driven by cost and comfort.

"The energy costs are a lot. Even though nobody's inside the house, we still have to pay a lot."

In regard to home energy use, most participants and community members were motivated by household comfort and cost savings. Concerns surrounding the impact of extreme temperatures on comfort in homes were also prevalent. Actions such as home energy audits or the installation of a smart thermostat were of interest but often viewed through the lens of everyday comfort and cost savings on utility bills, not necessarily environmental impact.

Pattern 3: Barriers to multi-modal transportation.

"There is a freeway which separates the route to Walmart, so walking is difficult."

Participants shared that while they are interested in alternative modes of transportation such as walking and biking, the built environment poses challenges. For example, many emphasized the lack of sidewalks and trails and key amenities being far apart and not accessible without a car. Participants also displayed low enthusiasm for public transit, with highlighting safety, accessibility, and inefficiency as key concerns. This cohort noted the need for more suburban-specific solutions that address current barriers in multi-modal transportation.

Pattern 4: Comfort and education as prerequisites for action.

"I don't really want to tell people what to do. I'd rather do actions on my own home."

"If they understand, they'll advocate."

Comfort and perceived lack of education came up repeatedly as barriers to climate action. Some participants and community members felt uncomfortable talking to others about climate topics if they felt they didn't know enough or feared disagreement. Despite community misinformation about various climate actions, participants still displayed an interest in learning more, especially about home-based or individual actions.

Engagement data insights

Insight 1: Electric vehicle concerns

"I don't like electric cars at all. I much prefer gas vehicles compared to electric vehicles, I like the "vroom" of the car, and I think that electric cars are controlled by the government and are 'girl cars'."

Many participants expressed hesitation and concern regarding the adoption of electric vehicles (EVs). Some cohort members highlighted that car culture, often associated with social connection and personal identity especially among men, is tied to gas-powered vehicles. Some feared government EV mandates or unpredictability and risks with new technology, such as battery explosions or government control. A lack of charging infrastructure only further discouraged interest in EVs.

Insight 2: Tensions around affordable housing, density, and equitable decarbonization.

"Will affordable housing affect property costs of others?"

Concerns about affordable housing and density came up when participants discussed climate-related planning. While some youth prioritized affordability of solutions and the need to make decarbonization available to low-income households, some felt that affordable housing would reduce quality of housing and lower property values and that higher levels of density would pose safety and traffic issues.

Insight 3: Support for micro-mobility programs.

"I was thinking taxis could be a main form of transportation and we could combine routes with other people that we don't know. We could do that, it would be like a minibus sort of thing. I feel like that's way better than just using like cars and SUVs."

Some participants expressed interest in micro-mobility transportation options, such as city-wide shuttles, and the development of more biking and walking infrastructure. Participants saw these tools as potentially easier to use, less stigmatized, more suited to short trips or errands, and more adaptable to suburban life.

Insight 4: Suburban context requires different climate solutions.

"Downtown Minneapolis is a walkable city, but the suburbs aren't. It's a bit dangerous because cars aren't used to people walking. There aren't enough sidewalks. Everything is way too spread out."

Some participants reflected on the different realities within suburban communities that must be accounted for in climate planning. Many climate strategies are designed with urban contexts in mind and don't easily translate to suburban life including public transit, dense housing, and walkable cities and neighborhoods. Many people in suburban communities travel longer distances for school, work and daily errands, making car ownership feel necessary. Overall, climate efforts need to consider the distinctions within suburban communities in order to be successful.

Insight 5: Gendered interest in thrifting, and recycling.

"In our apartment, we threw everything away. Now we have a recycling habit."

Participants, mostly women, showed an interest in waste-reduction practices such as thrifting and recycling. Many saw it as a habit that needed more reinforcement and education, with some voicing concern about how recycling behaviors may be perceived by others, reflecting a subtle social stigma around waste sorting.

Karen Organization of Minnesota Engagement Summary

Organizational summary

The Karen Organization of Minnesota (KOM) is a Roseville-based social service provider, offering a variety of programs to help refugee and immigrant communities transition to life in a new country and remove barriers to achieving economic, social, and cultural well-being.

Participant description

This workshop series was attended by 14 Karen high school students from Ramsey County. Workshop curriculum focused on energy, waste, transportation, nature, and environmental justice sectors, with the cohort interviewing Ramsey County community members on energy and nature actions.

Engagement data patterns

Pattern 1: Home country roots and nature.

“Nature is a very big part of my life. I grew up in camp. The houses are made from bamboo, and we eat food straight from the ground, it’s very organic. So, I would love to be a part of this.”

Participants emphasized a deep cultural connection to nature, in many cases reminiscent of ideology and lifestyle practices in their home countries. Activities such as gardening, seed saving, foraging, and cooking were cited as sustainable practices linked to family traditions. Participants also highlighted Karen cultural beliefs of nature as a living entity and a source of spiritual and physical health. The concept of caring for the environment was met with enthusiasm from this cohort, especially when framed as a community project.

Pattern 2: Culturally specific messages, outreach, and solutions.

“I find it really interesting that so much of this is happening, but the only sad part is that not a lot of it is being shared with a lot of communities. As students, we understand English. But when it comes to our parents, they don’t understand English. I find it surprising that we have all this data and it’s hard to get it to our elders.”

Many participants highlighted the lack of accessible and culturally relevant climate action outreach. Especially with large, multi-generational communities, one-size-fits-all messaging isn’t effective. Participants suggested climate action messaging strategies that are rooted in their community’s own organizing structure, including culturally relevant examples and materials in their native language, and working with trusted sources such as local faith-based venues, elders, and community experts.

Pattern 3: Survival comes first; cost is a barrier to participating in climate actions.

“We got other things to worry about like surviving in this economy and helping earth is not on our mind.”

For many, the cost of living makes more costly climate actions feel inaccessible. Many participants mentioned the inability for themselves or their families to prioritize longer-term or seemingly abstract goals due to a focus on meeting basic needs. While many saw value in climate actions such as installing solar panels, they also recognized the up-front expense posed a large barrier and called for more financial support.

Engagement data insights

Insight 2: Desire for a community fix-it center (for technology, clothing, and more).

“Create centers to repurpose old electronic parts – a fix-it center for phones, clothes, and technology.”

Participants identified the need for a local fix-it center where community members could reduce waste and push back against fast fashion and consumerist tendencies by repairing clothes, electronics, and household items. While recycling programs had relatively low enthusiasm among the cohort, a fix-it center felt like an empowering, hands-on, communal way to reduce waste that aligned with many participants values.

Insight 3: Use culturally-relevant examples to make connections to actions.

"In Japan, the transportation is mostly bus, trains, biking and walking. It seems like they have cleaner air. I would like that."

Some participants noted the power of drawing from global examples, particularly East Asian models of sustainability. Referencing cultural traditions or current practices from these regions may help to bridge ideas between lived experience and new action and develop a system of peer-based learning.

Insight 4: Accountability for government.

"Government should be better about trash and waste cleanup and hold polluters and government accountable."

Within this cohort, there was an undertone of frustration with government systems that are perceived as polluting or underprioritizing the environment. Participants wanted to see real accountability, visible action, subsidies for climate actions, climate policies, and community-informed spending.

Insight 5: Safety as barrier to alternative transportation modes.

"I would never take a bus. A friend of mine had a really bad experience and it affected her a lot. I hear stories about it a lot, and I wouldn't want that to happen to me or future generations."

Transportation is deeply tied to feelings of safety, especially for women and families. Many participants voiced concerns about unsafe biking and walking infrastructure and gendered fears surrounding public transit use and reliability. These concerns highlight that making sustainable transportation more viable means not only addressing infrastructure, but emotional and physical safety as well.

Park Plaza Engagement Summary

Organizational summary

Park Plaza Cooperative is a resident-owned 90-home manufactured home community located in Fridley.

Participant description

This cohort group consisted of 10 Park Plaza residents of all ages and of Hispanic and white backgrounds. Workshop curriculum focused on energy, transportation, waste, agriculture, and environmental justice sectors, with the cohort interviewing community members from across the region on energy and transportation actions.

Engagement data patterns

Pattern 1: Communal and intergenerational actions and practices.

"One idea I have is for all of us to come together to clean because there are areas in the parks that are really dirty, and there are many kids that come and go and who knows what they are going to pick up or put in their mouths."

Participants described a strong interest in environmental work and climate actions done within community. Actions such as community gardening, neighborhood cleanups, and tree planting events were seen as ways to care for both people and the environment. There was a strong emphasis on making sure community climate actions were accommodating and accessible to all generations including elders, youth and more. Some participants expressed a desire for the community to manage resources themselves, to ensure that benefits reach their whole community, not just those with more power or proximity to decision-making.

Pattern 2: Trust with the government.

"We want to feel secure and comfortable in who is working with us. In the past, the community was misled with a program that made us lose trust. Not having trust could lead to hesitation from people in our community and we might lose out on opportunities."

Some cohort members voiced skepticism or distrust towards government programs, in many cases rooted in negative past experiences or current federal administration actions. This distrust creates a barrier to a community's comfort in engaging with government-prompted climate actions. Building trust may require governments to alter traditional outreach approaches and work through community-led structures.

Pattern 3: Affordability and access are major barriers to climate action.

"An Xcel Energy audit resulted in a meter reading that looked higher than peer homes due to the draftiness and low insulation of trailers."

"Access is really important to us because if we have the right resources, it could help struggling families, elders, and those in the lower-income communities."

The high cost of energy to keep poorly insulated homes comfortable, challenges accessing healthy food, and health and transportation costs culminated in a feeling that climate action is inaccessible for lower income communities. Participants noted that many climate actions and home energy programs aren't designed for or compatible with manufactured homes. Participants voiced that effective climate actions will need to address barriers to access and affordability within low-income and marginalized communities, meeting them with more relevant messaging, resources, and program design.

Pattern 4: Transportation safety and accessibility limit mobility options.

"Create changes to the environment like adding more streetlights so that people can walk more and feel safe."

Many cohort and community members expressed a desire to use more sustainable modes of transportation but felt blocked by safety and infrastructure issues. Busy roads without safe crosswalks, unreliable or infrequent buses, and even negative experiences with school bus service contributed to a general preference for cars. Carpooling was seen as one of the most frequently used and accessible alternatives, though participants expressed interest in seeing it normalized and supported further within their community.

Engagement data insights

Insight 1: Compounding burdens.

"Todo está muy caro – la comida cada día cuesta más." (*Everything is very expensive – food costs more every day.)*

Some participants described how compounding burdens such as financial strain, health challenges, immigration stress, and environmental issues shape their daily life, and thus their ability to participate in climate actions. Climate change is just one of the many challenges communities feel they must juggle and often cannot be prioritized over addressing more immediate needs for themselves and their families.

Insight 2: Desire for community independence, empowerment, and self-reliance.

"Tal vez algún día se puede ir la luz y eso nos ayuda tenar energía propia aquí." (*Maybe one day the power will go out and that will help us have our own energy here.)*

The desire to build solutions within their communities rather than rely on external systems was expressed by some participants. Many saw independence as a path to power, community stability, and control over who benefits from resources. It also addressed longstanding concerns over finding trustworthy partners in the private or public sector.

Insight 3: Cultural perspectives and strategies in countries of origin shape expectations for climate action.

"We could have days only certain cars can drive to reduce carbon emissions. If cars still drive on no-drive days, have them pay a fine. For reference Mexico City does something similar to reduce the country's pollution and carbon emissions."

Participants' ideas of what climate actions are possible are shaped by their experiences in countries of origin, such as Mexico. Familiarity with different policies or infrastructures abroad influenced what felt logical or frustrating in their current U.S. communities. This global perspective offers opportunities to build on existing knowledge, expand the scope of what feels possible, and adapt solutions with which residents are already familiar.

Insight 4: Frustration with government and utility inaction.

"Sometimes the cold freezes our water. Our toilet was frozen. We have two toilets in our house. I don't know what happened but sewage came up. It was like that for like 2 weeks."

"Last year there was a power outage. It just exploded. [...] .It was so dark. It took forever for it to get fixed and it was really big and there was a burn mark somewhere. That's something I won't forget."

Some participants raised frustrations about basic services such as water quality and public maintenance that go unaddressed or are fixed only after long delays. This disillusionment and frustration with the current system makes it harder to trust new initiatives. Participants expressed feeling like they'd first like to see basic issues addressed before larger actions feel feasible and believable.

Insight 5: High value placed on ecology and high-quality community spaces.

"Planting more trees can improve air quality, provide more shade, reduce energy use, and support wildlife."

Many cohort and community members emphasized the importance of trees, plants, and clean, well-kept parks and public spaces in their neighborhoods. These spaces were seen as both an environmental benefit and a community asset. There was also concern about how climate change might harm these valued areas, signaling that investments in urban greening and nature access resonates strongly.

Appendix B: Workforce Planning Analysis

Introduction

Achieving the climate goals outlined in the CCAP will require a robust and ready workforce. As communities implement measures across transportation, energy, buildings, industry, waste, agriculture, and natural systems, a coordinated workforce strategy will help ensure these efforts support high-quality jobs and open pathways for all residents to participate in and benefit from the ongoing economic transition.

A wide range of jobs and businesses contribute to and are affected by climate action. This breadth makes it challenging to forecast workforce needs, especially as technologies evolve and policy and investment priorities shift. In response, most climate workforce reports focus on specific sectors or technologies—such as electric vehicles, wind energy, or building electrification—because this allows for targeted analysis of impacted industries and occupations. This report takes a different approach: it examines a broad set of industries and occupations connected to the region's CCAP strategies, offering a foundation for more comprehensive future planning.

The scope of industries and occupations was developed using a combination of national and state-level sources that link economic activity and jobs to climate-aligned sectors. Key references include the U.S. Energy and Employment Report (USEER), the archived Bureau of Labor Statistics Green Goods and Services (GGS) survey, the Occupational Information Network (O*NET), and RMI's Clean Growth Tool.

Where possible, data are presented for the Twin Cities metro Metropolitan Statistical Area (MSA) to align with standard labor market definitions. However, not all data sources are available at that level; in those cases, we rely on the 7-county metro area or county-level data. Geographic coverage is noted where relevant in the report.

The analysis reflects current employment patterns and status quo projections. It does not yet incorporate the effects of new local climate policies, investments, or initiatives tied to CCAP strategies. Instead, it provides a baseline for identifying occupations and industries already experiencing workforce pressures—pressures that may intensify as CCAP strategies are implemented.

This report is organized into the following sections:

- Overview of Workforce Demand
- Priority Occupations
- Current Training Landscape
- Community Impacts
- Next Steps
- Data Sources & Methodology

Overview of Workforce Demand

Currently, there is no dataset that tells us how many workers in Minnesota or the Twin Cities region are employed specifically in “clean” or “green” jobs — that is, jobs we can confirm spend all or part of their time producing climate-related goods and services. Capturing that information would require a dedicated survey, which has not yet been conducted in Minnesota.

Instead, this analysis identifies industries and occupations that have the **potential** to contribute to climate action. These include, for example, construction trades that may work on efficiency retrofits, or manufacturing firms that may produce clean energy components. The result is a scoped set of industries and occupations that together represent the potential pool of jobs relevant to the region’s Comprehensive Climate Action Plan (CCAP). Some workers in these industries will be directly engaged in climate-related work, while others will not.

The scope focuses on industries that are — or could be — directly contributing to low-carbon energy, goods, and services production, as well as parts of the supply chain that support climate-relevant work. This reflects workers and businesses that can or could play a role in implementing CCAP strategies across transportation, electricity, buildings, industry, waste, agriculture, and natural systems. Supporting detail on data sources and selection criteria — including which sectors were excluded — is provided in the methodology section at the end of this report.

Together, industries most directly tied to climate action account for roughly **182,000 workers — about one in ten jobs** in the region — spread across 144 NAICS codes. Construction and manufacturing dominate, both in terms of the number of industries included (65.9%) and the number of workers employed (77.9%). At the same time, the scope is broad: sectors such as agriculture, waste services, utilities, and professional services are included, underscoring that climate action is not confined to a narrow part of the economy. These jobs sit at the center of the work needed to implement CCAP

Clean Energy Employment

The one exception — jobs that we know are directly working on clean technologies — is clean energy employment (solar, wind, efficiency, etc.), which the U.S. Department of Energy measures these through its annual U.S. Energy and Employment Report (USEER)[1], and is reported for Minnesota and Wisconsin in the Clean Job Midwest[1] fact sheets. These figures are based on a national survey and provide state- and county-level estimates.

In 2024, the 11 participating counties[1] had more than 39,100 jobs in clean energy:

- ~31,600 in energy efficiency
- ~1,900 in clean transmission, distribution, & storage
- ~4,700 in clean electric power generation
- ~700 in clean fuels

[1] 2025 U.S. Energy & Employment Report (USEER) | Department of Energy

strategies, from building retrofits and clean energy deployment to industrial process changes and material reuse.

Figure 23 shows historical and projected employment in industries directly tied to climate action ("in scope"). From 2024 to 2032, in-scope industries are projected to grow by roughly **5.6%**, compared to about **3.5%** growth in out-of-scope industries. The in-scope industries rate is also faster than overall state growth rate, suggesting that climate-relevant sectors will continue to be an engine of local job growth. (Note the in-scope industries shown here exclude industries without published employment projections. As a result, the totals in this figure are lower than the 182,000 jobs shown in climate related industries.

The in-scope industries also show more volatility in the historical period, with sharper swings year to year. This pattern is consistent with sectors shaped by emerging technologies, evolving markets, and policy shifts. Together, these trends suggest that while climate-relevant industries are poised for faster-than-average growth, they may also face more uncertainty — underscoring the importance of flexible workforce strategies.

