Climate Solutions and Economic Opportunities

A foundation for Minnesota's state climate action planning

Kadunce River, Lake Superior

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Board of Water and Soil Resources

Department of Administration

Department of Agriculture

Department of Employment and Economic Development

Department of Health

Department of Natural Resources

Department of Transportation

Metropolitan Council

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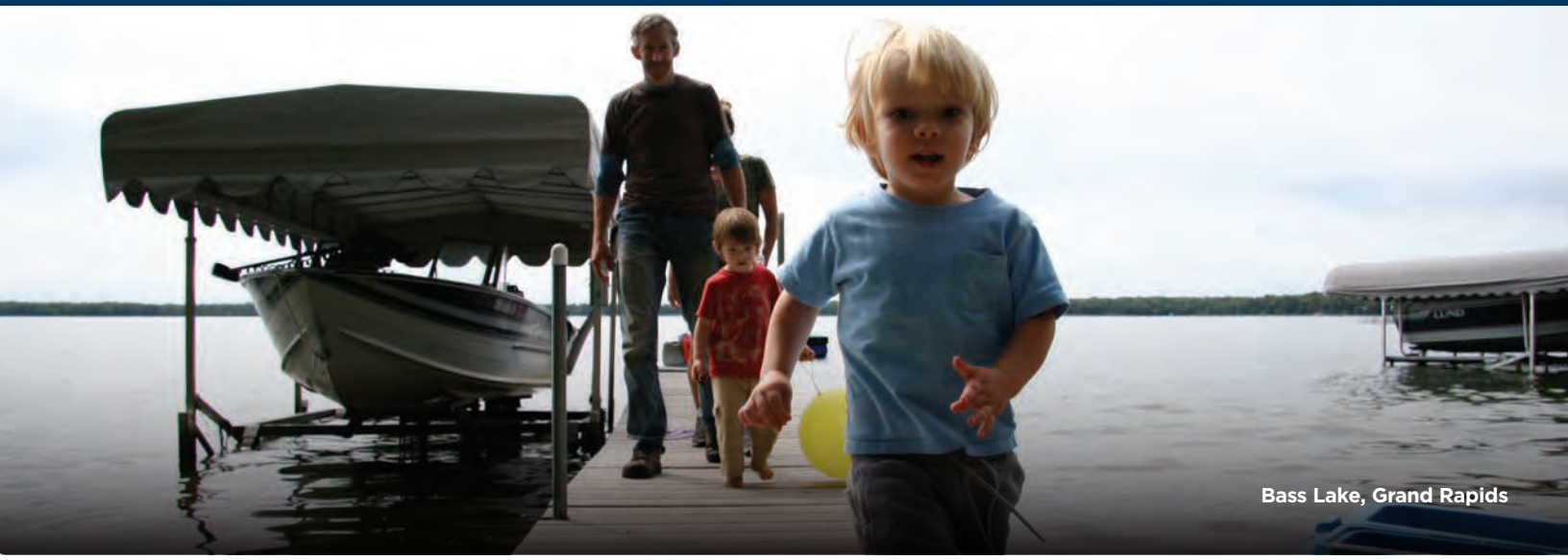
A Call to Action



Bass Lake, Grand Rapids

Minnesota has made significant strides to address climate change. Renewable energy now accounts for 21% of the Minnesota's in-state electricity generation, up from 4% in 2000. Wind energy alone provides over 17% of our state's electricity – equal to the total electricity use in one in six homes, businesses, and community institutions.

Despite this progress, we missed our 2015 greenhouse gas emission targets and will miss the 2025 goal without additional work. Minnesota needs bold action to meet these goals and secure the environmental, health, and economic benefits of tackling climate change. This report provides the foundation for state climate planning. We need to work together to transform plans into actions.

The need for action is clear: Minnesota is already feeling the impacts of climate change. We have experienced four 1,000-year rainfalls since 2002. We have watched our spruce, fir, aspen, and birch forests retreat northward. And air pollution related to greenhouse gas emissions annually cost us more than $800 million in increased health care costs.

Addressing climate change also has the potential to grow our economy. By aggressively investing in climate policies, Minnesota could add 25,000 new jobs and generate more than $2 billion in additional wages during the next 15 years. To achieve these results, Minnesota needs clean energy policies that have an immediate impact on reducing emissions from our homes, buildings, and industries. We also need long-term strategies to transform our communities and their transportation systems to reduce our use of gasoline.

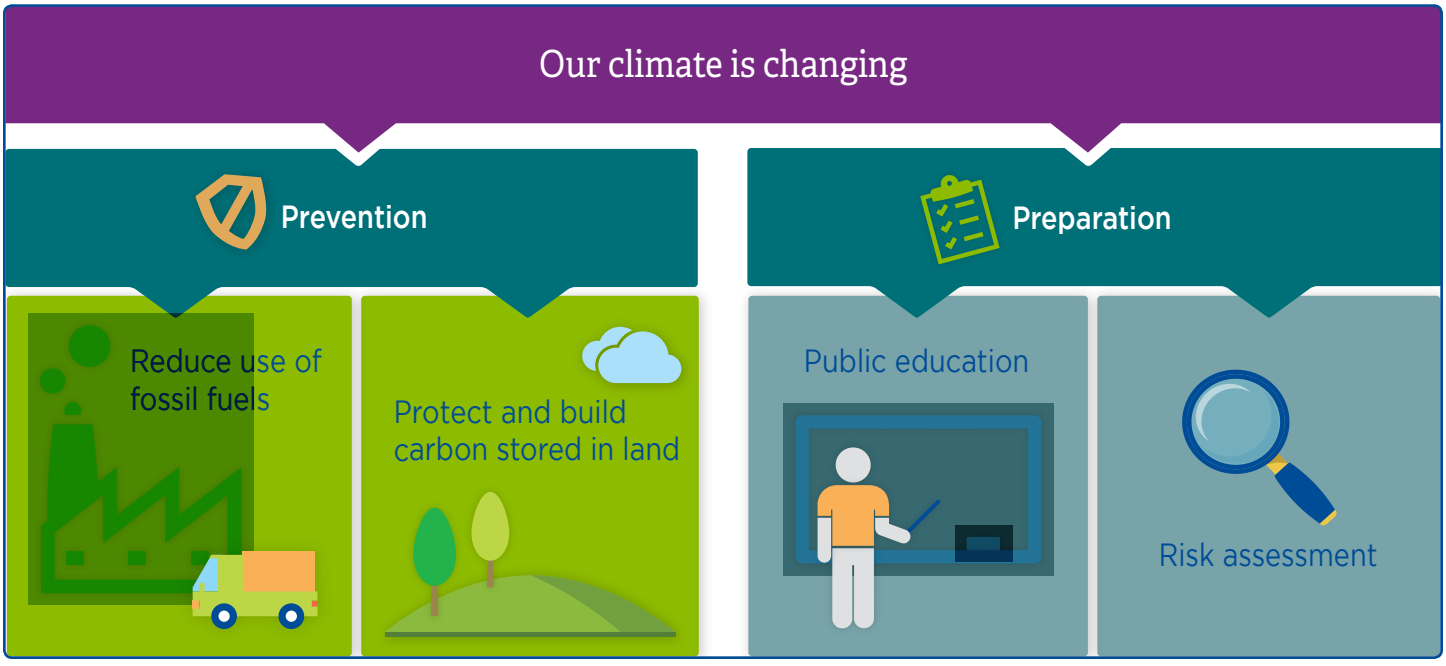
We also must protect and increase the carbon stored in our wetlands, forests, and agricultural lands. These actions will not only help us address climate change, but will also support habitat and water quality, benefiting public health and wildlife.

Working together, we can take steps that protect the environment, improve our health, and grow our economy.

Tina Smith
Lt. Governor

Executive Summary

Minnesota is committed by statute to do its part for the climate by meeting its Next Generation Energy Act goals. This 2007 law requires the state cut its annual emissions of greenhouse gases by 80% between 2005 and 2050. While much progress has been made, the 2050 goal will require policies well beyond what is already in place at the federal or state level. This report focuses on near-term emissions reductions between the present and 2030. It includes analysis and discussion of the options before us, providing a framework for decision-making that is based in part on the Minnesota Environmental Quality Board and member agencies' Climate Solutions and Economic Opportunities (CSEO) project.



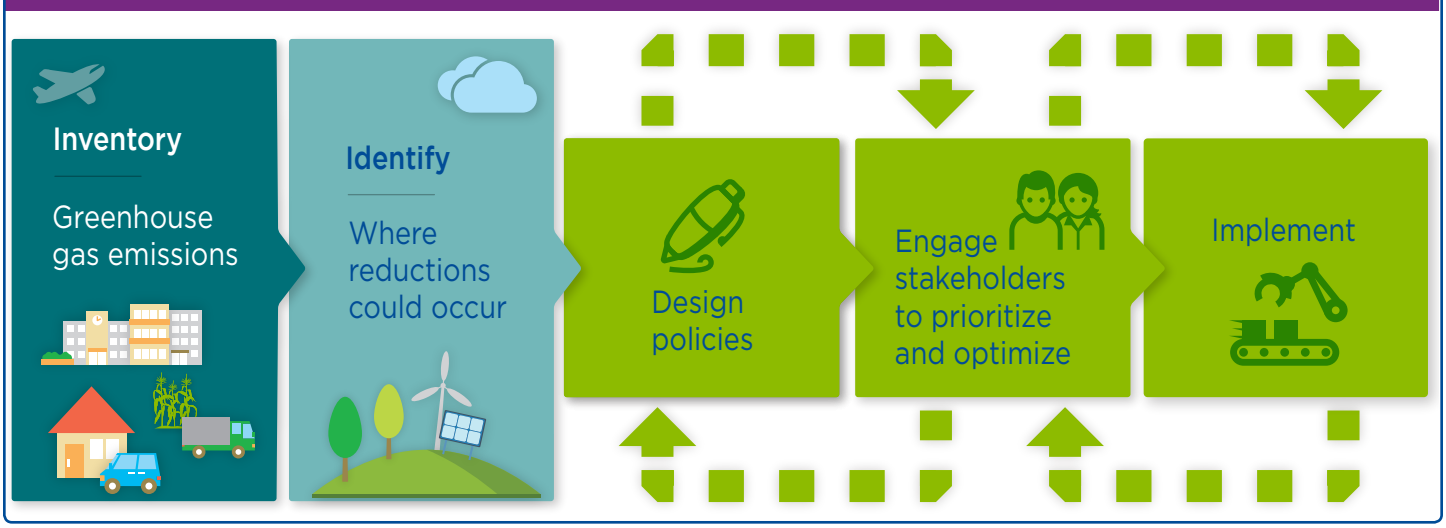
What is Climate Action?

Minnesota's climate is changing: communities are already experiencing warming temperatures and more frequent extreme rain events. The state is already paying the cost in infrastructure damage, loss of winter tourism, and a cascade of effects on agriculture, natural resources, and wildlife. To prevent the situation from becoming worse, the state needs to reduce its greenhouse gas emissions. Doing so will require the state to reduce use of fossil fuels and to protect the carbon stored in its trees and lands. Government and communities also need to assess and plan for the risks posed by the changing climate. Climate action requires efforts at global, federal, state, community, and household levels.

Prevent the problem from getting worse

The first step to reducing the greenhouse gas emissions that contribute to climate change is to create an inventory of the sources of emissions and then to identify where reductions could occur. The next step is to design policies to implement these reductions. Stakeholder engagement is important for prioritizing policies, optimizing design, and providing ongoing feedback and input.

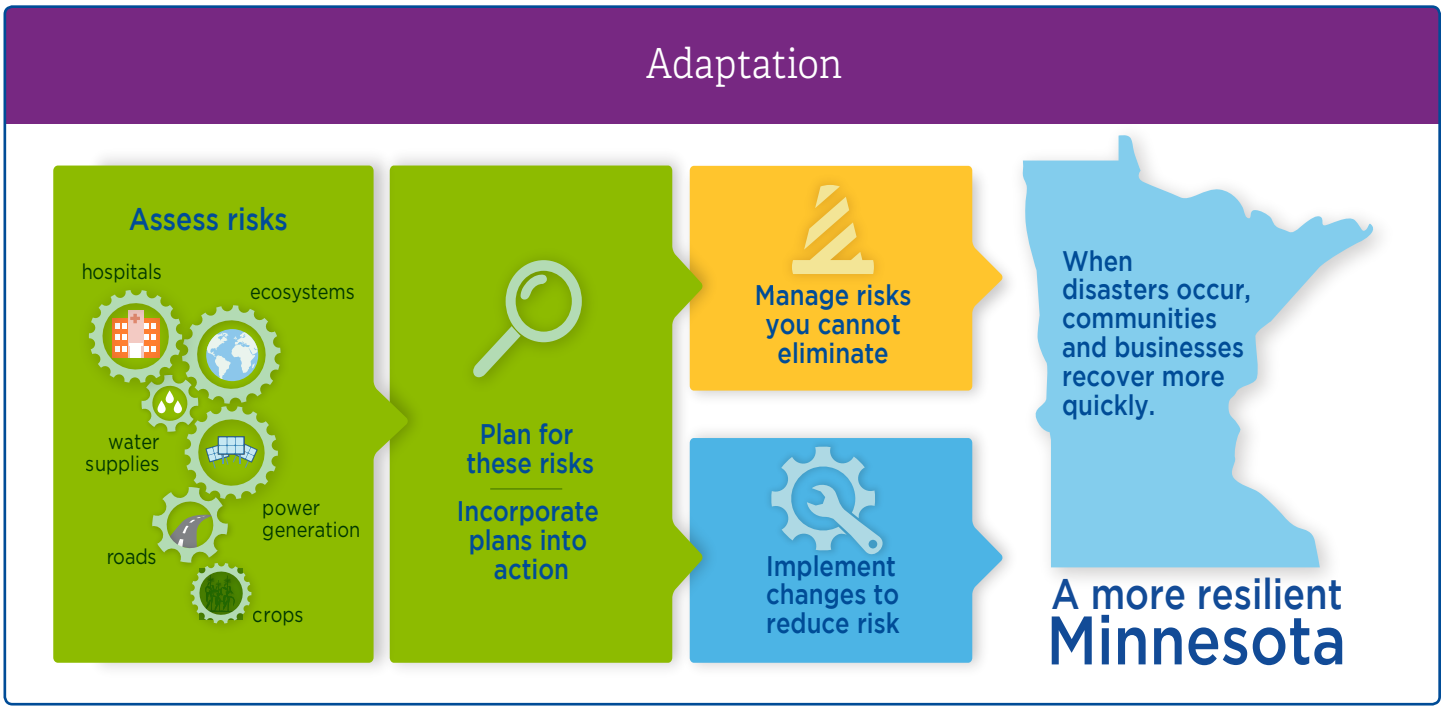
This report reflects the first three out of the five steps shown in the climate planning process. It presents Minnesota's greenhouse gas inventory, identifies where reductions could occur, and describes policy options to do so. To meet the state's 2025 greenhouse gas emissions reduction goal, the state will need to take immediate actions to reduce fossil fuel use in the electricity and industrial sectors. To meet the state's 2050 goal, the state needs to immediately begin to implement long-term strategies that reduce fossil fuel use in vehicles and that protect carbon stored in the state's land. Finally, the state needs to test new technologies and ideas through small-scale pilot projects.



Prepare for extreme weather and climate warming

More frequent extreme weather and changing climate pose risks to Minnesota's communities and businesses. The state needs to adapt to these changes and increase its resilience so that when events occur, communities and businesses recover more quickly. Doing so requires that Minnesota assess the risks to its critical infrastructure, natural resources, and businesses. Then the state can plan for risks and incorporate those risks into program and policy development. The state can do much of this planning through existing programs and efforts such as relate to storm water management, urban trees and land management, water conservation, agricultural best practices, and wetland protection and restoration. While this document focuses on climate mitigation, many of the strategies also have adaptation co-benefits that are noted.

