DRAFT

Minnesota's Climate Action Framework

Appendix 2

GHG emissions reductions and carbon sequestration

MINNESOTA

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APPENDIX 2: GHG EMISSION REDUCTIONS AND CARBON SEQUESTRATION

The Climate Change Subcabinet conducted an analysis of the GHG emission and sequestration impacts of some of the actions proposed in Appendix 1. This appendix explains that analysis.

ACTIONS MODELED IN ENERGY POLICY SOLUTIONS SIMULATOR

The primary analysis tool for the Framework is the Minnesota Energy Policy Solutions tool created by Energy Innovation LLC and Rocky Mountain Institute.[1] It is a free and open-source computer model developed with input from the Minnesota Pollution Control Agency, Fresh Energy, and MN Center for Energy and Environment.[2] Other analysis supplements our understanding of emission reductions and carbon sequestration and are noted where incorporated.

The climate actions in the model do not exactly match the actions identified by the state in the Framework. Therefore, to estimate the impact of a proposed Framework action, the inputs for the model had to be translated and/or generalized. In some cases, the proposed climate actions needed to be grouped and modeled together. Estimated GHG impacts are displayed here, separate from the Framework actions because the model is not an exact fit to the structure of proposed actions.

Despite the structural mismatch between the model and the proposed Framework actions, the modeling offers an understanding of the relative impacts of the proposed actions. Actions are reported with cumulative estimated reductions (2022-2050) and sorted into categories of high, medium, or low GHG reductions. We used cumulative estimated emission reductions because many actions accumulate benefits over time and many take time to ramp up, increasing emissions benefits year-over-year. This scale is sufficient to indicate the magnitude of possible GHG reductions as one of many criteria used to prioritize actions.

Ranking of cumulative GHG reduction potential

Low	0-10 Million Metric Tons CO2-e
Medium	10-100 Million Metric Tons CO2-e
High	> 100 Million Metric Tons CO2-e

The modeled policies are listed in the table below with the model inputs. Detailed descriptions of each policy are included. The implementation trajectory is assumed to be linear from 2022-2050 unless interim goals are specified.

[1] https://minnesota.energypolicy.solutions/

[2] Documentation of original model assumptions is available here: https://github.com/Energy-Innovation/eps-minnesota/blob/main/MN%20Policy%20Assumptions_FINAL.pdf

Modeled policy list

Number	Model Policy	Early target year	Early target Goal	2050 goal	Units
1	Electric vehicle (EV) charger deployment			100	chargers per 100k population (additional)
2	EV range and charging time			10%	% reduction in concern
3	EV sales: Passenger and commercial light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs)	2030	LDVs: 50% HDVs: 7%	LDVs: 75% HDVs: 10%	% of new sales
4	Electric vehicle subsidy: Passenger LDV	2024-2040[3]	1%		% of purchase price
5	Fuel Economy Standard: Passenger and commercial LDVs and HDVs[4]			LDVs: 88% Passenger HDVs: 45% Freight HDVs: 56%	% increase in miles per gallon (mpg)
6	Low Carbon Fuel Standard (LCFS)[5]	2030	8%	15%	% reduction in emissions
7	Mode Shifting: Passenger LDVs	2025 2030 2035 2040	4% 8% 11% 14%	20%	% of trips shifted
8	Building component electrification			30%	% of components sold
9	Building energy efficiency standards			10%	% reduction in energy use
10	Retrofit existing buildings			10%	% of existing buildings
11	Clean electricity standard	2040	100%	100%	% of generation
12	Increase transmission			20%	% increase in capacity
13	Industry energy efficiency standards: water and waste			20%	% reduction in energy use
14	Material efficiency, longevity, and re-use			10%	% demand reduction

[3] The EV subsidy is modeled fully in place for 2024-2040.

[4] Used to model Clean Car Standards impact. See setting recommendations in policy description.

[5] Only addresses liquid fuels used in conventional vehicles. Electric vehicles are separate policies in the model and combined for evaluation to better match the proposed LCFS.

Cumulative GHG reductions 2022-2050

In order to fit closer to the intent of the proposed low carbon fuel standard identified in the Framework, we combined the results for policies 3, 4, and 6. Also, to fit closer to the intent of multiple proposed Framework actions addressing existing buildings and a net-zero building goal, we combined the results for policies 8, 9, and 10. Estimates of cumulative impacts from natural and working lands policies will be added when available.

Looking at the 2030 and 2050 annual emissions reduction, policies fall in roughly the same order and magnitudes, though the annual reductions are much smaller. For many of the policies, the annual reductions increase over time because the implementation of policies is ramped to fully meet the goal by 2050. Reducing emissions sooner has a significant impact on reached emissions reductions goals to avoid predicted climate change.

