FINAL REPORT

DECARBONIZATION STUDY

Charlottesville Natural Gas Municipal Utility

PREPARED FOR

City of Charlottesville Department of Utilities

19 DECEMBER 2024

BLACK & VEATCH

About the Contributors

City of Charlottesville Department of Utilities

The Charlottesville Department of Utilities provides the Charlottesville community with drinking water that exceeds safety standards, efficient wastewater services, stormwater system management, and safe and reliable natural gas, which are all delivered at a reasonable cost in an environmentally responsible manner.

Charlottesville Gas is a natural gas utility owned and operated by the City of Charlottesville. Charlottesville Gas has provided residents of Charlottesville and urban areas of Albemarle County with safe, efficient, reliable, and economical service for over 150 years. It currently has approximately 21,500 customers in the area.

The Department of Utilities assembled a project team for this study, drawing upon expertise from the City of Charlottesville's Office of Sustainability and the Department of Finance. Working collaboratively, the team addressed all aspects of this study, from selecting the consulting company, Black & Veatch, to reviewing the final report.

Black & Veatch

Black & Veatch is a 100% employee-owned global engineering, procurement, consulting, and construction company with a more than 100-year track record of innovation in sustainable infrastructure. Since 1915, Black & Veatch has helped clients improve the lives of people around the world by addressing the resilience and reliability of our most important infrastructure assets. Black & Veatch's global professionals include experienced industry executives, senior analysts, and technology experts from across the electric, water, oil, natural gas, and technology industries. This experience, combined with seamless access to the company's professional engineering, procurement, construction and operations capabilities, executives, and internationally respected subject matter experts (SMEs), makes Black & Veatch particularly qualified to assist clients with their most complex challenges. Its advisory solutions span financial, process, and technology solutions, and many of Black & Veatch's experienced professionals possess cross functional skills that include asset management, cost of service/rate design, business process, analysis, and implementation services.

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Executive Summary

ES.1 Report Background and Objectives

The City of Charlottesville (the City) joined the Global Covenant of Mayors for Climate & Energy, committing the City to adopting greenhouse gas (GHG) emissions reduction targets. Following two comment periods and presentations, on July 1, 2019, the Charlottesville City Council set two goals: a 45% GHG emissions reduction by 2030 and carbon neutrality by 2050, compared to a 2011 baseline. Further, the City committed to the development of a community-wide Climate Action Plan (CAP) outlining its GHG emissions reduction targets and a plan to achieve the adopted targets.

In 2023, the City adopted its CAP providing a strategic framework for how the City can reach its 2050 carbon neutrality goal.[1] As part of this CAP, strategies and actions that the City and community can take to reduce GHG emissions were outlined. More specifically, and as relevant to the purposes of this report, the CAP includes a key action to *complete analysis* of decarbonization options for the municipal gas utility - Charlottesville Gas Utility (Charlottesville Gas) through the *Charlottesville Natural Gas Decarbonization Study*.

The Charlottesville Department of Utilities initiated and provided funding for this study as part of an ongoing initiative to address the challenges of decarbonizing energy-related emissions in the City of Charlottesville.[2] The Charlottesville Department of Utilities engaged with Black & Veatch to explore the opportunities to decarbonize the existing gas system and assess the associated cost, impact on customer gas rates, and emissions impacts of such decarbonization initiatives. Further, this study examines Charlottesville Gas's existing energy efficiency programs, benchmarks against similar utilities, and proposes enhancements to existing energy efficiency programs. This study also reviews reported methane emissions from Charlottesville Gas operations and identifies operational improvements for consideration to further reduce its emissions footprint.

This study and its results are intended to support Charlottesville Gas's emissions reduction efforts, providing a detailed narrative, assessment, and evaluation of possible decarbonization opportunities for Charlottesville Gas, specifically. More directly, this study explores how the utility can promote more efficient gas usage, procure lower carbon fuel supplies, and enhance its system to reduce methane emissions. Additional studies outlining decarbonization initiatives pertaining to municipal buildings, electrification, transportation, and renewable energy generation are outside of the scope of services provided by Charlottesville Gas but should be considered in additional studies by the City to contribute to its 2030 and 2050 emissions reduction targets.

The main narrative of this study includes the methodology, assumptions, and decarbonization analysis for Charlottesville Gas to meet its proportional emissions reduction target of reducing natural gas-related emissions 45% by 2030 (from a 2011 baseline) and to achieve carbon neutrality by 2050. Five appendices are provided adjacent to this main study report, which provide additional details of the stakeholder

[1] Additional details regarding the City of Charlottesville's Climate Action Plan can be found at the following site: https://www.charlottesville.gov/1085/Climate-Action-Planning.

[2] Charlottesville Gas is used as short-hand for the gas utility as part of the Charlottesville Department of Utilities.

engagement process and legal studies also completed complementary to this report.[3] The appendices provided include the following:

- **Appendix A. Review of Federal, State, and Local Laws and Codes:** Charlottesville Gas engaged with legal counsel to review applicable federal, state, local laws, and codes that provide specific conditions to regulate aspects of natural gas utilities providing services to its customers. This included an assessment of the legality of decommissioning the municipal natural gas utility operations and banning new customer connections. Though this is not the intent of this decarbonization study, these topics were reviewed to provide an assessment of the legal and regulatory framework surrounding this topic.
- **Appendix B. BeHeardCVA Gas Mitigation Report:** The University of Virginia's (UVA) Center for Survey Research (CSR) conducted a survey in 2022 sponsored by Charlottesville Gas to understand attitudes toward natural gas and sustainability among residents of Charlottesville City and Albemarle County. This appendix provides a summary of those results.
- **Appendix C. Commercial Gas Customer Listening Session Summary Notes:** Launch! Consulting facilitated a discussion among participants, covering a wide variety of topics. Eight participants attended, which included commercial business owners, manufacturers, residential community managers, property management representatives, and transportation service providers. This appendix provides a summary of notes from that session.
- **Appendix D. Decarbonization Study Community Session Notes and Feedback:** Between July and August 2024, the City of Charlottesville Department of Utilities hosted three community listening session opportunities to discuss the Charlottesville Gas Decarbonization Study. This appendix provides a summary of their notes and feedback.
- **Appendix E. Estimated End-User Electrification Costs:** Though electrification initiatives and adoption were not modeled or proposed as a gas utility-driven action, high-level residential end-user fuel conversion costs were developed and estimated to demonstrate the upfront capital costs required by end-users to convert from natural gas to electrification. This appendix provides the summary results of this research.

ES.2 About Charlottesville Gas

The Charlottesville Municipal Gas Utility has a rich history dating back to the late 19th century. The utility was established in 1876 and has been providing natural gas to the residents and businesses of Charlottesville and parts of Albemarle County ever since. Currently, Charlottesville Gas provides natural gas services to over 21,000 customers including nearly 20 industrial customers, over 2,300 commercial customers, and approximately 19,000 residential customers in both the city and in the county.[4] Similar to the City of Charlottesville, Albemarle County has adopted a GHG emissions reduction target of 45% by 2030 and carbon neutrality by 2050.

Charlottesville Gas is one of three municipally owned natural gas systems in Virginia; the City of Danville Gas and the City of Richmond Gas are the other two. The gas system currently consists of approximately 343 miles of main lines and over 303 miles of service lines. A map of Charlottesville Gas's service

[3] Black & Veatch did not complete the legal assessment or stakeholder engagement workshops referenced throughout this assessment. A summary of the findings of these two workstreams are provided as complementary appendices to this report to provide a consolidated view of this full initiative.
[4] 11,700 customers are located in the City of Charlottesville and 9,350 are located in Albemarle County. This data is current as of March 2024.

territory is shown in Figure ES-1. The existing footprint of Charlottesville Gas's service territory is defined and not expected to expand.

Figure ES-1 Charlottesville Gas Service Territory

Charlottesville Gas's pipeline system is a relatively new system with the greater majority installed in the 1990s following pipeline replacement. The existing system is made up almost entirely of cathodically protected steel and high-density polyethylene (HDPE) plastic pipe, with only one mile of cast-iron remaining.[5,6] In 2023, the City was awarded a $7.1 million grant from the US Department of Transportation, and its Pipeline and Hazardous Materials Safety Administration (PHMSA), through the Natural Gas Distribution Infrastructure Safety and Modernization (NGDISM) grant program. Funds from this grant will facilitate completion of Charlottesville Gas's infrastructure upgrade project by completing the replacement of the last remaining section of legacy cast iron pipes with HDPE pipes in one of the City's busiest and most densely populated corridors and enhance the resiliency of the gas system.

[5] Cathodic protection is a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell. In the case of cathodically protected steel, it is used to slow down or prevent corrosion. This is commonly used in the construction of pipelines, offshore oil rigs, and other structures that are exposed to harsh environments where corrosion is a major concern.

[6] HDPE plastic pipe is a type of flexible plastic pipe that is lightweight, durable, and corrosion-resistant, which makes it a popular choice for pipeline infrastructure projects that require long-lasting materials.

ES.2.1 Policy Context and Energy Regulation

Natural gas customers in Virginia are served by multiple investor-owned distribution utilities and municipally owned gas utilities. With minimal in-state natural gas production, utilities rely upon procured natural gas supplies from key production basins and subscribe to natural gas pipeline transportation capacities to serve Virginia customers.

In 2020, the Virginia Clean Economy Act (VCEA) was signed into law requiring the state of Virginia to achieve 100% clean electricity by 2050. Dominion Energy (Dominion), the state's largest electric utility, must meet this target by 2045 and Appalachian Power Company (ApCo) by 2050. Further, the VCEA requires Dominion and ApCo to retire their carbon-emitting electricity generating units and replace them with generating capacity located in Virginia that uses renewable energy sources like wind and solar power. VCEA also mandates that by 2030, 30% of Virginia's electric system will be powered by renewable energy resources and by 2035, Virginia will deploy 3.1 gigawatts (GWs) of energy storage systems to support a clean and reliable grid.

The VCEA does not have mandatory carbon reduction targets for investor-owned natural gas utilities under the jurisdiction of Virginia's State Corporation Commission. As one of the three municipally owned utilities in the state of Virginia, Charlottesville Gas operates under a different regulatory purview. Charlottesville Gas is among the first municipal natural gas utilities to commission a comprehensive study to explore and evaluate decarbonization pathways. Unlike investor-owned utilities, Charlottesville Gas rates are developed on a break-even basis to ensure that the utility has sufficient funds to sustain operations. Charlottesville Gas rates are approved by the Charlottesville City Council to "furnish reasonably adequate service and facilities at reasonable and just rates" consistent with Code of Virginia 56-234.

In 2022, Virginia passed a bipartisan law (§56-265.4:7), considered a customer protection bill. It defined a procedure that if a municipality was interested in discontinuing natural gas service, then it would be required to give customers a 3-year notice period and attempt to sell or auction the utility in good faith or potentially face legal challenge. Charlottesville Gas operates within the Columbia Gas service area, so it is likely that Columbia Gas is the only viable buyer for the gas utility, removing leverage from the City in negotiating a sale. If the City chose to sell the gas utility, it would have to meet the conditions of the City Charter and State Law. Further exploration of the discontinuation of service is excluded from the scope of this assessment.[7]

Electricity in Charlottesville Gas's service area is provided by Dominion, a utility participant in the PJM, a regional transmission organization that coordinates the wholesale electricity supply and demand in 13 states and the District of Columbia. Incremental increases in demand for electricity resulting from electrification of gas demand served by Charlottesville Gas will require Dominion to procure firm generation capacity in the PJM market, which could have significant implications for electric customer bills under the current constrained PJM market conditions.[8]

ES.3 Decarbonization Study Overview

Decarbonization and emissions reduction initiatives are central to the global effort to address climate change. In 2021, the United States rejoined the Paris Agreement, a legally binding international treaty on climate change. Domestically, the White House further committed to combat climate change, introducing

[7] Additional detail can be found in Appendix A. Review of Federal, State, and Local Laws and Codes. Black & Veatch did not conduct legal research included in this analysis.
[8] 2025-2026-base-residual-auction-report.ashx

mid-term and long-term emissions reduction targets. Today, approximately 45 states (including Virginia) have published Priority Climate Action Plans (PCAPs) with the Environmental Protection Agency (EPA). At a high level, these plans summarize GHG emissions reduction efforts and proposed strategies to achieve climate and emissions reduction goals.[9] In 2023, the City of Charlottesville adopted its own communitywide CAP identifying strategies and specific actions to help the City meet its emissions reduction targets.

Though the CAP outlines important strategies for the City to consider on its journey to carbon neutrality, initiatives by both the City and Charlottesville Gas have been underway for a number of years. In 2010, the City installed its first municipal photovoltaic (PV) system, and seven additional systems have since been installed. In 2012, the City identified its first initial emissions reduction goals and incorporated its first electric vehicle (EV) and EV chargers in the City's municipal fleet.[10]

Since 2001, Charlottesville Gas has offered energy efficiency rebates to its natural gas customers. These rebates incentivize the use of technologies and solutions (such as programmable thermostats, tankless hot water heaters, attic insulation, and more) to reduce the amount of natural gas consumed by its customers.[11] In 2019, the Charlottesville Gas Energy Efficiency Program (CGEEP) was launched in partnership with a nonprofit, the Local Energy Alliance Program (LEAP). Starting in 2022, Charlottesville Gas partnered with the Arbor Day Foundation, providing annual opportunities for residents to receive free trees. Further, since 2022, Charlottesville Gas procures certified carbon offsets in an effort to address emissions associated with 25% of the utility's natural gas throughput.

Though the above efforts contribute positively toward reducing the City's emissions, Charlottesville Gas recognizes additional actions can be taken to further contribute to meeting the City's emissions reduction targets. Along this line, Charlottesville Gas engaged with Black & Veatch to evaluate emissions reduction strategies for the municipally-owned gas utility. Black & Veatch collaborated with Charlottesville Gas to develop a decarbonization study approach that would provide a comprehensive view of gas utility specific actions which should be evaluated and considered as part of its decarbonization efforts. As part of this engagement, Black & Veatch completed the following:

- **Energy Efficiency Evaluation and Recommendations:** Black & Veatch reviewed existing energy efficiency services and rebates provided by Charlottesville Gas. Further, Black & Veatch reviewed energy efficiency programs offered by other municipal gas utilities located along the east coast of the United States and compared programs to inform areas where Charlottesville Gas can enhance energy efficiency offerings.[12]
- **Methane Emissions Review and Benchmarking:** To review and evaluate the largest potential source or activity of methane emissions and recommend operations improvements or innovations to reduce emissions, Black & Veatch reviewed Charlottesville Gas's Department of Transportation PHMSA data.

[9] Priority Climate Action Plans developed are ongoing and updated as completed on the Environmental Protection Agency's website: https://www.epa.gov/inflation-reduction-act/priority-climate-action-plans-states-msas-tribes-and-territories. Updated as of December 1, 2024.
[10] Many additional sustainability and climate action-related activities and initiatives have been implemented by the City. For a comprehensive list, refer to the City's Climate Action Plan.
[11] A deep-dive into Charlottesville Gas's energy efficiency programs is provided in Section 2.0.
[12] Black & Veatch completed this analysis via desktop research from publicly available information as of February 2024. Any programs, results, or other details not easily publicly accessible may not be reflected in the results.

Using this data, the City's natural gas system methane emission leakages were compared to utilities of similar operation characteristics.[13]

- **Decarbonization System Modeling:** Black & Veatch explored various emissions reduction options, assessed resource availability, and determined the amount of GHG emissions estimated to be reduced. Further, Black & Veatch forecasted the associated costs of new resource implementation and potential rate payer impact of each decarbonization pathway. As part of this assessment, Black & Veatch considered the role of renewable natural gas, hydrogen, and the expansion of certified carbon offsets.
- **Stakeholder Communication and Outreach:** Black & Veatch engaged in numerous stakeholder engagement activities aimed at ensuring that the City of Charlottesville City Council was kept informed and involved in the progress of the decarbonization study, and to gain valuable insight into the concerns of the larger Charlottesville community. Specifically, a City Council work session was held on March 2, 2024, that included a presentation by the Director of Utilities, the Director of the Office of Sustainability, and Black and Veatch staff.[14] Additional community outreach and engagement sessions were completed outside of the Black & Veatch scope. This work is provided in more detail in Section 1.5, Community Engagement.
- **Final Summary Decarbonization Study Report:** This report is intended to provide an overview and summary of the findings of the previous tasks as part of this engagement and offer decarbonization strategies for Charlottesville Gas to contemplate as it considers its opportunities and challenges to meet decarbonization goals. This report will also provide recommendations for next steps that Charlottesville Gas should consider as it evaluates decarbonization pathways.

ES.3.1 Community Engagement and Outreach

In addition to the tasks summarized above, Charlottesville Gas engaged in numerous community outreach programs to help develop this decarbonization study. In Fall 2022, Charlottesville Gas enlisted the UVA CSR to conduct a survey to understand attitudes about natural gas from residents in both Charlottesville and Albemarle County. Participants were asked questions involving five aspects of concern: Natural Gas Service and Access, Energy Efficiency Programs, Carbon Offsets, Electrification Path, and Decarbonization Path.

Driven by a lack of awareness of the decarbonization study itself, Charlottesville Gas engaged with Launch! Consulting to facilitate a series of community engagement sessions regarding the decarbonization study. These sessions were completed in Spring and Summer 2024 and included a Commercial Gas Customer Focus Group with local representatives from commercial business owners, manufacturers, residential community management, property management representatives, and transportation service providers. Three community listening sessions (two virtual and one in-person) were conducted, where 133 members of the wider Charlottesville and Albemarle County community attended.

Additional details on the 2022 Gas Mitigation Survey, Commercial Gas Customer Focus Group, and the Community Listening Sessions are summarized in Section 1.5 of this report. A summary of all community engagement activities is included as part of the following appendices:

- Appendix B. BeHeardCVA Gas Mitigation Report.
- Appendix C. Commercial Gas Customer Listening Session Summary Notes.

[13] The same set of comparative utilities was used in both the energy efficiency evaluation and in the methane emissions and benchmarking task. A description of the methodology is provided in model detail in Section 2.0.
[14] The referenced presentation can be found here: Gas Decarbonization Study March 26,2024 Update

- Appendix D. Decarbonization Study Community Session Notes and Feedback.

ES.3.2 Decarbonization Methodology, Scope, and Solutions

To accomplish its decarbonization objectives, Charlottesville Gas and Black & Veatch leveraged a scenario-based approach to model decarbonization pathways of the gas utility. The team considered known policy drivers and trends, reviewed, and examined existing decarbonization and emissions reduction strategies, and leveraged subject matter expertise to forecast and evaluate the impact of decarbonization initiatives on the entire Charlottesville Gas system.

As part of this pathway-based approach, Black & Veatch, in coordination with inputs from Charlottesville Gas, developed a business-as-usual (BAU) systemwide gas throughput forecast to serve as the basis against which decarbonization pathways would be evaluated. More specifically, the study forecasts systemwide throughput as the amount of natural gas on an annual basis in which emissions reduction strategies must be applied. The results of this BAU forecast are shown in Figure ES-2. The assumptions and results are discussed in more detail in Section 3.0, Decarbonization Pathways, of this report. Of note, Charlottesville Gas is forecasted to be close to achieving the 2030 emissions reduction target for city-only emissions through a combination of existing initiatives and efforts, including the use of certified carbon offsets. However, more aggressive measures are required for Charlottesville Gas to meet the 2050 carbon neutrality target.

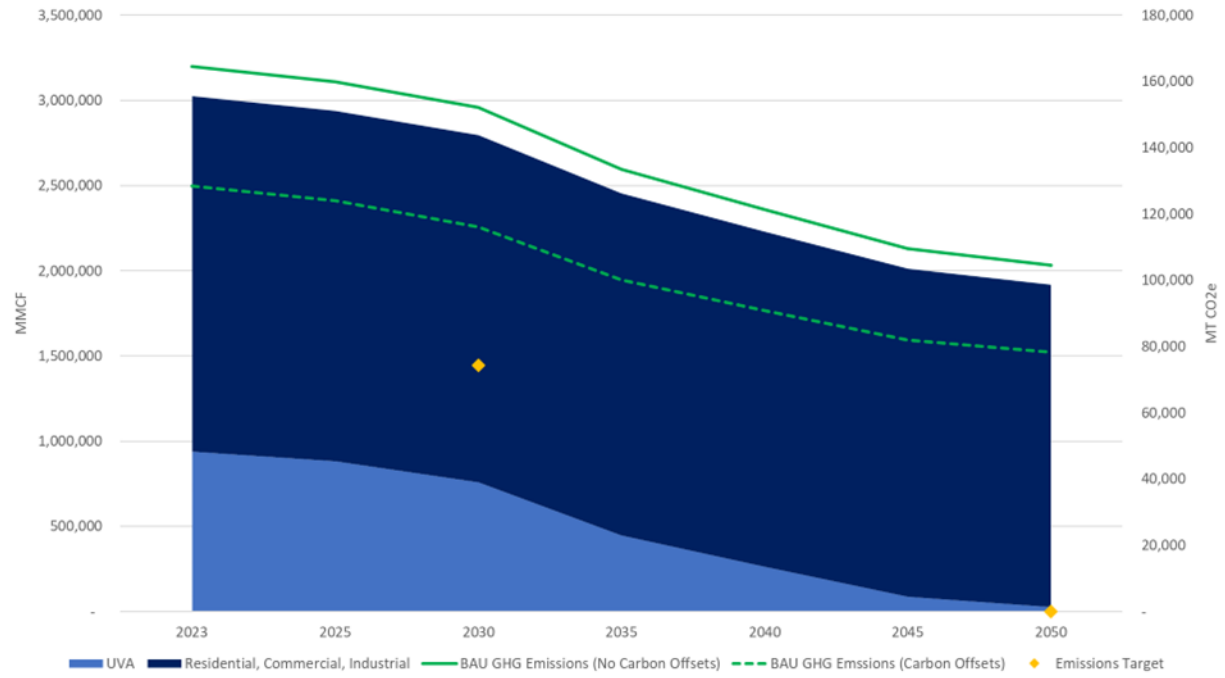

Figure ES-2 Business-as-Usual Systemwide Natural Gas and Emissions Forecast

Following the BAU, six alternative decarbonization forecasts (referred to as decarbonization pathways) were modeled to evaluate the full range of solutions that Charlottesville Gas could consider, with some pathways meeting the required emissions targets and others not. This study was designed this way to demonstrate the range of decarbonization investment decisions required. Notably, these pathways were developed through the lens of lowering the emissions from natural gas provided by Charlottesville Gas only. Municipal actions outside of the scope of this study and funded by non-gas rate payers such as citywide electrification efforts, utility fleet EVs, and municipal building on-site renewable energy are

outside of the scope and intent of this study. Further, impacts of federal, state, or electric utility incentives such as electrification rebates to promote switching from natural gas to electric are funded by the local electric utility and are outside of the scope of this study.

A combination of low-carbon fuels and certified carbon offsets were evaluated to determine the potential pathways for Charlottesville Gas. A brief description of the solutions evaluated are provided below. An evaluation of these solutions is provided in Section 3.0, Decarbonization Pathways.

Low Carbon Fuel Alternatives

The following solutions provide low to zero carbon options in which Charlottesville Gas may consider replacing some of its natural gas to lower the emissions of the total pipeline blended fuel. Blending of these fuels is proposed in various quantities while considering economic, commercial, and existing infrastructure.

- **Renewable Natural Gas (RNG):** RNG is a pipeline quality biogas developed using feedstock from landfills, livestock operations, wastewater treatment plants, food waste, and other organic feedstock that is fully interchangeable with conventional natural gas but has a much lower carbon footprint. Charlottesville Gas could consider entering an agreement with its gas provider or partner with local entities producing RNG, if applicable.
- **Green Hydrogen (Green H_2):** Green H_2 is produced from the electrolysis of water powered by renewable energy.
- **Blue Hydrogen (Blue H_2):** Blue H_2 is produced from reforming natural gas (or other fossil fuels) paired with carbon capture. Thus, blue H_2 has a lower emissions content compared to natural gas, but higher emissions than green H_2 which is generally assumed to be carbon free.

Together, the blending of hydrogen and RNG into the pipeline presents an opportunity for Charlottesville Gas to provide emissions reduction benefits, while still providing the pipeline gas services that it operates today. However, by capping pipeline blending of hydrogen at 15% (by volume) and RNG blending at approximately 22% (by volume) based on informed forecasts, there remain natural gas and pipeline emissions that will need to be reduced for Charlottesville Gas to meet its 2030 and 2050 decarbonization targets. Charlottesville Gas can deploy several strategies to reduce such remaining pipeline system emissions: adoption of certified carbon offsets and enhanced energy efficiency.

Additional Solutions

- **Certified Carbon Offsets:** Carbon offsets are a mechanism for mitigating the effects of GHG emissions by funding projects that reduce or remove carbon dioxide (CO_2) from the atmosphere. By purchasing carbon offsets, organizations can offset their own carbon emissions by supporting projects that promote renewable energy, energy efficiency, reforestation, or other activities that reduce GHG emissions. *Certified* carbon offsets have undergone a rigorous third-party verification and certification processes to ensure that the carbon reduction or removal projects they support are credible, transparent, and permanent. These offsets are certified by independent organizations that follow recognized standards and protocols for measuring, tracking, and reporting GHG emissions. By purchasing carbon offsets, individuals and organizations can support high-quality projects that reduce GHG emissions and contribute to sustainable development, while also offsetting their own carbon footprint. Charlottesville Gas is already leveraging certified carbon offsets as part of its ongoing emissions reduction strategies.
- **Energy Efficiency:** Energy efficiency recommendations were developed and provided as part of this assessment. Extensive energy efficiency impact modeling is not included in the BAU nor the

decarbonization pathways but should be considered a critical tool to reducing the use of natural gas by customers, thereby reducing GHG emissions. A 1% year-over-year decline in residential natural gas demand is assumed in all forecasts, reflecting trends observed by Charlottesville Gas. Recommendations outlined in this summary report, if approved and adopted, are likely to further increase energy efficiency adoption by customers.

- **Other Emerging Technologies:** Though additional decarbonization solutions such as networked geothermal and direct air capture were not modeled as part of the proposed decarbonization pathways, Black & Veatch provides a high-level overview of these solutions that Charlottesville Gas may consider in the mid-to-long term as these solutions become more commercially viable.

Summary Energy Efficiency and Methane Leak Prevention Recommendations

As part of the Energy Efficiency Benchmarking and Methane Emissions Benchmarking, additional recommendations, such as expansion of Charlottesville Gas's energy efficiency programs and additional actions to reduce methane emissions are also discussed and outlined in Section 2.0, Charlottesville Gas Benchmarking. Regarding energy efficiency, it is recommended that programs be revised to encourage switching from low-efficiency natural gas appliances to high-efficiency appliances. Charlottesville Gas should consider offering more tailored incentives to target specific customer segments, such as customizing rebate programs for residential and commercial customers and providing more incentives targeting building envelope enhancements. Further, the Utility should expand the eligibility of existing energy efficiency programs and consider leveraging local partnerships for more funding. Increasing customer engagement and advertising of the energy efficiency programs is also critical to greater adoption.

Charlottesville Gas has lower than average methane emissions from its distribution system compared to its peers. Since 2007, the Utility has a public awareness program that has been effective in reducing excavation damage related leaks. Black & Veatch recommends the continuation and expansion of this program to ensure continued leak prevention. Additional recommendations include the following:

- Continue completion of leak surveys every 3 years (compared to every 5 years as recommended by PHMSA).
- Install excess flow valves on service lines. The valves shut when a service line is severed or when damage from incidents occur such as excavation.
- Develop and implement preemptive pipeline and equipment maintenance or repair.
- Continue investing in the Public Awareness Program to prevent third-party excavation damage leaks, especially important in plastic systems.
- Continue to emphasize and prioritize existing training and the Operator Qualification Program.

ES.4 Decarbonization Pathways and Summary Findings

Decarbonization pathways were developed via a stakeholder engagement and Black & Veatch subject matter experts process in which solutions and clusters of technologies and solutions were grouped into clear and defined decarbonization pathways. As described above, varying combinations of low carbon fuels paired with certified carbon offsets are combined to reach emissions reduction targets. The six pathways were each developed with varying levels of emissions reduction to reflect the range of impact that Charlottesville Gas may have in supporting the City's emissions reduction targets. Blue and green H_2 were modeled independently in each pathway to demonstrate the impact of emissions and required investment for each type of H_2.

- **Full Decarbonization Pathway: Green:** This pathway was developed to demonstrate what is required to meet the 2030 and 2050 emissions reduction targets. Together, a combination of RNG and green H_2 will lower the overall emissions of the pipeline gas. Natural gas, green H_2, and RNG will serve natural gas customers at the end of the horizon. Certified carbon offsets are maximized to reduce the remaining emissions to meet the 2030 and 2050 emissions targets.
- **Full Decarbonization Pathway: Blue:** This pathway is identical to the Full Decarbonization Pathway: Green except that it uses blue H_2 instead of green H_2. Certified carbon offsets are maximized to reduce the remaining emission to meet the 2030 and 2050 emissions targets.
- **Moderate Decarbonization: Green:** This pathway demonstrates the impact green H_2 and RNG on emissions from Charlottesville Gas, assuming the same use of certified carbon offsets as today. This pathway does not achieve the emissions targets but does achieve significant emissions reduction from the use of lower carbon fuels.
- **Moderate Decarbonization: Blue:** This pathway is identical to the Moderate Decarbonization Pathway: Green except that it uses blue H_2 instead of green H_2.
- **Light Decarbonization: Green:** This pathway demonstrates the least aggressive of all the decarbonization pathways, assuming the expiration of all certified carbon offsets following the end of the existing contract in 2026. Though emissions reductions are achieved due to green H_2 and RNG blending, overall reductions are far less compared to the other pathways.
- **Light Decarbonization: Blue:** This pathway is identical to the Light Decarbonization Pathway: Green except that it uses blue H_2 instead of green H_2.

Figure ES-3 demonstrates the systemwide emissions impact of each pathway compared to the BAU and the emissions reduction target. As shown, only the two Full Decarbonization Pathways meet the required emissions reduction target. All forecasts, including the BAU, incorporate reasonable projections of natural gas demand by Charlottesville Gas customers, and the projected decline of natural gas usage at the University of Virginia (one of Charlottesville Gas's largest customers) driven by their own decarbonization initiatives. Realized variations to these projections will alter these forecasts. Additional details regarding modeling assumptions are described in greater detail in Section 3.0 Decarbonization Pathways.

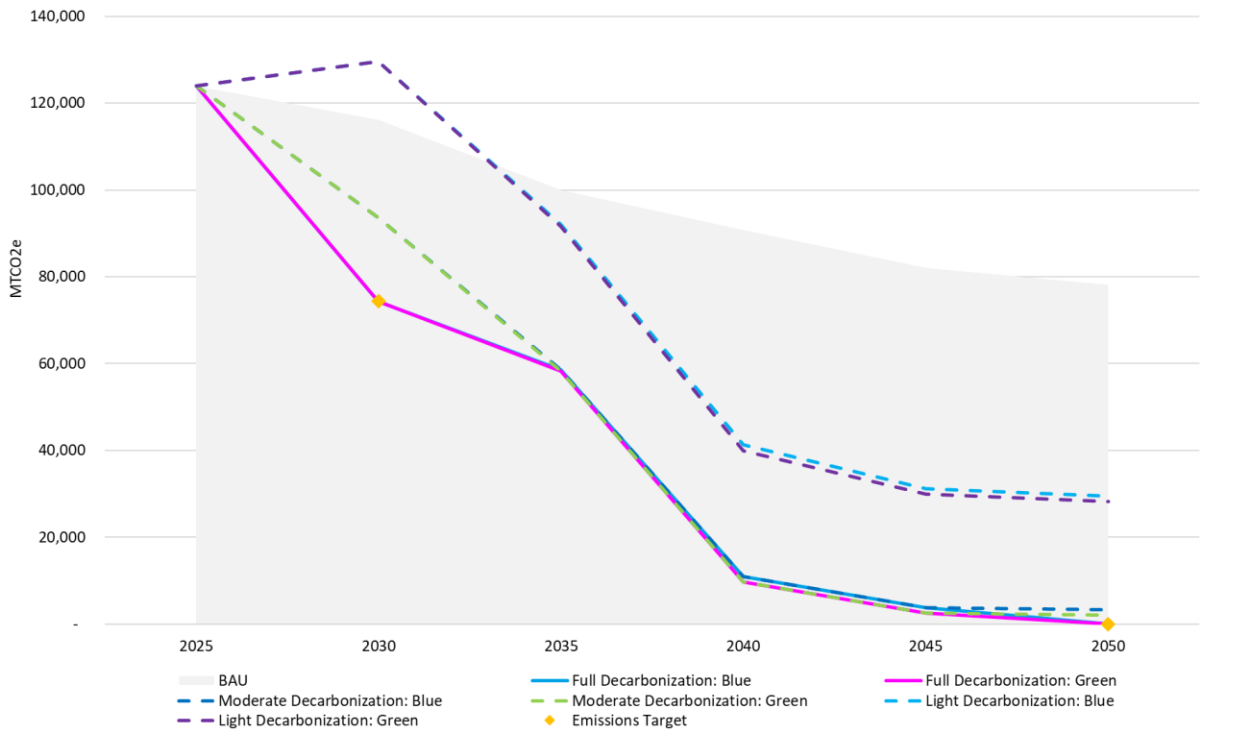

Figure ES-3 Decarbonization Pathway's Projected Systemwide Emissions Reduction

ES.5 Executive Summary Conclusion and Overview of the Main Narrative

This study evaluated potential decarbonization pathways for Charlottesville Gas to consider as it explores opportunities to lower its GHG emissions footprint and contribute to the City's overall emissions reduction targets of achieving a 45% GHG reduction by 2030 and carbon neutrality by 2050, compared to a 2011 baseline. The results of this analysis demonstrate several options available for Charlottesville Gas to consider reducing its emissions footprint, notably with pipeline blending of low carbon fuels and continued procurement of carbon offsets.

Though this analysis provides six decarbonization pathways for Charlottesville Gas to consider, the pace at which Charlottesville Gas considers these opportunities will be influenced by the impact to ratepayers and willingness to pay, as well as commercial availability of low carbon fuel supplies. Charlottesville Gas is one of the first, if not the first, municipal gas utility of its size to pursue a publicly available decarbonization study and initiative. Because of this, challenges arise that should be carefully contemplated as part of this engagement. This includes requirements of community engagement and education, limited funds for decarbonization solutions, and legal constraints paired with a highly evolving market with varying levels of decarbonization solution commercialization.

This study provides an analysis and thorough examination of potential emissions reduction opportunities for Charlottesville Gas between now, 2030, and 2050 to meet its decarbonization goals. Though this study provides a comprehensive analysis into the possibility of the impact of decarbonization pathways, energy efficiency, and methane leak prevention, the assumptions of this study are reasoned projections of the future based on today's knowledge; additional studies and analyses should be considered in the future as technologies and energy markets evolve. The analyses performed in this study should be leveraged and built upon to further assess and finalize decarbonization strategies to optimize and balance investment.

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1.0 Introduction to Charlottesville Gas Utility and the Decarbonization Study

1.1 About the Charlottesville Gas Utility

The Charlottesville Municipal Gas Utility has a rich history dating back to the late 19th century. The utility was established in 1876 and has been providing natural gas to the residents and businesses of Charlottesville and parts of Albemarle County ever since. Charlottesville Gas currently provides natural gas services to over 21,000 customers including nearly 20 industrial customers, over 2,300 commercial customers, and approximately 19,000 residential customers in both the city and in the county.[15] Similar to the City of Charlottesville, Albemarle County has adopted an emissions reduction target for 45% by 2030 and carbon neutrality by 2050.

One of Charlottesville Gas's largest customers is the University of Virginia (UVA). UVA has its own decarbonization initiatives, with the goal to be carbon neutral by 2030 and fossil fuel-free by 2050.[16] In the last 10 to 15 years, UVA has made a significant shift from burning coal to natural gas, which has a dramatically lower carbon footprint. Because of this, natural gas consumption at the campus has increased to support the transition away from coal. UVA's increase in natural gas usage is the single largest driver of natural gas demand for Charlottesville Gas. However, this trend is not expected to continue as UVA becomes more aggressive in meeting its own decarbonization targets. Even though UVA's decarbonization initiatives were not evaluated as part of this study, its expected shift from natural gas between now and 2050 does impact the forecasted business-as-usual (BAU). This is outlined in more detail in Section 3.0, Decarbonization Pathways.

