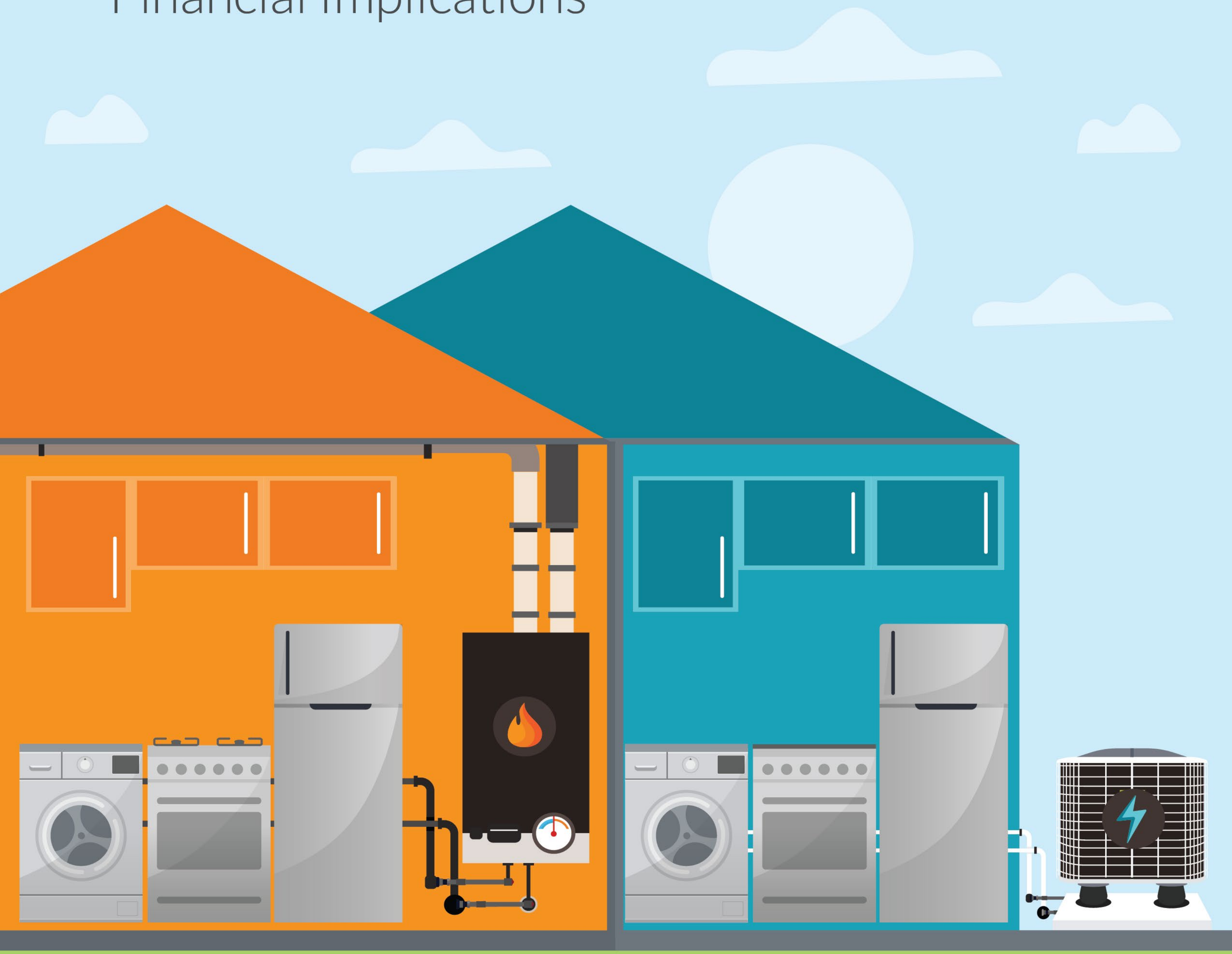
OPC
Office of People's Counsel
State of Maryland

Climate Policy for Maryland's Gas Utilities

Financial Implications



November 2022

DEAR READERS

The most promising path to transforming Maryland's homes and apartments to meet the State's climate goals involves transitioning to electric heating and cooling systems and appliances. This point is not seriously disputed.

What remains at issue for a decarbonized future is the role of the gas utilities' distribution infrastructure and gas itself. As our recent report, Maryland Gas Utility Spending: Projections and Analysis, shows, despite the State's electrification goals, Maryland's gas utilities are on a business-as-usual path, spending tens of billions of dollars on their delivery systems. Gas utilities hope to recover the costs of this spending over many future decades through higher customer rates. Yet these investments are being made in a declining market—inevitably, the number of gas customers and gas sales will decline with electrification. In fact, electrification already is slowly and steadily eating into gas's market share. Residential customers have been turning more and more to electricity for home heating for more than a decade. These declines in gas use will only accelerate in coming years as federal and State policies favoring electrification take effect.

This dynamic of decreasing gas sales and escalating rates raises a fundamental question: Should Maryland's gas utilities continue to invest heavily in gas distribution infrastructure given the declining market?

How this important question is resolved has significant implications for utility customers in the near and long term. The answer determines whether billions of customer dollars will go toward retaining and enhancing

Should Maryland's gas utilities continue to invest heavily in gas distribution infrastructure given the declining market?

the gas distribution infrastructure or whether those dollars can be used to fund any costs associated with electrification or otherwise reduce customer burdens and help Maryland's economy.

To better understand the scale of the problem, our office engaged a consultant, Synapse Energy Economics, to evaluate what happens to residential utility rates under the current regulatory model and utility spending trajectory as gas sales decline. The results—described in this report—are telling: Replacing fossil gas with lower carbon alternatives causes the rates of the State's largest gas utility, Baltimore Gas & Electric, to increase two to three times 2021 levels by 2035 and seven to 11 times 2021 levels by 2050, with similar ranges of rate increases for Maryland's two other large gas utilities. Such rates are not sustainable. As rates increase to these levels, the resulting high bills will lead many customers—likely most all customers who have options—to leave the gas system, leaving behind customers without alternatives; those remaining gas customers will be unable to afford continued gas service.

No matter the path forward, electrification holds major consequences for gas utilities and their customers. The potential consequences of business-as-usual spending—tens of billions of stranded

Electrification holds major consequences for gas utilities and their customers.

gas infrastructure assets—has huge implications for the State. Who will bear the consequences of the uneconomic investments? Shareholders? Electricity customers? Taxpayers? Indeed, a recent BGE report acknowledges the unsustainability of maintaining its gas distribution system, foreshadowing that it may seek subsidies for its gas business through "transfer payments from the company's electric business."

Similar to our October 2022 report on gas utility business-as-usual capital spending, our estimates are generally conservative. For the price of fossil gas, the report uses prices ranging from $2.94/MMBtu to $4.05/MMBtu, based on U.S. Energy Information Administration's Annual Energy Outlook 2022 Henry Hub natural gas spot price projections (in 2020 dollars). These prices are well below the EIA's September 2022 price of $7.88/MMBtu. For alternative fuel prices, we use a low-price scenario based on a study prepared for Washington Gas Light, and for the high-price scenario we use estimates from E3's 2021 study for the Maryland Commission on Climate Change.

We hope this report helps educate stakeholders and policymakers on the significance of unmitigated gas utility spending for Maryland's gas utility customers as the State electrifies and initiates policies to meet its greenhouse gas reduction goals, with corresponding reductions in gas utility customer base and gas sales.

David S. Lapp
People's Counsel

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INTRODUCTION

The Maryland Office of People's Counsel (OPC) asked Synapse Energy Economics, Inc. (Synapse) to analyze the gas rates likely to materialize as more Marylanders switch from fossil-fuel-fired building furnaces and appliances to electric ones as part of the effort to meet the State's greenhouse gas (GHG) reduction targets.

Released in 2021, the Maryland Department of Environment's *2030 Greenhouse Gas Emissions Reduction Act (GGRA) Plan* recommends reducing emissions from buildings using energy efficiency and by electrifying building heating systems. Under this plan, the Mitigation Working Group (MWG) of the Maryland Commission on Climate Change (MCCC) developed and issued the *Building Energy Transition Plan.*[1] To inform this plan, Energy + Environmental Economics (E3) analyzed scenarios for achieving reductions in emissions to near net-zero levels for Maryland's residential and commercial buildings by 2045. In total, E3 modeled four scenarios, including the *MWG Policy Scenario*, which was found both to be the lowest-cost scenario and to reduce residential and commercial building emissions by 95 percent. This scenario reflects four core concepts and objectives, including: ensuring an equitable and just transition; shifting to fossil-free space and water heating for new construction; replacing almost all fossil heating systems in homes with heat pumps by 2045; and implementing an emissions standard that provides commercial buildings compliance alternatives.[2]

In 2022, the Maryland State House and Senate passed the *Climate Solutions Now Act*, which requires the State to reduce GHG emissions by 60 percent from a 2006 baseline by 2031 and to achieve net-zero GHG emissions by 2045.[3] On April 8, 2022, Governor Hogan released a letter stating that he would allow the bill to pass without his signature.[4]

To better understand the potential effects of the MCCC Mitigation Working Group's *MWG Policy*

> The **MWG Policy Scenario** was found to be the lowest-cost scenario and to reduce residential and commercial building emissions by 95 percent.

1 Maryland Commission on Climate Change. *Building Energy Transition Plan: A Roadmap for Decarbonizing the Residential and Commercial Building Sectors in Maryland.* Approved by the Mitigation Work Group on Oct. 13, 2021.

2 Id., p. 4.

3 Maryland Senate Bill 528. "Chapter 38: an Act Concerning Climate Solutions Now Act of 2022." Available at: https://mgaleg.maryland.gov/2022RS/Chapters_noln/CH_38_sb0528e.pdf.

4 Governor Larry Hogan. April 8, 2022. *Letter from Governor Hogan to State Senate President Ferguson and State House Speaker Jones.* Available at: https://governor.maryland.gov/wp-content/uploads/2022/04/SB-528-CSNA-SB-566-Investment-Climate-Risk-EWS-Letter.pdf.

To achieve net zero GHG emissions by 2045, the vast majority of **buildings will have to either fully electrify their loads or use alternative gaseous fuels for any gas needs**, including backup heating.

Scenario, we modeled the progress of Maryland's electrification to project GHG emissions, trends in gas consumption, and space heating type and space heating equipment sales. Synapse then used these projections to analyze the financial implications of Maryland's climate goals for gas utilities in the State through 2050. Our analysis focuses on the residential sector, consistent with OPC's statutory mission.

To achieve net zero GHG emissions by 2045, the vast majority of buildings will have to either fully electrify their loads or use alternative gaseous fuels[5] for any gas needs, including backup heating. Buildings are relatively low-cost to electrify with commercially available technologies. On the other hand, the most likely candidates for alternative gaseous fuels pose issues related to cost, availability, emissions, safety, and energy use during production. However, certain end-uses would be far more expensive to electrify or have no viable electric alternatives. Given these considerations, it is important to consider how alternative gaseous fuels should be used.

