Hidden beneath our feet: Minnesota’s growing decarbonization challenge

An overview of the past and future of Minnesota’s natural gas system

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Executive Summary

Natural gas[1] is the primary fuel source used to heat buildings in Minnesota. In order to meet the state's greenhouse gas (GHG) reduction goals, the buildings sector must transition to technologies that do not rely on the combustion of natural gas. The gas system itself, which is comprised of the network of pipes delivering gas to customers, must also undergo a transition to meet future customer and system needs. The exact shape of this transition, and the policies that should be considered, will be the subject of future analyses and a broader discussion with stakeholders and policymakers. But, in order to properly consider the gas system of the future, it is critical to understand the gas system of the present.

This white paper will provide an overview of the components of the gas system, historical trends and future projections of the gas system in Minnesota, and analyses of usage and emissions trends. Together, these analyses will present a snapshot of the present-day gas system along with insights into historical trends and future projections so that prudent policy options can be considered with this understanding.

Notable findings from this study include:

- The historical trends and projected growth for Minnesota's largest investor-owned gas utilities demonstrate consistent growth in infrastructure and gas throughput/usage.
- The state currently contains 34,483 miles of gas mains—enough to circumvent the earth nearly one and a half times.
- The total miles of all Minnesota gas mains have risen steadily year-over-year, mainly due to connecting more and more customers to the distribution system.
- Minnesota's gas system is both expanding and being rapidly replaced, as gas utilities have accelerated the replacement of their *existing* system over the past decade.
- Based upon utility growth estimates, emissions from burning gas in buildings could generate 15% or more of the state's carbon budget by 2030 (i.e., by the end of this decade), compared to 10% of the state's carbon budget in 2020. This represents a 50% increase over the span of the current decade, when we urgently need to be reducing greenhouse gas emissions from all sources.

[1] For this white paper, the authors use the term "natural gas" or "gas" to describe the predominantly methane-based fossil fuel while acknowledging that other nomenclature may be preferred in certain contexts.

Introduction

Minnesota's buildings and greenhouse gas emissions

Minnesota has economy-wide GHG reduction goals of 50% by 2030 and net-zero emissions by 2050.[2] In recent years, the state has made the most progress toward these climate goals by reducing emissions from electricity generation. Recent data from the Minnesota Pollution Contral Agency (MPCA) show a 54% reduction in emissions from electricity generation from 2005 to the most recently released data (2020).[3] The state also adopted a carbon-free electricity standard with a requirement for all Minnesota electric utilities that 100% of electricity sold in the state be produced from qualifying carbon-free sources by 2040.[4]

After electricity generation, transportation emissions account for the most emissions, followed by buildings.[5] Natural gas powers about 72% of end uses in residential buildings, 57% in commercial buildings, and 39% in industry in Minnesota.[6] The largest residential emissions source in Minnesota is natural gas used for home heating and appliances.[7] The Minneapolis Climate Equity Plan reports that 42% of GHG emissions in Minneapolis in 2021 were due to the combustion of natural gas in buildings, making it the largest source for GHG emissions in Minneapolis, followed by electricity (28%) and on-road transportation (24%).[8] To achieve our state GHG reduction goals, we will need to phase out use of natural gas for building end uses and industrial processes.

Minnesota's buildings emission reduction policies are not currently as developed as the state's electricity emission reduction policies. While there are goals for building emissions reductions in state and city action plans, there are currently no legally binding requirements for building decarbonization. The Minnesota Climate Action Framework has a goal to reduce GHG emissions from existing buildings by 50% by 2035, compared to 2005 levels.[9] Minneapolis' Climate Equity Plan has goals to reduce GHG emissions from combustion of natural gas in buildings by 35% by 2030 and by 80% by 2035, compared to a 2006 baseline.[10]

The overarching purpose of this study is to understand how buildings emissions have grown over time and their current trajectory. To do this, we will present a comprehensive overview of the primary contributor to building emissions: the combustion of natural gas. This white paper will

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[2] MN Stat. § 216H.02.
[3] Minnesota Pollution Control Agency, Greenhouse Gas Emissions in Minnesota 2005-2020 (January 2023) at 7 https://www.pca.state.mn.us/sites/default/files/lraq-2sy23.pdf (hereinafter MPCA Report).
[4] Minn. State 216B.1691.
[5] MPCA Report at 4.
[6] Burdette J. 2021. Minnesota Energy Overview. Minnesota Department of Commerce https://www.revenue.state.mn.us/sites/default/files/2021-11/Energy%20Landscape%202021_Burdette_Commerce.pdf.
[7] MPCA Report at 9.
[8] City of Minneapolis, 2023 Climate Equity Plan (July 2023) https://www2.minneapolismn.gov/media/content-assets/www2-documents/government/MPLS-CEP_Report-2023-Digital.pdf.
[9] Minn. Climate Change Subcabinet, Minnesota's Climate Action Framework (2022) https://climate.state.mn.us/sites/climate-action/files/Climate%20Action%20Framework.pdf.
[10] City of Minneapolis, 2023 Climate Equity Plan (July 2023) https://www2.minneapolismn.gov/media/content-assets/www2-documents/government/MPLS-CEP_Report-2023-Digital.pdf.

present overviews of: Minnesota's fuel types used in buildings; the natural gas system and gas utilities in Minnesota; trends in gas usage and emissions; and trends in gas infrastructure growth over time. Together, these analyses will provide important context as we work to develop a roadmap to successfully decarbonize emissions from Minnesota's buildings sector.

Methodology Overview

Key questions we aimed to answer through our research included:

- To what extent are Minnesotans using gas to heat their homes?
- What is the current state of Minnesota's gas distribution system?
- Are there any significant trends in the system, consumption, and emissions? Are there significant use-per-customer trends?
- Are there significant drivers to these trends? How does energy efficiency fit in?
- How do the buildings sector's emissions compare to Minnesota's economy-wide goals and to other economic sectors?
- What are utilities' plans for replacement of the gas distribution system and how much will it cost ratepayers?

Below we provide an overview of our study methods. Detailed methods are provided in the Appendix.

Home heating fuel

Data on home heating fuel among occupied housing units were compiled from U.S. Census Bureau survey data on home heating fuels[11] acquired from the American Community Survey.

Gas utility service territories

Service territories that Minnesota's five gas IOUs operate in were approximated based on the lists of communities served that the gas utilities provide in their rate books. To make the map, these were matched to county subdivisions from publicly available shapefiles of geographic boundaries from the U.S. Census Bureau.

Gas distribution infrastructure

Data on miles of gas mains and number of gas distribution service lines were obtained from the Pipeline and Hazardous Materials Safety Administration (PHMSA) Annual Gas Distribution Data[12] for Minnesota's five investor-owned utilities (IOUs). Utilities are required to file these annual reports with PHMSA.

Natural gas sales and emissions for residential and commercial buildings

We reviewed publicly available documents, specifically Gas Jurisdictional Annual Reports filed by Minnesota's four largest gas IOUs from 2010 to 2023 with the Minnesota Public Utilities Commission (PUC). We sampled historical gas sales data from every third year of the analysis period. Historical sales data were weather normalized by each individual utility. We also independently normalized gas sales for weather using heating degree days (provided by the National Weather Service) which aligned with weather normalization performed by the utilities. Future sales projections were taken from each utility's most recent annual Natural Gas Utility Data Report filed with the PUC (2022 calendar year). For historical gas sales data, commercial and

[11] https://www.census.gov/acs/www/about/why-we-ask-each-question/heating/.
[12] Available at https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids.

residential building sales were combined. We also calculated energy intensity as energy use per customer, normalized for weather, separately for each utility's residential customers using utility dekatherm sales unadjusted for weather, customer count, and heating degree days (see the Appendix for details).

