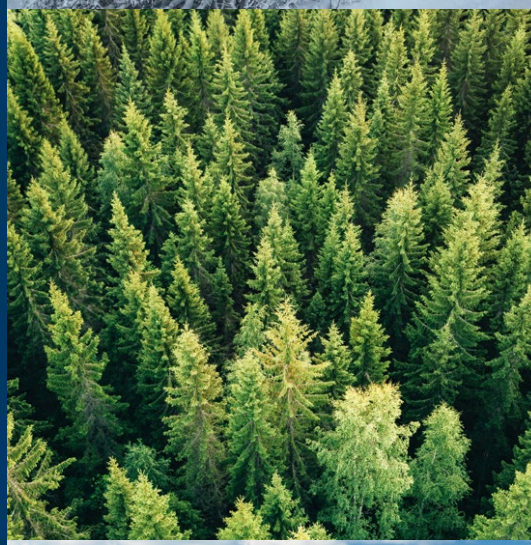
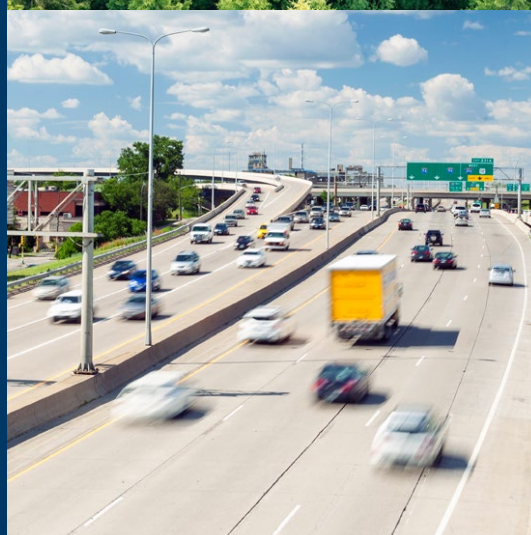
REPORT TO THE LEGISLATURE
JANUARY 2023

Greenhouse gas emissions in Minnesota 2005-2020

Biennial report to the Legislature tracking the state's contribution to emissions contributing to climate change.





MINNESOTA

Pollution Control Agency
Department of Commerce

Summary

Progress and opportunities to address climate change

A summary of Minnesota's greenhouse gas emissions

Minnesota is on track to meet greenhouse gas reduction goals for the first time.

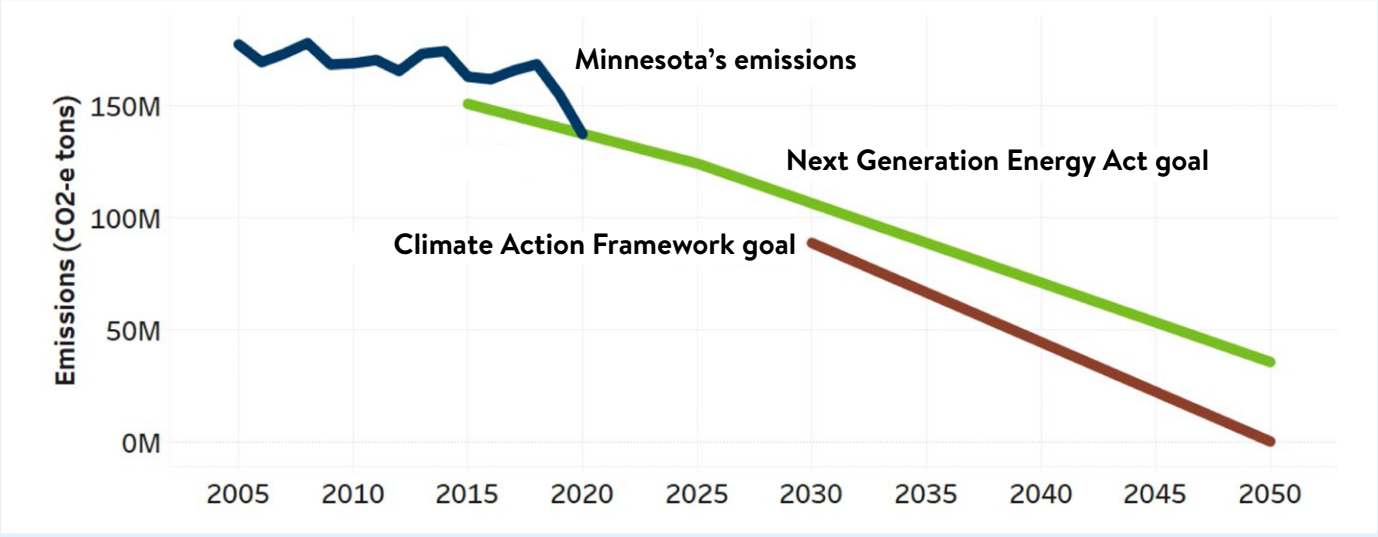
Efforts from individuals, businesses, and local governments as well as the COVID pandemic resulted in a sharp decline greenhouse gas (GHG) emissions in Minnesota. Minnesota's GHG emissions declined 23% between 2005 and 2020. If current trends continue, the state is on track to meet our goal of reducing emissions 30% by 2025. That goal was established in the bipartisan Next Generation Energy Act in 2007.

In 2022, Governor Tim Walz and Lt. Governor Peggy Flanagan rolled out Minnesota's Climate Action Framework that updates Minnesota's climate goals to reduce emissions 50% by 2030 and achieve net-zero emissions by 2050.

Decline in GHGs across all industry sectors 2005-2020

23%

GHG emissions 2005–2020 and goals from the Next Generation Energy Act and Climate Action Framework



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GHG emissions by sector 2005-2020

Transportation

↓ 18%

Largest sources:

- Light-duty trucks
- heavy-duty trucks

Transportation remains largest source of GHG emissions in Minnesota. Transportation accounts for approximately 25% of the state's GHG emissions. While GHG emissions in the transportation sector have fallen 18% since 2005, most of that decrease is attributed to the reduction in aviation and vehicle usage during the pandemic.

Agriculture, forestry and land use

↓ 0.5%

Largest sources:

- Crop agriculture
- Animal agriculture

Forests continue to offset agriculture emissions through carbon sequestration. This is important because the overall agriculture, forestry, and land use sector has become the second largest source of emissions as electrical generation emissions have declined. Emissions from manure and fertilizer use have increased since 2005.

Electrical generation

↓ 54%

Largest sources:

- Natural gas
- Coal

Electricity generation is a Minnesota success story. Since 2005, emissions from the electricity generation sector have declined by 54%. The significant decrease is mainly a result of producing electricity from renewable sources like wind and solar instead of coal.

Residential

↑ 14%

Largest sources:

- Oil
- Natural gas

Industrial

↑ 14%

Largest sources:

- Oil
- Natural gas

Emissions from homes and industrial facilities continue to rise. Emissions from Minnesota's homes and industrial facilities have risen 14%, due to the continued use of oil and natural gas to heat and operate.

Our path forward: Minnesota's Climate Action Framework

The Minnesota's Climate Action Framework sets a vision for how our state will address and prepare for climate change. It identifies near-term actions we must take to achieve our long-term vision of a carbon-neutral, resilient, and equitable future for Minnesota.

The Framework is organized around six climate action goals with specific steps and progress measures to guide and evaluate our work.

Clean transportation

Climate-smart natural and working lands

Resilient communities

Clean energy and efficient buildings

Healthy lives and communities

Clean economy

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Legislative charge

Minn. Stat. § 216H.02 Greenhouse gas emissions control.

Subd. 1. Greenhouse gas emissions-reduction goal. It is the goal of the state to reduce statewide greenhouse gas emissions across all sectors producing those emissions to a level at least 15% below 2005 levels by 2015, to a level at least 30% below 2005 levels by 2025, and to a level at least 80% below 2005 levels by 2050. The levels shall be reviewed based on the climate change action plan study.

Minn. Stat. § 216H.07 Emissions-reduction attainment; policy development process.

Subd. 3. Biennial report. (a) By January 15 of each odd-numbered year, the commissioners of commerce and the Pollution Control Agency shall jointly report to the chairs and ranking minority members of the legislative committees with primary policy jurisdiction over energy and environmental issues the most recent and best available evidence identifying the level of reductions already achieved and the level necessary to achieve the reductions timetable in section 216H.02. (b) The report must be in easily understood nontechnical terms.

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This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

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Contents

Introduction

Climate change is here and now. Damaging storms and floods have increased in frequency, and our winters are warming fast, reducing lake ice coverage across the state by 10 to 14 days over the past 50 years. Beloved Northwoods trees like spruce, aspen, and birch are expected to leave Minnesota over the next 80 years if we continue to change our climate.

