SB 22-051

Legislative Council Staff
Nonpartisan Services for Colorado's Legislature

Greenhouse Gas Emissions Report

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Prime Sponsors:	Sen. Hansen Rep. Sirota	**Analyst:**	Christina Van Winkle | 303-866-6289 Christina.VanWinkle@state.co.us
BILL TOPIC:	**POLICIES TO REDUCE EMISSIONS FROM BUILT ENVIRONMENT**		
Sectors Impacted:	☒ Electric Power ☐ Transportation ☐ Industrial Processes ☐ Waste Management ☐ Agriculture	☒ Natural Gas and Oil Systems ☒ Residential / Commercial / Industrial Fuel Use ☐ Coal Mining and Abandoned Mines ☐ Land Use / Land Use Change / Forestry ☐ Other	
Net Change:	☐ Increase ☒ Decrease ☐ Indeterminate ☐ Minimal		
Report Status:	This report reflects the introduced bill, as amended by the Senate Transportation and Energy Committee and the Senate Finance Committee.		

Emissions Summary

This greenhouse gas (GHG) emissions report[1] analyzes the potential impacts of Senate Bill 22-051 on greenhouse gas emissions and sequestration within a 10-year period following enactment, based on available data. This analysis is focused on selected provisions contained in the bill that directly impact GHG emissions and may not address all provisions found in the bill.

SB22-051 will reduce GHG emissions by providing incentives to purchase heat pumps and eligible decarbonizing building materials. Emissions savings will depend on a number of factors, including sales activity, existing heating technologies, and standards established by the Office of the State Architect related to eligible decarbonizing building materials. The bill may also reduce GHG emissions by incentivizing the purchase of energy storage systems.

[1] Pursuant to Section 2-2-322.2, C.R.S., this greenhouse gas emissions report uses available data to assess whether a legislative measure is likely to directly cause a net increase or decrease in greenhouse gas pollution within the ten-year period following its enactment, The report will identify new sources of greenhouse gas emissions, any increase or decrease in emissions from existing sources, and any impact on sequestration of emissions. The report is authorized but not required to quantify the magnitude of the impact on the emissions, to the extent that unbiased estimates are feasible given the available data.

Key Provisions

From January 1, 2023, through January 1, 2033, this bill exempts purchases of heat pump systems and heat pump water heaters from sales and use tax. Beginning in tax year 2023, the bill creates a 10 percent income tax credit for residential and commercial purchases of heat pump systems and residential energy storage systems, through 2033. Lastly, the bill exempts purchases of decarbonizing building materials from sales and use tax beginning July 1, 2024, through July 1, 2034.

In addition to these state tax provisions, local governments are authorized to exempt these same purchases from local sales and use taxes.

Background

Building fuel use. Around 70 percent of Colorado homes are heated by natural gas, compared to the national average of 47.8 percent.[2] The remaining of homes are heated using electricity (primarily electric resistance heaters), propane, and other sources of fuel. Fuels used in residential and commercial buildings for space and water heating and other purposes accounted for around one-tenth of statewide GHG emissions in 2019, emitting over 12 million metric tons of carbon dioxide equivalent. According to the U.S. Energy Information Agency's Residential Energy Consumption Survey, the average annual natural gas consumption by a household in Colorado's climate amount to 529 therms for space heating (69 percent) and 250 therms for water heating (30 percent), with the remaining 73 therms used for cooking and other purposes (8 percent).[3]

Heat pumps. Heat pump systems operate by using electricity to transfer heat from one area to another. In winter, heat pumps can draw heat from the air, ground, or water and transfer that heat to into buildings; in summer, this process is reversed and heat is transferred out buildings and cooled air is circulated into the building. Heat pumps can be used as stand-alone heating and cooling equipment or in combination with a gas furnace for heating (i.e., a dual-fuel system). Heat pump water heaters transfer heat from the surrounding air to the water and generally have higher energy efficiency ratings compared to gas and electric resistance water heaters.

GHG benefits of heat pumps for space conditioning. Replacing electric resistance space heaters with more energy efficient heat pumps reduces electricity use, and associated GHG emissions, by around one-half.[4] Replacing gas furnaces with heat pumps, combined with the projected decarbonization of the electric grid, also reduces greenhouse gas emissions. These emissions savings result from a reduction in the combustion of natural gas on-site, as well as reductions in methane leaks from the distribution and delivery of natural gas to the building. Emissions savings are partially offset by the emissions associated with the electric power needed to operate the heat pump, which consumes more electricity than a gas furnace. These emissions depend on the carbon intensity of the electricity generation mix. As more electric power is generated from carbon-free sources, the emissions intensity of the grid will decline, further contributing to emissions savings from heat pumps.

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[2] U.S. Energy Information Administration. Colorado State Energy Profile. Available at: https://www.eia.gov/state/print.php?sid=CO.
[3] U.S. Energy Information Administration. Residential Energy Consumption Survey. Available at: https://www.eia.gov/consumption/residential/data/2015/.
[4] U.S. Energy Information Administration. Available at: https://www.energy.gov/energysaver/heat-pump-systems#:~:text=The%20most%20common%20type%20of,as%20furnaces%20and%20baseboard%20heaters.