Greenhouse gas emissions were calculated as carbon dioxide emissions from combustion of natural gas in residential and commercial buildings using a standard CO_2 emissions factor for natural gas combustion.[13] Minnesota's emissions reduction goals for buildings, the electricity generating sector, and the statewide economy were taken from the Climate Action Framework[14], clean electricity standard, and 2023 legislative update to the state's Next Generation Energy Act, respectively. Goals that were set as a percent of the 2005 emissions baseline were applied to historical CO_2 emissions downloaded from the MPCA to determine projected emissions in terms of tons of CO_2.

Gas distribution expenditures

Information on the legacy plastic[15], bare steel[16], and legacy steel[17] main replacement projects was pulled from workpapers for CenterPoint's integrity management program in its most recent rate case.

The average cost per mile of main was calculated using the capital cost and miles to be replaced reported for each main replacement project in the infrastructure and integrity management program testimony.[18]

Average rate base for the IOUs were compiled from the 2022 Gas Jurisdictional Annual Reports.

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[13] U.S. Energy Information Administration, "Carbon Dioxide Emissions Coefficients by Fuel". Accessible at https://www.eia.gov/environment/emissions/co2_vol_mass.php.
[14] Accessible at https://climate.state.mn.us/minnesotas-climate-action-framework.
[15] Exhibit JMW-WP Schedule 2, Workpaper 6 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.
[16] Exhibit JMW-WP Schedule 2, Workpaper 4 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.
[17] Exhibit JMW-WP Schedule 2, Workpaper 5 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.
[18] JMW-D Tables 6-8 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.

Study Findings

Natural gas is the predominant fuel used for home heating in Minnesota

Natural gas heats approximately two of every three homes in Minnesota. According to the U.S. Energy Information Administration, space heating accounts for almost 80% of household natural gas consumption.[19] Natural gas service covers much of the larger population centers in the state, but many parts of the state have no natural gas infrastructure or service. In those areas, buildings rely upon propane, electricity, and wood for the majority of their fuel needs. Figure 1 shows the predominant home heating fuel by county subdivision, compiled from U.S. Census Bureau survey data.

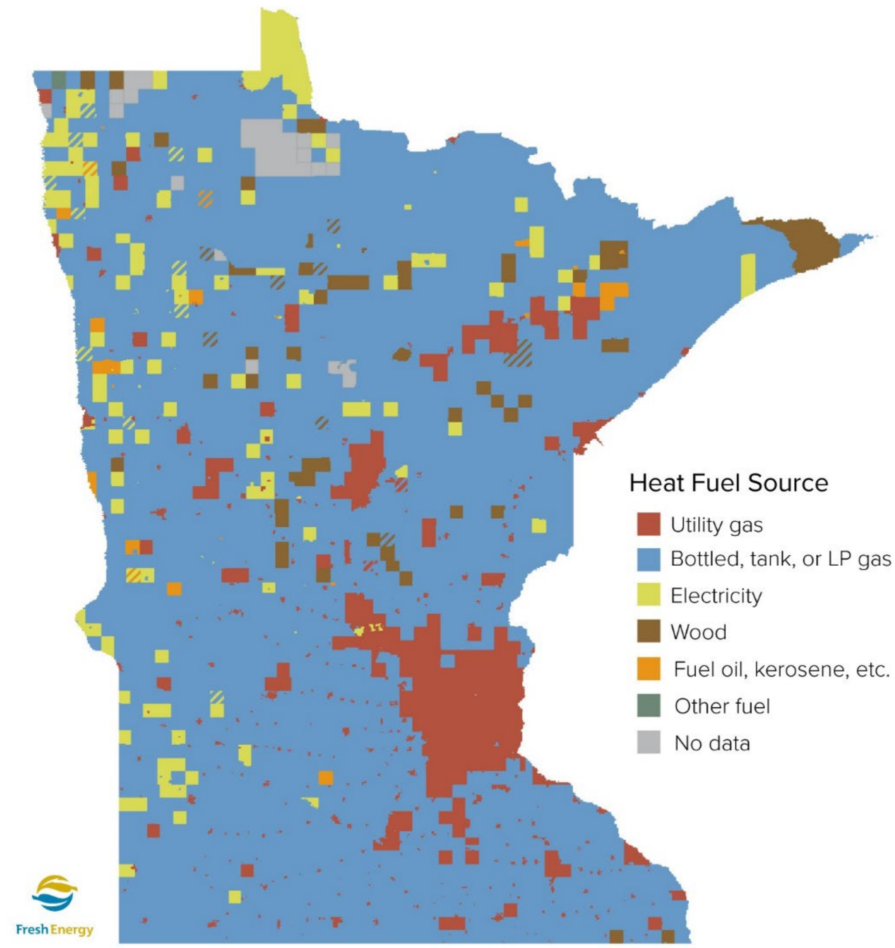

Figure 1. Map of predominant home heating fuel by Minnesota county subdivision

Statewide data on fuels used for space heating in Minnesota is presented in Table 1, which compares the distribution of space heating fuels among occupied housing units in Minnesota and

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[19] U.S. Energy Information Administration, 2015 Residential Energy Consumption Survey: Natural Gas and Propane End-Use Consumption (2018) https://www.eia.gov/consumption/residential/data/2015/c&e/pdf/ce5.2.pdf.

the United States in 2022. Minnesota differs from the national profile in several respects. A larger proportion of Minnesota's housing units are heated with natural gas and propane, a result of the state's relative proximity to natural gas supplies in Texas, Oklahoma, and Kansas and its position as a large importer of Canadian natural gas. (Two-thirds of propane supplies are produced from the processing of natural gas.)[20] Conversely, the share of units heated with electricity and fuel oil in the state are both less than half the national average. Note that among renter-occupied households, 39% heat their homes with electricity.

Table 1. Distribution of space heating fuels among occupied residential units, U.S. and Minnesota, 2022

Fuel	U.S. (percent)	Minnesota (percent)	Minnesota (units)
Utility gas	46%	65%	1,516,671[21]
Electricity	41%	19%	435,364
Bottled, tank, or LP gas	5%	11%	259,065
Fuel oil, kerosene, etc.	4%	1%	27,701
Coal or coke	0%	0%	283
Wood	1%	2%	36,781
Solar energy	0%	0%	1,536
Other fuel	1%	1%	24,177
No fuel used	1%	1%	20,612
Total	100%	100%	2,322,190

Minnesota is primarily served by investor-owned natural gas utilities

Natural gas serves residential, commercial, and industrial customers in Minnesota and is currently the predominant heating fuel used in Minnesota's buildings. Most end-use customers receive gas service from an investor-owned gas utility also known as a local distribution company (LDC). As the name suggests, the main function of an LDC is to distribute natural gas to customers via a vast, underground natural gas distribution system comprised of pipes, valves, and meters.

Two general kinds of distribution pipes transport natural gas within the utility's distribution system: gas mains and service lines. Gas mains are the larger, underground pipes that act like a highway for natural gas, delivering large volumes of gas to communities and through neighborhoods.[22] Gas mains often run under roads and streets along with other utility infrastructure. Service lines are the smaller pipes that run beneath yards and sidewalks before reaching the building's gas meter, similar to a driveway connecting a home to a road. Utility-owned gas meters serve as the connection between the service line and the customer's gas piping inside

[20] Bob Eleff, Residential Space Heating Fuels in Minnesota, Information Brief for Minnesota House of Representatives (2017) https://www.house.mn.gov/hrd/pubs/heatfuel.pdf.
[21] The discrepancy between the total number of occupied residential units using utility gas for space heating in Minnesota in Table 1 and the total number of natural gas investor-owned utility residential customers in Table 2 is due to the difference in data sources (i.e., survey data compiled by the U.S. Census Bureau versus annual reports from the utilities).
[22] Gas mains can also be further divided into transmission and distribution classifications. Continuing the analogy to roads, high-pressure transmission lines are akin to interstate freeways, whereas distribution mains could be anything from highways to side streets, depending on the pressure and size of the main. There are significantly fewer miles of transmission mains compared to distribution mains.

the building (which leads to end use equipment such as furnaces, boilers, water heaters, stoves, and fireplaces).

