

# The Future of Gas in New York State



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A report by the  
Building Decarbonization Coalition

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# Executive Summary

In 2019, New York State passed the Climate Leadership and Community Protection Act (Climate Law), landmark climate legislation that altered the context in which the Public Service Commission (PSC or Commission) regulates and in which New York's gas utilities operate. Bringing emissions from New York's buildings—which account for nearly one third of the State's total greenhouse gas emissions—into line with the Climate Law's ambitious mandates necessitates a rapid transition away from the fossil fuels that have dominated the sector for decades.

Growing competition from non-fossil alternatives is putting downward pressure on fossil methane gas consumption and gas utilities' ratepayer counts. Zero-emission electric technologies are improving, customer preferences are changing, and state and federal policy measures are encouraging and enabling ratepayers to reduce or eliminate their reliance on gas. Left unmanaged, declining gas consumption and gas ratepayers will concentrate growing system costs among a dwindling pool of gas ratepayers. More ratepayers will avoid paying for increasingly expensive gas, creating a self-reinforcing negative feedback loop for gas utilities, and placing a crushing financial burden on those left on the network, especially low-income New Yorkers. The Commission and other state actors have yet to intervene to avert this result.

New York's gas utilities' responses to the Climate Law put ratepayers at risk over the long term. Gas utilities are *increasing* their investments in their high fixed-cost pipeline networks despite growing risk

that those networks will become obsolete due to competition and climate policies. Over the past 10 years, the undepreciated balance of New York's gas utilities' investments in gas distribution infrastructure has more than doubled from \$13 billion to \$29 billion. Even after the Climate Law was passed in 2019, gas utilities spent nearly \$5 billion on capital investments and identified pipeline replacement plans that would cost a minimum of \$28 billion to implement.

Changes to the market for energy used in buildings mean that gas utilities can no longer keep gas service affordable by spreading the cost of large capital expenditures over many decades and over a growing ratepayer base. Today, due to the age of the gas system, nearly 9 out of every 10 miles of distribution mains installed are *replacements*. While replacing old pipes improves system safety and reduces fugitive emissions, the average cost to gas utilities of doing so has ballooned to \$3 million per mile. When calculating what will actually be sought from ratepayers, the costs more than double due to taxes, depreciation, and the regulated rate of return investors receive. As a result, today, every time a mile of gas main is replaced, the average cost to do so is over \$60,000 per ratepayer serviced by that line. It is unreasonable to expect that these costs can be recovered from ratepayers over many decades. Both climate laws and competition encourage gas ratepayers to opt for alternatives.

To date, New York gas utilities' proposals for aligning their business with the emission reduction man-

**“Today, due to the age of the gas system, nearly 9 out of every 10 miles of distribution mains installed are replacements.”**

dates in the Climate Law involve maintaining their gas networks at scale, keeping current ratepayers connected, and continuing to flow gas through the system—just different gas and less of it. That is, to reduce emissions, gas utilities propose incrementally replacing fossil methane gas with a mix of renewable natural gas (RNG) and hydrogen, with some ratepayers partially electrifying but retaining their connection to pipeline gas and treating it as a supplement or backup. These proposals are flawed. RNG does not avoid the greenhouse gas emissions that arise from the leakage or combustion of methane. The number of resources currently needed to produce sufficient RNG to substitute for fossil methane gas would require twice the amount of all the cropland currently in use in the State of New York. As such, the use of RNG should be limited to producing higher-value energy products for non-residential uses. Hydrogen is even less suitable than RNG. Existing pipeline materials and appliances can safely accommodate it only at low-blend concentrations. Like RNG, hydrogen is more valuable for use in other hard-to-electrify sectors. Attempting to maintain gas networks at scale to deliver these fuels will increase ratepayer costs, leading to declining consumption and the start of a negative feedback loop of ratepayer exits from which gas utilities cannot recover.

New York’s legislature and Public Service Commission have an opportunity to intervene before the economics of the state’s gas networks unravel. The Commission, furthermore, has a duty to do so. That

intervention can set the state’s gas utilities and their ratepayers on the path of a managed, phased transition away from gas. The alternative—passively letting gas planning proceedings and rate cases roll ahead and quietly acknowledging tensions between gas utilities’ business model and compliance with the Climate Law—will not protect New York’s gas ratepayers nor, eventually, its taxpayers, from the disruption that lies ahead.

An effective, managed, phased transition will require coordinated engagement by state actors and rethinking of the dominant role that gas utilities have played in charting their climate future. At the state level, this would require updating old laws, written with an outmoded system in mind, with new legislation that envisions and enables transition. It would also require the Commission to take a more directive role with gas utilities as they plan for Climate Law compliance. At the regional and local levels, this approach would require a thorough energy asset planning process to map out energy resources and needs, followed by coordinated measures to shift groups of ratepayers off the gas system.