Red River Valley



Key Findings of This Report

This report is based on work done by the State of Minnesota to better understand the state's progress on the road to reaching its climate goals and with the objective of advancing discussion of additional policy options to achieve the state's climate goals. Some of the key findings of these efforts are reflected here.

Status of climate action

- Minnesota has strong climate goals and a commitment to help maintain a stable climate on Earth.
- Minnesota is not on track to meet these goals and does not have policies in place to meet them.
- The state's renewable energy and energy efficiency policies have been hugely successful, but do not go far enough to meet the state's greenhouse gas reduction goals.
- Minnesota's climate action thus far shows a pairing of economic growth with decreasing emissions.

What the state can do to meet its climate goals

- Increase levels of energy efficiency and renewable energy in electric generation, which will have an immediate impact on emission reductions.
- Strengthen efforts to transform land use patterns and mass transit systems to reduce reliance on single occupancy, internal combustion engine vehicles.
- Plan and implement the conversion from gasoline to electric- and hybrid-powered cars and transit.
- Identify overlap between climate action and other environmental protections and economic interests and work to leverage best outcomes.
- Modify agricultural production to prevent the additional loss of soil carbon, increase carbon storage in soils, and avoid emissions from fertilizer. These changes will also greatly improve soil health and water quality.
- Invest in urban and rural forests, wetlands, peatlands, and prairies to maintain and expand sequestered carbon. These investments will also protect Minnesota's air, water, recreation opportunities, and wildlife habitat.

Opportunities to grow cross-sector partnerships

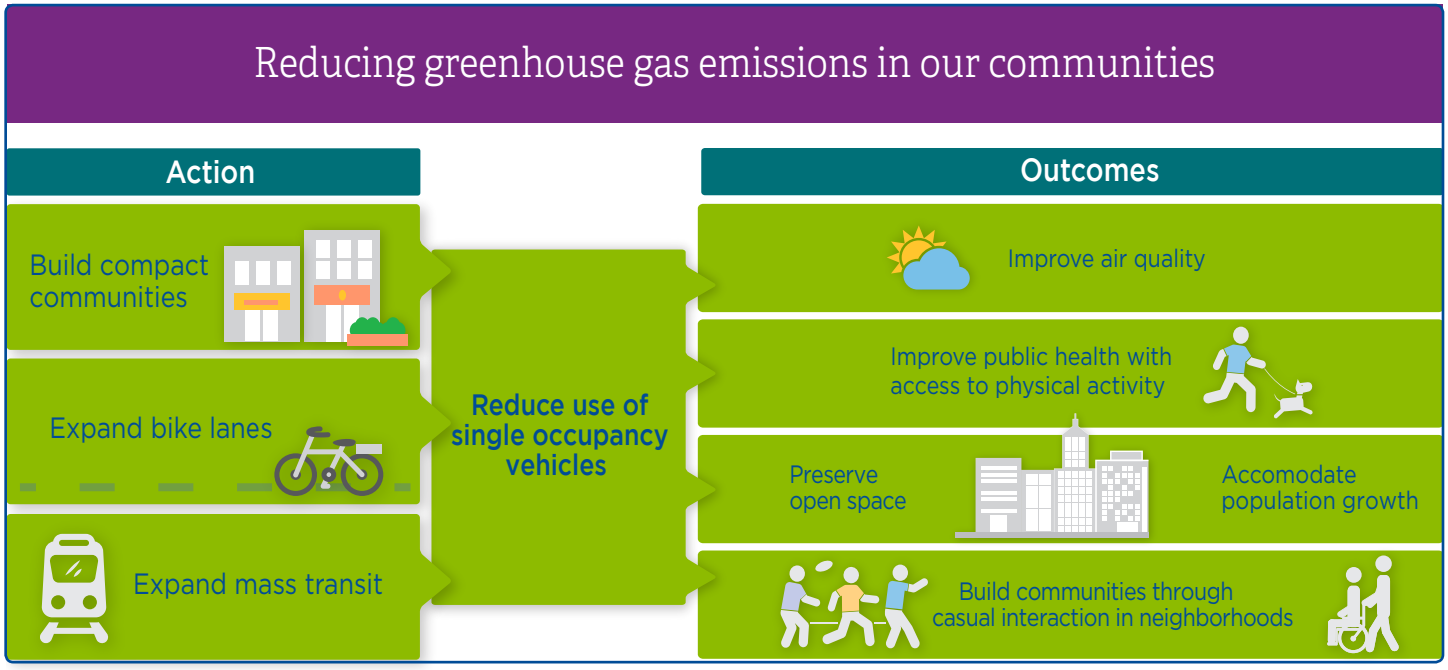
- Build capacity in state government, regional and local governments, and the public sector for ongoing assessment of the economic and greenhouse gas impacts of environmental and climate policies.
- Partner across interest groups focused on issues such as air quality, water quality, wildlife protection, as well as climate change to move policies forward. There is much opportunity to do this as climate policies include significant co-benefits for public health, the environment, and the economy.
- Recognize and support private businesses for their sustainability and climate planning.

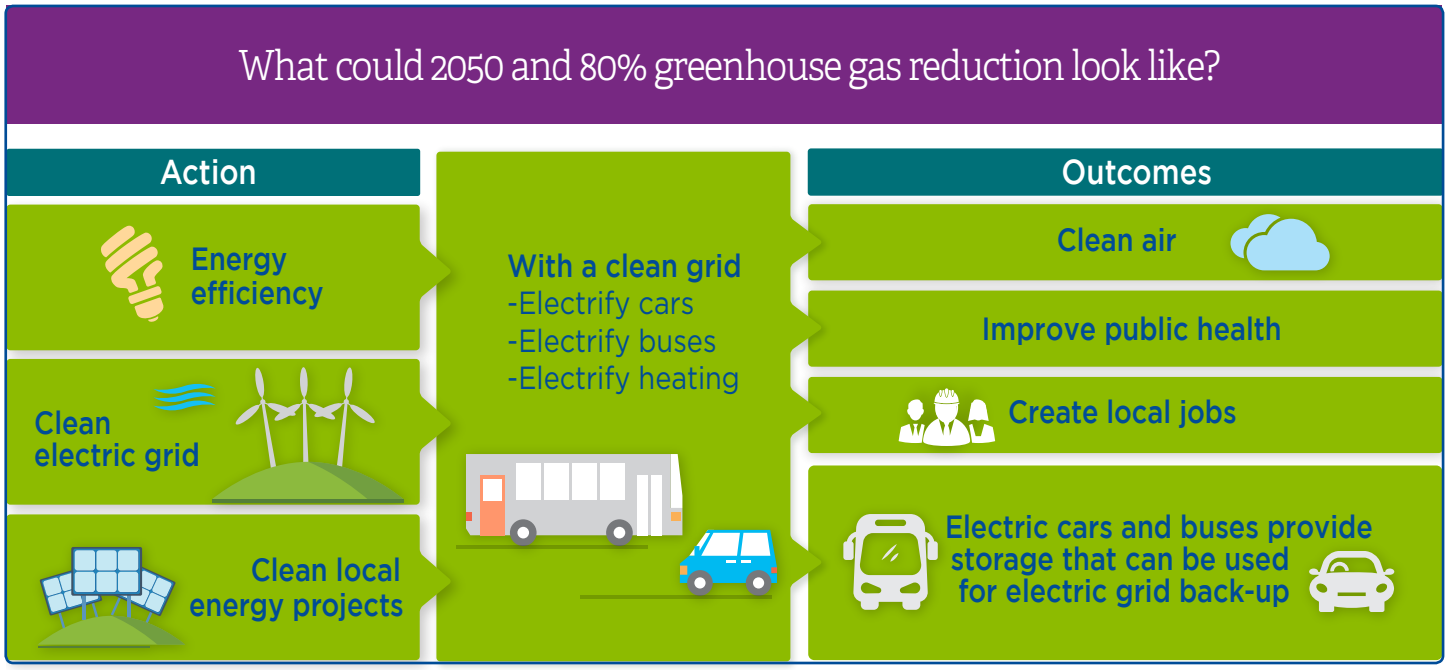
Visions for the Future

While this report focuses on being on track in 2030, the ultimate goal is 80% reduction by 2050 from 2005 greenhouse gas emission levels. To do so will require ongoing analysis and climate planning. Achieving the 2050 goal will likely require changes in how Minnesota builds and grows its communities, as well as changes in the electricity and transportation systems. The policy options discussed in this report seek to lay the groundwork for actions to set a path for 2050, recognizing a need for ongoing updates over time.

Emission reductions in Minnesota communities

The shift away from fossil fuels offers opportunities to make Minnesota communities more livable and to achieve public health benefits through greater opportunities to walk or bike, cleaner air and water, and more green spaces. In communities, climate action could take the form of reducing how much cars are driven, increasing the connectivity and density of where people live, and using more mixed zoning to allow people to live near the places they enjoy and rely on. By locating businesses and residential areas together, residents have more opportunities to go places by foot, bike, mass transit, or with shorter drive times. Expanding bike lanes and mass transit options as viable travel choices can further support the shift away from single occupancy vehicles.



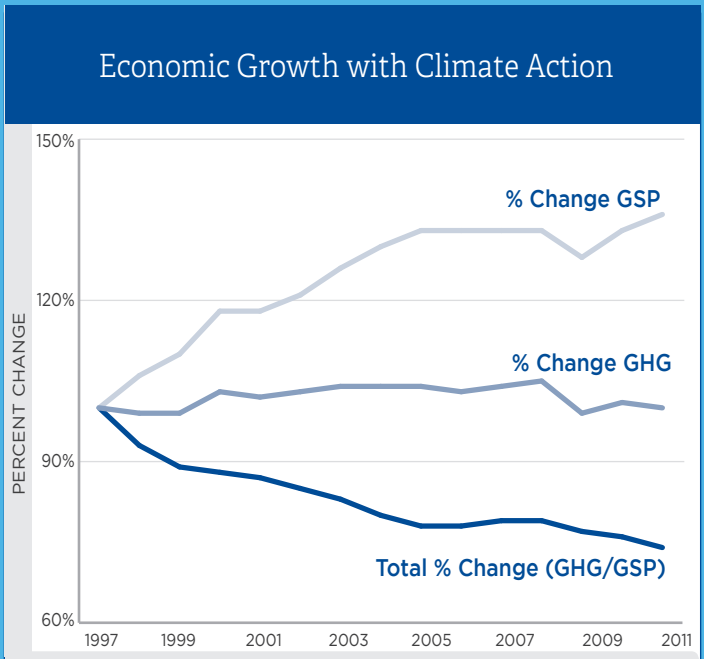


What could 2050 look like?

There are many pathways to reach 80% greenhouse gas reductions by 2050. One vision for doing so is to make the electric grid nearly carbon free through renewable energy and energy efficiency. Other energy needs could then move from directly burning fossil fuels in vehicles, homes, and industries to using clean, renewably generated electric power. For instance, cars, buses, and trains could be powered by electricity and electric-charged batteries. Heating in homes and industry could switch from directly burning fuels like propane and natural gas to using electric power or fuel from biomass.

Little Chippewa Lake

Introduction



Minnesota continues to grow its economy as it reduces greenhouse gas emissions. Relative to 1997, Gross State Product (GSP) has increased while emissions have declined and reached a plateau.

Minnesota is committed in statute to do its part to maintain a stable climate through its Next Generation Energy Act goals. This commitment requires reduction of greenhouse gas emissions well beyond what existing state policies will achieve. In Minnesota, these goals can be achieved by reducing fossil fuel consumption and by protecting and increasing carbon stored in the land and trees. This report provides a framework for directing the state's climate action planning, including descriptions of policy options and consideration of their economic and emission-reduction potential. Minnesota's climate action thus far shows a pairing of economic growth with decreasing emissions. This means that Minnesota is continuing to grow its economy while also reducing its greenhouse gas emissions.

The state of Minnesota began assessing policy options for the potential to reduce emissions through the Minnesota Climate Change Advisory Group (MCCAG) in 2007 and 2008. In 2014, the Minnesota Environmental Quality Board with all its member agencies began updating this work with the Climate Solutions and Economic Opportunities (CSEO) project. To set priorities for this reanalysis, stakeholders were convened in a public meeting in March of 2014. Stakeholder discussion focused on trends in technology adoption and new policy ideas that had emerged since 2008. State agencies designed policy options and discussed them in several stakeholder meetings in 2014 and 2015. The Center for Climate Strategies (CCS) consulting group, under a memorandum of agreement with the state, analyzed policy options to estimate greenhouse gas emission reductions and economic impacts of policy options. The analysis focuses on being on track in 2030, where the 2030 target is a linear interpolation between the 2025 and the 2050 goal. This report reflects the state's takeaways from the project and presents them as a foundation for climate action planning.

Immediate-impact policies	Long-term strategies to start now	Pilot programs to develop
Electricity: • Increase the renewable electricity standard • Retire and repower coal plants	**Urban development:** • Transit and multimodal travel • Compact development • Electric vehicles • Urban forests	**Transportation:** • Advanced biofuels • Pay-as-you-go car insurance • Fuel- or carbon-based tax
Energy efficiency opportunities: • Conservation improvement programs • Combined heat and power • SB 2030 building guidelines • Wastewater facilities	**Land management:** • Forest health • Conservation and working lands • Agricultural soil development	**Energy:** • Renewable thermal energy **Agriculture:** • Fertilizer efficiency • Market development for cover crops and perennials

Minnesota's greenhouse gas reduction goals

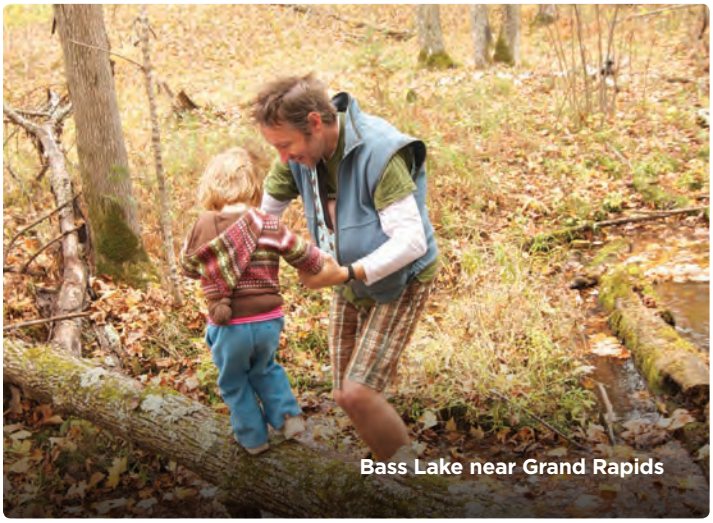
In the 2007 Next Generation Energy Act signed by Governor Tim Pawlenty, Minnesota set a greenhouse gas emission reduction goal of 80% below 2005 levels by 2050. The goal includes benchmarks of a 15% reduction by 2015 and a 30% reduction by 2025. Since then, Minnesota has successfully changed the trajectory of its emissions profile so it is no longer increasing. However, this trajectory is not adequate to meet the goal.

In 2015, Governor Mark Dayton reaffirmed the state's climate goals by signing the Under 2 MOU. This non-binding international agreement represents over 700 million people worldwide. The agreement focuses on keeping the changes in global temperature below two degrees Celsius, which is consistent with the magnitude of the goals of the 2007 Next Generation Energy Act.