One study found that a new home fitted with a cold climate air-source heat pump could save, on average, 5,822 pounds (2.64 metric tons) of carbon dioxide equivalent annually, or 58 percent compared to a new home fitted with a gas furnace. An existing home retrofitted with a ducted air-source heat pump system with a backup gas furnace is estimated to save, on average, 6,000 pounds (2.72 metric tons) of carbon dioxide equivalent annually, or 48 percent, compared to an efficient gas furnace and central air conditioning system. These emissions savings assume a 15-year marginal emissions intensity of 600 pounds of carbon dioxide per megawatt-hour of electricity generated, around one-half of today's emissions intensity. Emissions savings are greater for retrofit homes primarily due to older homes' less-efficient building envelopes. The results of this study are presented in Table 1.

Table 1
Annual Energy Consumption and GHG Emissions Savings of Air-Source Heat Pumps

		New Home		Retrofit Home	
	Unit	Gas Furnace	Heat Pump*	Gas Furnace	Heat Pump*
Average Gas Use	*therms*	761	0	941	162
Average Electricity Use	*KWh*	568	7,045	706	7,268
GHG Emissions	*lbs CO_2e/year*	10,040	4,218	12,422	6,422
GHG Savings of ASHP	*lbs CO_2e/year*		**5,822**		**6,000**
Percent Savings	**%**		**58%**		**48%**

Source: LCS calculations based on average results from Denver, Eerie, and Pueblo cities. Based on the study by Southwest Energy Efficiency Project (2022), Benefits of Heat Pumps for Colorado Homes.
** The heat pump scenario in the new home reflects a cold-climate heat pump without a backup gas furnace. The heat pump scenario for the retrofit home reflects a 2-stage heat pump with a gas furnace backup with a 20 degree Fahrenheit changeover scenario, where the heat pump provides 80 percent of the annual heating needs.*

Another study analyzed the GHG emissions impacts associated with switching residential heating systems from the current fuel (i.e., natural gas for furnaces and electricity for electric resistance heating) to heat pumps, and found that under the current electricity generation, GHG emissions would decline compared to the electric resistance heating, and remain unchanged, initially, compared to a natural gas furnace. This study further found that as the electricity grid decarbonizes over time, heat pumps will reduce GHG emissions relative to natural gas over the lifetime of the heat pump.[5]

GHG benefits of heat pump water heaters. Heat pump water heaters can reduce operating GHG emissions by around two-thirds compared to both gas water heaters and standard electric water heaters, according to one study. The study found that heat pump water heaters can save around 1,300 pounds of carbon dioxide equivalent annually compared to both gas water heaters and standard electric water heaters. These emissions savings are associated with the operation of the water heater and do not account for the emissions associated with the manufacturing and processing of the equipment. The table below presents the findings of this study.

[5] Vaishnav, P. and Fatimah, A., The Environmental Consequences of Electrifying Space Heating. Environmental Science & Technology, 2020. Available at https://pubs.acs.org/doi/10.1021/acs.est.0c02705?ref=pdf.

Table 2
Energy Consumption and GHG Emissions of Water Heaters

	Heat Pump Water Heater	Gas Water Heater	Standard Electric Water Heater
Energy Consumption per year	802 KWh	15 MMBtu	3,100 KWh
GHG Emissions per year (lbs CO_2e/year)	595	1,884	1,846
GHG Savings (lbs CO_2e/year)	*n/a*	**1,289**	**1,251**
Percent Savings	*n/a*	**68%**	**68%**

Source: Southwest Energy Efficiency Project (2022), Benefits of Heat Pumps for Colorado Homes.

Decarbonizing building materials. House Bill 21-1303 enacted the Buy Clean Colorado Act, which requires the Office of the State Architect to establish a maximum acceptable global warming potential for certain building materials used in public projects, including asphalt, cement, glass, steel, and wood by January 1, 2024. The maximum acceptable global warming potential will be based on industry averages for each material and may be adjusted over time to reflect industry conditions. The global warming potential represents the amount of GHGs that are emitted per unit of material produced (e.g., kilograms of carbon dioxide equivalent per metric ton of material produced) and is reported through environmental product declarations. Life cycle assessments quantify the emissions associated with raw material extraction, transportation, manufacturing, and processing, and typically exclude emissions associated with the use and end-of-life of the material.

As reported in the GHG Emissions Report for HB 21-1303, examination of environmental product declarations for select building materials from public databases suggests that GHG emissions savings of 14 to 47 percent is achievable, compared to industry averages. For example, manufacturers of ready mix concrete report industry averages of around 400 kilograms of carbon dioxide equivalent per cubic meter, whereas some manufacturers are able to achieve lower emissions of around 300 kilograms of carbon dioxide equivalent per cubic meter, a 25 percent savings compared to the industry average. Emissions savings associated with decarbonizing building materials will depend on a number of factors, including how industry averages change over time, the availability of materials, and standards set by the Office of the State Architect.