**“The amount of cropland needed to produce sufficient RNG to substitute for all fossil methane gas in New York would require twice the amount of cropland currently used in the state.”**

## Key Findings

This report's findings on the future of New York's gas system demand immediate attention from policymakers and regulators. Without intervention by the legislature and state agencies, gas utilities will continue to prioritize their business interests over the public interest, and steer toward a situation in which rates rise unsustainably, compliance with the Climate Law is in doubt, and gas utilities find themselves unable to provide safe and reliable service at just and reasonable rates.

- 1. New York's gas utilities continue to invest heavily in their distribution networks.** Their collective balance of undepreciated distribution assets has more than doubled over the past 10 years and they have spent an additional \$5 billion to maintain and expand their gas networks since the Climate Law was enacted in 2019. They are on pace to incur, at minimum, an additional \$28 billion in capital expenditures between now and 2043.
- 2. Gas mains are very expensive to replace.** The average cost per mile of a gas distribution main installed for New York's gas utilities is over \$3 million, with a total cost to ratepayers that is closer to \$6 million after additional expenses are taken into account. In New York, a mile of gas main serves, on average, 100 ratepayers. Thus the avoidable cost of installing new gas distribution main averages over \$60,000 per ratepayer.
- 3. Growing competition from non-gas alternatives will make gas more expensive.** The market for energy use in buildings is becoming more competitive, undermining the primary ways in which gas utilities have historically kept rates affordable: ongoing network expansion and the spreading of costs over many decades under the assumption that the network will see continued use.
- 4. Consumers want features that gas cannot provide.** Consumer preferences are changing: desire for comfort and convenience, recognition of potential cost savings from more efficient and flexible devices, and concerns about the impacts of gas and other fossil fuels on indoor air quality and health are increasing the demand for electric appliances.

- 5. Consumers are already electrifying.** The performance of electric technologies is steadily improving, reducing the competitive advantage of gas for space heating, water heating, cooking, and other applications. Consumers are responding by purchasing these technologies: more heat pumps were installed than furnaces in 2022.
- 6. Federal subsidies will accelerate electrification.** The trend toward electrification is being accelerated by the federal Inflation Reduction Act, which will inject \$7 to 11 billion into the marketplace for energy use in buildings, and thereby supplement the significant policy supports already provided by New York State to make alternatives to gas more readily available to consumers.
- 7. A decline in the number of gas ratepayers will significantly increase gas rates.** As competition and climate policies put downward pressure on gas consumption and ratepayer counts, the costs of safely maintaining gas networks will concentrate on the shrinking pool of ratepayers who remain, further incentivizing ratepayer exit. Gas utilities' own data indicate that a 2% annual decline in ratepayers and gas consumption would drive delivery costs unsupportably high: four times the present level by 2040 and seven times by 2050.
- 8. Intervention is needed to prevent an energy cost crisis.** Gas utilities' current business model cannot survive the self-reinforcing feedback loop of ratepayer exits and increasing rates. Without swift, proactive intervention, the Governor and legislature will eventually face a crisis over the widening gap between the costs of infrastructure fewer and fewer people want to use and waning available revenues to safely manage it.
- 9. Lower-income gas ratepayers are especially at risk.** Low- and moderate- income ratepayers are least able to make the investments needed to exit the gas system, and so they are at risk of being trapped and made to shoulder a disproportionate share of the burden of higher energy costs as gas rates spiral upward.
- 10. Proposals that rely on renewable natural gas or hydrogen are not credible.** Gas utility proposals to maintain their gas networks and comply with the climate law by substituting renewable natural gas or hydrogen for fossil methane lack a credible scientific or economic foundation, and they should be viewed as dangerous efforts to further delay the proactive management of an aging, increasingly outmoded system.
- 11. New York should take a managed, phased approach to gas system transition.** A managed, phased transition—a well-planned strategic downsizing of gas distribution networks that minimizes stranded assets through state and local-level planning and implementation efforts—is necessary to help individuals and communities end reliance on gas without compromising access to safe, affordable, and reliable energy services.
- 12. The legislature must act to make a managed, phased transition possible.** New York law currently impedes implementation of a managed, phased transition. First, it imposes an "obligation to serve" on utilities, defines that obligation as being fuel-specific, and does not provide for exceptions to that obligation. Second, the law provides for a cross-subsidy that defrays the cost of extending mains and service lines to new ratepayers.