More information about climate trends and the impacts of climate change is available from the Department of Natural Resources www.dnr.state.mn.us/climate

These changes are caused by human activities that release greenhouse gases (GHGs). This emissions inventory summarizes what we know about GHG emissions in Minnesota, including the major sources and trends over time. Tracking GHG emissions and identifying their sources are two important ways that state government can help Minnesotans understand our changing climate and respond accordingly.

To guide our response to climate change, the State of Minnesota has developed a Climate Action Framework mn.gov/framework. The Framework identifies immediate, near-term actions to reduce climate pollution and prepare Minnesota communities for the impacts of climate change. It also sets new goals for Minnesota to reduce GHG emissions by 50% by 2030 and achieve net-zero emissions by 2050. Analyzing Minnesota's emissions through this inventory allows us to track progress on the framework goals and focus actions for maximum impact to address climate change.

This inventory documents Minnesota's GHG emissions from 2005 through 2020 and shows the impact of actions taken by individuals, organizations, and governments across Minnesota. The COVID-19 pandemic changed how Minnesotans lived and worked in 2020, further reducing emissions, but emissions were trending downward, even before the lifestyle shifts caused by the pandemic. Future years' data will show whether these are sustained trends or if some emissions bounced back when COVID-19 restrictions were eased. While there is much work ahead of Minnesota to meet our climate goals, this inventory demonstrates that collaborative action works.

Evaluating greenhouse gas emissions

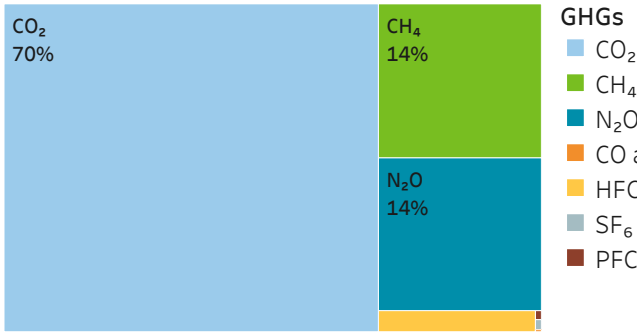
GHGs are gases that warm the atmosphere and surface of the planet. Human activity increases the amount of GHGs in the atmosphere, leading to changes in Earth's climate. The primary GHGs are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulfur hexafluoride (SF_6), and two types of compounds called hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

GHGs come from a variety of sources:

- Fossil fuel combustion is responsible for most carbon dioxide emissions in Minnesota and the United States. The majority of fossil fuels used today generate electricity and fuel vehicles.
- Animal agriculture is responsible for most methane emissions in Minnesota, and the anaerobic decomposition of organic material also emits methane.
- Agricultural nutrient management practices, including fertilizer application and subsequent mineralization, cause over 50% of nitrous oxide emissions.
- Most hydrofluorocarbon emissions are from refrigerants, such as air conditioners in vehicles and buildings.
- Perfluorocarbons and sulfur hexafluoride account for a small portion of GHG emissions and are emitted from technical applications like semiconductor manufacturing and electricity transmission.

Carbon dioxide is the most abundant GHG and has the most significant effect on our climate. In Minnesota, CO_2 emissions account for most GHG emissions, followed by methane and nitrous oxide. Other GHGs are emitted in smaller amounts but can trap heat more effectively than carbon dioxide, and some stay in our atmosphere for a very long time.

Net 2020 GHG emissions in Minnesota by gas, in CO_2-equivalent tons (includes carbon storage)



Global warming potential (GWP) is a relative measure of how much heat a GHG traps in the atmosphere. To compare different emissions and pollutants, we use the effect of carbon dioxide on our climate as a standard reference. In this report, emissions are reported as carbon dioxide-equivalent (CO_2-e) tons, meaning emissions are stated in relative terms that reflect their impact on global temperatures.

Primary GHGs, their 100-yr global warming potentials, and their persistence in Earth's atmosphere

Greenhouse gas	Global warming potential	Persistence in Earth's atmosphere
Carbon dioxide (CO_2)	1	Variable, up to thousands of years
Nitrous oxide (N_2O)	298	114 years
Methane (CH_4)	25	12 years
Sulfur hexafluoride (SF_6)	22,800	3,200 years
Hydrofluorocarbons (HFCs)	Up to 14,800	Up to 270 years
Perfluorocarbons (PFCs)	Up to 12,200	2,600 to 50,000 years

Source: IPCC Fourth Assessment Report, Working Group 1 Chapter 2

Tracking Minnesota's emission reduction progress

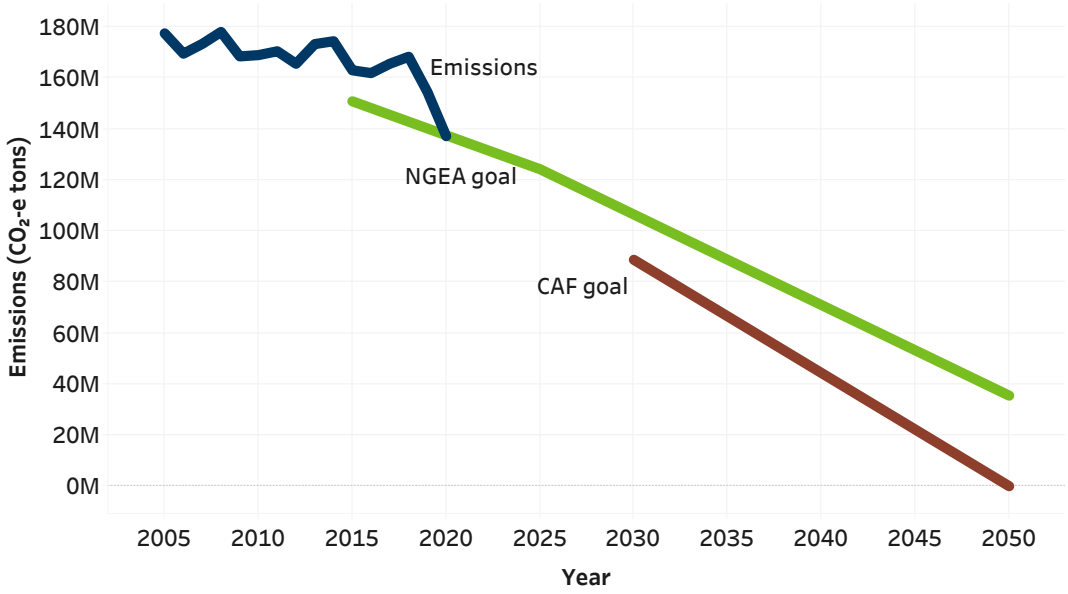
In 2007, the Minnesota Legislature passed the Next Generation Energy Act (NGEA), setting goals to reduce our GHG emissions in the state compared to our emissions in 2005.[1] The NGEA goals – based on the best science at the time – are to reduce emissions by 15% by 2015, 30% by 2025, and 80% by 2050. Today, science tells us that we must go farther, faster. To address this reality, Minnesota's Climate Action Framework includes additional goals to reduce GHG emissions by 50% by 2030 and achieve net-zero emissions by 2050.

Minnesota did not reach the NGEA goal of reducing emissions by 15% by 2015, but between 2005 and 2020, Minnesota's GHG emissions fell by 23%, putting us on track to meet future goals if we maintain current trends. Changes in electricity generation have resulted in significant emission reductions from the power generation sector and are the most significant contributor to statewide emission reductions.

The year 2020 was unusual as individuals, organizations, and governments took action to reduce the impacts of the COVID-19 pandemic. These actions caused disruptions across all parts of the economy and thus impacted Minnesota's GHG emissions in unique ways. Due to the unusual nature of 2020, this report is cautious in interpreting trends with a 2020 endpoint. All economic sectors had declining emissions between 2019-2020. While the pandemic certainly impacted those results, emissions across many sectors were already declining between 2018-2019. The declines between 2018-2019 may indicate longer-term trends, but it is too soon to tell. Future years' data will show whether these are lasting trends.

Recent emission reductions show that collaborative action can get us on track to achieve our Next Generation Energy Act goals and reach net-zero emissions by 2050. However, much work is ahead to achieve these ambitious but necessary goals.

Minnesota's GHG emissions 2005-2020 and goals from the Next Generation Energy Act and Climate Action Framework



[1] Data revisions and changes in methodology can cause the baseline to change, but continuity is provided when making relative year-to-year emissions comparisons.