If alternative gaseous fuels are used for building end-uses, the cost of the commodity will increase, and that additional cost will be reflected in customers' bills. Given the availability of cost-competitive electric alternatives, increased gas costs will drive customers off the gas system and decrease gas sales. At the same time, the utilities' investments in pipeline infrastructure, documented in OPC's recent report, Maryland Gas Utility Spending: Projections and Analysis, will also increase gas customers' bills. With more customers leaving the gas system due to electrification, these higher gas commodity and infrastructure costs will have to be recovered through fewer sales. This will mean higher rates for those remaining customers, which will further drive customers off the gas system and increase the risk that the utility will have stranded assets.

In the remainder of this document, we provide context and describe our findings. Section 2 describes how, under traditional ratemaking, gas companies will be affected as customers migrate away from gas use with increasing electrification of their end-uses. In Section 3, we describe technologies available for decarbonizing buildings. In Section 4, we describe our methodology for analyzing decarbonization trajectories and gas utility financials as sales decline. Appendix A features a list of definitions and abbreviations. Appendix B provides figures for the commercial sector.

Given the availability of cost-competitive electric alternatives, **increased gas costs will drive customers off the gas system and decrease gas sales**.

5 Here we assume that Alternative Gaseous Fuels reduce GHG emissions. However, as explained below, recent studies suggest otherwise.

SECTION 2

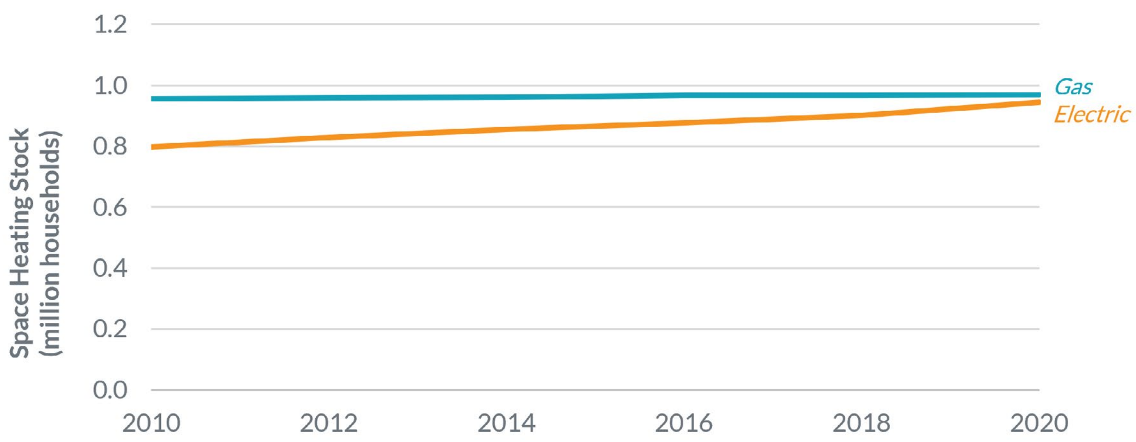
ELECTRIFICATION'S IMPACTS ON GAS RATES

Basic ratemaking principles explain how electrification (the process of switching fossil-fuel-based appliances and other energy end-uses over to electric ones) will affect gas companies by causing customers to migrate away from gas use. The traditional ratemaking model allows utilities to invest in and earn a return on assets such as gas mains and service lines. Utilities recover and earn a return on their investment, typically over the asset's useful lifetime, by including the costs of their investments and the returns on them in the rates they charge customers. This traditional utility business model is designed to ensure utilities can attract shareholders who will put up the money for the investments in exchange for a fair return of—and on—the utility's investments. Without such investments, the thinking goes, utilities would not be able to ensure reliability or meet customers' needs. This model works reasonably well when sales increase over time, but it leads to higher rates when sales are decreasing. Whether occurring as a result of market trends or policy intervention, building electrification will result in declines in gas utility sales, holding all else equal.

Electric heating stock has been increasing for years now, while gas heating stock has stagnated.

Figure 1 shows electric heating stock (mostly heat pumps) has been increasing for years now, while gas heating stock has stagnated. Data from the American Community Survey show that this trend of electrification is occurring across the country. It is notable that

Figure 1. Gas and Electric Space Heating Stock in Maryland Households, 2010-2020



Source: US Census Bureau: American Community Survey. Table DP04: Selected Housing Characteristics for Maryland, 5-year Estimates. June 2, 2022. Available at: https://data.census.gov/cedsci/table?q=DP04&g=0400000US24&tid=ACSDP5Y2020.DP04

this trend toward heating buildings with electricity rather than gas is occurring without significant policy initiatives at the State or local level. While federal and State electrification policies are being discussed (and recently adopted as is the case of the recently enacted *Inflation Reduction Act*, for example), their effects have largely yet to be realized. These policy efforts can be expected to accelerate electrification.

This electrification trend means fewer gas sales. If gas sales decline faster than utilities' asset bases depreciate and faster than the utilities can lower their operating and maintenance costs, gas utilities will seek approval for increasing gas rates to recover the capital invested over fewer unit sales. In turn, higher gas rates are likely to spur more customers to electrify their gas end-uses (furnaces and appliances). As this process goes on, those with the means to electrify—i.e., those who can afford the upfront costs of changing their gas appliances to electric ones and can modify their buildings to accommodate the switch—will do so first. Without changes to regulatory practices or direct assistance, those without access to capital (e.g., low- and moderate-income customers) or the ability to make changes to their dwellings (e.g., renters) will be left on an increasingly costly gas system. Rate escalation will likely hit these groups the hardest.

This trend toward heating buildings with electricity rather than gas is occurring **without significant policy initiatives at the State or local level**.

SECTION 3

TECHNOLOGIES THAT SUPPORT DECARBONIZATION

Achieving net zero by 2045 means that buildings will have to either fully electrify their energy loads or use alternative gaseous fuels for any gas needs, including backup heating. This section discusses key considerations about the available building decarbonization technologies to provide context for the rate analysis in Section 4.

The total cost of installing heat pumps in residential new construction is much less than the cost of installing fossil gas equipment for heat plus central air conditioning (AC) for cooling.

3.1. Electric Space and Water Heating

Heat pumps. Heat pumps provide both energy-efficient cooling and heating. The total cost of installing heat pumps in residential new construction is much less than the cost of installing fossil gas equipment for heat plus central air conditioning (AC) for cooling. For retrofitting an existing building, the cost of installing heat pumps is similar to or less than the combined installed cost of the furnace and central AC. A study by the Lawrence Berkeley National Laboratory (LBNL) found that, on average nationally, a new gas furnace and AC have a combined installed cost of almost $11,000 for residential retrofits. In contrast, the installed cost of heat pumps is substantially less, at just over $8,000.[6] In the absence of extreme price volatility, operating costs, including fuel, are similar for these options.[7] In addition to cheaper up-front costs, heat pumps serve as both the heating and cooling device for a home, requiring a household to only maintain one system. Comparatively, a gas furnace cannot be used for home cooling and requires an additional system for air conditioning.[8]

Electrification will gradually advance as current heating stock reaches the end of its useful life and is increasingly replaced with heat pumps. Moreover, since almost 50 percent of residential buildings in

6 Less, B. D., et al. 2021. *The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes*. Lawrence Berkeley National Laboratory. Available at: https://escholarship.org/uc/item/0818n68p.

7 Energy + Environmental Economics. "Maryland Building Decarbonization Study: Final Report." October 20, 2021.

8 For commercial heating and cooling systems, retrofit costs are harder to compare than for residential ones, because costs vary by building type and data are relatively sparse for the variety of building types in use for commercial applications. Some studies suggest that installed costs for heat pumps are comparable to the cost of gas heating and separate electric AC systems for commercial buildings. (Group 14 Engineering, *Electrification of Commercial and Residential Buildings*, (2020) available at: https://bit.ly/3skNqAp.) For small commercial customers, E3's study for Maryland found that all-electric new construction is cheaper than mixed-fuel new construction due to lower capital and operating costs. (Energy + Environmental Economics. "Maryland Building Decarbonization Study: Final Report." October 20, 2021.)

Maryland are already heated primarily with an electric heating unit (either electric resistance or heat pumps), electrification is already underway in the State.[9]

Hot water heaters. The total equipment and installation costs of electric heat pump water heater (HPWH) retrofits are generally much higher than those of gas storage water heaters.[10] As with space heating, the operating costs of electric and gas appliances are generally similar. Considering fuel costs, electric rate structures such as time-of-use rates can give electric appliances and equipment an edge over gas systems. (Customers billed under a time-of-use rate generally pay more during peak energy-usage hours than during off-peak hours, such as late at night or early in the morning.)

Panel upgrades. Electrification may require upgrades to electrical circuits and panels to accommodate additional load. The cost of upgrading the electrical panel typically ranges from about $500 to $2,000 for most homes, while the costs could be more than $3,000 for others.[11] For some households, these costs can be mitigated. Newer buildings generally have high electrical capacity and thus may not need upgrades. Some customers may upgrade their electrical panels to support electric vehicles and be ready for building electrification measures without additional upgrades. Finally, these costs also can be avoided in the future by using low-amp appliances that are currently in development.

Inflation Reduction Act. The recently enacted federal Inflation Reduction Act (IRA) could substantially reduce the costs of electrification through tax credits. Homeowners can receive a tax credit of up to $2,000 per year to install heat pumps or electric water heaters and up to $600 per year for electrical panel upgrades.[12] The IRA also authorizes rebates for qualifying households for electrification and efficiency measures, including heat pumps, heat pump water heaters, electric stoves, heat pump clothes dryers, circuit panels, wiring, and insulation and air sealing.

3.2. Heat Pumps with Fuel Backup (Hybrid Systems)

Heat pumps can be used in concert with fossil fuel backup or supplemental heating systems. Such backup systems could reduce pressure on the electric system to accommodate higher loads from electrification. However, in a moderate climate like Maryland (with only around 4,000 heating degree days annually)[13] fuel backup is unnecessary. ACEEE found that households in the State would not need fuel backups when using cold-climate heat pumps, which are advanced heat pump systems that provide

Fuel backup systems are unnecessary, and deploying them is costly for consumers.

9 U.S. Energy Information Administration. Residential Energy Consumption Survey: 2020 RECS Survey Data. Available at https://www.eia.gov/consumption/residential/data/2020/index.php?view=state&src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20(RECS)-f2, accessed October 20, 2022.

10 Less, B. D., et al. 2021. *The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes*. Lawrence Berkeley National Laboratory. Available at: https://escholarship.org/uc/item/0818n68p.

11 HomeAdvisor. July 6, 2022. "Cost to Upgrade an Electrical Panel." Available at: https://www.homeadvisor.com/cost/electrical/upgrade-an-electrical-panel/.

12 Inflation Reduction Act of 2022, §13301. Available at: https://www.congress.gov/bill/117th-congress/house-bill/5376/text.