Most natural gas distribution infrastructure in Minnesota is owned and operated by IOUs, which are regulated by the Minnesota PUC. Minnesota has five IOUs and approximately 30 municipally-owned natural gas utilities. The IOUs serve approximately 94% of the state's natural gas sales, with the remaining 6% served primarily by municipal utilities.[23]

This white paper focuses on Minnesota's five gas IOUs: CenterPoint Energy (CPE), Xcel Energy (Xcel), Minnesota Energy Resources Corporation (MERC), Great Plains Natural Gas Co. (GPNG), and Greater Minnesota Gas (GMG). Figure 2 shows the service territories where Minnesota's five gas IOUs operate based on the lists of communities served that the gas utilities provide in their rate books.

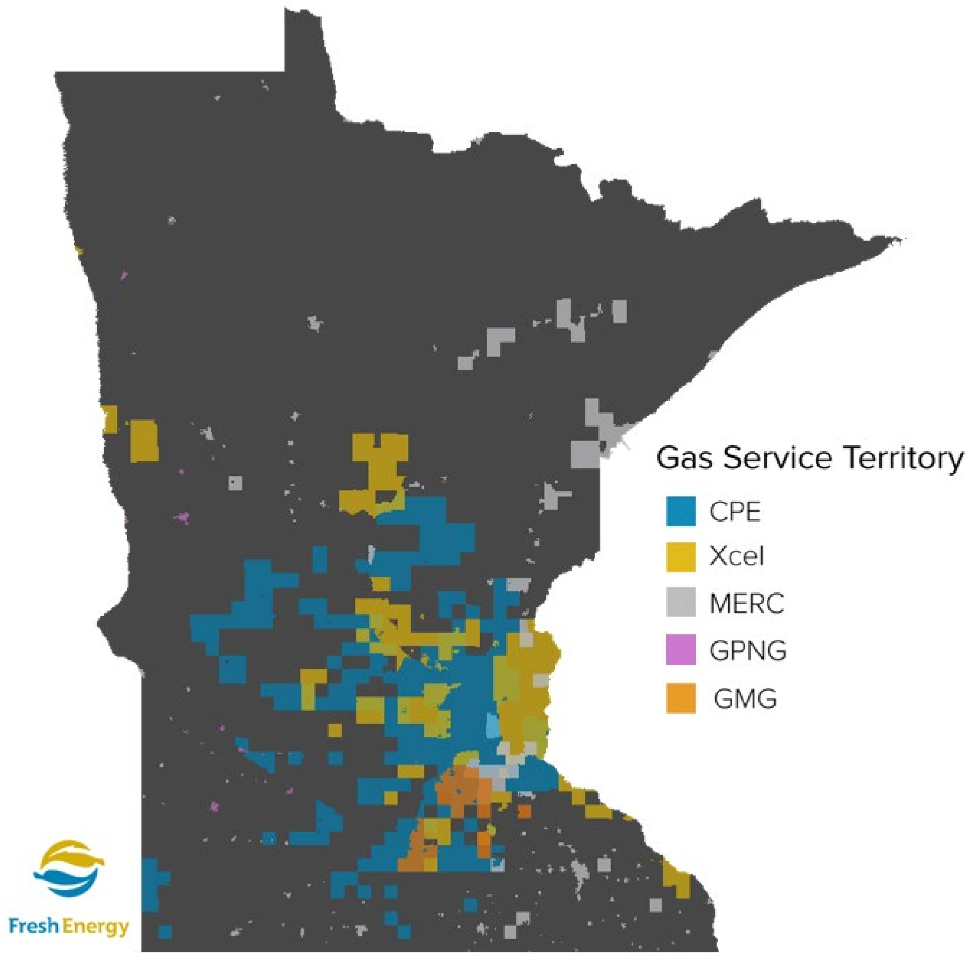

Figure 2. Map of Minnesota's investor-owned gas utility service territories

CenterPoint is the largest gas utility in Minnesota, serving the majority of Minneapolis and the west metropolitan area. Xcel is the second largest gas utility, serving the majority of Saint Paul and the

[23] Center for Energy and Environment, Minnesota Energy Efficiency Potential Study: 2020–2029 (December 2018) at 28 https://mn.gov/commerce-stat/pdfs/mn-energy-efficiency-potential-study.pdf.

east metropolitan area, and many cities/towns surrounding the metro area, including St. Cloud. MERC is the third largest gas utility, serving Rochester, Duluth, and many cities/towns in northern and southern Minnesota. These three utilities collectively make up 98% of natural gas IOU customers in Minnesota, as shown in Table 2.[24]

Table 2. Number of Minnesota natural gas customers by investor-owned utility, 2022

	Total customers as a percent of all IOU customers	Total number of customers	Number of residential customers	Percent of total customers that are residential
CPE	54%	905,186	833,463	92%
Xcel Gas	29%	480,711	444,425	92%
MERC	15%	246,146	221,933	90%
GPNG	1%	22,278	19,091	86%
GMG	1%	10,246	9,235	90%
Total	100%	1,664,567	1,528,146	92%

Minnesota's natural gas infrastructure is growing and expected to continue growing

Minnesota's gas mains could circumvent the earth nearly 1.5 times!

Minnesota's natural gas distribution system is incredibly large, and it is growing every year. The state currently has 34,483 miles of gas mains. Given the Earth's circumference is 24,901 miles, all the miles of Minnesota's gas main could circumvent Earth 1.4 times. 90% of these gas mains are owned by gas IOUs, with the rest owned by municipally-owned gas utilities that are generally smaller than IOUs. CenterPoint's gas mains alone would reach 60% of the way around the Earth. Table 3 shows the total miles of gas mains owned and operated by utilities in Minnesota compared to the circumference of Earth.

Table 3. How many times would Minnesota's gas mains wrap around Earth?

	Miles of Main (2022)	Times Around Earth
CPE	14,608	0.59
Xcel	9,735	0.39
MERC	5,329	0.21
GPNG	466	0.02
GMG	925	0.04
Total IOUs	31,063	1.25
All MN Utilities	34,483	1.38

The total miles of gas mains in Minnesota have risen steadily year-over-year, mainly due to connecting more and more customers to the distribution system. Figure 3 shows the growth of natural gas mains in Minnesota owned and operated by the five largest gas utilities.

[24] Gas Jurisdictional Annual Reports, 2022. See MN DOC Efiling Dockets 23-04.

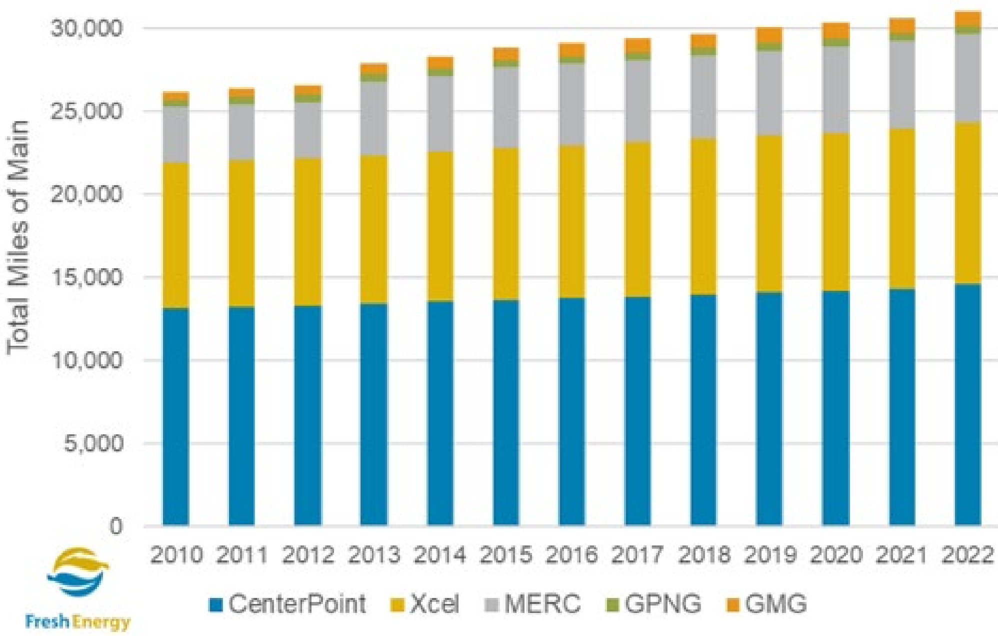

Figure 3. Total miles of gas mains owned and operated by Minnesota's five largest investor-owned natural gas utilities, 2010-2022.
The miles of main owned by each utility underwent regular growth during the time interval studied.