[15] 11,700 customers are located in the City of Charlottesville and 9,350 are located in Albemarle County. This data is current as of March 2024.

[16] UVA describes carbon neutral as follows: All Scopes 1 and 2 carbon emissions are mitigated to zero. (Scope 1 refers to carbon emissions from UVA-owned facilities, and Scope 2 refers to indirect emissions from energy sources purchased by UVA. Fossil fuel-free – No fossil fuels are used on grounds for heating and cooling, electricity generation, or University transportation. Refer to https://sustainability.virginia.edu/climate-action.

Charlottesville Gas is one of three municipally-owned natural gas systems in Virginia; City of Danville Gas, and City of Richmond Gas are the other two. The gas system currently consists of approximately 343 miles of main lines and over 303 miles of service lines. A map of Charlottesville Gas's service territory is shown in Figure 1. The existing footprint of Charlottesville Gas's service territory is defined and not expected to expand.

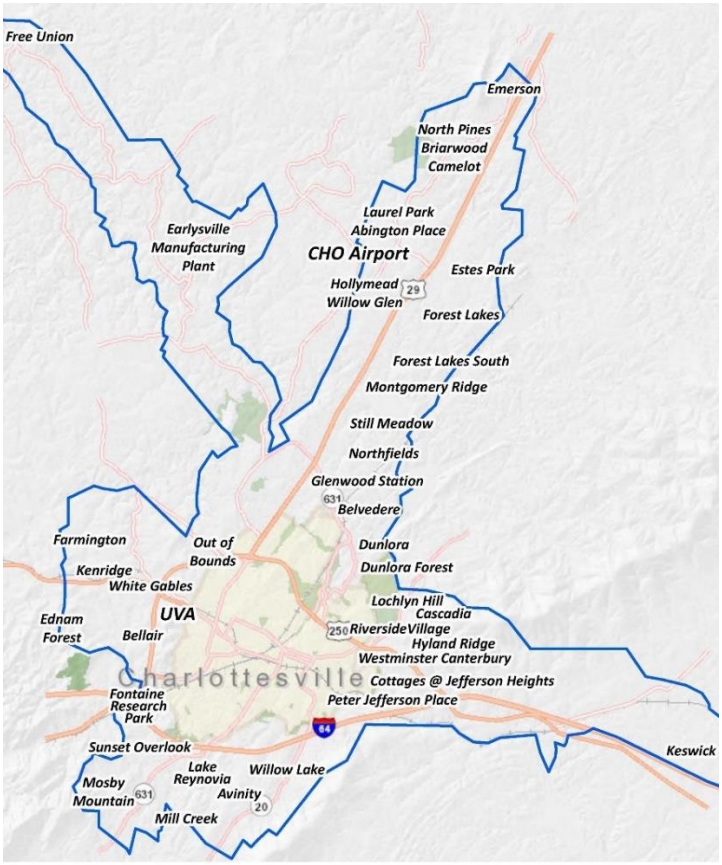


Figure 1 Charlottesville Gas Service Territory

In 2011 (the benchmark year of this study), Charlottesville Gas provided roughly 2,500 million cubic feet (MMCF) of natural gas to its customers across the City of Charlottesville, Albemarle County, and UVA. In 2023 (the starting year for this study), Charlottesville Gas provided approximately 3,000 MMCF, a relatively moderate increase of approximately 22% over the 12-year period. While city-only usage has declined since 2011, the system-wide increase is primarily due to UVA.

In more recent years, the requests for new natural gas connections have continued to decline. As an example, a 62% decline in requests for new natural gas connections occurred between 2018 and 2023, a trend that Charlottesville Gas expects to continue. Figure 2 shows this historical decline in new connection requests. This decline is likely attributed to less demand for new natural gas-fueled homes.

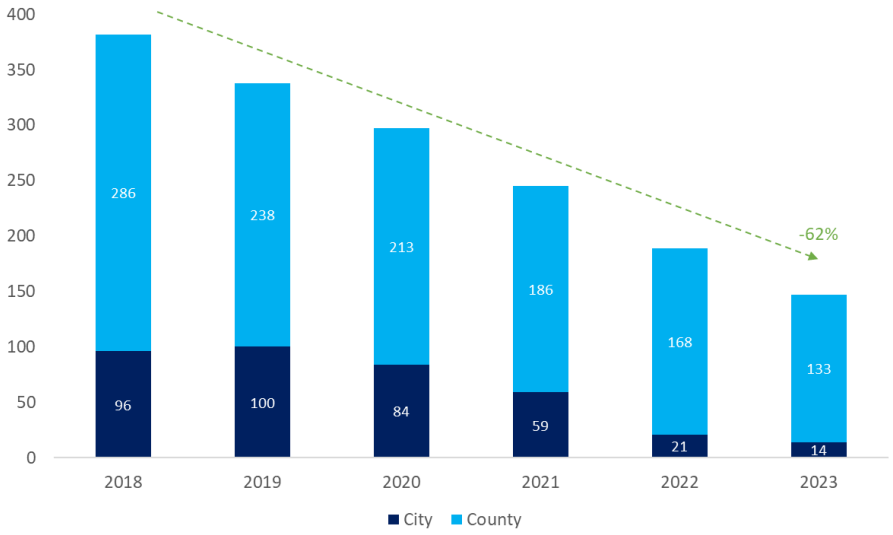


Figure 2 New Gas Connections: 6-Year Trend

Emissions from 2011 to 2023 follow the same trend as natural gas demand. Systemwide, approximately 135,000 metric tons carbon dioxide equivalent ($MTCO_2e$) of greenhouse gas (GHG) emissions came from natural gas in 2011, compared to approximately 165,000 $MTCO_2e$ in 2023.[17] City-only (excluding UVA) natural gas related emissions are expectedly lower at roughly 86,920 $MTCO_2e$ in 2011.[18] According to the City of Charlottesville's Office of Sustainability, natural gas is the third largest contributor to GHG emissions within the City, representing an average of approximately 25% of emissions. Electricity and transportation related emissions represent the largest and second largest source of emissions, respectively.

1.2 Decarbonization and Existing Environmental Stewardship Programs

Decarbonization and emissions reduction initiatives are at the forefront of global climate policy. In 2021, the United States rejoined the Paris Agreement, a legally binding international treaty on climate change. Domestically, the White House further committed to combat climate change, introducing mid-term and long-term emissions reduction targets. Today, approximately 45 states (including Virginia) have published Priority Climate Action Plans (PCAPs) with the Environmental Protection Agency (EPA). At a high level,

[17] 2023 GHG emissions does not consider the impact of carbon offsets under contract.
[18] Estimated emissions were calculated by Charlottesville Gas using the emissions factor in EPA reporting (0.0544 MTCO2e/MCF). This is in line with the emissions 2011 benchmark found here: City of Charlottesville 2016 Greenhouse Gas Inventory.

these plans summarize GHG emissions reduction efforts and proposed strategies to achieve climate and emissions reduction goals.[19]

The City of Charlottesville (the City) joined the Global Covenant of Mayors for Climate & Energy, committing the City to adopting greenhouse gas (GHG) emissions reduction targets. Following two comment periods and presentations, on July 1, 2019, the Charlottesville City Council set two goals: a 45% GHG emissions reduction by 2030 and carbon neutrality by 2050, compared to a 2011 baseline. Further, the City committed to the development of a community-wide Climate Action Plan (CAP) outlining its GHG emissions reduction targets and a plan to achieve the adopted targets. More specifically, and as relevant to the purposes of this report, the CAP includes a key action to complete analysis of decarbonization options for the municipal gas utility - Charlottesville Gas, through this Decarbonization Study.

Though the CAP outlines important strategies for the City to consider in its journey to carbon neutrality, initiatives by the City and Charlottesville Gas have been underway for a number of years. In 2010, the City installed its first municipal photovoltaic (PV) system, and seven additional systems have since been installed. In 2012, the City identified its first emissions reduction goals and installed its first electric vehicle (EV) and EV chargers in the City's municipal fleet.

In 2021, Charlottesville Gas entered into a 5-year contract for the procurement of certified carbon offsets from BP Energy Company (BP). The existing contract stipulates a 25% certified carbon offset for daily gas throughput of up to 7,500 million British thermal units (MMBtus) at a predetermined carbon dioxide (CO_2) equivalency factor to offset natural gas emissions. Currently, Charlottesville Gas's program includes both technology and nature based global certified carbon offset projects. BP currently uses a third-party verification service to ensure that projects meet required carbon offset standards. Charlottesville Gas also offers a number of energy efficiency programs described in greater detail in Subsection 2.3.1, Existing Programs: Energy Efficiency.

Though the above efforts contribute positively toward reducing the City's emissions, Charlottesville Gas recognizes additional actions can be taken to further contribute to meeting the City's emissions reduction targets. Along this line, the Charlottesville Department of Utilities initiated and provided funding for this study as part of an ongoing initiative to address the challenges of decarbonizing energy-related emissions in the City of Charlottesville. The Charlottesville Department of Utilities engaged with Black & Veatch to explore the opportunities to decarbonize the existing gas system and associated cost, impact on customer gas rates, and emissions impacts of such decarbonization initiatives. Black & Veatch collaborated with Charlottesville Gas to develop a decarbonization study approach that would provide a comprehensive view of gas utility specific actions which should be evaluated and considered as part of its decarbonization efforts. As part of this engagement, Black & Veatch completed the following:

- **Energy Efficiency Evaluation and Recommendations:** Black & Veatch reviewed existing energy efficiency services and rebates provided by Charlottesville Gas. Further, Black & Veatch reviewed energy efficiency programs offered by other municipal gas utilities located along the east coast of the United States and compared programs to inform areas where Charlottesville Gas can enhance energy efficiency offerings.[20]

[19] Priority Climate Action Plans developed are ongoing and updated as completed on the EPA's website: https://www.epa.gov/inflation-reduction-act/priority-climate-action-plans-states-msas-tribes-and-territories. Current as of December 1, 2024.

[20] Black & Veatch completed this analysis via desktop research from publicly available information as of February 2024. Any programs, results, or other details not easily publicly accessible may not be reflected in the results.

- **Methane Emissions Review and Benchmarking:** To review and evaluate the largest potential source or activity of methane emissions and recommend operations improvements or innovations to reduce emissions, Black & Veatch reviewed Charlottesville Gas's Department of Transportation PHMSA data. Using this data, the City's natural gas system methane emission leakages were compared to utilities of similar operation characteristics.[21]
- **Decarbonization System Modeling:** Black & Veatch explored various emissions reduction options, assessed resource availability, and determined the amount of GHG emissions estimated to be reduced. Further, Black & Veatch forecasted the associated costs of new resource implementation and potential rate payer impact of each option. As part of this assessment, Black & Veatch considered the role of renewable natural gas, hydrogen, and the expansion of certified carbon offsets.
- **Stakeholder Communication and Outreach:** Black & Veatch engaged in numerous stakeholder engagement activities aimed at ensuring that the City of Charlottesville City Council was kept informed and involved in the progress of the decarbonization study, to gain valuable insight into the concerns of the larger Charlottesville community. Specifically, a City Council work session was held on March 2, 2024, that included a presentation by the Director of Utilities, the Director of the Office of Sustainability, and Black and Veatch staff.[22] Additional community outreach and engagement were completed outside of the Black & Veatch scope. This work is provided in more detail in Section 1.5, Community Engagement.
- **Final Summary Decarbonization Study Report:** This report is intended to provide an overview and summary of the findings of the previous tasks as part of this engagement and offer decarbonization strategies for Charlottesville Gas to contemplate as it considers its opportunities and challenges to meet decarbonization goals. This report will also provide recommendations for next steps that Charlottesville Gas should consider as it evaluates decarbonization pathways.

1.3 The Charlottesville Gas Utility Decarbonization Study

This study and its results are intended to support the City's emissions reduction efforts, providing a detailed narrative, assessment, and evaluation of possible decarbonization opportunities for Charlottesville Gas, specifically. More directly, this study explores how the municipal gas utility can promote more efficient gas usage, procure lower carbon fuel services, and enhance its system to reduce methane emissions. Additional studies outlining decarbonization initiatives pertaining to municipal buildings, electrification, transportation, and renewable generation are outside of the scope of services provided by Charlottesville Gas but should be considered in additional studies by the City to contribute to its 2030 and 2050 emissions reduction targets.

This final report includes the methodology, assumptions, and decarbonization analysis for Charlottesville Gas to meet its proportional emissions reduction target of reducing natural gas-related emissions 45% by 2030 (from a 2011 baseline) and to achieve carbon neutrality by 2050. Five appendices are provided adjacent to this main study report, which provide additional details of the stakeholder engagement

[21] The same set of comparative utilities was used in both the energy efficiency evaluation and in the methane emissions and benchmarking task. A description of the methodology is provided in model detail in Section 2.0.
[22] The referenced presentation can be found here: Gas Decarbonization Study March 26,2024 Update

process and legal studies also completed complementary to this report.[23] The appendices provided include the following:

- **Appendix A. Review of Federal, State, and Local Laws and Codes:** Charlottesville Gas engaged with legal counsel to review applicable federal, state, local laws, and codes that provide specific conditions to regulate aspects of natural gas utilities providing services to its customers. This included an assessment of the legality of decommissioning the municipal natural gas utility operations and banning new customer connections. Though this is not the intent of this decarbonization study, these topics were reviewed to provide an assessment of the legal and regulatory framework surrounding this topic.
- **Appendix B. BeHeardCVA Gas Mitigation Report:** The University of Virginia's (UVA) Center for Survey Research (CSR) conducted a survey in 2022 sponsored by Charlottesville Gas to understand attitudes toward natural gas and sustainability among residents of Charlottesville City and Albemarle County. This appendix provides a summary of those results.
- **Appendix C. Commercial Gas Customer Listening Session Summary Notes:** Launch! Consulting facilitated a discussion among participants, covering a wide variety of topics. Eight participants attended, which included commercial business owners, manufacturers, residential community managers, property management representatives, and transportation service providers. This appendix provides a summary of notes from that session.
- **Appendix D. Decarbonization Study Community Session Notes and Feedback:** Between July and August 2024, the City of Charlottesville Department of Utilities hosted three community listening session opportunities to discuss the Charlottesville Gas Decarbonization Study. This appendix provides a summary of their notes and feedback.
- **Appendix E. Estimated End-User Electrification Costs:** Though electrification initiatives and adoption were not modeled or proposed as a gas utility-driven action, high-level residential end-user fuel conversion costs were developed and estimated to demonstrate the upfront capital costs required by end-users to convert from natural gas to electrification. This appendix provides the summary results of this research.

1.4 Overview of the Virginia Energy Market

Natural gas is an important energy source in the state of Virginia. In 2023, Virginia customers consumed 614,000 MMCF, across residential, commercial, industrial, and electric generation sectors.[24] Natural gas used in the power generation sector represents the largest natural gas end use, accounting for approximately 56% to 60% of total gas end use in the state.

Virginia has minimal natural gas production in the state. Multiple investor-owned and municipal utilities provide natural gas to customers in Virginia. The utilities rely upon procured natural gas supplies from key production basins and subscribe to natural gas pipeline transportation capacities to serve Virginia customers.

As shown in Figure 3, Virginia natural gas customers are served by several interstate pipelines including Transcontinental Pipeline (Transco), Columbia Gas Transmission (Columbia), Dominion Gas

[23] Black & Veatch did not complete the legal assessment or stakeholder engagement workshops referenced throughout this assessment. A summary of the findings of these two workstreams are provided as complementary appendices to this report to provide a consolidated view of this full initiative.
[24] Natural Gas Delivered to Consumers in Virginia (Including Vehicle Fuel) (Million Cubic Feet), Energy Information Administration (EIA)

Transmission (DGT) and East Tennessee Gas Pipeline (East Tennessee). The primary supply source to Virginia is the Marcellus/Utica shale in Pennsylvania, West Virginia, and Ohio. Gas supplies from the Gulf Coast gas production sources, such as the state of Texas, Louisiana and offshore Gulf of Mexico could also reach Virginia customers through the interstate pipeline network.

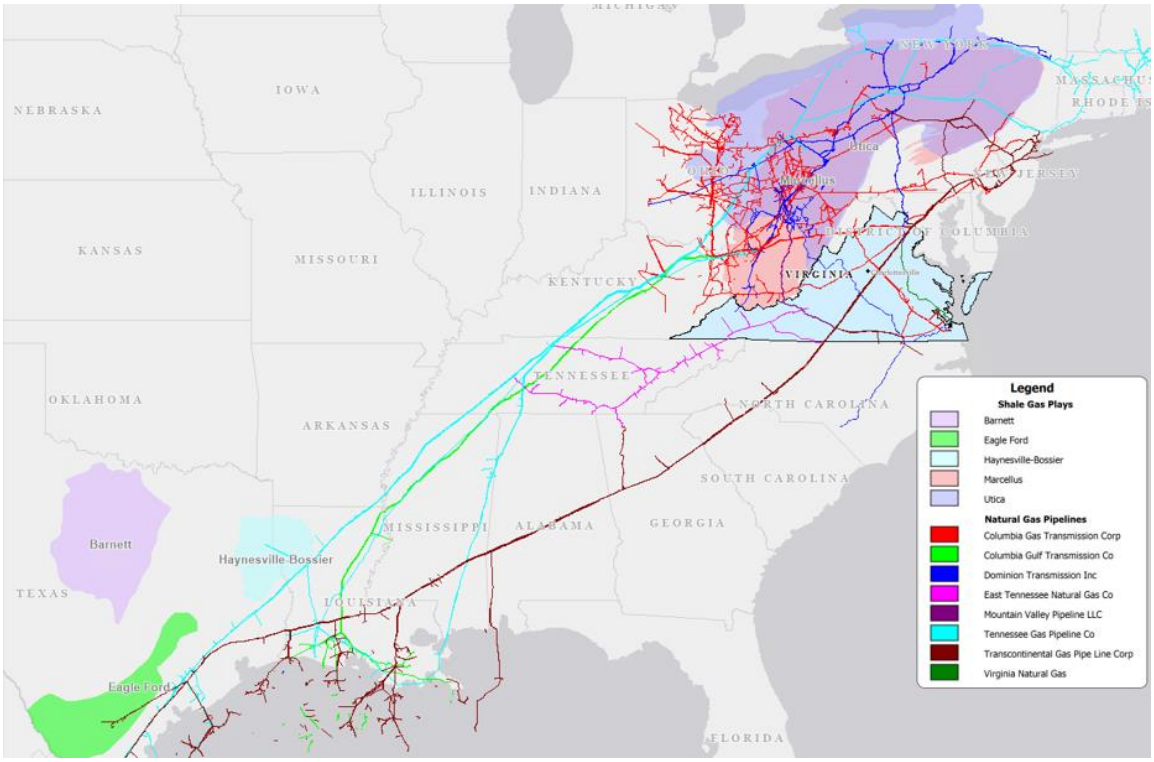


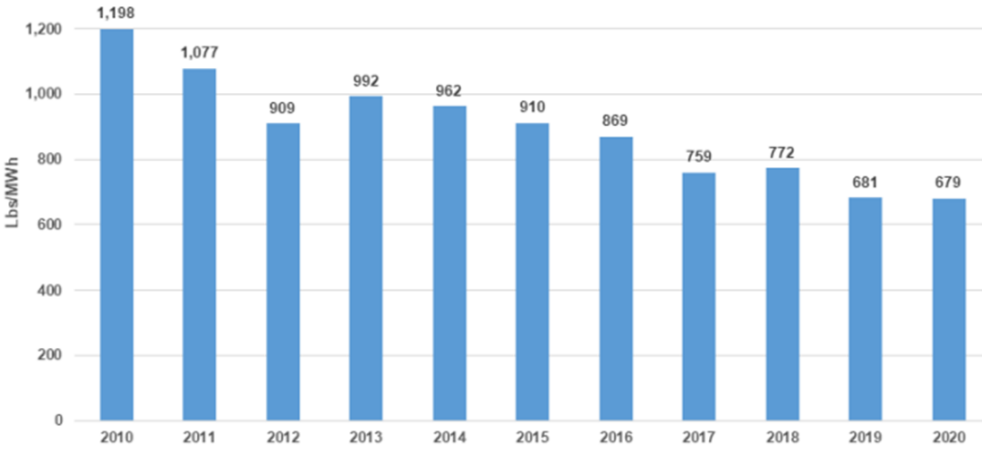
Figure 3 Natural Gas Infrastructure Serving Virginia

Investor-owned natural gas utilities are regulated by Virginia's State Corporation Commission and their plans to serve customers and customer bill rates are subject to the Commission's review and approval. Conversely, as one of the three municipally owned utilities in the state of Virginia, Charlottesville Gas operates under a different regulatory purview.

Electricity in Charlottesville Gas's service area is provided by Dominion Energy (Dominion), a utility participant in the PJM, a regional transmission organization that coordinates the wholesale electricity supply and demand in 13 states and the District of Columbia. Incremental increases in demand for electricity resulting from electrification of gas demand served by Charlottesville Gas will require Dominion to procure firm generation capacity in the PJM market, which could have significant implications for electric customer bills under the current constrained PJM market conditions.

In 2020, the Virginia Clean Economy Act (VCEA) was signed into law, requiring the state of Virginia to achieve 100% clean electricity by 2050, Dominion, the state's largest electric utility, must meet this target by 2045 and Appalachian Power Company (ApCo) by 2050. Further, the VCEA requires Dominion and ApCo to retire their carbon-emitting electricity generating units and replace them with generating capacity located in Virginia that uses renewable energy sources like wind and solar power. VCEA also mandates that by 2030, 30% of Virginia's electric system will be powered by renewable energy resources and by 2035, Virginia will deploy 3.1 gigawatts (GWs) of energy storage systems to support a clean and reliable grid.

Today, the impacts of the VCEA have yet to be fully realized as it is still early in the state's transition to cleaner energy. According to the Energy Information Administration (EIA), 54% of electricity generation in the state was fueled by natural gas in 2022, followed by nuclear energy (31%).[25] Electricity generation from renewable resources accounted for 11% of generation in 2022, with the largest share (6%) from solar. Despite the progress required in renewable adoption, the state has made significant progress toward meeting its clean energy targets. The 2022 Virginia Energy Plan reported that from 2010 to 2022, coal generation declined from 35% to 4%, shifting power generation to lower carbon natural gas. Further, the Plan reported that the transition from high-emitting coal-fired generation to low carbon natural gas turbine has realized significant carbon emissions reduction as displayed in Figure 4.[26]



Source: 2022 Virginia Energy Plan

Figure 4 Power Sector Carbon Emission Rates in Virginia

VCEA, however, does not have a mandatary decarbonization target for natural gas utilities, as it focuses on the electricity sector. Utilities serving Virginia customers have proposed various approaches to reduce the carbon footprints of their operations while maintaining reliable and affordable supplies to their customers. Charlottesville Gas is among the first municipal natural gas utilities to commission a comprehensive study to explore and evaluate decarbonization pathways.

1.5 Community Engagement

Charlottesville Gas engaged in numerous community outreach programs to help inform this decarbonization study. In Fall 2022, in anticipation of the Charlottesville Gas Decarbonization Study, Charlottesville Gas enlisted the services of UVA's Center for Survey Research (CSR) to conduct a survey to understand attitudes toward natural gas and sustainability among residents of the City of Charlottesville and Albemarle County. This survey was conducted with CSR's regional survey panel, BeHeardCVA, providing Charlottesville Gas with a set of participants that mirror the diversity of thought in the community. Between October 13, 2022, and November 12, 2022, 846 BeHeardCVA panelists were invited to take the survey online or over the phone. Panelists were asked questions that revolve around five aspects of concern: Natural Gas Service and Access, Energy Efficiency Programs, Carbon Offsets, Electrification Path, and Decarbonization Path. A total of 303 panelists completed the survey, for a

[25] Source: EIA https://www.eia.gov/state/analysis.php?sid=VA.
[26] Source: The Commonwealth of Virginia's 2022 Energy Plan.

response rate of 36%. Survey results were weighted to align more closely with the demographic composition of the population of Charlottesville and Albemarle.

As the Decarbonization Study progressed, Charlottesville Gas wanted to ensure that the community remained engaged with the study and included a question addressing the level of awareness of the Decarbonization Study among customers in its Annual Customer Satisfaction Survey. Results from the satisfaction survey showed that 84% of respondents were not at all familiar with the Decarbonization Study. Charlottesville Gas used this high level of unfamiliarity with the study as an opportunity to raise awareness and to ensure that the study included community feedback. Launch! Consulting was hired to help facilitate a series of community engagement sessions in Spring and Summer 2024.

In March 2024, commercial business owners, manufacturers, residential community managers, property management representatives, and transportation service providers attended a Commercial Gas Customer Focus Group. The session began with presentations by the project team from the Decarbonization Study to contextualize the City's climate action plan and its commitment to achieving carbon neutrality. Presenters provided an overview of the City's gas utility and their environmental stewardship initiatives within its gas framework. They also introduced the Gas Decarbonization Study to provide information on its objectives and projected timeline. Participants introduced themselves and provided context on the role that natural gas plays in their businesses. Topics covered by the group included Natural Gas and Decarbonization, Cost and Infrastructure Concerns, Regulatory and Support Issues, Financial and Environmental Motivations for Conversion, Reliance on Natural Gas for Emergency Situations, Infrastructure Updates and Leak Prevention, and Broader Considerations and Future Outlooks.

Between July and August 2024, Charlottesville Gas offered the wider community opportunities to attend one of three Community Listening Sessions on the Decarbonization Study. Two virtual sessions and one in-person session were hosted. At the beginning of each session, project team presenters provided introductory information to contextualize the City's Climate Action Plan, an overview of the gas utility and its environmental stewardship initiatives, and the objectives and projected timeline of the Decarbonization Study. A total of 133 community members attended the sessions, which included residents and business owners from both the City of Charlottesville and Albemarle County. During the sessions, participants could move around and join three different breakout groups. The first group focused on Environmental Impacts of Decarbonization and Natural Gas Usage, the second focused on Economic Impacts of Decarbonization and Natural Gas Usage, and the third group focused on Benefits of Natural Gas Usage and Concerns about Decarbonization. Each group brought up a range of topics that included electrification, energy efficiency resources, carbon offsets, and cost and reliability considerations.

Greater detail on the 2022 Gas Mitigation Survey, Commercial Gas Customer Focus Group, and the Community Listening Sessions are provided in the complementary appendices of this report.

2.0 Charlottesville Gas Benchmarking

As part of this decarbonization study, Black & Veatch completed two assessments: (1) an energy efficiency evaluation and (2) a methane emissions assessment. The purpose of these assessments was to gain an understanding as to how Charlottesville Gas compares against other similarly sized municipal utilities with respect to these issues. Both energy efficiency and reduced methane emissions result in a positive emissions impact on achieving the City's decarbonization goal.

Black & Veatch reviewed existing energy efficiency services and rebates provided by Charlottesville Gas. Further, Black & Veatch reviewed energy efficiency programs offered by other municipal gas utilities located along the East Coast of the United States and compared energy efficiency programs to inform opportunities for Charlottesville Gas to enhance offerings to its customers.[27] The purpose of this task was specifically to contemplate the additional opportunities that Charlottesville Gas can explore to promote more efficient gas practices among its customers.

2.1 Methodology

Prior to benchmarking, Black & Veatch established a Peer Group of utilities similar to Charlottesville Gas. Black & Veatch leveraged publicly available data from the Pipeline and Hazardous Materials Safety Administration (PHMSA) and identified 21 municipally owned gas utilities located in the eastern United States with between 100 and 1,000 miles of distribution mains and 10,000 to 50,000 distribution services (Peer Group). [28] These Peer Group municipal utilities operate in six states: Virginia, Tennessee, North Carolina, South Carolina, Georgia, and Florida.

As demonstrated in Table 1, Charlottesville Gas is one of the denser utilities in the Peer Group with lower-than-average distribution mileage (339 miles), yet a higher-than-average number of services (20,594). Charlottesville Gas's average number of services per main is 60.82, second only to the City of Sugar Hill in Georgia. The other Peer Group municipal utility in Virginia, the City of Danville, is a comparable system in terms of miles of mains. Miles of distribution mains and number of services for each Peer Group utility is presented in the following table. The same Peer Group was used in both the methane assessment and the energy efficiency assessment.

[27] Black & Veatch completed this analysis via desktop research from publicly available information as of February 2024. Any programs, results, or other details not easily publicly accessible may not be reflected in the results.
[28] A distribution main is a large pipeline that carries the fluid from the transmission system to individual customers or smaller distribution networks. It is typically located in the main road or street and is responsible for delivering the fluid to a large area. Distribution mains are usually made of larger diameter pipes that can handle high pressure and flow rates. A distribution service line is a smaller pipeline that connects the distribution main to an individual customer's property. It is responsible for delivering the fluid to a specific building or location. Distribution service lines are usually made of smaller diameter pipes that can handle lower pressure and flow rates.

Table 1 Peer Group Comparison[29]

Operator Name	State	Miles of Distribution Mains	Number of Services	Services per Mile of Mains
City of Charlottesville	VA	339	20,594	60.82
Lake Apopka Natural Gas District	FL	984	28,514	28.98
Greater Dickson Gas Authority	TN	846	19,658	23.24
Powell Clinch Utility District	TN	845	18,162	21.49
Elk River Public Utility District	TN	796	21,297	26.79
Clinton-Newberry Natural Gas Authority	TN	786	17,626	22.42
Greenville Utilities Commission*	NC	750	26,279	35.02
Gibson County Utility District	TN	640	12,712	19.86
Chester County Natural Gas Authority	SC	604	10,117	16.76
City of Rocky Mount Municipal System*	NC	559	19,545	34.99
City of Lexington Gas Department*	NC	518	12,218	23.59
City of Shelby Gas Department*	NC	511	10,719	20.99
City of Monroe Gas Department*	NC	471	13,507	28.67
Albany Water Gas & Light Commission*	GA	420	16,748	39.88
City of Wilson Gas Department*	NC	409	15,144	37.03
Orangeburg Public Utilities	SC	399	10,038	25.16
City of Cartersville Gas Department*	GA	360	11,561	32.08
Fountain Inn Natural Gas System	SC	351	11,683	33.31
City of Leesburg*	FL	349	16,504	47.26
Warner Robins Gas System	GA	343	13,194	38.44
City of Danville*	VA	339	16,047	47.40
City of Sugar Hill Natural Gas System	GA	195	12,174	62.41
Average		537	16,093	29.97

[29] Utilities with an (*) denote those with electric service in addition to gas service.

To assess and compare methane leak-related emissions, Black & Veatch reviewed several primary public sources for the information: the Charlottesville Gas Distribution Integrity Management Plan (DIMP), the City's Lost and Unaccounted for Gas Study from March 2022, the EPA's Subpart W GHG Summary Report, and the calendar year 2022 Annual PHMSA report.[30] Peer Group data was gathered from the publicly available PHMSA data. The methane assessment summary results relied upon information gathered from all these sources.

EPA Subpart W reporting was a critical data source in this assessment as it is the customary method by which local distribution companies report fugitive GHG emissions. More specifically, facilities must report emissions from the natural gas distribution industry segment only if emission sources specified in § 98.232(i) emit 25,000 $MTCO_2e$ or more per year. Under Subpart W(r), fugitive emissions from equipment leaks can be estimated based on applying emissions factors to population count. The emissions factors produce annual volumetric emissions of natural gas from the emission source type in standard cubic feet. The emission source type may be a component (e.g., connector, open-ended line, etc.), below grade metering-regulating station, below grade transmission-distribution transfer station, distribution main, distribution service, or gathering pipeline.

2.2 Methane Emissions Review and Benchmarking

The Charlottesville Gas Utility pipeline system is a relatively new system with the greater majority installed in the 1990s following pipeline replacement. The existing system is made up almost entirely of cathodically protected steel and high-density polyethylene (HDPE) plastic pipe, with only one mile of cast iron distribution main remaining. Currently, 183 of its services are protected steel with 20,282 plastic services. The system includes 35 above grade metering and regulating stations.

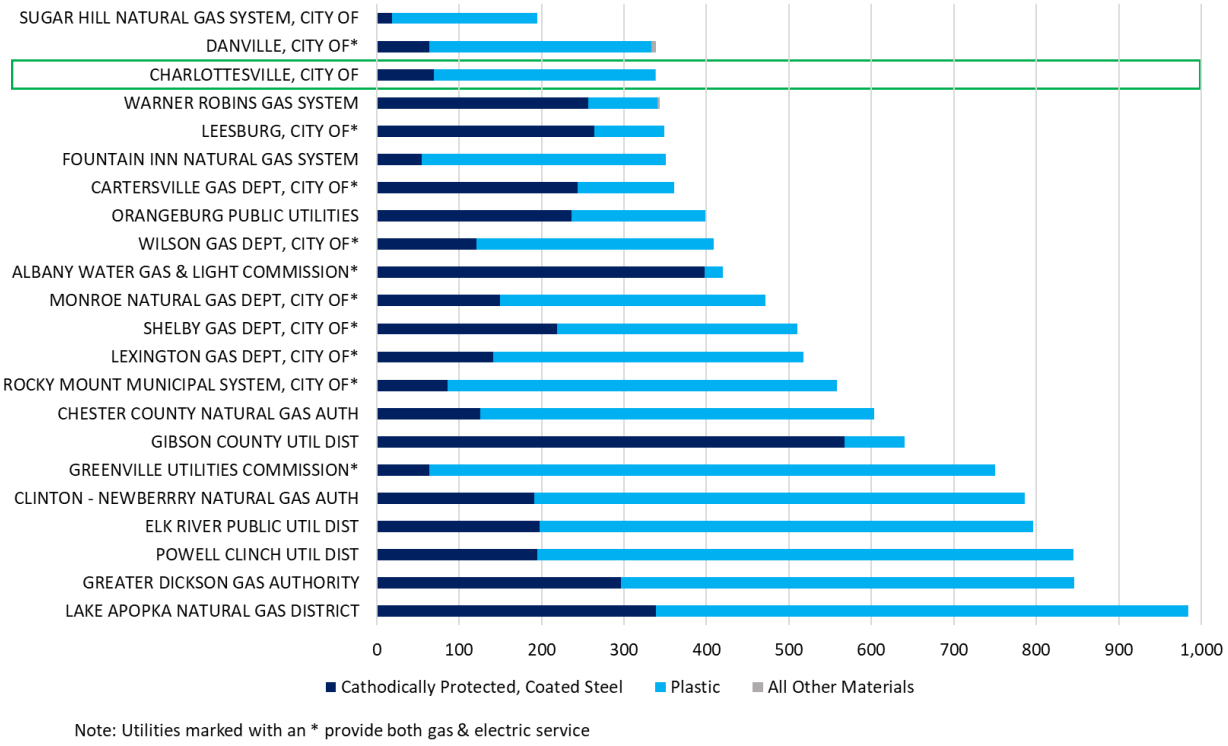
In 2023, the City of Charlottesville was awarded a $7.1 million grant from the US Department of Transportation through the Natural Gas Distribution Infrastructure Safety and Modernization (NGDISM) grant program. Funds from this grant will facilitate completion of Charlottesville's gas infrastructure upgrade project by expediting the replacement of the last remaining section of legacy cast-iron pipes with HDPE pipes in one of Charlottesville's busiest and most densely populated corridors. The replacement of the legacy cast-iron pipes will reduce the risk of pipelines susceptible to corrosion, cracking, and other forms of damage over time, such as leaks and other failures resulting in methane emissions, thereby improving system resiliency.

2.2.1 Mains and Services Composition Comparison

The average utility in the Charlottesville Gas Peer Group has approximately 540 miles of distribution mains, of which approximately 64% are made of plastic and 36% are cathodically protected, coated steel. Charlottesville Gas's split is approximately 80% plastic and 20% cathodically protected, coated steel. The majority of distribution systems are comprised of plastic mains, consistent with the current industry standard. Plastic became the predominant construction material in the 1980s and is known to be one of the least leak-prone materials in the natural gas industry, primarily due to not being susceptible to corrosion-based leaks. Charlottesville Gas has a smaller service territory in terms of distribution mains mileage (339 total miles) than the average utility in the Peer Group. Only the City of Danville, Virginia, and Sugar Hill, Georgia, have smaller footprints. The other Virginia municipal gas utility in the Peer Group, City

[30] Charlottesville Gas is mandated to have a DIMP in place. This program requires the identification and tracking of all new and existing leak threats to the natural gas system.