13 Heating degree days measure how cold the outdoor temperature is relative to a standard temperature, generally 65° Fahrenheit (F), over a period of time. For example, a day with a mean temperature of 40°F would have 25 HDD. (U.S. Energy Information Administration, Units and calculators explained: Degree days. Available at: https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php.) Over the course of a year, Maryland has approximately 4,000 HDD. (Nadel, S. and L. Fadali. 2022. *Analysis of Electric and Gas Decarbonization Options for Homes and Apartments*. Washington, DC. ACEEE. Available at: https://www.aceee.org/sites/default/files/pdfs/b2205.pdf.)

heat down to 5 degrees Fahrenheit or lower.[14] Fuel backup systems are unnecessary, and deploying them is costly for consumers because the gas utilities would need to upgrade old parts of the distribution system and maintain the entire system for use during just a small portion of the year.

3.3. Alternative Gaseous Fuels

Considering that some uses of fossil gas do not currently have electric alternatives, replacing fossil fuel gas with lower carbon alternatives will play an important role for the State's achievement of its climate goals. The most likely alternative gaseous fuels that have potential for replacing fossil gas are biomethane, recovered methane, hydrogen, and synthetic natural gas or synthetic methane.

3.3.1. Biomethane and recovered methane

Recovered methane is methane captured from gas distribution system leaks or other sources. *Biomethane* (also called renewable natural gas, or RNG) is a mixture of carbon dioxide and hydrocarbons released from the decomposition of organic matter. Biomethane must be processed to remove impurities, liquid water, and hydrocarbons, and to attain acceptable heat content.[15] Processing increases costs, consumes energy, and requires investment in processing facilities.

Both biomethane and recovered methane pose **collection, processing, and transportation challenges that raise their costs.**

Both biomethane and recovered methane pose collection, processing, and transportation challenges that raise their costs. It may be more economical to use these fuels for some other purpose, in a less-processed form and closer to their sources, rather than using them in distant buildings to replace fossil gas consumption.

Both biomethane and recovered methane supplies are currently limited and likely to remain constrained well into the future. According to the consulting firm ICF International's 2019 report for the American Gas Foundation, constraints in available biomass feedstocks severely limit biomethane that is potentially carbon-negative, which includes anaerobic digestion of food waste, dairy, and swine manure. (Other feedstocks—gasification of agricultural and forest residue, municipal solid waste, and energy crops—have fewer supply constraints but unfavorable carbon footprints.) The 2019 ICF International report estimates that supplies of the feedstocks that are likely to be carbon negative from Maryland sources will amount to just 5.766 tBtu in 2040 in a high-potential scenario.[16] Relative to current residential gas consumption in Maryland—80.418 tBtu for the residential sector alone in 2020—carbon negative biomethane could displace only a small portion of current gas sales in the State, even assuming

14 One field study in Vermont observed that cold climate heat pumps operated under -20° F at above 1 coefficient of performance (COP) but with reduced capacity. (Walczyk, J. 2017. Evaluation of Cold Climate Heat Pumps in Vermont. Prepared by The Cadmus Group, LLC for the Vermont Public Service Department. Available at: https://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/Reports/Evaluation%20of%20Cold%20Climate%20Heat%20Pumps%20in%20Vermont.pdf.) *See also*, Nadel, S. and L. Fadali. 2022. *Analysis of Electric and Gas Decarbonization Options for Homes and Apartments.* Washington, DC. ACEEE. Available at: https://www.aceee.org/sites/default/files/pdfs/b2205.pdf.

15 Gas quality specifications may vary by pipeline. (Thomson Reuters Practical Law: Pipeline Quality Natural Gas (US). Available at: https://content.next.westlaw.com/practical-law/document/Iee1c892db6ea11eabea4f0dc9fb69570/pipeline-quality-natural-gas?viewType=FullText&originationContext=document&transitionType=DocumentItem&ppcid=b60bf2510cb649d7a374f9f88d3199f5&contextData=(sc.DocLink)&firstPage=true, accessed October 18, 2022.)

16 ICF International. 2019. *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment. Prepared for the American Gas Foundation.* Available at https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf.

Carbon negative biomethane could displace only a **small portion** of current gas sales in the State.

declining gas sales in future years.[17] There also will be competition for the limited biomethane supplies as other states seek to decarbonize their economies.[18]

Because methane is a potent GHG, leaks undercut overall climate efforts. A GHG emissions mitigation strategy that integrates these fuels into the existing distribution system for widespread use should account for fugitive emissions during transport.

Methane leakage also poses safety concerns. Local fire departments in the United States respond to 4,200 home fires caused by ignition of fossil gas per year, most of which involve some type of leak. Each year on average, these fires result in $54 million in direct property damage, 140 civilian injuries, and 40 civilian deaths.[19]

Like fossil gas, in-home use of biomethane and recovered methane poses health and safety concerns due to combustion and leaks.[20] Indoor nitrogen oxide (NO_X) emissions contribute to increased respiratory symptoms and asthma attacks.[21]

3.3.2. Hydrogen

There are different methods of producing hydrogen that impact its carbon footprint. "Gray" hydrogen is produced from fossil gas. As the most common hydrogen production method, gray hydrogen accounts for 6 percent of fossil gas consumption worldwide.[22] "Blue" hydrogen is produced using the same process, but the associated GHG emissions are captured and stored. With both gray and blue hydrogen, emissions result from fossil gas extraction, processing, and use. As a result, gray and blue hydrogen do not provide emissions reductions relative to direct combustion of fossil gas, diesel, or coal for generating heat, as shown in Figure 2.

Gray and blue hydrogen do not provide emissions reductions relative to direct combustion of fossil gas, diesel, or coal for generating heat.

17 Maryland Department of the Environment. 2020. "GHG Emission Inventory." Available at: https://mde.maryland.gov/programs/air/climatechange/pages/greenhousegasinventory.aspx.

18 For example, New York will likely dramatically reduce gas consumption in compliance with its Climate Leadership and Community Protection Act, with likely high demands for RNG for difficult-to-electrify end uses. Current gas consumption in New York, excluding gas for electric power generation, is about 950 Tbtu—far outstripping a recent study's projected statewide potential RNG supply of 47 tBtu/yr. and 147 tBtu/yr. (New York State Energy Research and Development Authority (NYSERDA). 2021. "Potential of Renewable Natural Gas in New York State," NYSERDA Report Number 21-34. Prepared by ICF Resources, L.L.C., Fairfax, VA 22031. nyserda.ny.gov/publications.)

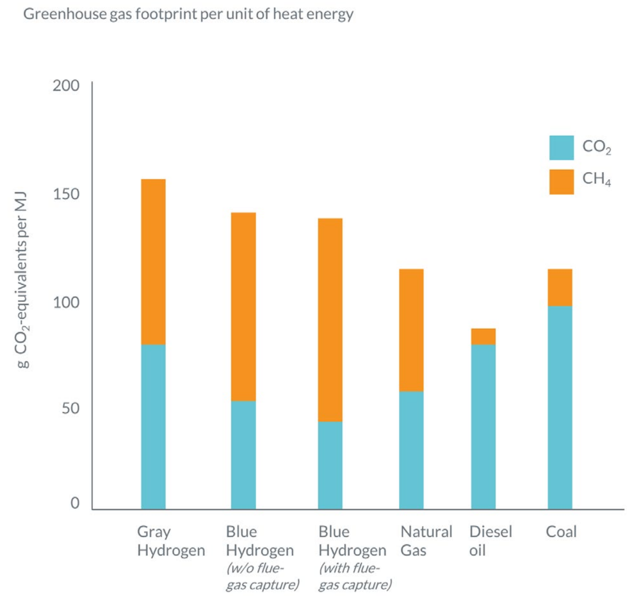
19 The National Fire Protection Association. 2018. "Natural Gas and Propane Fires, Explosions and Leaks: Estimates and Incident Descriptions." Available at https://bit.ly/3vCjxLw.

20 California Energy Commission 2020. *Final Project Report: Air Quality Implications of Using Biogas to Replace Natural Gas in California.* Available at: https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-034.pdf.

21 Seals, B., Krasner, A. 2020. *Health Effects from Gas Stove Pollution.* Rocky Mountain Institute, Physicians for Social Responsibility, Mothers Out Front, and Sierra Club. Available at: https://rmi.org/insight/gas-stoves-pollution-health/.

22 Howarth, R., Jacobson, M. 2021. "How green is blue hydrogen?" *Energy Science & Engineering*: 12. August. Available at https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956.

Figure 2. Comparison of GHG emissions intensity of gray and blue hydrogen with direct consumption of gas, oil, and coal



Note: Assumes a methane leakage rate of 3.5 percent.

Source: "Greenhouse gas footprint per unit of heat energy" © by Howarth, R., Jacobson, M. 2021. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956. Used under Creative Commons Attribution 4.0 International (CC BY 4.0)-Modified to be black and white, remove title, and remove 200 g CO2-equivalents per MJ axis label.

"Green" hydrogen is produced using water as the source of the hydrogen and a carbon-free resource to convert the water to hydrogen. Green hydrogen is not currently cost-competitive with gray hydrogen, although the relative costs may decline as renewable energy costs continue to decrease or policies are enacted that raise the price of fossil fuels.[23]

Hydrogen poses **difficulties for integration** into existing gas infrastructure.

Hydrogen poses difficulties for integration into existing gas infrastructure. Hydrogen can be blended into the gas in the existing pipeline network in small quantities. While some literature has suggested that it may be safe to blend hydrogen into the existing infrastructure up to 20 percent by volume (equivalent to 7 percent by energy content), analysis for the California Public Utilities Commission indicates that only up to 5 percent by volume can be blended in safely.[24] Even if blending hydrogen up to 20 percent by volume (7 percent by energy content) into the existing gas network is safe, doing so would have a limited impact on offsetting fossil fuel use and the corresponding emissions. Higher concentrations of hydrogen would require replacing much of the existing distribution system, since the heat content of hydrogen is lower than methane (requiring larger pipes to accommodate the same energy content) and since some metals (such as those used for pipes) become brittle when exposed to hydrogen.[25]

Hydrogen cannot be interchanged with methane in today's household gas appliances. Beyond relatively low hydrogen blends, consumers would need to purchase new appliances to burn hydrogen safely. As with fossil gas, hydrogen will leak and thereby have reduced carbon benefits. Finally, hydrogen raises safety concerns because it can ignite more easily than natural gas.[26]

23 Howarth, R., Jacobson, M. 2021.

24 Melaina, M., Antonia, O., Penev, M. 2013. *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*. National Renewable Energy Laboratory Technical Report NREL/TP-5600-51995. Available at: https://www.nrel.gov/docs/fy13osti/51995.pdf. Penchev, M., T. Lim, M. Todd, O. Lever, E. Lever, S. Mathaudhu, A. Martinez-Morales, and A.S.K. Raju. 2022. *Hydrogen Blending Impacts Study Final Report*. Agreement Number: 19NS1662. California Public Utilities Commission. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF.

25 U.S. Department of Energy. 2022. "Safe Use of Hydrogen." Available at: https://www.energy.gov/eere/fuelcells/safe-use-hydrogen#:~:text=A%20number%20of%20hydrogen's%20properties,in%20case%20of%20a%20leak.

26 For a technical discussion of the issues discussed here, see Livermore, S., "Exploring the potential for domestic hydrogen appliances," *The Engineer* (2018), available at https://bit.ly/3C2vigD.