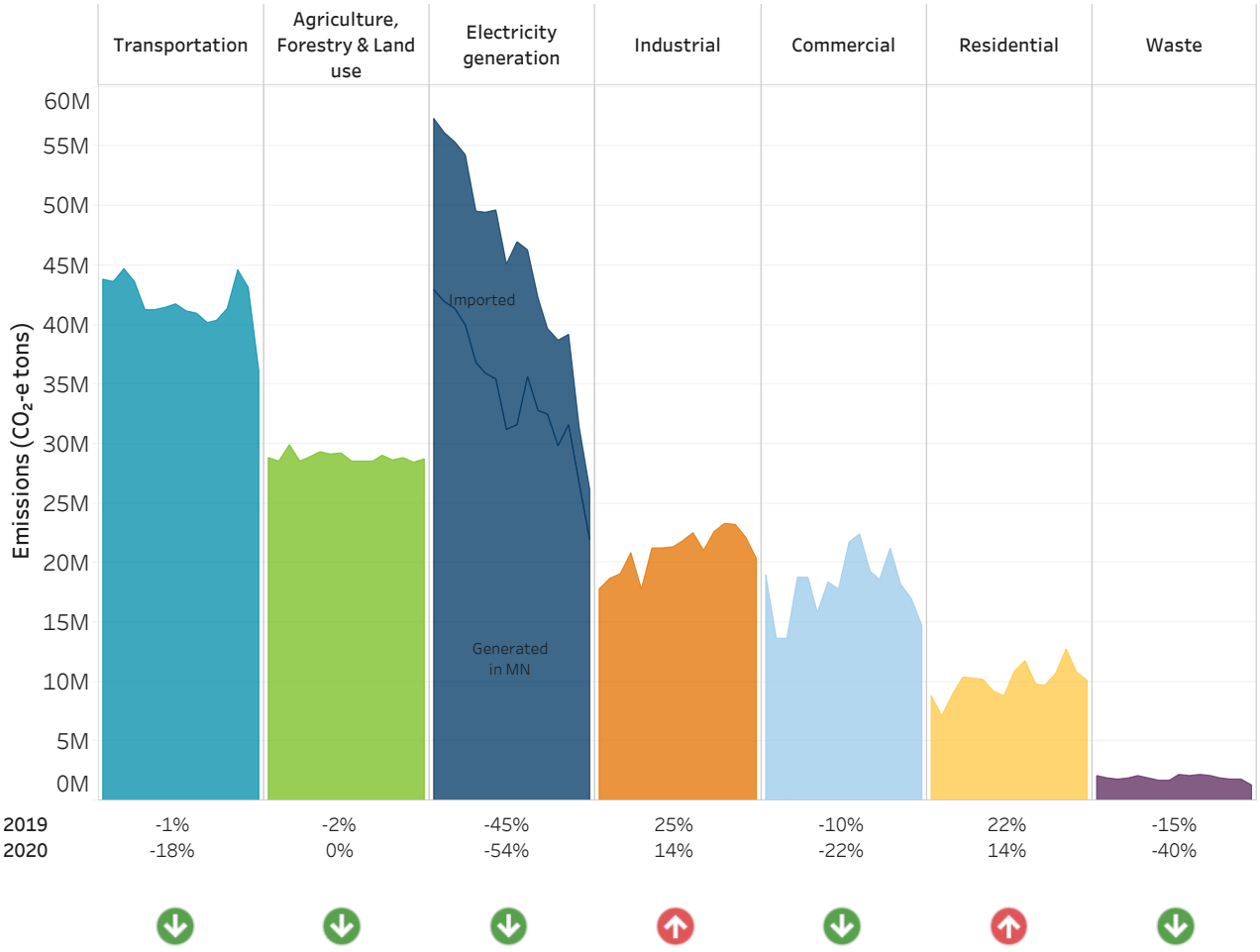
Greenhouse gas emissions across sectors

This section outlines changes to GHG emissions across seven economic sectors in Minnesota: transportation, electricity generation, agriculture and forestry, industrial, residential, commercial, and waste.

Interactive GHG emission dashboards are available at https://www.pca.state.mn.us

Minnesota's GHG emissions across economic sectors, 2005-2020, ranked by net emissions.

The dark line in the column for the electricity generation sector represents the division between emissions from electricity generated in Minnesota (below the line) and emissions from imported electricity (above the line). The percent change from 2005 is shown beneath the charts for 2019 and 2020, with an arrow indicating the 2020 change compared to 2005.



Transportation

Minnesota's largest source of GHG emissions is the transportation sector, accounting for about one-quarter of the state's total emissions. GHG emissions from transportation have decreased by about 18% since 2005. A significant decrease in aviation and vehicle miles traveled during the COVID-19 pandemic played a prominent role in the emissions reduction in 2020.

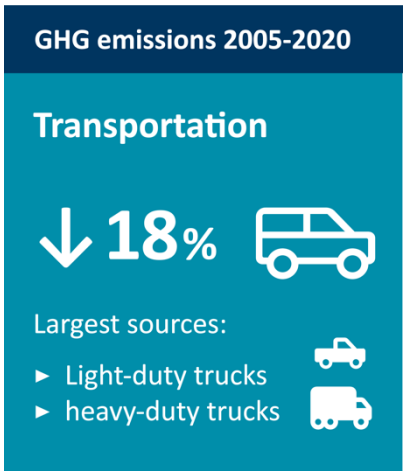
Methods to measure vehicle miles traveled and types of vehicles on our roads have changed over time. This means that we understand current transportation activity much better than we did in the past, and it also means that there is more uncertainty in estimates for past years. However, our emissions trend is similar to other published estimates, such as the U.S. Environmental Protection Agency (EPA) state inventory.

Emissions sources in the transportation sector include:

- on-road vehicles
- airplanes and other aviation equipment
- trains
- vehicle air conditioning units
- natural gas transmission pipelines

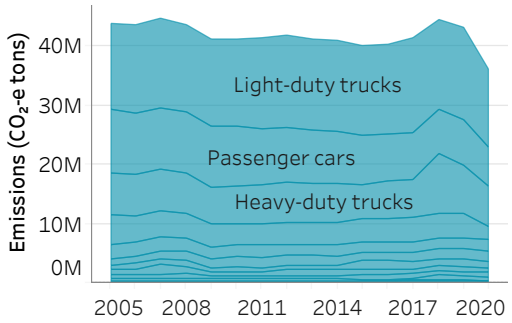
Our personal choices have a significant impact on emissions, especially when it comes to how we move around. Within the transportation sector, passenger vehicles, light-duty trucks (including SUVs), and medium- to heavy-duty trucks produce more than 70% of emissions.

Stronger vehicle emissions standards at the federal level have lowered vehicle GHG emissions generally. However, the long-term consumer trend of choosing larger vehicles and the general trend of more miles driven (except during the pandemic) prevent more significant emissions reductions in this sector. Continued investment in cleaner vehicles and transportation options, including transit, biking, walking, and rolling, is critical to continuing the trend of emission reductions in this sector.