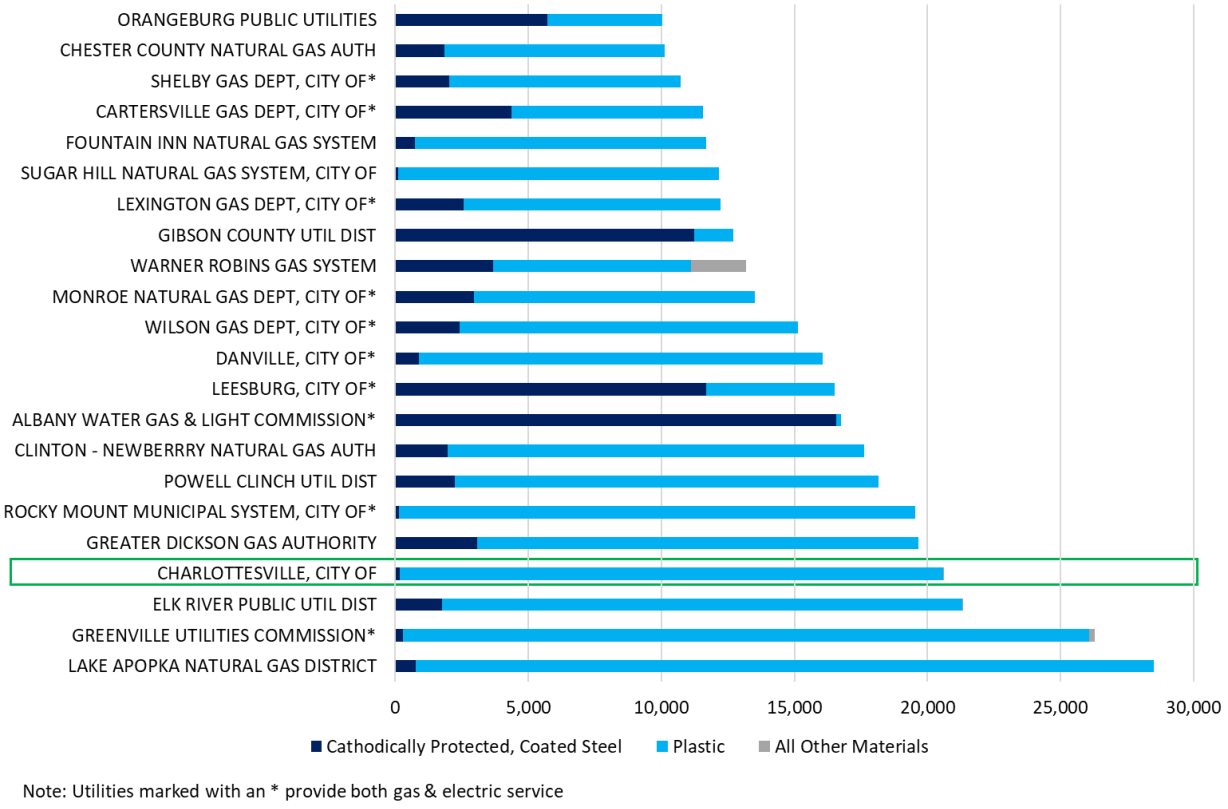
of Danville, has a very comparable distribution mains composition and system size. Figure 5 shows the distribution mains composition comparison of the Peer Group utilities.



Note: Utilities marked with an * provide both gas & electric service

Figure 5 Distribution Mains Peer Group Comparison

The average utility in the Peer Group has a little under 16,100 distribution services, of which approximately 78% are made of plastic and 22% are cathodically protected, coated steel. Charlottesville Gas's split is approximately 99% plastic and 1% cathodically protected, coated steel. The majority of the distribution systems are comprised of plastic services. Cathodically protected, coated steel services are typically deployed for more industrial applications. However, given the lower strengths of plastic services versus steel services, plastic is prone to excavation damage-caused leaks in addition to joint failures when installed improperly. These are less common in coated steel applications. Despite having one of the smaller distribution mains mileage, Charlottesville Gas has the second highest number of services (nearly 20,600 services) within the Peer Group. Figure 6 provides a comparison of the distribution services composition among the Peer Group.



Note: Utilities marked with an * provide both gas & electric service

Figure 6 Distribution Services Peer Group Comparison

2.2.2 Methane Emissions and Leaks

Charlottesville Gas's system comprises significantly less leak-prone materials when compared to other gas utilities in the nation, as reported by the US Department of Transportation's PHMSA. Charlottesville Gas's system of plastic is a differentiator with 79% plastic distribution mains, compared to only 61% of distribution mains nationally. Charlottesville Gas does not have a significant portion of leak-prone pipe (generally classified as bare steel, or cast/wrought iron), as compared to the national average where approximately 3% of distribution mains are of this type. Because of this, Charlottesville Gas's system is less susceptible to corrosion-based leaks. Table 2 shows a comparison of the Charlottesville Gas system compared to the entire gas distribution industry.

Table 2 The City of Charlottesville System Versus National Gas Distribution Industry

Distribution Main Pipe Material	CoC Miles[31]	Percent of Total Distribution Mains	National Miles	Percent of Total Distribution Mains
Unprotected, Bare Steel	0	0%	27,202	2%
Unprotected, Coated Steel	0	0%	14,315	1%
Cathodically Protected, Bare Steel	0	0%	9,883	1%
Cathodically Protected, Coated Steel	69	20%	460,242	34%
Plastic	269	79%	839,137	61%
Cast/Wrought Iron	1	0%	17,005	1%
Ductile Iron	0	0%	444	0%
Copper	0	0%	5	0%
Other	0	0%	942	0%
Reconditioned Cast Iron	0	0%	38	0%
Total	339	100%	1,369,211	100%

Over 90% of Charlottesville Gas's total fugitive emissions can be attributed to distribution mains. More specifically, almost 80% of total fugitive emissions are attributed to plastic distribution mains, considered current industry standard for distribution assets and significantly less prone to leaks than bare steel or cast iron).[32, 33] Charlottesville Gas's one mile of cast iron has slightly higher emissions than the emissions from 69 miles of protected steel which makes it a good target for replacement, as planned.

Applying EPA Subpart W emissions factors for distribution mains and services to each utility's inventory, it is apparent that Charlottesville Gas's methane emissions are significantly lower than their peers, estimating only four of the Peer Group utilities to have lower emissions profiles. The average estimated CO_2e emissions for a utility in the Peer Group is 2,276.92 MT in 2021, while Charlottesville Gas's estimated emissions are 1,570.25 MT in the same year.[34] Charlottesville Gas has lower emissions than a majority of pure gas service utilities in the Peer Group. Figure 7 provides a comparison of the estimated system methane emissions among the Peer Group.

[31] CoC - City of Charlottesville.

[32] Fugitive pipeline emissions refer to the unintended release of gases or vapors from a pipeline system into the surrounding environment. These emissions can occur due to leaks, equipment malfunctions, or other operational issues, and can include gases such as methane, ethane, propane, and other hydrocarbons.

[33] Consistent with EPA Subpart W GHG Emissions Summary Report from Charlottesville Gas.

[34] Peer Group methane emissions were extrapolated based on publicly available data. Actuals may vary and this data should be considered as estimates only.

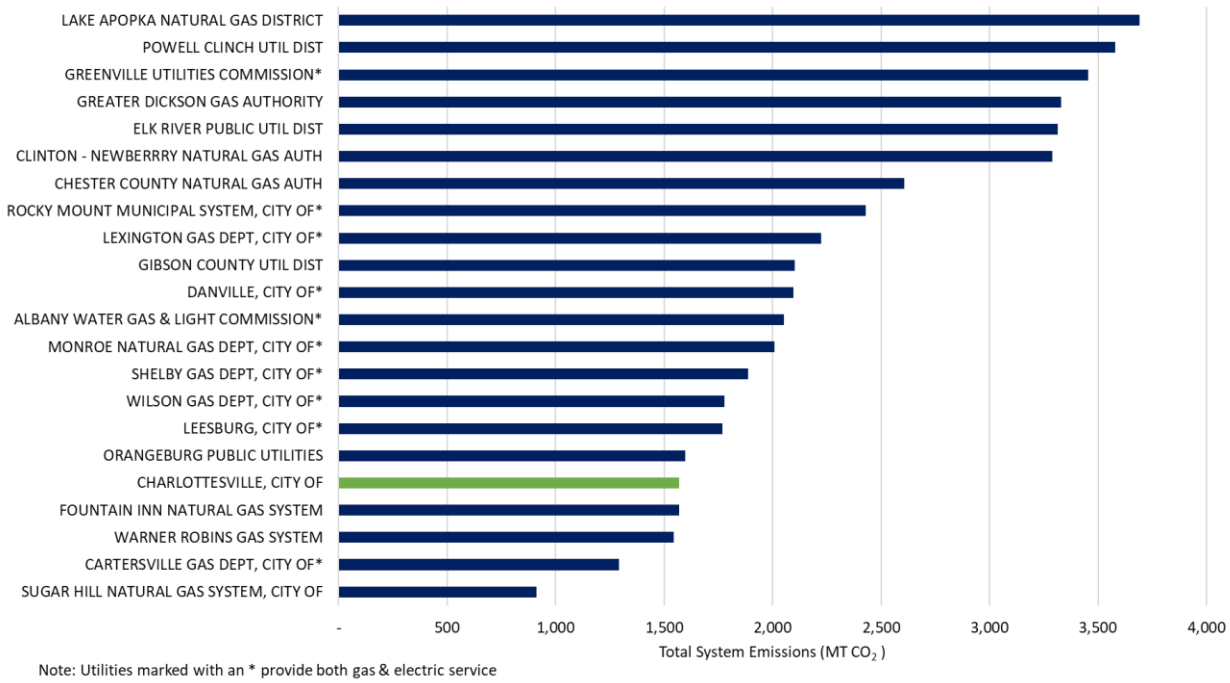


Figure 7 Estimated Total System Methane Emissions Peer Group Comparison

Black & Veatch also calculated total methane emissions per 100 services and notes that, in general, Charlottesville Gas's methane emission rate per customer is lower than the average utility, an estimated 7.6 $MTCO_2e$ per 100 Services, compared to the Peer Group average of 14.4 $MTCO_2e$. Charlottesville Gas has lower emissions than all but one Peer Group utility. Figure 8 displays the results of this analysis and comparison.

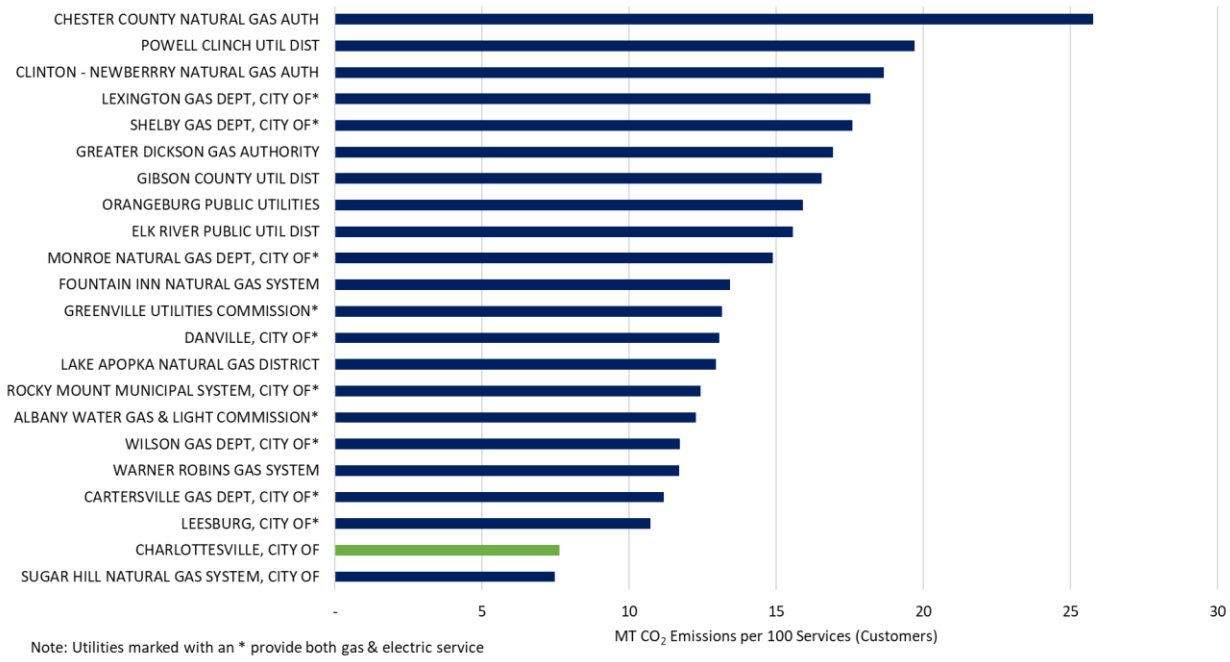


Figure 8 Estimated System Methane Emissions Per 100 Customers Peer Group Comparison

In evaluating pipeline system leaks, Black & Veatch evaluated and compared the number of leaks and types, as well as excavation-specific leaks. Black & Veatch compared Charlottesville Gas and Peer Group data over a 5-year period (2018 to 2022) to account for any COVID-19 pandemic-related impacts. At the time of this analysis, 2023 data was not yet publicly available.

The total number of Charlottesville Gas leaks has generally been on the decline over the past 5 years, reaching the lowest in 2020 possibly due to COVID-19 pandemic related impacts. Leaks are most heavily concentrated around equipment failures, followed by pipe weld and joint failures, not unusual for gas distribution systems with high levels of plastic. Excavation damage-caused leaks are somewhat consistent year over year, although third-party excavation incidents, specifically, have declined by approximately 76% since the implementation of Charlottesville Gas's Public Awareness Program in 2007. Leaks in the Peer Group are most heavily concentrated around equipment failures, accounting for 43% of leaks in 2022, as opposed to 26% in Charlottesville Gas during the same period.

Black & Veatch calculated the leak rates on the distribution services per 100 services based on the PHMSA-reported data. Charlottesville Gas's leak rate on services is consistently below the Peer Group in each of the last 5 years, as shown in Figure 9. Black & Veatch also calculated the ratio between excavation damages and tickets issued at Charlottesville Gas and the Peer Group. Charlottesville Gas's excavation damages per ticket appear below the Peer Group's as shown in Figure 10, a testament to the excavation damage/one call procedures established by the utility.

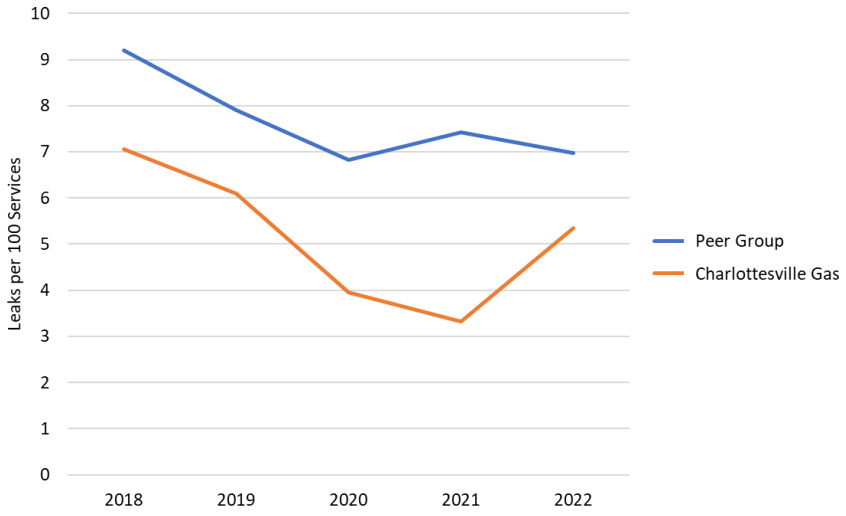


Figure 9 Estimated Services Leak Rate Comparison

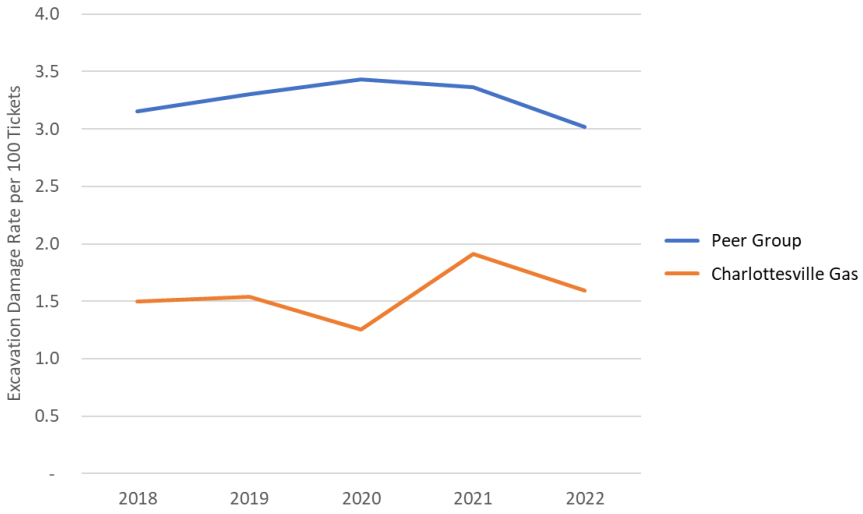


Figure 10 Estimated Excavation Damage Rate Comparison

Black & Veatch completed an assessment of two other municipal gas utilities in Virginia: City of Danville Utilities and City of Richmond Utilities. Compared to Charlottesville Gas, Richmond has six times the mileage of distribution mains and five times the number of services. The proportion of plastic mains and services to other materials is lower in the Richmond system than observed in both the Charlottesville Gas and Danville systems, with over 190 miles of mains comprised of cast/wrought iron and ductile iron and close to 2,300 service lines comprised of bare steel, each of which are typically more leak-prone. Figure 11 shows the composition comparison of mains and services of Charlottesville Gas, Danville, and Richmond.

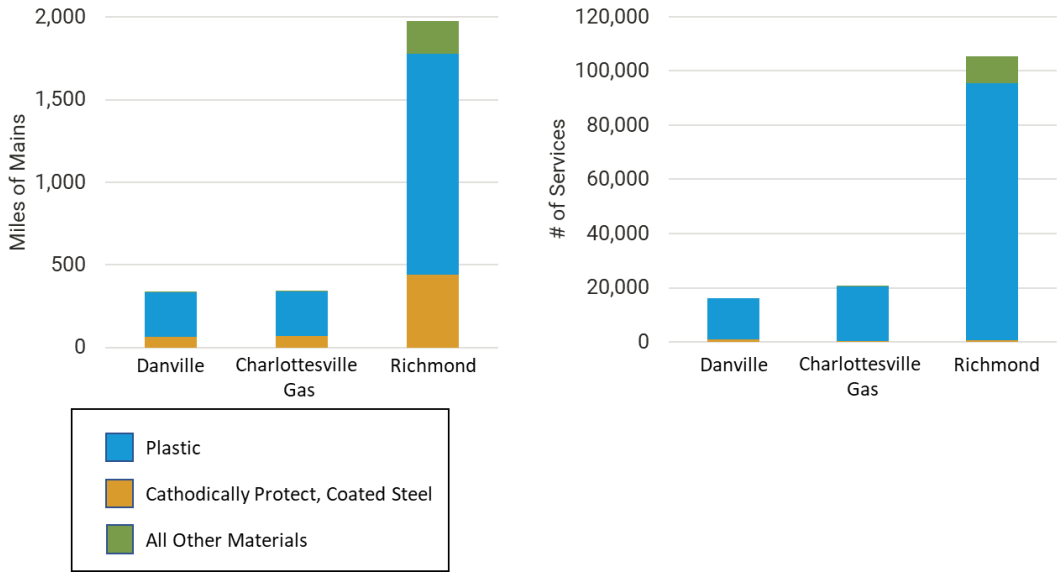


Figure 11 Virginia Municipal Utilities Composition Comparison: Mains and Services

Richmond's number of leaks on mains is over 10 times and the number leaks on services is four times that reported by Charlottesville Gas. The proportion of plastic mains and services is lower on Richmond's system compared to both Charlottesville Gas and Danville. Figure 12 and Figure 13 provide a comparison of leaks between mains and services of the three Virginia municipal utilities in 2022.

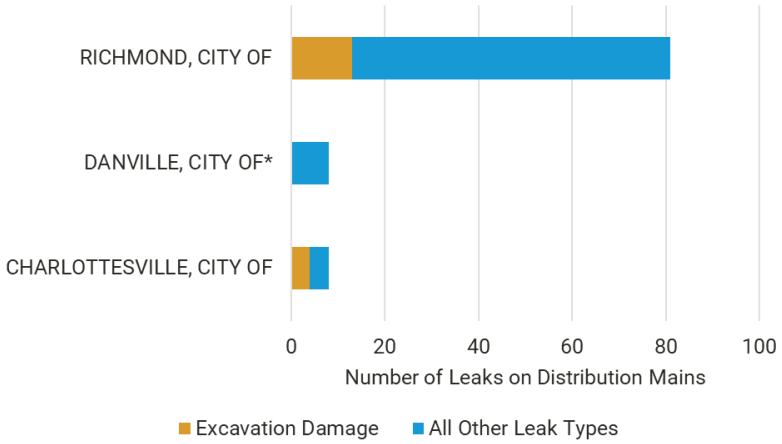


Figure 12 Distribution Mains Leak Comparison (2022)

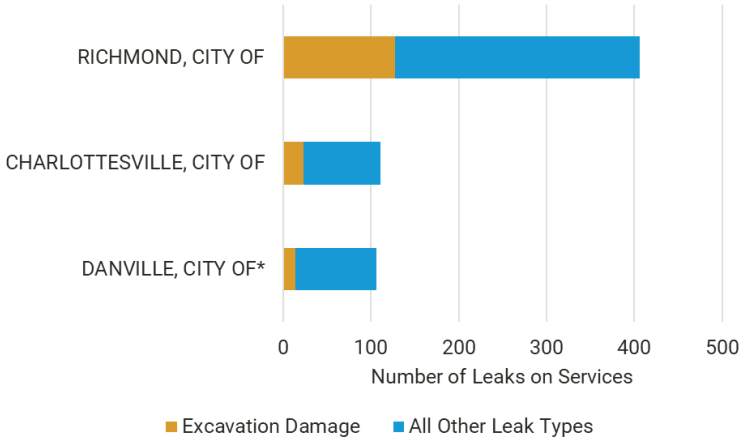


Figure 13 Distribution Services Leak Comparison (2022)

2.2.3 Existing Actions and Recommended Next Steps

After review of Charlottesville Gas's existing programs, consideration of composition of the system pipeline, and benchmark comparisons of Charlottesville Gas to its identified Peer Group utilities, Black & Veatch recommends the following actions to consider.

Charlottesville Gas should continue and consider expanding the existing Public Awareness Program to further prevent third-party excavation damage leaks. Although HDPE pipeline systems have many benefits as described earlier in this report, HDPE is susceptible to excavation related damages. Investment in this program has realized benefits, with Charlottesville Gas reporting an approximate 76% decrease in third-party excavation incidents since the implementation of the program in 2007.

Charlottesville Gas should continue to complete systemwide leak surveys once every 3 years rather than 5 years as recommended by PHMSA and the EPA. Charlottesville Gas should also continue its practice of completing a full leak survey in business districts on an annual basis. Understanding that this measure is already being implemented by Charlottesville Gas and Black & Veatch encourages continued investment and prioritization for optimal prevention of hazardous leaks and methane emissions.

Charlottesville Gas should continue to install excess flow valves on service lines. Excess flow valves close a severed service line when excavation damage occurs, reducing the overall damage of the hazardous leak. Charlottesville Gas has actively been installing excess flow valves at a rate of roughly 250 services per year over the past 10 years on new and replaced residential and commercial service lines. Charlottesville Gas should continue prioritizing investment in this area to minimize the impact of hazardous leaks.

Charlottesville Gas should continue to develop and implement preemptive pipeline and equipment maintenance or repair. As previously outlined, Charlottesville Gas is actively planning on the replacement of the last remaining mile of cast-iron pipe. Further, consistent with the DIMP, there are planned replacements of anodeless riser transitions and service tee caps, indirectly reducing emissions by improving the safety and reliability of the pipeline, to help prevent leaks and other accidents resulting in the release of GHGs and other harmful substances.

Charlottesville Gas should continue to prioritize its emphasis on training and the existing Operator Qualification Program to ensure that pipelines operators have best-in-class system operations training.

2.3 Energy Efficiency Benchmarking

As part of its decarbonization study, Charlottesville Gas engaged with Black & Veatch to understand how its existing energy efficiency offerings compare to other municipal utilities and understand specific actions that could be implemented in the near-term to increase energy efficiency adoption and behavior among its existing customer base. To ensure consistency in Peer Group benchmarking, Black & Veatch evaluated energy efficiency programs of the same set of utilities as in Section 2.2, Methane Emissions Review and Benchmarking. Importantly, evaluated Peer Group utilities do not appear to have public climate commitments (in accordance with desktop research as of February 15, 2024). This assessment will explore the existing energy efficiency programs being offered by Charlottesville Gas, compare these programs to the utilities in the Peer Group, and provide recommendations for enhancements and new energy efficiency programs.

2.3.1 Existing Programs: Energy Efficiency

Charlottesville Gas has been offering energy efficiency incentives to natural gas customers since 2001, with the launch of its programmable thermostat $100 USD rebate program. Since then, Charlottesville Gas has provided nearly 2,295 rebates and invested over $207,000 in the program. Charlottesville Gas also offers rebates for tankless water heaters (a $200 rebate) and attic insulation (a $300 rebate).[35] Combined, the Utility has provided more than 180 rebates and invested over $40,000.

In addition to these energy efficiency technology rebates, Charlottesville Gas, in partnership with the Local Energy Alliance Program (LEAP), offers no-cost energy efficiency upgrades to income qualified homeowners and renters. Since the program's inception in 2019, Charlottesville Gas has provided no-cost energy efficiency upgrades to over 190 participants with over $253,000 of investment from the Utility.

[35] In July 2024, Charlottesville Gas paused the Tankless Water Heater Rebate while evaluating its existing rebate offerings.

These energy efficiency upgrades have been instrumental in lowering natural gas usage at these homes, reflecting a 20% average reduction in natural gas consumption during winter months.[36]

In 2022, Charlottesville Gas partnered with the Arbor Day Foundation to launch the Utility's energy-saving trees program.[37] The program offers free trees to Charlottesville residents with guidance on where to best plant the tree for optimized energy savings. This program is highly successful, and trees are typically fully reserved within 48 hours of launching the reservation site. Since 2022, over 700 trees have been planted and resulted in an estimated 1.7 million pounds of carbon sequestered.[38] Charlottesville Gas has invested over $36,250 in this initiative to date.

Charlottesville Gas's investment in energy efficiency programs has been successful. On a weather normalized basis, the average natural gas usage per residential customer has declined by an estimated 1% year over year since 2010. Though Charlottesville Gas's initiatives cannot be directly attributed as the only factor of more efficient gas usage, it provides a supporting data point that in general, on a systemwide basis, average residential customer usage is declining.

2.3.2 Peer Group Comparison

As described previously, the focus of this benchmarking assessment was natural gas efficiency incentives, but many Peer Group utilities also offer electric efficiency incentives as many Peer Group utilities also provide electric service. Black & Veatch leveraged publicly available data found via desktop research and any programs, results, or other details not openly shared and easily accessible may not be reflected in these results.[39] Further, custom energy efficiency programs may exist that are also not summarized in this assessment.

Several trends can be observed from this benchmarking analysis and serve to help inform the short and mid-term actions Charlottesville Gas should consider. Prior to this study, Charlottesville Gas was already providing energy efficiency offerings to reduce natural gas usage, and at the time of this assessment, was the only Peer Group municipal utility with a formal decarbonization study publicly underway. Existing efforts to reduce natural gas usage highlight the commitment and willingness of Charlottesville Gas to invest in decarbonization-related initiatives.

Of the 21 Peer Group utilities, 86% (18/21) offer energy efficiency incentives, including 62% (13/21) with natural gas-specific incentives. However, of the gas-only utilities, there is limited emphasis on rebates for energy efficiency, with greater emphasis on conversion to natural gas from other fuels. Figure 14 shows the incentive types offered by utilities in the Peer Group.

[36] All energy efficiency program data spending and participation was provided by the Charlottesville Gas Utility.
[37] More information about the Arbor Day Foundation can be found here: https://www.arborday.org/.
[38] 20-year cumulative values projected by the Arbor Day Foundation in its 2024 Impact Report.
[39] Results reflect desktop research completed in January 2024. Changes in programs since that date will not be reflected in this assessment.

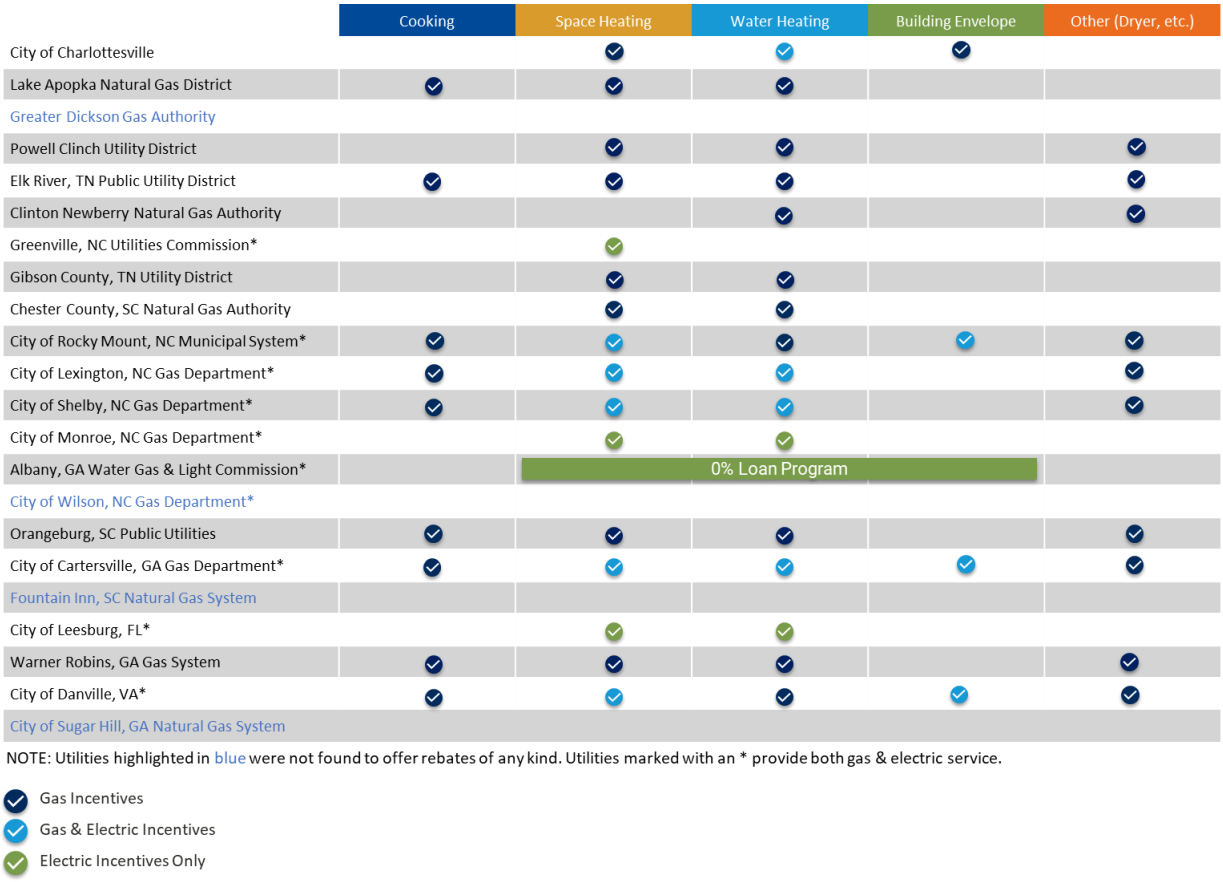


Figure 14 Energy Efficiency Rebate and Incentive Comparison

The assessment observed several key trends around the incentivized behaviors of their customers. Eight of the Peer Group utilities provide incentives or rebates for a fuel switch from electric to natural gas, and two offer rebates and incentives for switching from gas to electric. Generally, natural gas only utilities (those do not also provide electric service) primarily favor rebates incentivizing switching to natural gas from other fuels or switching to higher efficiency natural gas appliances or technologies.

Existing Virginia code limits Charlottesville Gas's ability to provide ratepayer-funded incentives to benefit non-gas customers (i.e., gas-to-electric shift), thus Charlottesville Gas limits energy efficiency activities to those that promote more efficient natural gas usage.[40] Because of this dynamic, an additional evaluation of the gas-only peer review utilities was also assessed. A high-level comparison of the incentives and rebates provided by the gas-only utilities in the Peer Group is provided in Figure 15.

	Cooking	Space Heating	Water Heating	Building Envelope	Other (Dryer, Generator, etc.)
City of Charlottesville		$100 Thermostat	$200 Electric or Gas	$300 Attic Insulation	
Lake Apopka Natural Gas District	$50-100	$50-300 Fireplace or Furnace	$100-300		$100
Powell Clinch Utility District		$400 Furnace	$250		
Elk River, TN Public Utility District	$100	$150-600	$100-400		$100
Clinton Newberry Natural Gas Authority			$100	$100	
Gibson County, TN Utility District		Free Service Line	$350		
Chester County, SC Natural Gas Authority		$50-150 Fireplace or Furnace	$100-150		
Orangeburg, SC Public Utilities	$150	$250 Fireplace or Furnace	$200-250		$100-250 Dryer or Gas light
Warner Robins, GA Gas System	$50	$150 Furnace	$200		$50

Figure 15 Gas-Only Utility Energy Efficiency Offerings

Of the 11 gas-only utilities, eight provide rebates targeting mostly new gas appliances and most offer larger rebates for conversion from either propane or electricity to natural gas. Rebates offered for conversion from legacy natural gas technologies often yield energy efficiency benefits, as new natural gas appliances are on average more efficient, resulting in less gas demand. Of the gas-only utilities space heating rebates, opportunities exist for Charlottesville Gas to expand rebates outside of programmable thermostats to include more efficient gas heating technologies to reduce overall gas usage. Charlottesville Gas is notable in providing rebates that encourage the overall reduction of natural gas usage via its programmable thermostat and attic insulation rebate programs.

Among natural gas utilities, there is generally a continued emphasis on providing incentives and rebates that promote new gas services. These actions include incentives for lowering the cost of new gas service connections, which is something Charlottesville Gas does not offer. Instead, Charlottesville Gas invests in providing incentives to reduce gas usage by its existing customers and recognizes that utilities that offer both gas and electric services have greater flexibility in the energy efficiency programs in which they can fund.

Of the 21 utilities in the identified Peer Group, 10 are also electric utility service providers. This is an important distinction to consider when reviewing these results. Combined electric and gas utilities have greater flexibility in fuel-switching incentives and often provide more robust energy efficiency programs, not applicable to the gas-only business model, such as that of Charlottesville Gas. Further, unlike investor-owned utilities, Charlottesville Gas rates are developed on a break-even basis to ensure that the utility has sufficient funds to sustain operations. Charlottesville Gas rates are approved by the Charlottesville City

[40] Virginia Code § 56-234. A.

Council to “furnish reasonably adequate service and facilities at reasonable and just rates” consistent with Code of Virginia 56-234. Thus, energy-efficient measures and recommendations are focused on natural gas energy efficiency – reducing the use of natural gas of Charlottesville Gas customers via more efficient appliances, technologies, and behaviors.

2.3.3 Additional Programs: Income Qualified Comparison

Charlottesville Gas and other Peer Group utilities offer income qualified energy efficiency programs that provide greater financial support for adoption of higher efficiency appliances and technologies. The Charlottesville Gas Energy Efficiency Program (CGEEP) provides financial support for income qualified customers who use natural gas for home heating and/or water heating via its partnership with LEAP. In review of the Peer Group utilities, many rely on the Federal Low-Income Home Energy Assistance Program to support customers in need, but 11 provide additional local assistance, including Charlottesville Gas. A summary of the comparison of these programs is provided in Figure 16.