3.3.3. Synthetic methane

Synthetic methane can be produced with hydrogen (obtained from electrolysis) and carbon dioxide, (captured either from the ambient air or from exhaust streams before it is released into the air). If renewable energy is used for electrolysis, carbon capture, and other processing, the fuel can have a low-carbon footprint but requires large quantities of energy to produce.[27] Similar to fossil gas, synthetic methane will leak from pipes, and there will be costs associated with fixing leaks, replacing leak-prone pipes, or losses of the fuel. Synthetic methane poses safety risks similar to fossil gas, biomethane, and recovered methane. Leaks of synthetic methane can lead to fires. In addition, synthetic methane combustion causes releases of NOx and other harmful air pollutants, which can lead to serious respiratory health impacts.[28]

3.3.4. Observations about Alternative Gaseous Fuels

The discussion above shows that the most likely candidates for alternative gaseous fuels pose challenges related to cost, emissions, safety, and energy use during production. None of the alternatives that would reduce GHG emissions are available now at scale or at a price similar to natural gas.

The most likely candidates for alternative gaseous fuels pose **challenges related to cost, emissions, safety, and energy use during production.**

Finally, competition for alternative gaseous fuels could be fierce, in Maryland and elsewhere. Other economic sectors—transportation, industrial processes, and electric generation—will compete with buildings for low-carbon alternative fuels. Alternative gaseous fuels will be important for certain of these non-building end-uses because they involve activities that are far more expensive to electrify or for which there are no available electric alternatives. In contrast, buildings are relatively low-cost to electrify and can take advantage of commercially available technologies for space and water heating and for other uses. As a policy matter, it may be important to reserve alternative gaseous fuels for activities that cannot easily be electrified.

27 Melaina, M., Antonia, O., Penev, M. 2013. *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues.* National Renewable Energy Laboratory Technical Report NREL/TP-5600-51995. Available at: https://www.nrel.gov/docs/fy13osti/51995.pdf.

28 The NOx that is formed when natural gas, biogas, or SNG is combusted comes primarily from nitrogen and oxygen in the air interacting in the high-heat conditions of combustion. Exposure to NOx pollution can aggravate existing respiratory problems and potentially lead to development of respiratory disease. (NRDC 2020. A Pipe Dream or Climate Solution? The Opportunities and Limits of Biogas and Synthetic Gas to Replace Fossil Gas." Available at https://www.nrdc.org/sites/default/files/pipe-dream-climate-solution-bio-synthetic-gas-ib.pdf.)

SECTION 4

MODELING

To better understand the potential effects of the *MWG Policy Scenario*, we modeled the progress of Maryland's electrification under E3's *MWG Policy Scenario*, which we call "Sector Specific Electrification" (SSE). Using our Building Decarbonization Calculator (BDC), we modeled total GHG emissions, trends in gas consumption, and residential and commercial building stock by space heating type and space heating equipment sales under SSE. The model analyzed the turnover of residential and commercial space and water heating systems across Maryland and calculated the corresponding emissions impacts. Our BDC assumptions are detailed in Section 4.1.1, below.

Synapse then applied its Gas Rate Model (GRM) to the BDC modeling results to assess the financial implications for Maryland's three largest gas utilities through 2050. The GRM uses the utilities' historical data and the BDC modeling results to project SSE's impacts on rate base, revenues, and expenses for each of the utilities: Baltimore Gas and Electric (BGE), Washington Gas Light (WGL), and Columbia Gas of Maryland (Columbia or CMD). We also evaluated the residential customer rate impact of using alternative gaseous fuels to offset increasing portions of remaining gas system emissions, culminating in zero remaining fossil gas by 2045.

The BDC modeling, combined with the GRM results, ultimately sheds light on the *MWG Policy Scenario's* effects on gas utilities. It also assesses the scenario's implications for residential customer rates and the stranding of gas utility investments.

4.1. Building Decarbonization Calculator

4.1.1. Assumptions

The BDC uses Maryland-specific data on existing buildings from the U.S. Census Bureau's *American Community Survey,* along with the U.S. Energy Information Administration's *Residential Energy Consumption Survey* and *Commercial Buildings Energy Consumption Survey,* to develop estimates for the characteristics of Maryland's building space and water heating system stock. To determine the current heat pump market share of new installations, we analyzed recent annual increases in the number of homes heated primarily with electricity as reported by the *American Community Survey*.[29]

Residential building electrification target: Consistent with the *MWG Policy Scenario*, under our SSE scenario heat pumps are the sole source of heating in over 95 percent of residential buildings by 2050. To achieve this, we assume that all new construction is all-electric by the late 2020s. In existing buildings, this level of electrification is achieved through steady increases in

29 American Community Survey. 2019. *Table B25040: House Heating Fuel for Maryland, 5-year Estimates.* Available at: https://data.census.gov/cedsci/table?q=house%20heating%20fuel&tid=ACSDT5Y2020.B25040.

We assumed that gas heating will be phased out as **heating units are replaced at the end of their useful lives**.

heat pumps' share of the Maryland market. By 2030, over 95 percent of households that are replacing space heating equipment at the end of the equipment's useful life use heat pumps, increasing to 100 percent by 2035.[30]

Heat pump market share: Based on recent historical data from the *American Community Survey*, we assumed that the number of residential households heating with heat pumps increased by about 8,000 households between 2019 and 2020. We calculated that this level of annual increase implied a heat pump market share (i.e., the percent of space heating equipment sales that are heat pumps) of approximately 10 percent of new heating systems replacing retiring residential fossil fuel systems. We modeled residential heat pump adoption curves starting at these market share values in 2020, and then escalating toward the electrification target over time.[31] While there is no fixed date by which all buildings will be all-electric, the modeling is designed to convert the market to 100 percent heat pumps, such that gas heating will be phased out as heating units are replaced at the end of their useful lives.

Multi-family housing units: Throughout our analysis, we categorized all households in Maryland as being in the residential sector, even though large multifamily residential buildings may require different types of heat pump systems than single-family homes. We measure the sizes of heat pump systems by the number of households they serve. For example, one large heat pump system serving 100 apartments is modeled as 100 individual heat pump systems. Where we were able to break out residential results from total, we present the residential sector here. The results for the commercial sector are provided in Appendix B. Industrial sector gas consumption is not included in this report.

4.1.2. Results

For each year between 2020 and 2050, our modeling shows how SSE impacts the new space and water heating system installations, the total stock of operating space and water heating systems, and the resulting on-site GHG emissions. We discuss these results in the paragraphs below:

- Residential GHG emissions
- Residential gas consumption
- Residential building stock by space heating type and space heating equipment sales

Residential GHG emissions

Figure 3 shows total residential space and water heating emissions. Figure 3 does not account for using low- or zero-carbon gases to reduce emissions. Also, this figure does not include off-site GHG emissions, such as those resulting from the generation of electricity[32] or the upstream methane emissions from

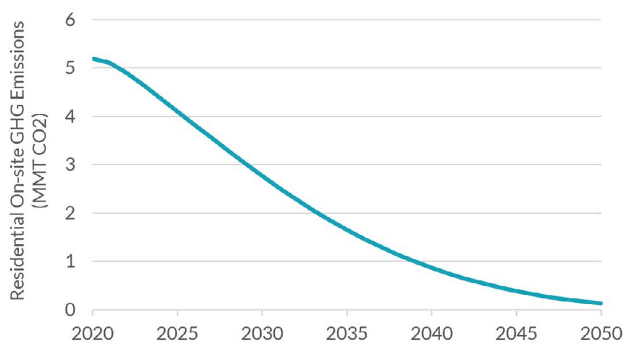
30 In commercial buildings, by 2050, 60 percent of gas-connected buildings switch to heat pumps as the sole source of heating and 40 percent of gas-connected buildings stay on gas for heating. Over 99 percent of all new construction is 100 percent electrified by 2035. Existing buildings with electric resistance heat convert to heat pumps by 2050 and existing buildings with heat pumps continue to use heat pumps.

31 Given that existing commercial buildings would have a harder time switching to heat pumps due to the complexity of their HVAC system configurations, we assumed initial commercial market shares equal to half of the historical residential sales rate. We assumed these market share rates to meet the residential and commercial building electrification targets, described above.

32 While increasing electricity consumption to power heat pumps will lead to some increase in electric generation emissions, that impact is beyond the scope of this report. The emissions increase will be mitigated by Maryland's Renewable Portfolio Standard, which requires 50 percent of electricity to come from renewable resources by 2030, as well as other future policies that may further decarbonize the power sector beyond 2030. Expanded demand-side management and demand response can also reduce electrification's impact on load and emissions.

leaks associated with production, distribution, and transmission of fossil or alternative gaseous fuels.

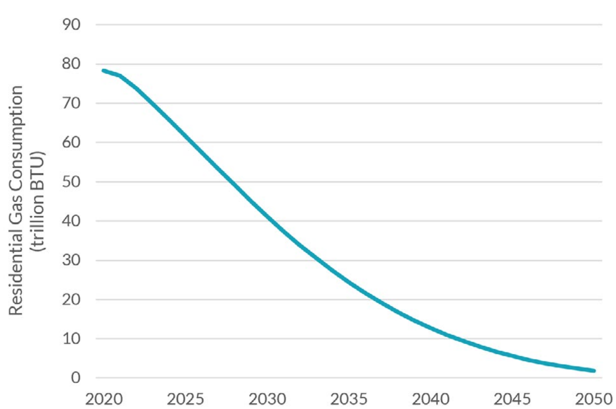
Figure 3. Residential on-site space and water heating GHG emissions, before accounting for use of low- or zero-carbon gas or off-site emissions



Gas consumption

Figure 4 shows SSE's impacts on residential space and water heating gas consumption. The corresponding commercial space and water heating gas consumption chart can be found in Appendix B. To fully decarbonize building energy consumption, remaining gas consumption will need to be displaced with low- and zero-emissions fuels.

Figure 4. Residential consumption of gas for space and water heating



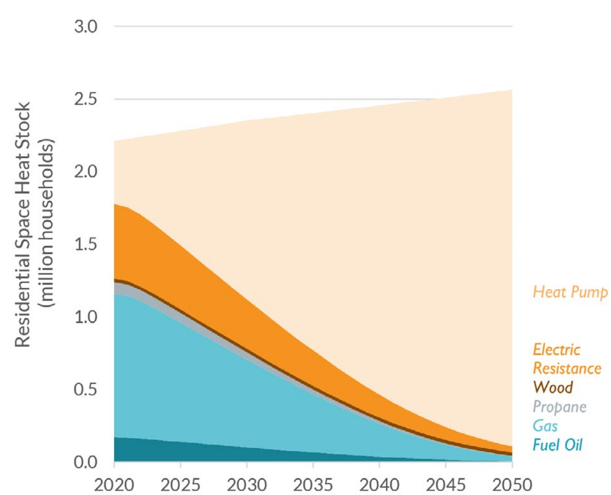
Space heating equipment stock and sales

In this section, we present charts that show the total stock and annual sales of space heating equipment under SSE. We focus on space heating equipment, because it is currently responsible for most on-site emissions from residential buildings.[33] The second largest source of on-site emissions from residential buildings is water heating, which represents a much smaller portion of current total emissions: For residential space and water heating equipment combined, space heating equipment accounts for 74 percent of on-site emissions and water heating equipment accounts for 26 percent of on-site emissions.