Figure 23. Employment Trends in Climate-related Industries

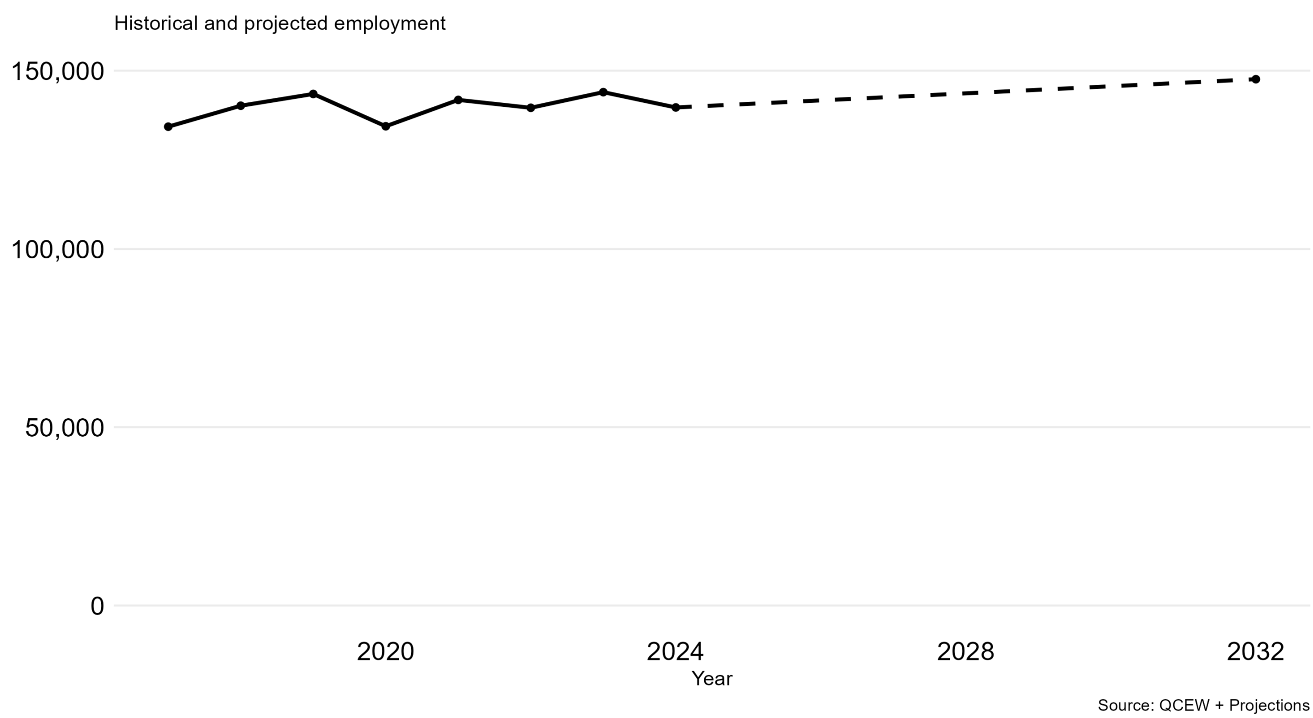


Figure 24, below, shows recent employment trends and projected growth for in-scope industry employment by industry sectors (NAICS 2 digits).

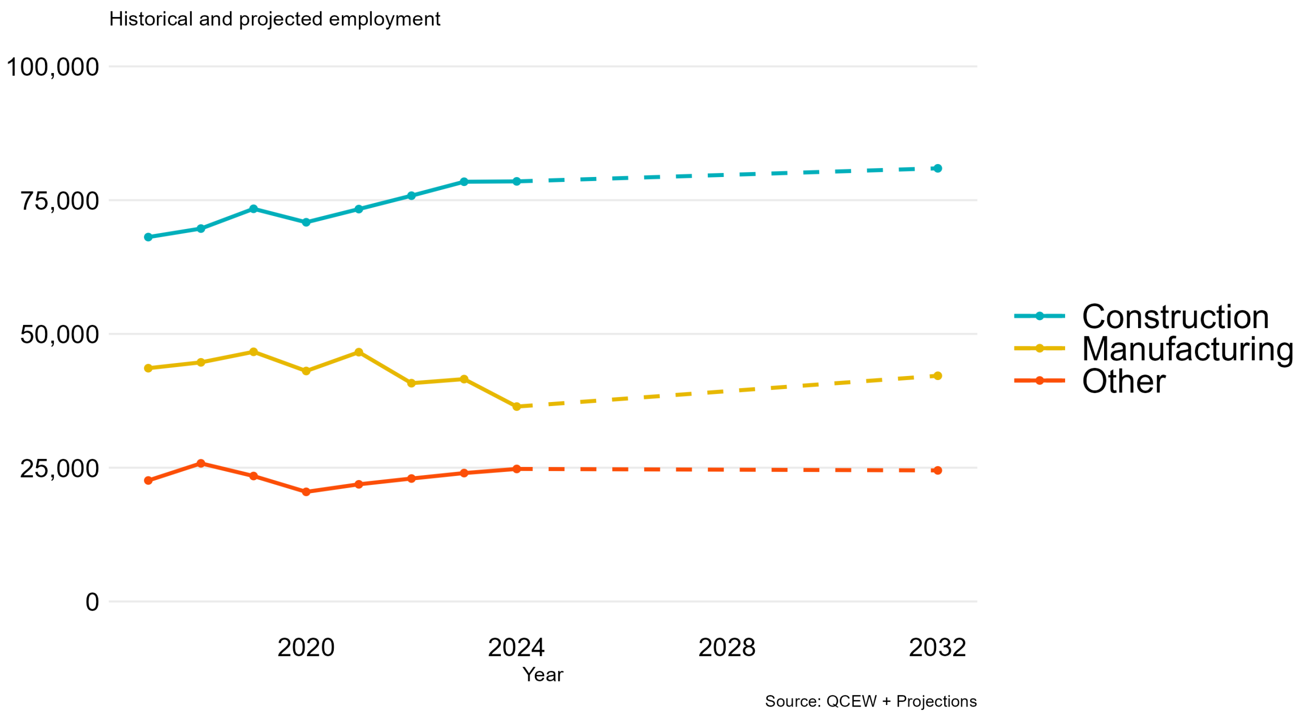
At the sector level:

- **Construction** is the largest in-scope employer and has expanded in recent years, boosted by infrastructure investments and favorable financing conditions. Projections suggest growth will continue to increase through the decade, remaining a core driver of climate-related employment, although not growing as quickly as seen in the early 2020s.

- **Manufacturing** shows the largest projected gains for in-scope industries, though still not returning to the levels of employment seen in the early 2020s. This reflects both risks and opportunities in a sector adapting to new clean technologies and shifting supply chains.

Other in-scope sectors such as utilities, professional services, and transportation and warehousing are much smaller in absolute size, but their projected growth indicates specialized workforce needs in areas like clean power generation and transit.

Figure 24. Employment Trends by Industry Sector



At the industry group level (NAICS 4 digits), several groups illustrate these dynamics:

- **Emerging high-growth:** *Environmental remediation services (NAICS 5629)* and *semiconductor/electronic component manufacturing (3344)* stand out with double-digit projected growth rates, pointing to expanding demand in both clean-up services and clean-tech supply chains. Specialized construction industries such as *highway, street, and bridge construction (2373)* and *utility system construction (2371)* are also projected to grow 10% or more, consistent with public infrastructure investments aimed at cleaner energy and greater resilience. Select transportation and repair/maintenance industries also show notable percentage gains, though they remain small in absolute employment terms.

- **Established building construction**: Many building-related construction industries *(NAICS 2361–2389)* are projected to add jobs at or above the metro-wide rate. Related industries such as *architectural and engineering services (5413)* show similar trends, underscoring the continued importance of buildings and design services in advancing climate action.
- **Declining subsectors:** A handful of smaller industries are projected to lose jobs by 2032, including *turbine and power transmission equipment (3336)*, *foundries (3315)*, *commercial & service industry machinery (3333)*, and *water and sewage systems (2213)*. While the absolute numbers are limited, these projected declines highlight how technological change, policy shifts, and market dynamics can affect different parts of the sector unevenly.

Taken together, these patterns show that climate-relevant industries are not monolithic: some subsectors will expand rapidly, while others plateau or decline. This unevenness reinforces the importance of **flexible, adaptive workforce strategies** that can respond to both emerging opportunities and dislocation risks.

Priority Occupations

The set of occupations relevant to climate action is broad. In the Twin Cities metro area, 354 different SOC codes appear across industries that fall within the CCAP scope. However, not all of these occupations are directly tied to clean energy or climate-related work. To refine the list, we applied an additional screen: occupations flagged by O*NET either in the 2009 "green occupations" dataset or through the 2022 "green topics" project.[2] This narrows the focus to 174 occupations, making it easier to identify workforce priorities that are both tractable and directly relevant to CCAP strategies.

It's important to note that the employment totals shown for industries and occupations are not meant to match. The **182,000 jobs** figure in the industry section reflects employment in metro industries that are — or could be — directly contributing to low-carbon energy, goods, and services production, as well as parts of the supply chain that support climate-relevant work. In contrast, the **514,000 jobs** shown in the occupation scope reflect workers in occupations with tasks or roles that could support climate action, regardless of the industry where they are employed.

Some occupations are fully within the set of scoped industries. Several construction-related occupations are entirely employed within construction industries. But this is the exception, not the norm. For most of the 174 occupations, employment is divided across both in-scope and out-of-scope industries. On average, about one-third of an occupation's jobs are in scoped

[2] Green and Clean Employment in Minnesota: An Occupational Approach / Minnesota Department of Employment and Economic Development

industries. For example, electricians may be employed in construction firms (included in the industry scope) or in hospitals, schools, or manufacturing plants (outside the industry scope).

Although much of the employment in these occupations lies outside CCAP-relevant industries, the skills themselves are transferable. Workers across settings often draw on a shared base of technical knowledge and training, and they move not only between climate-related and non-climate projects, but also across industries. For this reason, the occupational analysis retains the *full* employment base when identifying priority occupations, even if many current jobs are not in climate-focused industries.

This dual view — industries on one hand, occupations on the other — highlights both the economic footprint of climate-relevant sectors and the full set of skills that may be needed to deliver on CCAP goals.

To focus attention on the jobs most critical for CCAP implementation, we ranked each occupation using three demand signals:

- **Employment size** – how many people currently work in the occupation.
- **Projected growth rate** – how fast the occupation is expected to grow over the next 10 years.
- **Current hiring pressure** – measured by job vacancy rates.

These factors were combined into a single **priority score**, with employment size weighted at 20% and growth and vacancy rates together weighted at 40% each. To keep the list focused, we limited results to occupations that:

- support multiple measures (e.g. electricity and buildings, buildings and transportation)
- are on either O*NET green occupation list
- have a demand rating of 4 or 5 stars in DEED's Occupations in Demand dataset.

This filter avoids over-emphasizing small occupations that happen to show high growth and vacancies (for example, veterinarians).

To highlight both **accessible entry routes** and **specialized professional roles**, we divided the top priority occupations into two groups:

- **Occupations typically requiring less than a 4-year degree** — critical for ensuring on-ramps into climate-relevant work for a wide range of residents.
- **Occupations typically requiring a bachelor's degree or higher** — critical professional and technical roles that provide the advanced expertise needed to design, manage, and scale climate solutions.

A key focus of this analysis is identifying occupations that provide **accessible pathways** into climate-related work. These roles typically require less than a bachelor's degree, making them critical for ensuring that a wide range of residents can participate in and benefit from the transition.

The top ten priority occupations in this group (Table 14) illustrate three important patterns:

- **Core maintenance and repair skills cut across sectors.** Occupations such as *industrial machinery mechanics*, *maintenance and repair workers*, and *bus and truck mechanics* appear in multiple CCAP sectors, reflecting how essential repair and upkeep are to implementing climate strategies.
- **Construction and building trades remain central.** Supervisory roles in construction and HVAC technicians are in high demand, aligning with projected increases in building retrofits, electrification, and infrastructure investment.
- **Transportation and logistics connect multiple systems.** Truck drivers, diesel mechanics, and transportation/distribution managers play a pivotal role in supply chains and mobility systems that cut across nearly every sector of the plan.

Together, these occupations employ tens of thousands of metro residents, show consistent projected growth, and are experiencing elevated vacancy rates — a sign of current hiring challenges. While the education barrier is lower, many still require specialized technical training, certifications, or apprenticeships, underscoring the importance of **training pipelines and recruitment strategies** to ensure a steady workforce.

Professional and technical roles are equally important for CCAP implementation. These occupations (Table 15) include engineers, data and software professionals, and managers who bring specialized expertise to planning, design, analysis, and project leadership. Several trends stand out:

- **STEM and technical fields drive innovation.** *Civil, mechanical, and industrial engineers*, as well as *software developers* and *data scientists*, provide the backbone for designing clean energy systems, optimizing processes, and applying new technologies.
- **Management and coordination roles connect the pieces.** *Construction managers*, *marketing managers*, and *logisticians* highlight the need for leadership across projects, markets, and supply chains.
- **Information and cybersecurity are emerging needs.** *Information security analysts* show the growing importance of digital resilience in a modernized energy and infrastructure system.

These professional roles tend to be smaller in absolute employment than the <4-year group, but they are growing quickly, often show elevated vacancy rates, and are essential for scaling climate strategies across multiple CCAP sectors.

Table 15. Top 10 occupations requiring < 4-year degree (critical accessible pathways)

SOC Code	Occupation Title	Description	MSA Employment (2025)	Projected Growth Rate (2022–2032)	Job Vacancy Rate (2024)
499041	Industrial Machinery Mechanics	Repair, install, adjust, or maintain industrial production and processing machinery or refinery and pipeline distribution systems.	4,070	20.5%	3.90
499021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Install or repair heating, central air conditioning, HVAC, or refrigeration systems, including oil burners, hot-air furnaces, and heating stoves.	3,170	7.5%	4.30
533032	Heavy and Tractor-Trailer Truck Drivers	Drive a tractor-trailer combination or a truck with a capacity of at least 26,001 pounds Gross Vehicle Weight (GVW).	19,770	5.9%	3.20
499071	Maintenance and Repair Workers, General	Perform work involving the skills of two or more maintenance or craft occupations to keep machines, mechanical equipment, or the structure of a building in repair.	17,750	3.9%	4.00

113071	Transportation, Storage, and Distribution Managers	Plan, direct, or coordinate transportation, storage, or distribution activities in accordance with organizational policies and applicable government laws or regulations. Includes logistics managers.	2,820	8.3%	3.50
511011	First-Line Supervisors of Production and Operating Workers	Directly supervise and coordinate the activities of production and operating workers.	8,680	3.8%	4.40
119141	Property, Real Estate, and Community Association Managers	Plan, direct, or coordinate the selling, buying, leasing, or governance activities of commercial, industrial, or residential real estate properties.	3,940	4.8%	4.00
493031	Bus and Truck Mechanics and Diesel Engine Specialists	Diagnose, adjust, repair, or overhaul buses and trucks, or maintain and repair any type of diesel engines.	4,150	2.7%	4.90
471011	First-Line Supervisors of Construction Trades and Extraction Workers	Directly supervise and coordinate activities of construction or extraction workers.	7,470	6.8%	2.70
514041	Machinists	Set up and operate a variety of machine	11,340	5.6%	2.70

		tools to produce precision parts and instruments out of metal.			

Table 16. Top 10 occupations requiring BA or above (critical professional/technical roles)

SOC Code	Occupation Title	Description	MSA Employment (2025)	Projected Growth Rate (2022–2032)	Job Vacancy Rate (2024)
151212	Information Security Analysts	Plan, implement, upgrade, or monitor security measures for the protection of computer networks and information.	2,090	28.7%	8.80
151252	Software Developers	Research, design, and develop computer and network software or specialized utility programs.	29,550	23.9%	3.80
152051	Data Scientists	Develop and implement a set of techniques or analytics applications to transform raw data into meaningful information using data-oriented programming languages and visualization software.	2,870	33.1%	1.30
152031	Operations Research Analysts	Formulate and apply mathematical modeling and other optimizing methods to develop and interpret	1,160	22.7%	3.30

		information that assists management with decision making, policy formulation, or other managerial functions.			
112021	Marketing Managers	Plan, direct, or coordinate marketing policies and programs, such as determining the demand for products and services offered by a firm and its competitors, and identify potential customers.	6,670	7.0%	9.20
172051	Civil Engineers	Perform engineering duties in planning, designing, and overseeing construction and maintenance of building structures and facilities.	3,140	8.2%	8.40
119021	Construction Managers	Plan, direct, or coordinate, usually through subordinate supervisory personnel, activities concerned with the construction and maintenance of structures, facilities, and systems.	3,760	7.5%	8.70
172112	Industrial Engineers	Design, develop, test, and evaluate integrated systems for	14,250	16.4%	2.10

		managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination.			
172141	Mechanical Engineers	Perform engineering duties in planning and designing tools, engines, machines, and other mechanically functioning equipment.	4,510	12.1%	3.30
131081	Logisticians	Analyze and coordinate the ongoing logistical functions of a firm or organization.	3,110	19.3%	1.20

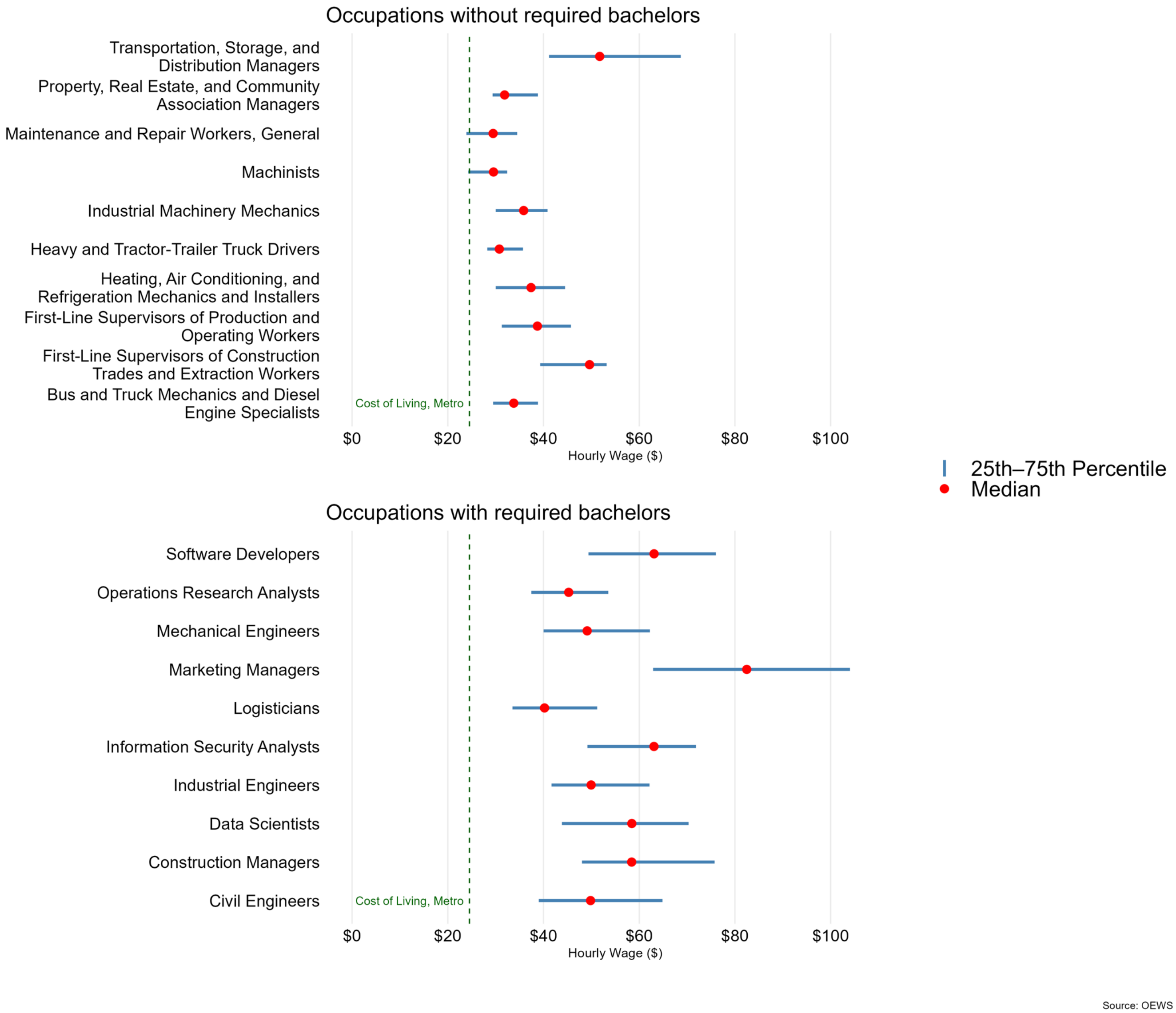
Job Quality and Wages

Job quality is a critical dimension for understanding the workforce implications of climate action. While job quality is more than high wages, wages are often used as a representation of job quality because wage data is readily available. Figure 24 shows the wage distribution for the twenty “priority occupations” identified in the previous section, split between those requiring less than a four-year degree and those requiring a bachelor’s degree or higher.