	Local Income Qualified Assistance Programs
City of Charlottesville	➢ Home energy efficiency improvements and maintenance in partnership with LEAP ➢ State of VA Energy Assistance Program ➢ Local Gas Assistance Program
Lake Apopka Natural Gas District	➢ Up to $350/year for heating ➢ Partnership with local United Way
Powell Clinch Utility District	➢ Partnership with local organizations ➢ Amount of aid not publicly listed
Gibson County Utility District	➢ Customer donation program funds assistance through community orgs
Greenville, NC Utilities Commission*	➢ Up to $200/year for heating ➢ Funded through matched customer donations up to $20,000/year
City of Rocky Mount, NC Municipal System*	➢ Up to $300/year for heating
City of Shelby, NC Gas Department*	➢ Up to 3 months of utilities ➢ Partnership with local United Way & community orgs
City of Wilson, NC Gas Department*	➢ Up to $300/year for heating
Fountain Inn, SC Natural Gas System	➢ Customer donation program funds assistance through community orgs
City of Leesburg, FL*	➢ Up to $100/year for utilities ➢ Funded by city in partnership with community orgs
City of Danville, VA*	➢ Heating and cooling assistance funded by city and donations from partnership with local United Way

Figure 16 Peer Group Income Qualified Program Summary

Of those offering additional programs outside of federal funding, several of the utilities offer income qualified assistance programs funded by community and/or local religious organizations or utility customer donations, thus not directly from the municipal utility. Based on the findings from this assessment, Charlottesville Gas’s income qualified program is a leader among its peers in this aspect, as smaller municipal utilities tend to have less robust income qualified programs.

Like the Methane Emissions Assessment and Benchmarking Exercise, Black & Veatch completed a complementary assessment of two other municipal gas utilities in Virginia: Danville and Richmond. These three utilities offer vastly different energy efficiency offerings, with Danville offering a wide range of both gas and electric rebates as shown in Figure 17. Conversely, Richmond has no publicly marketed energy efficiency program. As a dual-fuel utility (offering both natural gas and electric services) Danville's most attractive incentives are focused on dual-fuel systems. Charlottesville Gas's income qualified program is a leader among this group, despite Richmond being a much larger city and utility.

	Cooking	Space Heating		Water Heating	Building Envelope	Other
City of Charlottesville		$100 Thermostat		$200 Electric or Gas	$300 Attic Insulation	
City of Danville	$100 Gas Range	$145-200 Central AC $350-500 Heat Pump	$450 Gas Furnace $1,250-1,650 Dual Fuel	$200 Gas	$0.10-0.45 / ft² Attic, Wall, or Floor insulation	$50-200 Gas Dryer, Gas Logs, EV Charger
City of Richmond	No energy efficiency incentives					

	Local Low-Income Assistance Programs
City of Charlottesville	➢ Up to **$1,500** in home energy efficiency improvements and maintenance per household in partnership with LEAP ➢ State of VA Energy Assistance Program ➢ Local Gas Assistance Program
City of Danville, VA	➢ Heating and cooling assistance funded by city and donations from partnership with local United Way
City of Richmond	➢ Heating assistance up to $500 in partnership with local agencies

Figure 17 Virginia Municipal Utilities Energy Efficiency Program Comparison

2.3.4 Recommended Actions and Next Steps

Though Charlottesville Gas is a leader among its peers in providing energy efficiency rebates that decrease gas consumption and support the income qualified community, Black & Veatch recommends that additional actions be taken to enhance existing energy efficiency programs to decrease overall gas consumption of existing customers at Charlottesville Gas. It should be noted that Charlottesville Gas's service territory is defined, so energy efficiency measures can play a critical role in the Utility helping to meet its decarbonization targets. Black & Veatch has identified four specific actions which Charlottesville Gas should further explore in the short- to mid-term.

1. Charlottesville Gas should modify its existing appliance rebate program. The program should include rebates and incentives to encourage the adoption of high-efficiency natural gas appliances for its existing natural gas customers. As part of this program modification, Charlottesville Gas should discontinue any incentives or rebates that promote switching from electric service to gas service. However, it is understood that new rebates and incentives require funds to support, thus Black & Veatch recommends that Charlottesville Gas consider expanding partnerships with local Charlottesville organizations and focus on customers who are most likely to use low-efficiency equipment and least able to afford upgrades. Together these modifications will encourage existing gas customers to become more efficient with gas usage and dissuade future switching from electric service to natural gas.

2. Charlottesville Gas should leverage lessons learned from larger investor-owned utilities who offer custom incentives tailored for specific customer segments and Charlottesville Gas's own decarbonization and energy efficiency goals. This could include expanding some of its income qualified customer rebate offerings to all residential and commercial segments to provide greater energy efficiency opportunities. Custom commercial and industrial and multifamily programs have been successful in reducing gas consumption in other large utility programs.

3. Charlottesville Gas should review and consider marketing and stakeholder engagement strategies from larger natural gas utilities with successful energy efficiency programs. This should include expanding notification types and advertising periods to market and engage customers. Awareness of energy efficiency programs presents a dramatic opportunity for improvement among Charlottesville Gas's existing customer base. As an example, in the latest Gas Mitigation Survey conducted by the Charlottesville Gas Survey, approximately 70% of respondents indicated that they were "not at all familiar" with the attic insulation and tankless water heater rebates. Approximately 57% indicated they are not familiar with the programmable thermostat program and approximately 50% were unfamiliar with the weatherization programs. This indicates a significant opportunity to expand awareness of the existing rebate and incentive programs. Further, data gathered from these programs helps the Utility to gain valuable customer insights (usage, satisfaction, operations, etc.) to assist with evaluating future offerings. The Utility may also consider targeted campaigns with other community organizations to promote propane to cleaner fuel (gas or electric) conversion.

4. Charlottesville Gas should consider expanding building envelope incentives and explore offering incentives that further increase building efficiency such as ductwork and other insulation rebates. The expansion of existing rebates is supported by existing Charlottesville Gas customers. Based on the latest Gas Mitigation Survey conducted by Charlottesville Gas, approximately 55% of respondents support either increasing the value or types of rebates available.

3.0 Decarbonization Pathways

To accomplish its decarbonization objectives, Charlottesville Gas and Black & Veatch leveraged a pathway-based approach to model decarbonization pathways of the gas utility. The team considered known policy drivers and trends, reviewed, and examined existing decarbonization and emissions reduction studies, and leveraged subject matter expertise to forecast and evaluate the impact of decarbonization initiatives on the entire Charlottesville Gas system. This section of this summary analysis presents a review of the assumptions and approach necessary in developing the baseline BAU case, identification of decarbonization solutions, and development of the pathways presented herein.

As part of this pathway-based approach, Black & Veatch, in coordination with inputs from Charlottesville Gas, developed a BAU systemwide gas throughput forecast to serve as the basis in which decarbonization pathways would be developed. More specifically, the forecasted systemwide throughput is the amount of natural gas on an annual basis in which emissions reduction strategies must be applied.

In identifying and assessing further decarbonization activities Charlottesville Gas could undertake, Black & Veatch leveraged its internal subject matter expertise identifying solutions that comprehensively considered technical, economic, and jurisdictional viability. The framework incorporates feasible decarbonization strategies and combinations of such solutions in which decarbonization pathways were developed. Following the development of the pathways, Black & Veatch optimized real-world considerations such as availability of solutions in the short, mid, and long-term to form a timeline of decarbonization actions for the Utility. From here, emissions reductions and rough-order-of magnitude direction investment requirements were calculated.

This analysis proposes systemwide solutions for Charlottesville Gas. While this study is aimed at reducing the emissions and meeting the decarbonization target of the City of Charlottesville, decarbonization of pipeline fuel utilized by Charlottesville Gas will benefit all natural gas customers, including those in Albemarle County. Therefore, the emissions reduction is assessed for the total Charlottesville Gas system. Estimated Charlottesville-only emissions reduction forecasts are also included.

3.1 Analysis Methodology

3.1.1 Charlottesville Gas Business-as-Usual Approach

Black & Veatch first developed the BAU as the primary natural gas forecast in which all decarbonization pathways would be measured. The intent of the BAU is to estimate the systemwide natural gas demand for Charlottesville Gas every year through 2050 if Charlottesville Gas continued operating as it does today. As the basis for this forecast, Black & Veatch used 2023 systemwide throughput data provided by Charlottesville Gas. To provide a reasonable forecast through 2050, the following factors were considered as described below.

Black & Veatch reviewed EIA's Form 176 to run a weather-normalized regression on the historical throughput of the residential customer segment to calculate the weather-normalized trend of historical residential customer demand.[41,42] Based on the regression analysis, on a weather-normalized basis, average throughput per residential customer declined 1% per year between 2010 and 2022. This trend is

[41] Form EIA-176 data is gathered via a mandatory survey of all companies that deliver natural gas to consumers or that transport gas across state lines.

[42] Weather normalization is a process that adjusts energy consumption as to what it would have been under normal weather conditions.

consistent with Charlottesville Gas's own assessment of recent historical trends in this customer segment, representing both impacts of energy efficiency measures as well as declining requests for new natural gas connections. Thus, Black & Veatch applied a 1% year-over-year decline in throughput to the residential customer segment on an annual basis through year 2050. Commercial and industrial segment data was not weather normalized as these sectors vary less dramatically by weather-related events compared to the residential segment.

Though this study did not contemplate decarbonization initiatives at UVA, Black & Veatch did need to consider the university's projected decline in natural gas use to meet their own emissions reduction targets. Consistent with UVA's own decarbonization goals to be carbon-neutral by 2030 and fossil fuel-free by 2050, UVA-related natural gas demand is forecasted to decrease moderately between 2024 and 2030 (during which time it is assumed UVA will leverage carbon offsets in the short- to mid-term to meet carbon neutrality targets) and then more aggressively to 2050 to meet the fossil fuel-free goals with minor adjustment to keep approximately 3 to 5% of remaining gas demand to accommodate any remaining natural gas needs.[43] On average, approximately 30% of Charlottesville Gas's total demand comes from UVA and thus, a decline in UVA demand is the single largest driver of expected throughput decline over the study horizon.

The commercial and industrial sectors were forecasted using the EIA's Annual Energy Outlook's (AEO) 2023 South Atlantic forecasted natural gas growth rates. Absent a more detailed throughput-specific assessment (outside of the scope of this study), the AEO is a reasonable projection path since it considers the EIA's perspective of changes to natural gas demand driven by population growth, stock turnover and adoption, and more.[44] Figure 18 shows the projected BAU systemwide throughput and GHG emissions of the Charlottesville Gas system through 2050.

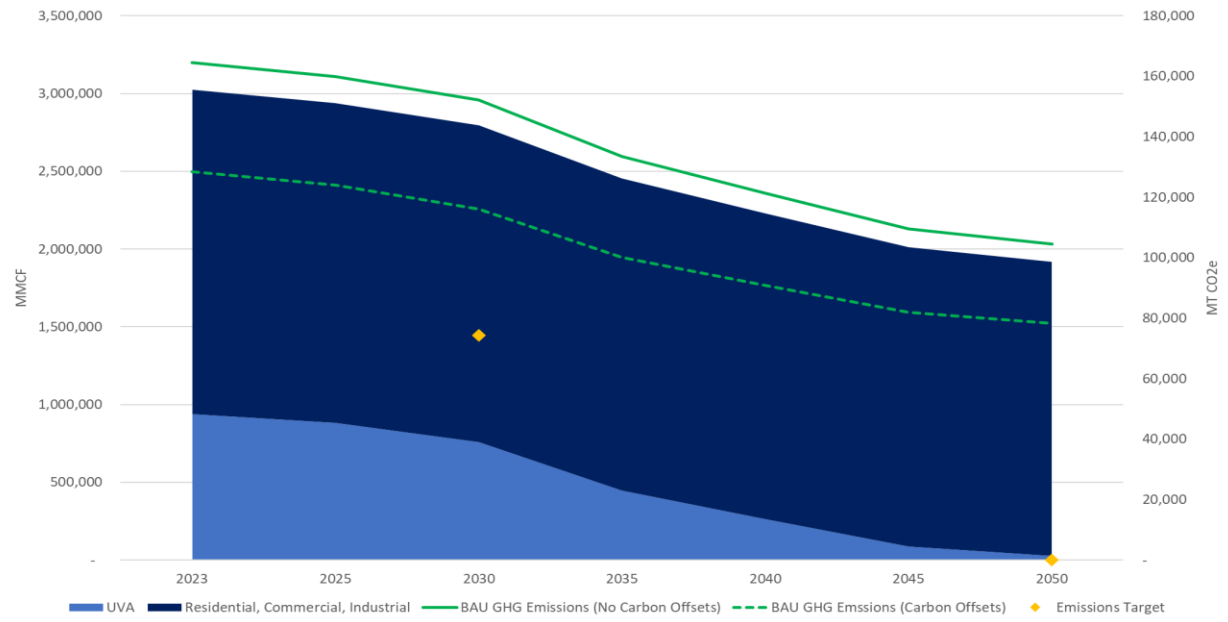


Figure 18 Business-as-Usual Systemwide Natural Gas and Emissions Forecast

[43] UVA's Climate Action goals are located in their 2030 Sustainability Plan and on their Climate Action webpage: https://sustainability.virginia.edu/climate-action. Remaining gas usage and offsets are assumed by the project team.
[44] Additional information on the EIA's 2023 AEO can be found here: https://www.eia.gov/outlooks/aeo/assumptions/.

BAU emissions forecasts and decarbonization pathways were all compared to the 2011 baseline emissions year. In the 2011 baseline year, Charlottesville Gas's systemwide emissions were an estimated 135,142 $MTCO_2e$ with city-only emissions (excluding UVA) were an estimated 86,920 $MTCO_2e$. Though this study explored systemwide decarbonization strategies resulting in systemwide emissions benefits, achieving city-only emissions reduction was the primary object of this study, and thus city-only and systemwide values are compared to measure progress towards emissions reduction goals.

As demonstrated in Figure 18, Charlottesville Gas is projected to see a relatively dramatic decline driven primarily by two key factors: the forecasted decarbonization of UVA, and the projected year-over-year decline in the residential segment. Despite forecasted growth in the commercial segment, the decline in demand from UVA and the residential sector results in a 37% reduction in systemwide natural gas demand and related emissions between 2023 and 2050.

Despite this decline, the remaining systemwide emissions fall above both the 2030 target (45% reduction from a 2011 baseline) and carbon neutrality in 2050. A 45% systemwide reduction in 2030 from 2011 would lead to estimated total emissions of 74,328 $MTCO_2e$ as opposed to what Charlottesville Gas is forecasted at (116,066 $MTCO_2e$) in the 2030 BAU case, assuming that carbon offsets are continuously utilized to reduce 25% of emissions associated with up to 7,500 MMBtu of daily usage. In 2050, an estimated 78,186 $MTCO_2e$ will remain, assuming the same carbon offset assumptions.[45]

However, city-only natural gas-related emissions are expected to decline to an estimated 49,287 $MTCO_2e$ in 2030, reflecting a 43% decrease from 2011, nearly achieving the 45% reduction target. This means in the BAU case, the 2030 carbon reduction target of 45% for city-only emissions is very close to being achieved through a combination of existing initiatives and efforts by Charlottesville Gas, which include energy efficiency measures and certified carbon offsets.

By 2050, city-only estimated emissions are forecasted to decline to 44,573 $MTCO_2e$, or a 49% reduction from the 2011 level, falling short of the carbon neutrality target, provided that certified carbon offsets continue to be utilized under the same assumptions.[46] To achieve the 100% carbon reduction goal, it is imperative that Charlottesville Gas take more aggressive measures to curb and offset carbon emissions.

A small but notable emissions decline expected in the BAU and in all decarbonization pathways is the replacement of the last mile of cast-iron pipe with the HDPE plastic pipe via the federal grant awarded to Charlottesville Gas. According to the EPA, the average mile of cast-iron distribution main loses nearly 240 thousand cubic standard feet (MCSF) of natural gas per year compared to 9 MCSF per year for one mile of plastic main. Between 2024 and 2050, an estimated 3,607 $MTCO_2e$ is expected to be reduced because of the replacement.

While the BAU forecast demonstrates positive progress towards Charlottesville Gas's emissions reduction targets, it should be noted that progress towards these targets will only be achieved if the

[45] Black & Veatch applied the emissions factor provided by Charlottesville Gas and used it in its GHG EPA reporting. The factor of 0.0544 $MTCO_2$/ MCF is used and applied in all scenarios.

[46] In all city-only emissions forecasts estimated UVA emissions are not included. As UVA related natural gas usage and emissions decline consistent with their own decarbonization strategies, the allocation of city-only emissions as part of the total systemwide emissions increases, explaining the relatively limited further decline in city-only emissions between 2030 and 2050. As an example, in 2030 it is estimated that city-only throughput and emissions account for 42.5% of systemwide throughput in 2030. In 2050, this number increases to 57% of systemwide throughput.

forecasted assumptions (or other natural gas demand declines not assumed in this analysis) are realized. As an example, if throughput on the Charlottesville Gas system does not decline as forecasted (driven particularly from the 1% year-over-year decline in consumption from residential energy efficiency and the decline of natural gas usage from UVA), Charlottesville Gas should not expect to realize the forecasted emissions reduction declines in the BAU nor in the forecasted decarbonization pathways. To account for these unknowns, Black & Veatch recommend that Charlottesville Gas consider updating this study on an iterative basis for more accurate emissions reduction projections.

3.2 Net Present Value and Rate Impact Methodology

In the BAU forecast, as well as in all six decarbonization pathways, Black & Veatch calculated the rough-order-of magnitude net present value (NPV) of total natural gas costs, certified carbon offset costs, and alternative low-carbon fuel costs under each pathway. All decarbonization pathways and the BAU NPVs are compared later in this section and represent the total horizon NPV. Cost assumptions were also used to calculate the expected rate impact of decarbonization pathways compared to the BAU. A weighted average cost of capital (WACC) of 7.2% was assumed in accordance with 2023 EIA AEO average WACC under moderate case. All financial results in this report are shown in nominal US dollars (which accounts for inflation of 3%) unless otherwise noted.

Black & Veatch leveraged a combination of Charlottesville Gas-provided inputs and proprietary inputs from Black & Veatch using in-house subject matter expertise. Natural gas costs were based on the recent Charlottesville Gas actuals and increased annually by 3% after 2028 on a year-over-year basis. Transportation costs were also based on recent actuals and increased annually with an annual inflation of 3%. Certified carbon offset prices remained consistent with actuals through the end of the contracted period in 2026, then increased by 3% on a year-over-year basis.

In the decarbonization pathways, Black & Veatch developed the inputs and assumptions by drawing on publicly available sources from 2023 EIA AEO and Renewable Sources of Natural Gas Study from the American Gas Foundation prepared by ICF as well as its in-house subject matter expertise and past project experience.[44,51]

- Hydrogen (H_2):
  - Blue or green H_2 was projected to be blended into the system starting in 2031. The blend rate as a percentage of total throughput (by volume) was assumed to ramp up to 15% from 2040 onward. H_2 costs were expected to experience a 0.8% increase from $10.4/MMBtu to $12.2/MMBtu in nominal terms between 2031 and 2050 due to slight decline of production cost and inflation; nominal transportation costs associated with H_2 were anticipated to grow by 3% on a year-over-year basis, from $6.6/MMBtu to $11.6/MMBtu for green H_2, and from $6.0/MMBtu to $10.5/MMBtu for blue H_2.
- Renewable Natural Gas (RNG):
  - RNG share of the total throughput was assumed to be introduced gradually at 5% from 2027, ramp up to 10% in 2031, jump to 20% by 2040, and maintain at 22% thereafter.
  - RNG production cost was derived from the analysis of all feedstocks, including landfill gas, animal manure, water resource recovery facility, and food waste. The cost was projected to start at $14.5/MMBtu in 2027 and then increased by 3% on a year-over-year basis to $22.7/MMBtu by 2050. RNG costs vary dramatically by feedstock, availability, and location. Additional assessment and procurement opportunities should be evaluated to further refine these costs assumptions.
  - It was estimated that existing natural gas pipelines would be utilized to transport RNG, so RNG transportation costs would mirror natural gas transportation costs.

- Certified Carbon Offsets:
  - In Full Decarbonization Pathways – Blue and Green, the carbon offset quantity was estimated to utilize the same calculation method as Moderate Pathways, except in 2030 and 2050 whereby certified carbon offset quantities were customized to ensure the decarbonization goals were met.
  - In Moderate Decarbonization Pathways – Blue and Green scenarios, Black & Veatch assumed that the certified carbon offset quantity would be determined using the same approach as in the BAU scenario, namely 25% of maximum 7,500 MMBtu of gas consumption per day.
  - In Light Decarbonization Pathways – Blue and Green, the certified carbon offset program was modeled to sunset after the existing contract terms in 2026.

Black & Veatch assessed the impact on the rate for an average single-family household using 4,600 cubic feet of natural gas per month by adding up the fuel charge, delivery charge, and revenue requirement (excluding gas costs) to calculate the monthly bill for all six decarbonization pathways. This approach provides an estimate as to how much the average monthly bill would increase under each pathway and how much it would increase over time from 2035 to 2050 under each scenario. All decarbonization pathways assumed the gradual replacement of natural gas with blue and/or green H_2 and RNG fuel.

The green and blue H_2 pricing assumed in this analysis is based on a gradual decline of capital costs for the production facilities, and the applicable Inflation Reduction Act (IRA) 45V credits obtained by H_2 producers will be reflected in lower production costs. However, as there are very few green and blue H_2 production facilities in operation, these cost estimates are expected to fluctuate significantly over time; therefore, the H_2 pricing assumptions should be monitored, and the analyses updated to reflect the continuous evolution of this market.

3.3 Decarbonization Pathways Development

Following the establishment of the BAU, six alternative decarbonization pathways were modeled to evaluate the full range of solutions that Charlottesville Gas could consider, with some pathways meeting the required emissions targets and others not. This study was intentionally designed this way to show the range of decarbonization investment decisions required. Notably, these pathways were developed through the lens of lowering the emissions from natural gas provided by Charlottesville Gas only. Municipal actions outside of the scope of this study and funded by non-gas rate payers, such as citywide electrification efforts, EVs, and municipally-owned on-site renewable energy, are outside of the scope and intent of this study. Customer-led initiatives such as fuel switching and behavior modification for fuel-switching or energy efficiency are largely dependent on end-use customer's willingness to invest or modify behavior. While Charlottesville Gas will continue to promote the efficient use of natural gas, customer adoption rates of fuel switching, and energy efficiency were not included in this scope of study. Financial incentives such as rebates to purchase heat pumps that could promote switching from natural gas to electric are available to qualified Virginia consumers.

Further, in 2022, Virginia passed a bipartisan law (§56-265.4:7), considered a customer protection bill. It defined a procedure that if a municipality was interested in discontinuing natural gas service, then it would be required to give customers a 3-year notice period and attempt to sell or auction the utility in good faith or potentially face legal challenge. Charlottesville Gas operates within the Columbia Gas service area, so it is likely that Columbia Gas is the only viable buyer for the gas utility, removing leverage from the City in negotiating a sale. If the City chose to sell the gas utility, it would have to meet the

conditions of the City Charter and State Law. Further exploration of the discontinuation of service is excluded from this scope of this assessment.[47]

To evaluate the decarbonization opportunities at Charlottesville Gas, Black & Veatch completed a rigorous data collection process with Charlottesville Gas to develop an understanding of its equipment, procurement, regulation, and operations today. From this process, Black & Veatch developed an extensive understanding of the Charlottesville Gas system, with four foundational findings informing the development of these decarbonization strategies:

- Charlottesville Gas procures all of its natural gas and certified carbon offsets via an agreement with BP.
- Charlottesville Gas does not operate any compressor stations or other large pipeline equipment eligible for electrification.
- Consistent with Virginia Code, Charlottesville Gas operates on a "break-even basis," unlike investor-owned utilities, who are able to earn a "fair" rate of return (profit). Further, the discontinuation of the natural gas utility itself is not an eligible alternative given the findings detailed in Appendix A. Review of Federal, State, and Local Laws and Codes.
- Strategies involving municipal buildings and municipally-owned facilities are outside the scope of this study.

Noting these findings, a framework was developed to comprehensively evaluate decarbonization alternatives considering technical, economic, and jurisdictional viability. Further, commercial accelerators and risks, economics, and business case applications were considered. The following criteria in evaluating options for consideration by Charlottesville Gas include:

- Commercial Viability
- Emissions Reduction Potential
- Feasibility in the Territory Footprint
- Safety
- Reliability and Resiliency
- Existing Infrastructure Compatibility
- Study Scope Confines
- Short-/Mid-/Long-Term Potential

After consideration of the above criteria, the study scope, and discussion with both Black & Veatch subject matter experts and Charlottesville stakeholders, a combination of low-carbon fuels and certified carbon offsets were evaluated to determine the potential pathways for Charlottesville Gas. As described earlier in this report, Charlottesville Gas hired a local consulting firm in the summer of 2024 to complete extensive feedback sessions. Further, throughout this engagement, Charlottesville Gas worked closely with the City's sustainability team members and presented interim results and decarbonization approaches to the Charlottesville City Council. Interim presentations to the Charlottesville City Council were provided in March 2023, October 2023, and March 2024.

[47] Additional detail can be found in Appendix A. Review of Federal, State, and Local Laws and Codes. Black & Veatch did not conduct legal research included in this analysis.

As a result of the above process, the following solutions were considered in development of decarbonization pathways for Charlottesville Gas to meet both its mid-term and long-term emissions reduction targets. The decarbonization strategies presented reflect actions that Charlottesville Gas can take to reduce or offset natural gas related emissions.

3.3.1 Low Carbon Fuel Alternatives

The emergence of low carbon fuels such as H_2 and RNG presents an opportunity for Charlottesville Gas to consider on its journey to decarbonization. Federal and state initiatives continue to drive investment toward further commercialization of these fuels, and the US Department of Energy's (DOE) multibillion dollar investment in H_2 hub development across the United States demonstrates the long-term value of these fuels in a decarbonized future. This assessment focuses on the role of green and blue H_2 and RNG specifically.

In 2023, the Biden Administration and DOE announced $7 billion for seven Regional Clean Energy Hubs (H_2Hubs).[48] The goal of these hubs is to "accelerate the commercial-scale deployment of low-cost, clean hydrogen."[49] The planning, design, and development of these hubs continues with three hubs awarded money for these efforts in July 2024. These hubs represent a range of clean hydrogen development, leveraging renewables, nuclear, natural gas, and more. This investment marks the confidence of the DOE in the future prospect of this low-carbon fuel.

The DOE also launched the Hydrogen Shot in June 2021, aimed at accelerating hydrogen technology breakthroughs and reducing the cost of clean hydrogen by 80% to $1 per kilogram within a decade. Further, the Bipartisan IRA allocated $1 billion to a Clean Hydrogen Electrolysis Program that aims to reduce the cost of hydrogen produced from clean electricity. The IRA also created a new Hydrogen Production Tax Credit (45V) that incentivizes the domestic production of clean hydrogen. It is expected that these combined incentives will reduce the overall commercial costs for customers like Charlottesville Gas.

As shown in Figure 19, green H_2 is produced from the electrolysis of water powered by renewable energy. While generally considered a carbon-free fuel, the production of green H_2 globally remains limited because of the limitation of renewable energy resource capacity, high electrolysis costs, and a limited distribution network to transport the fuel. Alternatively, blue H_2, which is produced from reforming natural gas (or other fossil fuels) with carbon capture, is more widely available today and at a lower cost given the prevalence of fossil fuel assets. Despite a far lower emissions content than natural gas, blue H_2 is often dismissed in decarbonization planning because of the continued use of fossil fuel to produce. Blue H_2, like green, faces distribution network challenges the future DOE H_2 hub could alleviate.

[48] The seven hubs were selected for award negotiations. Further details on hub specifics, defined funding, and next steps should be monitored on the DOE website.

[49] Biden-Harris Administration Announces $7 Billion For America's First Clean Hydrogen Hubs, Driving Clean Manufacturing and Delivering New Economic Opportunities Nationwide

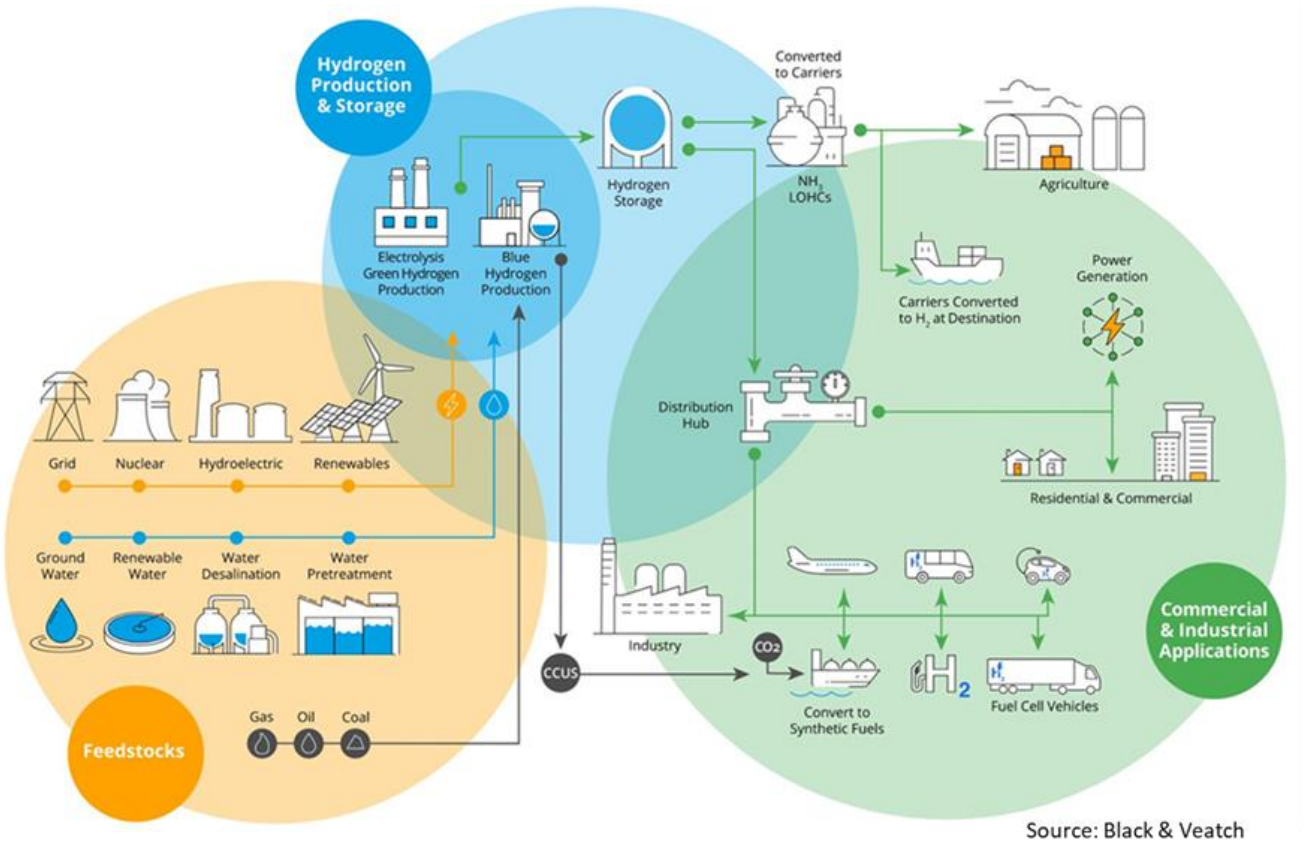


Figure 19 Hydrogen Value Chain

RNG is a pipeline quality biogas developed using feedstock from landfills, livestock operations, wastewater treatment plants, food waste, and other organic feedstocks. While still considerably more expensive on a unit basis than natural gas, the pipeline quality of this gas makes it an easy and lower carbon substitute to provide short-term emissions reduction benefits with little to no changes to system operations.

The solutions provide a low to zero-carbon option in which Charlottesville Gas may consider replacing some of its natural gas to lower the emissions of the total pipeline blended fuel. The blending of these fuels is proposed in various quantities in consideration of economic, commercial, and existing infrastructure limitations.

The decarbonization pathways developed in this study separately incorporate the use of the blue or green H_2 to clearly demonstrate the emissions and cost implication of one solution over the other. However, in all pathways, H_2 blending is capped at 15% blending by volume. Today, 15% hydrogen blending is considered safe and reliable on the existing pipeline system. Any blending amounts exceeding 15% are likely to require upgrades on the pipeline systems and end-user appliances. In all pathways, pipeline H_2 pipeline blending begins at 5% in 2031, increasing to 15% in 2040.[50]

[50] Hydrogen blending in 2031 coincides with the forecasted deployment of the nation's hydrogen hubs. Blending percentages are by volume.

RNG is consistent in all decarbonization scenarios and projected to be procured by Charlottesville Gas starting in 2027 based on the forecasted availability of RNG feedstock for landfill gas, wastewater resource recovery facility, and food waste. The ratio is estimated based on total RNG resource potential in the state of Virginia, from the American Gas Foundation report, as a percentage of total gas consumption in the state.[51] It is assumed that Charlottesville Gas can procure up to 22% of its natural gas demand in 2040 through 2050 (roughly 438,000 MMBtus of RNG in 2050) in all scenarios.

Together, the blending of H_2 and RNG into the pipeline presents an opportunity for Charlottesville Gas to provide emissions reduction benefits, while still providing the pipeline gas services that it operates today. However, by capping pipeline blending of hydrogen at 15% (by volume) and RNG blending at approximately 22% to incorporate the feasibility and availability of these low-carbon fuels, there are remaining emissions from conventionally sourced natural gas that will need to be reduced for Charlottesville Gas to meet the City's 2030 and 2050 decarbonization targets. The 2050 pipeline blend is shown in Figure 20. Charlottesville Gas can deploy several strategies in which to reduce such remaining pipeline system emissions: adoption of certified carbon offsets and enhanced energy efficiency.

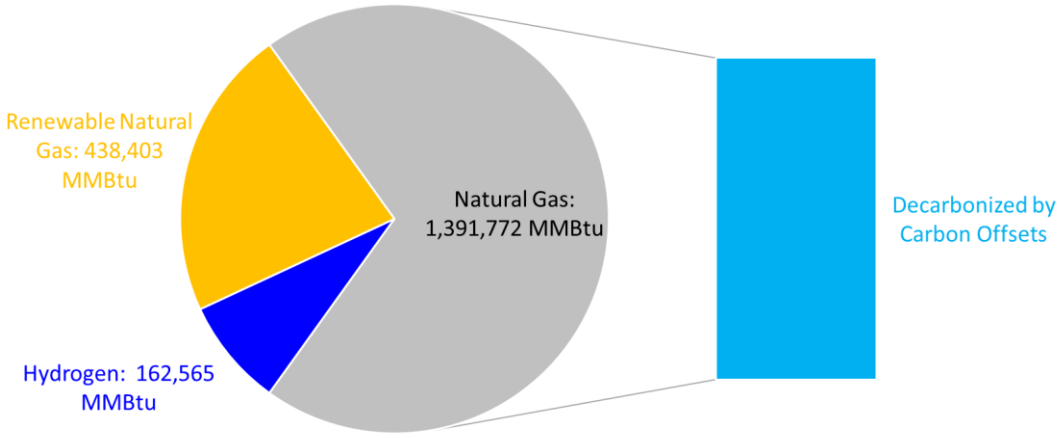


Figure 20 2050 Throughput Breakdown by Fuel Type

3.3.2 Certified Carbon Offsets

Carbon offsets are a mechanism for mitigating the effects of GHG emissions by funding projects that reduce or remove CO_2 from the atmosphere. By purchasing carbon offsets, organizations can offset their own carbon emissions by supporting projects that promote renewable energy, energy efficiency, reforestation, or other activities that reduce GHG emissions. *Certified* carbon offsets have undergone a rigorous third-party verification and certification processes to ensure that the carbon reduction or removal projects they support are credible, transparent, and permanent. These offsets are certified by independent organizations that follow recognized standards and protocols for measuring, tracking, and reporting GHG emissions. By purchasing certified carbon offsets, individuals and organizations can support high-quality projects that reduce GHG emissions and contribute to sustainable development, while also offsetting their own carbon footprint.

[51] Renewable Sources of Natural Gas - American Gas Foundation.

Charlottesville Gas has been leveraging certified carbon offsets as part of its ongoing emissions reduction strategies since the City Council approval in 2021. The certified carbon offset program has been generally supported with about 83% respondents to Charlottesville Gas's residential survey indicating that it supported the existing program, with 43% of respondents supporting greatly expanding the offset program, 28% supporting slightly expanding the offset program, and 12% believing the program should remain as is.[52] However, Charlottesville Gas recognizes that there are general concerns surrounding the potential of greenwashing and interest in sourcing more local offset projects.[53] To address these concerns, the presented decarbonization pathways include three levels of certified carbon offset adoption into the decarbonization pathways: continuation of the existing contract at 25% of daily throughput, discontinuation of certified carbon offset procurements after 2025, and maximized certified carbon offset procurement needed to meet decarbonization goals. Additional recommendations for future certified carbon offset procurement are outlined in Section 4.1, Decarbonization Pathway Considerations and Decision Points.