A few policies have greater impacts in the short term. Increasing transmission capacity has the greatest impact in the near term because it facilitates bringing early renewable expansion online. The biofuel component of the low carbon fuel standard has a greater impact in the near term because it reduces the carbon intensity of fuel in internal combustion engine vehicles, which are increasingly replaced by EVs in the future.

Changing the timing of fully achieving a goal would impact the effectiveness of the action, and early action will achieve greater emission reductions. For example, if the EV charging stations are installed earlier, it will have the impact of shifting more peoples' choices to EVs.

Magnitude of Cumulative GHG Impact 2022-2050

High	**> 100 Million Metric Tons CO2-e**
11	Clean Electricity Standard
Medium	**10-100 Million Metric Tons CO2-e**
5	Vehicle Fuel Economy
3, 4, 6	LCFS, EV Sales, EV Subsidy
8, 9, 10	Building efficiency, electrification, and retrofitting
7	Mode Shifting
Low	**0-10 Million Metric Tons CO2-e**
14	Material Efficiency Longevity & Re-Use
12	Increase Transmission
1	EV Charger Deployment
2	EV Range & Charge Time
13	Industry Energy Efficiency Standards

Policy descriptions

The following describes each of the policies modeled in the Energy Policy Simulator. The description includes the policy lever the model uses, what was actually modeled to determine the high/medium/low categories, and some context for existing conditions.

1 Electric Vehicle Charger Deployment

- Policy lever: 0-300 chargers / 100k population
- Modeled: 100 chargers / 100k population

  This policy represents increasing the deployment of EV charging stations, including DC Fast and Level 2 charging stations. It is set in chargers per 100,000 people (cumulative, not per year), additional to chargers in the business as usual (BAU) case.

2 *Electric Vehicle Range & Charging Time*

- Policy lever: 0-100% reduction in concern
- Modeled: 10% reduction in concern

This policy specifies a percentage reduction in vehicle buyers' aversion to electric vehicles due to concerns over the vehicles' range (how far the EV can travel on a charge) and charging time. A 100% setting implies consumers are no more concerned about EV range and charging time than they are about range and fueling time of gasoline vehicles.

3 *Electric Vehicle Sales: Passenger and Commercial LDVs and HDVs*

- Policy lever: 0-100% of new vehicles sold
- Modeled: 2030: 50% of new light duty vehicles sold, 7% of heavy duty vehicles sold
  2050: 75% of new light duty vehicles sold, 10% of heavy duty vehicles sold

This policy specifies percentage of new vehicles that consist of battery electric vehicles.

4 *Electric Vehicle Subsidy: Passenger LDVs*

- Policy lever: 0-50% of vehicle cost
- Modeled: 1% of vehicle cost (2024-2040)

This policy causes government to pay for the specified percentage of the purchase price of new battery electric passenger LDVs. This is in addition to EV subsidies that exist in the BAU case.

5 *Fuel Economy Standard: Passenger and Commercial LDVs and HDVs*

- Policy lever: Freight or passenger: HDVs: 0-66% increase in miles/gal, LDVs: 0-100% increase in miles/gal
- Modeled: light duty vehicles: 88% increase in mpg
  Passenger HDVs: 45% increase in mpg
  Freight HDVs: 56% increase in mpg

This policy specifies a percentage improvement in fuel economy (distance traveled on the same quantity of fuel with the same cargo or passenger loading) due to fuel economy standards for new vehicles.

U.S. fuel economy standards for heavy-duty vehicles vary by vehicle characteristics, but proposed standards for combination tractor-trailers (which are responsible for roughly 60% of freight HDV emissions) would reduce GHG emissions by 25% for 2027 model year trucks relative to the 2018 model year, then remain constant. Extrapolating this trend to 2050 would be a 96% improvement relative to 2018, compared to a 40% improvement relative to 2018 in the BAU case. This is represented by a policy lever setting of 56%.

Proposed standards for vocational vehicles (passenger HDVs) would reduce GHG emissions by 24% for 2027 model year vehicles relative to the 2018 model year, then remain constant. Extrapolating this trend to 2050 would be an 85% improvement relative to 2018, compared to a 40% improvement relative to 2018 in the BAU case. This is represented by a policy lever setting of 45%.

U.S. combined fuel economy standards for cars and light trucks were 35.5 mpg in 2016 and are scheduled to rise to 54.5 through 2025, then remain constant. The National Research Council identified a maximum 4.5% annual improvement in LDV fuel economy through 2040, which corresponds to a policy setting of 88%.