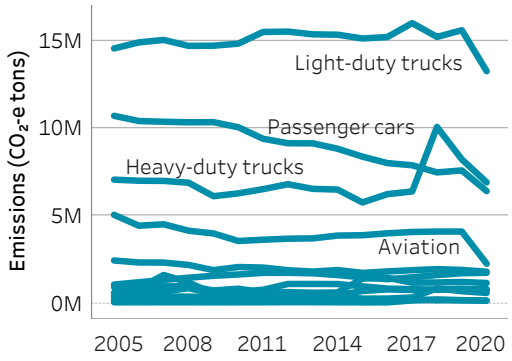


Transportation sector: 2005 to 2020

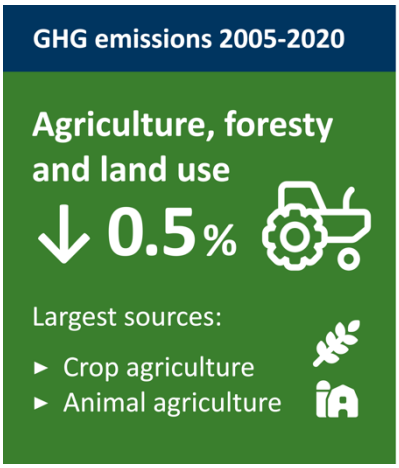
Total greenhouse gas emissions



Trends in greenhouse gas emission sources



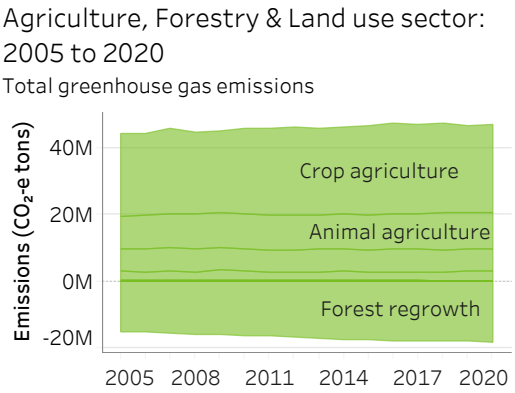
Agriculture, forestry, and land use

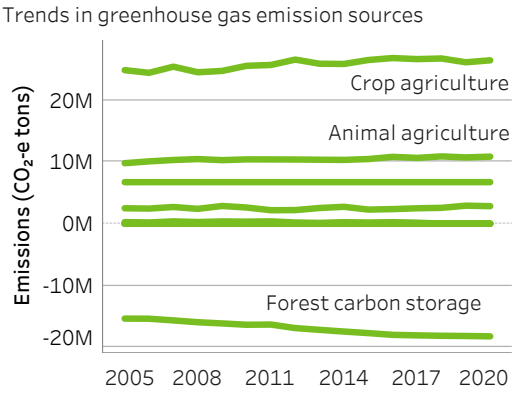


This sector groups together activities on natural and working landscapes. Some of these activities, like growing forests and grasslands, absorb and store carbon, offsetting the total amount of GHG emissions within this sector from growing crops and raising animals. Compared to the 2005 baseline, net emissions, considering both the sources and sinks of carbon, are flat, but both gross emissions and carbon sequestration have increased.

Emissions sources in the agriculture and land use sector include:

- livestock
- animal feedlots
- manure
- fertilizer
- crop cultivation practices
- anaerobic decomposition of material in lakes, rivers, and streams
- related fuel combustion of off-road implements, like tractors and combines





Agricultural practices in Minnesota are responsible for most nitrous oxide and methane emissions, two GHGs with higher GWP than carbon dioxide.

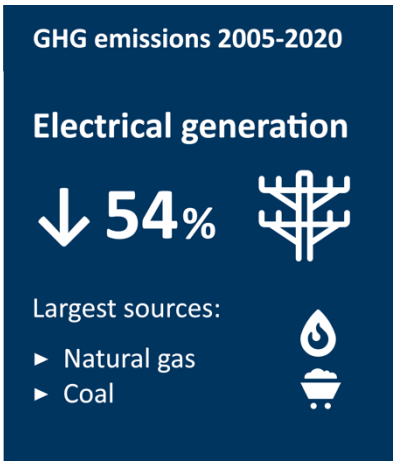
Nitrous oxide emissions from crop agriculture increased by approximately 9% from 2005 to 2020. The largest source of nitrous oxide emissions in Minnesota is nutrient management, which includes fertilizer use, mineralization, and runoff. The increase from 2005 to 2020 was due to increases in emissions from a variety of agricultural sources, including nutrient application, crop residues, and runoff. Animal agriculture also produces nitrous oxide from manure.

Animal agriculture is Minnesota's largest source of methane emissions, specifically from manure management and cattle digestion. Methane emissions from animal agriculture increased by 10% between 2005 and 2020. Lakes, rivers, and reservoirs are other significant sources of methane emissions. Plant material and fertilizers that enhance plant growth and productivity collect in waterbodies, and CH_4 is emitted during the anaerobic decomposition of organic matter. The CH_4 emissions from these biological systems are counted in the GHG inventory because methane, though short-lived, causes warming in our atmosphere before oxidizing into CO_2 and re-entering the carbon cycle.

Carbon sequestration in forest regrowth is a significant offset in this sector, as forests can act as carbon sinks or storage. Carbon is sequestered in our forests as they grow. Estimation methods for sequestered forest carbon have changed since the last inventory to reflect the current best practices and are described in the appendix to this report. The updated method to estimate sequestered forest carbon has also been applied to prior years to ensure consistency over the years of the inventory.

Policy, economic factors, and voluntary actions have begun to drive down emissions from the electricity generation and transportation sectors, while emissions from agriculture have remained relatively steady since 2005. The reductions in other sectors have left the agriculture, forestry, and land use sector as Minnesota's second-largest emitter of GHGs, and also our largest sink of GHGs. This sector also is one of the biggest opportunities for achieving emission reductions and carbon sequestration, as many practices that land managers use to improve water quality and soil health also reduce emissions and sequester carbon. More investment is needed in this sector to support emission reductions and increase carbon sequestration and storage. Minnesota's Climate Action Framework identifies specific priorities for this sector to reduce emissions, store carbon, and improve our ability to understand the emissions from the sector.

Electricity generation



Electricity generation is the third largest source of GHG emissions in Minnesota. Burning fossil fuels, especially coal, to generate electricity for Minnesotans, whether produced in-state or out-of-state, is the primary source of GHG emissions from this sector. Other small sources include:

- methane from coal storage
- the breakdown of organic matter in the sediments found in hydroelectric reservoirs
- carbon dioxide from flue-gas desulfurization
- sulfur hexafluoride from electricity transmission and distribution

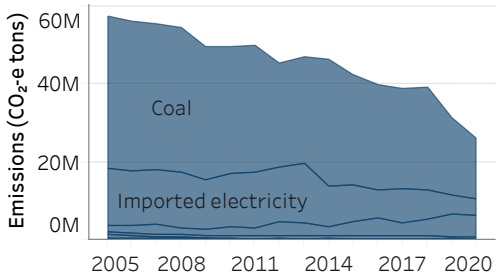
Since 2005, emissions from the electricity generation sector have declined by 54%. The significant decrease is mainly a result of the transition away from coal toward renewable energy to generate electricity. Previously, Minnesota's electricity generation sector was the largest source of GHG emissions. This sector has achieved the most emission reductions since 2005.

As required by the Next Generation Energy Act, this report measures total GHG emissions from electricity generation, including emissions from electricity generated at facilities within the state (in-state generation) and electricity used here in Minnesota that is generated outside of our state borders (imported). Emissions from in-state generation fell nearly 50% from 2005 to 2020, reflecting efforts by Minnesota's electric utilities to create a cleaner, lower-carbon electrical grid.

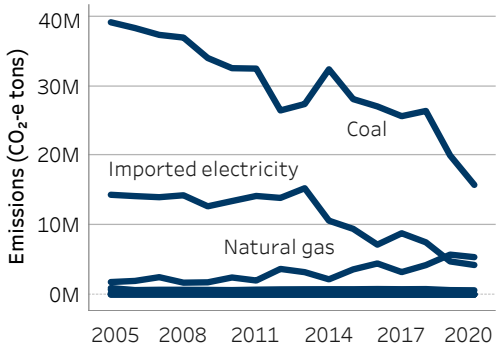
Emissions per kilowatt-hour from electricity imported from the regional electrical grid are higher than in-state generation because some neighboring states haven't reduced their emissions as much as Minnesota. The amount of electricity imported into Minnesota continues to decrease as in-state generation increases, reducing the amount of estimated imported electricity and associated GHG emissions.

Electricity generation sector: 2005 to 2020

Total greenhouse gas emissions



Trends in greenhouse gas emission sources



Continued emission reductions in the electricity generation sector are planned with future closures of coal plants. Achieving emission reductions in this sector is also important to help other sectors, such as transportation, residential, commercial, and industrial, reduce emissions through electrification. Continued focus on thoughtful planning for this transition to support reliability along with emission reductions is vital to achieving economy-wide GHG emission reduction goals.

Industrial

The industrial sector includes direct emissions from industrial facilities, processes, and fuel combustion. While this sector has increased emissions by 14% overall since 2005, in recent years, it has begun to experience emission reductions.