- **Accessible pathways (<4-year degree):** Median wages for these occupations all fall above the metro area’s cost-of-living benchmark, and the 25th percentile wage is above the cost-of-living threshold[3] for all but two of the occupations. These roles (e.g., HVAC technicians, general maintenance workers, machinists) are vital to implementation and provide middle-wage opportunities without requiring a bachelor’s degree.
- **Professional and technical roles (≥BA):** Median wages for these occupations are consistently higher, with many clustered in the $50–$70 per hour range. These roles (e.g., engineers, software developers, data scientists) are critical for designing, managing, and optimizing low-carbon systems. While they offer strong wages and career advancement opportunities, access depends on higher education pathways that may be less accessible for underrepresented workers.

[3] Cost of Living in Minnesota / Minnesota Department of Employment and Economic Development. This report uses the family sustaining wage threshold used by state agencies, which is the cost of living for a household with two adults and one child with one adult working full-time and one working part-time.

Figure 25. Wages Range for Priority Occupations in the 15-County MSA, 2025 Q1



Although most priority occupations provide hourly wages above the family-sustaining wage level, comparing the left and right sides of Figure 25 shows that the range of wages for occupations requiring less than a four-year degree is much narrower than the range for occupations requiring a bachelor's degree. This limited wage range suggests more constrained opportunities for upward mobility or career growth within that group; workers seeking advancement often need to transition into a different occupation or sector.

Job quality also depends on job conditions and worker fit. Many of the accessible-pathway roles provide stable, hands-on work that aligns with the skills and preferences of experienced tradespeople. However, they may also involve seasonal schedules or physically demanding conditions—factors that influence long-term job stability and retention. Supporting job fit is therefore important not only for worker satisfaction but also for employers, who benefit from lower turnover and a more reliable workforce.

Workforce Readiness and Representation

Understanding job characteristics is important, but it is equally critical to understand who currently holds these jobs and how workers are being attracted and retained in occupations that support climate action. Demographic patterns across these fields reveal both existing strengths and emerging challenges for workforce readiness and inclusion. Table 17**Error! Reference source not found.**, below, shows the current gender, age, education, and race distributions for priority occupations' major occupation groups.

- **Gender:** Women are well represented in management and business occupations but remain underrepresented in many technical fields. For example, women account for less than 20 percent of workers in architecture and engineering, and less than 5 percent in construction, installation, and repair. Low representation may reflect a combination of factors—such as limited awareness of opportunities, workplace culture, or structural barriers like scheduling and childcare availability—that make it difficult for qualified and interested candidates to enter or remain in these positions.
- **Race:** Workers of color are unevenly represented across occupation groups. Black workers, for example, are more concentrated in production and transportation roles than in engineering or management. Asian workers show higher representation in computer, mathematical, and engineering occupations. These differences highlight the need to ensure that new clean-economy opportunities are inclusive and visible across communities.
- **Age:** Most priority occupation groups still have more mid-career workers (ages 45–54) than those nearing retirement (ages 55–64). However, in transportation and material moving, production, and installation/maintenance/repair, the balance has already tipped the other way—signaling that retirements could outpace the available mid-career workforce in the coming decade. Attracting and retaining younger workers will be critical to maintaining capacity in these essential implementation fields.

It is also important to note that while these data describe current workforce composition, they do not capture differences in career ladders or advancement opportunities within occupation groups. Barriers to entry, awareness of opportunities, and differences in job conditions can all shape not only who enters these fields but also who is able to advance and stay over time. Ensuring that the clean-energy and infrastructure workforce is both accessible and appealing to a broader and more diverse population will be essential to sustaining the region's labor supply.

Table 17. Demographics of priority occupations

Major Occupation Group (SOC)	Sex	%	Age	%	Education	%	Race	%
Management (110000)	Female	44.1	16–24	3.7	< High school	1.1	American Indian or Alaska Native	0.3
	Male	55.9	25–34	17.7	High school diploma or GED	15.5	Black or African American	4.7
			35–44	26.2	Some college / Associate's	19.6	Asian or Pacific Islander	5.0
			45–54	22.9	Bachelor's degree	41.9	White	83.4
			55–64	20.6	Graduate degree	21.8	Two or more races	4.8
			65+	8.9			Other race	1.8
Business and Financial Operations (130000)	Female	54.8	16–24	6.1	< High school	0.5	American Indian or Alaska Native	0.1
	Male	45.2	25–34	24.4	High school diploma or GED	8.7	Black or African American	4.4
			35–44	23.0	Some college / Associate's	15.9	Asian or Pacific Islander	6.4
			45–54	20.1	Bachelor's degree	55.0	White	82.7
			55–64	17.9	Graduate degree	19.8	Two or more races	4.9
			65+	8.5			Other race	1.4
Computer and Mathematical (150000)	Female	25.5	16–24	6.2	< High school	0.8	American Indian or Alaska Native	0.1
	Male	74.5	25–34	25.3	High school diploma or GED	8.4	Black or African American	4.3
			35–44	27.2	Some college / Associate's	21.3	Asian or Pacific Islander	13.9
			45–54	19.7	Bachelor's degree	52.1	White	76.4
			55–64	15.2	Graduate degree	17.5	Two or more races	4.3
			65+	6.3			Other race	1.1

Architecture and Engineering (170000)	Female	17.7	16–24	8.9	< High school	1.6	American Indian or Alaska Native	0.2
	Male	82.3	25–34	25.3	High school diploma or GED	7.8	Black or African American	3.8
			35–44	19.4	Some college / Associate's	20.5	Asian or Pacific Islander	7.6
			45–54	17.2	Bachelor's degree	52.1	White	81.7
			55–64	19.6	Graduate degree	18.0	Two or more races	5.2
			65+	9.7			Other race	1.5
Construction and Extraction (470000)	Female	4.2	16–24	12.4	< High school	7.9	American Indian or Alaska Native	0.9
	Male	95.8	25–34	22.8	High school diploma or GED	53.0	Black or African American	4.0
			35–44	23.5	Some college / Associate's	30.4	Asian or Pacific Islander	2.0
			45–54	17.1	Bachelor's degree	7.6	White	82.1
			55–64	16.9	Graduate degree	1.1	Two or more races	5.4
			65+	7.3			Other race	5.5
Installation, Maintenance, and Repair (490000)	Female	4.7	16–24	12.3	< High school	5.4	American Indian or Alaska Native	0.2
	Male	95.3	25–34	22.1	High school diploma or GED	42.3	Black or African American	5.9
			35–44	21.4	Some college / Associate's	42.8	Asian or Pacific Islander	4.5
			45–54	15.8	Bachelor's degree	8.3	White	82.0
			55–64	19.6	Graduate degree	1.3	Two or more races	5.2
			65+	8.8			Other race	2.3
Production (510000)	Female	30.4	16–24	11.3	< High school	10.3	American Indian or Alaska Native	0.6
	Male	69.6	25–34	21.5	High school diploma or GED	52.9	Black or African American	10.6
			35–44	21.0	Some college / Associate's	25.2	Asian or Pacific Islander	16.5
			45–54	16.9	Bachelor's degree	9.9	White	61.9

			55–64	20.4	Graduate degree	1.6	Two or more races	5.2
			65+	8.9			Other race	5.3
Transportation and Material Moving (530000)	Female	22.8	16–24	21.3	< High school	10.0	American Indian or Alaska Native	0.6
	Male	77.2	25–34	17.4	High school diploma or GED	52.3	Black or African American	15.3
			35–44	17.0	Some college / Associate's	23.8	Asian or Pacific Islander	4.6
			45–54	15.4	Bachelor's degree	11.7	White	68.9
			55–64	17.5	Graduate degree	2.2	Two or more races	6.5
			65+	11.4			Other race	4.1

Source: American Community Survey, 2023

Current Training Landscape

The Twin Cities metro region has a robust network of education and training programs that feed into climate-relevant occupations. These pipelines span high schools, community and technical colleges, registered apprenticeships, training programs, and universities. Together, they prepare workers for both hands-on and professional roles across the clean economy. While programs vary in focus and credential level, most serve multiple occupations at once—building shared skill foundations that support mobility and resilience as technologies shift, markets develop, and peoples' work-life needs evolve.

Sub-Baccalaureate Programs and Certificates

The majority of occupations included on O*NETs green occupation lists require a high school degree or equivalent, non-degree postsecondary awards, or associate's degree. Programs requiring less than a four-year degree form the foundation of the clean-economy workforce. Many are long-established in the region's community and technical colleges, with strong ties to employers in construction, manufacturing, transportation, and energy. In fact, many programs prepare people for multiple possible occupations. For example, the same instructional program could prepare someone for a job as an Industrial Machinery Mechanic or Millwright or Installation, Maintenance, and Repair Worker.

The overlapping skillsets of priority occupations highlight several important features of the education and training landscape:

- **Shared pipelines:** Investments in sub-baccalaureate programs strengthen clusters of related occupations that are central to implementation of climate projects.
- **Accessible entry:** Programs offer practical, skills-based routes into climate-relevant careers for workers without a four-year degree.
- **Transferable skills:** Training supports movement across related roles, allowing workers to adapt as industries, technologies, and projects change.
- **Workforce resilience:** Emphasizing transferable skills helps people move from declining to growing industries, creating new pathways for mid-career workers and underrepresented groups. For employers, this broadens candidate pools and reduces hiring time for critical roles. For the state, it enables faster adaptation and stronger alignment between workforce and climate goals.

Since many priority occupations draw on a common base of technical skills, investments in one part of the training system can strengthen multiple parts of the clean-economy workforce.

Bachelor's Degree and Advanced Programs

For occupations requiring a bachelor's degree or higher, the training landscape looks different. These pathways are anchored in academic programs such as business and management, computer and information sciences, engineering, and physical and life sciences —fields that supply professional and technical talent supporting Minnesota's climate transition.

Similar to the sub-baccalaureate programs, these programs often feed multiple occupations but on a much broader scale. For example, business administration programs are related to more than 20 occupations, and computer sciences relates to more than ten.

The metro area's universities and colleges already have deep institutional capacity in key climate action related areas. Continued alignment of curricula and applied learning opportunities can further connect academic programs to CCAP workforce needs.

Graduate Outcomes and Gaps

While current data cannot directly link program graduates to their eventual occupations, outcomes from related instructional programs provide useful signals about workforce readiness and alignment with labor market demand.

Table 18 summarizes two-year employment outcomes for graduates in 2022 from programs that prepare workers for the twenty priority occupations identified earlier. Results are shown for employment in 2024 (two years after graduation).

Table 18. Regional training programs for priority occupations that do not require a bachelor's degree

Award	Graduates	Employed in MN	% Employed in MN	% Full-time	% Part-time or seasonal	Median annual wage for Full-time	Median annual wage for all
Associate Degree	883	759	86%	55%	45%	$61,816	$52,643
Certificates (less than Bachelor's Degrees)	1,197	1,064	89%	46%	54%	$62,080	$48,631
Bachelor's Degree	3,824	2,685	70%	63%	37%	$72,497	$64,738
Graduate (Certificates and Degrees)	2,617	1,717	66%	70%	30%	$109,692	$102,328

Several patterns stand out:

1. **Strong in-state employment for sub-baccalaureate graduates.**
   Graduates of associate and certificate programs were the most likely to be employed in Minnesota two years after graduation—86 and 89 percent, respectively. This suggests that investments in technical and sub-baccalaureate programs strengthen local labor markets by producing graduates who are more likely to live and work in their communities.

2. **Out-of-state or indirect employment among bachelor's and graduate completers.**
   Roughly 30–35 percent of bachelor's and graduate completers were not employed in Minnesota two years later. Because the state's unemployment rate (including discouraged workers) is below 4 percent, most of these individuals are likely employed elsewhere—either out of state or in roles not captured by available data systems such as self-employment.

3. **Full-time versus part-time employment reflects occupation type, not education level.**
   Across awards, 46–70 percent of graduates were employed full-time. The variation is driven more by occupational characteristics—such as seasonal construction or maintenance work—than by educational attainment.

4. **Wage levels vary by degree level and job placement.**
   Median wages increase with education level but remain below the metro area's estimated family-sustaining annual wage of $76,500 for all groups except graduate degree holders. This apparent mismatch with the hourly wage data in **Error! Reference source not found.** likely reflects differences in population coverage: the graduate outcomes data include all employed graduates, regardless of the occupation they entered, whereas the wage distribution analysis focused specifically on workers employed in the priority occupations. Entry-level wages and career-stage effects may also play a role.

5. **Training supply versus workforce demand.**
   In 2022, programs below the bachelor's level produced roughly 2,080 graduates, compared with an estimated 2,645 job vacancies in the related occupations two years later. While not directly comparable—since programs prepare workers for multiple occupations and additional training occurs outside higher education—this suggests that meeting climate workforce demand will require both expanding program capacity and improving connections between education, training, and employment systems.

6. **Data integration and visibility gaps.**
   Outcomes from registered apprenticeships, short-term credentials, and private or nonprofit training providers are tracked in separate systems, making it difficult to assess the full picture of workforce preparation. Better integration across education, training, and employment data would help the state identify where graduates go and what specific jobs they hold after completing their programs and where workforce gaps persist. This, in turn, would inform targeted investments, curriculum updates, and new credentials that align with emerging climate workforce needs.

Community Impacts

While data shows that there are high quality jobs in sectors with increasing demand in the clean and green economy, it is important to ensure that those positions are accessible to residents across the region, especially those facing unemployment or in jobs in slowing sectors. As clean and green sectors emerge and grow through dedicated climate action in the region, an intentional workforce development approach will help connect residents with these jobs. There is a robust network of workforce development and climate-focused non-profit organizations throughout the region that has a pivotal role in connecting potential workers with training and jobs as well as broader support for residents to enter or transition in the workforce.

These organizations, through the Workforce Development Work Group, helped identify several key barriers that limit access to clean economy careers and recruiting regional workforce. Transportation emerged as one of the most significant barriers, particularly for construction or trade positions that require workers to travel to varied job sites that are not always accessible by public transit. The lack of long-term reliable transportation, including access to driver's licenses, creates a challenge for entering apprenticeship programs and sustaining employment once hired. Childcare, especially for early-morning or non-traditional work hours, is a major obstacle, particularly for single heads of households and women looking to enter the workforce.

Other barriers relate to entry requirements and systemic inequalities which disproportionately impact underrepresented communities, such as workers of color. Many clean economy jobs require credentials such as post-secondary education, or specific licenses and training which may be inaccessible for individuals without targeted support. Additionally, there is a need for greater awareness or career opportunities and pathways, especially for younger generations, as well as resources to allow workers to view these positions not just as jobs but as long-term careers. Intentional action to address these barriers such as diversified training pipelines, support services, and outreach to non-traditional talent pools are important steps in supporting the success, equity, and growth of the clean economy workforce.

Next Steps

The data and synthesis behind this workforce analysis have raised ideas about how to make the information actionable for those working in climate and workforce development. This section summarizes those ideas with the recognition that many of these steps will be taken not by the Met Council but by partners.

Most immediately, the Met Council is developing technical assistance tools for local governments in the seven-county region as they begin 2050 comprehensive planning. Council staff are exploring how workforce data can integrate into climate planning tools that are in creation to show jobs and sectors that may see growth from climate action.

The Workforce Work Group also highlighted other ways this information and regional conversations could benefit the sector. First, the information could be reformatted into profiles that describe career pathways. This format would help people understand the required training, entry-level jobs, and advancement opportunities for different clean and green occupations. These career pathway profiles could highlight high growth occupations and where skills or training overlap may apply to multiple career pathways.

Second, the way data is collected and organized leaves a gap in understanding to what extent workers in any given occupation are working on green or clean projects. A targeted survey would provide much more nuanced data on how climate actions are showing up in the day-to-day work of occupation across the region.

Finally, the interconnected nature of economic development in the region and the feedback from sector stakeholders support taking regional approaches to workforce development efforts. The Workforce Work Group members shared that existing collaboration is useful, and there are additional opportunities to better coordinate efforts including grant applications and training and wrap around support programs.

Data Sources and Methodology

To understand workforce needs across the metro region's climate planning sectors, this analysis integrates multiple public data sources to identify relevant industries and occupations and locate potential workforce gaps.

Sector and Industry Identification:

We began by mapping CPRG emission reduction measures to affected economic sectors, using NAICS codes to identify industries most directly involved in implementing mitigation, adaptation, and resilience strategies. This sector scoping was informed by national green jobs datasets. including the U.S. Energy and Employment Report (USEER) and BLS Green Goods and Services classifications, as well as previous green and clean jobs research.[4]

Occupational Scoping:

Occupations were linked to these scoped industries using national and state crosswalks between industry (NAICS) and occupation (SOC) codes. We retained occupations with a substantial presence in the relevant industries and added roles identified as green or climate-supporting in O*NET.[5]

Prioritization Criteria:

We identified "priority occupations" based on:

- Current job vacancy rates (DEED Job Vacancy Survey)
- Projected 10-year growth (DEED Employment Projections)
- Total employment size (Occupational Employment and Wage Statistics)
- Indicators of demand from DEED's Occupations in Demand dataset
- Relevance to clean technology deployment and resilience-building

Education & Training Program Identification:

Education and training pipelines were analyzed to understand how instructional programs and certifications align with the identified priority occupations.