Every mile of gas main that is built represents a substantial investment in both cost (to install and maintain) and time, with many new gas pipes planned to be used and paid for as long as a half-century into the future. Since utilities recover their financial investments over time, every new mile of gas main also represents a potential commitment to burn gas for over a half-century while utilities recover their investment costs. In other words, a gas main installed in 2023 could still be in service in 2073, and customers could still be paying for it.

The total number of gas distribution service lines owned by Minnesota's IOUs have correspondingly increased over time, as shown in Figure 4.

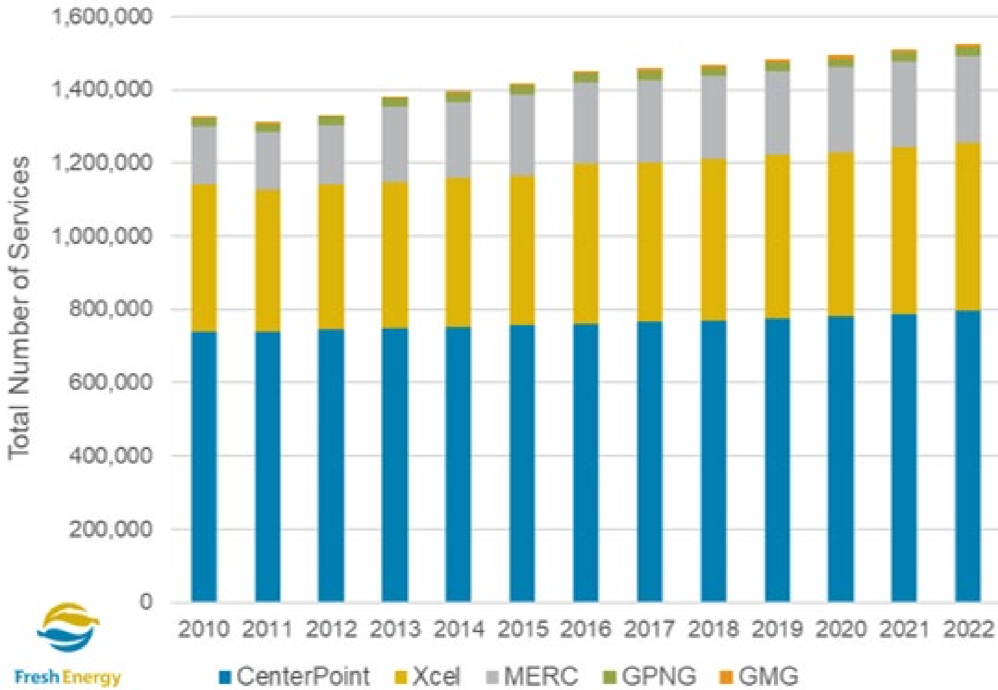

Figure 4. Total number of gas distribution services owned and operated by Minnesota's five largest investor-owned natural gas utilities, 2010-2022

Minnesota's natural gas sales are increasing

As expected from the growth in Minnesota's natural gas infrastructure, the total quantity of gas delivered to residential and commercial customers grew steadily from 2010 through 2022 based upon reports filed by utilities with the PUC (Figure 5). Year-to-year variation in gas sales can result from differences in overall temperatures for any given winter heating season. Despite that variation, there was a 22% increase in gas deliveries for 2019 relative to 2010 and a 24% increase in 2022.[25] According to data from the U.S. Energy Information Administration, residential and commercial gas consumption in Minnesota has increased 57% from 1967 to 2023.[26]

Projections by the same utilities indicate that utilities anticipate ongoing growth in residential and commercial gas deliveries for the next 15 years (Figure 5). Although the exact methodology for determining future projections varied for each utility, three of the four projected higher deliveries in 2038 relative to 2022. One utility did project lower gas deliveries for 2038, although the decrease

[25] Although these sales quantities reflect most gas deliveries in the state, there could be additional growth in the smaller investor-owned utilities and/or municipal gas utilities not captured here. Nonetheless, the sales data here are likely representative of overall gas sales in the state. See Appendix for comparison of this analysis to the state's buildings emissions inventory based upon CO_2 emissions.
[26] U.S. Energy Information Administration, 'Natural Gas Consumption by End Use'. Minnesota data accessible at https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SMN_a.htm.

was less than 1% lower than in 2022. As a group, the four utilities' projections were 42% higher for 2033 and 47% higher for 2038 relative to actual deliveries in 2010.

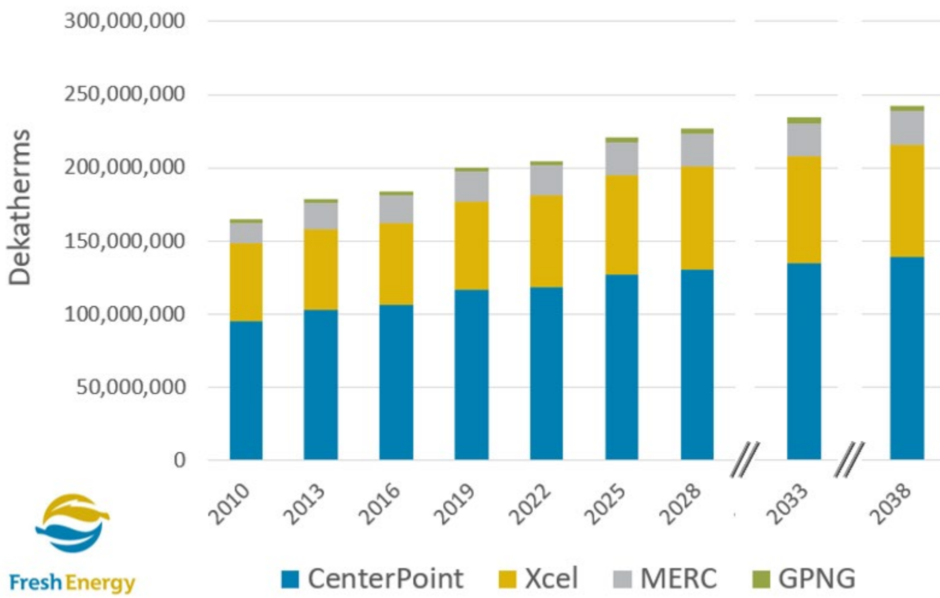

Figure 5. Annual dekatherms of natural gas delivered by Minnesota's four largest investor-owned utilities to residential and commercial customers, weather normalized.
Data on historical deliveries through 2022 were taken from gas jurisdictional reports, while future delivery projections were taken from 2023 annual reports (see the Appendix for details).

Energy efficiency gains have not offset increasing gas sales

Over the study period, gas utilities continued to deliver long-standing programs focusing on energy efficiency and conservation. To investigate the impact that energy efficiency had over this time period, the dekatherms delivered per residential customer over the historical 2010-2022 study period (normalized to heating degree days) were calculated. Surprisingly, there was no discernable trend in the dekatherms delivered on average to each customer (Figure 6).