Water heating equipment similarly transitions toward heat pump technologies in our analysis but is not separately shown here for simplicity.

Figure 5 shows that SSE results in nearly all buildings, including 96 percent of homes, being fully heated with heat pumps by 2050. Fossil fuel space and water heating is almost entirely eliminated, resulting in the greatest emissions reductions.

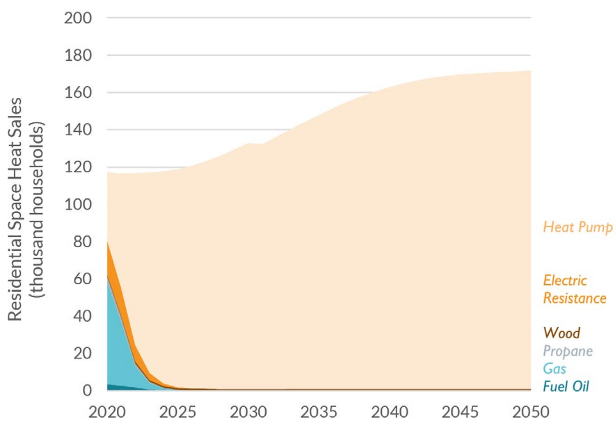
Figure 5. Residential building stock by space heating fuel and technology



33 In 2020, space and water heating equipment were responsible for most fossil gas use from residential buildings. Space and water heating equipment accounted for 91 percent of residential gas consumption, while the remaining 9 percent of gas consumption was attributable to cooking, clothes drying, and other end-uses that were not included in our modeling here. (U.S. Energy Information Administration. 2018. *Residential Energy Consumption Survey*. Available at: https://www.eia.gov/consumption/residential/.)

To achieve this level of electrification, residential space heating equipment sales almost entirely shift to heat pumps by the mid-2020s, as shown in Figure 6.

Figure 6. Residential space heating equipment sales[34]



As Figure 6 shows, gas heating equipment sales drop to near zero under this scenario, allowing for the almost complete removal of the gas system by 2050.[35]

Results for the commercial sector are provided in Appendix B.

4.2. Gas Rate Model

Applying the BDC results, we now model the financial impact on the gas utilities of electrifying the building heating stock.

The GRM allows Synapse to project gas utility rates based on different scenarios for utility investment, sales, and financial models. We use input data from annual utility reports to State regulators, alongside data from the Pipeline and Hazardous Materials Safety Administration[36] (for gas pipeline investment data) and rate cases[37] (such as depreciation and cost-of-service studies) to build a model of the past up to the present. The model tracks utility plant-in-service, depreciation, capital additions and retirements, operations and maintenance, and income taxes. It accounts for capital structure and changes in tax rates.

Looking forward from the present, the model allows us to test scenarios for different levels of investment and customer growth or decline, pipeline replacement programs, early retirements, stranded costs, and changes in depreciation rates. These cases can correspond to electrification, as assumed in the analysis here, or other decarbonization scenarios developed in the BDC. We have developed ways to map changes in customer numbers to changes in miles of pipeline in service and other aspects of capital assets.

The GRM must make assumptions about fuel prices. Here, as described below, we make assumptions for fossil fuel price and for alternative gaseous fuels. For alternative gaseous fuels, we use two fuel cost sensitivities—the Low AGF Price sensitivity and the High AGF Price sensitivity.

The following section details our assumptions for GRM inputs. The assumptions and projections are explained and analyzed in Sections 4.2.1 and 4.2.2, and Section 4.2.3 shows results of the modeling in terms of gas rate base per customer, rates, and bill impacts.

34 The slight decrease in new installations between 2030 and 2031 results from slower expected population growth (and consequently new housing construction) after 2030. (Weldon Cooper Center for Public Service. 2018. Observed and Total Population for the U.S. and the States, 2010-2040. *Demographics Research Group.* Available at: https://demographics.coopercenter.org/national-population-projections.)

35 Apart from replacing gas equipment, heat pumps will replace electric resistance heating stock. Replacing electric resistance heaters with more efficient heat pumps should reduce the electric load from those buildings and partially offset the increased electric load due to replacing the gas heating stock with heat pumps.

36 U.S. Department of Transportation: Pipeline and Hazardous Materials Safety Administration. August 2, 2021. Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data. Available at: https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids.

37 Maryland Public Service Commission. 2021. *Case Search.* Available at: https://www.psc.state.md.us/.

4.2.1. Assumptions and Analysis

Alternative Gaseous Fuel Pricing: In the Low AGF Price sensitivity, the price of alternative gaseous fuel from 2021 to 2050 ranges from $14.37/MMBtu to $22.92/MMBtu, based on a 2020 ICF report for AltaGas and WGL (in 2020 dollars).[38] In the High AGF Price sensitivity, the price of alternative gaseous fuel from 2021 to 2050 is $69.03/MMBtu, based on a report by E3 on building decarbonization in Maryland (in 2020 dollars).[39] The price of fossil gas is kept the same in both the Low and High AGF Price sensitivities. From 2021 to 2050, the price of fossil gas ranges from $2.94/MMBtu to $4.05/MMBtu, based on the U.S. Energy Information Administration's *Annual Energy Outlook 2022* Henry Hub natural gas spot price projections (in 2020 dollars).[40]

Assumptions about the climate impact of renewable and low-carbon gases: Synapse modeled the SSE scenario such that no fossil gas remains in the system past 2045 and that remaining gas use is provided by alternative gaseous fuels. Our modeling assumes that renewable and low-carbon gases are emissions-free and that the buildings sector will be responsible for emissions reductions proportionate to its current emissions. With this assumption, BGE, WGL, and Columbia Gas's conversion to all low-carbon gases would support the State's compliance with the *Climate Solutions Now Act*. Recent studies show, however, that alternative gaseous fuels have higher emissions rates than previously assumed. For example, a 2022 analysis by Imperial College London found that leakage rates from RNG may be twice as high as previously thought.[41] Though beyond the scope of our work here, such leakage rates would reduce the benefits associated with low-carbon fuels and make *Climate Solutions Now Act* compliance more challenging.

Infrastructure replacement: We assume that the Maryland Public Service Commission continues to approve each utility's current investment approach, as allowed under PUA § 4-210 (the *Strategic Infrastructure Development and Enhancement*, or STRIDE, law) as though electrification and customer departures are not occurring. Under STRIDE, gas utilities currently run programs to replace leak-prone pipes (generally cast-iron and bare-steel pipes) with plastic pipes. The STRIDE program replaces both *mains* (larger pipes that serve many customers) and *services* (the building-specific pipes that connect the mains to customer buildings). STRIDE permits utilities accelerated recovery of the costs of gas infrastructure replacements through a surcharge on customer bills. The surcharge is capped at $2.00/month on residential bills but is reset with each base rate case, when STRIDE investments are moved into base rates.

Recent studies show that **alternative gaseous fuels have higher emissions rates** than previously assumed.

38 ICF International. April 2020. *Opportunities for Evolving the Natural Gas Distribution Business to Support the District of Columbia's Climate Goals*. Available at: https://sustainability.wglholdings.com/wp-content/uploads/Technical-Study-Report-Opportunities-for-Evolving-the-Natural-Gas-Distribution-Business-to-Support-DCs-Climate-Goals-April-2020.pdf. AltaGas is the Canadian parent company of WGL.

39 Clark, T., D. Aas, C. Li, J. de Villier, M. Levine, J. Landsman. October 20, 2021. *Maryland Building Decarbonization Study*. Energy + Environmental Economics. Available at: https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG_Buildings%20Ad%20Hoc%20Group/E3%20Maryland%20Building%20Decarbonization%20Study%20-%20Final%20Report.pdf at 13 (showing a conservative alternative gaseous fuel price of $70/MMBtu (in 2021$), which we converted into 2020$ to arrive at the $69.03/MMBtu value).

40 U.S. Energy Information Administration. March 2022. *Annual Energy Outlook 2022: Table 13*. Available at: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=13-AEO2022&region=0-0&cases=ref2022&start=2020&end=2050&f=A&linechart=ref2022-d011222a.31-13-AEO2022&ctype=linechart&sourcekey=0.

41 Imperial College London. 2022. "Biogas and biomethane supply chains leak twice as much methane as first thought." Phys.org. Available at https://phys.org/news/2022-06-biogas-biomethane-chains-leak-methane.html.

The assumption in the SSE scenario that utilities continue under their current investment approach means that the STRIDE program continues as planned and depreciation rates for utility investment continue to be set at today's levels, based on the expected engineering life of assets—as long as 70 years for new plastic pipes, for example. STRIDE cost calculations are imported from analysis by DHInfrastructure for OPC. Although STRIDE investments continue, the GRM scenario assumes that customers are electrifying and departing the system, consistent with the BDC scenario results.

Depreciation: Additionally, Synapse assumed that the utilities do not update their depreciation approach, despite the customer departures. Accordingly, we used recent depreciation studies from each utility to determine their 2020 depreciation rates and used these 2020 values for each specific utility asset from 2021 to 2050 (approximately 100 utility assets per utility).[42]

Capital additions: In the GRM, we calculated capital additions for distribution plant mains, services, meters, meter installations, and house regulators based on net customer additions, pipeline retirement approach, and historical pipe data. All other capital addition line items grow at 2 percent per year. This growth rate corresponds to the 2 percent inflation rate that we used throughout the model.[43]

Operations & Maintenance: We projected operations and maintenance expenses based on the total number of customers, the miles of pipeline, and the number of services for each future year. This projection also used the model-wide inflation rate of 2 percent.

Other costs: We held after-tax return on equity, cost of debt, debt fraction of capital, federal income tax, and state income tax constant at their 2020 levels.

Rate Class Allocations: To determine the rates by class (residential versus commercial and industrial customers), we separated out each utility's revenue requirement based on the proportion of residential customers to commercial and industrial customers and the proportion of residential gas sales to commercial and industrial gas sales. The BDC modeling provided the split between residential and commercial and industrial customers both for customer counts and gas sales. The calculation to determine rates by class also accounts for different drivers of utility revenue requirements. Specifically, some costs (like billing and customer service) scale with the number of customers, while other costs (like maintenance) are more closely related to the miles of mains or number of services. Our methodology is informed by common practice in cost allocation studies.

4.2.2. Customer and Sales Projections

Customers: Using customer projections from the heating stock results of the BDC modeling, we determined that more customers leave the natural gas system than are added to the gas system in each year of the modeling, starting in 2021. Total annual customer additions decrease to zero by 2038 in BGE, by 2037 in WGL, and by 2033 in Columbia. By 2050, the total customers left on each of the three utility systems is just 5 to 7 percent of their total 2020 number of customers.