- Postsecondary programs were linked to occupations using the CIP–SOC crosswalk from the National Center for Education Statistics.

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[4] U.S. Energy and Employment Report (USEER), https://www.energy.gov/policy/us-energy-employment-jobs-report-useer, Bureau of Labor Statistics (BLS) Green Goods and Services (GGS) survey (archive) https://www.bls.gov/ggs/ (Note: This survey was discontinued in 2013, but archived materials are still available.), RMI – Clean Growth Tool, https://rmi.org/rmi-applications/clean-growth-tool/

[5] O*NET Green Topics, https://www.onetonline.org/search/green_topics/

- Certifications were linked to occupations using CareerOneStop's Certification Finder data.
- Occupational similarity measurements were collected from DEED's JobSTAT tool.
- Graduate outcomes were analyzed using the Graduate Employment Outcomes (GEO) tool, focusing on employment status, in-state retention, full-time/part-time distribution, and median wages two years after program completion.

Data Sources Used:[6]

- Minnesota Quarterly Census of Employment and Wages (2017–2024) for historical industry employment trends, 7 county metro
- Employment Projections for industry and occupation-level employment growth, 7 county metro
- Minnesota Occupational Employment and Wage Statistics (2024) for current occupation wages and employment, MSA and 7 county metro
- Minnesota Job Vacancy Survey (2024) for job vacancy rates, 7 county metro
- DEED Occupations in Demand (2024) for statewide demand indicators, 7 county metro
- O*NET for occupation role definitions and green task relevance

[6] Minnesota DEED – QCEW, https://mn.gov/deed/data/data-tools/qcew/,
Minnesota DEED – Employment Outlook, https://mn.gov/deed/data/data-tools/employment-outlook/, Minnesota DEED – OEWS, https://mn.gov/deed/data/data-tools/oes/, Minnesota DEED – Job Vacancy Survey https://mn.gov/deed/data/data-tools/jvs/
Census ACS, American Community Survey 5-Year Data (2009-2023)
Minnesota DEED - JobSTAT

Appendix C: GHG Inventory and Projections Methodology

Data analysis and quality control

All data manipulation and analysis were conducted in the R programming environment and were tracked in a Metropolitan Council GitHub repository. This repository is public, but projections use functions from a second repository that is still in development and will be made public in 2026. Sectors were broken up into subtasks and assigned to researchers. As researchers completed tasks, all code and data were submitted for peer review by another team member before being merged into the main branch of the repository. Datasets and functions were regularly tested and evaluated for reproducibility and consistency. Final datasets were compared with other GHG inventories and contextual data, like population estimates, for correlation and logical consistency. Our data analysis standards are in compliance with our QAPP. Below, we give detailed sector by sector description of our data acquisition and transformation process for analyzing our regional GHG emission inventory, projections, and strategy reductions.

Transportation

On-road inventory and baseline

Transportation emissions are tabulated using EPA data sources. We use a geographic, or territorial accounting method, aligning with Scope 1 in the Greenhouse Gas Protocol. Geographic methods account for any transportation emissions taking place within a geographic boundary, regardless of origin or destination[7]. Geographic emissions are essential for quantifying air pollution experienced by people living in the area, but they do not give information on the logistic decisions of individuals.

The EPA releases various emissions estimates as part of several programs and initiatives. We data from three programs: National Emissions Inventory[8] (NEI), EQUATES[9], and Air

[7] Fong, W. K., Sotos, M., Doust, M., Schultz, S., Marques, A., & Deng-Beck, C. (2021). *Global Protocol for Community-Scale Greenhouse Gas Inventories* (Version 1.1; pp. 1–190). World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI - Local Governments for Sustainability. https://ghgprotocol.org/ghg-protocol-cities

[8] USEPA. (2023). *2020 National Emissions Inventory Technical Support Document: Onroad Mobile Sources* (Government EPA-454/R-23-001e; NEI2020 TSD). Office of Air Quality Planning and Standards. https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-technical-support-document-tsd

[9] USEPA. (2024, March 29). *EQUATES: EPA's Air QUAlity TimE Series Project* (United States) [Data and Tools]. https://www.epa.gov/cmaq/equates

Emissions Modeling Platforms[10] all of which produce data in SMOKEFF10 formats and use EPA MOVES[11].

SMOKE FF10 data were aggregated to include all MOVES processes for on- and off-network vehicle operation, including running, starting, and idling exhaust, tire and brake wear, evaporative permeation, fuel leaks, and fuel vapor venting, and crankcase exhaust[12].

Table 19. On-road data sources by county and year

Data source	Years	Counties
EQUATES	2002 - 2019	Anoka, Carver, Chisago, Dakota, Hennepin, Pierce, Ramsey, Scott, Sherburne, St. Croix, Washington
National Emissions Inventory	2020	Anoka, Carver, Chisago, Dakota, Hennepin, Pierce, Ramsey, Scott, Sherburne, St. Croix, Washington
Air Emissions Modeling	2021 - 2022	Anoka, Carver, Chisago, Dakota, Hennepin, Pierce, Ramsey, Scott, Sherburne, St. Croix, Washington
Interpolation	2023 - 2049	Anoka, Carver, Chisago, Dakota, Hennepin, Pierce, Ramsey, Scott, Sherburne, St. Croix, Washington
Expected change in emissions in similar county	2050	Chisago, Pierce, Sherburne, St. Croix
RTDM and EPA MOVES4	2050	Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, Washington

Geographic accounting methods do not account for the decisions or travel behavior of individuals within the geographic boundaries. Within the Twin Cities region, this method will show high emissions per capita in low population areas with significant vehicle traffic, such as a lower-population county with major freeway traffic.

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[10] USEPA. (2025, June 26). *2022v2 Emissions Modeling Platform* [Air Emissions Modeling Platforms]. https://www.epa.gov/air-emissions-modeling/2022v2-emissions-modeling-platform
[11] USEPA. (2024). *MOVES Greenhouse Gas Guidance: Using MOVES for Estimating State and Local Inventories of Onroad Greenhouse Gas Emissions and Energy Consumption* (Government EPA-420-B-24-023; pp. 1–80). Office of Transportation and Air Quality. https://www.epa.gov/system/files/documents/2024-05/420b24023.pdf
[12] CMAS. (2024). *SMOKE v5.1 User's Manual*. Community Modeling and Analysis System Center (CMAS). https://www.cmascenter.org/smoke/documentation/5.1/html/ch02s02s03.html

EPA emissions data sources have consistent limitations

- The NEI, EQUATES, and Air Emissions Modeling platforms are based on MOVES, which does not account for activity on local roads.
- NEI, EQUATES, and Air Emissions modeling use different MOVES editions which may result in discrepancies between years.
- To reduce run times, the EPA uses fuel months to represent summer and winter fuels. The month of January represents October through April (winter), while July represents May through September (summer).[13] Variation within the summer and winter months is not accounted for using this method.
- The 2020 NEI had challenges in data availability due to COVID-19 pandemic effects on transportation behavior.
- Minnesota did not submit custom data inputs for the 2020 NEI, meaning that inputs to MOVES were based on national default values. Wisconsin submitted custom data for VMT, vehicle population, and road type distribution. Both Minnesota and Wisconsin submitted data for 2017, 2014, and 2011 USEPA.[14]
- The NEI augmented vehicle miles traveled (VMT) data for Minnesota and Wisconsin in 2020 using federal and state-level datasets due to data availability issues[15].
- To reduce model run-time, the EPA groups counties together and only runs MOVES on a single representative county. The resulting MOVES emissions factors are multiplied by county-specific activity data (including VMT, vehicle population, hourly speed distribution, among others) to get county-specific emissions.[16] Effectively, emissions factors are generated on a single representative county and are then applied to similar counties.
- Though nitrous oxide N_2O has a high global warming potential the amount of N_2O released is relatively small when compared to other sectors. N_2O is unavailable in EQUATES, except years 2018 and 2019.

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[13] USEPA. (2023). 2020 National Emissions Inventory Technical Support Document: Onroad Mobile Sources (Government No. EPA-454/R-23-001e; NEI2020 TSD). Office of Air Quality Planning and Standards. https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-technical-support-document-tsd, Section 5.6.6.2.

[14] USEPA. (2015). 2011 National Emissions Inventory, version 2 Technical Support Document (pp. 1–365) [Government]. https://www.epa.gov/sites/default/files/2015-10/documents/nei2011v2_tsd_14aug2015.pdf

[15] USEPA, Godfrey, J., & Eyth, A. (2022). Development of 2020 Default Onroad Activity Data for the National Emissions Inventory (pp. 1–7). https://gaftp.epa.gov/air/nei/2020/doc/supporting_data/onroad/DefaultOnroadActivity.pdf

[16] USEPA. (2023). 2020 National Emissions Inventory Technical Support Document: Onroad Mobile Sources (Government No. EPA-454/R-23-001e; NEI2020 TSD). Office of Air Quality Planning and Standards. https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-technical-support-document-tsd, Section 5.6.2.1

National Emissions Inventory

The National Emissions Inventory (NEI)[17] is a comprehensive and detailed estimate of air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from air emissions sources. The county-level GHG emissions included in the NEI for this category are calculated by running the MOVES model with State-, Local-, and Tribal-submitted activity data and EPA-developed activity inputs based on data from FHWA and other sources. NEI data used in the Metropolitan Council inventory were compiled from SMOKE FF10 for year 2020.

EQUATES

EQUATES (EPA's Air QUAlity TimE Series) is a set of modeled emissions and supporting data developed by EPA scientists spanning years 2002 to 2019. Between the 2008 and 2011 NEI releases, the EPA completed major changes to their source classification codes (SCCs), which rendered direct comparison between 2008 and prior years with 2011 and later years impossible. EQUATES is particularly useful in that it uses modern source classification codes (SCCs) to provide a continuous time series. EQUATES is based on the 2017 NEI and uses MOVES3. EQUATES data are used for years 2002 – 2019.

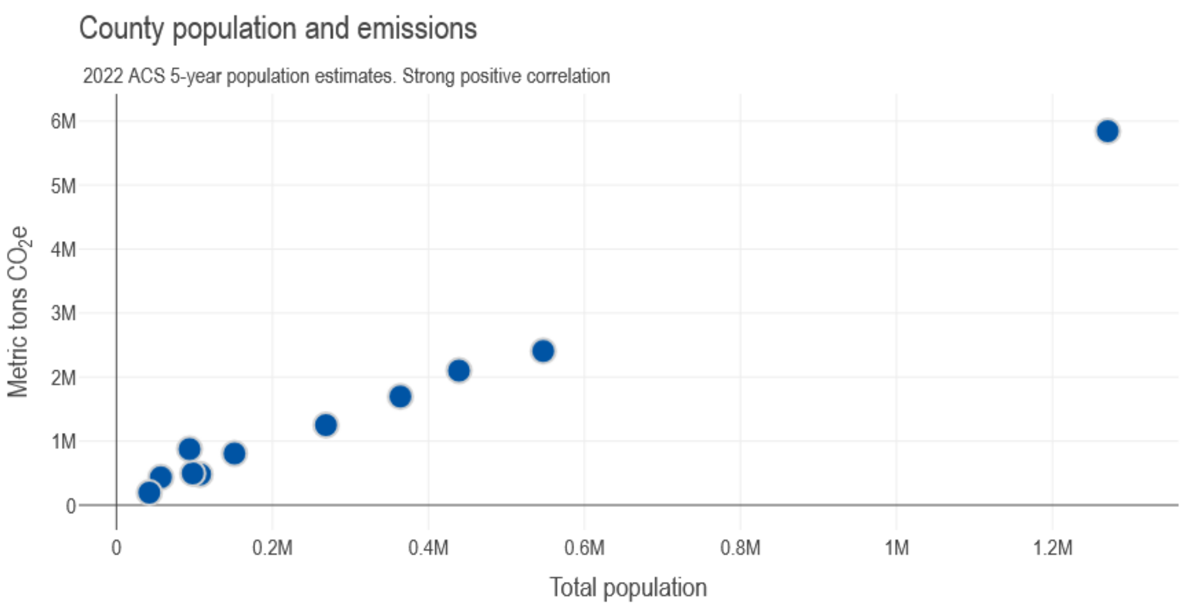
Air Emissions Modeling Platform

The EPA and various partner agencies continually work on emissions inventories for various projects. Air Emissions Modeling Platform data are available for several years, but only years 2021 and 2022 are used in the final inventory. Platform 2022v2, released in September 2025, is the most recent and up to date emissions data for our region. Both the 2021 and 2022 estimates are based on the 2020 NEI USEPA (2024).

[17] USEPA. (2023). 2020 National Emissions Inventory Technical Support Document: Introduction (Government No. EPA-454/R-23-001a; NEI2020 TSD, pp. 1–15). https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-technical-support-document-tsd

A simple validation plot (below) demonstrates that county-level on-road transportation emissions increase with population as expected.

Figure 26. Validation plot of county transportation emissions and population



Aviation inventory

Aviation emissions are derived from four data sources: Metropolitan Airport Commission (MAC) fuel distribution (2005, 2021), MAC Aircraft emission estimates (2016-2020), MPCA state GHG inventories, and EPA Air Emissions Modeling Platform point sources database[18].

Minneapolis-St. Paul International Airport

Fuel distribution at the airport is the most straight-forward approach, as it involves applying a direct emission factor for jet fuel to the total amount of fuel distributed. As aircraft are generally only fueled for one flight at a time, we are effectively capturing emissions for aircraft flights departing MSP. The assumption is that any given airport (MSP in this case), should be responsible for half of emissions for each arrival and departure, with the complementary departure/recipient airport being responsible for the other half.

[18] USEPA. (2023). *2020 National Emissions Inventory Technical Support Document: Point Sources* (Government EPA-454/R-23-001c; NEI2020 TSD, pp. 1–25). https://www.epa.gov/system/files/documents/2023-01/NEI2020_TSD_Section3_Point.pdf

The second data source, MAC provided emissions are also a highly useful source, with the one overlapping year (2021) resulting in an almost identical emission estimate. However, because it lacks the explicit activity data, we prefer using the fuel distribution.

The final data source, which we used to in-fill interstitial years, 2006-2015 and 2022, relies on MPCA statewide aviation emission estimates. Here, we calculated the proportion of MSP aviation emissions relative to statewide emissions and used a time-series imputation method to fill in the interstitial years' proportions. Then, we recalculated MSP emissions by multiplying the interpolated proportion by the statewide emission estimate. This method proved superior to directly imputing the MSP emissions between 2005 and 2016-2021 (i.e. not using the state data in any form), as those interpolations resulted in three years with MSP emission estimates exceeding the statewide emission estimate.

Reliever airports

In addition to MSP International, the EPA Air Emissions Modeling Platform identifies 22 other sources of aviation emissions in the eleven-county region in 2020. Emissions reported in this data set are only those associated with the landing and take-off portion of flights, and thus under reports emissions from these sources. However, these unaccounted-for emissions are likely to be small relative to those from MSP, and we do not know of an alternative data source. For all other years in our inventory, we calculated the proportion of emissions from these airports relative to the state totals reported by the MPCA in 2020 and used this proportion of state totals for all years. In 2020, reliever airports accounted for 3.3% of regional aviation emissions.

Forecasts

On-road emissions forecasts are completed using two data sources: our regional travel demand model and EPA MOVES.

Regional Travel Demand Model (RTDM) activity data

VMT forecasts for counties and cities are generated from our regional travel demand model[19]. We use the most recent available model runs, concurrent with our long-range transportation plan amendments. The current regional travel demand forecast model (TourCast) is an activity-based model, which means that it simulates transportation decisions made by individuals ranging from long-term (e.g. regular work/school location, whether to own an automobile), day-level (e.g, what activities to engage in, with whom, where, and when), and trip-level (what transportation mode to use, what route to take) in order to evaluate policy and investment choices at a high level of detail.

[19] Metropolitan Council. (2025). Metropolitan Council Travel Forecasting [Government]. Metropolitan Council. https://metrocouncil.org/Transportation/Performance/Travel-Forecasting.aspx

Model inputs include:

- Current population, employment, and other demographic characteristics
- Demographics from Council long-range forecasts[20]
- Road networks based on all projects programmed through year 2025[21]. The projects generally include
  - any project that has a change in capacity (number of lanes) or major interchanges
  - any regionally significant project
  - long-range capital projects

The base-year model outputs best represent 2025 and forecast out to year 2050.

The regional travel demand model network is made up of nodes and links (segments). We use the network link-level information to calculate VMT.

The network-based approach is based on attributing all the vehicle traffic that occurs within a given city or county to that city or county, regardless of where the trip starts or ends. VMT is calculated by multiplying link vehicle volume (vehicles) by link length (miles traveled). Network links are attributed to cities by a spatial join. When a link crosses more than one city boundary, the link is split at the boundary. The link total volume is attributed to both sub-link, and the link length is re-calculated for each sub-link. Thus, no volume is lost. All time periods and road types are aggregated to represent average daily vehicle miles traveled. Daily VMT are expanded to annual VMT using an annualization factor of 340[22].

There are significant limitations. The regional travel demand model, by definition, is built to function at a regional level. Scaling down to geographies smaller than counties might impact model outputs. The model outputs a base year estimate (2025) and future year estimate (2050). All intermediary years (2026-2049) are interpolated linearly between the two points. Total VMT estimates are affected by the truck VMT forecast, which is generally weaker than the passenger VMT forecast. The Council will improve our truck VMT forecasting methodology in coming years. To better homogenize data sources, we assigned the model base-year (2025)

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[20] Metropolitan Council. (2025, February 12). Long-Range Forecasts [Government]. Metropolitan Council. https://metrocouncil.org/Data-and-Maps/Research-and-Data/Thrive-2040-Forecasts.aspx

[21] Metropolitan Council. (2025). Imagine 2050: Long-Range Highway and Transit Capital Project Lists [Government]. Imagine 2050. https://imagine2050.metrocouncil.org/reference-materials/transportation/long-range-highway-and-transit-capital-project-lists/

[22] Porter, C., Chang, X. Y. (Jane), Cleveland, C. J., Fox-Penner, P., Walsh, M. J., Cherne-Hendrick, M., Perez, T., Atkins, J., Cook, C. (2019). Carbon Free Boston: Transportation Technical Report (Carbon Free Boston, pp. 1–117). Boston University Institute for Sustainable Energy. https://sites.bu.edu/cfb/carbon-free-boston-report-released/technical-reports/

estimate to year 2023 and did not use MnDOT VMT estimates from 2023 or 2024. Further research and validation to improve the regional travel demand model is in progress.