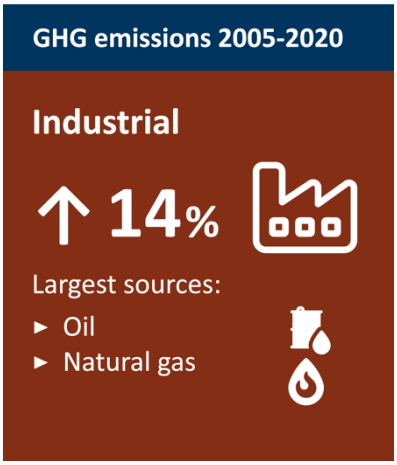
Emissions sources in the industrial sector include:

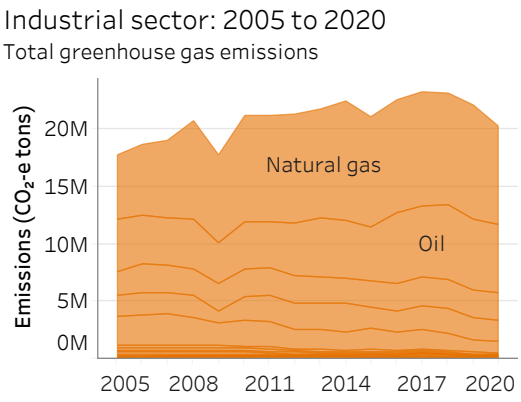
- fossil-fuel combustion
- taconite processing
- petroleum refining
- magnesium casting
- lead recycling
- peat mining
- industrial wastewater treatment
- solvent use
- manufacturing of steel, glass, insulating foam, and semiconductors

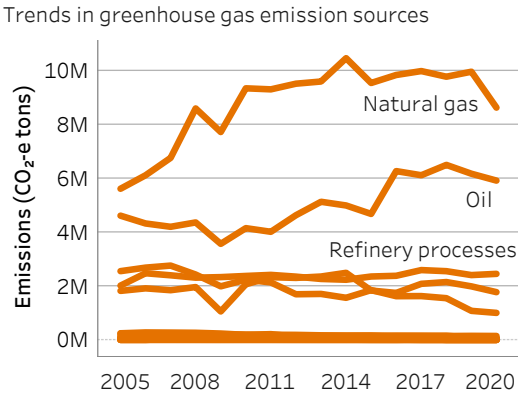
Although recent emissions are declining, emissions from the industrial sector increased by about 2.5 million tons from 2005 to 2020. Within the industrial sector, coal use has continued to decline steadily, and natural gas use has increased since 2005 but has declined from a peak in 2014.

GHG emissions from this sector have declined since a peak in 2018, but more is needed to achieve the reductions needed to meet the Next Generation Energy Act goals. The pandemic likely forced changes that reduced emissions in 2020; however, some of the changes that caused emissions to fall may persist.

The Climate Action Framework includes a focus on transforming Minnesota's economy through innovation. With federal funding and assistance, industrial businesses can be national leaders in changing operations and using greener fuels to reduce GHG emissions.







Residential

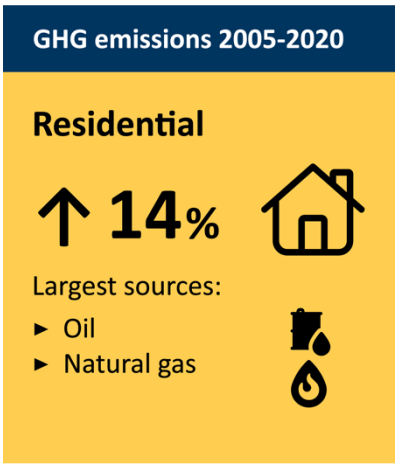
The residential sector includes products used in homes, direct combustion of fuel for heating and appliances, and carbon stored in structural materials. Relative to 2005, net emissions from the residential sector rose by 14%, but in recent years, it has begun to experience some emission reductions.

Emissions sources in the residential sector include:

- fossil-fuel combustion for heating and in-home appliances, such as furnaces that run on natural gas
- home-product use
- food additives
- refrigerant leakage from air conditioners and refrigerators
- fertilizer use

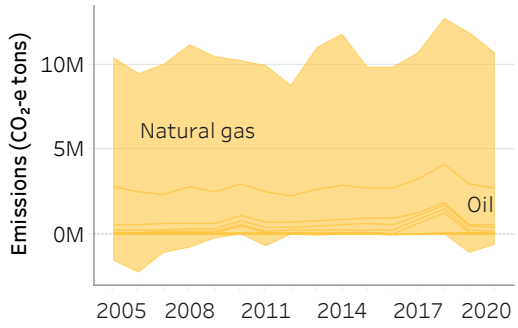
The residential sector does not include emissions from electricity use in residences – these emissions are captured in the electricity generation sector. Also, this category contains carbon stored in wood construction materials. Over the lifetime of a house, carbon is sequestered, effectively removed from the atmosphere and carbon cycle, which offsets some emissions.

The largest residential emissions source is natural gas used for home heating and appliances. Weather influences the need for heating, but switching to technologies like solar furnaces, geothermal heat pumps, electric appliances, and high-efficiency furnaces to reduce emissions from homes. The Climate Action Framework includes initiatives to renovate older buildings, replace natural gas home appliances with electric models, and improve the insulation in housing.

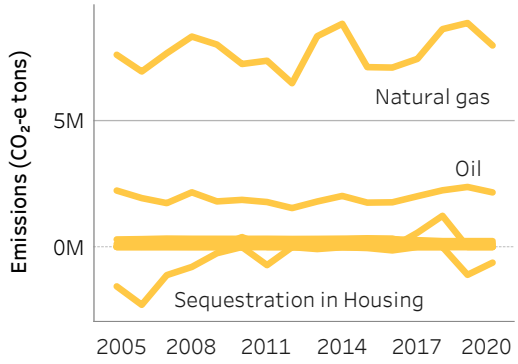


Residential sector: 2005 to 2020

Total greenhouse gas emissions



Trends in greenhouse gas emission sources

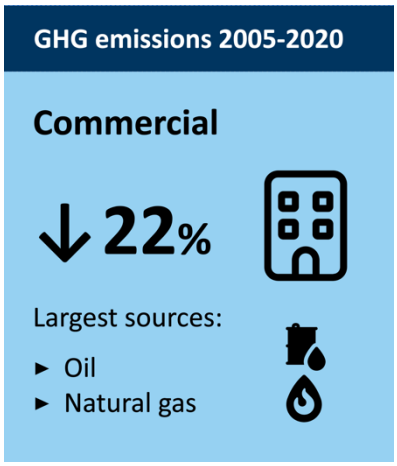


Commercial

The commercial sector includes activities, products, and combustion in buildings that house businesses, governments, and institutional sources, such as schools, corrections facilities, or state hospitals. Relative to 2005, emissions from the commercial sector were 22% below the 2005 baseline.

Emissions sources in this sector include:

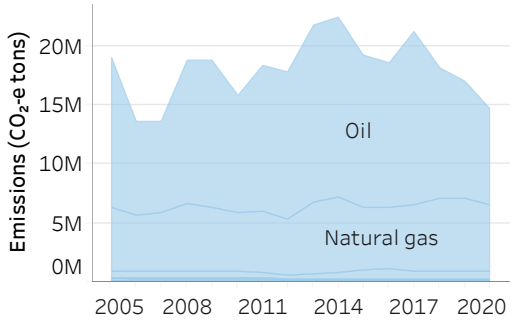
- fossil-fuel combustion
- solvent use
- air conditioning
- medical N_2O emissions



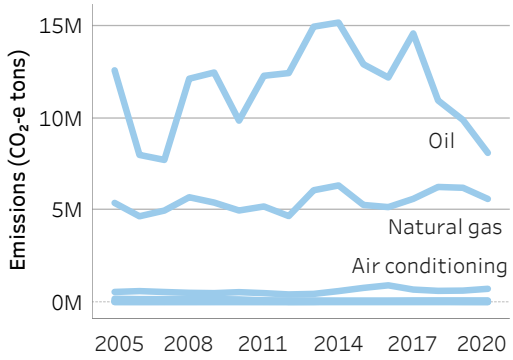
The decrease in emissions from the commercial sector was driven, at least in part, by the declining use of oil and natural gas, which peaked in 2014. Emissions from air conditioning and refrigeration chemical leakage increased. Continued investments in energy efficiency, electrification, and building efficiency, will help commercial and institutional sources reduce their fossil fuel use and energy consumption. The scheduled phase down of high global warming potential HFC refrigerants will also reduce GHG emissions.

Commercial sector: 2005 to 2020

Total greenhouse gas emissions



Trends in greenhouse gas emission sources



Waste

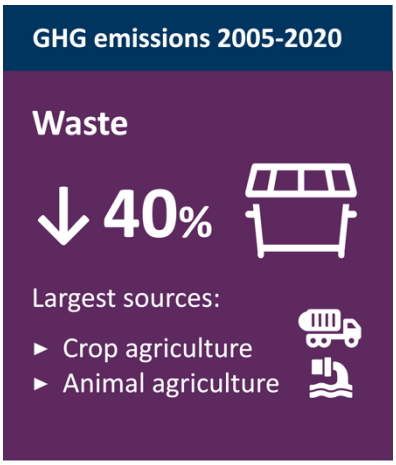
The waste sector produces about 1% of GHG emissions annually in Minnesota. Compared to the 2005 baseline, GHG emissions from the waste sector have decreased by about 40%.