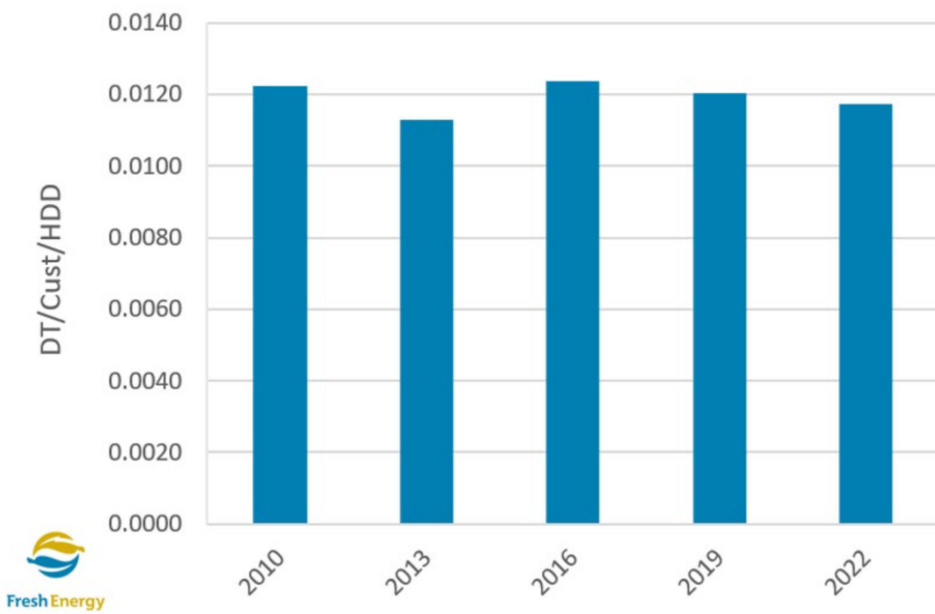

Figure 6. Natural gas deliveries per customer, normalized to winter heating demand (dekatherms per customer per heating degree day) for Minnesota's four largest investor-owned gas utilities. Data obtained from public utility filings (see the Appendix for details). Data represent weighted averages across the four utilities.

Since the state did make progress in implementing energy efficiency programs during that time interval, there are multiple possibilities to account for this finding. First, efficiency gains have been greater in electricity consumption than in gas consumption.[27] Second, the size of Minnesota residences could have increased over time and offset any efficiency gains, resulting in a roughly constant energy intensity per customer. Third, residential customers could have increased their overall consumption to the extent that their consumption offset efficiency gains (e.g., a residential customer started paying lower heating costs due to insulation and window upgrades, so they could afford to keep the thermostat set higher in the winter and thus negate some or all the efficiency gains). Finally, it should be noted that the efficiency savings over the 3-year interval from 2010 to 2013 and again from 2013 to 2016 were about 0.2% of total natural gas sales in the state.[28] Although important, these efficiency gains would not have noticeably impacted the per-customer gas use values reported in Figure 6.

Minnesota will not meet its goals for buildings emissions reductions under the current gas utility growth projections

After determining the historical and projected gas deliveries to residential and commercial customers, the next analysis estimated the emissions from burning natural gas in residential and commercial buildings using several simplifying assumptions. First, it was assumed that all natural

[27] Center for Energy and Environment, Minnesota Energy Efficiency Potential Study: 2020–2029 (December 2018) at 10-11 https://mn.gov/commerce-stat/pdfs/mn-energy-efficiency-potential-study.pdf.
[28] *Id.*

gas reported as delivered to customers was fully combusted (i.e., no leakage or incomplete combustion). Second, a constant emissions factor was utilized for carbon dioxide produced per unit of natural gas burned in residential and commercial buildings from the U.S. Energy Information Administration, across all utilities and time points.

Given the linear relationship between natural gas consumption and CO_2 emissions, the growth trend noted for natural gas delivery was also noted for greenhouse gas emissions (Figure 7).

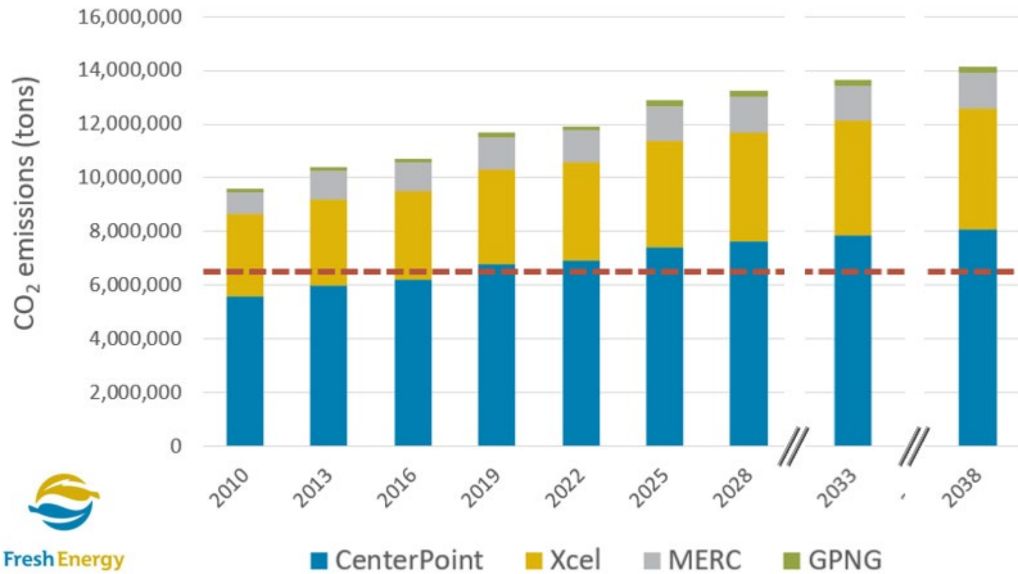

Figure 7. Historical and projected growth in CO_2 emissions from natural gas combustion in Minnesota buildings for the state's four largest investor-owned gas utilities.
CO_2 emissions were derived from gas delivery data provided by the utilities, including projected emissions growth. The dashed red line corresponds to the overall buildings emission goal from Minnesota's guiding Climate Action Framework, of a 50% reduction in buildings emissions by 2035 relative to 2005.

We also compared the projected growth in CO_2 emissions from natural gas consumption in buildings to the relevant statewide emissions reduction targets. The Climate Action Framework[29] outlines policies and interim goals to reach the state's greenhouse gas reduction targets. Those include a reduction in buildings-related emissions of 50% by 2035, relative to 2005. By comparison, the most recent growth projections filed by the state's four largest IOUs show that they expect growth in gas deliveries, and hence emissions, to continue increasing through 2038 even though the state's climate policies call for a 50% reduction prior to that time. In fact, gas deliveries by the state's largest gas utility alone could exceed the state's buildings emissions goal.

Importantly, the historical and projected emissions in Figure 7 do not take into account utility operational emissions (e.g., from metering and regulating stations and gas leaks), emissions from the state's other gas utilities, and emissions from other fuels burned in buildings such as oil, wood, and propane.

[29] Accessible at https://climate.state.mn.us/.

Minnesota buildings emissions could exceed emissions from electricity generation by 2030 under current gas utility growth projections

Unlike Minnesota's buildings emissions reduction goals, which currently exist as policy only in the Climate Action Framework, the state's goals for reducing emissions from electricity generation are legislatively mandated by the 100% carbon-free electricity standard passed into law in 2023. Under the standard, 80% of electricity consumed in the state must be generated by carbon-free sources by 2030 and 100% by 2040. The legislature also updated the state's economy-wide emissions reduction goals in its 2023 energy and environment appropriations legislation to a 30% reduction by 2025, 50% by 2030, and net zero by 2050 (reductions relative to 2005).

Figure 8 shows the historical and projected growth in emissions from natural gas consumption in Minnesota's buildings relative to a 2010 baseline as compared to the economy-wide emissions and reduction targets (relative to the 2005 baseline but adjusted to set 2010 as 100% for comparison to buildings emissions). Although the utility projections only extend to 2035, the general trend of growth in buildings emissions is contrary to actual emissions reductions across the state from 2010 to 2020, and to the reduction targets in the 2030 to 2050 interval. In other words, emissions from gas consumption in buildings is projected to continue to diverge from state GHG emission reduction goals.