EPA MOVES forecast

Emissions forecasts for our region were calculated using the EPA's Motor Vehicle Emissions Simulator (MOVES).[23] MOVES calculates emissions using outputs from the Regional Travel Demand Model, Minnesota Department of Vehicle Services' county vehicle registration data, and the Minnesota Pollution Control Agency's vehicle age distribution. Each of these inputs helps the model estimate the characteristics of vehicles on the road in our region and expected changes in the regional fleet. The model considers differences in fuel economy (miles per gallon) depending on a vehicle's age and size, as well as its fuel intake (diesel or gasoline).

Aviation and freight

Emissions forecasts for aviation and medium- and heavy-duty vehicles were linked to a GCAM[24] model run on behalf of the MPCA for their Climate Action Framework update. Specifically, in each year past 2022, we calculated the expected change in emissions from aviation and medium- and heavy-duty trucks in the GCAM model relative to their baseline of 2020 for their current policy pathway (i.e. business as usual) and potential policy pathways. We based our proposed policies for these subsectors in this climate action plan in accordance with proposals by the MPCA.

Reduction Measures

Emissions reduction forecasts were calculated using the Met Council Greenhouse Gas Reduction Tool underlying code base. The Tool is designed for use at the city level for municipalities in the 7-county core region. Vehicle miles traveled data used in the tool are consistent with data sources referenced

Total emissions for the 11-county region were compiled by totaling up passenger miles traveled and vehicle stocks by fuel type from the city level to the region. The four collar counties (St. Croix, Pierce, Sherburne, Wright) were estimated using the values from Carver County, the most comparable county by current and forecasted number of households, persons, and jobs.

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[23] USEPA. (2023). Population and Activity of Onroad Vehicles in MOVES4 (Government No. EPA-420-R-23-005; MOVES4, pp. 1–233). Office of Transportation and Air Quality. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P101867U.pdf

[24] Calvin, K., Patel, P., Clarke, L., Asrar, G., Bond-Lamberty, B., Cui, R. Y., Di Vittorio, A., Dorheim, K., Edmonds, J., Hartin, C., Hejazi, M., Horowitz, R., Iyer, G., Kyle, P., Kim, S., Link, R., McJeon, H., Smith, S. J., Snyder, A., … Wise, M. (2019). GCAM v5.1: Representing the linkages between energy, water, land, climate, and economic systems. Geoscientific Model Development, 12(2), 677–698. https://doi.org/10.5194/gmd-12-677-2019

The emissions estimates generated using the Tool differ from EPA estimates but work from similar underlying assumptions and use the same critical vehicle miles traveled datasets.

Table 20. Data sources for transportation analysis components

Variable	Data source
Vehicle stock by fuel type, passenger light duty	Market Acceptance of Advanced Automotive Technologies (MA^3T)[25]
Average vehicle occupancy, passenger light duty	2019-2023 Metropolitan Council Travel Behavior Inventory
Vehicle miles traveled	MnDOT VMT Reports; Metropolitan Council Modeling; Metropolitan Council Travel Demand Model
Passenger miles traveled	Vehicle miles traveled multiplied by average vehicle occupancy
Battery electric vehicle electricity fuel consumption	FASTSim, 2015[26]
Electricity fuel cost equivalency in dollars per kWh	Xcel Energy Minnesota Residential Electrical Prices, 2024[27]
Passenger vehicle fuel economy forecast	EIA Annual Energy Outlook 2020[28]
Electrical grid emissions rates in metric tons CO_2e per mWh	MISO[29]

[25] Zhenhong Line, David Greene, & Jake Ward. (2013). User Guide of the ORNL MA3T Model (Government No. V20130729; pp. 1–16). Oak Ridge National Laboratory. https://teem.ornl.gov/assets/custom/pdf/MA3T%20User%20Guide%20v20130729.pdf
[26] Brooker, A., Gonder, J., Wang, L., Wood, E., Lopp, S., & Ramroth, L. (2015). FASTSim: A Model to Estimate Vehicle Efficiency, Cost and Performance (SAE Technical Paper Nos. 2015-01–0973). SAE International. https://doi.org/10.4271/2015-01-0973
[27] Xcel Energy. (2024). Minnesota Residential Electrical Prices (Nos. 24-01-406-MN-Res-ElecRates-MN-Res-E-2002; p. 2). https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/24-01-406-MN-Res-ElecRates-MN-Res-E-2002.pdf
[28] EIA. (2021). Annual Energy Outlook (pp. 1–33) [Government]. US Energy Information Administration. https://www.eia.gov/outlooks/aeo/pdf/AEO_Narrative_2021.pdf
[29] MISO. (2025). 2024 Regional Resource Assessment (pp. 1–45). Midcontinent Independent System Operator (MISO). https://cdn.misoenergy.org/2024%20RRA%20Report_Final676241.pdf

Passenger vehicle emissions rates in metric tons per mile traveled, gasoline and diesel	EPA GHG Factor Hub[30]

The potential policy pathway scenario assumes that 56% of passenger-light duty vehicles in the region are battery electric vehicles by 2050 and an 18% reduction in passenger light-duty vehicle miles traveled relative to the 2050 business-as-usual forecast, which is roughly equivalent to a 20% reduction in vehicle miles traveled per person.

Electricity

Inventory and Baseline

Electricity emissions are quantified using a demand-side approach, aggregating all electricity delivered to end-use customers by utilities operating within our eleven-county study area. This includes deliveries to residential, commercial, and industrial sectors as reported to state and federal authorities. Emissions therefore reflect consumption of electricity within the region/counties, rather than generation, with generation-related emissions occurring outside the region captured instead through emissions factors that reflect the regional grid mix.

The inventory integrates multiple datasets from both Minnesota and Wisconsin to comprehensively capture electricity deliveries and avoid duplication. In Minnesota, energy utilities are required to file annual data reports under MN Rules Chapter 7610, providing county-level energy deliveries in megawatt-hours (mWh)[31]. In Wisconsin, equivalent data are drawn from the Public Service Commission's regulatory filings[32], supplemented by federal Electric Power Energy Report (EIA Form 861) data for cooperative utilities not required to file state-level reports[33]. Together, these datasets encompass the total activity of all utilities operating within the region. The use of state- and federal-level regulatory filings to establish the baseline of electricity activity ensures that our data collection is at the highest level. These data were not available for 2005 in Minnesota, and so a copy of the *Minnesota Utility Data Book,* a report prepared by the MN Dept. of Commerce, which records total energy deliveries by county for the year 2005, was leveraged to establish baseline activity for year 2005.[34]

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[30] USEPA OAR. (2015, July 27). GHG Emission Factors Hub [Overviews and Factsheets]. https://www.epa.gov/climateleadership/ghg-emission-factors-hub
[31] CHAPTER 7610, ENERGY INFORMATION REPORTING (2005). https://www.revisor.mn.gov/rules/7610/
[32] Chapter 196, Regulation of Public Utilities, 35.18 1 (2024). https://docs.legis.wisconsin.gov/statutes/statutes/196
[33] U.S. Energy Information Administration. (2023). *Annual Electric Power Industry Report, Form EIA-861 detailed data files (2021)* [Dataset]. https://www.eia.gov/electricity/data/eia861/
[34] *Minnesota Utility Data Book ... : A Reference Guide to Minnesota Electric and Natural Gas Utilities 1965-2005*. (n.d.). Minnesota Dept. of Commerce; MN Legislative Library. Retrieved July 5, 2024, from https://www.lrl.mn.gov/docs/2008/mandated/080499.pdf

To transform electricity activity data into linked emissions, electricity consumption data from utilities are paired with regional emissions factors from the EPA's *Emissions & Generation Resource Integrated Database* (eGRID) for the Midwest Reliability Organization – West (MROW) subregion[35]. This subregional factor represents the average emissions intensity of electricity consumed in our area, accounting for the specific mix of generation resources feeding the regional grid. The eGRID dataset provides CO_2, CH_4, N_2O, and CO_2e emissions per unit of electricity generated, which we convert to metric tons and multiply by county-level energy deliveries to estimate total emissions.

Identifying Utilities

Electric utilities operating within the eleven-county study area were identified using state-maintained service territory maps. For Minnesota, these are provided by the Minnesota Public Utilities Commission and the Geospatial Information Office.[36] For Wisconsin, service areas are obtained from the Wisconsin Public Service Commission's Electric Service Territory dataset.[37] The combined spatial dataset allows cross-walking of service areas with county boundaries to determine the set of utilities operating within each county.

Collecting and Aggregating Utility Data

Minnesota

For each identified Minnesota utility, 2022 annual data reports were retrieved from the Minnesota Public Utilities Commission's eFiling system. County-level energy deliveries were extracted from the section titled "*ITS DELIVERIES TO ULTIMATE CONSUMERS BY COUNTY FOR THE LAST CALENDAR YEAR."* Reports for all utilities were compiled into a uniform dataset with three core fields: county, utility, and mWh_delivered. For utilities lacking filings (Elk River Municipal Utilities, New Prague Utilities Commission), publicly available financial reports were used to identify total energy delivered, and EIA Form 861 was referenced as a double check. Reports submitted by Great River Energy (GRE), a wholesale cooperative which provides almost 100% of the energy to retail cooperatives within our study area in Minnesota, were used in lieu of the individual reports from these organizations, as their inclusion would have represented full double counting.

Wisconsin

Under Wis. Stat. §196.07, investor- and municipally-owned utilities report annual energy

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[35] United States Environmental Protection Agency (EPA). (2023). Emissions & Generation Resource Integrated Database (eGRID), 2021. Washington DC: Office of Atmospheric Protection, Clean Air and Power Division. https://www.epa.gov/egrid.

[36] Minnesota IT Geospatial Information Office. (2023). *Electric Utility Service Areas, Minnesota, January 2023* [Dataset]. https://gisdata.mn.gov/dataset/util-eusa

[37] Wisconsin Public Service Commission, D. of E. R., & Tomaszewski, T. (2024). *Electric Service Territories* [Dataset]. https://maps.psc.wi.gov/portal/apps/webappviewer/index.html?id=bb1a9f501e3d472cbde970310540b466

deliveries to the Public Service Commission.[38] Cooperative utilities, however, do not report at the same level of detail; for these, we used EIA Form 861,[39] which provides total annual retail sales and customer counts. Utility-county level allocations were estimated by multiplying statewide deliveries by the proportion of customer accounts or population residing in each county, depending on data availability. This approach assumes uniform per-account electricity demand across counties within a utility's service area, which introduces modest uncertainty but maintains internal consistency across reporting types.

Sectoral Allocation

While utility-reported data typically represent total deliveries across all customer types, sector-level emissions (residential, commercial, industrial) were estimated using modeled proportions from NREL's SLOPE platform,[40] which provides county-sector level forecasts of electricity consumption out to 2050. We used these proportions at the county level in year 2022 to distribute total utility-delivered electricity into sectoral components for reporting and comparison purposes.

As a simple validation test, we see that county level electricity consumption emissions increase with population.

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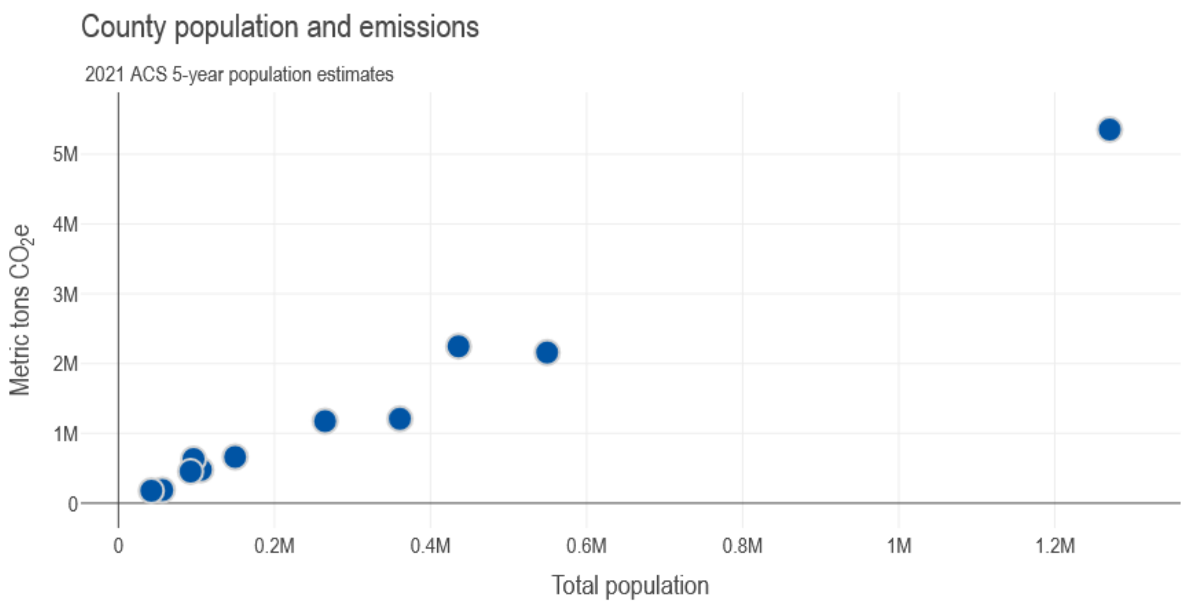
[38] NREL. (2019). *Business-as-Usual Electricity and Natural Gas Consumption and Expenditure Projections* (State and Local Energy Planning (SLOPE) Tool, pp. 1–4) [Government]. NREL. https://app.box.com/s/t0t3j6zztzan94a4tu1so8pse4btkkn1

[39] U.S. Energy Information Administration. (2023). *Annual Electric Power Industry Report, Form EIA-861 detailed data files (2021)* [Dataset]. https://www.eia.gov/electricity/data/eia861/

[40] NREL. (2019). *Business-as-Usual Electricity and Natural Gas Consumption and Expenditure Projections* (State and Local Energy Planning (SLOPE) Tool, pp. 1–4) [Government]. NREL. https://app.box.com/s/t0t3j6zztzan94a4tu1so8pse4btkkn1

Figure 27. Validation plot of county electricity emissions and population



Projections and reduction measures

Electricity emissions projections represent forecasted emissions linked to utility-delivered electricity across the residential, commercial, and industrial sectors. Projection methods differ across sectors but follow a common structure: the BAU projection extends baseline consumption using local growth and activity data with fixed intensities, while the current policy scenarios reflects expected response of utilities to the Minnesota Clean Energy Standard and Wisconsin's Office of Sustainability and Clean Energy stated goal of a carbon-free grid by 2050. For each subsector, electricity emissions are calculated as the product of total projected electricity consumption and the projected carbon intensity of the regional grid. We used MISO grid emission projections based on their 2024 Regional Resource Assessment[41]. These projections were provided out to 2043 and we extended them to 2050 by extrapolating linearly in log-log space to avoid negative projected emissions. While the grid projection includes states beyond Minnesota and Wisconsin we observed that emissions are near zero by 2040 and functionally zero by 2050, in line with the aspirations of the two states in our inventory.

The BAU projection reflects the continuation of recent consumption trends and the growth of underlying activity. In the BAU, electricity demand is projected as a function of three parameters (forecast employment, population, and households) for the entire 11-county study

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[41] MISO. (2025). 2024 Regional Resource Assessment (pp. 1–45). Midcontinent Independent System Operator (MISO). https://cdn.misoenergy.org/2024%20RRA%20Report_Final676241.pdf

area. For the seven MN counties included in the core metro (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, Washington), these jobs and population/households projections come from the Metropolitan Council's local forecasts for the seven-county core area, which were developed using UrbanSim[42]. UrbanSim is a microsimulation model that projects household and employment location choices at the Census block level, and enables the provision of forecasted population, households, and employment at the city- and county-levels out to 2050[43]. UrbanSim integrates demographic, economic, and land-use inputs to produce forecasts of housing at these geographies by type (single-family detached, single-family attached, multifamily), allowing emissions projected to be enriched by housing-type-specific energy intensities.

For the two MN counties and the two WI counties within the CPRG planning area but outside the core metro, where projected residential housing mix (prevalence of single family and multifamily housing) data from UrbanSim do not exist, we quantify residential housing mix (% of households in single family or multifamily) using the most recent ACS data[44]. We extend these proportions forward to 2050, thus assuming that residential housing mix does not change for the purposes of our projection. We extend these projections using demographic and employment data from the Minnesota and Wisconsin state demographers.[45][46] In these counties, total housing unit growth is used to approximate residential energy demand, applying the same per-unit electricity intensities from comparable housing types in the UrbanSim-modeled area. This ensures that total regional residential electricity use remains consistent with observed growth patterns while maintaining realistic differences in household energy use across counties in our study area.

For commercial and industrial electricity, BAU projections are calculated by quantifying megawatt-hours per job using observed 2022 data, and then subsequently applying these factors to forecasted job growth by county forward through 2050. Each year's MWh total is converted to emissions using a year-specific grid carbon intensity factor, which means our projections implicitly assume that emissions decline over time only as a function of grid decarbonization and not some presently expected program of structural energy efficiency improvements.

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[42] Metropolitan Council. (2025, February 12). *Long-Range Forecasts*. Metropolitan Council. https://metrocouncil.org/Data-and-Maps/Research-and-Data/Thrive-2040-Forecasts.aspx
[43] *UrbanSim Artificial Intelligence For Sustainable Development with AI*. UrbanSim. https://www.urbansim.com
[44] U.S. Census Bureau. (2021). *American Community Survey 5-Year Estimates: Comparison Profiles 5-Year,* [Dataset]. http://api.census.gov/data/2022/acs/acs5
[45] Dayton, M. (2024). *Minnesota Long Term Population Projections* [Dataset]. https://mn.gov/admin/demography/data-by-topic/population-data/our-projections/
[46] Department of Administration, S. of W. (n.d.). *Wisconsin State and County Population Projections 2020-2050* [Dataset]. https://doa.wi.gov/Pages/LocalGovtsGrants/Population_Projections.aspx

We model only one pathway in this sector: business-as-usual. Because both states have carbon-free grid targets, with Minnesota's encoded in statute, we do not model further policy pathways for this sector. In the CCAP itself, we nonetheless encourage energy efficiency and electricity generation policies such as solar microgrids to address increased demand on the grid from electrification.