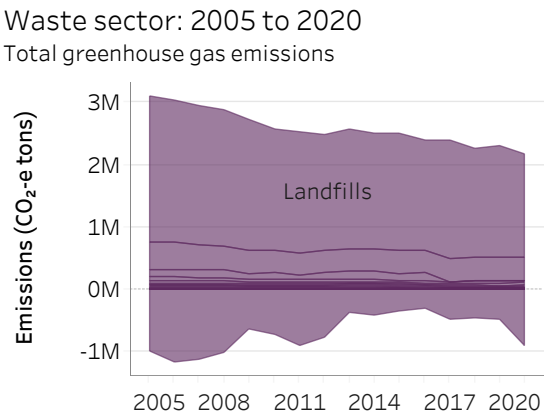
Emissions sources in the waste sector include:

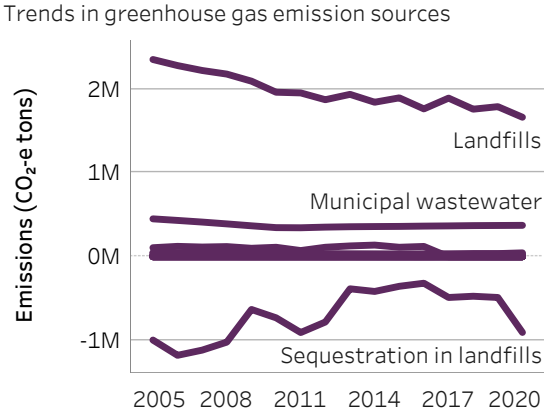
- energy use in waste processing
- incinerator fuels
- waste incineration
- methane from landfill gas and wastewater treatment

Carbon is stored or sequestered from the atmosphere as wood waste in demolition and construction landfills, which offsets other waste emissions. Today, less wood waste is landfilled than it was in the past, so carbon sequestration in landfills has declined, leading to a lower emissions offset.

Gradually decreasing methane emissions from landfills are driving the overall GHG reduction trend in this sector. Declining methane emissions are due to a combination of factors, partly the aging of waste in open landfills – older waste emits less methane as the organic fraction decomposes and becomes more stable. Also, gas capture technologies used at landfills reduce emissions of methane, either combusting it in a flare or using it to produce usable energy. As the administrator of the state's closed landfill program, the Minnesota Pollution Control Agency (MPCA) is working to address methane emissions from these facilities.



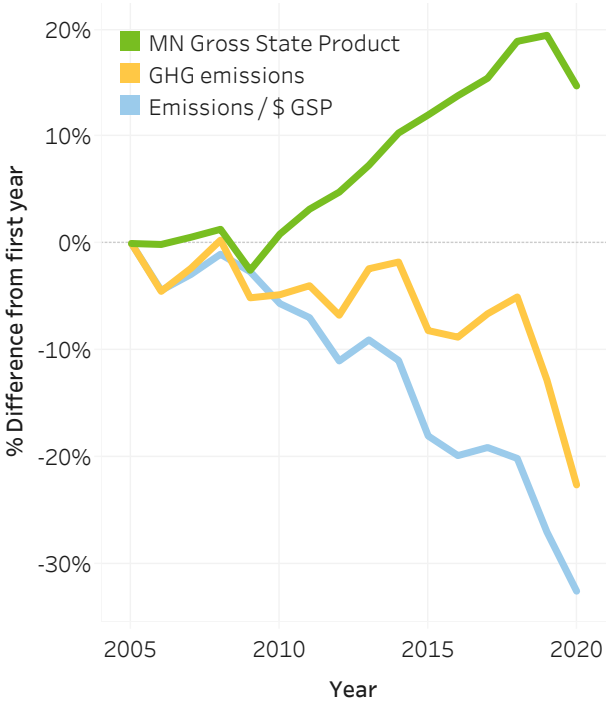




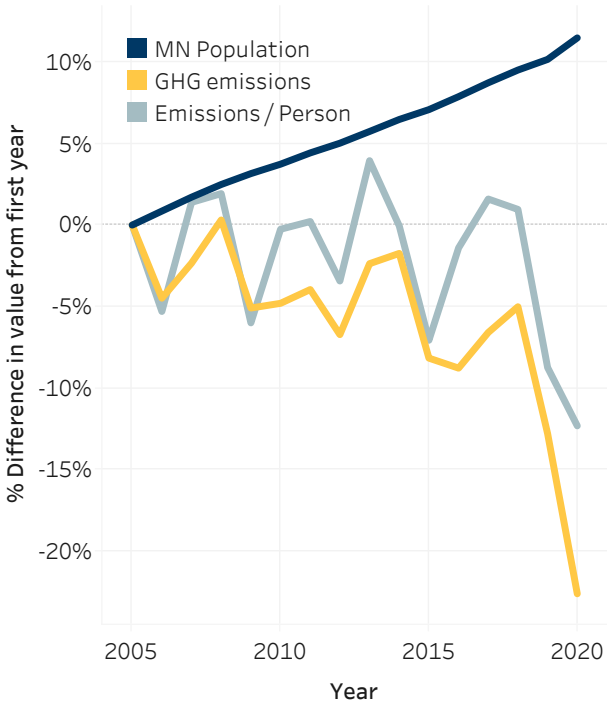
Greenhouse gas emissions and our economy

Measuring the amount of GHG emissions compared to other economic indicators is one way to understand how GHG emissions relate to the state's economy. Trends show that Minnesota has begun disconnecting economic growth from GHG emissions. Minnesota's gross state product has grown since 2005, while GHG emissions have generally decreased, demonstrating that the state economy can grow without necessarily increasing GHG emissions. Similarly, Minnesota's generally decreasing GHG emissions show that population growth can occur while reducing GHG emissions. Though the population in Minnesota is increasing, there is a net decrease in emissions per person. The Climate Action Framework includes initiatives that will help Minnesota continue to grow with a clean economy.

Minnesota's GHG emissions per dollar gross state product (GSP), 2005-2020.



Minnesota's GHG emissions per capita, 2005-2020.



Our Path Forward: Minnesota's Climate Action Framework

In September of 2022, Minnesota's Climate Action Framework was released. The Framework, developed with input from 3,000+ Minnesotans, sets a vision for how the state will address and prepare for climate change. It identifies near-term actions we must take to achieve the long-term vision of **a carbon-neutral, resilient, and equitable future for Minnesota**.

The Framework is organized around six climate action goals with specific steps and progress measures to guide and evaluate our work.

- **Clean transportation**
  Transportation represents the greatest opportunity to reduce climate pollution. The Framework's goal is to connect and serve all people through a safe, equitable, and sustainable transportation system.
- **Climate-smart natural and working lands**
  Minnesota can manage natural and working lands to address climate change by absorbing and storing carbon, reducing emissions, and sustaining local economies.
- **Resilient communities**
  Communities experience the impacts of climate change differently, and solutions must be tailored to local needs. The state can prepare communities with the resources they need to plan and build a more resilient future for themselves.
- **Clean energy and efficient buildings**
  Minnesotans can benefit from investments in clean energy and energy efficiency that will create jobs, lower energy costs, and contribute to a more stable climate.
- **Healthy lives and communities**
  Changes in Minnesota's climate threaten the health of every community, but not everyone experiences these impacts equally. The Framework's goal is to protect the health and well-being of all Minnesotans in the face of climate change.
- **Clean economy**
  Transitioning to a cleaner economy must include solutions that benefit everyone. Minnesota will build an economy that addresses climate change and equitably provides family-sustaining job opportunities.

The Framework will guide the state of Minnesota's priorities for addressing climate change in the coming years. Actions identified in the document will be developed into new policies, programs, and grants to reduce our greenhouse gas emissions.

Learn more about our next steps to tackle climate change and how you fit into this work by visiting **mn.gov/framework**.

Climate policy leadership

Ongoing state-led efforts will support GHG emission reductions in the coming years. These actions aim to accelerate our downward emissions trends to achieve our long-term goals of reducing GHGs 50% by 2030 and net zero emissions by 2050. The state is an important leader in this work, but must collaborate with businesses, other levels of government, nonprofit organizations, and individuals to achieve the Framework's goals. This section highlights a few key areas of state leadership.