# Recommendations

The recommendations below would help to steer away from harmful disruption, and toward a managed, phased transition—a result consistent with the vision articulated in the Climate Action Council’s Scoping Plan.

Legislature



## 1 Update utility laws that impede Climate Law implementation

Entity: **Legislature**  
Timing: **Immediately**

Update utility laws that impede the Commission and the utilities it regulates in implementing the Climate Law. The update should be enacted as soon as possible. Provisions requiring amendment include but are not limited to:

- ▶ Public Service Law sections 30 and 31 (imposing a utility obligation to provide gas service upon request to residential would-be ratepayers and establishing a “100-foot rule” that incentivizes connection and shifts its costs to other ratepayers)
- ▶ Transportation Corporations Law section 12 (similar but for commercial ratepayers)

Public Service  
Commission

Public  
Service  
Commission



## 2 Adopt an overarching gas planning framework to govern filings in both the Gas Planning docket (20-G-0131) and Climate Law Compliance docket (22-M-0149)

Entity: **Public Service Commission**  
Timing: **By the end of 2023**

That framework should:

- ▶ Specify emission reduction obligations for gas utilities under the Climate Law for both 2030 and 2050 and direct utilities to meet those obligations.
- ▶ Avoid unnecessary carbon and cost lock-ins by requiring that near-term LDC investments be consistent with longer-term plans for deep decarbonization to meet Climate Law emissions mandates.
- ▶ Implement concrete recommendations from the Scoping Plan, including halting the expansion of gas networks and requiring zero emission appliance replacements by specified dates.
- ▶ Accurately account for the lifetime costs of pipe replacement projects for comparison with non-pipeline alternatives and otherwise.
- ▶ Identify and direct stakeholders to act on opportunities for zonal phase-out and decommissioning of gas network segments based on potential cost savings, emissions reductions, and improved outcomes for end-users’ health and comfort.



### 3 Clarify issues related to RNG and hydrogen

Entity: **Public Service Commission**

Timing: **As soon as practicable**

- ▶ Direct the Department of Public Service, in collaboration with the New York State Energy Research and Development Authority, to issue assessments of the viability of RNG or hydrogen as decarbonization solutions for New York's buildings in light of constraints on cost, availability, climate impacts, and competition with other sectors also needing to decarbonize.
- ▶ Require any gas utility's plans or proposals involving RNG or hydrogen, whether submitted to the Commission in the context of a rate case or non-adjudicatory docket, to carry the burden of proof that those resources are: (1) are cost-effective relative to more readily available alternatives such as electrification, (2) deliver additional and directly attributable emissions reductions—including accounting for fugitive emissions, and (3) represent a clear best use case from a cost and emissions perspective for RNG and hydrogen feedstocks relative to their potential use in other sectors such as electricity, liquid fuels or chemical feedstocks.
- ▶ Scrutinize assumptions embedded in filings in planning proceedings or rate cases about demand for RNG and hydrogen from other sectors.

### 4 Steer gas utilities' development of their Climate Law Compliance Pathways Studies

Entity: **Public Service Commission**

Timing: **In response to March 2023 submissions of study proposals**

- ▶ Give direction to gas utilities regarding:
  - decarbonization strategies to model;
  - how they should model energy efficiency retrofits;
  - assumptions gas utilities should make regarding firming resources in the electric sector;

- required disclosure of assumptions about RNG feedstocks and emissions; and
- how gas utilities should incorporate thermal energy networks into their modeling.

#### ▶ Engage an independent consultant

- direct the consultant to review utility pathways analyses for consistency with Climate Law emission mandates and recommendations in the final Scoping Plan; and

authorize the consultant to request changes to these analyses where deficiencies are identified.

Department of  
Environmental  
Conservation



Department of  
Environmental  
Conservation

### 5 Medium- and long-term sector-specific emissions reduction targets

Entity: **Department of Environmental Conservation**

Timing: **As part of January 1, 2024 regulation issuance**

Include medium- and long-term sector-specific emissions reduction targets for the gas system in the emissions regulation to be adopted pursuant to Environmental Conservation Law section 75-0109. The price signals sent by a cap-and-invest program, such as the one New York plans to adopt, are unlikely to produce an optimal decarbonization strategy in the buildings sector. Gas utilities have a higher tolerance for emissions allowance costs because they can pass those costs through to ratepayers. And ratepayers will have both limited information about what is affecting their bills and limited options to respond. Because gas utilities and ratepayers are less likely to be responsive to price signals, an additional mechanism should further encourage the adoption of measures that reduce emissions from the gas system in line with the Climate Law's overarching target.