UNDER 2°

Reduce fossil fuel use

The majority of the state's emissions currently come from burning fossil fuels. Minnesota has no fossil fuel resources of its own: according to the Energy Information Administration, the state imported over $18 billion of fossil fuels in 2012 from other states and countries to power vehicles, homes, businesses, and industries. Minnesota energy sources include wind, solar, biomass, and hydro. These home-grown, renewable resources produce little or no greenhouse gas emissions and can be used for electricity, direct heating, and vehicle fuel. In addition to renewable energy sources, energy efficiency offers opportunity to reduce fossil fuel use while saving money. According to Minnesota's 2025 Energy Action Plan draft report, the state wastes more energy through inefficiencies – an estimated 58% – than it actually uses for electricity, direct heating, and vehicle fuel.



Bass Lake near Grand Rapids

Protect carbon stored in lands

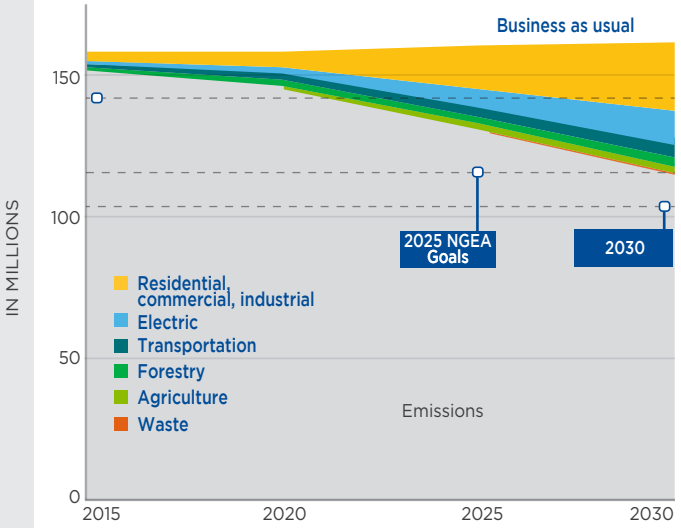
Minnesota stores significant amounts of carbon in its land and trees. As of today, an estimated 15 billion CO_2-equivalent short tons (CO_2-e) remain sequestered in Minnesota wetlands and peatlands – this represents thousands of years of carbon accumulation. An estimated 6 billion CO_2-e tons are preserved in Minnesota forests. Since the beginning of European settlement, the state lost or diminished many of its wetlands, forests, prairies, peatlands, and other natural landscapes. This has reduced the landscape's capacity to store carbon and provide other environmental benefits, such as clean water and habitat for plants and animals. Protecting and restoring natural features of the landscape and increasing adoption of agricultural best practices can have multiple environmental benefits, including reduction of greenhouse gas emissions.

Federal and state policy recognizes that there is a social cost associated with carbon emissions that can be considered in decision making. Globally, many groups are advocating for the development of a universal price for carbon emissions that would capture the social costs associated with climate change. With such a price, the value of natural lands and efforts to protect them would be recognized and encouraged by the markets.

Build compact communities with more transit options

A significant portion of emissions in Minnesota comes from vehicles. Increasing compact development of Minnesota cities by locating housing, commercial areas, workplaces, and institutions like schools nearer to each other and near transportation corridors and nodes, could provide more opportunities for people to bike, walk, and ride public transit. These strategies take careful planning and infrastructure improvements over years, but have the potential to improve neighborhoods and improve the sense of connection within communities. Replacing vehicle miles traveled with active travel such as biking and walking can have important public health benefits, while also reducing emissions of greenhouse gases and other harmful air pollutants.

Emissions Reductions from CSEO Policy Options (CO_2-e short tons)



2014-2016 analyses of policies to reduce emissions in Minnesota are shown by sector. The height of the gray area and all the colored wedges represent business-as-usual emissions, the colored (non-gray) areas represent emissions avoided through policies discussed in this report. The height of the gray area represents the remaining emissions after policy options are implemented.

Policy options for meeting climate goals

Meeting state greenhouse gas reduction goals will require both near- and long-term planning and additional actions that must begin now. Based on analysis, and further informed through public engagement, policies are divided into three categories:

- **Immediate-impact policies –** These policies result in immediate reduction of greenhouse gas emissions. These policies account for 64 to 79% of the emissions reductions the analysis showed could be made between now and 2030. All the immediate-action policies focus on the electric sector.
- **Long-term strategies –** These policies are critical for reaching the 2050 goals, but they require more time for development. Generally, these policies reduce the use of single-occupancy internal combustion vehicles and protect or increase carbon stored in soils and trees.
- **Pilot programs –** These policies have high potential to reduce emissions; however, they involve new programs or technologies that need to be explored and tested before they can be implemented at a large scale. These policies include transportation options, distributed renewable energy for direct heating and cooling, and agricultural best practices.

Policies are comprised of state-level actions that could be implemented through legislative or administrative action by state government. Many of the policies could also be implemented on a smaller scale by local governments, grassroots community initiatives, and some individual actions. Additionally, many of these policies could be implemented or supported by federal policy.

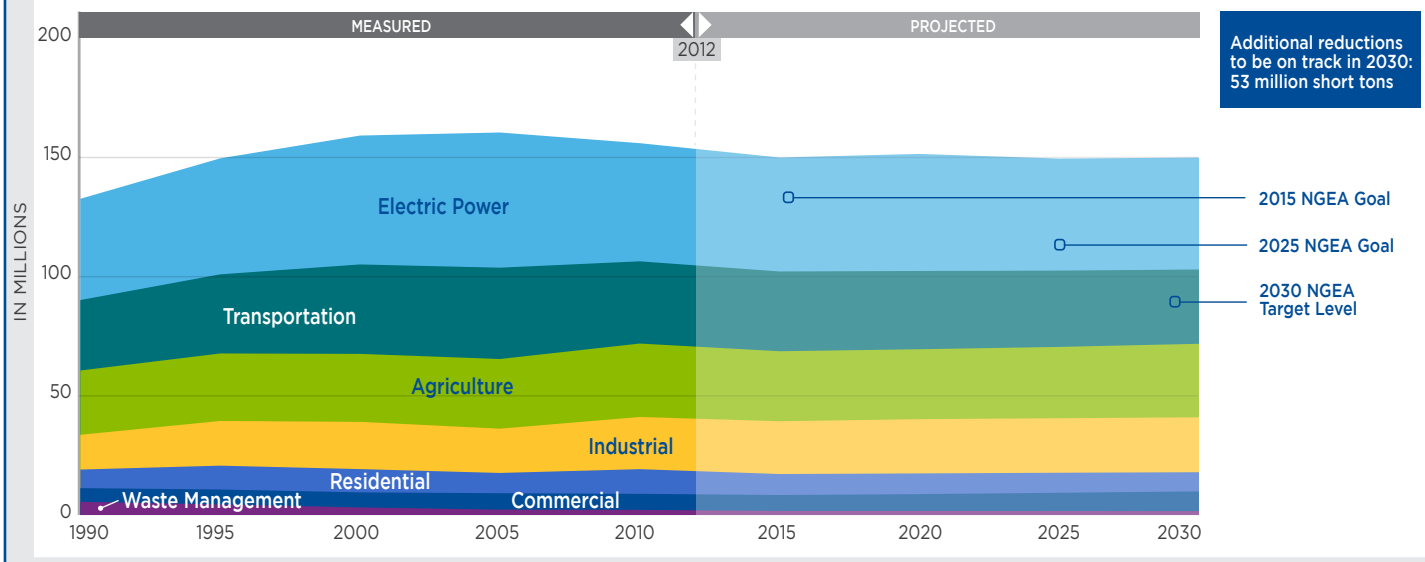
What are the broader impacts of these policies?

In addition to reducing greenhouse gas emissions, several of the policies have the potential for broader impacts on the environment and economy that could increase the quality of life in Minnesota, such as:

Business as Usual: How Are We Doing?


Sappi Paper Mill, Cloquet

Greenhouse Gas Emissions by Sector (CO_2-e short tons)



Historic greenhouse gas emissions (1990-2011) and projected emissions (2012–2030) are shown by economic sector. To be on track in 2030 for meeting Next Generation Energy Act Goals, an additional 53 million CO_2-equivalent short tons (CO_2-e) a year need to be reduced beyond business as usual. (Data source: Minnesota Pollution Control Agency, September 2013).

Greenhouse gases are gases in the atmosphere that trap heat from the sun and warm the atmosphere and surface of the planet. Man-made increases in the amount of these gases in the atmosphere are altering Earth's climate. To track progress toward the Next Generation Energy Act reduction goals, the Minnesota Pollution Control Agency estimates and reports emissions of several greenhouse gases: carbon dioxide (CO_2), nitrous oxide, methane, sulfur hexafluoride, and two classes of compounds known as hydrofluorocarbons and perfluorocarbons. For planning purposes, the state also projects greenhouse gas emissions in future years. Projections are based on compliance with existing state and federal law, population and economic trends, forecasted technology changes, and proposed energy projects and new large industrial production facilities.

Greenhouse gas emissions in 2012 totaled 154 million CO_2-e tons. Between 2005 and 2012,

Minnesota's emissions declined by about 7%. Some of these reductions resulted from the temporary outage of one of the state's largest coal-fired power plants and thus don't reflect long-term decreases.

In addition to the greenhouse gas emissions inventoried and produced in state, significant indirect emissions result from products and services purchased by Minnesotans that are not tracked by the state inventory. Many of these products and services are manufactured, distributed, grown, or disposed of outside of the state, resulting in emissions outside of state borders that are not addressed in this report. Minnesotans can reduce these emissions by purchasing fewer new goods and growing the state's reuse and refurbishment industry. Businesses and corporations can also work to track and reduce emissions in their supply chain.

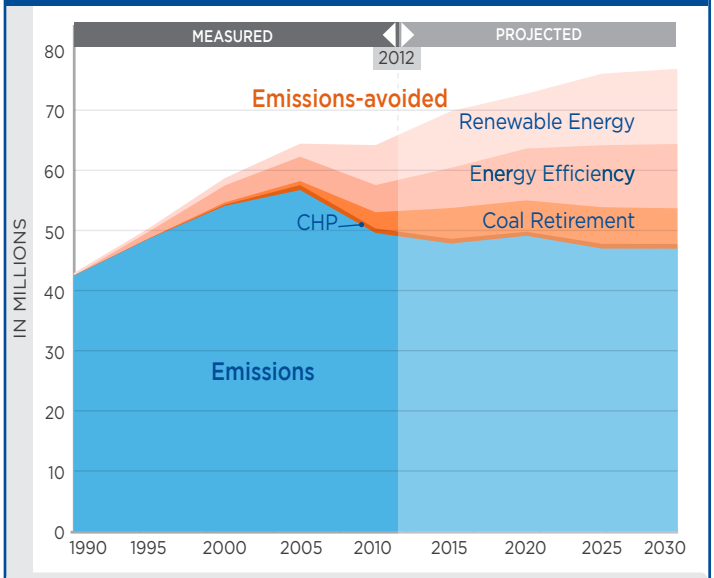
Significant greenhouse gas emissions reductions can be achieved in many sectors of Minnesota's economy. The following sections provide information on each sector of the economy and the sources of greenhouse gases and background on what has already been done to achieve emissions reductions.

Emissions come from all sectors of the economy with 85% of the state's emissions coming from electricity generation, transportation, and agriculture.

Electricity generation 	Combustion of fuel for generation of electricity
Transportation 	Fuel combustion, air conditioning leakage, leakage from natural gas pipelines and stations
Agriculture 	Livestock flatulence, manure management, fertilizer use, crop cultivation, fuel combustion
Commercial, industrial, and residential buildings and processes 	Fuel combustion to directly heat spaces and water, chemical use, non-combustion industrial processes *note this does not include electricity use in buildings, industry, or homes
Waste 	Waste processing and incineration, methane from landfill gas and wastewater, carbon sequestered in demolition landfills

Electric Utility Sector

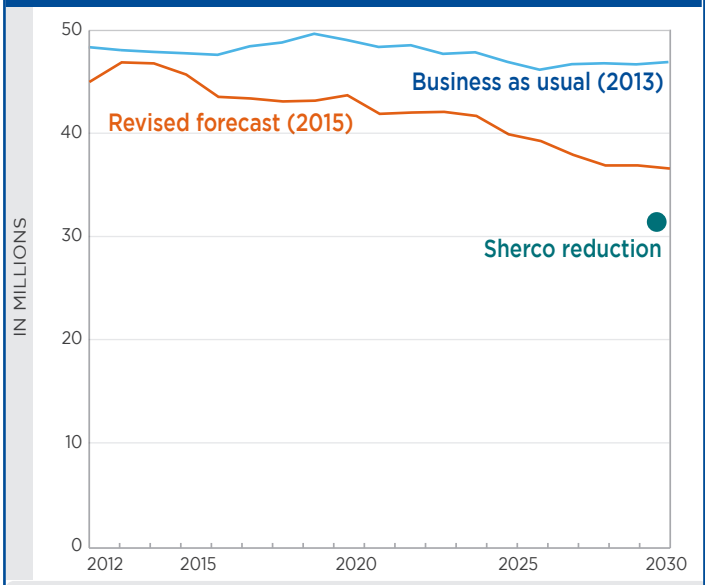
Electricity Sector (CO_2-e short tons)



Historic emissions (1990 – 2011) and projected emissions (2012 – 2030) are shown for the consumption of electricity in blue. These values include emissions from generation imported from other states. Estimated avoided emissions from renewable energy, energy efficiency, and coal retirement or replacement are shown in orange. (Data source: Minnesota Pollution Control Agency, September 2013). ***CSEO analysis is based on this 2014 forecast.

Emissions from electricity generation result primarily from the combustion of coal and natural gas at power plants. This electricity is used to light Minnesota homes, offices, and commercial buildings. It powers electronic devices and air conditioners. It's also used in industrial and manufacturing processes that don't generate electricity onsite. Emissions from electric power generation peaked in Minnesota in 2006. Between 2006 and 2011, emissions declined about 13% at a rate of approximately 3% per year. By 2030, electric sector emissions are projected to decline by 27% based on the updated 2015 forecast despite increased customer demands. The state is increasing electricity output while lowering emissions through the deployment of energy efficiency and renewable energy and by switching from coal to natural gas. Electricity from in-state renewable sources could comprise as much as 33% of net generation to service Minnesota electric demand in 2030 based on the 2015 forecast. Energy efficiency will reduce the state's electricity use by an estimated 11 million megawatt hours (MWHs) by 2030.

Revised Electricity Sector Forecast (CO_2-e short tons)



The Minnesota Pollution Control Agency (MPCA) completed its greenhouse gas forecast for the state's business as usual emissions in early 2013. The forecasts use information provided annually to the Minnesota Public Utilities Commission (PUC) by utilities in their Electric Utility Annual Report, Advanced Forecast (EUAR AF). The MPCA revised its electric power sector forecast in December 2015, using a more recent EUAR. The downward revision reflects more robust renewable energy expansion, lower expected natural gas prices, retirements at six coal-burning facilities in the state (Black Dog, Hoot Lake, Silver Lake, Austin Northeast, Taconite Harbor, and Boswell Energy Center), somewhat slower expected growth in retail electric sales, and a general reduced intensity of emissions associated with imported power. In October 2015, Xcel Energy proposed shuttering its large coal-burning units 1 and 2 in Sherburne County, and replacing one with a natural gas combined cycle unit. The MPCA estimates that this proposal, subject to PUC approval, would result in an additional emission reduction of roughly 5 million CO_2-e tons annually.