Building Energy

Natural Gas

Inventory and Baseline

For this inventory, we quantify natural gas emissions using a demand-side framework that aggregates all gas deliveries to end-use customers served by utilities operating within our eleven-county study area. Emissions are calculated based on reported volumes of gas delivered to end users, multiplied by emissions factors from the EPA Greenhouse Gas Emissions Factor Hub.[47]Primary data sources include state-mandated utility filings to the Minnesota Public Utilities Commission (PUC)[48] and Wisconsin Public Service Commission (PSC),[49] supplemented by federal data when state filings were unavailable. These datasets provide regulatory-grade coverage of utility activity and form a comprehensive record of natural gas use across the region.

Identifying Utilities

We identified all natural gas utilities operating within the eleven-county study area using a combination of state and federal service territory datasets. For Wisconsin, we used the *Natural Gas Service Territory* dataset published by the Wisconsin Public Utilities Commission.[50] For Minnesota, since no state-maintained equivalent exists, we used the Homeland Infrastructure Foundation-Level Data (HIFLD) Natural Gas Service Territories dataset maintained by the US Department of Homeland Security.[51] Spatial intersections between these utility service areas and county boundaries were used to establish which utilities operate within each of the eleven counties.

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[47] USEPA. (2021). *GHG Emission Factors Hub* (Version 2021) [Dataset]. https://www.epa.gov/system/files/documents/2023-04/emission-factors_sept2021.pdf
[48] CHAPTER 7610, ENERGY INFORMATION REPORTING (2005). https://www.revisor.mn.gov/rules/7610/
[49] Chapter 196, Regulation of Public Utilities, 35.18 1 (2024). https://docs.legis.wisconsin.gov/statutes/statutes/196
[50] Wisconsin Public Service Commission, D. of E. R., & Tomaszewski, T. (2024). *Natural Gas Service Territories* [Dataset]. https://maps.psc.wi.gov/portal/apps/webappviewer/index.html?id=a412f6ab20fb4ef8afe361621847c472
[51] Department of Homeland Security. (2017). *Natural Gas Service Territories—Homeland Infrastructure Foundation-Level Data* [Dataset]. https://hifld-geoplatform.opendata.arcgis.com/maps/natural-gas-service-territories

Collecting and Aggregating Utility Data

MINNESOTA

All natural gas utilities authorized to operate in Minnesota must file annual reports under MN Rules Chapter 7610.[52] These filings, available through the PUC's eFiling system, include county-level energy deliveries reported in *thousand cubic feet (mcf)* under the section titled *"ANNUAL GAS DELIVERED TO ULTIMATE CONSUMERS BY COUNTY."* Data for each in-scope utility were aggregated to the county level to produce total reported deliveries for all utilities operating within each county.

WISCONSIN

In Wisconsin, all municipal and investor-owned natural gas utilities are required to file annual operational and financial reports under Wis. Stat. §196.07.[53] These reports are accessible through the PSC's E-Services Portal and contain information on total energy deliveries (in *therms*) and the number of customer accounts by county.

Since all four in-scope Wisconsin gas utilities are investor-owned, state filings alone provided the necessary data—no federal sources were needed. For each utility, we calculated the proportion of customer accounts located in either Pierce or St. Croix counties, multiplied that proportion by the utility's total statewide energy deliveries, and allocated results to each county. This approach implicitly assumes uniform per-account demand within a utility's service area, though in reality energy use varies by land use and customer mix.

Sectoral Allocation

While utility-reported data typically represent total deliveries across all customer types, sector-level emissions (residential, commercial, industrial) were estimated using modeled proportions from NREL's SLOPE platform, which provides forecasts of natural gas consumption out to 2050.[54] We used these proportions at the county level in year 2021 to distribute total utility-delivered natural gas into sectoral components for reporting and comparison purposes.

Emissions Calculation

Reported natural gas deliveries (in mcf or therms) were converted to emissions (in metric tons CO_2e) using factors from EPA's 2022 Greenhouse Gas Emission Factors Hub.[55] Factors

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[52] CHAPTER 7610, ENERGY INFORMATION REPORTING (2005). https://www.revisor.mn.gov/rules/7610/
[53] Chapter 196, Regulation of Public Utilities, 35.18 1 (2024). https://docs.legis.wisconsin.gov/statutes/statutes/196
[54] NREL. (2019). *Business-as-Usual Electricity and Natural Gas Consumption and Expenditure Projections* (State and Local Energy Planning (SLOPE) Tool, pp. 1–4) [Government]. NREL.
[55] USEPA. (2021). *GHG Emission Factors Hub* (Version 2021) [Dataset]. https://www.epa.gov/system/files/documents/2023-04/emission-factors_sept2021.pdf

account for CO_2, CH_4, and N_2O associated with the combustion of pipeline natural gas. Conversions between therms, mcf, and metric tons CO_2e were standardized across utilities, ensuring consistent treatment of state and federal data sources. Total regional emissions represent the sum of all natural gas delivered to ultimate consumers across the eleven counties, inclusive of all sectors.

Double Counting

Avoiding double counting between sectors is essential for accurate accounting of natural gas emissions. While this analysis reflects total utility-delivered natural gas consumption, combustion of natural gas at industrial facilities that maintain independent supply (e.g., refineries) is captured within the industrial process sector. Conversely, natural gas delivered by utilities to industrial customers is counted here under the natural gas sector and omitted from the industrial process inventory.

The two major refineries in the region—both of which maintain their own independent gas access—are assumed to account for all non-utility natural gas combustion, ensuring no overlap with utility-reported consumption. Natural gas used for electricity generation is captured within our electricity demand analysis.

Projections and Reduction Measures

Natural gas emissions projections represent forecasted on-site combustion from utility-delivered fuel across residential, commercial, and industrial buildings. These emissions are organized into three subsectors (residential, commercial, and industrial building fuel) to align with end-use categories rather than specific fuel types or industrial processes. Natural gas represents a significant portion of building fuel use projected for our region. Projection methods differ across subsectors but follow a common structure: the BAU projection extends baseline consumption using local growth and activity data with fixed intensities, while policy scenarios apply downscaled proportional changes from GCAM's state-level emissions pathways to reflect expected efficiency gains, electrification, and fuel switching.

In the BAU, natural gas demand is modeled as a function of three forecast parameters (forecasted employment, population, and households) for the entire 11-county study area. For the seven MN counties included in the core metro (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, Washington), these jobs and population/households projections come from the Metropolitan Council's local forecasts for the seven-county core area, which were developed using UrbanSim[56]. UrbanSim is a microsimulation model that projects household and employment location choices at the Census block level, and enables the provision of forecasted population, households, and employment at the city- and county-levels out to

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[56] Metropolitan Council. (2025, February 12). *Long-Range Forecasts*. Metropolitan Council. https://metrocouncil.org/Data-and-Maps/Research-and-Data/Thrive-2040-Forecasts.aspx

2050[57]. UrbanSim integrates demographic, economic, and land-use inputs to produce forecasts of housing at these geographies by type (single-family detached, single-family attached, multifamily), allowing emissions projected to be enriched by housing-type-specific energy intensities.

For the two MN counties and the two WI counties within the CPRG planning area but outside the core metro, where projected residential housing mix (prevalence of single family and multifamily housing) data from UrbanSim do not exist, we quantify residential housing mix (% of households in single family or multifamily) using the most recent ACS data[58]. We extend these proportions forward to 2050, assuming that residential housing mix does not change for the purposes of our projection. We extend these projections using demographic and employment data from the Minnesota and Wisconsin state demographers.[59][60] In these counties, total housing unit growth is used to approximate residential natural gas demand, applying the same per-unit natural gas intensities from comparable housing types in the UrbanSim-modeled area. This ensures that total regional residential electricity use remains consistent with observed growth patterns while maintaining realistic differences in household energy use across counties in our study area.

Policy-aligned residential natural gas projections are calibrated to match GCAM's long-term decarbonization pathways by adjusting retrofit and electrification parameters in the building model. Specifically, we identify the combination of new homes built to LEED Gold, existing homes retrofitted for efficiency, and homes adopting heat pumps that yield 2050 emissions levels consistent with GCAM's proportionate reductions from 2005. This optimization process ensures our regional policy pathway mirrors GCAM's emission intensity trajectory while maintaining a locally grounded representation of the housing stock and retrofit potential. For the commercial and industrial subsectors, we project natural gas emissions using employment-based scaling. We compute baseline emissions per job from observed 2022 emissions and apply these ratios to county-level employment forecasts, generating a BAU trajectory that reflects projected economic expansion (using jobs as an analogue) without policy-driven reductions. Policy pathways are downscaled from GCAM by matching our subsectors to GCAM's "Commercial natural gas," "Industrial natural gas," and "Commercial fuel combustion" categories and applying GCAM's proportion-of-2020 reductions to local baselines. This preserves the shape of the GCAM decarbonization pathway while ensuring regional totals remain consistent with observed data and local growth patterns.

Together, these methods produce a set of internally consistent natural gas projections that capture the interplay between population and employment growth, building stock evolution,

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[57] *UrbanSim Artificial Intelligence For Sustainable Development with AI*. UrbanSim. https://www.urbansim.com
[58] U.S. Census Bureau. (2021). *American Community Survey 5-Year Estimates: Comparison Profiles 5-Year,* [Dataset]. http://api.census.gov/data/2022/acs/acs5
[59] Dayton, M. (2024). *Minnesota Long Term Population Projections* [Dataset]. https://mn.gov/admin/demography/data-by-topic/population-data/our-projections/
[60] Department of Administration, S. of W. (n.d.). *Wisconsin State and County Population Projections 2020-2050* [Dataset]. https://doa.wi.gov/Pages/LocalGovtsGrants/Population_Projections.aspx

and state-level policy ambition. The BAU scenario represents a continuation of current energy use intensities with growth in activity, while the policy scenarios apply GCAM-derived proportional reductions scaled to local baselines and adjusted for ambition in policy adoption.

Industrial Processes

Inventory and baseline

Industrial process emissions are distinguished here as emissions stemming from industrial point sources that are *not* associated with utility delivered electricity or natural gas. In other words, a large amount of industrial emissions are represented in the electricity and building energy sectors. Emissions detailed here are derived from data provided by the MN Pollution Control Agency (MPCA) on industrial and commercial fuel combustion data and the EPA Greenhouse Gas Reporting Program[61] (GHGRP), including its subpart C breakout of fuel combustion emissions. These datasets have strengths and limitations which complement one another. The MPCA data has smaller facilities and commercial fuel combustion, but dates back only to 2016 and only provides emissions from fuel combustion. GHGRP has facility source data dating back to 2010, but only facilities with 25,000+ metric tons of annual CO_2e emissions are required to report to this program. We also consider the National Emissions Inventory[62] (NEI), which aggregates county data including smaller facilities, but only has GHG emission estimates for 2017 and 2020 and lacks source level specificity needed to avoid double counting.

Double counting

A key concern for industrial emissions is avoiding double counting, particularly natural gas combustion, electricity generation, and waste management. Our energy analysis uses a demand side approach to allocate electricity usage and natural gas combustion to residential, commercial, and industrial sectors. For electricity, this meant omitting industrial emissions that arise from electricity generation (note GHGRP and NEI already avoid counting electricity consumption at industrial facilities in their analyses). Natural gas consumption requires greater care, as combustion for industrial units (e.g. boilers) may be one of or some combination of natural gas, petroleum products, coal, or other fuel sources; additionally utility provisioning of natural gas may not account for all natural gas combustion at industrial sources. Our current approach assumes only the two major refineries in-bounds have natural gas access independent of the utilities; thus all other natural gas combustion reported by industrial point sources are assumed to be counted in utility reporting[63]. Our waste sector accounts for

[61] US EPA, OAR. (2014, June 10). *Greenhouse Gas Reporting Program (GHGRP)* [Other Policies and Guidance]. https://www.epa.gov/ghgreporting
[62] US EPA, OAR. (2015, June 2). National Emissions Inventory (NEI) [Other Policies and Guidance]. https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei
[63] We verified this assumption through personal communication with two of the larger point sources with significant natural gas combustion.

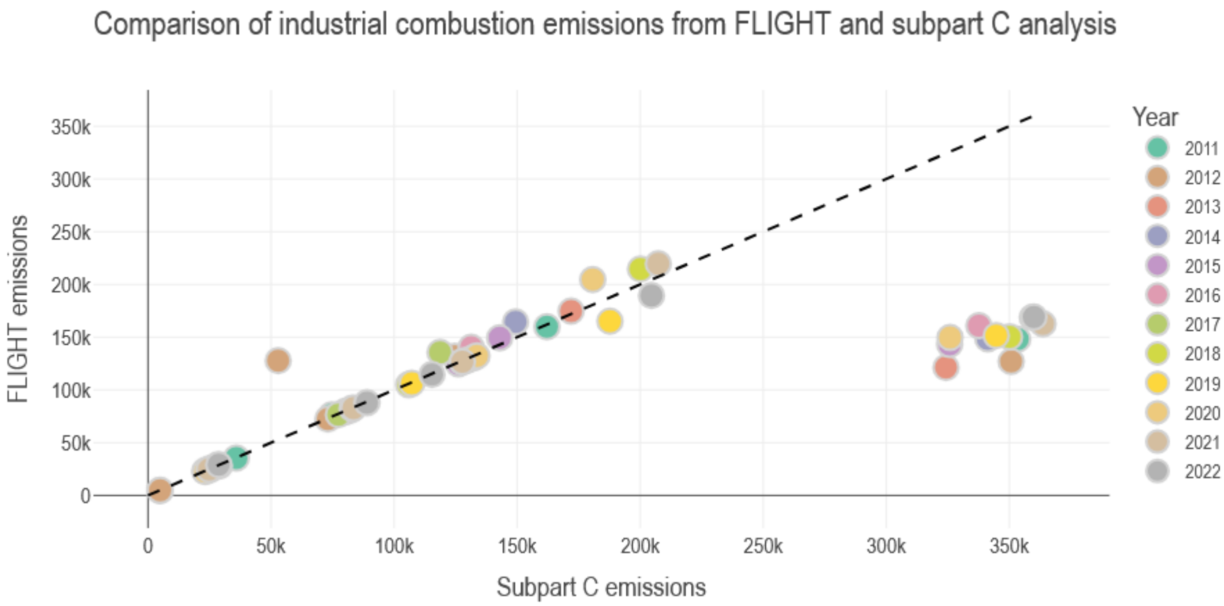
municipal waste emissions but not industrial waste facilities, so the latter is included here while the former is omitted.

Data processing

In the GHGRP data, we identified and omitted industrial sources labeled with subpart D (electricity generation) or DD (municipal waste) and separated sources labeled with subpart Y (refineries) as we would retain all of their emissions as noted above. For validation, we also extracted total emissions associated with facilities that only had subpart C, or fuel combustion, emissions. Next, in the subpart C, we used the "FUEL_DATA" tab of the Excel workbook. Because this tab only reported in N_2O and CH_4 emissions and not CO_2 emissions, we back-calculated each of these to the activity data based on IPCC AR4 assessment global warming potential and EPA's factor hub[64] on emissions per fuel unit. We found high agreement on fuel units between back-calculating from CH_4 and back-calculating from N_2O, providing high confidence in this approach. From there, we calculated CO_2 emissions again using EPA's factor hub. In the graph below, there is high agreement between our subpart C analysis (x-axis) and the facilities with only subpart C emissions from GHGRP (y-axis). The clear outlier to the right is the Hennepin Energy Recovery Center which has significant on-site emissions from biogenic carbon dioxide emissions (i.e. biofuel combustion) which is assumed to be carbon neutral in GHGRP and thus not counted.

[64] USEPA. (2021). *GHG Emission Factors Hub* (Version 2021) [Dataset]. https://www.epa.gov/system/files/documents/2023-04/emission-factors_sept2021.pdf

Figure 28. Comparison of industrial emissions from facilities reporting only combustion emissions from two GHGRP component datasets



Our subpart C analysis allowed us to subtract out emissions associated with natural gas that was assumed to be delivered by utilities. We aggregated the industrial facility data into four categories: industrial fuel combustion, refinery processes, and industrial processes. Refinery processes includes emissions associated with hydrogen fuel production, stationary combustion, and natural gas flaring. The industrial process category includes non-combustion emissions such as methane from industrial waste facilities and fluorinated gas emissions from electronics manufacturing.

We used MPCA fuel combustion data to account for fossil fuel combustion other than natural gas at facilities that are not required to report to the GHGRP (i.e. less than 25,000 metric tons of annual CO_2e emissions). This dataset assigned point sources to either the commercial or industrial sector. We incorporated both, keeping the sector designations. To again avoid double counting, we omitted industrial emissions from any city or township that was counted in the GHGRP data, as matching facilities between datasets proved difficult. Thus, we likely under-reported from this dataset, although combustion emissions beyond natural gas we generally minimal. We did not have an analog dataset for the two Wisconsin counties and no point sources were reported in GHGRP, so we have no industrial process emissions to report there.

Projections and reduction measures

We anchored business as usual and potential policy pathways to projections generated by the GCAM[65] model run on behalf of the MPCA for their Climate Action Framework update. Specifically, we identified emissions sources that matched our three broad categories of industrial fuel combustion, industrial processes, and refinery processes. In each year past 2022, we calculated the expected change in emissions from each of these subsectors relative to their baseline of 2020 for their current policy pathway (i.e. business as usual) and potential policy pathways. We based our proposed policies in this climate action plan in accordance with proposals by the MPCA.

Waste

Inventory and baseline

Waste emissions consist of two primary sources: solid waste disposal and wastewater treatment. Each source is estimated using distinct methods and data sources that reflect the nature of the underlying systems and the availability of information in Minnesota and Wisconsin. Solid waste emissions are based on the management and processing of municipal solid waste, while wastewater emissions are tied to the treatment of domestic and industrial effluent. Because data collection, reporting structures, and applicable methodologies differ between these systems, the following sections describe separate approaches for estimating emissions from solid waste and wastewater across the Twin Cities metropolitan region.

Solid waste

Solid waste emissions for Minnesota and Wisconsin are calculated using two different methods due to a difference in data availability.

Minnesota

Minnesota's solid waste emissions are estimated using methodologies recommended by the Intergovernmental Panel on Climate Change (IPCC)[66]. The methodologies were selected to align with best practices for community-wide inventories using the IPCC recommendations and the guidance of the Global Protocol for Community-Scale Greenhouse Gas Inventories[67].