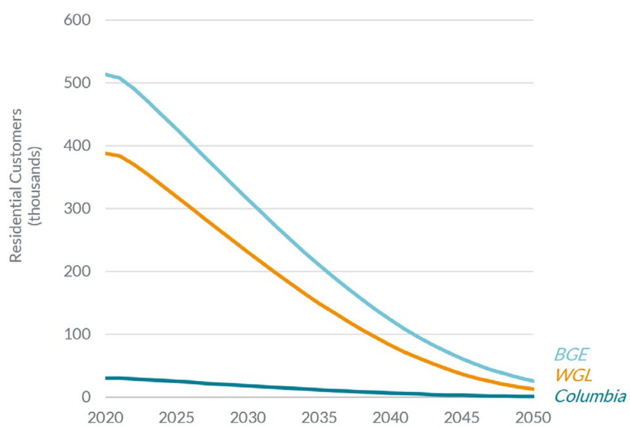
42 DHInfrastructure used total distribution, transmission, and composite non-STRIDE depreciation rates and held the 2022 values constant throughout its analysis. DHInfrastructure did not break out distribution, transmission, and depreciation rate projections by specific utility asset, as Synapse did. The difference between the Synapse and DHInfrastructure depreciation methodologies reflects the difference in granularity needed for each model and the overall projection methodology for each analysis. Relative to DHInfrastructure's analysis, Synapse tracked a greater number of individual data points to allow consideration of alternative futures.

43 In comparison, DHInfrastructure assumed that total non-STRIDE capital expenditures stay constant at their 2022 values and do not increase with inflation. Synapse broke out the non-STRIDE capital expenditure projections by utility asset or utility asset grouping. Synapse further used a separate, more detailed methodology for certain capital additions, preventing us from using just one set rate of change for all capital additions. Since DHInfrastructure was tracking fewer data points, holding the non-STRIDE capital expenditures constant was sufficient to effectively project the results of a status quo approach.

By 2050, the total customers left on each of the three utility systems is just 5 to 7 percent of their total 2020 number of customers.

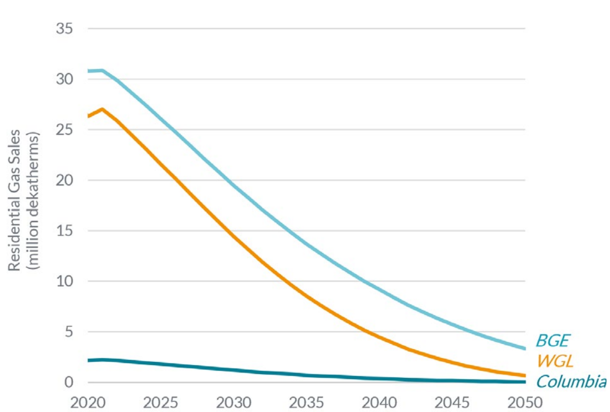
Figure 7 shows detailed residential customer projections by utility.

Figure 7. Residential customers by utility



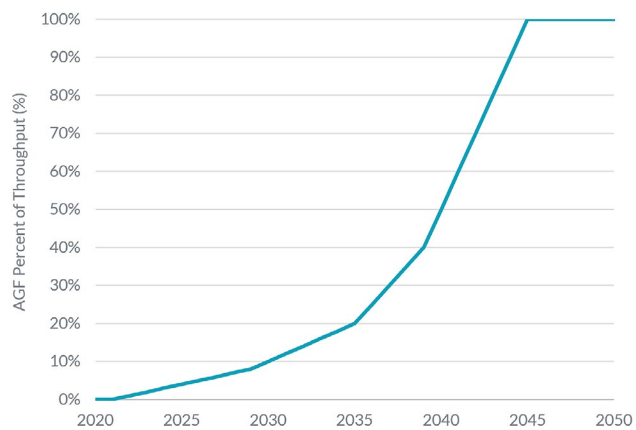
Sales. Using BDC heating stock results and historical utility sales, we determined total gas sales per utility. Our projection shows that total volumetric gas sales decrease from 2020 to 2050, by 89 percent for BGE, 90 percent for WGL, and 84 percent for Columbia. Figure 8 shows residential volumetric gas sales by utility.

Figure 8. Residential gas sales by utility



To meet Maryland's climate goals, all remaining gas throughput in the pipeline system is alternative gaseous fuels by 2045. This is shown in Figure 9.

Figure 9. SSE alternative gaseous fuels percent of throughput



4.2.3. Utility-Specific Modeling Results

Rate base per customer

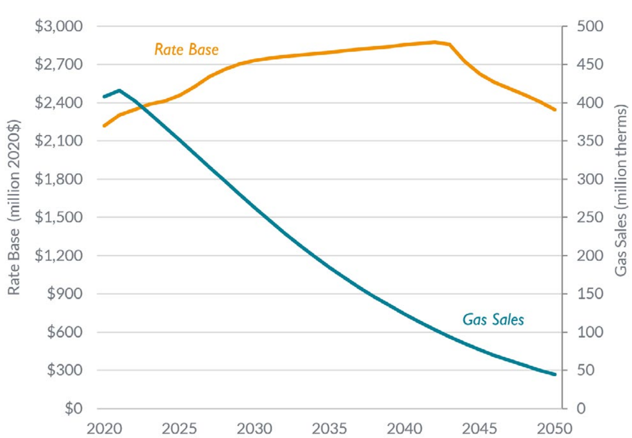
Rate base is the total value of the original cost of assets used and maintained by a utility less accumulated depreciation. Rate base is an identifiable, yet changing, number that has been approved in a regulatory proceeding—generally a rate case in which regulators approve a utility's capital expenditures. The amount of rate base is the cumulation of a utility's capital spending, paid for by customers, and is multiplied by the utility's rate of return (the cost of its debt and equity) to calculate the utility return on its investments. Customers pay down rate base when they pay the utility's depreciation expense that is reflected in the rates on their bills.

To keep rate base (and therefore rates) constant with gas sales continuing at the same level, a utility's approved spending on new capital assets must not exceed the pace at which its existing assets are retired, as customers pay for them through depreciation expense. Rate base—and rates—must increase when regulators approve utilities' capital expenditures (e.g., to replace old infrastructure and for system expansion) faster than existing assets are retired. And if sales are declining, rates must be increased even further to cover the fixed original costs of a utility's previous and ongoing approved capital expenditures. In other words, if utilities invest in pipeline infrastructure faster than existing assets are depreciated and despite decreasing numbers of customers and sales, they will seek substantial rate increases to recover the fixed costs of their rate bases.

Figures 10 through 12 illustrate declines in customers and sales. The figures show that with electrification, the utility's rate base becomes bigger and bigger relative to the utility's fuel throughput (or sales). This drives substantial increases in the utility's rates (the charges per unit measured in a therm of gas throughput) so that the utility can recover its rate-base-related costs across its reduced sales. Rate increases, in turn, will further drive customers off the gas system. **As high levels of customers abandon the gas system over a short period of time, the utility will be forced to strand assets.**

As shown in Figure 10, BGE's STRIDE program increases the utility's rate base and keeps it at roughly that level through the early 2040s. After the completion of its current STRIDE program, rate base falls slightly, assuming customers continue to pay the utility's depreciation expense.

Figure 10. BGE rate base, in real $2020 (left axis) and gas sales (right axis), in the SSE scenario



WGL has a smaller remaining STRIDE program, projected to end in the mid-2030s. Rate base starts to decline gradually around 2028 when annual STRIDE costs decrease about 55 percent compared to the previous year; it decreases faster in 2036 when its current STRIDE program ends, as shown in Figure 11.

Figure 11. WGL rate base, in real $2020 (left axis) and gas sales (right axis), in the SSE scenario

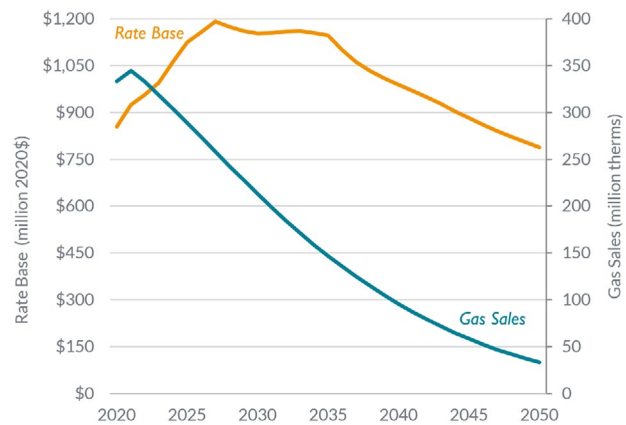
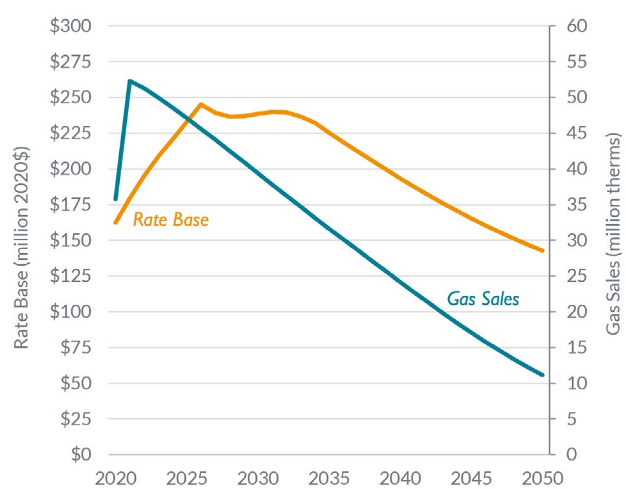


Figure 12 shows that Columbia Gas's rate base begins to flatten out and eventually decline after 2026, when its current STRIDE program ends.

Figure 12. Columbia Gas rate base, in real $2020 (left axis) and gas sales (right axis), in the SSE scenario



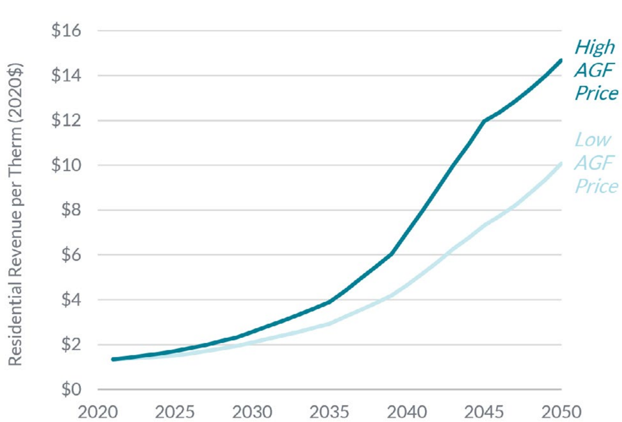
Rates

We approximate utility rates under SSE by taking the utility's annual revenue requirement (including fuel costs, return on rate base, and depreciation and operating expenses) and dividing by the projected amount of gas sold to customers.