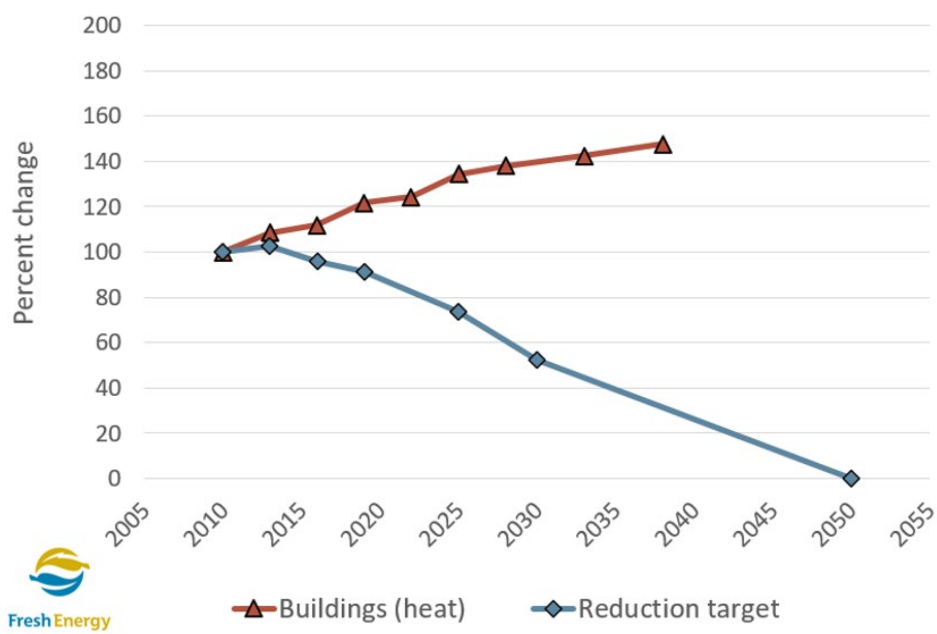

Figure 8. Comparison of emissions growth from burning natural gas in commercial and residential buildings (Minnesota's four largest investor-owned utilities) relative to state economy-wide emissions reduction targets.
Historical and projected percent change in CO_2 emissions are relative to 2010 for buildings relative to economy-wide reduction targets set in the Next Generation Energy Act and updated in 2023.

In contrast, emissions from electricity generation in the state have declined dramatically since 2010 compared to buildings emissions from burning natural gas, which have increased (Figure 9).

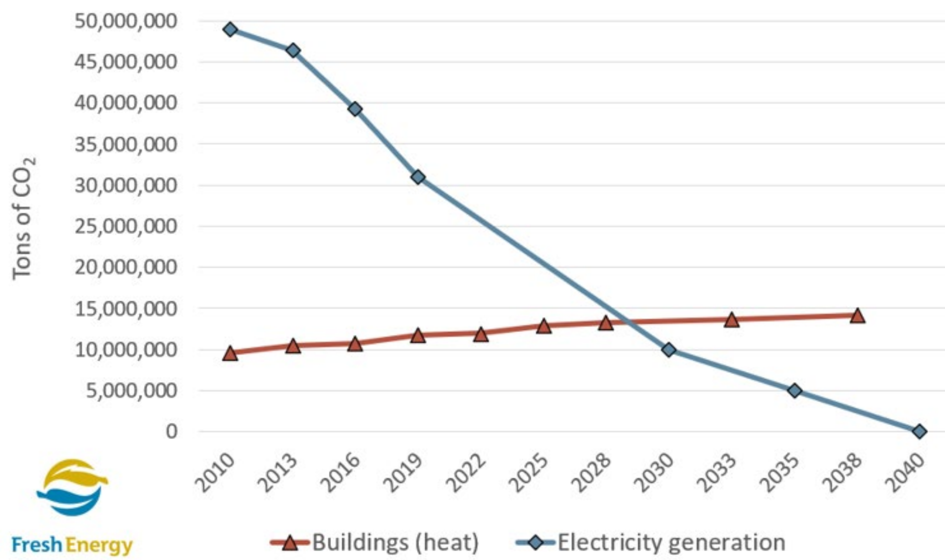

Figure 9. Historical and projected CO_2 emissions from natural gas combustion in commercial and residential buildings versus emissions from electricity generation.
Projected emissions taken from natural gas utility filings and the Minnesota Legislature's 2023 clean electricity standard.

Given the legislatively mandated reductions in carbon emissions from electricity generation, it is possible that emissions from buildings will exceed those from electricity generation before the end of the current decade if those mandated reduction targets are met. Although that conclusion may seem surprising, it is not wholly unreasonable given that the projected emissions trends in Figure 9 are effectively a continuation of recent historical emissions trends. Even though the state is considering options for decarbonizing the gas system, it remains unclear whether those options could substantially impact buildings emissions in the next 5-7 years when electricity generation emissions will likely continue falling with ongoing renewable energy deployment.

Gas infrastructure is being rapidly replaced, increasing costs and the risk of stranded assets

As noted above, Minnesota's gas system is expanding in terms of infrastructure and gas deliveries. Minnesota's gas utilities have also accelerated the replacement of the *existing* system over the past decade. Work performed over this time period has resulted in much of the oldest, leakiest, and riskiest pipe material like cast iron being replaced. Going forward, gas utilities continue planning to spend on these accelerated replacement projects, moving on to other older, legacy pipe materials such as steel and plastic pipe.

These infrastructure replacement efforts will have significant rate impacts for customers, as utilities seek to recover the costs of these expenditures through customer rate increases, either via rate cases or rider proceedings. For example, CenterPoint testified in its 2023 rate case that its capital expenditures are expected to grow to at least $330 million annually for at least the next several years.[30] In 2022, CenterPoint's capital expenditures were $415 million, with distribution expenditures making up almost 90% of that total.[31]

As shown in Figure 10, CenterPoint is planning to invest over a billion customer dollars to replace existing pipe over the next three decades.