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[65] Calvin, K., Patel, P., Clarke, L., Asrar, G., Bond-Lamberty, B., Cui, R. Y., Di Vittorio, A., Dorheim, K., Edmonds, J., Hartin, C., Hejazi, M., Horowitz, R., Iyer, G., Kyle, P., Kim, S., Link, R., McJeon, H., Smith, S. J., Snyder, A., … Wise, M. (2019). GCAM v5.1: Representing the linkages between energy, water, land, climate, and economic systems. Geoscientific Model Development, 12(2), 677–698. https://doi.org/10.5194/gmd-12-677-2019

[66] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. (2006). Intergovernmental Panel on Climate Change. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

[67] Fong, W. K., Sotos, M., Doust, M., Schultz, S., Marques, A., & Deng-Beck, C. (2021). *Global Protocol for Community-Scale Greenhouse Gas Inventories* (No. Version 1.1; pp. 1–190). World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI - Local Governments for Sustainability. https://ghgprotocol.org/ghg-protocol-cities

LANDFILL

The IPCC suggests two alternatives for calculating landfill emissions, a first order decay model and a methane commitment model. The first order decay model is often used for larger-scale inventories, such as the US Federal Inventory, and requires waste data going back to 1950. Given the data available and the scope of this inventory, we chose to instead use the simpler methane commitment model to calculate county-level emissions for Minnesota.

The methane commitment model calculates methane emissions from landfills for a given year by multiplying municipal solid waste totals by a methane generation potential and adjusting for oxidation and methane flaring,

$$\mathrm{Emissions}_{\mathrm{CH_4}} = [(\mathrm{MSW} \times \mathrm{L_0}) - \mathrm{rec}] \times (1 - \mathrm{ox})$$

where MSW is the amount of municipal solid waste processed in landfills, reported on a county level by MPCA's SCORE report[68]. $\mathrm{L_0}$ is the methane generation potential. In some processes, the amount of methane recovered from landfills (rec), either through methane flaring or landfill gas to energy programs, is subtracted here. Due to data concerns and best practices recommendations, we have chosen not to include methane recovery in our Minnesota emissions calculations. $1 - \mathrm{ox}$ accounts for oxidation in the landfill. Our oxidation value is assigned the IPCC default of 0.1.

$\mathrm{L_0}$, the methane generation potential, is calculated as follows:

$$\mathrm{L_0} = \mathrm{MCF} \times \mathrm{DOC_f} \times \mathrm{F} \times 16/12 \times \mathrm{DOC}$$

where:

- $\mathrm{MCF} =$ methane commitment factor. Assigned IPCC default of 0.5 for managed, semi-aerobic landfills.
- $\mathrm{DOC_f} =$ fraction of degradable organic carbon degraded. Assigned IPCC default of 0.6.
- $\mathrm{F} =$ fraction of methane in landfill gas. Assigned IPCC default of 0.5.
- $16/12 =$ ratio of methane (CH_4) to carbon (C) by atomic weight.

[68] MPCA. (2023). *Sustainable materials management and solid waste policy report* (Government No. lrw-sw-1sy23; pp. 1–68). Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/lrw-sw-1sy23.pdf

- DOC = degradable organic carbon. Calculated based on local waste makeup data from MPCA's 2013 Statewide Waste Characterization study[69], using the equation:

$$\mathrm{DOC} = \left(0.4 \times \frac{\text{paper}}{\text{textiles}}\right) + (0.17 \times \text{non-food organics}) + (0.15 \times \text{food waste}) + \left(0.3 \times \frac{\text{wood}}{\text{straw}}\right)$$

COMPOST

Compost produces both methane and nitrous oxide. Emissions are calculated by multiplying waste activity totals by emissions factors divided between aerobic and anaerobic digesters. Since Minnesota only has one anaerobic digester that is outside the inventory area, we assumed 0% anaerobic digestion within the inventory area.

$$\mathrm{Emissions}_{\mathrm{CH_4}} = \mathrm{MSW}_{\mathrm{compost}} \times 10 \times 10^{-3}$$

$$\mathrm{Emissions}_{\mathrm{N_2O}} = \mathrm{MSW}_{\mathrm{compost}} \times 0.6 \times 10^{-3}$$

As in other sections, MSW activity data comes from MPCA's SCORE report. The emissions factors of 10 and 0.6 come from IPCC default values.

INCINERATION

Since incineration data is reported to SCORE as Waste to Energy, it is assumed that all incineration in the MSA is considered Waste to Energy.

Incineration of waste produces CH_4, CO_2, and N_2O emissions. However, the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories reports negligible CH_4 emissions for continuous incineration facilities.

$$\mathrm{Emissions}_{\mathrm{CO_2}} = [(\mathrm{MSW}_{\mathrm{incinerated}} \times \mathrm{E_i}) + (\mathrm{MSW}_{\mathrm{onsite}} \times \mathrm{E_0})] \times \mathrm{FCC} \times \mathrm{FFC} \times 44/12$$

$$\mathrm{Emissions}_{\mathrm{N_2O}} = \mathrm{MSW}_{\mathrm{incinerated}} \times \mathrm{EF}_{\mathrm{N_2O}} \times 10^{-6}$$

where:

- $\mathrm{MSW}_{\mathrm{incinerated}}$ = municipal solid waste incinerated, as reported by SCORE.
- $\mathrm{E_i}$ = efficiency of combustion for incineration. Assigned IPCC default of 95%.
- $\mathrm{MSW}_{\mathrm{onsite}}$ = municipal solid waste burned onsite, as reported by SCORE.
- $\mathrm{E_0}$ = efficiency of combustion for onsite burning. Assigned Greenhouse Gas Protocol default of 71%.

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[69] MPCA & Burns & McDonnell Engineering Company, Inc. (2013). *Minnesota statewide waste characterization study* (Government No. w-sw1-60; pp. 1–59). Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/w-sw1-60.pdf

- FCC = fraction of carbon content in MSW. Assigned IPCC default of 40%.
- FFC = fraction of fossil carbon in MSW. Assigned IPCC default of 40%.
- $44/12$ = ratio of carbon dioxide (CO_2) to carbon (C) by atomic weight.
- EF_{N_2O} = aggregate N_2O emission factor for MSW. Assigned GHG Protocol default of 50 g N_2O/ metric tons waste for continuous and semi-continuous incinerators.

LIMITATIONS

Because the methane commitment method for landfill emissions calculates emissions slightly differently than the IPCC-encouraged First Order Decay model, landfill results may differ slightly from sources that use First Order Decay, such as the EPA's National Inventory and its State Inventory Tools. Both methods are accepted as valid ways to estimate solid waste emissions.

MPCA SCORE does not report activity data for waste generated and processed by industry.

Emissions are not calculated for waste that is recycled, as any emissions generated in the recycling process come from the energy use of the facilities or transportation and are accounted for in other sectors of this inventory.

Wisconsin

Wisconsin emissions are calculated by interpolating and scaling down state-level emissions data from the Wisconsin DNR[70].

This 2022 inventory estimates landfill and waste-to-energy emissions for the years 2005 and 2018, including methane recovery offsets. Emissions between 2005 and 2018 were linearly interpolated when data were unavailable for a particular year. Due to the small amount of change in emissions, it was assumed that emissions from 2018 to 2022 were constant. These emissions were then allocated to counties based on population.

A simple validation test shows that county level solid waste emissions increase with population as expected.

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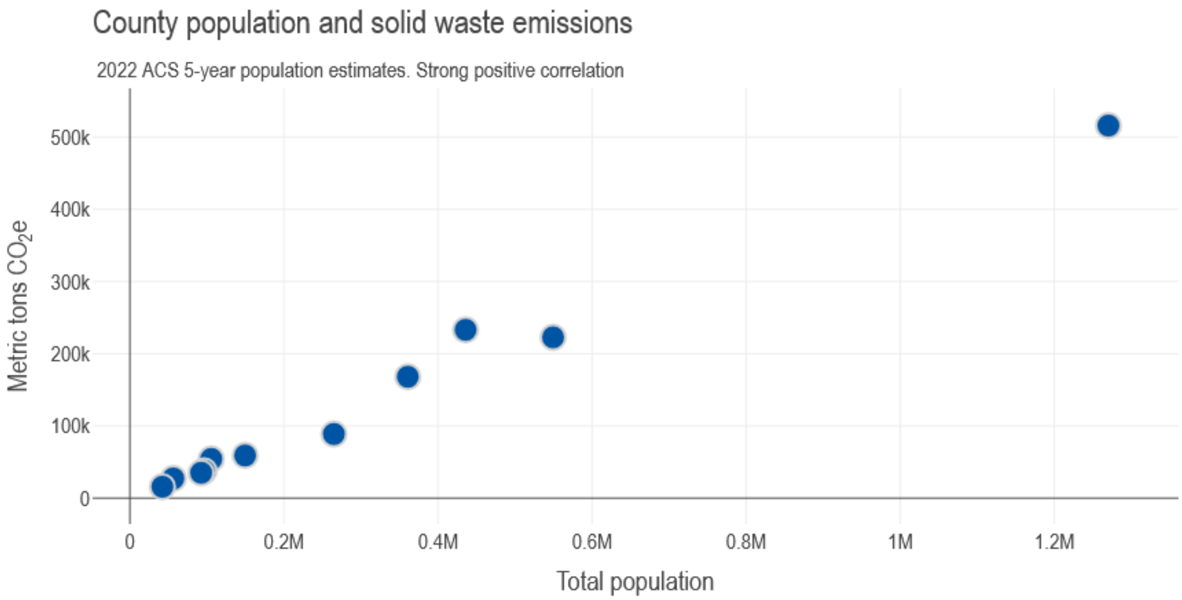
[70] Wisconsin DNR. (2021). *Wisconsin Greenhouse Gas Emissions Inventory Report* (Government No. AM-610-2021; pp. 1–45). https://widnr.widen.net/view/pdf/o9xmpot5x7/AM610.pdf?t.download=true

Figure 29. Validation plot of county solid waste emissions and population



Wastewater

Municipal wastewater emissions were calculated using two primary data sources: county population, used as a first-order driver, and the EPA State Inventory Tool (SIT)[71], which provides state-specific emission factors and algorithms based on IPCC guidelines[72].

Municipal CH_4

CH_4 emissions from municipal wastewater treatment are calculated by multiplying the county population by a per-capita biological oxygen demand rate (BOD_5, kg/day), which is then scaled to an annual BOD mass (in metric tons). That value is multiplied by the fraction of wastewater that is treated anaerobically, and by the CH_4 produced per metric ton of BOD_5 (i.e. the emission factor).

$$\mathrm{Emissions}_{\mathrm{CH_4}} = \text{Population} \times \mathrm{BOD}_5 \times 365 \times 10^{-3} \times \mathrm{FTA} \times \mathrm{EF}_{\mathrm{CH_4}}$$

Where:

[71] USEPA. (2024). *State Greenhouse Gas Inventory Tool User's Guide for the Wastewater Module* (GHG Inventory Tools: State, pp. 1–18) [Government]. State Energy and Environment Program. https://www.epa.gov/system/files/documents/2024-02/wastewater-users-guide_508.pdf

[72] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. (2006). Intergovernmental Panel on Climate Change. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

- Population = the population of a given county.
- BOD_5 = per capita 5-day biological oxygen demand rate. Assigned EPA default is 0.09 kg/day.
- 365 = days per year.
- 10^{-3} = metric tons per kg.
- FTA = fraction treated anaerobically.
- EF_{CH_4} = CH_4 emission factor for wastewater, expressed as the ratio of CH_4 produced per metric ton of BOD_5. Assigned EPA default is 0.6 Gg CH_4/ Gg BOD_5.

Municipal N_2O

N_2O is emitted from domestic wastewater containing nitrogen-rich organic matter through the natural processes of nitrification and denitrification. Nitrification occurs aerobically and converts ammonia (NH_3) into nitrate (NO_3^-), whereas denitrification occurs anaerobically, and converts nitrate to N_2O. Human sewage is believed to constitute a significant portion of the material responsible for N_2O emissions from wastewater[73].

Direct N_2O emissions from municipal wastewater treatment are calculated by multiplying total population served with the fraction of the population not using septic systems, and by a per-capita N_2O emission factor:

$$\mathrm{Emissions}_{N_2O,\ \text{direct}} = \text{Population} \times \mathrm{FNS} \times \mathrm{EF}_{N_2O} \times 10^{-6}$$

Where:

- Population = the population of a given county.
- FNS = fraction not on septic systems. EPA default is 83%.
- EF_{N_2O} = direct N_2O emission factor for wastewater, expressed as the ratio of N_2O produced per person per year. Assigned EPA default is 4 g N_2O/person/year.
- 10^{-6} = metric tons per g.

Municipal wastewater N_2O emissions from biosolids are calculated by multiplying the county population by the total annual protein consumption, by the nitrogen content of protein and fraction of nitrogen not consumed, and by an N_2O emission factor per metric ton of nitrogen treated, then subtracting direct emissions as well as the percentage of biosolids used as fertilizer. Data on annual per capita protein consumption for the United States have been

[73] Spector, M. (1998). Production and decomposition of nitrous oxide during biological denitrification. *Water Environment Research*, *70*(5), 1096–1098. https://doi.org/10.2175/106143098X123453

published by the United States EPA in Table 7-34 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks (U.S. EPA)[74].

$$\text{N in domestic wastewater (metric tons)} = \text{Population} \times \text{Protein} \times \mathrm{FNP} \times \mathrm{FNC} \times 10^{-3}$$

$$\text{Biosolids available N (metric tons)} = \text{N in domestic wastewater} - (\mathrm{Emissions}_{N_2O\text{, direct}} \times 44/28)$$

$$\mathrm{Emissions}_{N_2O\text{, effluent}} = \text{Biosolids available N} \times (1 - \mathrm{FBF}) \times \mathrm{EF}_{N_2O} \times 44/28$$

Where:

- Population = the population of a given county.
- Protein = annual per capita protein consumption (kg/person/year).
- FNP = fraction of N in protein. EPA default is 16%.
- FNC = fraction of N not consumed. EPA default is 1.75.
- 10^{-3} = metric tons per kg.
- $44/28$ = ratio of nitrous oxide (N_2O) to nitrogen (N_2) by atomic weight.
- FBF = fraction of biosolids used as fertilizer. EPA default is 1.75.
- EF_{N_2O} = effluent N_2O emission factor for wastewater, expressed as the ratio of kg N_2O produced per kg sewage N produced. Assigned EPA default is 0.005.

Total N_2O emissions are thus expressed as the sum of direct and effluent N_2O emissions:

$$\mathrm{Emissions}_{N_2O\text{, total}} = \mathrm{Emissions}_{N_2O\text{, direct}} + \mathrm{Emissions}_{N_2O\text{, effluent}}$$

Projections and reductions measures

Our business as usual and potential policy pathways for the waste sector were based on projections generated from the GCAM[75] model (provided by the MPCA for their Climate Action Framework). For the BAU scenario, we assumed constant 2022 per-capita rates of waste emissions extended out to 2050 and scaled to the region's population. For the potential policy pathway, we downscaled GCAM estimates by matching our subsectors to GCAM's "Solid

[74] USEPA. (2024). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022* (Government No. EPA 430R-24004; pp. 1–919). https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf

[75] Calvin, K., Patel, P., Clarke, L., Asrar, G., Bond-Lamberty, B., Cui, R. Y., Di Vittorio, A., Dorheim, K., Edmonds, J., Hartin, C., Hejazi, M., Horowitz, R., Iyer, G., Kyle, P., Kim, S., Link, R., McJeon, H., Smith, S. J., Snyder, A., … Wise, M. (2019). GCAM v5.1: Representing the linkages between energy, water, land, climate, and economic systems. Geoscientific Model Development, 12(2), 677–698. https://doi.org/10.5194/gmd-12-677-2019

waste” and “Wastewater” categories then calculated the expected change in emissions from all waste in the GCAM model relative to its baseline of 2020.

Agriculture

Inventory and baseline

Agricultural emissions are derived from two primary sources. First is the USDA agricultural census[76] which provides county level livestock head counts, crop production, and fertilizer sales. Second is the EPA State Inventory Tool[77] (SIT) that provides state specific values for emission factors as well as activity data such as state-wide fertilizer application (different from sales). These are both the highest rank of data. The USDA census is conducted once every five years (years ending in ’2 and ’7). For interstitial years we used linear interpolation to provide county level estimates.

The SIT provides guidance on how to translate livestock counts, crop production, and fertilizer use into emission factors. A brief description of the major emitters in this sector is listed here, but please refer to the SIT documentation for more detailed information.

Livestock

Enteric fermentation

Enteric fermentation is methane (CH_4) emitted from livestock during digestion. We sorted cattle into four categories with unique emission factors for: beef cows, dairy cows, calves, and feedlot cattle. Cattle accounted for 98.6% of enteric fermentation emissions in 2022 (424,152 MT CO_2e), with goats, sheep, and swine accounting for the remainder.

Manure emissions

The other avenue livestock contribute to emissions is through manure, which emits methane and nitrous oxide. Manure emissions occur at site of storage, site of on-field application, and off-site runoff. The first step is calculating the metric tons of volatile solids (VS) excreted by livestock. The EPA SIT tool provides emission factors per livestock type, often further dependent on typical animal mass, which is also provided in the tool.

MANURE MANAGEMENT

From there, methane is calculated as:

$$\text{Emissions (Metric tons CH}_4\text{)} =$$

[76] USDA. (2022). *USDA - National Agricultural Statistics Service—Census of Agriculture*. https://www.nass.usda.gov/AgCensus/

[77] USEPA & ICF. (2023). State Greenhouse Gas Inventory Tool User’s Guide for the Agriculture Module (pp. 1–31) [Government]. US EPA. https://www.epa.gov/system/files/documents/2023-06/Ag%20Module%20User%27s%20Guide_508.pdf

$$\sum_{i}(\text{MT VS}_i \times \text{Maximum Potential Emissions (m3 CH4/kg VS)}_i \times \text{Methane conversion factor}_i)$$

where *i* represents livestock from the following categories: Dairy Cows, Beef Cows, Feedlot Cattle, Calves, Swine, Sheep, Goats, Chickens (Broilers, Pullets, and Layers), and Turkeys.

Nitrous oxide is calculated as:

$$\text{Emissions (Metric tons } N_2O) =$$

$$\sum_{i,j}(\text{MT VS}_{i,j} \times \text{(1 - Volatilization Percent)} \times \text{Percentage manure management}_{i,j} \times \text{Manure management emission factor}_{i,j})$$

where i represents livestock from the following categories: Dairy Cows, Beef Cows, Feedlot Cattle, Calves, Swine, Sheep, Goats, Chickens (Broilers, Pullets, and Layers), and Turkeys; and j is dry or wet manure management systems. In other words, total nitrous oxide emissions are the sum of manure managed in wet systems or dry systems, each of which have different emission factors. EPA assumes no nitrogen is volatilized prior to storage (i.e. Volatilization Percent is 0 in the above equation).