# Introduction

New York State's Public Service Commission (PSC or Commission) regulates the state's gas distribution networks and the utilities that own and operate them. In 2019, New York enacted the Climate Leadership and Community Protection Act (Climate Law),<sup>1</sup> committing the state to reducing its greenhouse gas emissions 40% from 1990 levels by 2030 and at least 85%—with a goal of net-zero—by 2050. Additionally, the Climate Act directs state agencies to assess their decisions in light of the act's overarching goal and to avoid decisions that do not move towards it.<sup>2</sup> As a result, the Commission must now guide New York's gas utilities towards compliance with the Climate Law. At the same time, the Commission must discharge its traditional duty of ensuring that energy utilities provide safe and reliable service at just and reasonable rates.

The consumption of fossil methane gas delivered by gas utilities through their distribution pipeline networks to residential and commercial buildings accounts for approximately 25% of New York's economy-wide emissions.<sup>3</sup> As such, gas utilities will need to reduce and eventually eliminate their use of fossil methane gas in order to comply with the Climate Law.

Since the enactment of the Climate Law, the Commission has authorized gas utilities to install and replace over 1,500 miles of gas mains and service lines at a cost of nearly \$5 billion.<sup>4</sup> As the Commission explained in an August 2021 order, these authorizations reflected in part that the Climate Law was then "a still nascent law," whose relevant requirements

would eventually be clarified by regulations and the adoption of the Climate Action Council's Scoping Plan. That clarification has now occurred.<sup>5</sup>

The Climate Law does not directly prescribe how the state must achieve its emissions mandates across various sectors. Instead, the law establishes the Climate Action Council, along with supporting advisory panels and working groups, and instructs that Council to develop "recommendations for attaining the statewide greenhouse gas emissions limits" in the form of a scoping plan.<sup>6</sup>

The Scoping Plan, which the Climate Action Council overwhelmingly voted to adopt in December 2022, "outlines a variety of regulatory and legal changes, market mechanisms, and technologies essential to achieving the goals and requirements of the Climate Law."<sup>7</sup> With respect to the state's buildings, the Scoping Plan envisions electrification as the primary means of decarbonization: it indicates that by 2050, 85% of the building stock will have been electrified.<sup>8</sup> To achieve that vision, the Scoping Plan recommends requiring new construction to be all-electric within the next five years and imposing zero-emissions standards on space heating, water heating, and other equipment installed in existing buildings shortly thereafter—standards that would disallow combustion of fossil methane gas.<sup>9</sup> With respect to the gas distribution system, the Scoping Plan is unequivocal that there will be a "transition away from fossil natural gas" and that the gas distribution system, which comprises nearly 50,000 miles of gas lines, must undergo "strategic down-

# “With respect to the gas distribution system, the Scoping Plan is unequivocal that there will be a “transition away from fossil natural gas”

sizing and decarbonization.”<sup>10</sup> The contents of the Scoping Plan will be embodied in New York’s next State Energy Plan,<sup>11</sup> which is binding guidance on the Commission.<sup>12</sup>

The Climate Law also directs the Department of Environmental Conservation (DEC) to adopt regulations that ensure compliance with statewide 2030 and 2050 emissions limits.<sup>13</sup> Those regulations, which are slated for adoption by January 1, 2024, must codify “legally enforceable limits, performance standards, or measures or other requirements” and reduce emissions from “sources<sup>14</sup> Importantly, these regulations must “[r]eflect, in substantial part, the findings of the scoping plan.”<sup>15</sup>

Based on the final Scoping Plan, the future of New York’s buildings sector is now largely established: over the next thirty years, pursuant to regulations and standards adopted under the Climate Law, New York’s residential and commercial buildings will electrify with few exceptions. The final Scoping Plan also establishes that widespread electrification will directly impact the state’s sprawling fossil methane gas distribution system and the gas utilities that own and operate it, such that those gas utilities “need to transform their business models.”<sup>16</sup>

While the Scoping Plan clarifies where New York’s building sector will arrive by 2050, the path that gas utilities will take to effectuate their part of that vision must still be prescribed. In contrast to its detailed and time-bound recommendations for electrifying New York’s buildings, the Scoping Plan does not suggest many concrete regulatory measures to the PSC and other agencies to manage the transi-

tion away from fossil methane gas or the attendant transformation of gas utilities. Instead, it offers “a framework” of “key principles,” research, considerations, and priorities for a coordinated multi-agency plan.<sup>17</sup> Put another way: the Scoping Plan instructs the PSC to delineate the path forward with due consideration for the vision and policy measures recommended for the buildings sector.