The 2015 forecast shows that between 2011 and 2030 the amount of emissions produced per MWH of electricity in Minnesota will decline 34%

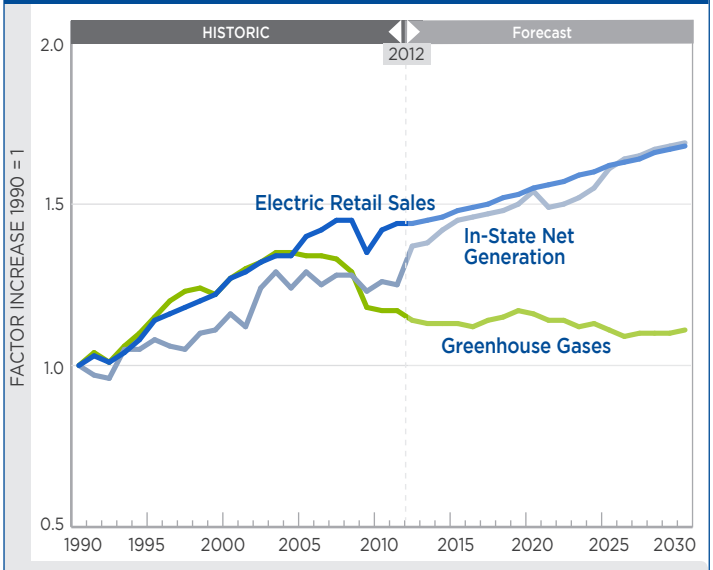
Between 1990 and 2011, several policies were implemented in Minnesota that in combination reduced 15.6 million CO_2-e tons of emissions per year from the electric power sector. Major policies include:

- In 1994, an initial investment was made in wind power and solid biomass generation capacity as part of Prairie Island nuclear spent storage legislation.
- In 2004, the state implemented its Renewable Energy Objective.
- Adoption of the "emissions reduction rider" statute M.S. 216B.1692 allowing Minnesota utilities to propose projects through an expedited cost recovery process.
- In 2007, the Renewable Electricity Standard (RES) required that by 2025, about 27% of power provided to consumers by electric utilities be generated using renewable forms of energy.
- In 2007, the state implemented electric utility requirements to reduce 1.5% of retail sales through programs that target the users of electricity, building on previous successful efficiency programs.
- In 2013, the state added a Solar Electricity Standard of 1.5% by 2020 for investor owned utilities and a goal of 10% solar electricity by 2030.

These clean energy policies continue to drive emission reductions. By 2030, existing policies will drive annual reductions of about 30 million CO_2-e tons below 2005 levels. These avoided emissions result primarily from increases in renewable energy and energy efficiency. Most of this renewable energy capacity has been utility-scale wind power. Many programs designed to help rate-payers reduce energy use also have increased energy efficiency. Energy efficiency improvements generally are the least expensive source of additional power to meet demand, often costing less than half the cost of power from new generating sources.

In addition to state policies, federal environmental standards are also influencing the electric sector in Minnesota. In particular, the 2011 Mercury and Air Toxics Standard and the ongoing Clean Power Plan process require reductions in mercury and carbon dioxide pollution, respectively, from coal-fired power plants. These policies are contributing to the switch from coal to natural gas as well as increasing investment in new renewable energy capacity.

Electricity is Getting Cleaner

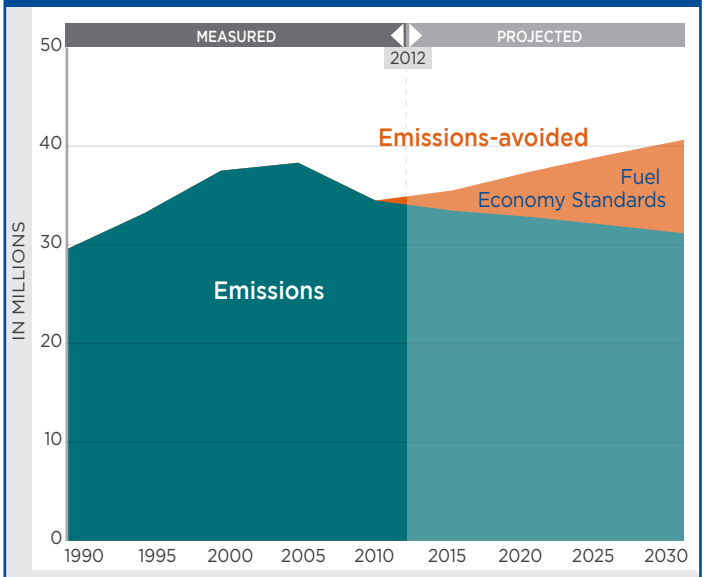


While electricity demand has increased and is forecasted to continue to increase, the greenhouse gas emissions from the electric sector will continue to decline from increased renewable energy and switching from coal to natural gas. (Data source: Minnesota Pollution Control Agency, September 2013).

Between 1990 and 2011, increased efficiency allowed Minnesota utilities to forego the construction of roughly 1,400 megawatts (MW) of new power generation capacity.

Transportation Sector

Transportation Sector (CO_2-e short tons)

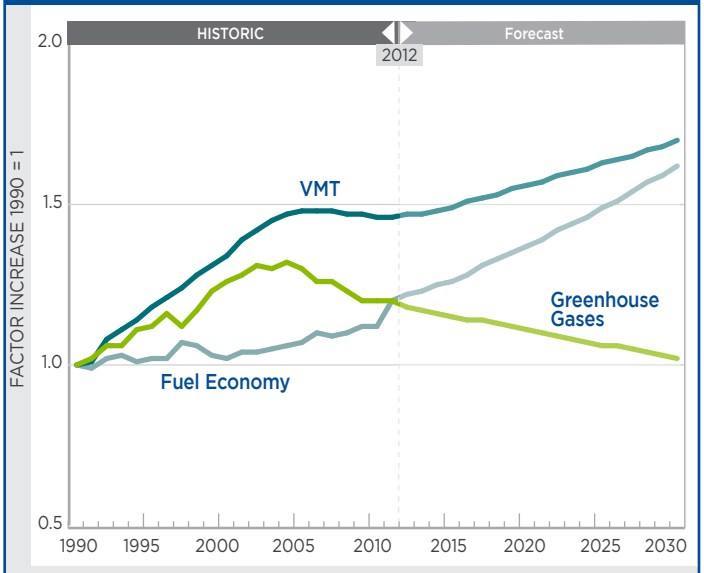


Historic emissions (1990 – 2011) and projected emissions (2012 – 2030) are shown for the transportation sector. Estimated avoided emissions from federal fuel economy standards are shown in orange. (Data source: Minnesota Pollution Control Agency, September 2013).

The largest source of emissions in the transportation sector is from combustion of fossil fuels in vehicles. Significant emissions also come from aviation. This category does not include emissions from the construction of transportation infrastructure, which is accounted for in industrial emissions. The manufacturing of concrete and asphalt are energy-intensive and produce significant greenhouse gas emissions. Transportation emissions increased about 30% from 1990 to 2004, peaking in 2004. Emissions declined about 11% between 2004 and 2011 as a result of improved vehicle efficiency, petroleum replacement by ethanol and biodiesel, and a decline in overall driving.

Emissions from transportation are projected to continue to decline. By 2030, emissions are projected to be about 9% below 2011 levels. This decline reflects a projected decrease in emissions from improved fuel efficiency of vehicles balanced against an increase in emissions from air travel. While the number of vehicle miles traveled on roads is projected to increase, highway vehicle emissions are projected to decline about 18% as a result of federal fuel economy standards for light- and heavy-duty vehicles. By contrast, emissions from aviation are projected to rise more than 25% between 2011 and 2030.

Vehicles are Getting More Efficient



Vehicle miles travelled are forecast to increase about 15% between 2011 and 2030. This increase in miles traveled will be somewhat offset by improved federal fuel economy standards. (Data source: Minnesota Pollution Control Agency, September 2013).

Reducing surface transportation emissions can be impacted by three main variables:

- Reducing the number of trips taken
- Making shorter trips
- Increasing the efficiency of vehicles or traveling by foot or bike

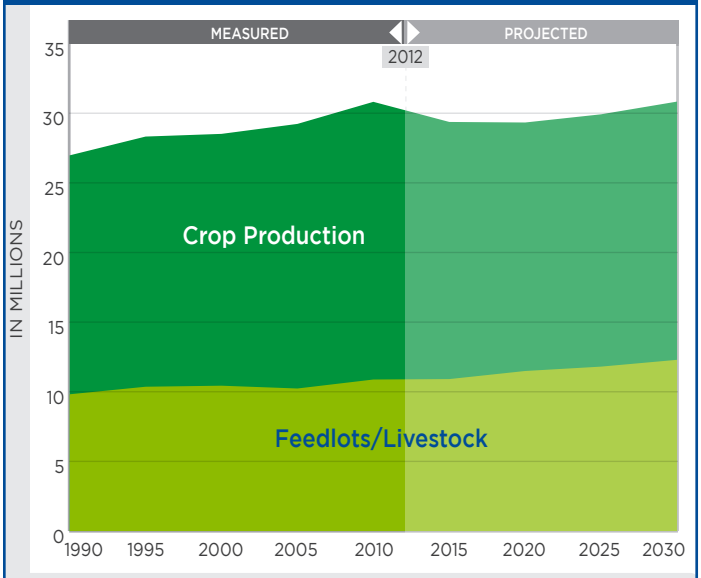
The first two variables are affected by land use and the way communities are planned and laid out. For instance, mixed zoning that allows grocery stores, places of worship, and day care

centers to be located near to where people live or work can reduce the distance people travel and increase the number of trips taken by foot, bike, or public transportation. Carbon emissions per mile traveled is determined by the mode of transportation and the efficiency of the vehicle, so walking or biking have no associated emissions; wide-spread use of mass transit results in significantly less emissions compared to driving a car; and electric, hybrid, fuel flex, or more efficient vehicles result in fewer emissions than driving a conventional vehicle.

Minnesota is investing in improved transit offerings and bike and pedestrian facilities, especially in the Twin Cities Metropolitan Area and other regional centers. Many more transportation alternatives are being considered as part of the Minnesota Department of Transportation, the Metropolitan Council, and other regional and local government transportation plans.

Agriculture Sector

Agricultural Sector (CO_2-e short tons)



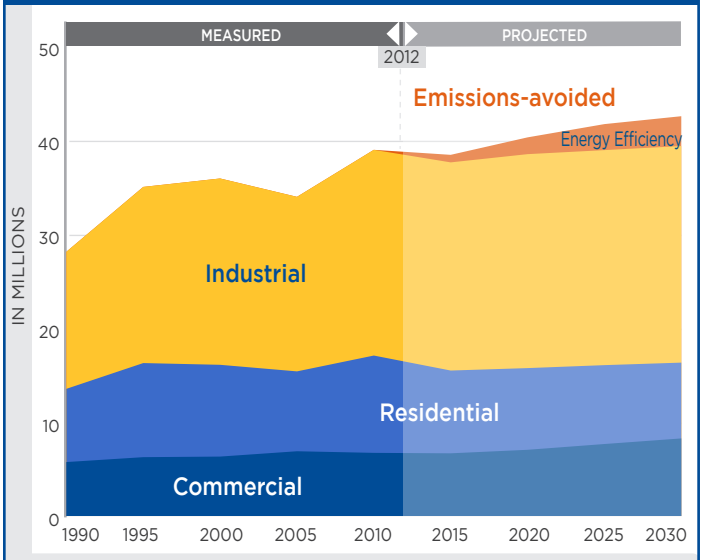
Historic emissions (1990 – 2011) and projected emissions (2012 – 2030) are shown for the agricultural sector. (Data source: Minnesota Pollution Control Agency, September 2013).

Agriculture is a critical part of Minnesota's diversified economy and is also the third-largest source of greenhouse gas emissions. About 65% of these emissions derive from crop production and the remainder comes from the production of livestock. About half of emissions from crop production are related to the use of nitrogen fertilizers. Nitrogen fertilizers release a powerful greenhouse gas called nitrous oxide. The other half of crop production emissions are from the combustion of fuel by farm tractors and other equipment or from the oxidation of soils rich in organic matter. Of livestock emissions, about one-half originate directly from animal flatulence and about one-third comes from stored manure. Agricultural emissions reductions can be achieved through using practices that reduce or increase the efficiency of nitrogen fertilizer use and improve manure management.

Agricultural emissions increased 15% from 1990 levels by 2011. Of this increase, about 70% was attributable to crop production, mainly from increased nitrogen fertilizer applications to farm fields and increased use of petroleum fuels in farm equipment. The other 30% increase came from livestock production: in particular, methane emissions increased as a result of a change in manure management from solid to liquid storage. Under current policies, agricultural emissions are projected to remain roughly constant between 2011 and 2030. The agricultural sector has the potential to achieve greenhouse gas emissions reductions by using practices that improve nitrogen fertilizer and manure management, while also sequestering carbon in soils and perennials.

Commercial, Industrial, and Residential Sectors

Residential, Commercial, and Industrial Sector (CO_2-e short tons)



Historic emissions (1990 – 2011) and projected emissions (2012 – 2030) are shown for the Industrial, Residential, and Commercial sectors. Estimated avoided emissions are shown in orange. (Data source: Pollution Control Agency, September 2013).

The residential, commercial, and industrial categories include fuel combusted to directly heat spaces and water. They also include emissions from chemicals associated with solvents, fertilizer, air conditioners, and refrigerators, as well as fuel used in processes like petroleum refining, taconite processing, and manufacturing. The direct emissions from electricity use in homes, businesses, and industries are accounted for in the electric sector.

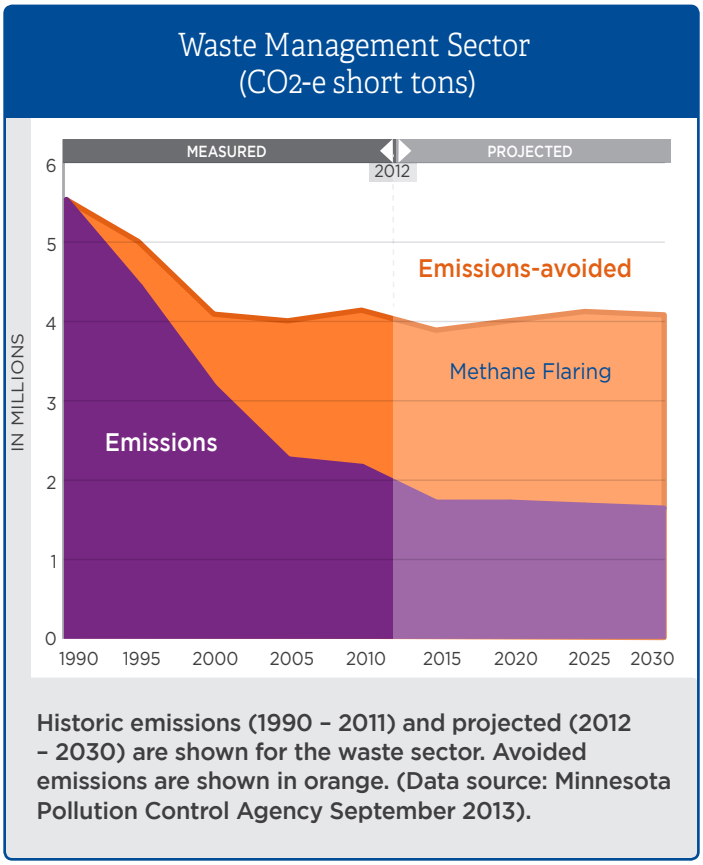
The state's Conservation Improvement Program drives avoided emissions in this sector by requiring natural gas utilities to implement cost-effective energy efficiency end-use programs to reduce energy use by 1% per year. Similar to efficiency in the electric sector, the opportunity to reduce wasted energy is significant and these efficiencies save consumers money on their energy bills.