Decarbonizing electricity

Minnesota's work on clean energy shows that GHG emissions can be reduced cost-effectively while meeting the energy needs of a growing economy. The electricity generation sector's steep reductions in GHG emissions in Minnesota have resulted from policies to reduce demand for electricity and shift generation to cleaner energy sources. These policies have worked with market forces that make many renewable resources more cost-effective than coal facilities.

In Minnesota and surrounding states, utilities continue to close coal plants and replace that power generation with a mix of renewables supported by natural gas. Several electricity generating facilities, especially those powered by coal, have either recently retired or are planned to be retired soon.

The Infrastructure Investment and Jobs Act and Inflation Reduction Act are two recent federal laws that will direct significant funding towards actions to reduce GHG emissions. Minnesota state agencies will use the Climate Action Framework to guide direction and prioritizing of these funds, with focuses on equitable access to funding, quality jobs, healthy communities and environment, and GHG emission reductions. This investment will support substantial progress towards achieving our climate change goals.

Utility-owned coal-fired electricity generating units in Minnesota (as of December 2022)

Facility	Size (MW)	Status
Hibbing Public Utilities Commission		
Hibbing 3	10	Standby/backup: available for service but not normally used
Hibbing 5	20	Standby/backup: available for service but not normally used
Hibbing 6	6	Standby/backup: available for service but not normally used
Minnesota Power		
Boswell unit 3	365	Operating: Cease coal-fired operations by year-end 2029
Boswell unit 4	558	Operating: Proposed to cease coal-fired operations by 2035
Taconite Harbor Energy Center unit 1	75	Retired
Taconite Harbor Energy Center unit 2	75	Retired
Otter Tail Power Company		
Hoot Lake 2	54	Retired
Hoot Lake 3	75	Retired
Xcel Energy		
Sherburne County 1	680	Operating: full retirement by 2026
Sherburne County 2	682	Operating: full retirement by 2023
Sherburne County 3	876	Operating: full retirement by 2030
Allen S King	511	Operating: full retirement by 2028

Future emissions reductions in Minnesota's power sector depend on resources entering the regional market as utilities retire aging power plants and bring new sources of electricity into service. Current utility plans show a transition to an energy mix that is over 75% carbon-free by 2034.[2] However, transmission capacity limits could slow the region's long-term growth of wind and solar energy development. The Minnesota Department of Commerce and the Minnesota Public Utilities Commission (PUC) continue to advocate for the state's interest in regional and federal forums to improve long-range regional transmission planning for a reliable and affordable transition to a decarbonized economy.

Supporting clean buildings and industry

Natural Gas Innovation Act (NGIA)

Passed in 2021 with strong bipartisan support, the Natural Gas Innovation Act (NGIA) creates a regulatory pathway to help Minnesota's natural gas utilities invest in innovative clean-energy resources and technologies. These resources could include electrification, renewable natural gas, biogas, green hydrogen, energy efficiency, carbon capture, district heating systems, or other resources. These resources offer the potential to reduce emissions, diversify Minnesota's energy supply, improve waste management, and support job creation and economic development throughout the state. The PUC has approved the framework to assess resource carbon intensity and cost-effectiveness within NGIA. Utilities are currently developing 5-year plans to be filed in 2023 for review and approval by the PUC. If done right, the NGIA can decrease GHG emissions from sectors that have been the hardest to decarbonize.

Energy Conservation & Optimization Act (ECO)

The 2021 Energy Conservation & Optimization Act (ECO) modernizes the Conservation Improvement Program (CIP) framework by allowing utilities to optimize energy use and delivery with load management and efficient fuel-switching programs. Fuel-switching measures must reduce energy usage and GHG emissions, be cost-effective, and improve the utility system load factor, compared to the displaced fuel source. ECO also raises the energy savings goals for the state's electric investor-owned utilities (IOUs), more than doubles the low-income spending requirement for all IOUs, provides greater planning flexibility for municipal and cooperative utilities, and includes activities to improve energy efficiency for public schools. Since the passage of ECO, the Minnesota Department of Commerce has focused on working with Minnesota stakeholders to develop the guidance and methodologies utilities need to deliver innovative and cost-effective CIP programs. Implementation of ECO-related programs will start in 2023.

Minnesota Efficient Technology Accelerator (META)

The Minnesota Efficient Technology Accelerator (META), working under the umbrella of the Conservation Improvement Program, supports programs that accelerate deployment and reduce the cost of emerging innovative technologies. META activities may include strategic initiatives with technology manufacturers to improve the efficiency and performance of products, as well as with equipment installers and other key actors in the technology supply chain. Benefits of activities expected from META include cost-effective energy savings for Minnesota utilities, lower bills for utility customers, enhanced employment opportunities in Minnesota, and avoidance of greenhouse gas emissions. The Center for Energy and Environment will begin implementing an approved 5-year META plan in 2023.

[2] Based on Xcel, Minnesota Power, OtterTail Power, and Great River Energy resource plans and announced retirements as of October 2022.

Advancing transportation options

National Electric Vehicle Infrastructure Program

The federal National Electric Vehicle Infrastructure (NEVI) program funds states to build electric vehicle charging infrastructure along highway corridors. The NEVI program provides $68 million to Minnesota and requires a $17 million match. The Minnesota Electric Vehicle Infrastructure Plan describes how Minnesota will spend the first year of NEVI Program funds. Minnesota's plan identifies potential exits along the I-35 and I-94 Alternative Fuels Corridors for fast charger installation. The Minnesota Department of Transportation (MnDOT) will conduct site feasibility analyses and manage a competitive site selection process in 2023 to install fast chargers at 16 sites. Minnesotans can expect to see the first round of fast chargers installed with NEVI funds by the end of 2024.

VW Settlement Grants

The Volkswagen Corporation (VW) violated air pollution standards for its diesel cars and sport utility vehicles. As part of the national legal settlement, Minnesota received $47 million to spend on projects to replace older, more polluting diesel vehicles and install electric vehicle charging infrastructure. The MPCA has invested $5 million from the VW Settlement fund in EV charging. Grants have funded 60 stations statewide, bringing the total miles of EV charging corridors to 3,600 miles. All stations from the first two phases of funding will be installed by early 2024. Between 2024 and 2027, there will be $1.76 million available for additional EV charging grants.

Active Transportation Program

MnDOT's Active Transportation Program envisions a state where all people can access safe and convenient active transportation where they live, work, and play. This year, thirteen cities and counties are receiving help with plans for walking and biking, and two communities are receiving assistance with quick-build or demonstration projects. Successful applicants in the Active Transportation Program receive support from a qualified consultant team. Each plan creates a road map for improvements through grants or community-led initiatives. Quick-build or demonstration projects assist communities in creating a concept and implementing a short-term change to a street in the community. Projects will begin being installed in 2023.

Climate-smart natural and working lands

Innovative technology to create renewable fuel

Deploying innovative technologies and increasing the adoption of climate-smart practices in Minnesota's agricultural sector holds tremendous opportunity for reducing GHG emissions, increasing carbon sequestration, and offsetting fossil fuel usage. Minnesota farmers are already using technologies like anaerobic digestion to treat livestock manure and other agricultural wastes. Anaerobic digestion reduces methane emissions from manure and creates renewable biogas that can be used on-site and lowers electricity and fossil fuel natural gas usage. Minnesota currently has three industrial-scale anaerobic digesters that remove impurities from biogas and convert it to renewable natural gas that is injected into natural gas pipelines for distribution for off-farm users. There is significant potential for expanding anaerobic digestion in Minnesota through implementing the Natural Gas Innovation Act, funding from the Minnesota Department of Agriculture's (MDA) Methane Digester Loan Program and Advanced Biofuel Incentive Program, payments through Low Carbon Fuel Standards, and federal funding available through the Inflation Reduction Act.

Soil health, water quality and carbon markets

Soil health activities mitigate climate change in several ways. Enhanced nitrogen and manure management can reduce both nitrous oxide and methane. Continuous living cover can store carbon in

the soil and decrease nitrogen fertilizer use. Investments comprehensively incentivize soil health practices that address climate resilience and adaptation on the farm, within Minnesota agri-businesses, and in broader agricultural market activities. On-farm activities include grant and loan funding to implement soil health activities. Agri-business funding assists with developing and enhancing markets for continuous living cover, encourages broader markets for climate-smart goods and services, and assists farmers as they consider carbon markets.