MANURE RUNOFF

Manure from managed and unmanaged systems enters the soil via application or runoff, resulting in nitrous oxide emissions. The SIT calculates emissions by multiplying each animal population by the rate of N excreted by animal type, provided in kg/head/year for cattle (excluding calves), and kg/1,000 kg animal mass/day for calves and all other livestock (i.e., swine, poultry, sheep, goats, and horses). For cattle (excluding calves), animal population is multiplied by the K-nitrogen excretion rate (kg/head/year) for total K-nitrogen excreted. For calves and all other livestock, animal population is multiplied by the typical animal mass (kg), the K-nitrogen excretion rate (kg/1,000 kg animal mass/day), and 365 days per year for annual K-nitrogen excreted. Next, the total K-nitrogen is disaggregated into manure handled in managed systems, manure applied as daily spread, and manure deposited directly into pastures, ranges, or paddocks.

Direct emissions from manure handled in management systems and applied as daily spread is multiplied by the volatilization factor (0.8) to obtain the total unvolatilized N. Additionally, for poultry an adjustment must be made for the small portion of waste used as animal feed. For all poultry categories (i.e., layers (hens, pullets, and chickens), broilers, and turkeys), the total K-nitrogen in managed systems is multiplied by 0.958, as it is assumed that 4.2 percent of all poultry manure is used as animal feed and not applied to agricultural soils [78]. The total unvolatilized N is multiplied by the emission factor for direct emissions of N_2O (1.0 percent) to obtain the amount of emissions in N_2O-N/yr.

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[78] Carpenter, G. H. (1992). Current Litter Practices and Future Needs. *1992 National Poultry Waste Management Symposium*.

$$\text{Emissions (Metric tons } N_2O) = \sum_i (\text{MT manure}_i \times (1 - \text{Indirect Volatilization Percent}) \times \text{Non-volatized emission factor} \times N_2O{:}N_2)$$

where *i* is the livestock type. EPA provides estimates of 20% for Indirect Volatilization Percent, 0.0125 as the non-volatized EF, and 1.571 is the ratio of nitrous oxide to N_2.

For animal waste deposited directly onto pasture, range, and paddock the total K-nitrogen is multiplied by the percent of manure deposited on pasture, range, and paddocks and the IPCC default emission factor for direct emissions (0.02 kg N_2O-N/kg N excreted)[79] to obtain the amount of emissions in N_2O-N/yr.

$$\text{Emissions (Metric tons } N_2O) = \sum_i (\text{MT manure}_i \times \text{Pasture emission factor} \times N_2O{:}N_2)$$

where *i* is the livestock type. EPA provides an emissions factor of 0.02 for manure on pasture soils and 1.571 is the ratio of nitrous oxide to N_2.

Lastly, indirect manure runoff emission also occurs when unvolatilized nitrogen is applied via manure and later volatilizes on or off site. It is calculated as:

$$\text{Emissions (Metric tons } N_2O) = \sum_i (\text{MT VS}_i \times (1 - \text{Volatilization Percent}) \times \text{Leaching Percent})$$

where EPA provides an estimate of volatilization percent of 0% (i.e. all volatilization occurs after manure runoff) and a leaching percent of 30%.

Cropland

Plant residue

Croplands emit nitrous oxide via legumes (i.e. soybeans, alfalfa, beans) that fix atmospheric N_2 in the soil, some of which is converted to nitrous oxide via soil biochemical processes. Additionally, non-legume crops have residues that are left on soils and breakdown into the soil, emitting further nitrous oxide.

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[79] IPCC. (1997). *IPCC Guidelines for National Greenhouse Gas Inventories: Reporting Instructions, Workbook, and Draft Reference Manual*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/revised-1996-ipcc-guidelines-for-national-greenhouse-gas-inventories/

LEGUME CROPS

$$\text{Emissions (Metric tons } N_2O) =$$

$$\sum_i (\text{MT Crop Production}_i \times \text{Mass ratio (residue/crop)}_i \times \text{Dry Matter Fraction}_i \times \text{N content}_i \times \text{ Emission Factor } (1.0 \times N_2O{:}N_2)$$

NON-LEGUME CROPS

$$\text{Emissions (Metric tons } N_2O) =$$

$$\sum_i (\text{MT Crop Production}_i \times \text{Mass ratio (residue/crop)}_i \times \text{Dry Matter Fraction}_i \times \text{Fraction Residue Applied}_i \times \text{N content}_i \times \text{ Emission Factor } (1.0 \times N_2O{:}N_2)$$

where in both, *i* is the crop type. EPA provides an emissions factor of 0.01 percentage of N content that is ultimately converted to N_2O and 1.571 is the mass ratio of nitrous oxide to N_2.

Fertilizer application

Synthetic and organic fertilizers breakdown to provide N to crops, but are typically over-applied. A fraction of the fertilizer not taken up by plants is converted to nitrous oxide that is emitted to the atmosphere. Some proportion of applied fertilized is additionally leached into the soil and runs off into streams and adjacent soils, where it further is chemically converted to nitrous oxide.

$$\text{Emissions (Metric tons } N_2O) =$$

$$\sum_{i,j} (\text{MT Fertilizer applied}_i \times \text{Fraction volatilized}_i \times \text{ Emission Factor}_j \times N_2O{:}N_2)$$

where *i* is the type of fertilizer applied, either synthetic or organic, and *j* is the emission factor for either direct, on-site N_2O emissions (0.01) or off-site, run-off emissions (0.001).

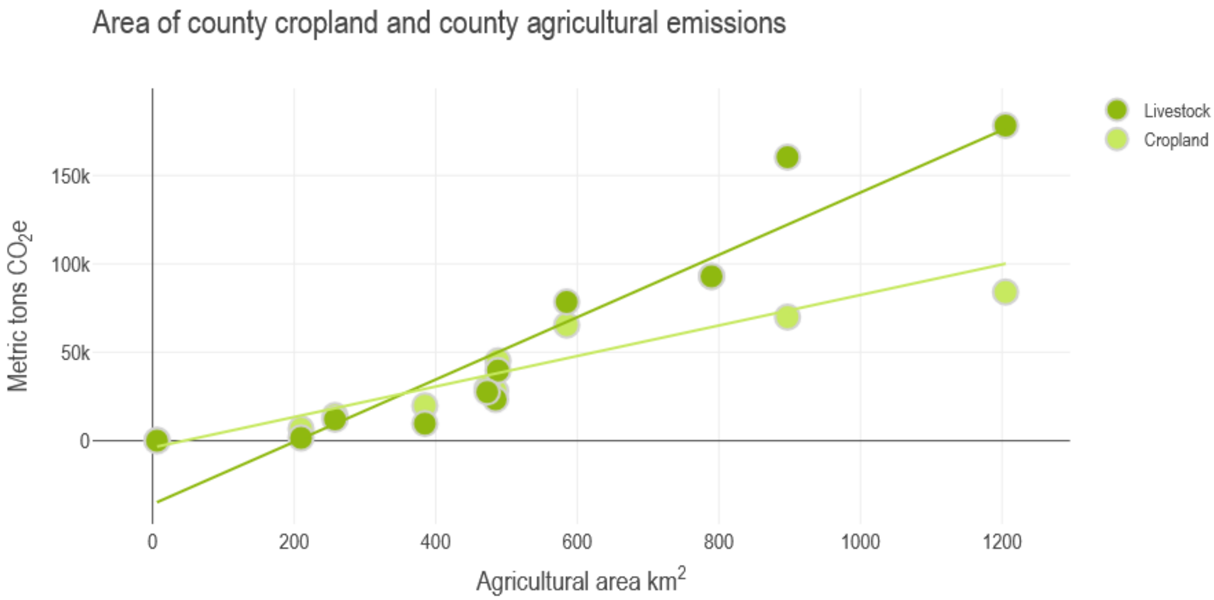
Missing data

The USDA census program does not report data in counties having less than a minimum number of operations. This most notably affects Ramsey County in our inventory, meaning that its agricultural emissions are larger than reported, but still likely a negligible portion of the county emissions. Agricultural farm equipment also emits greenhouse gases but is not included in this analysis. Similarly, agricultural soils sequester carbon and this offset has not yet been analyzed. Future work will aim to include these components of agriculture.

Data validation

We would expect that counties with higher amounts of agricultural land would have higher emissions associated with crop production and likely livestock, though the latter may be more poorly predicted as area required for livestock can vary greatly depending on management.

Figure 30. Validation plot of county agricultural emissions and agricultural area



As expected, we see that livestock and crop emissions increases with area devoted to agriculture.

Projections and reduction measures

Business as usual

The biggest influence on future agricultural emissions in the region is likely to be the expanding metropolitan area into current agricultural lands. We calculated the average loss of agricultural area in the last ten years from the National Land Cover Database (0.29% annual loss or 16.8 square kilometers per year) and applied that average rate of decay to regional agricultural emissions from 2022 onward to estimate this effect.

Potential policy pathway

We anchored expected decreases in agricultural emissions to the potential policy pathway output generated in the COMET-Farm[80] tool for evaluating agricultural emissions run by the Minnesota Pollution Control Agency for their Climate Action Framework update. Specifically, we identified emissions sources that matched our three broad categories of enteric fermentation, manure, and cropland soils. In each year past 2022, we calculated the ratio of emissions between their potential policy pathway emissions and their current policy pathway

[80] Hanson, W. L., Itle, C., & Edquist, K. (n.d.). *Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory*.

(i.e. business as usual). Proposed policies in the state's work matched well with our proposed policies in this climate action plan.

Natural Systems

Inventory and baseline

We estimated carbon sequestration by natural systems using a land area–based approach. Total land area for each natural cover type (e.g., forest, grassland, wetland) was multiplied by literature-derived sequestration rates as follows:

$$\text{Sequestration}_j = \sum_i (\text{Area}_i \times \text{Sequestration Rate}_i)$$

Where:

- **Sequestration** is the total annual CO_2-equivalency uptake (metric tons CO_2 per year) for a given geography *j*;
- **Area** is the total area (square kilometer) of land cover class *i*; and
- **Sequestration Rate** is the estimated annual CO_2 sequestration rate (metric tons CO_2 per square kilometer per year), which varies by natural cover type.

Land Cover Data and Classification

To evaluate land cover change from 2005 through 2022, we used two datasets from the U.S. Geological Survey's National Land Cover Database (NLCD) at 30-m resolution: (1) land cover classification and (2) percent tree canopy cover.

We first clipped both datasets to the 11-county Twin Cities Metropolitan Statistical Area (MSA). From the NLCD land cover layer, we identified natural cover types (e.g., forests, wetlands, grasslands) occurring outside of "Developed" or built-up areas, which we re-classified into three broad natural categories:

- Any forest type (evergreen, deciduous, or mixed) → **Forest**
- Any wetland type (woody or herbaceous) → **Wetland**
- Any grassland or shrub ecosystem → **Grassland**

All other classes retained their original NLCD classification.

To identify natural cover within urban areas, we overlaid the NLCD percent tree canopy map on the land cover map. We then applied the following logic:

- Pixels classified as *Developed, Open Space* with 0% tree canopy → **Turfgrass**.
- For all *Developed* classes containing > 0% tree canopy, we partitioned each pixel into **Community Tree** and its original *Developed* classification.
  - *Urban Tree area* = total pixel area × percent tree canopy
  - *Residual area* = remaining portion of the pixel's original *Developed* class
- In cases where *Developed, Open Space* pixels contained partial tree canopy, the non-canopy fraction was assigned to **Turfgrass**.

This process produced five natural system land cover categories for the region: Community Tree, Turfgrass, Forest, Grassland, and Wetland. Using these cover classes, we computed the sum of each natural system type (in square kilometer) within the region for each year from 2005 through 2022. Since tree canopy data was not available prior to 2011, we extrapolated county-level 2011 values back to 2005 to ensure consistency in our new land cover classifications. Next, we applied the following sequestration rates (in metric tons CO_2-equivalency per square kilometer per year) to each natural cover type:

Cover Type	Sequestration Rate
Grassland[81]	−125
Forest[82]	−329
Turfgrass[83]	−299
Community Tree[84]	−620
Wetland[85]	−266

Finally, we computed annual sums of total CO_2-equivalency sequestered by natural systems in the region using the equation above.

[81] Knops, J. M. H., & Bradley, K. L. (2009). Soil Carbon and Nitrogen Accumulation and Vertical Distribution across a 74-Year Chronosequence. *Soil Science Society of America Journal*, *73*(6), 2096–2104. https://doi.org/10.2136/sssaj2009.0058

[82] Russell, M. (2020). *Carbon in Minnesota trees and woodlands*. University of Minnesota Extension. https://extension.umn.edu/managing-woodlands/carbon-minnesota-trees-and-woodlands

[83] Phillips, C. L., Wang, R., Mattox, C., Trammell, T. L. E., Young, J., & Kowalewski, A. (2023). High soil carbon sequestration rates persist several decades in turfgrass systems: A meta-analysis. *Science of The Total Environment*, *858*, 159974. https://doi.org/10.1016/j.scitotenv.2022.159974

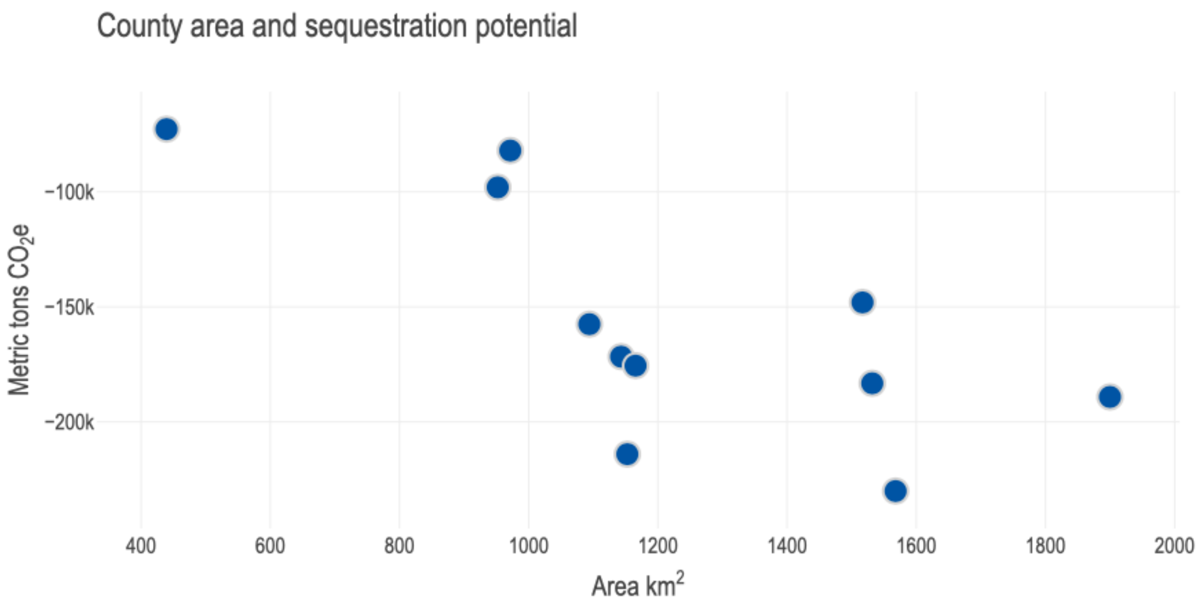
[84] Nowak, D. J., Greenfield, E. J., Hoehn, R. E., & Lapoint, E. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States. *Environmental Pollution*, *178*, 229–236. https://doi.org/10.1016/j.envpol.2013.03.019

[85] Polasky, S., & Liu, Y. (2006). The Supply of Terrestrial Carbon Sequestration in Minnesota (pp. 1–25). University of Minnesota. https://conservancy.umn.edu/server/api/core/bitstreams/adaabc43-56a1-483d-ae26-6dc92dd99932/content

Data validation

We would expect that larger counties have higher carbon sequestration rates due to more acreage for green spaces, a trend which we observe across our 11-county region:

Figure 31. Validation plot of county natural systems sequestration potential and land area



Projections and reduction measures

Business as usual

Since 2005, total land area occupied by natural systems has changed marginally: outside of built-up environments, green spaces (e.g., wetlands, forests, and grasslands) have declined at an average annual rate of 1.2 square kilometers per year, representing a 0.59% loss in green area from 2005 through 2022. This has been partially compensated by the addition of green spaces in developed environments, where urban tree and turfgrass area have increased by approximately 10.4 square kilometers per year, a 13% increase from 2005 values. To account for the compensatory loss of natural areas outside the urban core with increased green spaces in developed environments, we opted to hold land cover values constant from 2022 onward in our business-as-usual scenario.

Potential policy pathway

Our potential policy pathway for natural systems involves a series of land cover modules that act by altering one (or more) cover types into a new cover classification that can sequester carbon. In one module, we identify opportunities for community tree planting as those that are currently classified as ‘Developed’. Using the impervious fraction definitions from NLCD (where ‘Low’ intensity development represents 20-49% impervious, ‘Medium’ represents 50-79% impervious, and ‘High’ represents 80-100% impervious), we assumed the following tree plantable fractions:

Table 21. Determination of available tree cover per developed area land use type

Developed Intensity	Percent Imperviousness	Percent Available for Tree Planting	Percent Unavailable
Low	20-49	30	70
Medium	50-79	15	85
High	80-100	5	95

For our potential policy pathway, we assumed that 100% of all tree plantable areas would be covered by Community Trees in 2050.

In another module, we projected increases in forest cover via restoration of underproductive grasslands and barren lands. Additionally, we estimated that approximately 25% of the agricultural area likely to be developed by 2050 (~8% of existing cropland; see agricultural BAU section) could be instead restored to forests if we encourage compact development in the expanding suburban edges of our region. Here, we estimated that by 2050, 2% of all cropland area, 10% of all grassland area, and 100% of barren lands would be restored into forest ecosystems.

Finally, using the Minnesota Restorable Wetland Index[86], we estimated that the region stands to gain ~33% of wetland area above 2022 inventory estimates following successful restoration initiatives. We applied this 33% increase to estimate total wetland area for 2050 across the MSA.

After applying the land cover changes from these modules, we calculated new annual estimates of total carbon sequestration by natural systems for 2023 through 2050. As we took an in-boundary approach to all emissions and sequestration, this ambitious potential policy pathway also is likely to set the upper limit of natural sequestration in the region, and thus the net-zero goal for the region.

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[86] Johnson, L., Bartsch, W., Kovalenko, K., Kloiber, S., & Nixon, K. (2024). *Minnesota Restorable Wetland Index* [Dataset]. Data Repository for the University of Minnesota (DRUM). https://doi.org/10.13020/VMMD-RS84

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