Emissions Assessment

Heat pump sales. The fiscal note for SB 22-051 estimates that approximately 300 heat pump water heaters and 5,000 heat pump systems are sold annually in Colorado, with sales growing at around 6 percent annually. This analysis assumes that around 50 percent of these sales will be induced from the tax incentives created in this bill, with the remaining purchases accounting for sales that would have occurred in the absence of the tax incentives.

Table 3 below provides the GHG emissions savings estimates from these assumed induced sales. The GHG savings for heat pump systems were comparable in both the new home and the retrofit home scenarios, so average emissions savings for each heat pump system (5,911 pounds of carbon dioxide equivalent per heat pump system per year) is applied here. The same holds true for heat pump water heaters, averaging around 1,270 pounds of carbon dioxide equivalent in savings compared to both gas water heaters and standard electric water heaters.

Table 3
Estimated Annual GHG Emissions Savings from Heat Pump Tax Incentives
(Metric Tons of Carbon Dioxide Equivalent)

	Heat Pump Water Heaters		Heat Pump Systems		
Year	Number in Use	Emissions Savings	Number in Use	Emissions Savings	Total Reduction
2023	153	88.1	2,478	6,643.6	6,731.7
2024	315	181.5	5,102	13,678.6	13,860.1
2025	486	280.0	7,886	21,142.7	21,422.6
2026	667	384.2	10,840	29,062.4	29,446.7
2027	858	494.3	13,974	37,464.8	37,959.1
2028	1,060	610.6	17,299	46,379.3	46,989.9
2029	1,274	733.9	20,827	55,837.9	56,571.9
2030	1,500	864.1	24,570	65,873.1	66,737.2
2031	1,739	1,001.8	28,541	76,519.5	77,521.2
2032	1,992	1,147.5	32,754	87,814.7	88,962.2
10-Year Total	**1,992**	**5,786.0**	**32,754**	**440,416.5**	**446,202.5**

Source: LCS calculations, based on SWEEP study results.

Based on these sales assumptions, the tax incentives for heat pump systems and heat pump water heaters are expected to reduce annual GHG emissions by 6,732 metric tons of carbon dioxide equivalent in 2023, increasing to around 88,962 metric tons by 2032, the last tax year the income tax credit and sales and use tax exemption is available. These emissions savings are expected to continue throughout the lifespan of the heat pumps, estimated to be between 10 to 20 years. Heat pumps purchased in later years may result in greater emissions savings as the electric grid continues to decarbonize to achieve 2050 emission reduction goals. This estimate is based on ducted air-source heat pumps. To the extent that other heat pump systems such as ductless, ground-source, or water-source heat pump are purchased, these emissions savings may differ.

Residential energy storage systems. The bill also provides tax incentives for residential energy storage systems, which may reduce GHG emissions. The emissions impacts of residential energy storage systems depend on a number of factors, including the energy inputs to produce the batteries, whether storage systems are used in conjunction with distributed energy systems such as rooftop solar, and the operation mode of the storage system. Because of these unknown variables, the GHG emissions impacts associated with energy storage systems are not quantified in this report.

Decarbonizing building materials. The emissions impacts associated with the sales and use tax exemption for decarbonizing building materials will largely be driven by future decisions at the Office of the State Architect related to establishing and adjusting downward the maximum acceptable global warming potential of material eligible for the tax exemption. To the extent that this tax exemption drives purchases of eligible decarbonizing building materials, GHG emissions may reduce compared to comparable materials that do not meet the standards as established by the Office of the State Architect. The fiscal note for SB 22-051 estimated the net taxable sales for the construction industry and retail trade for building materials totaled around $11 billion in FY 2020-21, demonstrating the sizable impact these sectors could have on purchases of eligible decarbonizing building materials.

Limitations. It is not known to what extent increased purchases of heat pumps and energy storage systems will be driven primarily from the tax incentives created in SB 22-051, or by other measures to promote adoption of these technologies. For example, in 2021, the General Assembly enacted SB 21-246, that requires the state's two regulated electric utilities (Xcel Energy and Black Hills Electric) to develop beneficial electrification plans for their residential, commercial, and industrial customers. These plans may include programs to promote heat pumps, heat pump water heaters, and energy storage systems through rebates and other incentives.

In addition, SB 21-264 requires the state's regulated gas utilities to develop clean heat plans to reduce GHG emissions. These emission reductions may result from reducing methane leaks in distribution systems, assisting customers with improved energy efficiency, accelerating building electrification, and replacing natural gas with renewable gas or recovered coal mine methane.

Lastly, the GHG emissions impacts of heat pumps are not based on lifecycle analyses, and therefore do not account for any potential emissions impacts associated with the manufacturing and processing of heat pumps. Heat pumps use refrigerants for the heat exchange process, which may contain hydrofluorocarbons, a potent greenhouse gas. This gas may leak during equipment malfunction, or when the device is destroyed at the end of its useful life.

Data Sources and Agencies Contacted

U.S. Energy Information Agency
U.S. Environmental Protection Agency
Southwest Energy Efficiency Project