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) promotes and quantifies the climate benefits of water quality and soil health practices that MAWQCP-certified farms implement. MAWQCP further accelerates the adoption of climate-smart practices through the program's Climate Smart Farm endorsement, which includes climate incentive payments to facilitate farmers' voluntary entry into carbon markets or public programs. MDA anticipates continuing and expanding programs that build climate-smart activities, including MAWQCP, Agriculture Best Management Practices loans, soil health grants, continuous living cover grants, Forever Green Initiative grants, groundwater nitrate research, technical assistance, and financial assistance.

State investment to increase seedling production at the State Forest Nursery

In 2021, the state legislature appropriated $2.5 million to the Minnesota Department of Natural Resources (DNR) to increase seedling production at the State Forest Nursery. The DNR put these funds to work by purchasing additional equipment and boosting procurement of seeds and cones. Increasing seedling production will accelerate sustainable forestry strategies that generate multiple benefits, including carbon sequestration. For example, high-quality seedlings are essential for replanting forests after harvest on public and private lands each year – a practice that promotes carbon sequestration in working forests. More seedlings are needed to increase forestlands – planting trees on formerly forested open lands – which also increases forest carbon sequestration. However, this one-time investment is only a start. Additional funding for procuring greater quantities of seeds, updating aging buildings and facilities, and developing a trained workforce is critical to sustained increases in seedling production.

Waste

Prevention of wasted food and food rescue

The MPCA received $1 million to award grants to organizations working to prevent food from going to waste or rescue food for donation. These funds are focused on prevention and rescue, and they cannot be used for waste management efforts (e.g., composting) to maximize the impact on GHG reduction. Reducing food waste both reduces emissions from Minnesota's waste sector and also emissions from the production and transportation of food, whether those emissions occur in Minnesota or outside of the state. To date, the MPCA has executed grant agreements for two rounds of grants, awarding eight projects. These grant funds support projects that reduce GHG emissions and increase food security for Minnesotans.

Solid Waste Management Act

Recycling in Minnesota has significant benefits in reducing greenhouse gas emissions. Making a product from recycled material generally uses up to 90% less energy than virgin material. The MPCA supports recycling in several ways. Numerous recycling grants pass money through to local government programs and private companies. The Recycling Education Committee helps haulers, counties, and cities get information to residents about the right way to recycle and decrease contamination. Dedicated staff work on developing new recycling markets so that recyclable materials maintain a fair price in the marketplace. In 2020, Minnesotans recycled 1.8 million tons of paper, plastic, aluminum, steel, and glass.

Conclusion

Minnesota's work to reduce climate pollution is paying off. The state has successfully reduced emissions approximately 23% since 2005 and we are closer than ever to meeting our Next Generation Energy Act goal of reducing emissions 30% by 2025. Individuals, organizations, and governments across Minnesota are taking steps to reduce climate pollution. This inventory shows these actions are working. During the pandemic, emissions declined across all sectors of the state's economy. However, emissions from key sectors like transportation, industry, and power generation were already trending downward in 2018 and 2019.

There is still significant work ahead to meet Minnesota's long-term goals. Minnesota's Climate Action Framework sets new GHG reduction goals for the state, based on the best available science. This includes reducing GHG emissions by 50% by 2030 and achieving net-zero emissions by 2050. To meet these goals, the state has put forward a roadmap of actions that will reduce greenhouse gas pollution in the form of Minnesota's Climate Action Framework. Visit mn.gov/framework for more information.

Appendix: Methodology

Greenhouse gas emission inventory

The GHG inventory reports progress toward statutory goals and provides information with high confidence and transparency. The long record of emissions and high level of data disaggregation using the best available data and methods based on EPA and Intergovernmental Panel on Climate Change (IPCC) recommendations helps ensure that the inventory is complete, consistent, transparent, accurate, and relevant.

Minnesota's state-level emission reduction goals are expressed as percentage reductions from estimated emissions in a historical baseline year (2005). Like most GHG inventories, the Minnesota GHG inventory has undergone substantial revisions since it was first built. It is in a state of continuous revisions as methods and data improve, and new emission sources are incorporated. These changes are applied to all inventory years to ensure consistency, including the 2005 baseline year. Developing a consistent time series of emissions estimates is essential to measure progress.

Not all emissions are included in statewide emission totals. Only those sources which can be included in the baseline year are evaluated. While ideally, all sources of GHG emissions from Minnesota would be inventoried and tracked, in practice, the inventory includes only those sources for which there exists a well-developed scientific understanding of the physical and biological processes involved in the production and emission of GHGs. Protocols or methods must exist, and data must be available to support estimation.

Only emissions that occur within the geographical borders of the state are estimated, with two exceptions. Our estimate includes net electricity imports to meet Minnesota's electricity demand, which exceeds in-state electricity production. Emissions from the combustion of aviation fuel purchased in Minnesota but not necessarily combusted within Minnesota air space are also included.

GHG inventory protocols require accounting for photosynthetically-removed carbon dioxide stored in biomass in forests, landfills, and structures. Long-term storage of wood-carbon in residential structures and demolition and construction landfills is included in statewide GHG emission totals as sequestration because the materials will remain as carbon stores for a long time. Forest carbon fluxes are included from forest land that remains forest land and land converted to forest land following the EPA state methodology report (2022). Other land use and land use change emissions and sequestration are not yet included in the inventory but may be incorporated in the future.

Emissions are estimated from 1970 to 2020, though presented here in an abbreviated timeline. With a few exceptions, the methods used to develop these estimates are derived from the following sources:

- U.S. Environmental Protection Agency (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020.
- U.S. Environmental Protection Agency (2022) Methodology Report: Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990-2020.
- Intergovernmental Panel on Climate Change (2006) IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 1-4.
- Intergovernmental Panel on Climate Change (2019) 2019 Refinement to the 2006 IPCC Guidelines on National Greenhouse Gas Inventories.
- Radian Corporation (1996) Methane emissions from the natural gas industry. Vol. 1-15. Prepared for the U.S. Environmental Protection Agency and the Gas Research Institute.

- California Air Resources Board, et al. (2010) Local government operations protocol for the quantification and reporting of greenhouse gas emissions inventories, version 1.1.
- The Climate Registry (2008) General reporting protocol, version 1.1.
- Minnesota Pollution Control Agency (2012) Greenhouse gas emissions in Minnesota: 1970-2008.

Changes in methods and data sources

The methods used to develop the emission estimates are generally consistent from year to year, and changes made since the last report are discussed here.

Data collection methods implemented by MnDOT improved our understanding of vehicle miles traveled and the breakdown of miles traveled by vehicle types, but it is only available for recent years. Comparisons to 2005 details are less accurate, but the trend in emissions is reflected in other inventories and still useful for tracking overall progress.

Since the last report, significant changes have been made to estimate forest carbon sequestration. The DNR recommended using forest carbon data produced by the U.S. Department of Agriculture Forest Inventory and Analysis and published in the Environmental Protection Agency Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990-2020.

Uncertainty of estimates and opportunities for improvements

It is difficult to calculate the precise amounts of GHG emissions; however, getting a reasonable estimate is still helpful in understanding the general scope of emissions.

Several methods and data sources are used to estimate emissions from each activity within a sector to get a comprehensive view. Some of the methods for generating the estimates are very detailed and are the result of site-specific measurements for both activity and emissions, while others are based on the use of a model with only general data to characterize the source of emissions.

The accuracy of data for different economic sectors can vary:

- Economic sectors that use fossil fuel combustion, such as electricity generation and heating, have low uncertainty, especially when aggregated to state totals because the activity is regulated and tracked.
- Emissions from on-road transportation are estimated using the MOVES model, which depends on vehicle population data and vehicle miles traveled.
- Methane generated from municipal solid waste in landfills is modeled. There is some uncertainty from data inputs and the model's underlying equations and assumptions.
- Emissions and sequestration from agriculture, forestry, and land use have a higher degree of uncertainty due to the multitude of factors influencing biological processes and the difficulty of obtaining accurate, relevant detailed information.

Within the scope of natural and working lands, there has been significant scientific development and growth in data collection because our lands offer ways to manage emissions and store carbon. As we implement new policies and change practices, it can be challenging to reflect those actions in the inventory calculations. As a result of the Climate Action Framework, teams of specialists, including state agency staff, academics and representatives from the agricultural sector, have begun to focus on this issue in Minnesota, and we plan to incorporate their recommendations into the state GHG inventory where possible. An example is to include any offsetting or reduction in emissions achieved through climate-smart practices such as cover crop, continuous living cover establishment, and nitrogen fertilizer management. While the extent of such practices is difficult to assess, an estimate of CO_2-equivalent reductions due to conservation practices funded through state cost-share and grants in 2022 indicated reductions of over 450,000 tons CO_2-e per year.