Many industrial and household products include chemicals that emit greenhouse gases with a high global warming potential. These chemicals are found in everything from hair styling products to refrigerators. There are many alternative products that use less-potent chemicals. Recently released new federal standards are critical to decreasing the use of these chemicals. The state could support federal efforts by tracking and reporting on quantities of these chemicals in products.

Businesses and individuals often do not have information about the presence of high global warming potential chemicals in the products they buy. Without this information, there is no market force to drive changes. If the state tracks and reports on these chemicals, and adds it to labels or otherwise makes it widely available to the public, it could better inform the choices of individual consumers and private business supply chains.

Minneapolis Water Treatment Plant

Waste Sector



Historic emissions (1990 – 2011) and projected (2012 – 2030) are shown for the waste sector. Avoided emissions are shown in orange. (Data source: Minnesota Pollution Control Agency September 2013).

Waste sector greenhouse emissions result from landfills, solid waste incineration, and wastewater treatment. Greenhouse gas emissions from landfills currently account for more than half of all emissions from waste management. Wastewater treatment accounts for about 40% and solid waste incineration and other minor sources account for the remainder. Methane, a greenhouse gas that, on a per-ton basis, has approximately 25 times the atmospheric warming effect as carbon dioxide, is produced by decomposition of organic wastes in landfills, municipal wastewater treatment facilities, and septic systems. The combustion of solid waste in large incinerators or in backyard burn barrels also releases emissions.

Waste emissions in Minnesota peaked in 1990 and have since fallen by about two-thirds to about 2 million CO_2-e tons. Emissions are projected to decline an additional 17% below 2011 levels by 2030. These reductions largely resulted from capturing and flaring landfill gas. Thirty-one landfills in Minnesota currently capture methane and either destroy it in flares or use it to generate electricity or energy for space and water heating. At present, about half of all methane that is produced in Minnesota's landfills – roughly 2 million CO_2-e tons – is captured and destroyed.

Aside from flaring, it is also possible to reduce the amount of methane produced in landfills by reducing the amount of material that goes into landfills by providing recycling and composting opportunities. Recycling collects metals and plastics, melts them down, and uses the material to make new products. Composting or digesting organic materials such as food waste provides a means of keeping food and organic waste out of landfills as well. While more than 70% of waste can theoretically be recycled, at present only about 45% of solid waste in Minnesota is recycled. Many local governments are working to find ways to divert waste away from landfills through programs such as curb-side pickup of recycling and composting, one-stream recycling, and education campaigns.

The policy analysis in this report showed that reduction of packaging, increased composting, and increased recycling could drive waste reductions. These types of policies create jobs. However, Minnesota does not currently have extensive recycling processing facilities, and thus most of the economic gains and emissions reductions from these policies likely occur out of state.

Climate Action Policies

Immediate-Impact Policies

Electricity:
- Increase the renewable electricity standard
- Retire and repower coal plants

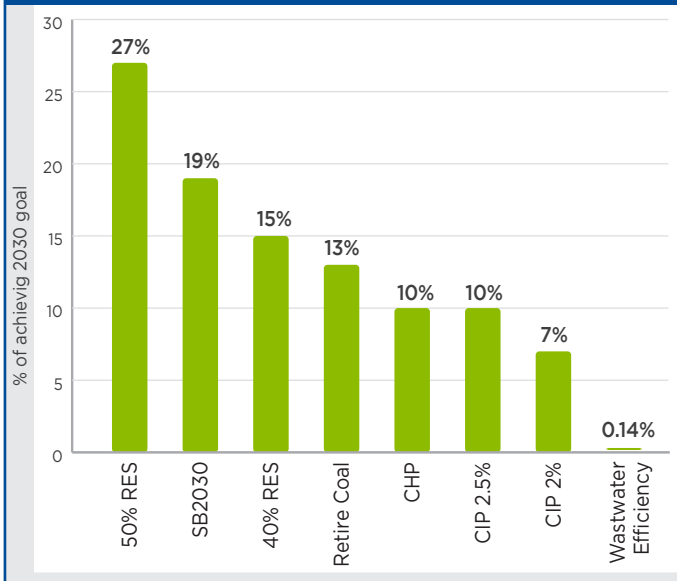
Energy efficiency opportunities:
- Conservation improvement programs
- Combined heat and power
- SB 2030 building guidelines
- Wastewater facilities


Washington County Landfill

The policy options discussed in this section would result in an immediate reduction of greenhouse gases through deployment of clean energy. Clean energy includes both renewable energy and energy efficiency. Together, the policies in this section would achieve 64–79% of the emission reductions needed to be on track in 2030, with the range depending on their level of implementation. Policies were analyzed for their potential to reduce greenhouse gas emissions and for their potential economic impact on Minnesota.

In addition to contributing to meeting state goals, the immediate-impact policy options described in this section could be used to support Minnesota's compliance with the federal Environmental Protection Agency's (EPA) Clean Power Plan, a federal rule intended to reduce greenhouse gas emissions from electricity generation. The federal rule does not start until 2022; however, the state will need to design an implementation plan to meet the rule well ahead of 2022. In addition, utilities need time to plan for compliance. By increasing energy efficiency, increasing renewable energy, and decreasing use of coal, Minnesota can decrease its greenhouse gas emissions without decreasing economic productivity or quality of life.

Percent of Achieving 2030 Target

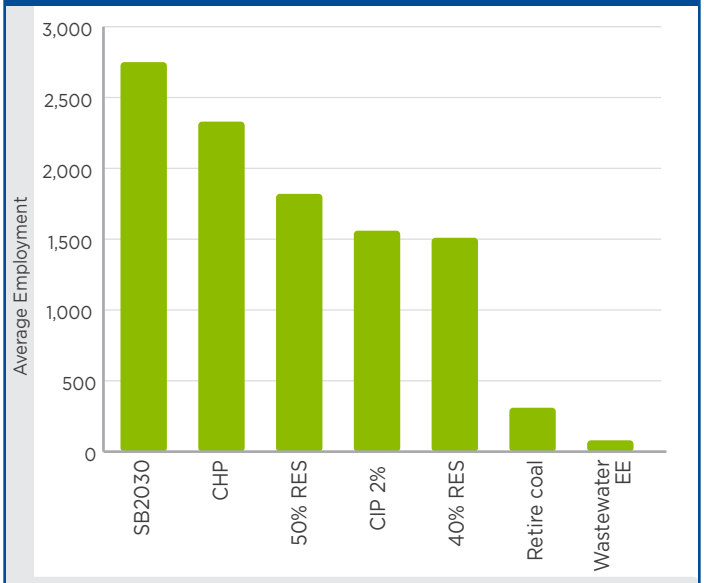


Clean energy policies that immediately reduce emissions are shown. Bar height corresponds to the percent of emission reductions towards the 2030 target.

BROADER IMPACT KEY

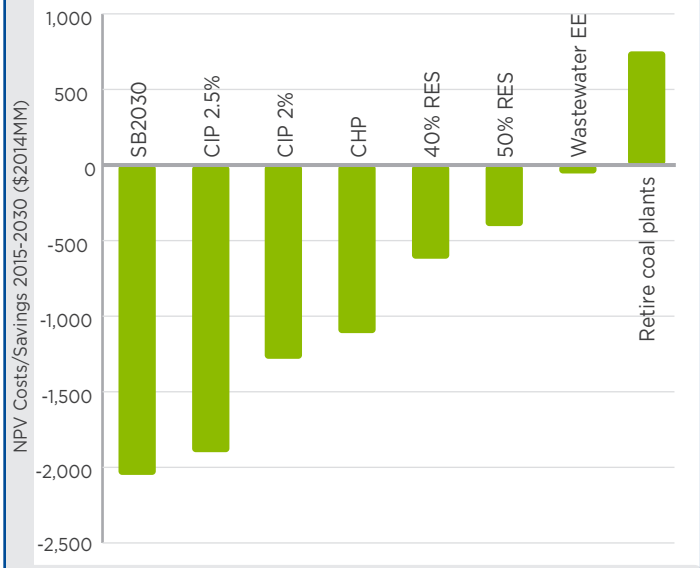
JOBS | CLEAN WATER | CLEAN AIR | PROTECT HABITAT | RESILIENCY

Minnesota Job Creation



Clean energy policies that immediately reduce emissions are shown. Bar height corresponds to the average annual jobs created in the economy through policy implementation using the Regional Economic Models, Inc. (REMI) model of Minnesota's economy.

Cost Versus Savings



Clean energy policies that immediately reduce emissions are shown. Bar height correspond to the net costs and savings of policies where negative numbers are savings and positive numbers are costs. Net present value (NPV) takes all future dollars and discounts them back to the value of a dollar (in this case) in 2014.

Decrease Fossil Fuel Use in Electricity

Increase Renewable Electricity Standard

Minnesota's Renewable Electricity Standard (RES) is a state mandate that requires different categories of electricity providers (investor-owned utilities, publically owned municipal utilities, and cooperatives) to source a minimum amount of their retail electricity sales from eligible renewable energy technologies. Legislation passed in 2013 supports higher levels of renewable energy use in Minnesota (Minnesota Laws 2013, Chapter 85 HF 729, Article 12, Sections 1, 4, and 7). State legislation also sets the goal that by 2030, 10% of the retail electric sales in Minnesota should be generated by solar energy (Minnesota Stat. §216B.1691). Increasing the renewable electricity standard would need to be done by legislation and not by administrative action.

Analysis shows that a 50% RES alone would reduce more than a quarter of the emissions needed to be on target in the year 2030. This emissions reduction is the largest for any policy analyzed. Analysis also projected that this could create on average 1,500 new jobs annually in the state. Since the analysis was done, several new renewable energy projects have been proposed that, if built, would potentially increase renewable generation to levels over 30% and potentially closer to 40% of the electricity mix. Some of these changes are pending in the Integrated Resource Planning processes. A 50% RES could move the state beyond these projects and create more certainty in increasing use of renewables.

The analysis found that, while increasing the RES would require upfront investments, there would be a net savings because instillation of renewable energy equipment, such as wind turbines and solar

panels, is less expensive than new gas or coal units. Further, once wind and solar equipment is installed, they have much lower operation and maintenance costs compared to fossil fuel equipment. It is important to note that the analysis did not focus on the technical feasibility of policies, nor did it take into account the cost of transmission system upgrades needed to accommodate potential changes in the location of energy generation.

Other states are increasing their RES as they approach fulfillment of their standards. For instance, Vermont has a 75% RES by 2032, California has a 50% RES by 2030, and Hawaii has a 100% RES by 2045. These increased RES targets reflect successful development of renewable energy.

Retire and repower coal plants

Governor Dayton has publicly announced his intention to move Minnesota away from reliance on coal. Since 2005, the state has retired or converted 12 coal units to natural gas. There are 18 coal-fired utility units currently operating that provide about a quarter of Minnesota's electric-generating capacity (approximately, 4200 MW out of a total of about 15,100MW in the state). Six of the 20 currently operating units are greater than 250 MW, and some units are even greater than 500 MW. Closing units this size means that a large amount of electric needs must be provided through other means, including shifts to renewable electricity production and demand management. This makes long-range planning and evaluation critical. By 2020, four more units are proposed for retirement, and between 2020 and 2030, another four are up for consideration. Two of these units are assets owned by Xcel Energy in Sherburne County and are in a Minnesota Public Utilities Commission process of review for possible early retirement.

Clean energy policies in Minnesota have not only reduced greenhouse gas emissions, but also created jobs and improved air quality

To aid in considering options available to meet the state's greenhouse gas reduction goals, this analysis used Sherburne County (Sherco) Generating Plant Units 1 and 2 as a proxy for modeling the impact of replacing approximately 1,360 MWs of coal power with a combination of natural gas combined cycle generation and utility-scale wind power. Due to their size, Xcel Energy's Sherburne County Units 1 and 2 are some of the largest emitters of CO_2 in the state. This analysis is useful as a proxy for generically evaluating the potential impact of transitioning utilities from coal to natural gas and renewable energy. Evaluating the transition for any particular power plant requires a more in-depth analysis and consideration of both demand and supply alternatives.

Co-benefits to increasing renewable energy and decreasing the use of coal in Minnesota

Renewable energy growth has been rapid and has had a positive impact on the economy. In 2000, only 4.2% of Minnesota's in-state generation came from renewable sources like wind or solar. In 2015, 21% of in-state generation was renewable. Since Minnesota does not have fossil fuel resources, the growth in renewable energy represents economic growth for the state. Clean energy employment in Minnesota surged 78% between 2000 and 2014, growing steadily through the recession. That is in comparison to the state's total employment growth of only 11% over that period. Over 50,000 people work on renewable energy in some capacity, and more than 15,000 employees spend over 50% of their time on renewable energy.

Burning coal releases chemicals into the air that


Source: MPCA

can make it unhealthy to breathe. Breathing and exposure to polluted air can contribute to a variety of health problems from itchy eyes to asthma attacks. Air pollution can also contribute to serious illness and even early death. The Life and Breath Report (produced jointly by the Minnesota Pollution Control Agency and the Minnesota Department of Health) estimated that air pollution contributed to about 6 to 13% of all Twin Cities deaths in 2008. Air pollution in Minnesota also creates haze that impacts views in even the wildest and most remote parts of the state. Further, mercury deposits from coal-fired power plants (in and out of state) impact aquatic ecosystems and the health of people who consume fish. Reducing the amount of coal burned reduces air and water pollution in the state.

During extreme weather events, the electric grid can be knocked out for hours or days, impacting critical services and disrupting commerce. Renewable energy installations on-site can be designed to go into "island mode" to continue to power buildings and operations independent of the larger electric grid system. These types of microgrid installations improve resiliency to extreme weather and other electric grid disruptions.

Increase Energy Efficiency in Homes, Buildings, and Industrial Processes

In addition to renewable resources, great opportunity exists to reduce emissions and save money through energy efficiency. Minnesota wastes more energy than it actually uses – an estimated 58% (based on analysis of EIA data in *Minnesota's 2025 Energy Action Plan* draft report). Energy is wasted due to inefficiencies such as thermal power plant and transmission losses, leaky windows, buildings without proper insulation, and inefficient industrial processes. When the efficiency of energy use increases, it saves money for homeowners and businesses while reducing unnecessary greenhouse gas emissions.

Expand the conservation improvement programs

The state's conservation improvement programs established an energy efficiency resource standard requirement (EERS) for utilities that requires annual reductions in energy sold by utilities through end-use efficiency programs. This policy has successfully reduced energy consumption and demand, saving individuals and businesses money. The program could be expanded by increasing the standard:

- Electric utilities could increase the EERS to 2 or 2.5% with the ability to count electric energy savings from energy utility infrastructure improvements and electricity displaced by combined heat and power projects (CHP) on top of a minimum savings goal of 1.5% from end-use efficiency.
- Gas utilities could retain the EERS of 1.5%, with a minimum savings goal of 1% for end use efficiency and the addition of CHP as an eligible technology that could satisfy the remaining 0.5% requirement.

58% of the total energy consumed in Minnesota is lost through inefficiencies

- In addition to the demand-side management requirements through the EERS, natural gas utilities and electric utilities could be required to meet a CHP standard that is embedded in the EERS. Collectively, the natural gas utilities could be required to meet a CHP goal of 34 million British Thermal Units of displaced fossil fuel by 2030. Collectively, the electric utilities could be required to meet a CHP goal of 800 MW by 2030.