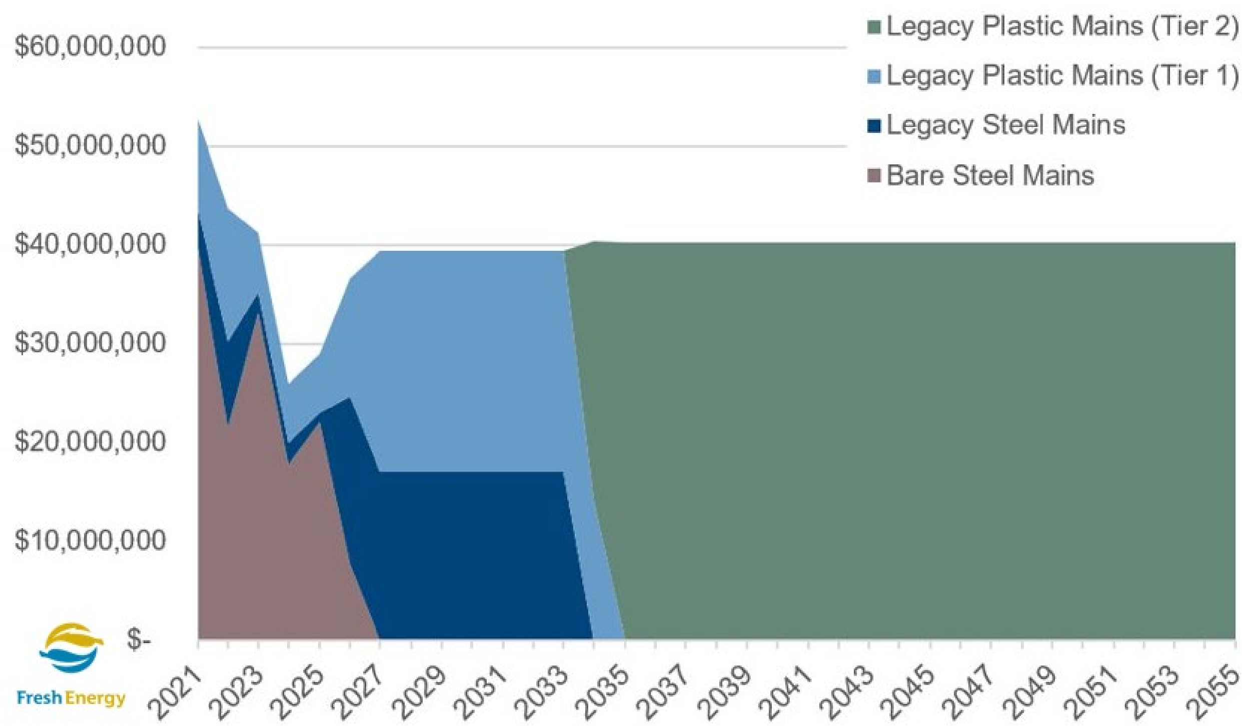

Figure 10. Cost of CenterPoint's gas main replacement projects

The challenge with replacing existing gas infrastructure is three-fold. First, replacing pipe generally increases costs by growing rate base, but does not add utility customers who can provide additional revenue to offset these costs. In its most basic formulation, the utility business model depends on making capital investments that lead to an increase in the number of customers (and corresponding revenue) to share those costs. This balance breaks down when capital investments do not lead to additional revenue/customer growth to offset costs.

The second challenge is that new utility pipe has an expected useful life of decades, which runs well beyond Minnesota's 2050 goal for net zero GHG emissions. This means we will be paying for replacement projects well into the latter part of this century, when Minnesota's buildings sector emissions should be net zero.

The third challenge is that utilities have a fundamental obligation to provide safe and reliable gas service, and an important part of that obligation necessitates continued investment in the system for the foreseeable future. Although these investments are driving increasing rates and increasing use of natural gas which runs counter to Minnesota's GHG reduction goals, utilities must be able to

30 CHS-D at 23 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.
31 CenterPoint's 2022 Gas Jurisdictional Annual Report (Docket #23-04), May 1, 2023.

fulfill their core objective of safety and reliability. Utilities must continue to be responsive to acute risks on the system, such as addressing active leaks or equipment malfunctions, while regulators must critically evaluate how utility spending impacts current and future ratepayers.

Together, these three challenges present risks for current and future customers and the public at large. Current customers face ever-increasing gas service rates that impact energy-burdened customers the most acutely. Future customers face the risk of increasing rates driven by capital spending and fewer customers across which costs can be spread, due to increasing electrification of the heating sector. Finally, the public faces the risk of addressing utility assets that are not fully depreciated, but are also not being utilized due to customer defection, also known as stranded assets.

New gas assets placed into service today have a useful life of approximately 40 years – well beyond target dates for decarbonization goals, creating cost-recovery risk.[32] Table 4 shows the average rate base reported by the IOUs for 2022. Rate base[33] is essentially the unrecovered gas distribution infrastructure, and therefore represents the potential stranded asset risk.

Table 4. Rate base by investor-owned utility, 2022

	Average rate base ($)
CPE	1,567,305,700
Xcel Gas	1,031,566,216
MERC	466,426,959
GPNG	39,298,585
GMG	44,409,541

[32] Brattle, The Future of Gas Utilities Series: Transitioning Gas Utilities to a Decarbonized Future, Part 1 of 3, (Aug. 2021), available at https://www.brattle.com/wp-content/uploads/2022/01/The-Future-of-Gas-Utilities-Series_Part-1.pdf.

[33] A utility's rate base is the undepreciated portion of its utility plant-in-service plus other non-plant capital assets.

Conclusions

This report provides important context for Minnesota's path to decarbonization with respect to emissions from buildings and specifically how the natural gas system contributes to GHG emissions from this sector.

Minnesota sits at a unique juncture on the path towards a net zero economy. This white paper investigated the ways in which natural gas and the gas distribution system have evolved over time and where it is projected to go without proactive policy to address the risks introduced above. While natural gas may have provided benefits in the past, at a time when net greenhouse gas emissions must fall to zero, *relatively* lower emissions are inadequate.

This study draws upon utility data to understand past growth in the distribution system's size, costs, and emissions as well as its projected growth as currently reported by utilities in regulatory filings. Mapping out a successful plan to fully decarbonize heat in Minnesota's buildings in a way that is both affordable and with the appropriate urgency, will require substantial policy discussions in the near term. This study will hopefully provide useful context for those discussions.

Appendix: Detailed methods

Map and distribution of home heating fuels in Minnesota (Figure 1 and Table 1)

Data on home heating fuel among occupied housing units were compiled from U.S. Census Bureau survey data on home heating fuels[34] acquired from the American Community Survey (ACS). The ACS has a new survey every year and collects data on a variety of categories including housing, which is where we pulled data for heat fuel source. The data was pulled using the ACS data query tool.[35] Figure 1 represents data collected over five years (2017-2021), whereas Table 1 represents data in 2022. The ArcGIS map was prepared by Christine McCormick (Fresh Energy), with data prepared by Caitlin Eichten.

Map of Minnesota's investor-owned gas utility service territories (Figure 2)

Service territories that Minnesota's five gas IOUs operate in were approximated based on the lists of communities served that the gas utilities provide in their rate books.[36] To make the map, these were matched to county subdivisions from publicly available shapefiles of geographic boundaries from the U.S. Census Bureau.[37] County subdivisions include townships, cities, and unorganized territories. Minnesota has approximately 2,760 county subdivisions versus 1,338 census tracts.[38] This allows for a more granular and accurate depiction of the communities that gas utilities serve. The ArcGIS map was prepared by Christine McCormick (Fresh Energy), with data prepared by Caitlin Eichten.

Number of Minnesota natural gas customers by investor-owned utility (Table 2)

Counts of total and residential IOU customers for 2022 were compiled from the 2022 Gas Jurisdictional Annual Reports filed by the IOUs in May 2023 (MN DOC Efiling Docket 23-04). Data were taken from 'Sales and Degree Days Data, Weather Normalized' reported in sheets 36 and 37 of the workbook.

Gas main and service line expansion (Figures 3 and 4 and Table 3)

Total miles of main (variable MMILES_TOTAL) and number of service lines (variable NUM_SRVCS_TOTAL) pulled for years 2010 through 2022 from PHMSA Annual Gas Distribution

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[34] https://www.census.gov/acs/www/about/why-we-ask-each-question/heating/

[35] https://data.census.gov/table/ACSDT5YSPT2021.B25040?q=B25040:+HOUSE+HEATING+FUEL&g=040XX00US27$0600000&moe=false

[36] Links to each utilities' rate book: https://www.centerpointenergy.com/en-us/Documents/RatesandTariffs/Minnesota/CPE-MN-Tariff-Book.pdf; https://www.xcelenergy.com/staticfiles/xe-responsive/Energy%20Portfolio/MN-Communities-Served.pdf; https://www.minnesotaenergyresources.com/company/tariffs/cities.pdf; https://www.gpng.com/wp-content/uploads/2023/07/MNGasCommunitiesServed.pdf; https://greatermngas.com/wp-content/uploads/2023/07/Greater-Minnesota-Gas-Inc.-Gas-Rate-Book-1-18-2023.pdf
The list of communities served by CenterPoint on its website (https://www.centerpointenergy.com/en-us/corporate/about-us/company-overview/where-we-serve/minnesota) was more expansive than the list in CenterPoint's rate book, so we used the list from its website.

[37] TIGER/Line files Minnesota County Subdivision 2021 (U.S. Census Bureau) available at https://catalog.data.gov/dataset/tiger-line-shapefile-2021-state-minnesota-county-subdivisions

[38] https://www2.census.gov/geo/pdfs/reference/GARM/Ch8GARM.pdf

Data[39] for CenterPoint Energy MN Gas, Xcel Gas (i.e., Northern States Power Co. of MN), Minnesota Energy Resources Corporation, Great Plains Natural Gas Co., and Greater MN Gas Inc.