3.4 Systemwide Decarbonization Pathway Emissions Forecast and Cost Impacts

As described above, varying combinations of low carbon fuels paired with certified carbon offsets are combined to reach emissions reduction targets. The six pathways were each developed with varying levels of emissions reduction and decarbonization to reflect the range of impact that Charlottesville Gas may have in supporting the City's emissions reduction targets. Blue and green H_2 were modeled independently in each pathway to demonstrate the impact of each on emissions and investment. Figure 21 and Figure 22 provide a summary comparison of each of the decarbonization pathway's key assumptions and approach.

[52] Results are from the BeHeardCVA survey conducted by UVA's Center for Research.
[53] These concerns are referenced in Appendix D, Decarbonization Study Community Session Notes and Feedback.

		Decarbonization Pathways	
	Business-As-Usual	**Full Decarbonization: Green**	**Full Decarbonization: Blue**
Scenario Description	Assumes now new decarbonization initiatives. Reflects realized trends of decreasing gas demand through study horizon.	Meets the City of Charlottesville's decarbonization targets leveraging green H_2, RNG, and maximized carbon offsets.	Meets the City of Charlottesville's decarbonization targets leveraging blue H_2, RNG, and maximized carbon offsets.
Renewable Natural Gas		Up to 22% pipeline blending	Up to 22% pipeline blending
Green Hydrogen		Up to 15% pipeline blend by volume	None
Blue Hydrogen		None	Up to 15% pipeline blend by volume
Carbon Offsets	~25% of daily throughput offset (daily maximum of 7,500 MMBtu)	Maximized to achieve emissions targets	Maximized to achieve emissions targets

Figure 21 BAU and Full Decarbonization Pathways Assumption Comparison

		Decarbonization Pathways			
	Business-As-Usual	Moderate Decarbonization: Green	Moderate Decarbonization: Blue	Light Decarbonization: Green	Light Decarbonization: Blue
Scenario Description	Assumes now new decarbonization initiatives. Reflects realized trends of decreasing gas demand through study horizon.	Offers moderate decarbonization while not meeting targets. Evaluates the impact of green H_2 and RNG, while leveraging existing carbon offset assumptions.	Offers moderate decarbonization while not meeting targets. Evaluates the impact of blue H_2 and RNG, while leveraging existing carbon offset assumptions.	Explores the impact of low carbon fuels (RNG and green H_2) without carbon offsets. Results in the smallest emissions reduction.	Explores the impact of low carbon fuels (RNG and blue H_2) without carbon offsets. Results in the smallest emissions reduction.
Renewable Natural Gas		Up to 22% pipeline blending	Up to 22% pipeline blending	Up to 22% pipeline blending	Up to 22% pipeline blending
Green Hydrogen		Up to 15% pipeline blend by volume	None	Up to 15% pipeline blend by volume	None
Blue Hydrogen		None	Up to 15% pipeline blend by volume	None	Up to 15% pipeline blend by volume
Carbon Offsets	~25% of daily throughput offset (daily maximum of 7,500 MMBtu)	Maintains BAU assumptions	Maintains BAU assumptions	Retires the carbon offset program after 2026	Retires the carbon offset program after 2026

Figure 22 BAU and Moderate, Light Decarbonization Pathways Assumption Comparison

Given that the emissions reduction strategies modeled will provide significant emissions reduction potential to all Charlottesville Gas customers (including those in Albemarle County), emissions reduction results are presented on a systemwide basis. A summary of the estimated emissions impact for the City of Charlottesville is presented as part of this analysis.

3.4.1 Full Decarbonization Pathways

The BAU forecast provided the basis for which each of the six decarbonization pathways were modeled. Two pathways were designed to use certified carbon offsets to completely offset the remaining natural gas-related emissions over the full study horizon to meet both the 2030 and 2050 GHG reduction goals. The two pathways are identical other than the use of blue H_2 in one and green H_2 in the other.

- **Full Decarbonization Pathway: Green:** This pathway was developed to demonstrate what is required to meet the 2030 and 2050 emissions reduction targets. Together, a combination of RNG and green H_2 will lower the overall emissions of the pipeline gas. Natural gas, green H_2, and RNG will serve natural gas customers at the end of the horizon. Certified carbon offsets are maximized to reduce the remaining emissions to meet the 2030 and 2050 emissions targets.
- **Full Decarbonization Pathway: Blue:** This pathway is identical to the Full Decarbonization Pathway: Green except that it uses blue H_2 instead of green H_2. Certified carbon offsets are maximized to reduce the remaining emissions to meet the 2030 and 2050 emissions targets.

When comparing the emissions results of the two pathways, both meet the 2030 and 2050 emissions reduction targets. As expected, emissions declines begin to accelerate slightly more aggressively in the green H_2 scenario, given the lower emissions content. The Full Decarbonization Pathway emissions results are shown on Figure 23. Charlottesville city-only emissions are included in Table 3, and both proposed Full Decarbonization Pathways towards the City-only emissions reduction are expected to successfully meet the 2030 and 2050 emissions reduction targets. Projections show that by 2030, the City-only emissions reduction is anticipated to reach an impressive 64%, surpassing the initial target by a significant margin.[54]

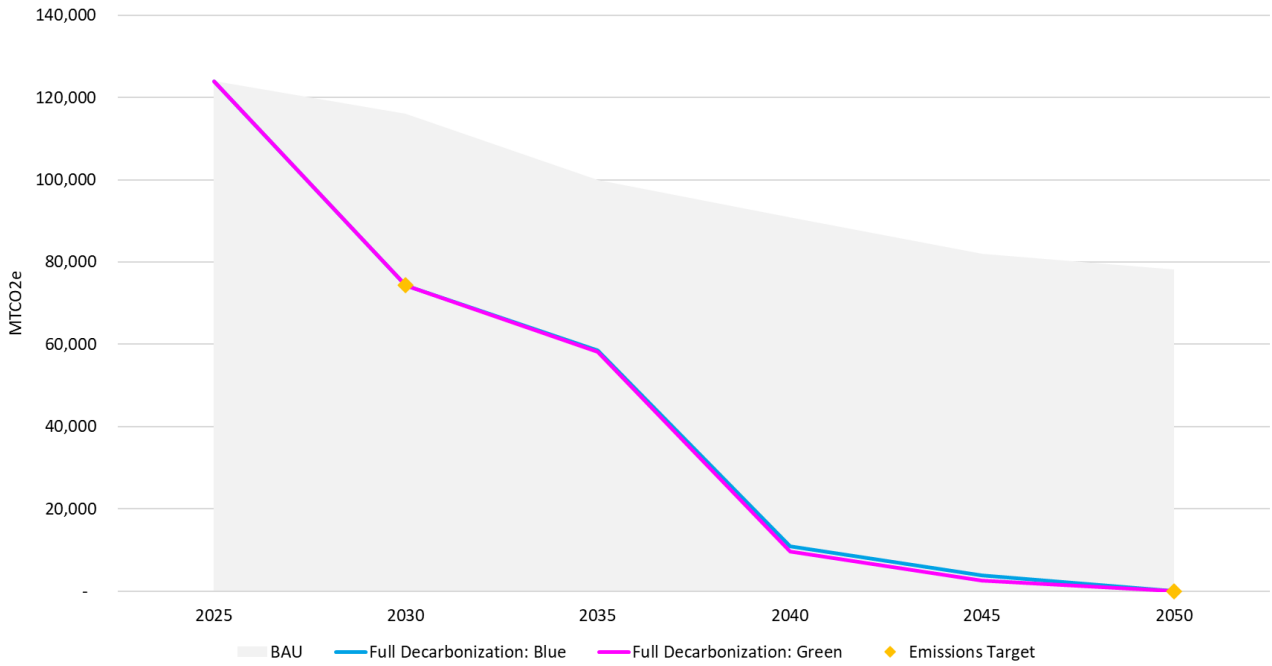


Figure 23 Full Decarbonization Pathway Systemwide Emissions Forecast

[54] UVA related emissions are excluded from city-only values throughout this report and summary results.

Table 3 Full Decarbonization Charlottesville City-Only Emissions Impact

	2030	2050
Charlottesville City Goal ($MTCO_2e$)	47,806	0
	% Reduced from 2011 Baseline	
Full Decarbonization: Green	64%	100%
Full Decarbonization: Blue	64%	100%

The total horizon NPV of the Full Decarbonization green H_2 versus blue H_2 are very close given the small volumes of H_2 being procured across both versions of the scenarios. However, both scenarios increase operational NPV by roughly $20 million ($21.1 million higher in the green H_2 pathways and $20.6 million higher in the blue H_2 scenario). This is driven by three decarbonization expenses: RNG procurement, hydrogen procurement, and additional certified carbon offsets. Additional certified carbon offset expenses account for only a small increase in the NPV ($134k in the green H_2 pathway and $138k in the blue H_2 pathway compared to the BAU). The Full Decarbonization: Green Pathway represents the highest NPV of all forecasted pathways. Figure 24 shows the comparison of the Full Decarbonization Pathways' NPVs compared to the BAU.

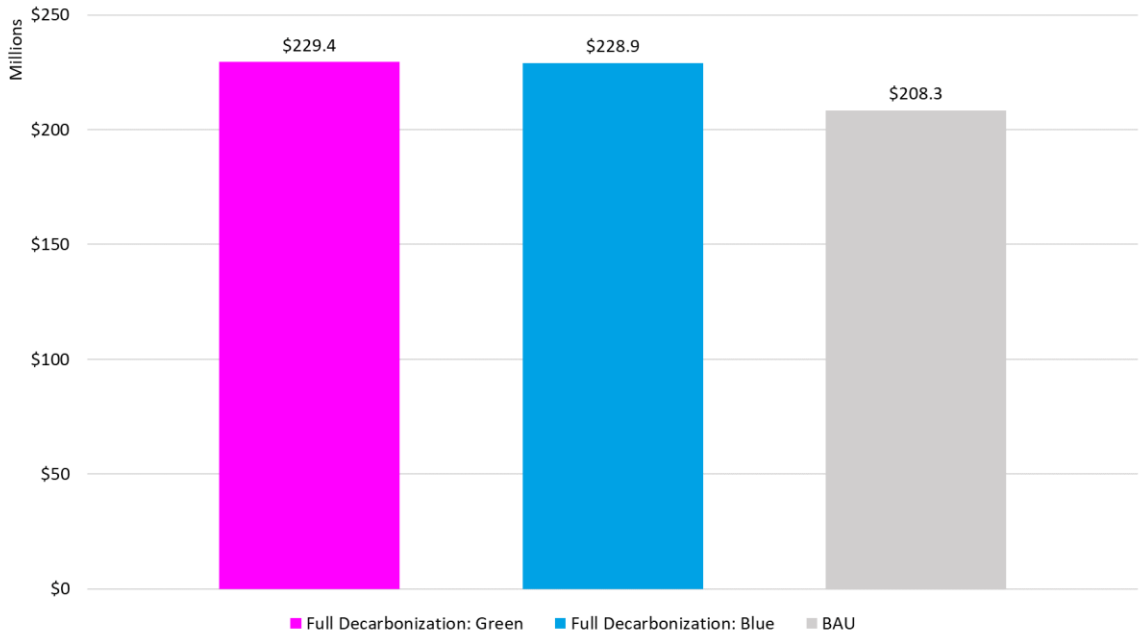


Figure 24 Full Decarbonization Pathway's Systemwide NPV Compared to BAU NPV

The Full Decarbonization Pathways represent an opportunity for Charlottesville Gas to decarbonize its natural gas system. If declines in throughput are not realized, Charlottesville Gas should expect to need more carbon offsets to meet emissions reduction targets. Currently, dramatic declines in UVA natural gas demand are forecasted, as well as a 1% year-over-year decline in the residential sector. If these forecasts are not realized, Charlottesville Gas should expect to spend more on carbon offsets and low carbon fuels to achieve the same emissions reduction targets. Differences between the forecasts and actuals should be considered in all decarbonization pathways modeled, as they will have both emissions and cost implications.

3.4.2 Moderate Decarbonization Pathways

Two pathways were designed to assume the same certified carbon offset contract volumes in place today to offset some the remaining natural gas-related emissions over the full study horizon. The two pathways are identical except for the use of blue H_2 in one and green H_2 in the other. The two pathways were developed to provide a realistic projection of what the emissions reduction potential could be if Charlottesville Gas continued its current strategy (including carbon offset procurement at the same levels) and added blending of H_2 and RNG. These two pathways are described below:

- **Moderate Decarbonization: Green:** This pathway demonstrates the impact of green H_2 and RNG on emissions from Charlottesville Gas, assuming the same use of carbon offsets as today. This pathway does not achieve the emissions targets but does achieve significant emissions reduction compared to the BAU from the use of lower carbon fuels.
- **Moderate Decarbonization: Blue:** This pathway is identical to the Moderate Decarbonization Pathway: Green except that it uses blue H_2 instead of green H_2. Similarly, this pathway does not fully achieve the emissions targets but leads to substantial emissions reduction compared to the BAU from the use of lower carbon fuels.

As shown in Figure 25, both Moderate Decarbonization Pathways fall short of meeting the 2030 and 2050 emissions targets. In 2050, the gap to full decarbonization is small with approximately 2,100 $MTCO_2e$ remaining in the green H_2 pathway and 3,300 $MTCO_2e$ remaining in the blue H_2 pathway. In 2030, the gap to the interim target is much greater; over 19,000 $MTCO_2e$ above the target in both pathways. The large gap between the forecast and 2030 emissions goals are driven by the conservative H_2 assumptions used in decarbonization modeling. If greater volumes of H_2 are available to Charlottesville Gas prior to 2031 (the forecasted start year for hydrogen blending), actual emissions reduction could be accelerated. Despite not firmly meeting the decarbonization target, these pathways provide significant emissions reduction potential by 2050.

City-only emissions are included in Table 4. Moderate Decarbonization Pathways city-only emissions reduction is forecasted to successfully meet and exceed the 2030 emissions target. Projections show that by 2030, city-only emissions reductions are anticipated to surpass the 2030 target by almost 10%. However, city-only carbon neutrality by 2050 may fall short by 1 to 2% under Moderate Decarbonization Pathways.

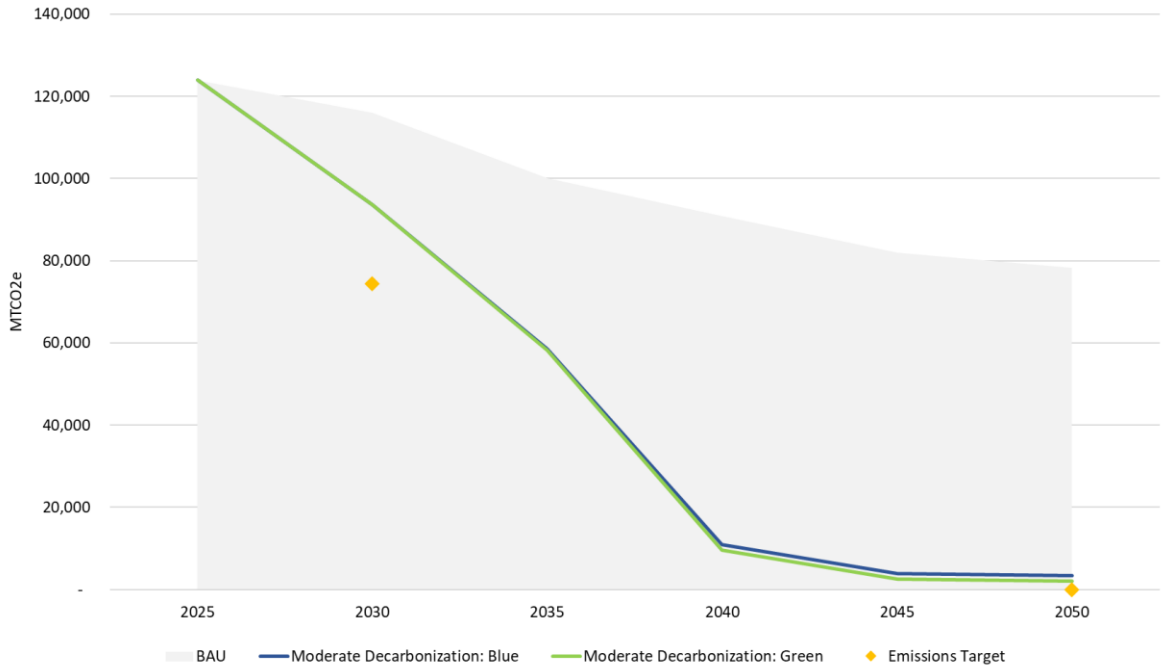


Figure 25 Moderate Decarbonization Pathway Systemwide Emissions Forecast

Table 4 Moderate Decarbonization Charlottesville City-Only Emissions Impact

	2030	2050
Charlottesville City Goal ($MTCO_2e$)	47,806	0
	% Reduced from 2011 Baseline	
Moderate Decarbonization: Green	54%	99%
Moderate Decarbonization: Blue	54%	98%

The Moderate Decarbonization Green Pathway NPV is only slightly lower than the Full Decarbonization: Green Pathway costs, given that the only difference between the two scenarios is the amount of certified carbon offsets procured. This same relationship exists between the Full Decarbonization Blue and Moderation Decarbonization Blue Pathways. Moderate Decarbonization Pathways NPVs are compared in Figure 26.

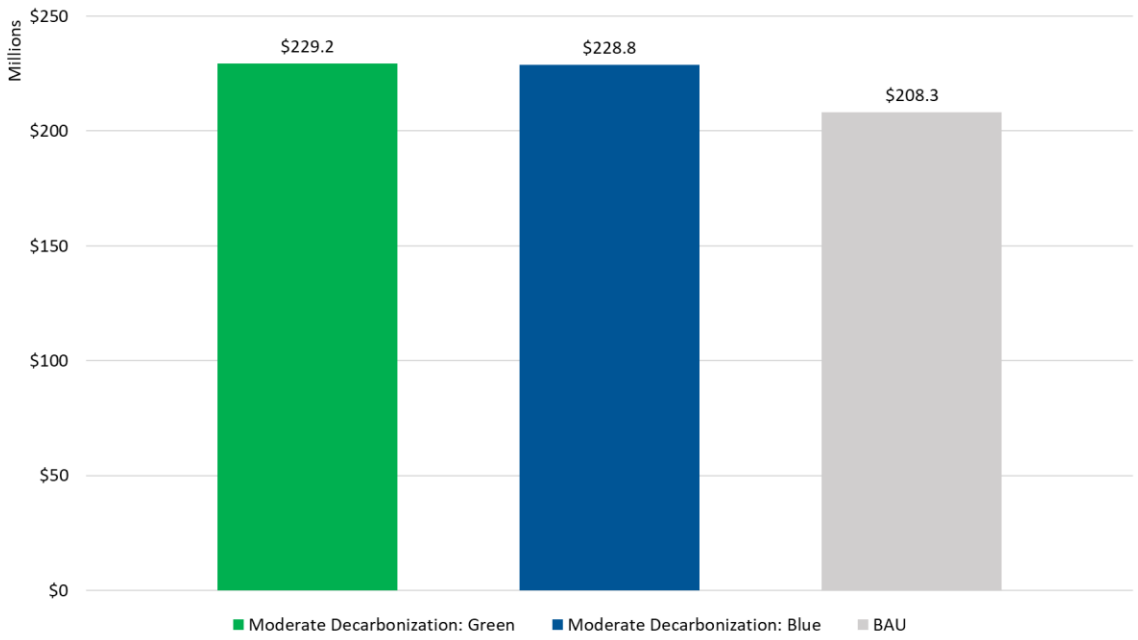


Figure 26 Moderate Decarbonization Pathway's Systemwide NPV Compared to BAU NPV

3.4.3 Light Decarbonization Pathways

Two pathways were designed to assume the elimination of certified carbon offsets when the existing contract expires at the end of 2025. The two pathways are identical aside from the use of blue H_2 in one scenario and green H_2 in the other. The two pathways were developed to provide a realistic forecast of what the emissions reduction potential could be if Charlottesville Gas discontinues the use of any kind of offsets and focused only on low-carbon fuel adoption. These two pathways are described below:

- **Light Decarbonization: Green:** This pathway demonstrates one of the least aggressive of all the decarbonization pathways, assuming the expiration of all certified carbon offsets following the end of the existing contract in 2026. Though emissions reduction is achieved due to green H_2 and RNG blending, overall reductions are far less when compared to the other pathways.
- **Light Decarbonization: Blue:** This pathway is identical to the Light Decarbonization Pathway: Green except that it uses blue H_2 instead of green H_2.

As shown in Figure 27, both Light Decarbonization Pathways fall short of meeting the 2030 and 2050 emissions targets. Because of the removal of certified carbon offsets, emissions in both pathways exceed that of the BAU. In 2050, the gap to full decarbonization is somewhat significant with approximately 28,000 $MTCO_2e$ remaining in the green H_2 pathway and 29,000 $MTCO_2e$ remaining in the blue H_2 pathway. In 2030, the gap to the interim target is much greater; over 55,000 $MTCO_2e$ above the target in both pathways. The dynamics of the Full Decarbonization and Moderations Decarbonization Pathways are true here too: limited hydrogen blending and RNG availability limit greater adoption of these low-carbon fuels in the short- to mid-term.

City-only emissions are included in Table 5. Neither the 2030 nor 2050 city-only emissions reduction targets are projected to be met under the Light Decarbonization Pathways, although significant carbon reductions are expected to be achieved when compared with the BAU.

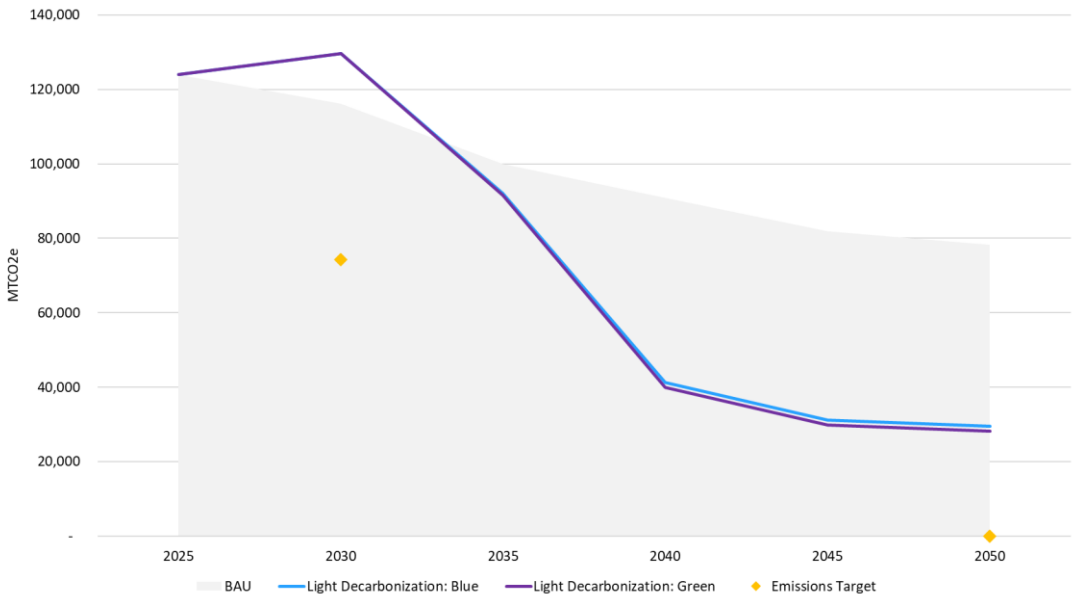


Figure 27 Light Decarbonization Pathway Systemwide Emissions Forecast

Table 5 Light Decarbonization Charlottesville City Emissions Impact

	2030	2050
Charlottesville City Goal ($MTCO_2e$)	47,806	0
	% Reduced from 2011 Baseline	
Light Decarbonization: Green	37%	82%
Light Decarbonization: Blue	37%	81%

The NPV of the Light Decarbonization Pathways represent the lowest cost to Charlottesville Gas when compared to the BAU. Cost savings are attributed only to the elimination of the certified carbon offset program from 2026 onward. NPV associated with RNG and H_2 remains consistent with the other decarbonization pathways. Light Decarbonization Pathways NPVs are compared in Figure 28.

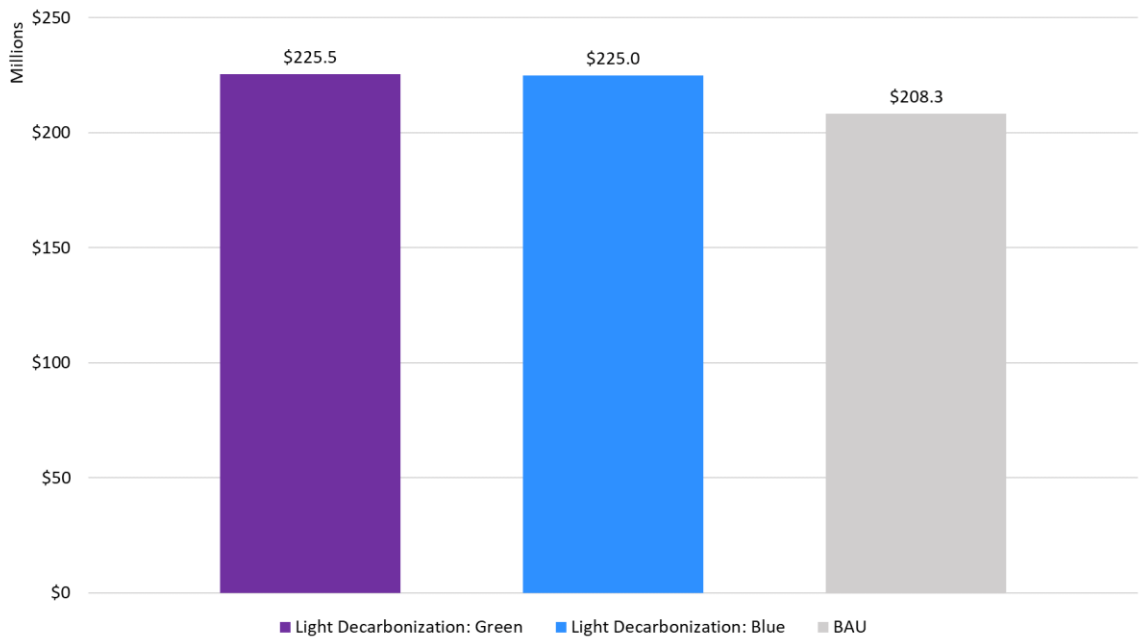


Figure 28 Light Decarbonization Pathway's Systemwide NPV Compared to BAU NPV

3.4.4 Decarbonization Pathway Considerations and Rate Impacts

Several primary levers drive the rate of emissions reduction, and the total emissions reduction potential of the strategies modeled in this decarbonization assessment. First is the availability of RNG for procurement. Sourcing reasonably priced RNG at the volumes required is currently still a challenge in most markets. RNG feedstock availability could also pose a risk and cost concern for Charlottesville Gas. Though these fuels are available today, demand for RNG continues to grow, and cost competitive procurement could increase cost and availability uncertainty. If required volumes become available sooner than currently assumed, Charlottesville Gas will yield greater emissions declines in the near- and mid-term.

A similar dynamic is true for H_2 fuels. While blue H_2 is commercially available today, it is still not available for procurement for utility use. Deployment of regional hydrogen hubs is likely to further increase accessibility and drive more favorable economics. This trend is even more true for green H_2, as costs for this fuel are still considerably higher than its blue H_2 counterpart. Any changes in prices and access to these fuels would greatly impact the speed at which Charlottesville Gas can decarbonize and the prices at which it does so.

As part of this study, Black & Veatch also calculated the estimated impact on end-user rates for each of the decarbonization pathways. The dynamics described above that result in changes to adoption of low-carbon fuels and the volumes of such would dramatically shift these rate impacts. Black & Veatch did not separately construct a rate model for different customer classes. Thus, these impacts should be viewed as directional in nature and highly speculative. However, given the increase in investment required and the comparatively low cost of natural gas today, Charlottesville Gas customers should expect that rates will increase significantly until low carbon fuels costs reach cost parity to natural gas. The directional bill impacts for Charlottesville Gas's average customer is provided in Figure 29.

Compared to Charlottesville Gas's existing customer bills, the estimated bill impact of each of the decarbonization pathways represents a considerable increase taking into account the historical 2023 bill

of $48.30 per month: the projections indicate that the bill is likely to increase at an average annual rate of 9% over time. By the year 2050, assuming the same monthly customer usage, the average bill could reach around $450 per month in nominal dollar terms under the decarbonization pathways. Estimated bill impacts should be carefully interpreted. If natural gas demand does not continue to decline as projected in this analysis, it is reasonable to assume that additional investment in decarbonization solutions, including the purchase of more certified carbon offsets and procurement of additional low carbon fuels, will be required to achieve emissions reduction targets in the Full Decarbonization Pathways. Additional expenses would absolutely increase estimated bill impacts and drive greater differences in bill impacts between all decarbonization pathways, but most significantly in the Full Decarbonization Pathway compared to the others.

As shown in Figure 29, forecasted bill impacts do not vary significantly between the Full, Moderate, and Light Decarbonization Pathways. This is driven by the fact that all assumptions, revenue requirement assumptions, gas pricing, RNG pricing and blending, blue and green H_2 pricing and blending, are identical in each pathway. Further, the same natural gas demand forecast was used in all pathways. The driver of the small bill impact differences is the amount of certified carbon offsets procured in each scenario. In the Full Decarbonization Pathways, certified carbon offset procurement is maximized to achieve emissions reduction targets. However, this could increase dramatically.

As an example, if between 2030 and 2045 if Charlottesville Gas does not realize the throughput declines forecasted in this study, Charlottesville Gas will need to procure more certified carbon offsets and more units of low carbon fuels to meet its 2050 goal. More simply, the greater the natural gas demand, the more investment in low carbon fuels and carbon offsets will be required to achieve decarbonization goals. Conversely, if natural gas demand declines greater than forecasted, it could result in less investment in decarbonization solutions.

	2023 Historical Estimated Average Bill	$ 48.3						
	2035			2050			%	
	Fuel + Delivery (Nominal $/Mcf)	Revenue Requirement (excluding gas costs) (Nominal $/Mcf)	Monthly Average Gas Bill (Nominal $)	Fuel + Delivery (Nominal $/Mcf)	Revenue Requirement (excluding gas costs) (Nominal $/Mcf)	Monthly Average Gas Bill (Nominal $)	Estimated YoY Increase from 2023 to 2050	
Full Decarbonization: Blue	$ 8.6	$ 17.6	$ 120.3	$ 16.7	$ 82.5	$ 456.4	9%	
Full Decarbonization: Green	$ 8.6	$ 17.6	$ 120.5	$ 16.8	$ 83.0	$ 458.9	9%	
Moderate Decarbonization: Blue	$ 8.6	$ 17.6	$ 120.3	$ 16.7	$ 82.3	$ 455.4	9%	
Moderate Decarbonization: Green	$ 8.6	$ 17.6	$ 120.5	$ 16.8	$ 82.9	$ 458.3	9%	
Light Decarbonization: Blue	$ 8.6	$ 17.2	$ 118.6	$ 16.7	$ 80.7	$ 448.1	9%	
Light Decarbonization: Green	$ 8.6	$ 17.2	$ 118.8	$ 16.8	$ 81.3	$ 451.0	9%	

Figure 29 Directional Residential Bill Impact of Decarbonization Pathways[55]

3.5 System Modeling and Considerations

This study considered the continued use of certified carbon offset to offset the remaining emissions in four of the six decarbonization pathways modeled. Today, this is a reasonable assumption for Charlottesville Gas to adopt in its decarbonization journey. However, there are alternative strategies and market dynamics that could reduce the amount of natural gas required to be offset, thereby reducing the currently forecasted dependency on certified carbon offsets.

[55] Estimated bill impacts assumed an average monthly usage of 4.6 MCF.

3.5.1 Energy Efficiency

Energy efficiency recommendations were developed and provided as part of this decarbonization study. However, extensive energy efficiency impact modeling is not included in the BAU nor the decarbonization pathways but should be considered a critical tool to reducing the use of natural gas by customers. A 1% year-over-year decline in residential natural gas demand is assumed in all forecasts, reflecting trends observed by Charlottesville Gas.

Energy efficiency adoption and impact is contingent upon two primary factors, only one of which energy providers can meaningfully impact: (1) development and offering of robust energy efficiency programs and incentives and (2) adoption of such incentives and changes to end user behavior to reduce natural gas consumption. Together these two factors can have a significant impact on reducing the amount of remaining natural gas in the Charlottesville Gas system in which certified carbon offsets or other decarbonization strategies must be applied.

As outlined in Section 2.3, Energy Efficiency Benchmarking, Charlottesville Gas has promoted efficient use of natural gas via its energy efficiency programs since 2001. However, as indicated, additional programs, expansion of existing programs, and customer adoption are critical to driving further decrease in energy demand from customers.

3.5.2 Out-of-Scope Solutions

There are a number of actions that could be taken by the City or by end-use customers of Charlottesville Gas that could result in lower emissions from the gas utility. However, end-user or municipality responsible actions such as renewable energy adoption and electrification were not incorporated into the decarbonization pathways approach as they are outside the control of Charlottesville Gas, nor can they be funded by Charlottesville Gas.

However, electrification initiatives across the globe are promoted to decrease the use of fossil fuels. While electrification can and does provide this benefit, the impact on emissions is dependent on the generation assets used to generate electricity. For Charlottesville Gas customers, however, electrification may not lead to proportional reduction of overall GHG emissions as Dominion Energy may continue to rely on electricity generated from natural gas generators to complement intermittent renewable generation sources. In its 2024 Integrated Resource Plan (IRP) for Virginia and North Carolina, Dominion Energy has proposed 5,934 MW of new natural gas capacity across all planning scenarios through 2039 in addition to solar, offshore wind, and battery storage capacity additions.[56]

[56] 2024 VA IRP, page 55.

4.0 Decarbonization Study Recommendations and Next Steps

4.1 Decarbonization Pathway Considerations and Decision Points

Though this analysis provides six decarbonization pathways for Charlottesville Gas to consider, the pace at which Charlottesville Gas considers these opportunities will be influenced by the impact to ratepayers and willingness to pay, as well as commercial availability of low carbon fuel supplies. Charlottesville Gas is one of the first, if not the first, municipal gas utility of its size to pursue a publicly available decarbonization study and initiative. Because of this, challenges arise that should be carefully contemplated as part of this engagement. This includes requirements of community engagement and education, limited funds for decarbonization solutions, and legal constraints paired with a highly evolving market with varying levels of decarbonization solution commercialization.

As it relates to the proposed decarbonization pathways presented in this report, Charlottesville Gas should carefully consider a number of different decision points and market indicators that will inform its forward-looking adoption of decarbonization solutions.

First, Charlottesville Gas should carefully monitor the development and deployment of the nation's hydrogen hubs, especially the Mid-Atlantic Clean Hydrogen Hub ($MACH_2$). Project development and operationalization of this hub has the potential to unlock access to H_2 supplies, both green and blue. In the same vein, Charlottesville Gas should work directly with its natural gas procurement partner (currently BP) to understand that company's plans for H_2 and RNG procurement, as well as related costs and availability. As the biofuels and low-carbon fuels market continues to evolve, Charlottesville Gas should monitor additional procurement opportunities of all pipeline fuels outside of its existing provider.

With changes to the government administration expected in January 2025, Charlottesville Gas should monitor the impact on decarbonization related funds and tax credits funded by the federal government. If tax credits and clean H_2 incentives were to be repealed, it can be expected that price forecasts and availability of low-carbon fuels would need to be reevaluated.

It is recommended that Charlottesville Gas partner with the Charlottesville Office of Sustainability to review and select certified carbon offset projects.[57] The carbon offset market is evolving with comprehensive measurement and verification programs and vendors that should be reviewed and considered prior to renewing its existing contract. A survey of certified carbon offset providers should be pursued to optimize costs, reduce concerns around greenwashing, and ensure that the certified carbon offsets procured meet the expectations of the Charlottesville community.

Regarding energy efficiency initiatives, Charlottesville Gas has already identified several short-term actions. First, the utility has developed a new fee structure that would disincentivize new gas connections. Revenue gathered from this program will be reinvested to fund the expansion of the energy efficiency programs. This proposal will both reduce the number of new connections and help fund programs to drive more efficient gas usage.

Second, Charlottesville Gas plans to evaluate existing energy efficiency rebates as recommended in the energy efficiency benchmarking exercise. This process is already underway, and Charlottesville Gas plans to broaden its offerings and develop a new weatherization program. Further, Charlottesville Gas will

[57] Charlottesville Gas has indicated collaboration with the Office of Sustainability on this topic.

expand its Arbor Day Energy-Savings Trees Programs from annual to biannually (offered every spring and fall).