Increasing the state's energy efficiency requirements to 2 or 2.5% would reduce significant greenhouse gas emissions, making up between 5 and 10% of the emission reductions needed to be on target in 2030. This policy also has economic and health benefits. Energy efficiency saves homeowners, business owners, and utility ratepayers money. In addition, this policy is projected to create on average over 1,500 jobs annually. It would also lead to the health and environmental benefits of reducing coal and natural gas burning in the state.

Combined heat and power

Combined heat and power (CHP) systems reduce fossil fuel use and greenhouse gas emissions by recovering heat for useful purposes that would otherwise be wasted as reject heat in power plants. CHP systems can use this "waste" energy for heating buildings, domestic hot water, industrial processes, or for conversion to electric generation. Additional reductions are achieved both through the improved efficiency of the CHP systems, relative to separate heat and power technologies, and by avoiding transmission and distribution losses associated with moving power from central power stations that are located far away from the point of electricity end use.

Encouraging an increase in the use of CHP could be achieved through several existing statutes:

- **Conservation Improvement Program (Minnesota Statute 216B.241)** – Expand electricity and natural gas utility Conservation Improvement Program goals to promote use of CHP systems, including encouragement of electric or natural gas utility-owned CHP as well as incentives for implementation of non-utility owned CHP.
- **Renewable Electricity Standard (Minnesota Statute 216B.1691)** – Expand the Renewable Electricity Standard (RES) to include a specific goal for currently eligible CHP technologies, and incorporate additional provisions for RES credit to encourage use of biomass for thermal energy production without power production in areas of the state without access to natural gas service.
- **Integrated Resource Planning (Minnesota Statute 216B.2422)** – Require that electric utilities demonstrate that they have considered CHP opportunities before they propose building new generation capacity.

In addition, the following are needed to support CHP:

- Technical assistance for utilities and industry to analyze feasibility and apply implementation actions to commercialize high-performing CHP and other thermal recovery and advanced clean energy technologies
- Revision of standby rate practices
- Update of state rules on application of the capacity credit for avoided cost.
- Establishment of clear and consistent interconnection standards based on best- known practices

Analysis shows that this policy would save money over the fifteen-year modelling window and create an average of more than 2,000 new jobs annually, while achieving 10% of the emission reductions needed to be on target in 2030. Further, CHP can be integrated into microgrids to allow for systems to operate independent of the electric grid, making systems resilient to power outages.

SB2030 building guidelines

Buildings account for 40% of all the energy used in Minnesota. In 2011, the residential sector consumed about 21% and the commercial sector consumed about 18% of all the energy used. Ensuring that new or renovated buildings serve us well into the future means constructing energy-efficient buildings paired with renewable energy. Initiatives such as the national programs Architecture 2030 and Zero Energy Ready Homes and Buildings or Minnesota's Sustainable Building 2030 (SB2030) provide standards to progressively achieve improved building energy performance so that buildings avoid energy use through efficiency measures, produce as much as or more energy than they use annually, and can export excess renewable energy generation to the utility to offset the energy used.

State building energy codes specify minimum requirements for new and renovated buildings. These codes are uniform across the state and restrict local governments from setting their own standards. Possible ways to move this policy option forward include:

- Use a stepped process to require use of SB2030 for all new and renovated commercial buildings, all new one- and two-family dwellings, and multi-family residential buildings.
- Sufficient technical assistance and training could be made available to assist local units of government, architects, engineers, builders, and developers in moving toward SB2030.
- Adoption of SB2030 as an appendix into the Minnesota Building Code could make the SB2030 standards available for local jurisdictions to use.

Minneapolis, MN

- Legislation could require all state-licensed buildings use SB2030 design guidelines and could provide funding for the technical assistance and training required to support these changes.

This policy has great potential for job creation and financial savings, creating on average a projected 2,500 new jobs annually or more, saving $2 billion over a 15-year period, and reducing almost 20% of the emissions needed to be on track in 2030. Savings come from reduced energy needs over the 15-year period. It is important to note that upfront capital and investment in supportive programs would be needed to enact the policy.

Wastewater aeration tank

Metro Wastewater Treatment Plant

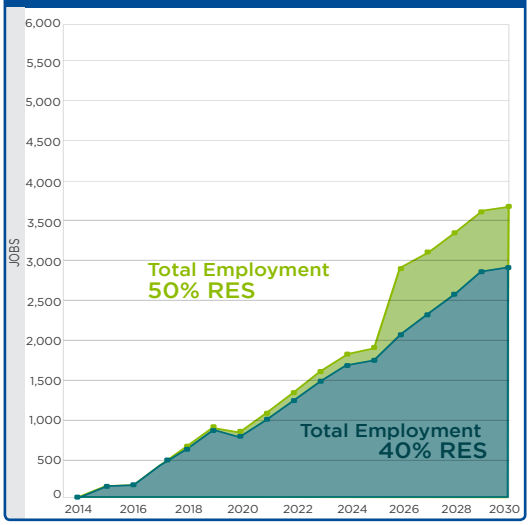
Wastewater facilities energy efficiency

There are approximately 600 wastewater treatment facilities in Minnesota. These critical, energy-intensive facilities have large electricity bills taxpayers pay. The potential for conservation is substantial and offers savings in electricity bills for local governments across the state. To achieve desired reductions, the state could require a 25% reduction of energy by 2025 at wastewater treatment facilities or the state could tie energy efficiency goals to public funding.

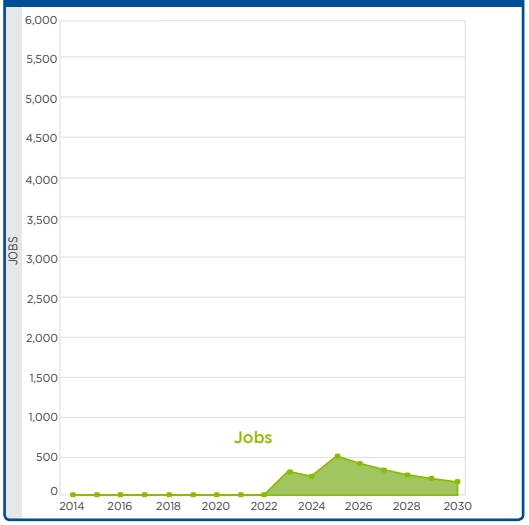
The best opportunity for achieving energy efficiency at wastewater facilities comes from replacing old aeration equipment with new, more efficient equipment. Aeration equipment typically accounts for half the energy usage at mechanical facilities and nearly all of the energy consumption for aerated lagoon facilities. Replacement of older aeration blowers with new high-efficiency blowers can reduce energy consumption for aeration by 50% or more.

This policy option does not have the potential to achieve huge reductions of greenhouse gas emissions at the state level, but may achieve important savings at the local level. As local governments are stressed by financial demands, additional funding would be key to the success of this effort.

40 or 50% renewable energy standard

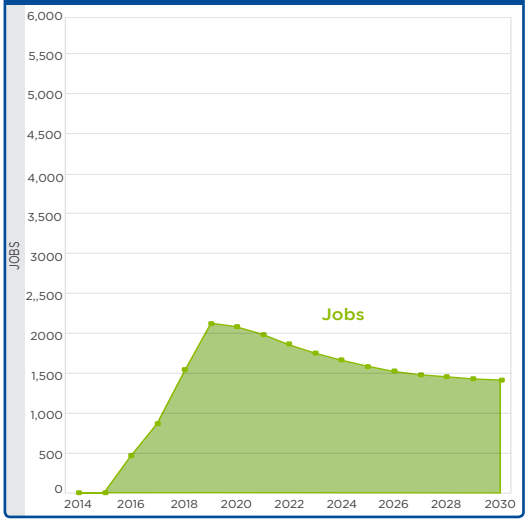


Retiring or replacing coal with natural gas and wind



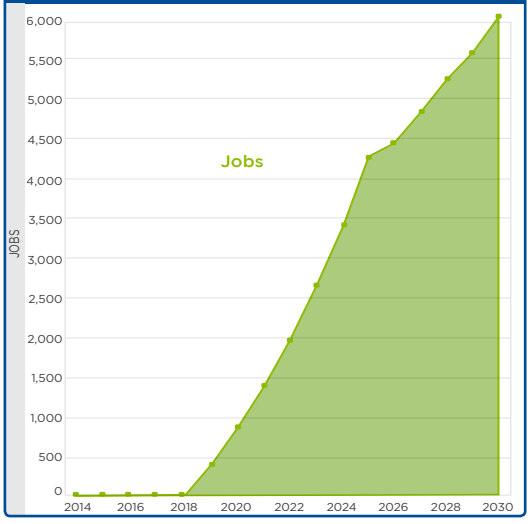
New full- and part-time jobs created over the 15-year modelling period using the Regional Economic Models, Inc. (REMI). All figures are shown on the same scale for comparison.

Increasing the Conservation Improvement Standard to 2% a year

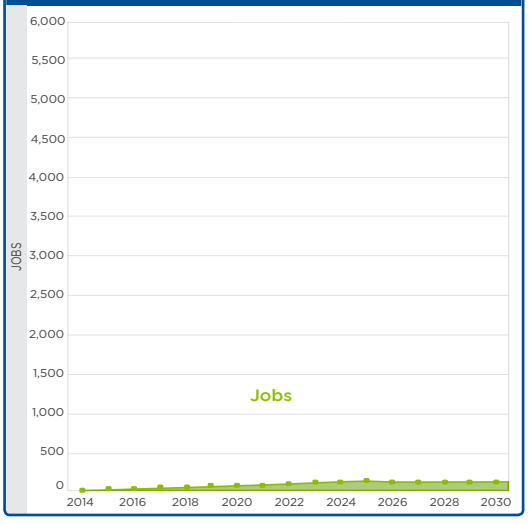


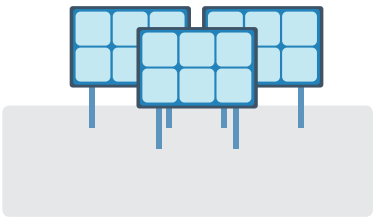
Combined heat and power

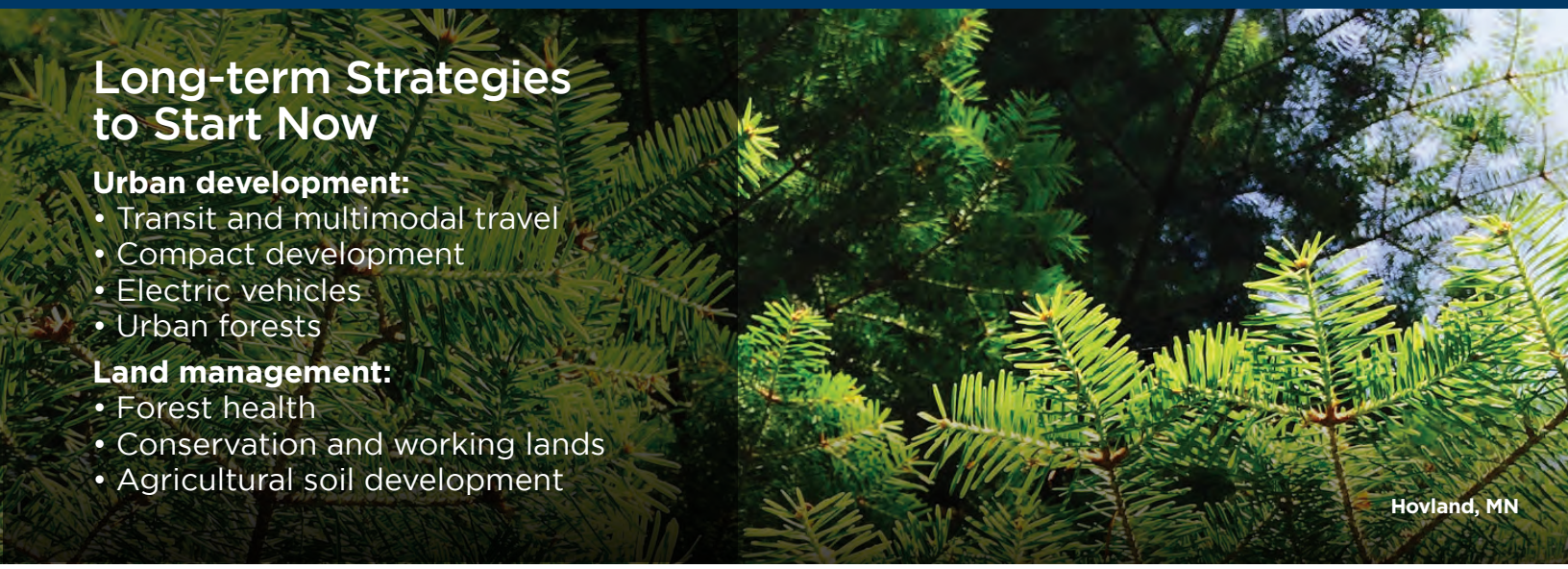
Implementing an energy stretch code for buildings (SB2030)



Implementing wastewater efficiency







Long-term Strategies to Start Now

Urban development:
- Transit and multimodal travel
- Compact development
- Electric vehicles
- Urban forests

Land management:
- Forest health
- Conservation and working lands
- Agricultural soil development

Hovland, MN

Emissions reductions from the policies in this section require more time for development, but they are critical for Minnesota to meet its 80% emissions reduction goal. Policy options include changes in urban and rural land management, which require long-term planning, infrastructure, and ongoing public discussion. In rural landscapes, policies could support land use practices that include protection of carbon stored in plants and soils. In urban areas, policies could support reductions in the use of automobiles.

Land management in the Metro and across the state has historically been designed to support automobile travel. While mass transit is available at some level across the state, it is not developed to accommodate a wide range of daily trips. The availability of bike lanes, pedestrian paths, and electric vehicle infrastructure are not wide-spread across all communities either. Policies could support a wider range of transportation options and more compact and energy-efficient development.

Urban and Community Development

Transit and multimodal travel

The Twin Cities Metropolitan Area's long-range transportation guide – the 2040 Transportation Policy Plan – is multimodal: addressing highways, transit, pedestrian facilities, bicycle facilities, freight, and aviation. Objectives and outcomes that strongly relate to greenhouse gas emissions reduction include:

- Reduced transportation-related air emissions
- Additional MnPASS managed lanes
- Additional transit-ways and arterial bus rapid transit lines
- Increased the of transit, bicycling, and walking
- Increasing availability of multimodal travel options

Each of these efforts focuses on relieving congestion and increasing opportunities for travel by means other than a single-occupant vehicle. Developing new and more convenient transit options and improving the quality and safety of bike and pedestrian facilities encourages people to use alternative means of transportation, which would reduce greenhouse gas emissions. A more balanced system has many co-benefits. Increased walking and biking are associated with better health. Decreased driving can lead to lower levels of harmful particulate pollution in the air.

How do Minnesotans get to work?

	NUMBER	PERCENT TOTAL
Drive alone	2,136,394	78.1%
Carpool	237,894	8.7%
Transit	94,172	3.4%
Bicycle	20,803	0.8%
Walk	79,106	2.9%
Other means (including taxi)	22,648	0.8%
Work at home	145,028	5.3%
Total	**2,736,045**	**100.0%**

(Data Source U.S. Department of Transportation for Minnesota in 2013)

Compact development in urban areas

Land use patterns and population density can have a significant impact on transportation and residential energy consumption. The implementation of urban planning and development strategies in larger communities and cities could lead to greater concentration of new development, a more compact urban form, more locally diverse land uses, and shorter trip distances. These policies can reduce the number of vehicle miles traveled and greenhouse gases emitted from transportation by making the places that people rely on, such as grocery stores, schools, and work, closer to home. If people don't have to travel far for the things they need or want, their vehicle trips are shorter and they are more inclined use transit or bike or walk instead of driving. Also, more compact development means municipalities need to build and maintain fewer roads and other infrastructure, which can reduce greenhouse gas emissions related to construction.