6 Low Carbon Fuel Standard

- Policy lever: 0-20% reduction in carbon emissions
- Modeled: 20% reduction in carbon emissions

This policy specifies the percentage reduction in carbon emissions from the transportation sector that must be achieved via fuel switching in conventional vehicles (not switching to electricity). This is in addition to BAU requirements. The National Renewable Fuel Standard equates to a BAU LCFS of 2.2% - 4.6%.

7 Mode Shifting: Passenger LDVs

- Policy lever: Passenger: LDVs: 0-26% of trips shifted
- Modeled: 10% of trips shifted

This policy represents a set of measures aimed at reducing demand for passenger travel in light-duty vehicles (cars and SUVs) by shifting to other travel modes, such as buses, rail, walking, biking, or eliminating trips through technology such as videoconferencing. Example measures include improved public transit systems, more walking and bike paths, zoning for higher density along transit corridors, zoning for mixed-use developments, roadway and congestion pricing, and increased parking fees.

8 Building Component Electrification: Urban and Rural Residential Heating and Appliances

- Policy lever: 0-100% of newly sold non-electric building components
- Modeled: 30% of new components (i.e. 70% of new components ARE electric)

This policy replaces the specified fraction of newly sold non-electric building components in buildings with electricity-using appliances. In the BAU case, in Minnesota, the share of electricity among fuels used by appliances in urban, residential buildings will remain constant at roughly 52% through 2050. In MN, approximately 17% of residential homes currently use electricity as a primary space heating fuel. In the BAU case, this is expected to grow by 40% by 2050.

9 Building Energy Efficiency Standards: Commercial, Urban and Rural Residential Heating, Cooling, Ventilation, Envelope, Lighting, Appliances, and Other Components

- Policy lever: 0-38% reduction in energy use (all lighting 0-40% reduction, all residential heating 0-20% reduction, all other residential 0-30% reduction)
- Modeled: 10% reduction in energy use

This policy tightens energy efficiency standards in buildings. The policy only applies to newly sold appliances each year (whether for new buildings or replacement of old appliances in existing buildings). Minnesota has a legislative goal to achieve 1.5 percent annual energy savings, under the "Energy Savings Policy Goal" (2007). Note that energy efficiency applies to both gas and electric appliances.

10 Retrofit Existing Buildings: Commercial, Urban and Rural Residential

- Policy lever: 0-50% of existing buildings
- Modeled: 10% of existing buildings

Each year, the specified percentage of commercial buildings that existed at the start of the model run will be retrofit with more efficient heating, cooling, and envelope components. By 2050, roughly 37% of the preexisting buildings will still survive without major renovations, so a value of 37% will retrofit all such surviving buildings by 2050. Policy settings higher than this will retrofit all eligible buildings sooner than 2050.

11 Clean Electricity Standard

- Policy lever: 0-100% of electricity generation
- Modeled: 100% in 2040 with 40% RES in 2025

This policy specifies an increase in the fraction of electricity generation that must come from qualifying carbon-free sources (wind, solar, biomass, hydro, or geothermal).

12 Increase Transmission

- Policy lever: 0-113% increase in transmission capacity
- Modeled: 20% increase in capacity

This policy causes additional transmission capacity to be built relative to the BAU case. Transmission increases the flexibility of the grid, allowing for the integration of more wind and solar PV, if the electricity system is flexibility-constrained. NREL's Renewable Electricity Futures study suggest that the most economical method of achieving 50% renewables penetration involves building an additional 21% of new transmission capacity. In a BAU case, Minnesota's transmission capacity is expected to increase by 3%.

13 Industry Energy Efficiency Standards: Water & Waste

- Policy lever: 0-33% reduction in energy use
- Modeled: 20% reduction in energy use

This policy reduces fuel consumption by the selected industry by increasing the efficiency of industrial equipment through stronger standards. The policy setting refers to overall energy use reduction, not the reduction in energy use of newly sold equipment. In 2016, the U.S. Department of Energy developed an industrial energy efficiency potential analysis that suggests the US could double its annual rate of improvement rate through 2030. Extended through 2050, this equates to a maximum potential improvement of 26% by 2050 relative to BAU.

14 Material Efficiency, Longevity, & Re-Use: Cement Industry, Iron and Steel Industry

- Policy lever: 0-100% demand reduction
- Modeled: 10% demand reduction (cement and iron/steel)

This policy reduces demand for cement through techniques such as material-efficient building codes (using modern designs that require less concrete per unit floor area), requirements for greater building and infrastructure longevity, greater re-use and re-purposing of buildings (rather than tearing down and building new), etc. This policy also reduces demand for iron and steel through techniques such as material-efficient building codes, requirements for greater building and metal product longevity, greater repair and re-use of metal products, etc.