4.2 Recommendations for Future Studies and Limitations

Natural gas is a reliable and affordable energy source that millions of customers rely upon for critical end use, such as cooking or heating. In 2023, natural gas represented 36% of primary energy consumption in the United States. Decarbonization of natural gas is a monumental undertaking – there are no easy solutions. Implementation of alternative solutions to conventionally sourced natural gas will have to consider their impact on the reliability of the fuel and affordability to customers.

The Black & Veatch study assessed six decarbonization pathways that illustrate the impacts on carbon reduction goals and customer bills while maintaining the same level of reliable services that Charlottesville Gas is providing today. These pathways were constructed relying upon technology and economic trajectory expected as of today; technological breakthroughs and significant cost reductions in the future could increase the pace of Charlottesville Gas's decarbonization progress or reduce the impacts on customer bills.

Further, the decarbonization pathways represent natural gas demand forecasts based on perceived realities known today. Charlottesville Gas should revisit and update these analyses in several years to align natural gas demand forecasts and actuals to continue refining the expected impact on emissions reduction and investment costs to achieve decarbonization.

There are emerging decarbonization technologies and solutions that the City or Charlottesville Gas should monitor and could potentially implement once they develop into a more mature stage and become economically feasible. These solutions include the following:

- **Geothermal:** The stable temperature in shallow depth subsurface can be utilized as a natural cooling and heating source to modulate seasonal temperature variations to achieve cooling and heating for buildings. It is typically designed as a series of heat pumps that circulate water through looped piping underground. The system is best applied in dense population centers and with significant seasonal temperature variations. Pilot programs have been established to understand the technical and operational effectiveness of these systems.
- **Direct Air Capture (DAC):** DAC projects directly extract CO_2 from the atmosphere utilizing specialized filters or chemicals. The captured CO_2 could be viewed as direct offset of the emissions from Charlottesville Gas's remaining gas operations procured from conventional sources. There is a tax credit available for DAC projects in the IRA (45Q). However, the current technology still makes DAC projects cost much higher than the tax credits and makes it an expensive offsetting mechanism.

Charlottesville Gas is a pioneer in performing a comprehensive review of strategies to decarbonize its natural gas system. Black & Veatch recommends close monitoring of natural gas utilities across the country exploring various carbon reduction solutions, as innovations and efficiency improvements could expedite Charlottesville Gas's pace of decarbonization strategy implementation.

5.0 Glossary

5.1 Abbreviations

AEO	Annual Energy Outlook
ApCo	Appalachian Power Company
BAU	Business-as-Usual
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CSR	Center for Survey Research
DAC	Direct Air Capture
DIMP	Gas Distribution Integrity Management Program
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EV	Electric Vehicle
GHG	Greenhouse Gas
GW	Gigawatt
H_2	Hydrogen
HDPE	High-Density Polyethylene
HEAR	Home Electrification and Appliance Rebate Program
HPWH	Heat Pump Water Heater
IRA	Inflation Reduction Act of 2022
kg	Kilogram
LEAP	Local Energy Alliance Program
MCSF	Thousand Cubic Standard Feet
MMBtu	Million British Thermal Units
MMCF	Million Cubic Feet
MT	Metric Tons
NPV	Net Present Value
PHMSA	Pipeline and Hazardous Materials Safety Administration
PV	Photovoltaic
RNG	Renewable Natural Gas
SME	Subject Matter Expert
UVA	University of Virginia
VCEA	Virginia Clean Energy Act
WACC	Weighted Average Cost of Capital

5.2 Definitions

Blue H_2	Hydrogen produced from reforming natural gas (or other fossil fuels) with carbon capture. Blue H_2 is assumed to have 1.0 kg CO_2e/kg H_2.
Carbon Offsets	A reduction or removal of emissions of carbon dioxide or other greenhouse gases made in order to compensate for emissions made elsewhere.
Cathodically Protected Steel	Cathodic protection is a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell. In the case of cathodically protected steel, it slows down or prevents corrosion. This is commonly used in the construction of pipelines, offshore oil rigs, and other structures that are exposed to harsh environments where corrosion is a major concern.
CO_2e	A single metric to compare the emissions from various GHGs based on their global warming potential. CO_2e signifies the amount of CO_2 which would have the same global warming impact as the emitted gas.
Distribution Main	The pipe that brings gas through a service territory to areas of mass consumption.
Distribution Service	The pipe that connects customer meters with the distribution main for consumption.
Dual-Fuel System	A home comfort system that pairs an electric heat pump with a gas furnace. Based on the outside temperature, the system will alternate between the two fuel sources maximizing efficiency to heat and cool a building.
Electrification	Replacing technologies or processes that use fossil fuels with electric powered equivalents.
Energy Efficiency	The practice of using less energy to perform the same tasks or achieve the same results. This can be achieved through various means, such as upgrading to more efficient appliances, using better insulation in buildings, or implementing more efficient transportation methods.
Fuel Switching	Transitioning from carbon-intense fuels (like gasoline or propane) to low or zero carbon alternatives (like renewable energy) in homes, vehicles, and across the electric grid.
Fugitive Pipeline Emissions	Refers to the unintended release of gases or vapors from a pipeline system into the surrounding environment. These emissions can occur due to leaks, equipment malfunctions, or other operational issues, and can include gases such as methane, ethane, propane, and other hydrocarbons.
GHG	Heat trapping gases in the Earth's atmosphere that contribute to the greenhouse effect. CO_2, methane, and water vapor are the most commonly referenced greenhouse gases.
Green H_2	Hydrogen produced from the electrolysis powered by renewable energy. Green H_2 is generally assumed to be carbon-free.
HDPE Plastic	A type of flexible plastic pipe that is lightweight, durable, and corrosion-resistant, which makes it a popular choice for pipeline infrastructure projects that require long-lasting materials.
HEAR Program	IRA Section 50122. A point-of-sale rebate program that is focused on efficient electrification projects for low- to moderate-income households (less than 150% of the area's median income). Projects include heat pump water heaters, heat pump for space heating/cooling, electric range, electric clothes dryer, insulation, air sealing, ventilation, Electric wiring, and electric load service center upgrades.
IRA	The IRA is a piece of federal legislation that was passed by the 117th US Congress and signed into law by the President in Summer 2022. It specifically allocates $369 billion to energy and climate change spending.
Methane	A colorless, odorless flammable gas which is the main constituent of natural gas.

MMBtu	A thermal unit of measurement for natural gas.
RNG	A pipeline quality gas that is fully interchangeable with conventional natural gas. The gaseous product of the decomposition of organic matter that has been processed to purity standards to match thermal qualities of natural gas.

APPENDIX A: REVIEW OF FEDERAL, STATE, AND LOCAL LAW AND CODES

DECARBONIZATION STUDY

Charlottesville Natural Gas Municipal Utility

PREPARED FOR

Utilities
City of Charlottesville

Charlottesville Gas Utility

DISCLAIMER: THIS SUMMARY WAS PREPARED BY EXTERNAL LEGAL COUNCIL FOR CHARLOTTESVILLE UTILITIES.

During the study scope development, there was an interest in reviewing the legality of decommissioning natural gas utility operations and banning new connections, even though this was not the intent of the decarbonization study. Virginia is a Dillon Rule state where powers must be explicitly granted to localities by the state, so if the Virginia General Assembly has not passed a law granting a locality the power to decommission a utility or ban new connections, then the locality cannot take those actions.

In local and state laws, there is language protecting the customer with regards to its utilities. Within the City Charter (§28), if the City wishes to sell the water, sewer or natural gas utility, City Council would have to pass a resolution requiring a super majority vote (4 out of 5) of the councilors seeking a special election of the majority of the qualified voters approving the sale of the utility. The City Charter only speaks to the sale of the utility and is silent on discontinuing utility services.

In 2022, Virginia passed a bipartisan law (§56-265.4:7) that was considered a natural gas protection bill. It laid out a procedure that if a municipality was interested in discontinuing natural gas service, then it would be required to give customers a 3-year notice period and try to sell or auction the utility in good faith or potentially face legal challenge. Charlottesville Gas operates within the Columbia Gas service area, so it is likely that they are the only viable buyer for the gas utility, removing leverage from the City in negotiating a sale. If the City chose to sell the gas utility, it would have to meet the conditions of the City Charter and State Law.

If the City of Charlottesville is interested in a new natural gas connection ban, then City Council would have to amend the City Code. While no city in Virginia has implemented a natural gas connection ban, other cities in other states have implemented a ban on new connections, and they are being challenged. Specifically, Berkeley, California, was the first city in the United States to ban natural gas hookups in new construction. However, in March 2024, Berkeley repealed its natural gas ban in new construction after losing a legal challenge. Charlottesville Gas ended marketing for new gas connections in 2018. Since that time, the utility has seen a natural decline in requests for new connections, with a 62% decrease from 2018 to 2023.

APPENDIX B: BEHEARDCVA GAS MITIGATION REPORT

DECARBONIZATION STUDY

Charlottesville Natural Gas Municipal Utility

PREPARED FOR

Utilities
City of Charlottesville

Charlottesville Gas Utility

DISCLAIMER: THIS SUMMARY WAS PREPARED BY BEHEARDCVA FOR CHARLOTTESVILLE UTILITIES.

BeHeardCVA - Gas Mitigation Survey 2022

UVA's Center for Survey Research (CSR) conducted a survey sponsored by the Charlottesville Gas Division to understand attitudes towards natural gas and sustainability among residents of Charlottesville City and Albemarle County. This survey was conducted with CSR's regional survey panel, BeHeardCVA. Between October 13, 2022 and November 12, 2022, 846 BeHeardCVA panelists were invited to take the survey online or over the phone. A total of 303 panelists completed the survey, for a response rate of 36%. Survey results have been weighted to align more closely with the demographic composition of the population of Charlottesville plus Albemarle. The following summary tables and graphs provide a summary of panelists' weighted responses.

Summary Tables

Which of the following best describes the status of your primary home?

S1	N	Percent
Owned by you or someone in your household with a mortgage or loan (including home equity loan)	128	42.1%
Owned by you or someone in your household free and clear (without a mortgage or loan)	49	16.1%
Rented	119	39.4%
Occupied without payment of rent	7	2.4%

Which of the following best describes the status of your primary home?

A1	N	Percent
I have natural gas service at my home	139	45.8%
There is natural gas service available on my street but I am not a natural gas customer	36	11.8%
There is no natural gas service available on my street	67	22.1%
I'm not sure if there is natural gas service on my street or not	61	20.3%

If natural gas service was available on your street, do you think you would want to become a gas customer?*

A1a*	N	Percent
Definitely	23	18.1%
Probably	28	21.8%
Probably not	41	32.2%
Definitely not	15	12.0%
Can't say	20	15.7%

*Note: This question was only asked of respondents who did not have or were not sure if they had natural gas service on their streets.

How important is it to have natural gas available to your home?

A2	N	Percent
Extremely important	80	26.4%
Very important	57	18.8%
Somewhat important	71	23.5%
Not at all important	95	31.3%

How important is it to have natural gas available to your home? (*Customers*)

A2	N	Percent
Extremely important	70	50.6%
Very important	39	28.4%
Somewhat important	24	17.4%
Not at all important	5	3.6%

University of Virginia | Weldon Cooper Center for Public Service
Center for Survey Research

How important is it to have natural gas available to your home? (*Non-Customers*)

A2	N	Percent
Extremely important	10	6.1%
Very important	18	10.7%
Somewhat important	47	28.6%
Not at all important	90	54.6%

What type of cooktop or range do you use in your home?

A3	N	Percent
Natural gas	168	55.5%
Propane gas	94	31.1%
Electric	33	10.8%
Induction	8	2.7%

A4_1 - How likely would you be to consider buying a propane cooktop or range?*	Count	Percent	Valid percent
Very likely	30	44.3%	50.9%
Somewhat likely	4	5.4%	6.2%
Not very likely	5	7.9%	9.1%
Not at all likely	20	29.4%	33.8%
#Total	58	87.1%	100.0%
Missing/Don't know/ No opinion	9	12.9%	NA

* Note: This question was only asked of respondents who did not have natural gas service on their streets.

A4_2 - How likely would you be to consider buying an electric cooktop or range?*	Count	Percent	Valid Percent
Very likely	30	44.0%	47.8%5
Somewhat likely	5	8.1%	8.7%9
Not very likely	14	20.9%	22.6%8
Not at all likely	13	19.0%	20.6%9
#Total	62	92.0%	100.0%0
Missing/Don't know/ No opinion	5	8.0%	NA

* Note: This question was only asked of respondents who did not have natural gas service on their streets.

A4_3 - How likely would you be to consider buying an induction cooktop or range?*	Count	Percent	Valid Percent
Very likely	7	10.6%	13.3%
Somewhat likely	12	18.4%	23.2%
Not very likely	8	12.0%	15.1%
Not at all likely	26	38.5%	48.4%
#Total	53	79.5%	100.0%
Missing/Don't know/ No opinion	14	20.5%	NA

* Note: This question was only asked of respondents who did not have natural gas service on their streets.

A5 - What is the primary way that you currently heat your home?	Count	Percent	Valid Percent
Natural gas furnace	76	25.0%	27.3%
Conventional heat pump with electric back-up ("emergency") heat	114	37.6%	41.2%
Dual-fuel heat pump with natural gas back-up heat	13	4.3%	4.7%
Dual-fuel heat pump with propane gas back-up heat	12	3.8%	4.2%
Geothermal	1	0.3%	0.3%
Electric furnace	12	4.0%	4.4%
Propane gas furnace	8	2.5%	2.8%
Wood burning furnace	8	2.6%	2.9%
Oil furnace	6	2.0%	2.2%
Space heater(s)	7	2.3%	2.5%
Electric baseboard heat	8	2.8%	3.0%
Something else	12	4.1%	4.4%
#Total	277	91.3%	100.0%
Missing/Don't know/No opinion	26	8.7%	NA

If you were to replace the primary heating system in your home, what type of system would you install?*

A6*	N	Percent
Conventional heat pump with electric back-up ("emergency") heat	53	30.1%
Natural gas furnace	29	16.3%
Dual-fuel heat pump with natural gas back-up heat	19	11.1%
Geothermal	15	8.5%
Dual-fuel heat pump with propane gas back-up heat	9	5.2%
Electric furnace	5	2.7%
Propane gas furnace	2	1.0%
Wood burning furnace	2	1.4%
Something else	2	1.3%
Oil furnace	1	0.5%
Space heater(s)	1	0.3%

*Note: This question was only asked of homeowners.

Do you currently have a fireplace in your home?

A7	N	Percent
Yes	177	58.4%
No	126	41.6%

What type of fireplace do you have?*

A7a*	N	Percent
Wood burning	104	34.4%
Natural gas	39	12.7%
Propane gas	29	9.6%
Electric	2	0.5%

*Note: This question was only asked of respondents who answered 'yes' to Question A7.

If you were in the market for a fireplace, how likely would you be to consider buying one of the following types?: Propane*

A8_1*	N	Percent
Very likely	15	23.2%
Somewhat likely	20	30.2%
Not very likely	5	7.8%
Not at all likely	23	35.0%
Don't know/ No opinion	2	3.8%

*Note: This question was only asked of respondents who did not have natural gas service on their streets.

If you were in the market for a fireplace, how likely would you be to consider buying one of the following types?: Electric*

A8_2*	N	Percent
Very likely	0	0.0%
Somewhat likely	8	12.3%
Not very likely	7	11.5%
Not at all likely	45	71.9%
Don't know/ No opinion	3	4.3%

*Note: This question was only asked of respondents who did not have natural gas service on their streets.

If you were in the market for a fireplace, how likely would you be to consider buying one of the following types?: Wood burning fireplace/ stove*

A8_3*	N	Percent
Very likely	19	28.7%
Somewhat likely	20	30.3%
Not very likely	8	12.9%
Not at all likely	16	24.9%
Don't know/ No opinion	2	3.2%

*Note: This question was only asked of respondents who did not have natural gas service on their streets.

A9abc_1 - Natural Gas	Count	Percent	Valid Percent
1: Not efficient	7	2.2%	3.2%
2	4	1.2%	1.8%
3	30	10.1%	14.7%
4	62	20.3%	29.8%
5: Efficient	105	34.5%	50.6%
#Total	207	68.3%	100.0%
Missing/Unable to rate	96	31.7%	NA

A9abc_2 - Electric	Count	Percent	Valid Percent
1: Not efficient	18	6.1%	7.4%
2	23	7.5%	9.3%
3	77	25.6%	31.4%
4	59	19.3%	23.8%
5: Efficient	69	22.9%	28.1%
#Total	247	81.4%	100.0%
Missing/Unable to rate	56	18.6%	NA

A9abc_3 - Propane Gas	Count	Percent	Valid Percent
1: Not efficient	26	8.6%	16.2%
2	33	11.0%	20.6%
3	41	13.6%	25.5%
4	37	12.2%	22.8%
5: Efficient	24	7.9%	14.8%
#Total	161	53.3%	100.0%
Missing/Unable to rate	142	46.7%	NA

A9def_1 - Natural gas	Count	Percent	Valid Percent
1: Unreliable	2	0.5%	0.7%
2	1	0.4%	0.6%
3	14	4.5%	6.2%
4	34	11.2%	15.6%
5: Reliable	168	55.6%	76.9%
#Total	219	72.3%	100.0%
Missing/Unable to rate	84	27.7%	NA

A9def_2 - Electric	Count	Percent	Valid Percent
1: Unreliable	8	2.7%	3.0%
2	20	6.6%	7.3%
3	74	24.4%	27.2%
4	87	28.7%	32.0%
5: Reliable	83	27.5%	30.6%
#Total	272	89.9%	100.0%
Missing/Unable to rate	31	10.1%	NA

A9def_3 - Propane gas	Count	Percent	Valid Percent
1: Unreliable	8	2.7%	5.2%
2	20	6.7%	13.0%
3	15	4.9%	9.5%
4	36	11.8%	23.0%
5: Reliable	77	25.3%	49.3%
#Total	156	51.3%	100.0%
Unable to rate	147	48.7%	NA

A9ghi_1 - Natural gas	Count	Percent	Valid Percent
1: Expensive	7	2.3%	3.6%
2	12	4.0%	6.2%
3	43	14.3%	22.4%
4	45	14.7%	23.1%
5: Cost efficient	86	28.4%	44.6%
#Total	193	63.6%	100.0%
Unable to rate	110	36.4%	NA

A9ghi_2 - Electric	Count	Percent	Valid Percent
1: Expensive	47	15.6%	18.7%
2	53	17.5%	21.0%
3	89	29.3%	35.2%
4	32	10.7%	12.9%
5: Cost efficient	31	10.2%	12.2%
#Total	252	83.3%	100.0%
Unable to rate	51	16.7%	NA

A9ghi_3 - Propane gas	Count	Percent	Valid Percent
1: Expensive	32	10.5%	21.5%
2	45	14.9%	30.7%
3	35	11.5%	23.7%
4	13	4.2%	8.7%
5: Cost efficient	23	7.6%	15.5%
#Total	148	48.7%	100.0%
Missing/Unable to rate	155	51.3%	NA

A9jkl_1 - Natural gas	Count	Percent	Valid Percent
1: Harmful to the environment	61	20.3%	27.3%
2	37	12.2%	16.4%
3	46	15.3%	20.6%
4	42	13.8%	18.5%
5: Friendly to the environment	39	12.8%	17.3%
#Total	225	74.3%	100.0%
Missing/Unable to rate	78	25.7%	NA

A9jkl_2 - Electric	Count	Percent	Valid Percent
1: Harmful to the environment	39	12.8%	15.6%
2	37	12.1%	14.8%
3	75	24.9%	30.3%
4	54	17.9%	21.8%
5: Friendly to the environment	44	14.4%	17.5%
#Total	249	82.2%	100.0%
Missing/Unable to rate	54	17.8%	NA

A9jkl_3 - Propane gas	Count	Percent	Valid Percent
1: Harmful to the environment	88	29.0%	44.3%
2	32	10.5%	16.1%
3	52	17.1%	26.2%
4	19	6.3%	9.6%
5: Friendly to the environment	8	2.5%	3.9%
Total	198	65.5%	100.0%
Missing/Unable to rate	105	34.5%	NA

A9mno_1 - Natural gas	Count	Percent	Valid Percent
1: Imported Energy	0	0.0%	0.0%
2	2	0.7%	1.0%
3	22	7.2%	10.1%
4	48	15.7%	22.3%
5: Made in America	142	46.9%	66.6%
Total	213	70.5%	100.0%
Missing/Unable to rate	90	29.5%	NA

A9mno_2 - Electric	Count	Percent	Valid Percent
1: Imported energy	0	0.2%	0.2%
2	7	2.4%	3.0%
3	20	6.5%	8.3%
4	41	13.7%	17.3%
5: Made in America	170	56.2%	71.2%
Total	239	79.0%	100.0%
Missing/Unable to rate	64	21.0%	NA

A9mno_3 - Propane gas	Count	Percent	Valid Percent
1: Imported energy	3	1.1%	2.0%
2	2	0.8%	1.4%
3	18	6.1%	11.3%
4	41	13.5%	24.9%
5: Made in America	99	32.7%	60.4%
Total	164	54.2%	100.0%
Missing/Unable to rate	139	45.8%	NA

Given a choice, which of the following types of cooktops or ranges would you prefer to cook with?

A10	N	Percent
Natural gas	135	46.1%
Electric	114	38.9%
Propane gas	12	4.2%
No preference	28	9.7%
I don't cook	3	1.0%

In my view, global climate change is . . .

A11	N	Percent
A very serious problem	230	78.8%
Somewhat serious	36	12.4%
Not too serious	21	7.1%
Not a problem	5	1.7%

Within the past three years, have any significant energy upgrades been made to your home?

B1	N	Percent
Yes	89	30.7%
No	195	66.8%
Don't know	7	2.5%

What energy upgrades were made to your home?*

B1a*	N	Percent
Updates to heating or air conditioning	47	52.9%
Insulation	39	43.4%
Replaced windows or doors	33	36.4%
Air sealing	25	27.8%
Installed solar panels	15	17.2%
Duct sealing	9	10.6%
Other	11	11.8%

*Note: This question was only asked of respondents who answered 'Yes' to question B1.

How familiar are you with the Attic Insulation Rebate Program?*

B2*	N	Percent
Familiar and I have applied for the rebate in the past	42	24.4%
Familiar but I have not applied for the rebate	14	8.2%
Not at all familiar	116	67.4%

*Note: This question was only asked of homeowners.

How likely you would be to apply for this rebate in the next year?*

B2a*	N	Percent
Very likely	18	11.5%
Somewhat likely	45	28.8%
Not very likely	60	38.3%
Not at all likely	34	21.4%

*Note: This question was only asked of homeowners who were unfamiliar with or had not applied for the rebate.

What would be the main reason for you to not apply for this rebate?*

B2b*	N	Percent
The amount of the rebate is insufficient to offset the majority of the cost of the attic insulation	13	13.4%
My house already has appropriate attic insulation	64	67.7%
Other	18	18.9%

*Note: This question was only asked of homeowners who indicated (in response to Question B2a) that they were not likely to apply for the rebate.

How familiar are you with the Tankless Water Heater Rebate Program?*

B3*	N	Percent
Not at all familiar.	117	68.4%
Familiar but I have not applied for the rebate.	48	28.2%
Familiar and I have applied for the rebate in the past.	6	3.4%

*Note: This question was only asked of homeowners.

How likely you would be to apply for this rebate in the next year?*

B3a*	N	Percent
Very likely	11	6.6%
Somewhat likely	37	22.6%
Not very likely	63	38.3%
Not at all likely	54	32.5%

*Note: This question was only asked of homeowners who were unfamiliar with or had not applied for the rebate.

What would be the main reason for you to not apply for this rebate?*

B3b*	N	Percent
The amount of the rebate is insufficient to offset the majority of the cost of the tankless water heater	41	35.6%
My house already has a tankless water heater	8	7.0%
Not interested in a natural gas tankless water heater	31	26.6%
Other	36	30.7%

*Note: This question was only asked of homeowners who indicated (in response to Question B3a) that they were not likely to apply for the rebate.

How familiar are you with the Programmable Thermostat Heater Rebate Program?*

B4*	N	Percent
Not at all familiar	97	56.8%
Familiar but I have not applied for the rebate	53	31.3%
Familiar and I have applied for the rebate in the past	20	12.0%

*Note: This question was only asked of homeowners.

How likely would you be to apply for this rebate in the next year?*

B4a*	N	Percent
Very likely	18	12.1%
Somewhat likely	25	16.4%
Not very likely	37	24.7%
Not at all likely	70	46.8%

*Note: This question was only asked of homeowners who were unfamiliar with or had not applied for the rebate.

What would be the main reason for you to not apply for this rebate?*

B4b*	N	Percent
The amount of the rebate is insufficient to offset the majority of the cost of the thermostat	6	5.2%
My house already has a programmable thermostat	80	75.3%
Not interested in a programmable thermostat	11	10.7%
Other	9	8.7%

*Note: This question was only asked of homeowners who indicated (in response to Question B4a) that they were not likely to apply for the rebate.

How could the Department of Utilities improve its Rebate Programs?*

B5*	N	Percent
Offering more rebates	56	31.7%
Increasing rebate value	42	23.6%
Other improvements	34	19.3%

*Note: This question was only asked of homeowners.

How familiar are you with the Free Home Weatherization Program?

B6	N	Percent
Familiar and I have already participated in the program	12	4.0%
Familiar but I don't meet the requirements	111	38.4%
Familiar but I don't know if I meet the requirements	23	7.9%
Familiar and I meet the requirements, but haven't participated yet	1	0.4%
Not at all familiar	143	49.4%

How familiar are you with the concept of carbon offsets?

C1	N	Percent
Very familiar	71	24.4%
Somewhat familiar	139	48.0%
Not very familiar	41	14.2%
Not at all familiar	39	13.4%

Before taking this survey, how familiar were you with Charlottesville Gas' carbon offsets program?

C2	N	Percent
Very familiar	9	3.1%
Somewhat familiar	46	16.0%
Not very familiar	49	17.3%
Not at all familiar	182	63.6%

I believe the carbon offset program should be…

C3	N	Percent
Greatly expanded	119	43.0%
Slightly expanded	77	27.7%
Should continue as is	34	12.2%
Slightly reduced	6	2.2%
Greatly reduced	9	3.3%
Completely eliminated	32	11.6%

D1 - Would you support a natural gas/propane ban?	Count	Percent	Valid Percent
Strongly support	13	4.2%	4.9%
Somewhat support	50	16.6%	19.7%
Neither support nor oppose	63	20.6%	24.5%
Somewhat oppose	50	16.4%	19.5%
Strongly oppose	80	26.4%	31.4%
Total	255	84.2%	100.0%
Missing/Not sure	48	15.8%	NA

How likely would you be to voluntarily convert all your gas appliances to electric ones in the next 10 years?

D2	N	Percent
Very likely	19	16.9%
Somewhat likely	19	16.3%
Neither likely nor unlikely	15	13.5%
Somewhat unlikely	17	15.0%
Very unlikely	44	38.3%

What would be the barriers to converting your appliances to electric? Please select all that apply.*

D3*	N	Percent
Cost of new appliances/ equipment	41	68.1%
Prefer natural gas appliances/ equipment	38	62.9%
Reliability of the electric grid	37	60.5%
Price of electricity	30	49.1%
Cost of upgrading my home's electric supply	26	42.3%
Other	10	16.6%

*Note: This question was only asked of respondents who indicated (in response to Question D2) that they were unlikely to convert their appliances to electric.

D4 - How confident do you feel that Dominion Energy will meet the VCEA's goal	Count	Percent	Valid Percent
Very confident	10	3.2%	3.6%
Fairly confident	48	15.9%	18.2%
Only slightly confident	106	34.9%	39.8%
Not confident at all	102	33.6%	38.4%
Total	265	87.6%	100.0%
Missing/Unable to rate	38	12.4%	NA

How familiar are you with each of the following types of decarbonization programs?: Renewable natural gas

E1_1	N	Percent
Very familiar	27	10.0%
Somewhat familiar	86	32.0%
Not familiar at all	156	57.9%

How familiar are you with each of the following types of decarbonization programs?: Certified natural gas

E1_2	N	Percent
Very familiar	22	8.1%
Somewhat familiar	58	21.5%
Not familiar at all	190	70.5%

How familiar are you with each of the following types of decarbonization programs?: Carbon offsets

E1_3	N	Percent
Very familiar	51	19.0%
Somewhat familiar	154	57.6%
Not familiar at all	63	23.4%

How familiar are you with each of the following types of decarbonization programs?: Green hydrogen technology

E1_4	N	Percent
Very familiar	21	7.9%
Somewhat familiar	84	31.5%
Not familiar at all	162	60.6%

How familiar are you with each of the following types of decarbonization programs?: Residential and commercial electrification

E1_5	N	Percent
Very familiar	49	18.1%
Somewhat familiar	73	27.0%
Not familiar at all	148	54.9%

E2 - How would you assess Gas Utility's commitment to Charlottesville's greenhouse gas emission reduction goals?	Count	Percent	Valid Percent
Highly committed	27	8.9%	15.2%
Somewhat committed	115	38.0%	64.9%
Not really committed	35	11.6%	19.9%
Total	177	58.6%	100.0%
Missing/Unable to rate	126	41.4%	NA

Crosstabulations

A11 * A1

			A1 Please select which of the following statements best applies to your household.				
			1 I have natural gas service at my home	2 There is natural gas service available on my street but I am not a natural gas customer	3 There is no natural gas service available on my street	4 I'm not sure if there is natural gas service on my street or not	Total
A11 In my view, global climate change is . . .	1 A very serious problem	Count	114	31	39	46	230
		% within A1	84.4%	86.1%	59.1%	83.6%	78.8%
	2 Somewhat serious	Count	13	4	17	3	37
		% within A1	9.6%	11.1%	25.8%	5.5%	12.7%
	3 Not too serious	Count	6	1	7	6	20
		% within A1	4.4%	2.8%	10.6%	10.9%	6.8%
	4 Not a problem	Count	2	0	3	0	5
		% within A1	1.5%	0.0%	4.5%	0.0%	1.7%
Total		Count	135	36	66	55	292
		% within A1	100.0%	100.0%	100.0%	100.0%	100.0%

Generally speaking, how satisfied or dissatisfied are you with the way things are going in your local community today?

F1	N	Percent
Very satisfied	9	3.4%
Somewhat satisfied	112	42.4%
Neither satisfied nor dissatisfied	31	11.7%
Somewhat dissatisfied	61	23.3%
Very dissatisfied	42	16.0%
Not sure	8	3.2%

Where would you place yourself on this scale of political views?

F2	N	Percent
Extremely Liberal	26	9.7%
Liberal	97	36.8%%
Slightly Liberal	45	17.3%
Moderate	67	25.5%
Slightly Conservative	12	4.7%
Conservative	14	5.2%
Extremely Conservative	2	0.9%

Generally speaking, do you usually think of yourself as a Republican, a Democrat, an Independent, or Other?