Compact urban development, which features multi-family homes and mixed-use commercial and residential buildings, can also reduce heating and cooling loads through improved efficiency, thus reducing greenhouse gas emissions from buildings. Since urban form and travel behavior are mutually reinforcing factors, limiting growth of vehicle miles traveled will require a suite of coordinated land use and transportation actions.

Electric vehicles

Electric Vehicles (EVs) are powered by electricity (via battery) instead of by fossil fuel burning combustion engines. EVs have several advantages. They have no tailpipe emissions and lower operating and maintenance costs. In addition, they can reduce greenhouse gas

In 2014, Minnesotans imported $11 billion of fossil fuels for transportation from out of state

emissions. The potential for emission reduction from EVs depends on the energy sources powering the electric grid. With renewable-based grid electricity, EVs offer a significant reduction of greenhouse gas emissions relative to conventional vehicles. The more renewable energy on the electric grid, the greater the emissions reduction. Currently, many EV customers choose to use utility renewable energy programs and some provide their own renewable power through residential solar panels. For example, Xcel Energy's Windsource program allows consumers to choose wind-powered electricity. Great River Energy offers the Revolt Program supplying renewable electricity for EVs at no added cost.


Como Lake, St. Paul

In order to meet the 2050 climate goal, Minnesota will need to significantly reduce gasoline and diesel consumption. For example, a recent study conducted by Siemens for Minneapolis, estimates that for the city to meet its greenhouse gas reduction goals (also 80% by 2050) they would need to replace 65% of passenger vehicles with electric vehicles. While EVs are being adopted by some drivers in Minnesota, there are many challenges and barriers to more wide-spread adoption. EVs are a relatively new technology and cost more than comparable conventional vehicles. With most new technologies, costs often start high, but with advances in manufacturing or design and with economies of scale, the prices come down dramatically. The same trend could be expected of EVs. The trajectory for EV prices is not known, but supportive policies could help grow the market and lower prices. As manufacturing of EVs is still a growing industry, early adoption and commitment to EVs in Minnesota might draw part of the supply chain to the state and have an added economic benefit. Minnesota can continue to grow its EV fleet through:

- Provide more utility programs that incentivize off-peak charging or that create a market value for vehicle-to-grid services as part of grid-modernization efforts.
- Join the existing Zero Emission Vehicle (ZEV) Standard, which would require that by 2030 automobile manufacturers, through their dealerships, ensure that 10% of the total light- and medium-duty vehicle sales in Minnesota are EVs.
- Build charging infrastructure along major highway corridors, in rest areas, and at public destinations such as state parks. Work with developers and private partners to expand options in parking ramps, commercial districts, and other locations.
- Provide incentives to support EV adoption: for instance, parking and metered highway lanes could be made free or discounted for EVs.
- Research, test, and deploy electric buses on regular route services in the Twin Cities region and urban areas in Greater Minnesota where feasible.
- Research and monitor new technologies that have the potential for expanding EV use, such as dynamic wireless power transfer and autonomous/self-driving vehicles.

Broad adoption of EVs in Minnesota could reduce air pollution from cars, improving public health and reducing greenhouse gas emissions. While EVs require new charging infrastructure, they otherwise work well with Minnesota's existing transportation system.

Community and urban forests

Trees and tree canopies in communities provide shade and windbreaks that reduce energy use. Trees also provide other economic, environmental, and public health benefits. For instance, trees improve air quality, slow the velocity of storm water, provide habitat for birds and other wildlife, mitigate temperature extremes, improve soil health, and sequester carbon. Trees also contribute to the aesthetics of communities, increasing property values and supporting the physical and mental well-being of residents.

To support Minnesota's community forests, funding is needed to protect, maintain and expand the canopy. For instance, the emerald ash borer poses a significant threat to ash trees across Minnesota. Communities would benefit by planning to mitigate the potential loss of ash trees.

Urban heat islands in Minnesota can be extreme, with temperature differences of up to 10°F, even within an area of just a few miles in the Metro Area. Investing in expanding canopy in areas impacted by urban heat islands can reduce these impacts. Priority could be given to planting and protecting trees in areas with vulnerable populations, including low-income individuals, children, and the elderly who are disproportionately impacted by the negative health and economic effects of tree loss.

Como Park, St. Paul

Land Management

Forest health

Although disturbances, such as blow downs, fires, pests, and disease outbreaks are natural features of forest ecosystems, they release large amounts of carbon and reduce the rate at which the state's forests as a whole remove carbon from the atmosphere. With anticipated changes in climate, the frequency and intensity of landscape-level forest disturbance (tens to a few hundreds of thousands of acres) in Minnesota will likely increase. Re-establishing forests without delay on disturbed sites helps restore high levels of carbon sequestration. Dedicated resources, however, are needed to ensure timely restoration of forests following large disturbances.

Conservation and working lands

Perennial vegetation in natural ecosystems and agricultural systems sequesters more carbon than do row crops. Restoring and protecting prairies, wetlands, forests, hay fields, and pastures will increase carbon sequestration. In the case of working lands, it will minimize carbon losses from annual cultivation and erosion. Protecting forests sustains high rates of carbon sequestration while preventing large emissions associated with forest loss. In addition, conserving vegetative cover improves groundwater recharge, wildlife habitat, and ecological integrity.

Conservation policy actions are pursued for many reasons other than climate change, but policy makers should consider ways that these actions can also achieve and be tracked for greenhouse gas emissions reductions.

Several existing federal and state programs support landowners setting aside lands from row crop production, including the federal Conservation Reserve Program (CRP), Reinvest in Minnesota (RIM), and Minnesota's Conservation Reserve Enhancement Program (CREP). Typically, the land that is set aside is vulnerable to erosion and not ideal for production. The expansion of these programs is limited by funding to pay landowners for the retirement of working land and establishment of perennial vegetation. To make land conservation programs effective at protecting and increasing carbon stored in the land, there need to be guarantees that the land will be set aside for a long enough period for carbon to collect. If land taken out of these programs is returned to row crops, the carbon stores would be removed and the greenhouse gas benefits of the programs would be lost.

Agricultural soil development

Soils contain vast quantities of carbon and are in fact the largest terrestrial carbon pool on Earth. On a global scale, the soil carbon pool is about three times larger than the atmospheric pool.

St. Peter, MN

Carbon levels in soils vary depending on climate, soil parent material, vegetation type, landscape position, and human activities. Organic carbon is an important part of soil health and is critical for growing crops and other plants. Carbon escapes from soils when it is exposed to the air through tilling and other agricultural practices. Loss of carbon from the soil both impacts climate change and decreases the agricultural value of the soil, making it less productive. Agricultural soil carbon stocks can be increased by practices such as diversifying production systems with perennials, minimizing tillage, using manure as a soil amendment, and incorporating cover crops where practicable. These strategies are most efficient at sequestering carbon when implemented as a suite of practices rather than stand-alone activities. Minnesota has approximately 19.5 million acres of cropland. Even a modest change in soil carbon content per acre results in significant total greenhouse gas benefits.

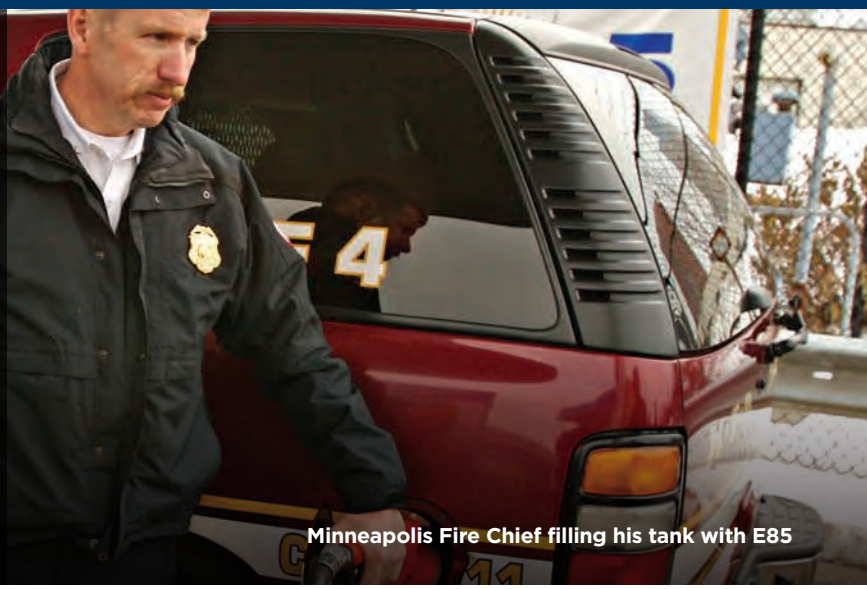
Cover crops and perennial crops sequester and store greater quantities of carbon than row crops. Row crops grow for 3 to 4 months of the year before harvest, leaving the soil bare for the remaining 8 months. Cover crops can be incorporated into annual row crop systems to lengthen the amount of time there are living plants holding the soil in place on fields. Cover crops both protect soil from erosion and increase carbon sequestration in the soil with their root structures. Similarly, perennial crops increase carbon storage by maintaining permanent root systems that add biomass to the soil and minimize the loss of carbon resulting from tillage operations.

Pilot Programs to Develop

Transportation:
- Advanced biofuels
- Pay-as-you-go car insurance
- Fuel or carbon based tax

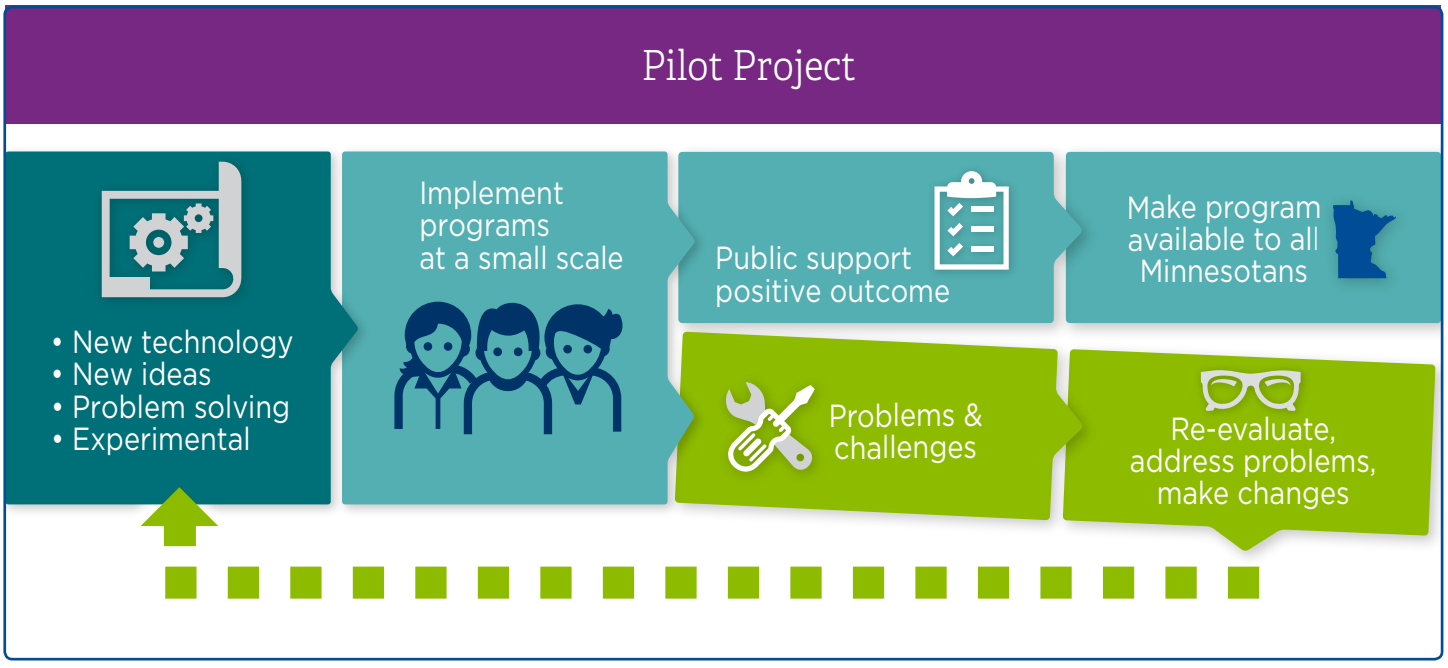
Energy:
- Renewable thermal energy

Agriculture:
- Fertilizer efficiency
- Market development for cover crops and perennials


Minneapolis Fire Chief filling his tank with E85

New programs and technologies have a lot of potential to reduce greenhouse gas emissions, but they need to be further explored and tested before they can be implemented on a larger scale. Designing and implementing pilot programs can provide the opportunity to test these programs and technologies. These policies include transit options, distributed renewable energy, and agriculture strategies.


Source: MPCA



Transportation

Advanced biofuels

Minnesota has been a national leader in renewable fuel policy and development. It was the first state to mandate the use of ethanol and biodiesel in the state's fuel supply. Today, Minnesota has an ethanol production capacity of more than 1 billion gallons, has the most E85 stations in the nation, and it is estimated that the state's biodiesel requirement will replace over 65 million gallons of petroleum-based diesel fuel. The state has aggressive goals for in-state liquid biofuels consumption to replace gasoline: 14% by 2015, 18% by 2017, 25% by 2020, and 30% by 2025 (Minnesota Statute 239.7911). However, it is not on track to achieve these goals. Further, biofuels have yet to achieve their full potential for emissions reductions.

For biofuels to produce a significant life-cycle reduction in greenhouse gas emissions as compared to fossil fuels, further development of "advanced biofuels" is needed. Advanced biofuels are biofuels other than ethanol produced from corn starch, with a minimum 50% improvement in greenhouse gas emissions over the use of fossil fuels. Advanced biofuels can be sourced primarily from Minnesota biomass from agricultural or forestry sources, or from the organic content of municipal solid waste. While electrification is increasingly an option for passenger vehicles, larger commercial vehicles are less likely to be electrified, so advanced biofuels offer a viable cleaner alternative for these large vehicles.

A state financial incentive is now in place to assist with the commercial production of advanced biofuels (Minnesota Statute 41A.16) and federal funds and matching funds from state and private sources are supporting grants for retail biofuel pumps and storage tanks. Minnesota can further support the development of advanced biofuels and related technology through incentives for commercial production in Minnesota and incentives to improve fuel delivery infrastructure for higher biofuel blends.

Pay-as-you-go car insurance

Under most current insurance plans, drivers pay a flat amount regardless of how many miles they drive. However, the more one drives the more likely one is to incur damages and seek repayment from insurance. As a result, some insurance companies now offer plans that vary based on how much a person drives, called "pay-as-you-go" insurance pricing. Conversion from existing fixed cost for insurance to a per-mile variable cost would incentivize a reduction in vehicle miles traveled without increasing costs to Minnesota drivers. Modeling of this policy found that it would save consumers money while reducing emissions, but adoption rates to-date have been slow. One of the key challenges to broader adoption of pay-as-you-go insurance is concerns about privacy related to how a consumers' mileage is tracked.