Gas sales quantities (Figure 5)

Historical natural gas delivery quantities in dekatherms were obtained for the four largest regulated gas utilities using data from Gas Jurisdictional Annual Reports every 3rd year for calendar years 2010 through 2022 (Minnesota PUC dockets 2011-04, 2014-04, 2017-04, 2020-04, and 2023-04). Data were taken from 'Sales and Degree Days Data, Weather Normalized' reported in sheet 36 of the Excel workbook template distributed to utilities by the Minnesota Department of Commerce. When a utility reported separate sales for residential customers with and without heating, gas sales for both categories were added to capture all residential natural gas use.

Future natural gas delivery projections were determined for the same four utilities from the 2022 annual Gas Utility Information Reporting form (found in docket 23-19), in volumes of thousand cubic feet (MCF) of sales as reported in the 'SalesByCategory_Large' sheet. Commercial firm and interruptible sales were added together. Cubic feet were converted to dekatherms for consistency with historical data using the U.S. Energy Information Administration's most recent heating value for natural gas in Minnesota (2022; 1,057 BTU per cubic foot) and using an approximating conversion factor of 1 million BTU = 1 dekatherm.

Per-customer energy use (energy intensity) (Figure 6)

Gas sales data were obtained for the same historical years as described above, except that uncorrected sales data (not normalized for weather) were used. Number of customers was also provided in the utility jurisdictional reports. Statewide heating degree days were downloaded from the National Weather Service. Energy intensity was calculated for each of the study years to determine the change in energy use per customer over time, after taking heating demand (heating degree days) into account:

$$Energy\ Intensity\ = \left(\frac{Dekatherms}{Customer}\right)\left(\frac{1}{HDD}\right)$$

Where Energy Intensity = Weather-normalized natural gas use per customer, Customers = Number of residential customers reported by the utility and HDD = Heating degree days. All values were for a given calendar year. Data were presented as an average of all four utilities, weighted by number of customers for each utility for a given year.

CO_2 emissions calculations (Figure 7)

Weather-adjusted dekatherm sales were further converted to tons of CO_2 emitted by assuming complete combustion of all gas sold and complete emission of all CO_2 produced through natural gas combustion. We also assumed that variation in the non-methane hydrocarbon content of natural gas delivered to Minnesota would not have a meaningful impact on CO_2 emissions. These assumptions were deemed reasonable given known proportions of behind-the-meter gas leaks relative to gas consumed, and that carbon capture technology for residential and commercial

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[39] Available at https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids

appliances has not been deployed yet in Minnesota (to the best of our knowledge). Furthermore, while appliance efficiency impacts the heat derived from a given volume of natural gas, appliance efficiency does not affect the stoichiometry of the combustion reaction with respect to hydrocarbons and carbon dioxide other than the completeness of hydrocarbon combustion (already assumed to be 100% complete). Therefore, a given dekatherm of natural gas was assumed to produce the equivalent CO_2 emissions regardless of the combustion source.

A CO_2 emission coefficient was taken from the U.S. Energy Information Agency,[40] where one million BTU (equivalent to one dekatherm in this analysis) of natural gas combusted produces 116.5 pounds of CO_2. Pounds of CO_2 were then converted to short tons.

Buildings emissions growth vs state goals (Figures 8 and 9)

Percent change in emissions from natural gas use in buildings (commercial and residential combined) was determined from CO_2 emissions as described above. State greenhouse gas emissions reductions goals were taken from the most recent update by the 93rd MN Legislature (2022-2023) in its Energy, Natural Resources, Climate, and Energy Finance and Policy appropriations bill (HF2310, Article 12, Section 61, Subdivision 1, lines 415.1 through 415.25).[41] Actual statewide emissions were calculated as a percent of 2010 emissions through 2019 using data from the MPCA.[42] Future emissions goals were converted from a relative baseline in 2005 as described by the Minnesota Legislature to a relative baseline of 2010 for comparison to the natural gas emissions data.

We additionally compared the CO_2 emissions determined by this analysis to those reported by the MPCA for statewide emissions from natural gas consumption in buildings. Since we only calculated emissions from sales by the four largest IOUs in the state, this analysis did not include smaller IOUs (e.g., Greater Minnesota Gas) and municipal natural gas utilities (e.g., Duluth Public Works & Utilities). There was a small but relatively constant gap between the emissions reported by this analysis and statewide emissions, with this analysis capturing 90-93% of the statewide emissions (data not shown). Notably, this analysis therefore slightly underestimates statewide emissions by approximately 7-10%. The analysis conducted thus provides a reasonable, albeit not perfect, approximation of statewide emissions from natural gas consumption in residential and commercial buildings.

CenterPoint's gas main replacement projects (Figure 10)

Information on the legacy plastic,[43] bare steel,[44] and legacy steel[45] main replacement projects was pulled from workpapers for CenterPoint's integrity management program in its most recent rate case (docket #23-173). The workpapers for each main replacement project provide actual and estimated annual data on the miles of main addressed by the project.

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[40] Taken from "Carbon Dioxide Emissions Coefficients", found at https://www.eia.gov/environment/emissions/co2_vol_mass.php
[41] Available at https://www.revisor.mn.gov/bills/bill.php?b=House&f=HF2310&ssn=0&y=2023
[42] https://public.tableau.com/app/profile/mpca.data.services/viz/GHGemissioninventory/GHGsummarystory
[43] Exhibit JMW-WP Schedule 2, Workpaper 6 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.
[44] Exhibit JMW-WP Schedule 2, Workpaper 4 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.
[45] Exhibit JMW-WP Schedule 2, Workpaper 5 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.

For the Legacy Plastic Main Replacement project, CenterPoint reported in Workpaper 6 that active replacement of Tier 2 legacy plastic main will begin in the year when Tier 1 is completed, which CenterPoint currently projects to be 2034. CenterPoint notes that at the end of 2022, there were 1,049 miles of Tier 2 legacy plastic main remaining, and that the completion of the Tier 2 replacement phase is estimated to occur in the mid-2050s. Therefore, to estimate the full completion of this project, we distributed the 1,049 miles of Tier 2 main evenly over the years 2035-2055 and assumed the same average cost per mile of main as Tier 1 legacy plastic.

For the Legacy Steel Main Replacement project, CenterPoint reported in Workpaper 5 that it currently plans to increase its annual spending on the project in 2026, as the Bare Steel Main Replacement project winds down, and that spending on the projects is then expected to continue at about the same level until legacy steel main is eliminated from CenterPoint's distribution system. Therefore, to estimate the full completion of this project, we distributed the remaining 31.5 miles of legacy steel main evenly over eight years starting in 2026. This results in a projected 3.9 miles of main replaced annually, which is similar the estimated annual miles that CenterPoint reported for this replacement project in its 2021 rate case workpapers.[46]

The average cost per mile of main was calculated using the capital cost and miles to be replaced reported for each main replacement project in the infrastructure and integrity management program testimony.[47] The calculated averages are presented in the table below.

The estimated cost per mile of main for each replacement project was then multiplied by the miles of main addressed by the project to get an average spend per year on the project. The calculated total cost from 2021 to the end of the project is shown in the table below.

	Average cost per mile of main	**Total cost from 2021 to end of project**
Legacy Plastic Main (Tier 1)	$832,178	$223,522,885
Legacy Plastic Main (Tier 2)	$832,178	$872,954,230
Bare Steel Main	$1,283,200	$142,013,048
Legacy Steel Main	$4,318,182	$153,727,273

Average rate base (Table 4)

Average rate base for the IOUs for 2022 were compiled from the 2022 Gas Jurisdictional Annual Reports filed by the IOUs in May 2023 (MN DOC Efiling Docket 23-04). Data were taken from 'Rate of Return on Rate Base and on Common Equity' reported in sheet 34 of the workbook.

[46] Exhibit JMW-WP Schedule 2, Workpaper 6 in CenterPoint Rate Case (Docket #21-435), November 1, 2021.
[47] JMW-D Tables 6-8 in CenterPoint Rate Case (Docket #23-173), November 1, 2023.