F3	N	Percent
Republican	12	4.8%
Democrat	133	51.0%
Independent	90	34.5%
Other	25	9.7%

Demographic Tables

Distribution by Respondent Age Group

Category	N	Percent
Under 45 years	140	46.1%%
45 - 64 years	94	31.0%
65 years and older	69	22.8%

Distribution by Respondent Gender

Gender	N	Percent
Female	162	53.3%
Male	137	45.2%
Own Description	4	1.4%

Distribution by Respondent Location

Category	N	Percent
Albemarle	149	49.1%
Charlottesville	154	50.9%

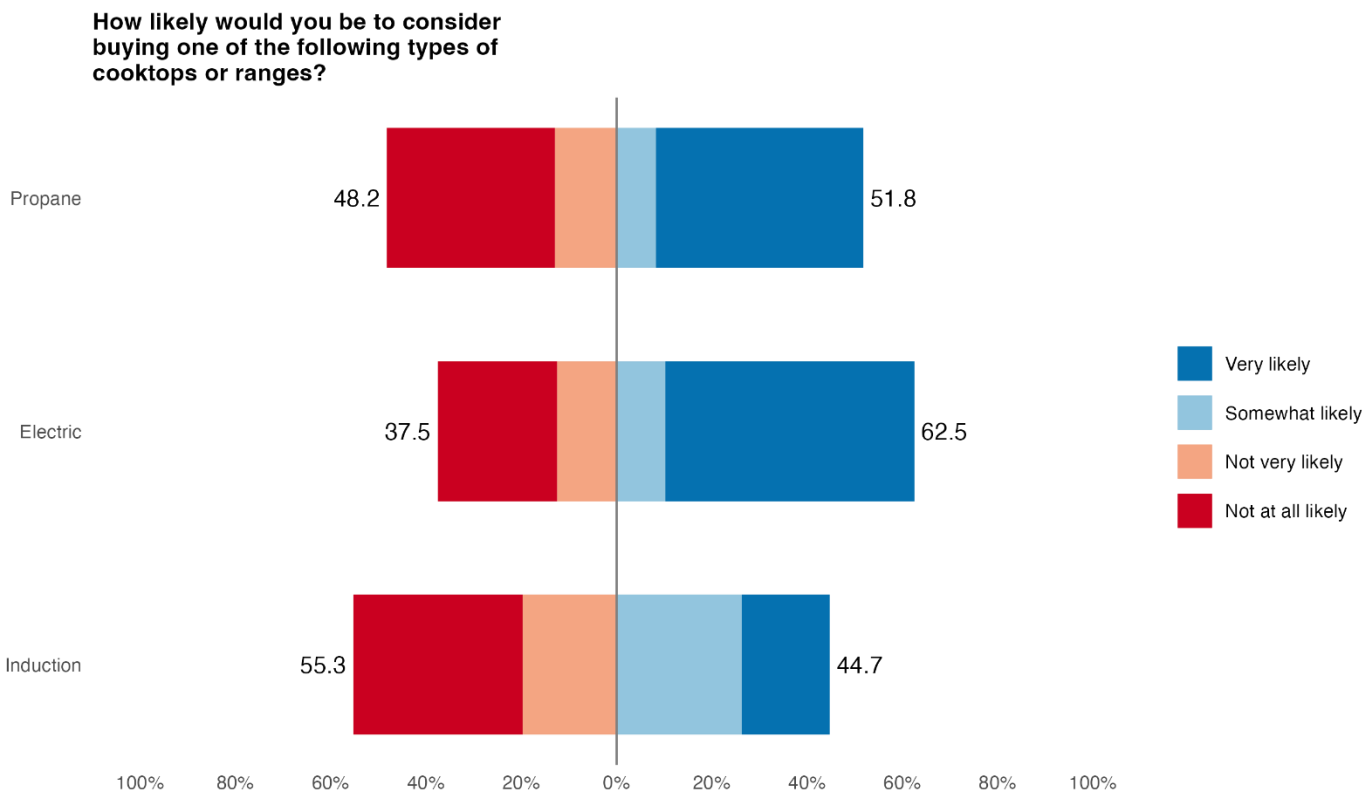
Distribution by Respondent Race

Category	N	Percent
Black/African-American	14	4.5%
White/Caucasian	246	81.2%
Another racial category	40	13.1%
Unknown	4	1.2%

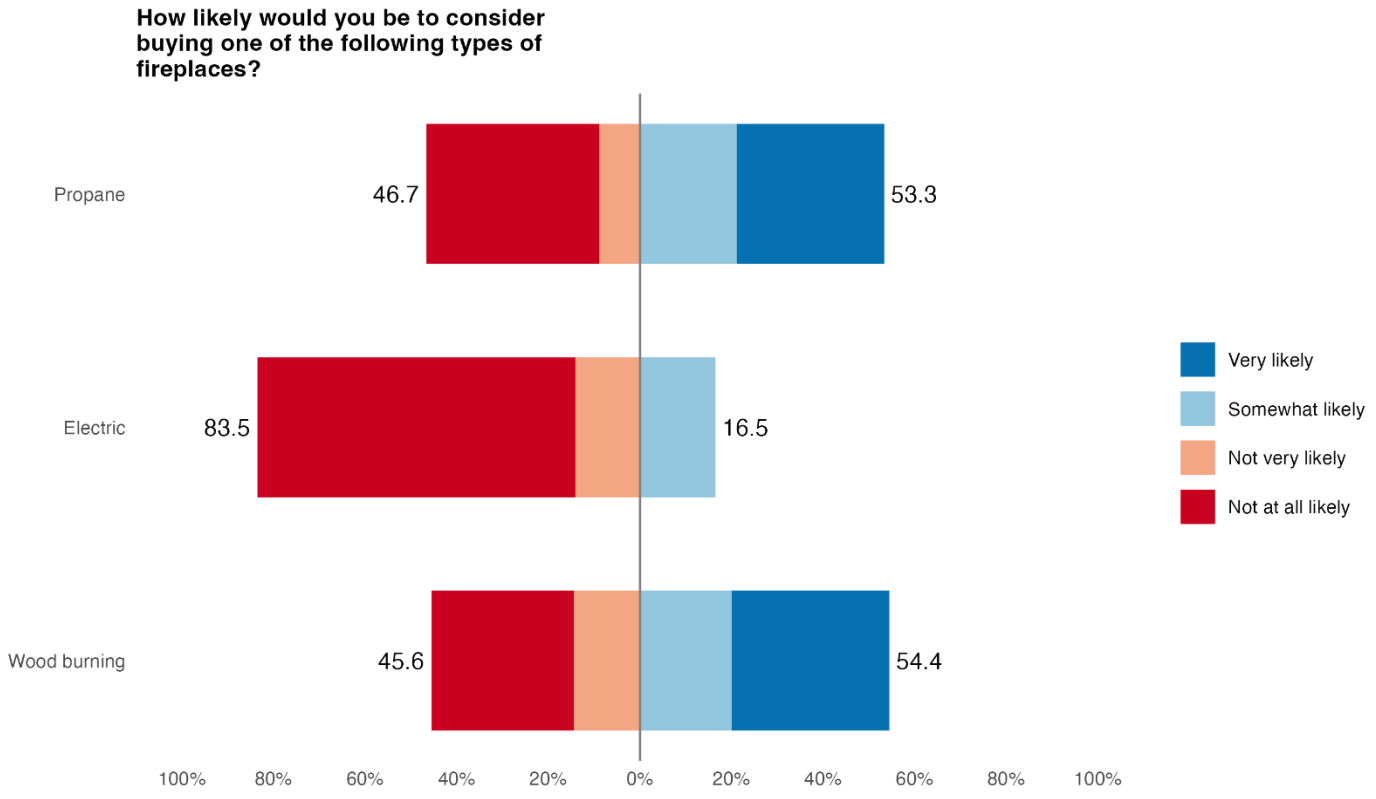
Distribution by Respondent Ethnicity

Category	N	Percent
Not Hispanic	295	97.2%
Hispanic	8	2.8%

Selected Graphics

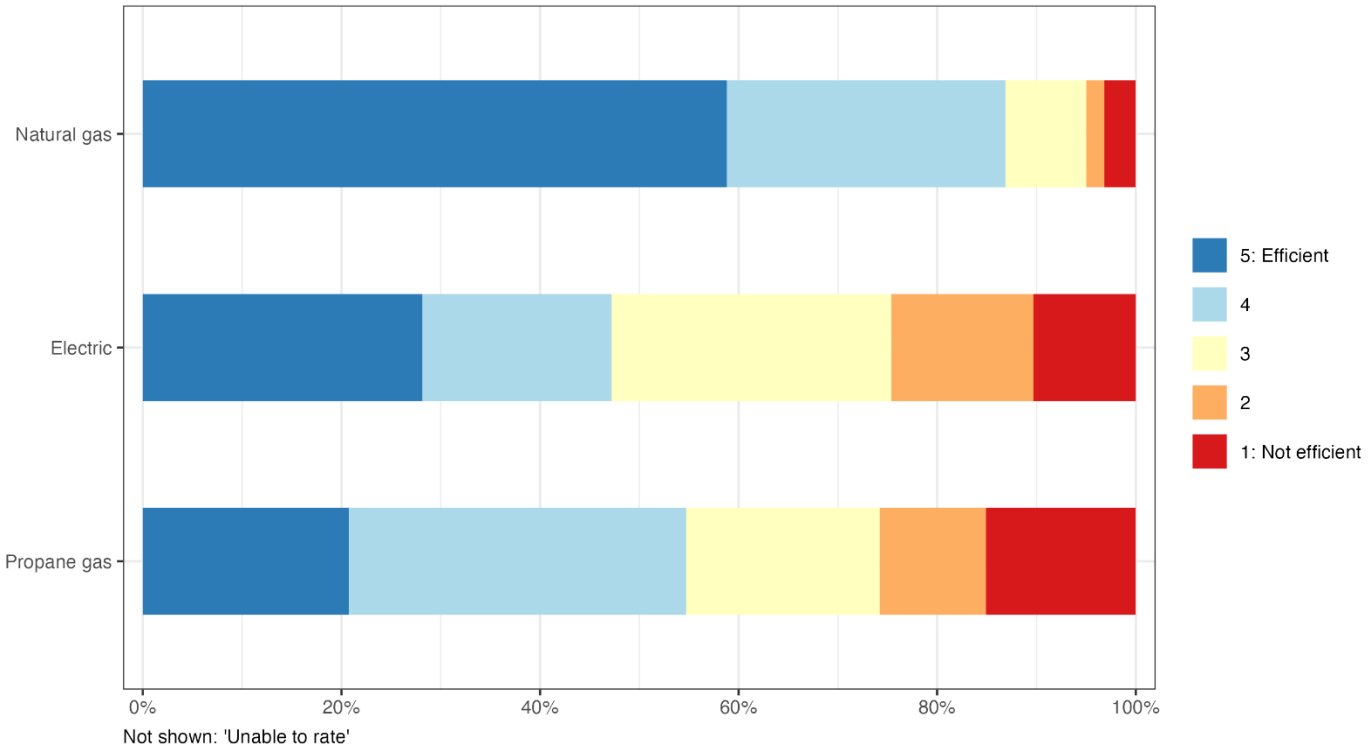


Note: This question was only asked of respondents who did not have natural gas service available on their street.



Note: This question was only asked of respondents who did not have natural gas service available on their street.

How efficient is...



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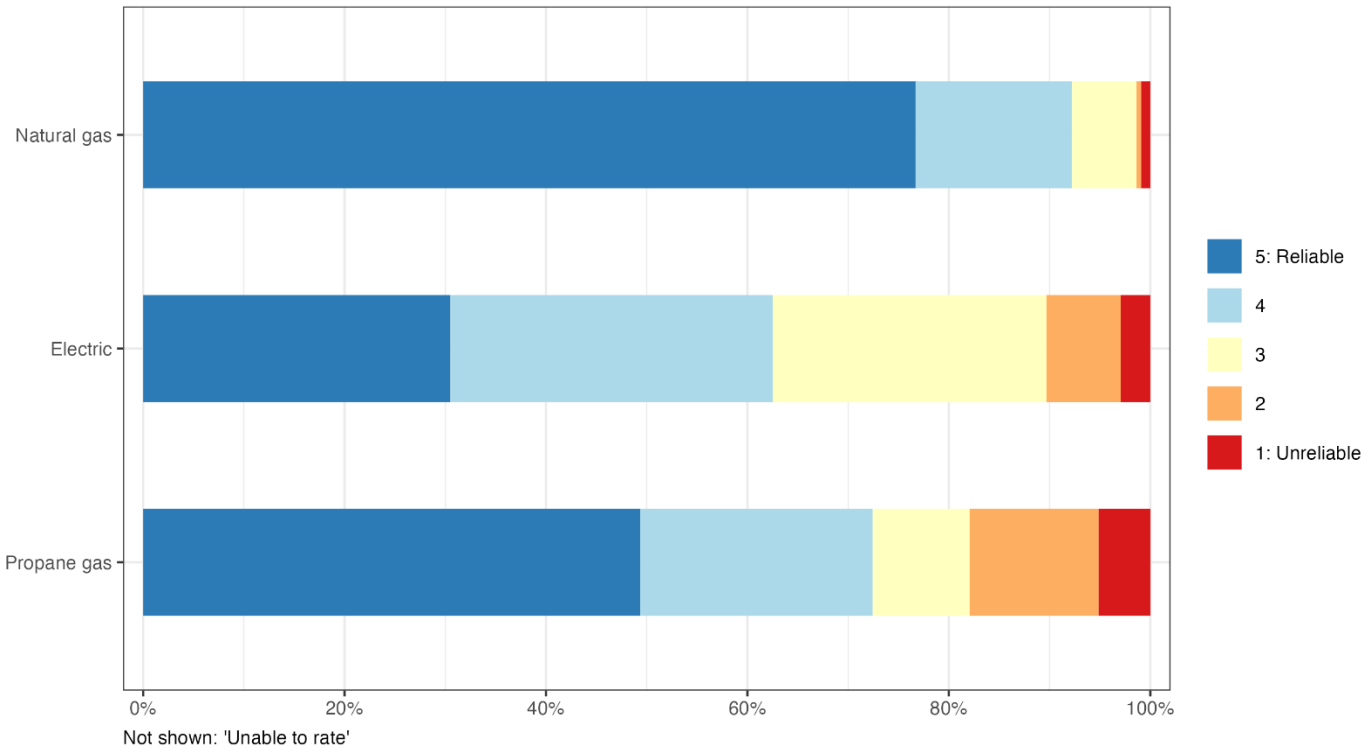
How reliable is...



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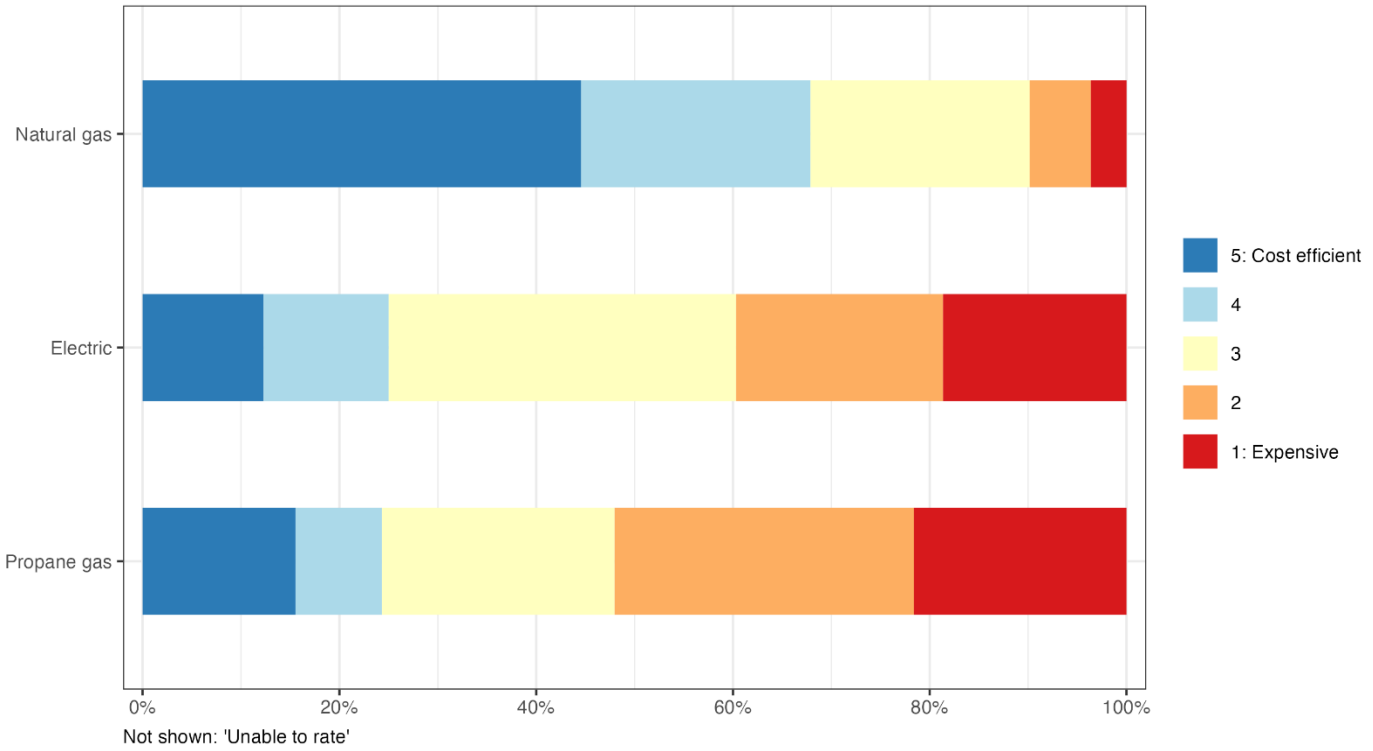
How cost efficient is...



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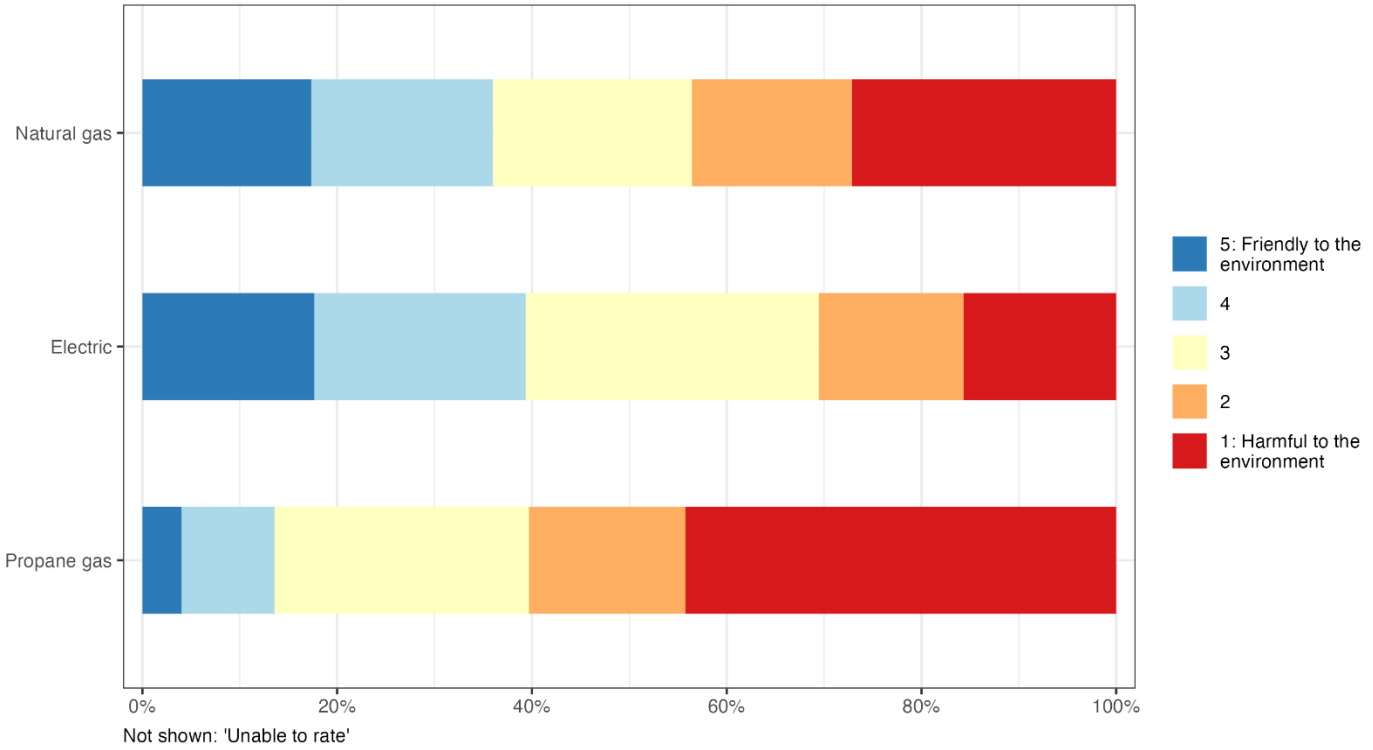
How would you rate the impact on the environment of…



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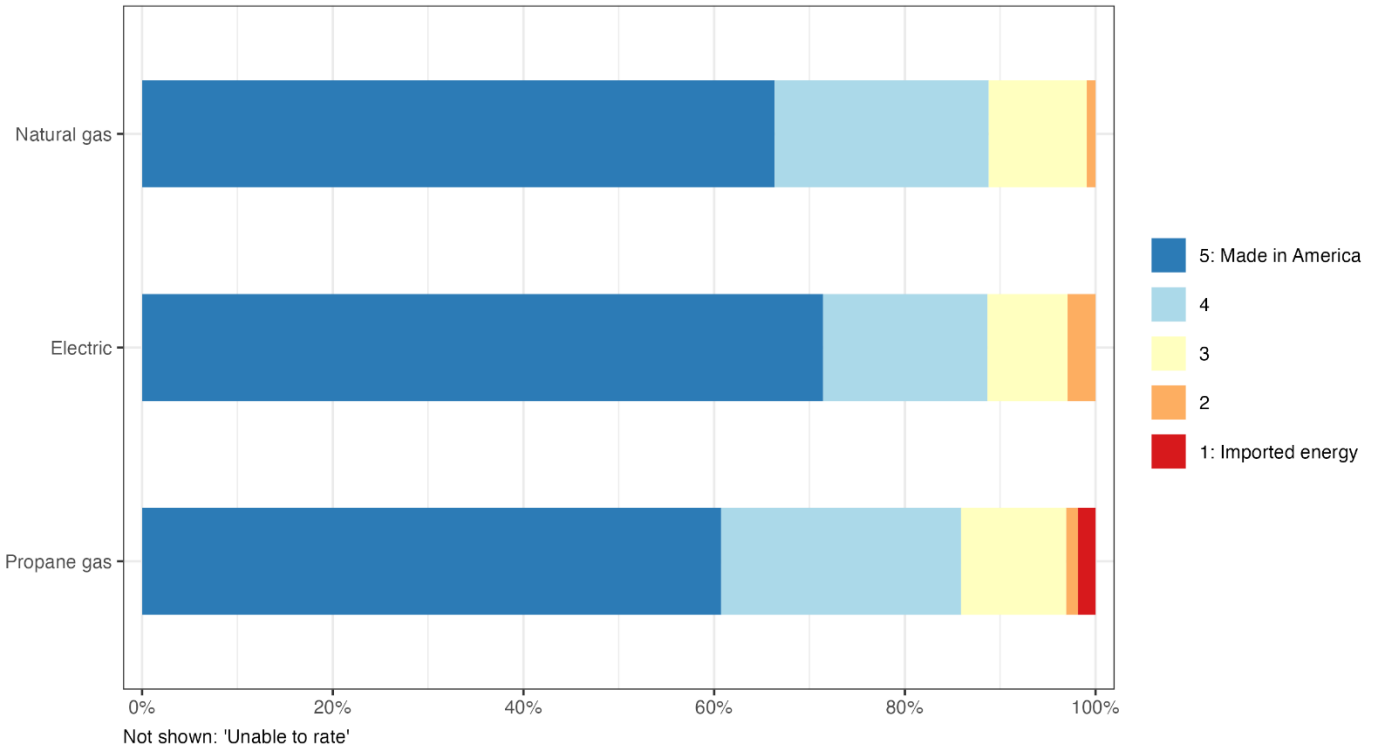
Made in America or Imported?



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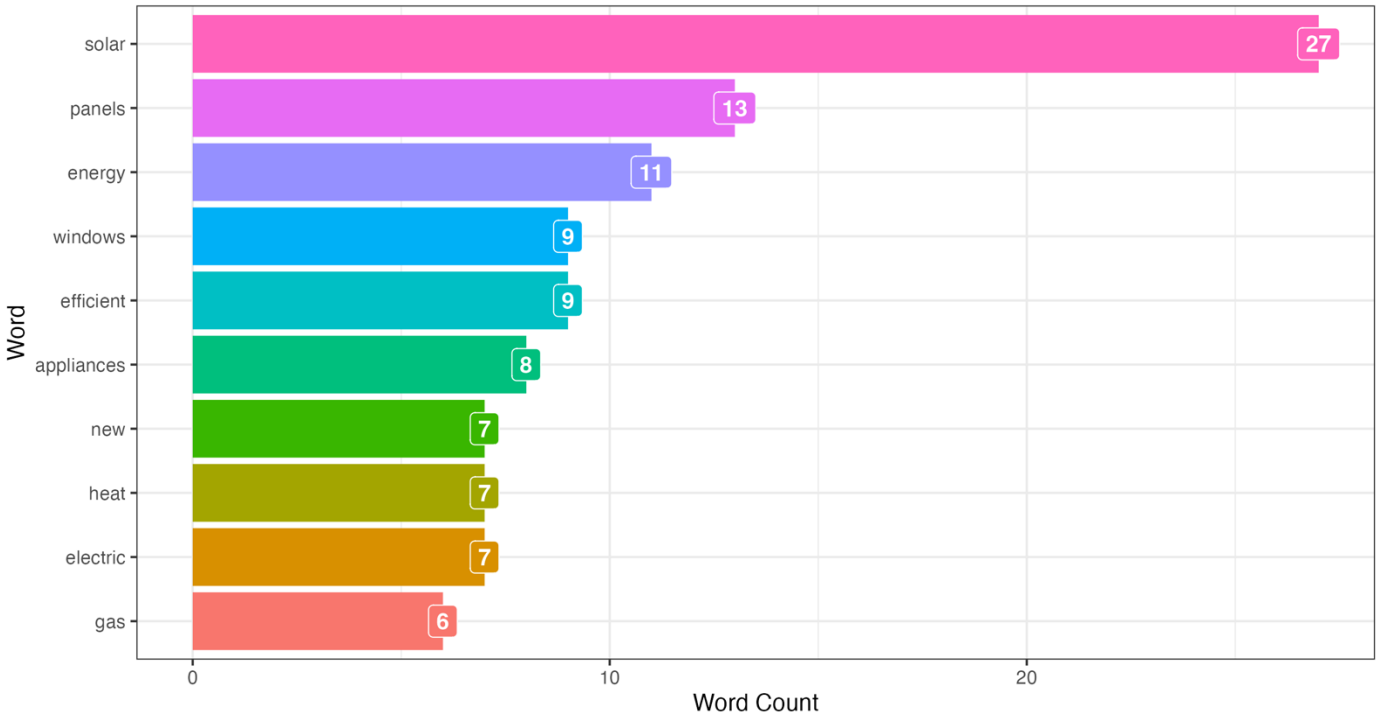
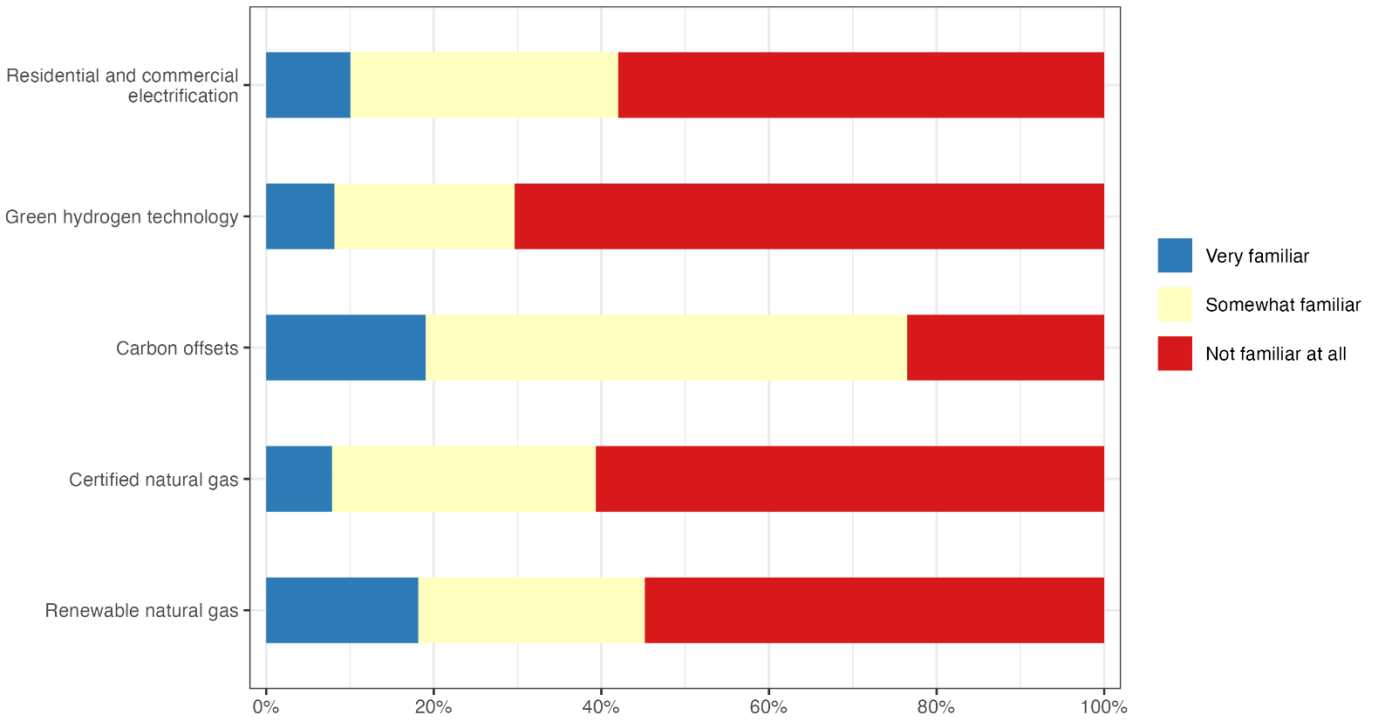
Top 10 Most Used Words When Describing How the Department of Utilities Could Improve by Offering Rebates for...



How familiar are you with the following decarbonization programs?



APPENDIX C: COMMERCIAL GAS CUSTOMER LISTENING SESSION SUMMARY NOTES

DECARBONIZATION STUDY

Charlottesville Natural Gas Municipal Utility

PREPARED FOR

Utilities
City of Charlottesville

Charlottesville Gas Utility

DISCLAIMER: THIS SUMMARY WAS PREPARED BY LAUNCH! CONSULTING FOR CHARLOTTESVILLE UTILITIES.

City of Charlottesville Gas Utility

Charlottesville Gas Decarbonization Community Engagement

Virtual Commercial Gas Customer Listening Session

SUMMARY

SESSION DATE: Monday, March 11, 2024

SESSION TIME: 8:30 am – 10:00 am

LISTENING SESSION OVERVIEW:

Eight participants attended the Commercial Gas Customer Focus Group, which included commercial business owners, manufacturers, residential community managers, property management representatives, and transportation service providers. The session began with presentations by the project team to contextualize the City's climate action plan and its commitment to achieving carbon neutrality. Presenters provided an overview of the City's gas utility and their environmental stewardship initiatives within its gas framework. They also introduced the Gas Decarbonization Study to provide information on its objectives and projected timeline.

Launch! Consulting facilitated a discussion among participants, covering a wide variety of topics including the following:

- Attitudes toward natural gas usage
- Legal considerations
- Strategies for reducing carbon footprint
- Comparative costs of alternative energy sources
- Methods for reducing greenhouse gas emissions
- Suggestions for enhancing energy efficiency

Throughout the session, participants shared their perspectives and exchanged ideas based on their knowledge and experience as commercial gas customers in the City of Charlottesville.

LISTENING SESSION SUMMARY OF NOTES:

Participants introduced themselves and provided context on the role that natural gas plays in their businesses. These commercial gas customers rely heavily on natural gas for various essential functions within their operations. It is used for cooking, heating hot water, powering HVAC systems during outages, residential heating in communities, and heating facilities. Additionally, natural gas is integral to restaurant operations, apartment heating, and providing heat for a significant amount of indoor space through gas boilers. Despite exploring alternative fuel options, participants expressed that natural gas remains a cornerstone of their energy infrastructure.

The following is a list of the discussion's main themes and associated points raised by participants:

1) **Natural Gas and Decarbonization:**
   a) Participants expressed concern about the transition away from natural gas, emphasizing its efficiency and the challenges of switching to electric alternatives, especially regarding cost and infrastructure upgrades.
   b) There is a need for clarity and understanding around decarbonization and the full lifecycle of energy production, including the carbon footprint of manufacturing new equipment.
   c) One participant reflected on previous promotional campaigns by the City Gas Utility and the challenges that could be associated with reversing messaging regarding the benefits of gas.
   d) Questions were raised about the intricacies of gas decarbonization, especially in heating applications where gas has traditionally been prevalent.
   e) A property management representative expressed that customers value when gas is provided in the homes for appliances like stoves and fireplaces.

2) **Cost and Infrastructure Concerns:**
   a) Converting from gas to electric heating is seen as expensive and complicated, requiring significant upgrades to electrical systems.
   b) Participants discussed the financial aspects of transitioning to electric heating, particularly in multi-unit residential buildings.
   c) Participants highlighted the challenges of upgrading electric infrastructure to accommodate load from electric heating systems.
   d) The financial and practical implications of such conversions were discussed, including the impact on real estate taxes and the continuous cycle associated with higher expenses for materials, like asphalt.
   e) Participants expressed interest in learning more about the cost-effectiveness, carbon footprint, and energy sourcing of alternative electric solutions.

3) **Regulatory and Support Issues:**
   a) Participants highlighted the importance of infrastructure improvements and regulatory support, with examples of updated systems reducing leaks and improving efficiency.
   b) Participants requested more information and support from the City for gas efficiency audits and incentives to help residents and businesses reduce their carbon footprints.

4) **Financial and Environmental Motivations for Conversion:**
   a) One participant noted that their business recently converted from heating oil to natural gas, driven by environmental and financial motivations as converting to electric would be double the cost.
   b) Participants shared insights into their broader efforts to adopt electric technologies, including the installation of Electric Vehicle (EV) charging stations and LED lights.
   c) One participant spoke on how some companies focus on decarbonization through means other than reducing gas usage like utilizing solar power, conducting building audits, optimizing HVAC systems and schedules (which has helped them achieve 40% reduction in gas consumption), and partnering with community groups to leverage incentives that support these initiatives. They expressed a need for financial backing to implement alternatives and to recognize cost savings over time.
   d) Challenges were discussed in balancing sustainability goals with the operational and financial constraints faced by businesses.

5) **Reliance on Natural Gas for Emergency Situations:**
   a) The importance of natural gas in emergency situations, such as power outages or an act of terrorism, was underscored for ensuring redundancy and preserving critical supplies and products.
   b) Concerns were raised about the long-term viability and cost implications of relying on natural gas, especially given the evolving landscape of alternative energy solutions.

6) **Infrastructure Updates and Leak Prevention:**
   a) Updates were provided on infrastructure improvements and leak prevention efforts, with a focus on minimizing gas leaks and enhancing safety measures.
   b) Participants were interested in understanding the role of academic institutions like UVA in driving decarbonization efforts and their broader impact on the community.

7) **Broader Considerations and Future Outlook:**
   a) One participant mentioned emerging Technologies like liquid natural gas (LNG) and hydrogen as potential future options, though participants noted the need for more information and understanding of these alternatives.
   b) Participants explored the effectiveness of carbon offsetting strategies and discussed additional initiatives such as nutrient and wetland credits as part of broader environmental conservation efforts.

8) **Closing Remarks and Reflections:**
   a) Overall, participants appreciated that there is no mandate to eliminate natural gas and valued the City's efforts to explore efficient and sustainable energy solutions.

b) There was a reaffirmation of the commitment to sustainability, with an emphasis on transparency and inclusivity in the decarbonization process.
c) Participants highlighted the importance of ongoing communication, updates, and collaboration in achieving shared environmental goals and driving meaningful change.

APPENDIX D: DECARBONIZATION STUDY COMMUNITY SESSION NOTES AND FEEDBACK

DECARBONIZATION STUDY

Charlottesville Natural Gas Municipal Utility

PREPARED FOR

Utilities
City of Charlottesville

Charlottesville Gas Utility

DISCLAIMER: THIS SUMMARY WAS PREPARED BY LAUNCH! CONSULTING FOR CHARLOTTESVILLE UTILITIES.

City of Charlottesville Gas Utility

Charlottesville Gas Decarbonization Community Engagement

Virtual and In-Person Community Listening Sessions

SUMMARY

Listening Sessions Details:

Listening Session #1	
Date	Tuesday, July 9, 2024
Time	10:00 am – 11:15 am
Location	Virtual on Zoom
Total Participants	60
Listening Session #2	
Date	Tuesday, July 16, 2024
Time	5:30 pm – 6:45 pm
Location	Virtual on Zoom
Total Participants	33
Listening Session #3	
Date	Thursday, August 22, 2024
Time	6:00 pm – 7:15 pm
Location	In person at CitySpace
Total Participants	40

Listening Sessions Overview:

Between July and August 2024, the City of Charlottesville Department of Utilities hosted three community listening session opportunities to discuss the upcoming Charlottesville Gas Decarbonization Study. In 2023, Utilities began working with the consulting firm Black & Veatch on this study to responsibly and accurately determine how its natural gas utility can help meet community greenhouse gas reduction goals. Essential to this comprehensive analysis is public input, and Utilities encouraged residents and business owners in both the City of Charlottesville and Albemarle County to take part in helping to shape the outcome of an initiative with community-wide impacts.

Each session followed the same agenda:

1. Listening Session Background, Outcomes, and Introductions (10 minutes)
2. City of Charlottesville Presentation (20 minutes)
    a. Office of Sustainability – Climate Context
    b. Charlottesville Gas – Background, Environmental Stewardship Approach, Gas Decarbonization Study, and Actions to Align with City Climate Goals
3. Breakout Group Discussions (40 minutes)
    a. Breakout Room 1: Environmental Impacts of Decarbonization and Natural Gas Usage

b. Breakout Room 2: Economic Impacts of Decarbonization and Natural Gas Usage
c. Breakout Room 3: Benefits of Natural Gas Usage and Concerns about Decarbonization

4. Closing Remarks (5 minutes)

Listening Sessions Findings

The following sections provide a detailed summary of findings from the three listening sessions. Findings are presented by breakout groups, which had an associated topic area to help guide discussion based on participant interests. Participants were asked to choose a breakout group to begin with and had the opportunity to move to different breakout groups throughout the allotted 40 minutes. Findings within breakout groups are organized by main themes and associated points raised by participants. Some points were raised by the same participants in more than one breakout room; this is the reason for some similar comments in different breakout rooms. Participants attended only one of the three listening sessions.

Breakout Room 1: Environmental Impacts of Decarbonization and Natural Gas Usage

- **Carbon Offset Programs and Carbon Credits**
  - Carbon offset programs vary in quality, with concerns raised about their transparency and reliability.
  - Carbon offsets may look good on paper but could function as "greenwashing" if they don't deliver on promised reductions.
  - A gas customer pointed out that 25% of their gas bill goes to carbon offsets and suggested reallocating those funds to local projects, such as weatherization and energy efficiency.
  - Participants emphasized the need for more transparency in carbon offset programs, including specific details on how they are verified.
  - Global carbon offset programs were questioned, with suggestions to focus more on local emissions reduction initiatives.
  - Carbon credits were mentioned as a financial tool to incentivize businesses to reduce emissions and sell reductions on the open market.
  - Concerns were expressed about whether carbon offsets are being duplicated and sold to multiple companies.
  - Attendees expressed support for voluntary and proactive tree planting programs for landowners, emphasizing the need to preserve mature trees.
  - There should be stronger incentives for developers to retain existing trees in new developments.
  - Participants highlighted the need for coordination with organizations like ReLeaf Charlottesville to strengthen tree planting efforts.
  - Trees offer environmental benefits but need to be part of a comprehensive strategy for maintaining the City’s tree canopy.

- **Decarbonization Strategy and the Gas Utility**
  - The decarbonization study's narrow focus on the gas utility was seen as insufficient. Broader solutions, such as electrification, should be prioritized.
  - Participants called for accelerating the City's decarbonization goals from 2050 to a faster timeline, like 2035 or even within 10 years, due to the urgency of climate change.
  - Concerns were raised about whether the City is considering the entire lifecycle of emissions from natural gas, including extraction, transportation, and usage.
  - Renewable Natural Gas (RNG) and hydrogen were seen as limited, short-term solutions with concerns over scalability, infrastructure, and safety.
  - RNG may offer limited benefits in the short term, but participants questioned if it is enough to achieve complete decarbonization by 2050.
  - Hydrogen could be useful in industrial applications but has limited applications in residential heating and cooking.
  - Participants suggested focusing on converting homes using heating oil to natural gas to reduce overall emissions.
  - Participants raised concerns about transitioning UVA's power plant from coal to 100% natural gas.