Fuel- or carbon-based transportation tax

Transportation taxes and user fees can reduce greenhouse gas emissions by increasing the marginal and/or total cost of driving, which may encourage behavior changes that reduce the total vehicle miles traveled or encourage the purchase of more fuel-efficient vehicles. The economic impact of these policies hinges on how the tax revenue is reinvested. Reinvestment in households and infrastructure would grow the economy. In particular, investing in infrastructure can create new

construction jobs. Two examples of transportation taxes that could be implemented are:

- Carbon Tax: A $30 per ton societal cost for each ton of carbon. This amounts to a tax of $0.24 per gallon for E10 gasoline.
- Fuel Tax: A 6.5% statewide wholesale fuel sales tax on gross gasoline and special fuel (including diesel) purchases.

Revenue from these taxes could be used to fund road improvements, provide rebates to low-income households to address equity issues or they could be used to support other greenhouse gas mitigation opportunities, such as increased mass transit.

Energy

Renewable thermal energy

A renewable thermal energy policy could take advantage of in-state resources such as sun and biomass to heat homes and businesses. Currently many Minnesotan homes are heated using natural gas, fuel oil, and propane. A renewable thermal energy policy could establish a goal of switching from delivered fuels to renewable thermal sources, such as solar heat and biomass fuels. A goal could be set for 5% renewable thermal by 2020 and 20% by 2030. Minnesota has significant biomass and solar resources, as well as a history of heating with wood. Opportunities exist to meet heating load with more of these renewable resources, resulting in reduced greenhouse gas emissions.

To achieve a renewable thermal energy goal, Minnesota would need to develop incentives that would encourage consumers to purchase renewable-fueled heating systems. One policy that could encourage this switch would be the establishment of a state-wide renewable thermal incentive fund that would provide financial aid for the installation of thermal renewable technologies and could target high-value customers including farmers, delivered-fuel customers, low-income housing authorities, and commercial users. The state could establish the fund by collecting a fee on natural gas, fuel oil, and propane sold in Minnesota.

Recent propane infrastructure changes and the severe shortages of propane in the winter of 2013-2014 highlight the benefits of diversifying heating options to mitigate volatility in fuel pricing and availability throughout greater Minnesota. However, since renewable thermal energy sources are only used in small quantities, the cost is often higher than fossil fuels with established distribution systems.

Renewable thermal energy can be developed at a pilot project scale to determine where and how these resources might best be put to use. Upfront investment to develop supply chains and distribution networks could result in long-term solutions that mitigate volatility of fossil fuel markets and supplies, as well as reducing greenhouse gas emissions.

Agriculture

Fertilizer efficiency

The nitrogen in fertilizer is the primary contributor to nitrous oxide emissions from crop, which is a potent greenhouse gas. The nitrogen in fertilizer that plants do not use can leach into groundwater and be emitted into the atmosphere, contributing to global warming. Practices that can increase efficiency of fertilizer use include:

- Implementation of nitrogen fertilizer best management practices
- Improved nitrogen fertilizer products and

techniques such as the "4Rs": Right fertilizer source at the Right rate at the Right time and in the Right place

- Precision agriculture materials and methodologies such as variable fertilizer rate application, drone use, plant tissue sensors, global positioning system-based yield monitoring, enhanced soil sampling, etc.

Reducing fertilizer use in Minnesota through efficiency improvements has significant public health and environment co-benefits. In areas of the state, Minnesota's groundwater aquifers are susceptible to contamination due to geology, soils, climate, and land use. In these sensitive areas, nitrate from fertilizer is polluting drinking water in Minnesota at levels that are a threat to public health. An increasing number of municipal water supply systems need to invest in costly nitrate treatment facilities to meet drinking water standards, while private well owners are on their own to mitigate contamination. Nitrate in surface water leads to the growth of algal blooms in aquatic ecosystems that can choke out other species and cause serious harm. As waters flow out of Minnesota and into other states and eventually into the Gulf of Mexico and Lake Winnipeg, these excess nutrients are contributing to massive environmental and health problems.

Market development for cover and perennial crops

Current market forces do not provide adequate incentives for perennial crop production or the use of cover crops. Markets for perennials can be enhanced through implementing policies that support grass-fed beef and dairy products or support producing energy from perennial crops. The state may also be able to encourage the development of consumer markets to support cover and perennial crops based on consumers' interest in sustainability. Many consumers and companies want to know that the products they purchase are produced sustainably and do not degrade water quality or contribute to climate change. Likewise, producers who choose best management practices, especially if those practices come at a cost, want their products valued more highly for their environmental responsibility. Many consumers and companies, for instance, choose to pay more for US Department of Agriculture organic–certified farm products and Forest Stewardship Council–certified wood products. Along these lines, the new Minnesota Agricultural Water Quality Certification Program certifies farmers when every field and cropping system on a farm attains an environmental standard determined by a water quality risk assessment. This program does not specifically track or focus on achieving greenhouse gas reductions, but the best practices for water overlap with climate action. Further, the program provides a framework that could be expanded to specifically include climate action.

While cover crops work well for short season sweet corn, edible beans, and other "canning" vegetables, market, logistical, technical, financial, and agronomic barriers exist that prevent widespread adoption of cover crop use in corn and soybean systems. Pilot programs could help reduce these barriers by developing and testing new cover crop varieties and seeding equipment, demonstrating on-farm successes, and quantifying on-farm economic benefits.

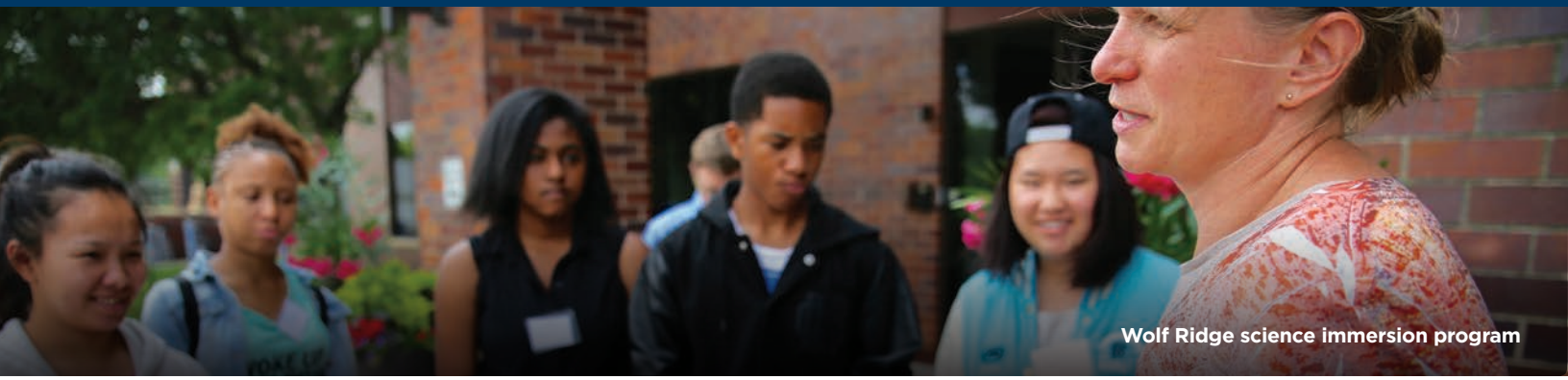

Source: MPCA

Conclusion

St. Paul, Minnesota

Minnesota has made important strides in its efforts to reduce greenhouse gas emissions, achieve its Next Generation Energy Act Goals, and live up to its international commitments in the Under 2 MOU to address climate change. However, further action and leadership is needed to achieve state goals and international agreements for maintaining a stable global climate. This report provides many recommendations on policy options for immediate impacts, long-term strategies, and pilot programs that Minnesota could develop to address greenhouse gas emissions. **These recommendations by no means capture all that the state could do to reduce greenhouse gas emissions, but they provide a strong foundation for moving forward with planning and public discussion.** The scientific, economic, and social understanding of climate change and its impacts on Minnesota is constantly changing and plans must be flexible and adaptive. There are many things that can be done that will contribute to the global efforts to tackle climate change. It will require engagement at all levels of government as well as citizen and community efforts and voices.

CSEO Analytical Results



Wolf Ridge science immersion program

Consultants analyzed each of the policies in this report for potential greenhouse gas emissions reduction, cost, and other economic impacts. The summary of this analysis is shown in the table below. For analysis, policies were assessed for the period of 2015 to 2030 for greenhouse gas emissions reductions, costs and savings, and for jobs. The analysis focuses on being on track in 2030, where the 2030 targer is a linear interpolation between the 2025 and the 2050 goal. Minnesota would need to reduce annual greenhouse gas emissions by an additional 53 million CO_2-equivalent short tons (CO_2-e) beyond projected business as usual emissions by 2030 in order to be on track. Policies are divided into three categories based on the length of time it would take to see an emissions reduction and based on the degree to which policies have already been developed in the state. Results are shown for each policy, not taking into account potential overlap when multiple related policies are implemented.

Immediate Action – These policies result in immediate reduction of greenhouse gas emissions. They account for 64 to 79% of the emissions reductions that could be made between now and 2030. All the immediate action policies focus on the electric sector.

Policy options	2030 annual in-state GHG reduction (CO_2e-tons)	% Reduction towards 2030 target	NPV costs/savings 2015-2030 ($2014MM)	Average annual employment (full- and part-time)
Increase the renewable electricity standard to 50%	14	27	-404	1,820
Increase the renewable electricity standard to 40%	8	15	-620	1,510
Retire and repower coal plants	7	13	752	310
Increase energy efficiency requirements 2.5%	5	10	-1,882	1,560
Increase energy efficiency requirements 2%	4	7	1,272	N/A
Combined heat and power (CHP)	5	10	-1,112	2,330
Zero energy building codes (SB2030)	10	19	-2,050	2,750
Wastewater treatment facilities energy efficiency	0.07	0.14	-56	80

Long-term Strategies – These policies are critical for reaching Minnesota's 2050 goals, but they require more time for development. Generally, these policies reduce the use of single-occupancy internal combustion vehicles and protect or increase carbon stores in soils and trees.

Policy options	2030 annual in-state GHG reduction (CO_2e-tons)	% Reduction towards 2030 target	NPV costs/savings 2015-2030 ($2014MM)	Average annual employment (full- and part-time)
Transit and multimodal travel	0.28	1	-330	450
Compact development in urban areas	1	2	-425	220
Electric vehicles on 100% renewable energy	1	3	3,000 *	-1,220
Community and urban forests	1	1	1,806	4,180
Forest health	2	4	187	-210
Increased conversion of row crops to perennial crops	2	3	-2,104	-490
Increased use of cover crops	1	1	-1,346	230
Re-use, composting, and recycling	0.17	0.31	-817	2,750
Source reduction	0.06	0.12	-277	60

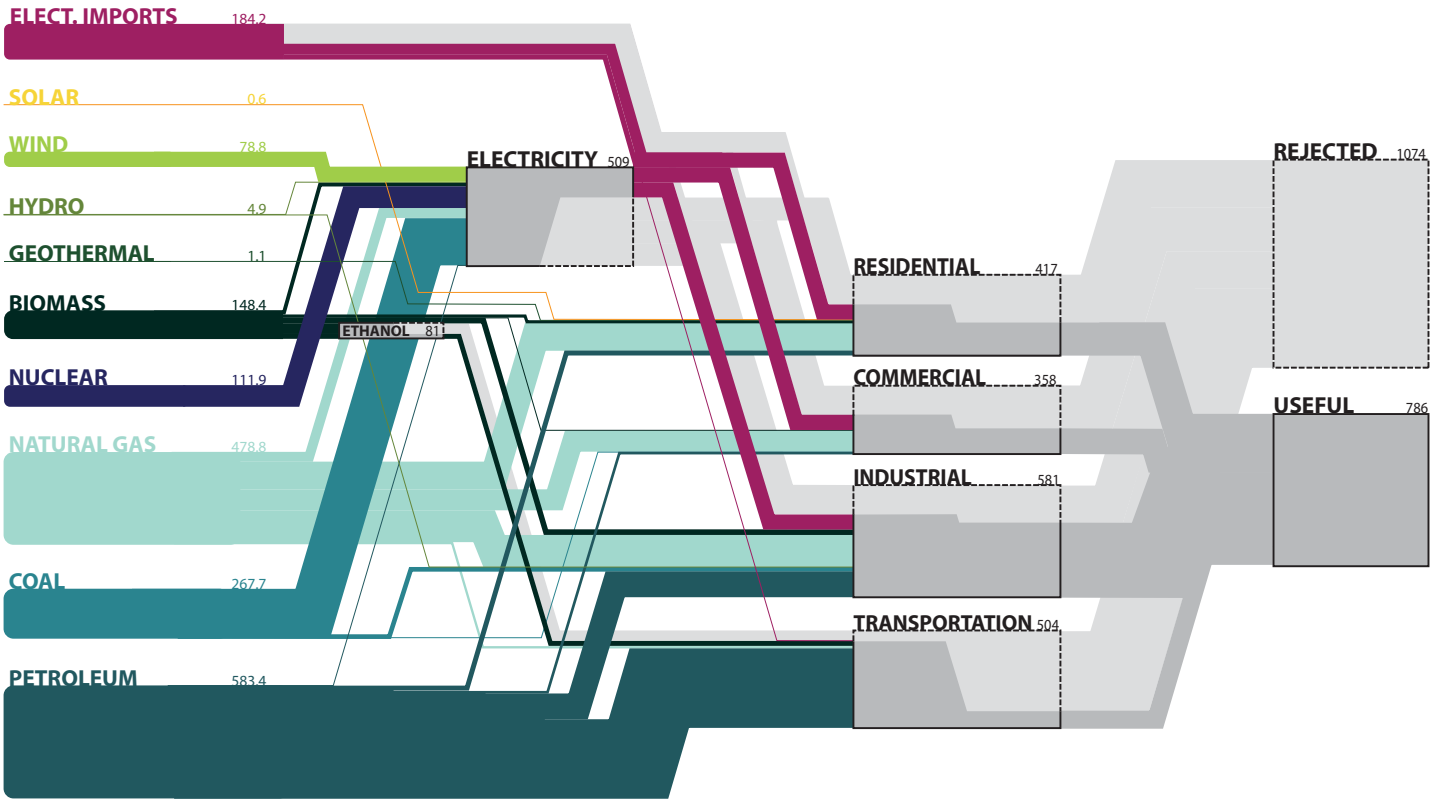
***assumes little change in the price of an electric vehicle**

Pilot Programs – These policies have high potential to reduce emissions; however, they involve new programs or technologies that need to be explored and tested before they can be implemented at a large scale. These policies include transportation options, distributed renewable energy for direct heating and cooling, and agriculture practices.

Policy options	2030 annual in-state GHG reduction (CO_2e-tons)	% Reduction towards 2030 target	NPV costs/savings 2015-2030 ($2014MM)	Average annual employment (full- and part-time)
Advanced and conventional biofuels	0.19	0.35	462	3,420
Transportation pricing cumulative	2	4	2,718	8,230
Transportation pricing: PAYD insurance component	1	2	-2,160	N/A
Transportation pricing: carbon tax component	1	1	1,898	N/A
Transportation pricing: fuel tax component	0.46	1	2,980	N/A
Thermal renewable energy	3	6	872	-690
Nutrient management in agriculture	0.15	0.29	-131	-200

How do we use energy and where is it wasted?

This diagram illustrates Minnesota's energy use. Primary fuel source use and losses due to inefficiencies are shown by sector: electricity generation, residential use, commercial use, industrial use, and transportation. Notably, more than half of the energy that is produced in the state is wasted due to inefficiencies. Ultimately, 42 % of the energy consumed in Minnesota is useful and the rest is wasted.



Data Source: U.S. Energy Information Administration. State Energy Data System (SEDS): 1960-2013. July 2015. End use efficie y is estimated as 65% for the residential and commercial sectors, 80% for the industrial sector, and 21% for the transportation sector.

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Jackson County

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