We modeled two fuel cost sensitivities to determine the range of potential customer rates. The Low AGF Price ranges from $14.37 per MMBtu to $22.92 per MMBtu and the High AGF Price is set at $69.03 per MMBtu (all in $2020). From 2020 to 2050, utility rate base increases in the near term and stays relatively high (as seen above in Figures 10 through 12). Due to electrification, however, the total therms of gas throughput decreases. At the same time, fuel costs rise as fossil gas is replaced with alternative gaseous fuels. As a result, the revenue the utility must receive per therm sold—i.e., customer rates—must rise for the utility to recover its costs. The effect on customer rates—the required revenue per therm—is illustrated in Figures 13 through 15. The results show that **sector-specific electrification will lead to substantial increases in gas rates**.

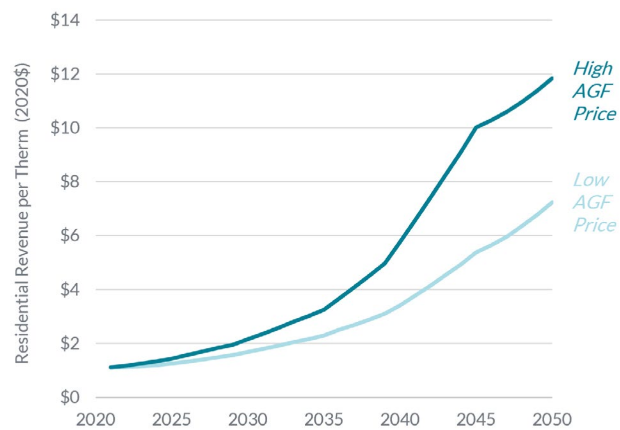
For BGE, our analysis shows that rates increase from $1.34 per therm in 2021 to $2.94 per therm in 2035 and $10.06 per therm by 2050 under the Low AGF Price scenario. In the High AGF Price scenario, the rates increase from $1.34 per therm in 2021 to $3.90 per therm in 2035 and $14.68 per therm in 2050.

Figure 13. BGE residential gas rates



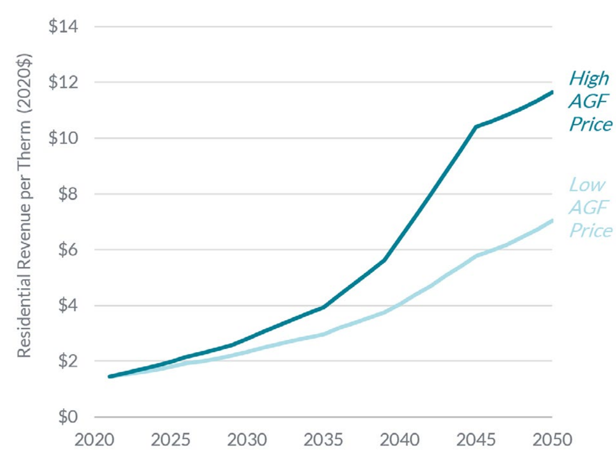
For WGL, our analysis shows that rates increase from $1.11 per therm in 2021 to $2.30 per therm in 2035 and $7.23 per therm by 2050 under the Low AGF Price scenario. Under the High AGF Price scenario, rates increase from $1.11 per therm in 2021 to $3.26 per therm in 2035 and $11.85 per therm in 2050.

Figure 14. WGL residential gas rates



For CMD, our analysis shows that rates increase from $1.44 per therm in 2021 to $2.97 in 2035 and $7.03 per therm by 2050 under the Low AGF Price scenario. In the High AGF Price scenario, rates increase from $1.44 per therm in 2021 to $3.93 per therm in 2035 and $11.65 per therm in 2050.

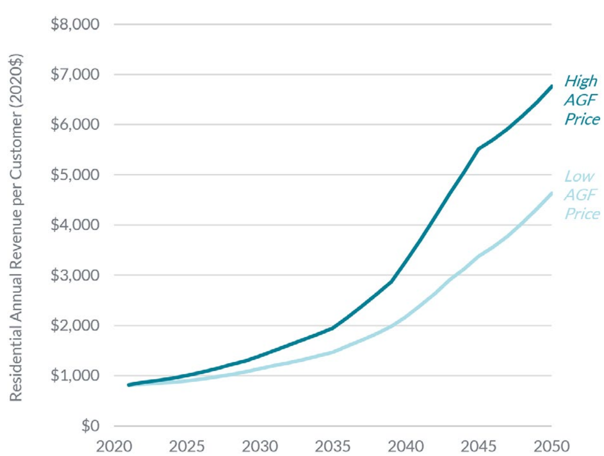
Figure 15. Columbia residential gas rates



Bill impacts of rate increases

Figures 16 through 18 show the annual energy-related operating cost of an average home for space and water heating end-uses under the SSE scenario for BGE.[44] Figure 16 shows the calculation for BGE. In the SSE scenario, building operating costs for residential customers staying on the gas system increase considerably by 2050, from $820 per year in 2021 to $1,464 per year in 2035 and $4,634 per year in 2050 under the Low AGF Price scenario. In the High AGF Price scenario, building operating costs for residential customers increase from $820 per year in 2021 to $1,944 per year in 2035 and $6,759 per year in 2050.

Figure 16. BGE residential building total gas costs (Low and High AGF Price)



As seen in Figure 17, WGL residential building operating costs increase from $780 per year in 2021 to $1,315 per year in 2035 and $3,827 per year in 2050 under the Low AGF Price scenario. In the High AGF Price scenario, building operating costs for residential customers increase from $780 per year in 2021 to $1,868 per year in 2035 and $6,270 per year in 2050.

Figure 17. WGL residential building total gas costs (Low and High AGF Price)

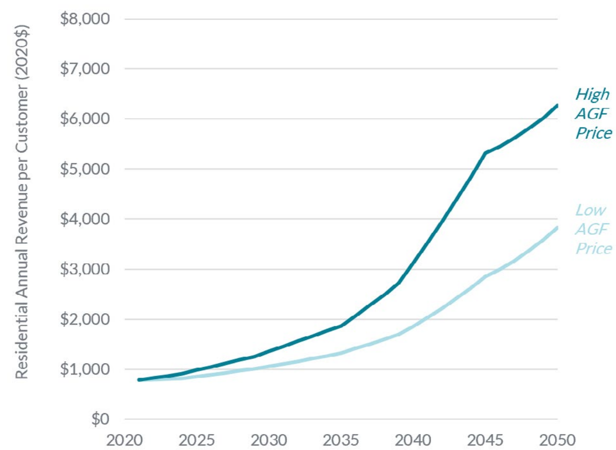
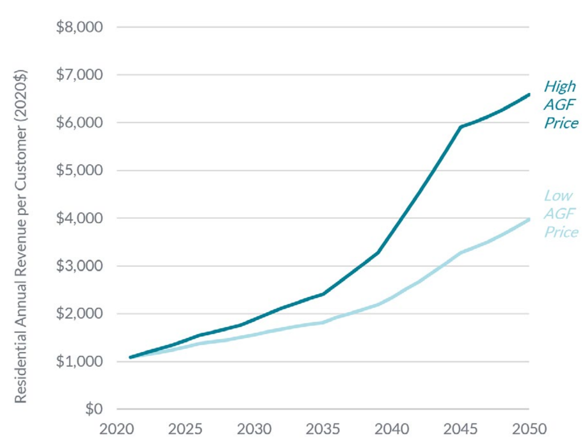


Figure 18 shows residential building operating costs for Columbia Gas. Costs rise from $1,086 per year in 2021 to $1,818 per year in 2035 and $3,979 per year in 2050 under the Low AGF Price scenario. In the High AGF Price scenario, building operating costs for residential customers increase from $1,086 per year in 2021 to $2,408 per year in 2035 and $6,591 per year in 2050.

Figure 18. Columbia residential building total gas costs (Low and High AGF Price)



44 These figures include the cost of fuel in addition to delivery costs.

The following tables provide a summary of the results of our modelling as shown in Figures 13 through 18 and described above.

2035 and 2050 range of residential rate impact depending on cost of alternative gaseous fuels

Rates ($2020/therm)

	2021	2035 AGF range	2050 AGF range
BGE	1.34	2.94 to 3.90	10.06 to 14.68
WGL	1.11	2.3 to 3.26	7.23 to 11.85
CMD	1.44	2.97 to 3.93	7.03 to 11.65

2035 and 2050 range of residential bill impact depending on cost of alternative gaseous fuels

Annual Bill (2020$)

	2021	2035 AGF range	2050 AGF range
BGE	$820	$1,464 to $1,944	$4,634 to $6,759
WGL	$780	$1,315 to $1,868	$3,827 to $6,270
CMD	$1,086	$1,818 to $2,408	$3,979 to $6,591

Importantly, Figures 13 through 18 provide the output for SSE modeling based on the *MWG Policy Scenario* that has heat pumps as the sole source of heating in over 95 percent of residential buildings by 2050. Our modeling achieves the 95 percent goal by gradually increasing heat pumps' share of the Maryland market from 2021 to 2050. As gas rates rise, however, customers will become increasingly likely to electrify their homes to avoid high gas rates. Thus, customer migration away from gas could be faster than the projections we used in modeling SSE. This increase in customer departures would further increase gas rates and perpetuate the cycle of customer departures and increasing rates for customers who remain on the gas system.

Customer migration away from gas could be faster than the projections used.

4.3. Implications of Analysis

The rapid decline in gas sales, together with a flat or increasing rate base (as shown in Figures 10 through 12), cause the dramatic increases in customer rates and bills found in our modeling of SSE in Section 4.2.3. While the overall impact on customer energy bills—across both electric and gas utilities—is beyond the scope of our analysis, our modeling confirms E3's conclusion that *gas* rates for residential customers remaining on the gas system will increase significantly as the State acts to meet its climate goals if the utilities do not alter their practices as a result of customer departures.[45]

Our analysis further holds important implications for the fixed costs that remain in the utilities' rate bases for decades into the future due to ongoing utility capital spending. Electrification will happen gradually as the building stock turns over. Gas rate increases due to electrification will also be gradual. But at some point, it could prove difficult—if not impossible—for gas rates to increase to the levels necessary for gas utilities to recover their fixed rate base costs and remain economically viable. Customers will electrify to avoid the high gas rates, and customers without alternatives nevertheless may not be able to afford continued gas service. If and when this plays out, the utilities will have substantial unrecovered and uneconomic assets remaining in rate base and on their books.

We note that such outcomes can be mitigated. If utilities adapt to electrification, they will be able to update their spending practices to lessen their revenue requirements to slow customer rate increases. In doing so, the utilities can mitigate their stranded assets, and customers who are unable to electrify in the near term will not see costs rise as rapidly.

45 MCCC, *Building Energy Transition Plan: A Roadmap for Decarbonizing the Residential and Commercial Building Sectors in Maryland*, at p. 14.