- **Energy Conservation, Electrification, and Public Education**
  - Many participants were unaware of the City's decarbonization efforts, indicating a need for better public communication through local outlets like *Charlottesville Tomorrow*.
  - There were calls for the City to focus on electrification as a key long-term strategy to reduce emissions.
  - Suggestions were made to provide financial assistance programs for homeowners transitioning from natural gas to electricity, including federal tax incentives like the IRA.
  - Participants encouraged the City to explore transitioning its business model from providing gas to offering solar energy subscriptions.
  - Health concerns were raised over natural gas appliances, such as gas stoves and furnace leaks, and whether the City would assume responsibility for related health risks.
  - Participants noted the energy loss in electricity generation and questioned whether it is a cleaner alternative to natural gas.

- **Gas Leaks and Methane Emissions**
  - Participants expressed significant concerns about methane emissions from gas leaks and the lack of proactive monitoring by the City.
  - Participants praised Charlottesville's gas utility for it rapid response to leaks, noting that gas providers in other localities in Virginia are inconsistent with their response to gas leaks.
  - There were suggestions to use advanced technologies like LIDAR to detect methane leaks in the City's infrastructure.
  - Participants suggested capturing methane from the Ivy landfill for power generation instead of flaring it.

- There were concerns about the percentage of methane emissions from gas leaks versus gas consumption and the need to address both.

- **Environmental Impact of Alternative to Natural Gas**
  - Participants raised concerns about the environmental trade-offs of alternatives to natural gas, such as the loss of green areas for solar farms and the environmental impact of lithium extraction for batteries.
  - Natural gas was noted as the cleanest fossil fuel available, with some participants expressing concerns about switching to other energy sources.
  - Calls were made for a comprehensive cost-benefit analysis comparing the local and global impacts of decarbonizing natural gas.
  - Hydrogen was suggested as a clean fuel alternative, with proposals to mix it with natural gas (5-20%) in the City's supply network.
  - Participants stressed the importance of using green hydrogen (produced via renewable energy) instead of blue hydrogen (produced from fossil fuels with carbon capture).
  - Infrastructure challenges with converting existing systems to support hydrogen were highlighted.

- **Composting and Methane Reduction**
  - Composting was suggested as an additional way to reduce methane emissions, complementing other strategies.
  - Participants called for the City to offer composting services to reduce methane emissions from organic waste, like how recycling services were implemented.

- **Proposals for Renewable Energy and Utility Transformation**
  - Participants suggested the City enter into power-purchasing agreements with solar and wind farms to accelerate renewable energy adoption.
  - The City was encouraged to transition from gas to solar subscriptions, helping reduce reliance on fossil fuels.
  - Concerns were raised about the environmental impact of solar farms and battery production.
  - Calls were made for broader changes in state energy policy, particularly regarding Dominion Energy's reliance on coal for electricity production.
  - There were suggestions for converting homes that use heating oil to natural gas as an interim step towards decarbonization.

Breakout Room 2: Economic Impacts of Decarbonization and Natural Gas Usage

- **Carbon Offset Programs and Local Offsets**
  - Concerns were expressed about the efficacy of carbon offset programs, especially when the benefits are not local.

- Suggestions were made to explore the feasibility of creating local carbon offsets, which would provide local benefits and be easier to verify against Charlottesville's own objectives.
- There is a preference for local offsets to ensure alignment with Charlottesville's environmental goals.
- Concerns were expressed about the efficacy of carbon offsets and skepticism regarding their impact.
- The U.S. withdrawal from the Kyoto Protocol was mentioned, questioning whether a local utility should be involved in carbon credits.
- Participants emphasized that the City's gas utility should focus on local decarbonization efforts and reduce carbon emissions by investing in electrification, rather than purchasing offsets.
- Several participants suggested reallocating funds currently spent on carbon offsets towards more direct, local decarbonization efforts, such as electrification.
- Suggestions to expand tree planting beyond current levels, such as planting more trees in places like the old McIntyre golf course, were raised.

- **Electrification, Renewable Energy, and Infrastructure**
  - Concerns were raised about the costs and feasibility of converting homes and businesses from natural gas to electric appliances. Many participants emphasized the need for more financial support and incentives to help with the cost of switching from gas to electric appliances. Participants requested financial support or rebates for customers who cannot afford to transition to electric appliances or deal with decommissioning gas systems.
  - Some concerns were raised about whether the funding and financial incentives are sufficient to support the transition to electrification.
  - The City needs to anticipate the cost of upgrading the electrical infrastructure to meet higher demand from electrification, as well as determining who will bear the financial burden for these upgrades.
  - Suggestions were made to ensure that the grid remains diversified, with gas used as a backup for reliability.
  - Renewable energy sources like solar, wind, biomass, and battery storage are rapidly evolving and should be part of Charlottesville's energy transition plan.
  - Some participants mentioned that good heat pumps, which could replace gas heating, are not widely available in the U.S., and there are concerns about the durability of compressors. Another participant disagreed and said that they know of good available heat pumps.
  - Participants questioned the purpose of the new connection fee and how it impacts the overall decarbonization goals of the City.
  - The instability of the electrical grid was questioned, with concerns about the local, regional, and national grid's ability to handle a widespread conversion to electricity.
  - Encouragement was voiced for broader electrification initiatives, including solar power, with suggestions to create community-based shared solar systems.
  - Participants offered ideas to convert City-owned properties into solar power generation facilities and sell the electricity into the grid to offset lost gas revenue.

- Participants had concerns about the long-term costs of transitioning away from gas, including upgrading the electrical grid and decommissioning the gas network.
- Participants raised concerns about how Dominion Energy would handle the increased demand on the grid if the City transitions away from natural gas and how customers would bear those costs.
- Participants expressed the idea to use gas generators as backup power when electricity fails due to widespread electrification efforts.
- Interest in district heating for downtown Charlottesville, which was mentioned as a possibility if the City already has piping infrastructure in place.

- **Economic Impacts of Decarbonization**
  - Participants expressed concern about rising electricity costs and the financial burden it places on low-income households, with some noting that electricity is already a significant cost for those who cannot afford it.
  - The importance of affordable housing was mentioned, with utilities being a significant cost factor.
  - Several participants worried about how the City will make up for the loss of income from the gas utility if the City transitions to electric energy.
  - Participants questioned how the City would manage rates with fluctuations in market prices and how the potential loss of large industrial customers (like UVA) switching to electric would affect residential gas rates.
  - Questions were raised about how the City would manage the impact of market fluctuations in natural gas prices, particularly if natural gas use decreases but remains part of the energy mix.
  - Concerns were voiced about the economic impact of a private utility gaining a monopoly in the area, as seen with Aqua Virginia's extremely high bills as a private water utility in Palmyra.
  - Suggestions were made to explore using the billing system for cross-subsidization to support low-income residents through decarbonization efforts.
  - Concerns were voiced about the economic costs of switching from natural gas to electricity for both customers and the City.
  - Participants were worried about rate increases as fewer customers remain on the gas utility, leading to higher costs for remaining users and potentially requiring taxpayer subsidies.
  - Participants mentioned the potential impact on small businesses and renters in older buildings with gas systems if the City does not continue to supply gas.

- **Natural Gas Transition and Long-Term Impacts**
  - Participants questioned how Charlottesville would manage the loss of income from gas, both in terms of staff employment and the City's operating budget if gas goes away. Questions were raised about the impact of natural gas decarbonization on gas staff and the City's ability to retain or reassign them.
  - Several participants were concerned about the cost of decommissioning the gas network and whether remaining gas customers would bear those costs.

- Participants also asked how other fees, like the new connection fee, would affect decarbonization and the overall transition away from gas.
- Some participants pointed out that natural gas provided an alternative to oil dependency for residents several years ago, but now they are concerned about what comes next if customers need to switch from natural gas.

- **University of Virginia (UVA), Large Industrial Consumers, and the Commercial Sector**
  - UVA's transition from coal to natural gas was mentioned, with participants questioning how this would interact with residential gas use and decarbonization goals.
  - Concerns were raised about the loss of large industrial consumers like UVA and how it would affect the cost burden for smaller residential gas customers.
  - Questions were raised about the role of large institutions like UVA in the City's decarbonization strategy, and how commercial and industrial gas users would be impacted by the transition to electrification.
  - Questions arose about how UVA and large commercial users of natural gas would impact overall gas consumption and costs if they transitioned to electric energy.

- **Community Engagement, Education, and Support**
  - Participants called for better communication and education around the City's decarbonization efforts and the financial incentives available to support electrification.
  - Suggestions were made to align Charlottesville's decarbonization efforts with state-wide initiatives to ensure consistency and maximize the impact of policy changes.
  - Some participants expressed concerns about the lack of a clear explanation of how financial incentives, such as those for weatherization, apply to non-profits as well as residents.
  - Participants called for the City to ensure that decarbonization efforts and energy transitions are equitable and accessible to all community members, particularly those with limited economic means.
  - Suggestions were made to expand the City's outreach efforts to engage more diverse parts of the community.
  - Participants called for more information-sharing about the City's infrastructure, utility systems, and decarbonization strategies.

- **Tree Planting and Environmental Concerns**
  - Some participants emphasized that tree planting should be well-planned to ensure maximum environmental benefit and should not be a substitute for broader decarbonization strategies.
  - Participants were concerned about the loss of trees in certain areas, such as along Route 29 North, and how this could undermine tree-planting efforts elsewhere.
  - Suggestions were made to provide rebates or incentives for residents to plant trees on their own property to increase the urban tree canopy.
  - Participants pointed out that merely planting trees is not sufficient for offsetting emissions, especially in the face of large-scale tree removal for development.

- **Affordable Housing and Utility Costs**
    - Affordable housing was mentioned as an important consideration in the City's decarbonization strategy, with utilities being a significant cost burden for residents.
    - Participants noted that while air conditioning can be optional, heating is essential, and decarbonization efforts should prioritize ensuring affordable, reliable heating options for low-income households.
    - The C3 report on how to use the billing system for subsidies was mentioned as a useful resource for managing cross-subsidization and supporting low-income households.

- **Solar and Wind Power Integration**
    - Multiple participants expressed interest in seeing more solar energy projects developed within the City, including City-owned land and rooftops being used for solar power generation.
    - Some participants suggested shared solar or wind energy systems where customers who are unable to install their own systems can buy into community renewable energy projects.
    - Participants called for the City to investigate alternative power models and to focus on long-term renewable energy integration rather than relying on fossil fuel-based energy sources.

- **Broader Energy Context and Planning**
    - Participants stressed the importance of connecting Charlottesville's decarbonization efforts with the broader energy context in Virginia, ensuring alignment with state initiatives and coordinating with other local governments.
    - Questions were raised about how decarbonization goals will factor into the City's larger energy picture, including how market forces, energy supply, and state policy changes will affect the City's decisions.
    - Participants expressed concern about federal policies encouraging a transition away from natural gas, which could lead to fewer customers for the gas utility and higher rates for remaining users.

Breakout Room 3: Benefits of Natural Gas Usage and Concerns about Decarbonization

- **Natural Gas Usage and Alternatives**
    - Some participants suggested upgrading from older gas-only systems to hybrid systems that use heat pumps with gas as backup.
    - Many residents expressed reluctance to move away from gas due to its affordability and effectiveness.
    - Several residents voiced concerns about transitioning entirely to electric heating and cooking, particularly due to perceived inefficiencies and higher costs associated with electric systems.
    - Many participants, especially those who currently use gas stoves, indicated they would be resistant to switching to electric stoves, citing gas as superior for cooking.

- One participant emphasized the potential for hydrogen energy, which is seen as cleaner and easier to produce. This was suggested as a discussion topic for future energy plans.
- There was uncertainty about whether homeowners would be required to replace their gas systems with heat pumps, with participants asking for clarification about potential mandates.
- Some residents with older homes expressed skepticism about heat pump efficiency in colder climates and raised concerns about whether heat pumps would be practical or effective for their specific situations.
- Participants noted that natural gas provides a reliable backup during power outages caused by storms, and transitioning away from gas could leave residents vulnerable.

- **Financial and Social Considerations**

  - Residents, especially those on fixed incomes or with disabled family members, voiced concerns about the financial burden of converting to electric systems. Many participants highlighted the potential economic burden on low-income, elderly, and disabled residents if forced conversions or significant cost increases occur.
  - A question was raised about whether the City would increase gas prices to push residents toward electric options. Although this has not been proposed, residents are wary of future price hikes.
  - A participant mentioned that the City has already added a $340 fee for new gas connections, which may act as a disincentive for future gas installations.
  - The LEAP program, which offers energy audits and solar panel installations, was praised as a way to assist residents with energy efficiency and decarbonization. Participants suggested expanding such programs to help vulnerable populations.

- **Environmental and Decarbonization Goals**

  - Some participants expressed concerns that the City's goal of a 45% carbon reduction by 2030 is ambitious, but questioned whether progress is being made quickly enough to meet these targets.
  - Solar panel installations were discussed as an effective way to reduce carbon emissions. Several residents had positive experiences with solar energy, though concerns about end-of-life solar panel waste and the need for battery backups were raised.
  - Some participants noted the upcoming offshore wind farm projects in Virginia, though there were concerns about reliability and long-term feasibility given infrastructure challenges.
  - Some participants felt that decarbonization should not only focus on electricity but also consider the overall environmental benefits of using natural gas as a transitional fuel.
  - Concerns were expressed about simply shifting carbon emissions from natural gas to electricity generation without achieving overall reductions.

- **Infrastructure and Utility Management**
    - Participants emphasized the need for infrastructure upgrades, including burying power lines, to make a full transition to electric systems feasible.
    - Several participants pointed out that natural gas serves as a critical backup during power outages, and removing this option could leave homes without heat or cooking options during emergencies.
    - Residents questioned whether the City has a comprehensive infrastructure plan in place to support a shift from gas to electric systems. They stressed the need for better planning to avoid creating new vulnerabilities in the energy system.

- **Planning and Transparency**
    - A few residents mentioned their lack of trust in the City's planning processes, citing past projects where they felt community input was not adequately considered.
    - Participants requested more transparency in the decarbonization planning process, including clearer guidelines for homeowners and a detailed timeline for implementation.
    - Several participants suggested that the City should collaborate with neighboring counties to develop renewable energy sources, such as wind and solar, and to invest in energy storage solutions for short- and long-term outages.
    - Participants expressed a desire for more community engagement and more inclusive discussions about decarbonization.
    - Concerns were raised about how property values might be affected if natural gas is eventually phased out, particularly if buyers perceive electric-only homes as less desirable.
    - One suggestion was to explore reusing methane emissions from landfills as part of the City's overall energy strategy.

Other Findings from Gas Decarbonization Outreach Beyond the Listening Sessions

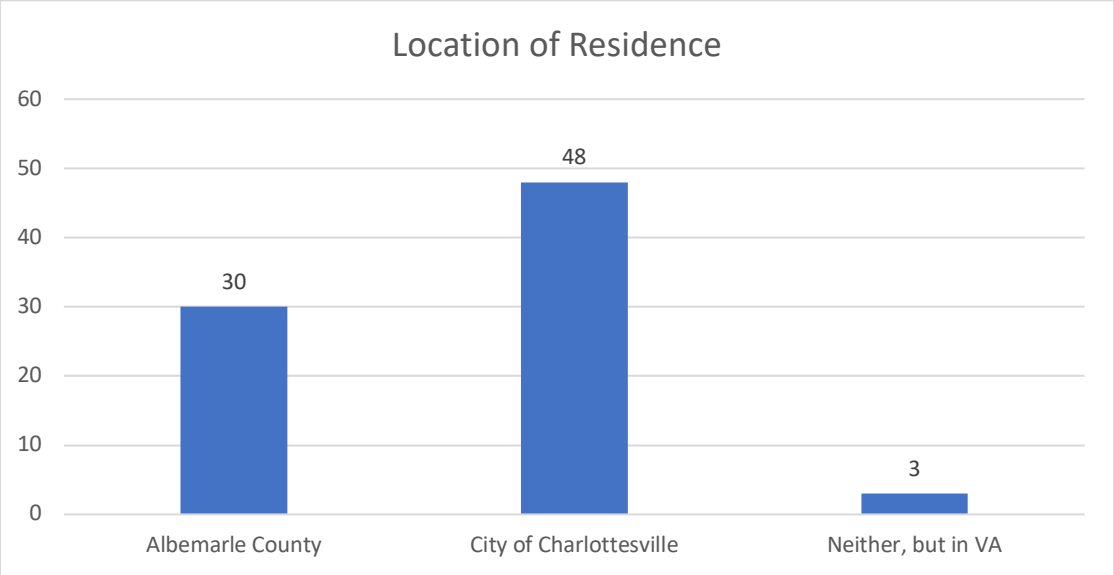
The City received additional phone calls and emails from residents and gas customers regarding the gas decarbonization study. The following feedback and questions were provided to the City by email or phone calls:

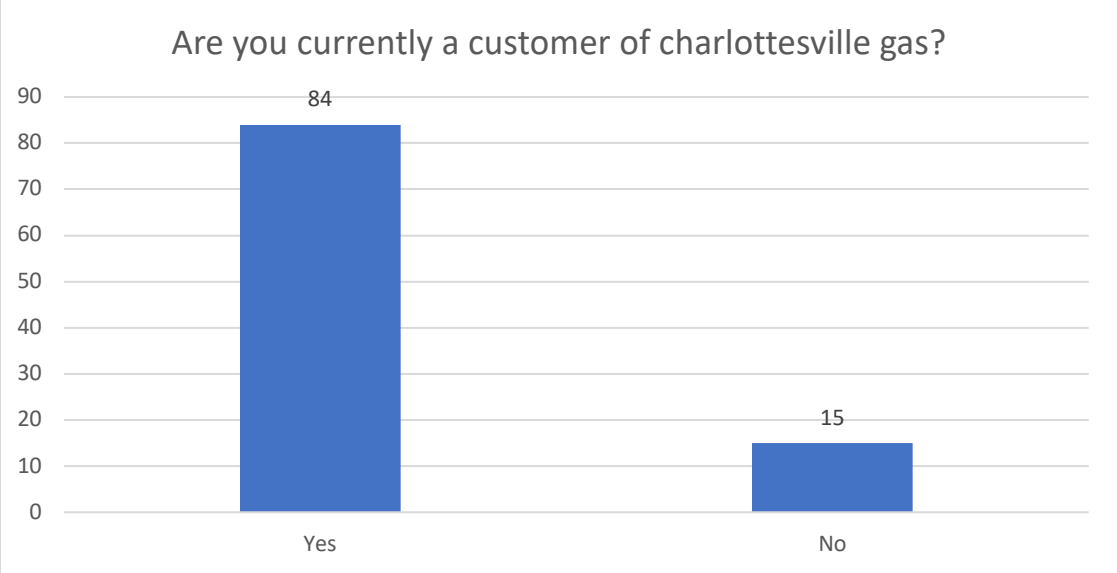
- **Feedback, Input, and Ideas**
    - Opposition to requiring existing homes to replace natural gas appliances such as ovens, water heaters, and fireplaces.
    - Concern over the rising price of utilities, especially with an increase in rates.
    - Suggestion to establish a phone number for public comments and government subsidies to help low-income households transition to green alternatives.
    - Fixed-income individuals worry that green subsidies primarily benefit wealthier households, emphasizing the need for programs to assist the lowest-income individuals.

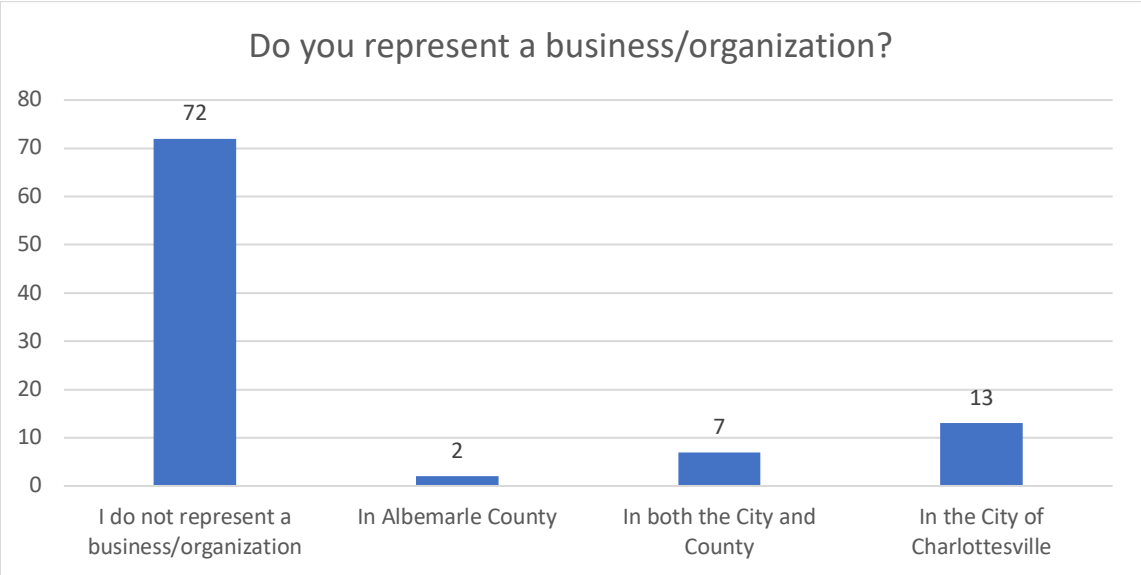
- Installing solar systems with batteries can reduce reliance on natural gas, but the transition to electricity may not significantly reduce carbon emissions due to the grid's reliance on carbon-based power generation.
- A forced shift from natural gas to electric in existing homes would be costly, particularly regarding infrastructure updates like circuit and panel upgrades.
- New residential gas hookups should face stricter requirements, including proper costing, venting, and health-related improvements.
- Gas system leaks should be strictly managed, with compliance costs passed to customers.
- Future gas rate increases should fund subsidies to help low-income households transition to electric.
- Long-term, natural gas should be phased out as renewable technology and grid capacity improve, with solar energy being emphasized.
- Consideration should be given to the impact of removing natural gas service, particularly for those relying on gas for backup power (e.g., generators).
- The City should bury power lines to avoid outages and improve infrastructure resilience.
- Heat exchange from buried pipes and increased use of solar and battery storage should be explored as interim solutions to a gas phaseout.
- The plan should focus on ambitious gas sector goals—40% reduction by 2030, 100% by 2050—to align with climate goals.
- Communicate information early on future gas rate increases to encourage customers to transition to electric appliances.
- There is a need for a clear financial plan for shutting down the gas utility, ensuring that costs don't unfairly burden taxpayers.
- Prioritize minimizing the impact of decarbonization on low-income families by working with non-profits and leveraging grant money.
- Phase out gas gradually, starting with customers farthest from the City, and provide time for residential users to transition.
- Industrial users, such as UVA, should retain methane gas for hard-to-decarbonize functions, with residential uses transitioning to electricity.
- Carbon offset programs should prioritize local projects, ensuring that low-income households are assisted in transitioning to electric systems.
- City Gas's tax contribution to the general fund must be considered in the transition plan, suggesting community solar as a potential revenue replacement.
- Expertise from UVA and local professionals should guide the transition to electric and renewable energy, especially in terms of cost and climate benefits.
- Urgency is needed in developing a set of solutions for net-zero GHG emissions, given the extreme weather events caused by climate change.

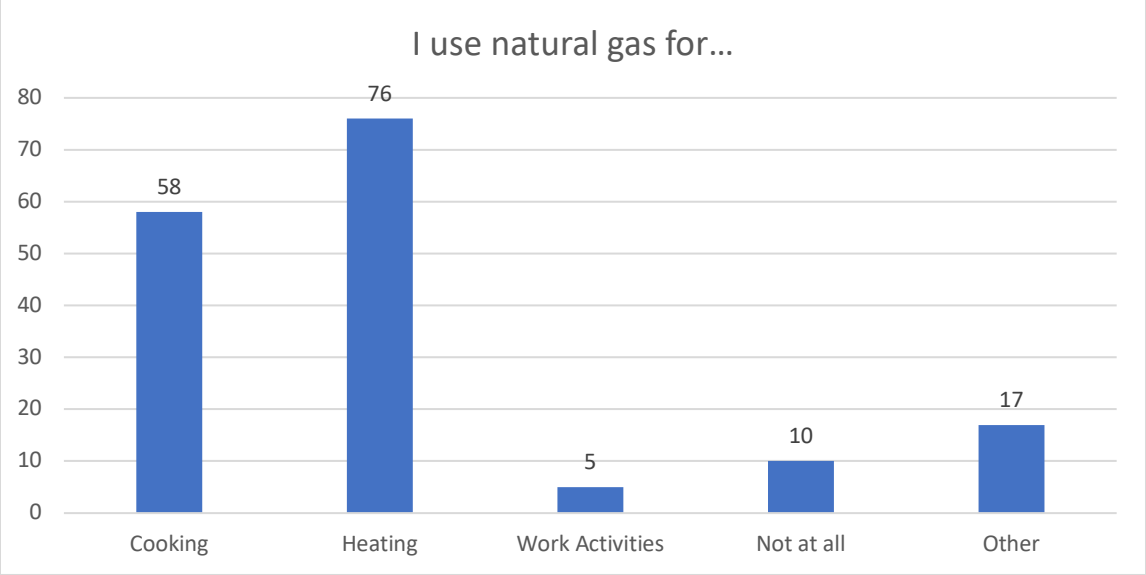
Poll Questions and Reponses

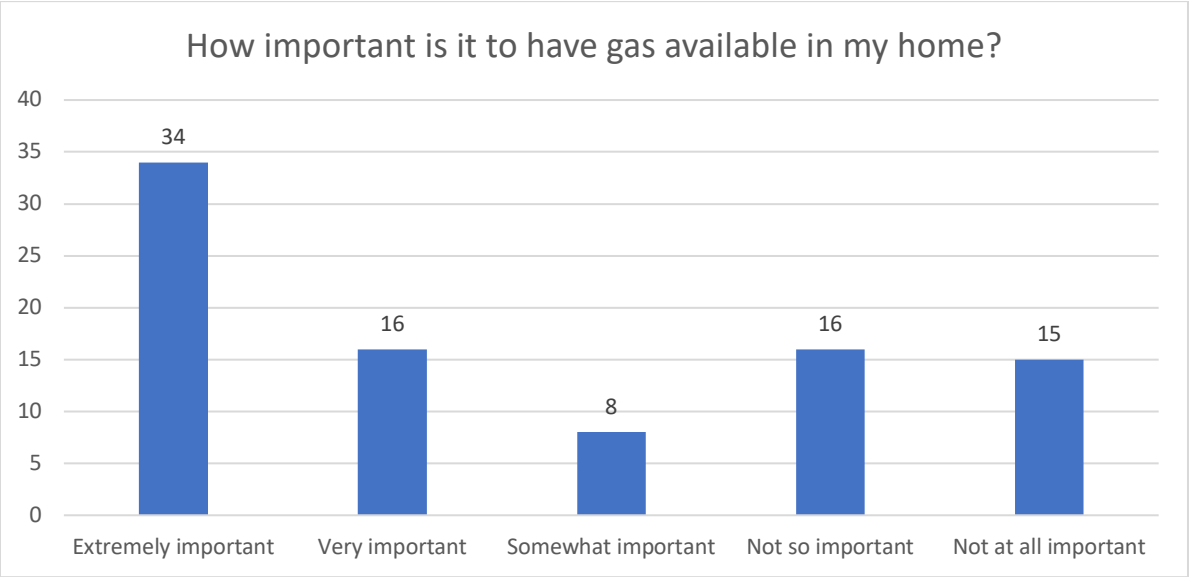
Several participant poll questions were asked during the three listening sessions. The findings from those questions are listed below. The number at the top of each result represents the number of people choosing that result from both virtual sessions and the in-person session, combined.






Do you represent a business/organization?
80
70
60
50
40
30
20
10
0
72
2
7
13
I do not represent a business/organization
In Albemarle County
In both the City and County
In the City of Charlottesville


I use natural gas for…
80
70
60
50
40
30
20
10
0
58
76
5
10
17
Cooking
Heating
Work Activities
Not at all
Other



COMMENTS From the Poll
There needs to be a dependable alternative to gas before we move forward.
Was looking for info on gas decarbonization. The meeting assumed we knew all about it.
There is obviously much more to be done in gathering appropriate information that will be helpful. I hope this will happen before this major decision is made, as it will have a huge impact on everyone. Thank you.
Assign breakout rooms and then change to each of the other rooms.
The City needs to do more to succintly and accessibly offer information to residents and utility customers. The Community Climate Collaborative has published a variety of research and resources on Cville Gas, which can be found at our website: https://theclimatecollaborative.org/.
The City needs to provide a full analysis with details on what has already been determined, the full scope of the study and any identified requirements of the plan.
I hope you will take input again after the study has outlined several options for aligning our gas utility policies to the City's climate goals.
Cville Gas needs to figure out how to go out of existence. You need a plan for that to meet decarbonization goals.
It would be helpful to know in advance that only minimal information will be provided; the bulk of the time is to submit comments and questions without expectation that you will receive any answers. Furthermore, in our breakout room, there wasn't enough focus to have a discussion. It just consisted of submitting more comments/questions.
Maintain gas until a viable and readily available and cost-effective alternative is provided.
I do think people brought up good points about what is needed is a look at the fuller picture of infrastructure and electrification.
Better messaging of what decarbonization is. Decarbonization in electric vs natural gas
This study needs to emphasize the economic impact on local residents, and the much larger/global impact of switching from Gas to Electricity, understanding that much of that power will come from sources that are not carbon friendly. Also, the larger issues of the capabilities of our electric grid.

The path forward does not truly grapple with "decarbonization". I get its hard, but this just won't do. A more creative approach is necessary. Residential and small commercial-scale use of natural gas (or biogas) in 2050 is not conducive with decarbonization.
Send us the City's response to concerns expressed today please.
This process feels like a waste of time. With decommissioning off the table, no tangible information was made about options for meaningful gas decarbonization.
I want to see the City take a long approach of weaning everyone off gas.
If shutting down the gas network is not on the agenda (at least not in the foreseeable future), and this seems to be the case, you need to make this *much* clearer to the public: since the disaster of the revision of the planning rules, where public input, except from expensive lawyers hired by a few upper class neighborhoods, had zero impact, there is a huge amount of distrust of the City, and all the more so when consultants from hundreds of miles away are involved.
There should be more coordination with other sectors of government in the City and county. You're studying decarbonization, apparently without coordination with those involved with land-use policy that has led and will lead to destruction of tree canopy. Do all parts and departments of government realize the effect of trees to sequestering carbon and to cooling the ambient temperature—thus enabling less use of air conditioning?
I think more community involvement & education are needed beyond the 3 planned sessions. Get out into the community.
Most important point made is focus on ways to decrease use of gas & go to renewals!
Please study why it is important to be ahead of the curve on this issue as a major political risk mitigation strategy for the City (in view of possible future policies imposed by the state or federal govt.)
Ensure discussion/info are in the hands of diverse communities.
Discussion dissolved into ideological arguments.
See www.ourwoods.org for research on effects of CO2.
Until the grid is upgraded with nuclear, natural gas is the more efficient use of energy. It takes X amount of natural gas to boil water on a stove, but X+Y amount of electricity to boil the same water. Encourage the use of natural gas to ease the stress on the grid.
As many offsets as possible should be located in surrounding communities.
The connection fee should gradually and transparently increase annually, staying ahead of inflation.
Incentives such as rebates should increase over time as well.
The City should not sell the utility.
The long-term costs of climate change and environmental and health impacts must be included in analyses, not just short-term costs.
Establish more aggressively at the outset of these meetings that the purpose is not to argue about the reality of climate change.
The unreliability of electricity in my City neighborhood has led a large percentage of neighbors to install gas-run, whole-house generators. Additionally, the new City zoning ordinance disincentivizes the installation of solar and the planting of trees in North Downtown. All City departments should communicate and cooperate toward common goals.
Please do everything you can to save our planet.
Major concerns about the reliability of the electrical grid and costs of electricity.
Concerns that while decommissioning is not currently proposed, it may quickly follow onto that path before new infrastructure is in place and costs of alternatives are reasonable.
Need further detailed info/focus prior to asking of attendees.

Explain your terms. What exactly is decarbonization? Does it work like dewatering in that you take carbon out of a material or does it mean taking carbon dioxide out of the energy stream, or something else?
Explain to people clearly if this means NOT using gas or not.
Why are we not targeting users of dirty fuel (like UVA/coal, local cement kilns, etc.) and switching them to Natural Gas? It may be a fossil fuel, but it's still the cleanest hydrocarbon available vs other fuels.
Why not capture methane at the landfill?

APPENDIX E: ESTIMATED END-USER ELECTRIFICATION COSTS

DECARBONIZATION STUDY

Charlottesville Natural Gas Municipal Utility

PREPARED FOR

Utilities
City of Charlottesville

Charlottesville Gas Utility

End-User Electrification Costs

Though electrification initiatives and adoption were not modeled or proposed as a gas utility-driven action, high-level fuel conversion costs were developed and estimated to demonstrate the upfront capital costs required by end-users to convert from natural gas to electrification.

For a household, decarbonization involves transitioning from natural gas to electric appliances. Major sources of natural gas use today in households include cooking with gas ranges, space heating with natural gas-fired furnaces, and water heating with gas-fired boilers. Households have an opportunity to switch to electric alternatives at a large capital investment. To understand what this capital investment could look like for an average household, an analysis was created to understand what the fully installed costs (appliance and installation cost) would be to switch cooking, space heating, and water heating appliances to electric.

Black & Veatch completed a high-level market assessment to develop a low-end and high-end average estimate for fully installed costs for a single household to fuel-switch from natural gas to electric. For cooking and space heating, it was assumed that an electric range and an electric heat pump would be installed in place of the currently installed gas appliances. New heat pumps are assumed to utilize the existing ductwork distributing heat from the natural gas fired furnace. In the case of water heating, two electrification scenarios were created that assumed the currently installed natural gas water heater would be replaced with either a heat pump water heater (HPWH) or an electric water heater. It was also assumed that an upgraded electric panel would be required to support these new appliances. Table 1 outlines the low- and high-end assumptions used for this analysis.[1]

Table 1 Estimated Range of Household Average Electric Appliance Fully Installed Costs[2]

Appliance	Fully Installed Estimated Costs (2024 $)
Electric Range	$975 - $1,725
Electric Heat Pump for Heating/Cooling	$4,500 - $20,000
Water Heating	
HPWH	$2,500 - $7,500
Electric Water Heater	$1,500 - $5,100
Electric Panel Upgrade	$1,275 - $1,550

Federal tax credits made available through the IRA have also been considered in this analysis.[3] Under the IRA 25C tax credit, each household qualifies for the lesser of $2,000 or 30% of the individual total installed costs in tax credits for electric heat pump and HPWH upgrades that meet efficiency requirements.[4] The 25C tax credit program also includes rebates for qualifying electric panel upgrades for the lesser of $600 or 30% of the total installed costs.

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[1] Electricity prices are not included. Estimates are only one-time appliance conversion estimates.
[2] Data points were informed using desktop research from the following data sources: Home Depot, Homewyse, EnergyStar, Forbes, FIXR, AVS, American Society of Home Inspectors, Rewiring America
[3] Income driven rebate programs such as the Home Electrification and Appliance Rebate (HEAR) Program made available through the IRA were not accounted for in this analysis.
[4] Tax credits for qualified energy efficient improvements are capped at $3,200 for all combined upgrades per year.

It was found that a single household fuel-switching to electric appliances would cost between $6,068 and $27,575 after IRA tax credits. Where a household would fall under this range is affected by a multitude of factors including house size, appliance electrical efficiencies, type of heat pump (air-source/ground source, ducted/ductless, absorption), hot water upgrade type, and the level of panel upgrades required. The full range of investment costs for a single household (with tax credits) is outlined in Table 2.[5]

Table 2 Estimated Cost Range for Households to Fuel Switch: Water Heating and Cooking

Upgrade Choices	Low-End Estimate (2024 $)	High-End Estimate (2024 $)
Electric Range, Heat Pump, HPWH, and Electric Panel Upgrades	$6,768	$27,575
Electric Range, Heat Pump, Hot Water Heater, and Electric Panel Upgrades	$6,068	$25,175

Electric load growth in Dominion Energy's service territory, the DOM (Dominion) Zone within PJM is expected to be one of the highest in the PJM, with an overall 6% 15-year CAGR through 2039, mostly driven by data centers and electric vehicles. Dominion Energy service territory's electric capacity is significantly constrained, as reflected in the capacity price in the DOM zone hitting $444.26 KW-year, an unprecedented level, in the recently completed 2025-2026 Base Residual Auction PJM auction. Incremental systematic conversion of natural gas demand to power generation will add to the capacity constraints in Virginia, which could lead to sustained electric rate increase for electric customers.

[5] The only difference between the two ranges provided in Table 2 is the use of a HPWH versus a hot water heater.