APPENDIX A

GLOSSARY AND ABBREVIATIONS

Term	Definition	Source
Alternative Gaseous Fuels	Non-conventional fuels such as hydrogen and various forms of natural gas including renewable, synthetic, and biomethane.	Environmental Protection Agency. "Alternative Fuels." Oct. 4, 2021. *Renewable Fuel Standard Program*. Available at: https://www.epa.gov/renewable-fuel-standard-program/alternative-fuels.
Biomethane	Pipeline-quality natural gas substitute produced by purifying biogas, a methane-rich gas produced from organic materials (also known as Renewable Natural Gas).	Natural Gas Vehicles for America. "The Potential of Renewable Natural Gas," 7 Jan. 2009, https://afdc.energy.gov/files/pdfs/biomethane_4.pdf. Accessed 6 July 2022.
Depreciation	The loss in service value not restored by current maintenance and incurred in connection with the consumption or prospective retirement of property in the course of service from causes against which the carrier is not protected by insurance, and the effect of which can be forecast with a reasonable approach to accuracy.	"18 CFR Ch. I, Pt. 352." *Code of Federal Regulations*. Available from: https://www.ferc.gov/sites/default/files/2020-06/18cfr352.pdf. Accessed 6 July 2022.
Fugitive Emissions	Unintended leaks of gas from the processing, transmission, and/or transportation of fossil fuels.	Glossary - U.S. Energy Information Administration (EIA), https://www.eia.gov/tools/glossary/.
Hydrogen (by type)	**Green hydrogen** is made by using clean electricity from surplus renewable energy sources, such as solar or wind power, to electrolyze water. **Blue hydrogen** is created from natural gas using steam methane reformation; the process captures and stores the emitted carbon dioxide underground. **Gray hydrogen** is created from natural gas using steam methane reformation but without capturing the greenhouse gases made in the process.	National Grid. "The Hydrogen Colour Spectrum." Available at: https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum.
Rate Base	The net investment of a utility in property that is used to serve the public; this includes the original cost net of depreciation, adjusted by working capital, deferred taxes, and various regulatory assets—the term is often misused to describe the utility revenue requirement.	Lazar, J. (2016). Electricity Regulation in the US: A Guide. Second Edition. Montpelier, VT: The Regulatory Assistance Project. Retrieved from https://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2/.

Term	Definition	Source
Recovered Methane	Methane gas that is captured from landfills, wastewater facilities, and farmland through the use of anaerobic digesters.	Environmental Protection Agency. "Learning About Biogas Recovery." *EPA*. Available at: https://www.epa.gov/agstar/learning-about-biogas-recovery.
Return on Equity	The rate of earnings realized by a utility on its shareholders' assets, calculated by dividing the earnings available for dividends by the equity portion of the rate base.	New York State Public Service Commission. "Glossary of Terms Used by Utilities and Their Regulators." Available at: https://www.dps.ny.gov/glossary.html.
Revenue Requirement	The annual revenues that the utility is entitled to collect (as modified by adjustment clauses). It is the sum of operation and maintenance expenses, depreciation, taxes, and a return on rate base. In most contexts, revenue requirement and cost of service are synonymous.	Lazar, J. (2016). Electricity Regulation in the US: A Guide. Second Edition. Montpelier, VT: The Regulatory Assistance Project. Retrieved from https://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2/.
Stranded Assets	Assets that have suffered from unanticipated or premature write-downs, devaluation or conversion to liabilities.	Lloyd's. 2017."Stranded Assets." Available at: https://www.lloyds.com/strandedassets.
Synthetic Natural Gas	A manufactured product, chemically similar in most respects to natural gas, resulting from the conversion or reforming of hydrocarbons that may easily be substituted for or interchanged with pipeline-quality natural gas.	U.S. Energy Information Administration. *Glossary - U.S. Energy Information Administration (EIA)*, https://www.eia.gov/tools/glossary/.

Abbreviation	Term
AGF	alternative gaseous fuels
BDC	Building Decarbonization Calculator
BGE	Baltimore Gas and Electric
C&I	commercial and industrial
GHG	greenhouse gas
GRM	Gas rate model
MWG	Mitigation Work Group
OPC	Office of People's Counsel
STRIDE	Strategic Infrastructure Development and Enhancement program
SSE	Sector Specific Electrification
WGL	Washington Gas Light

APPENDIX B

DETAILED COMMERCIAL RESULTS

Figure B-1. Commercial on-site space and water heating GHG emissions, before accounting for use of low- or zero-carbon gas or off-site emissions

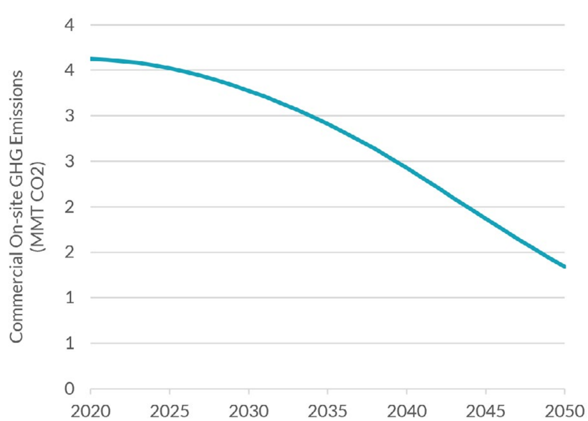


Figure B-3. Commercial building stock by space heating fuel and technology

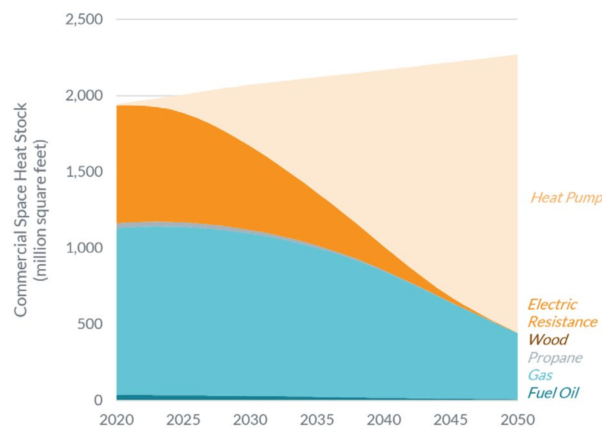


Figure B-2. Commercial gas consumption

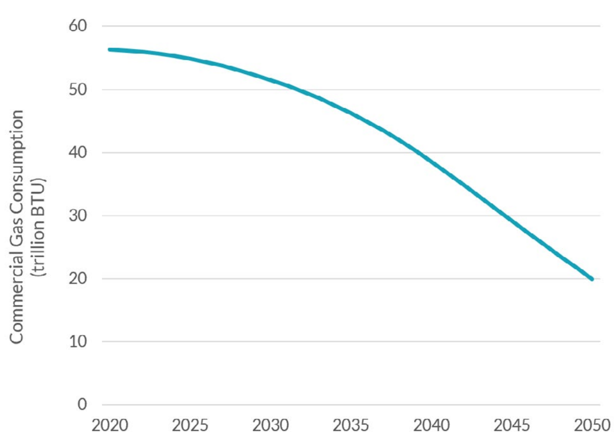
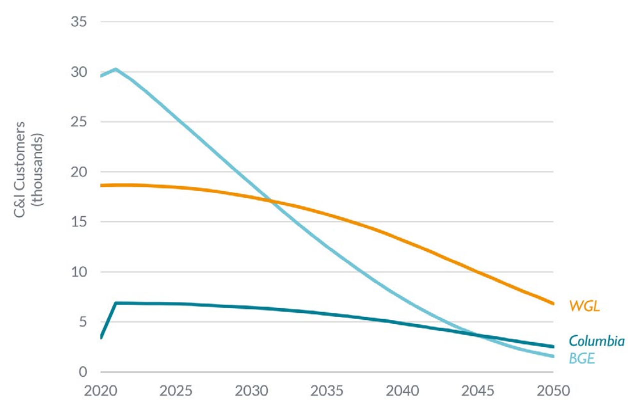


Figure B-4. Commercial and industrial customers by utility



B-5. Commercial and industrial gas sales by utility

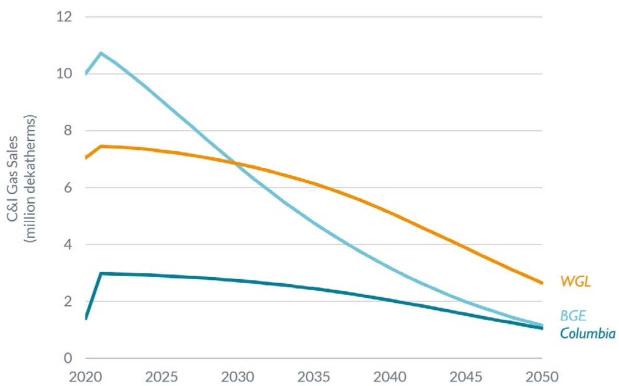


Figure B-6. BGE commercial and industrial building total gas costs (Low and High AGF Price)

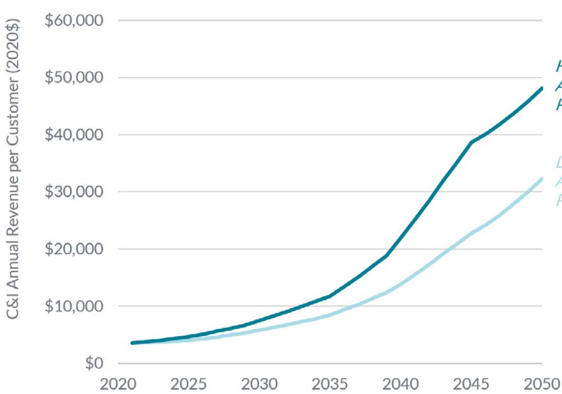


Figure B-7. WGL commercial and industrial building total gas costs (Low and High AGF Price)

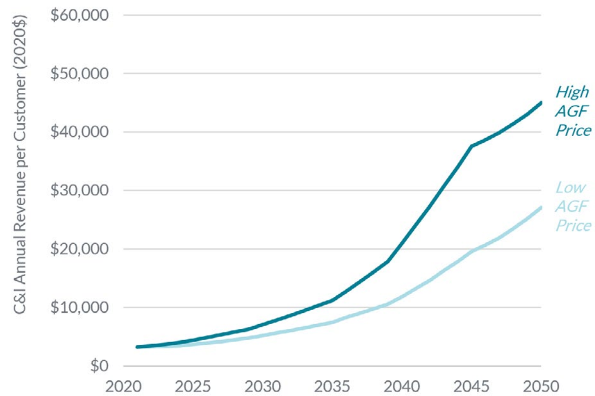
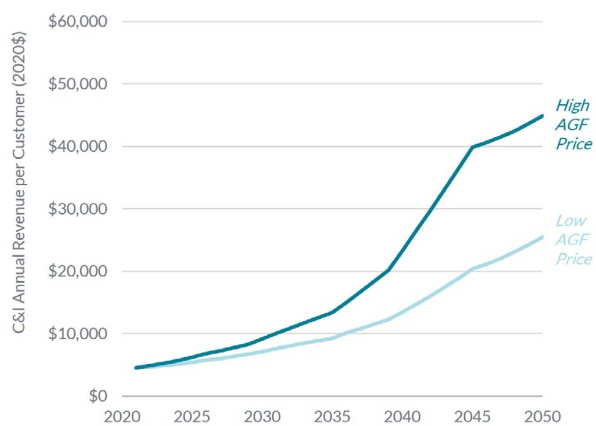


Figure B-8. Columbia Gas commercial and industrial building total gas costs (Low and High AGF Price)



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