The framework put forward by the Scoping Plan maps onto proceedings that the Commission has already initiated: the Gas Planning Proceeding in 2020 and the Climate Law Compliance Proceeding in 2022.<sup>18</sup> Two orders issued by the PSC in those proceedings on May 12, 2022, direct gas utilities to begin planning the required transformation. Each gas utility is required to develop a long-term plan that forecasts demand and supply; identifies methodologies for forecasting reliability; includes different scenarios—among them a “no infrastructure option” that excludes new mains or service lines—for matching supply to demand reliably; and is reviewed by an independent third-party consultant retained by the Commission.<sup>19</sup> As for the Climate Law Compliance Pathways Studies, the gas utilities must draft a Study Proposal that:

shall include an assessment of the Utilities’ proposed projects and programs needed to achieve the Climate Law’s goals and statewide emissions limits, potential carbon dioxide equivalent reductions per year, million British Thermal units (MMBTU) reductions in billed annual usage, and the numbers of customers heating with gas in residential, commercial, and industrial classes per year under different scenarios, including a scenario that assumes full electrification where the utility is reasonably capable of providing an alternative energy option to natural gas.<sup>20</sup>

Further, the Study Proposal must identify barriers to emissions reductions and consider how gas utilities can avoid burdening communities designated as “disadvantaged” under the Climate Law.<sup>21</sup> These planning processes are both just beginning and will be guided by the Commission in accordance with the constraints imposed by relevant law.

**This report aims** to assist the Commission and other stakeholders at this critical, early moment in gas distribution system transition planning. It draws on existing research and adds new data and analysis on several key topics, such as costs of the gas distribution system, the fragility of gas utility business models to competition from new electric technologies, the hurdles to substituting fuels like renewable natural gas (RNG) or hydrogen for fossil methane gas, and the benefits and pitfalls of pathways studies. This report also offers a synthesis of these and other factors in a scenario-based discussion of potential approaches to gas distribution system transition. It is organized in four sections.

**Section 1 provides an overview of New York’s gas distribution system, including its growth, extent and associated costs.**

These costs include both direct expenses, such as the capital and operations costs recovered from ratepayers by gas utilities, as well as indirect costs, such as global and local emissions. Crucially, even the direct costs of the system are substantially obscured from ratepayers, owing to depreciation practices that became conventional thanks to a stable pattern of system growth over decades. As this section explains, the age of the system and lack of prospects for its continued expansion ensure that its present cost—both systemwide and to individual ratepayers—will increase markedly if the system persists at its present scale.

**Section 2 explains why gas utilities’ current business model faces impending disruption.**

Causes of disruption include competitive electric substitutes for gas-fired end-uses, as well as rising compliance costs under the Climate Law. These factors will lead to declining ratepayer counts and rates of consumption, driving down gas utility revenues in turn and concentrating costs among a shrinking pool of ratepayers. Ultimately, this feedback loop will leave gas utilities unable to provide reliable service to their remaining ratepayers at affordable costs. This section also explains why substituting fossil methane gas with renewable natural gas (RNG) or hydrogen cannot avert this disruption.

## **Section 3** presents four scenarios that explore distinct futures for New York’s gas distribution system.

1. Continued reliance on pipeline gas
2. Unmanaged transition off pipeline gas
3. Hybrid heating with pipeline gas
4. A Managed phased transition

Each of the four corresponds to scenarios presented in multiple gas system pathways analyses published over the past two years, some focused on New York, some on other states. By describing these four scenarios’ outcomes in terms of a standard set of objectives, this section distills their pros and cons, notes the risks they invite, and identifies what policies are available to mitigate those risks.

After presenting these scenarios, the section outlines several key findings. Retaining extensive gas networks, irrespective of the type or volume gas transported, would lock in sizable costs and likely lead to non-compliance with the Climate Law. Alternatively, a managed, phased transition would yield significant advantages with risks that could be addressed through appropriate policy measures. However, New York cannot pursue this latter scenario effectively under current law because provisions of the Public Service Law and Transportation Corporations Law prevent the Commission from constraining consumers’ access to gas service.

## **Section 4** expands on the following recommendations for addressing the future of gas.

*The legislature* should **update utility laws** that impede the Commission and the utilities it regulates from fully implementing the Climate Law.

*The Commission* should:

- ▶ **adopt an overarching gas planning framework** to govern filings in both the Gas Planning docket (20-G-0131) and Climate Law Compliance docket (22-M-0149);
- ▶ **steer gas utilities through their development of Climate Law Compliance Pathways Studies** by issuing guidance and engaging an independent consultant to review those studies;
- ▶ **clarify key issues related to RNG and hydrogen.**

*DEC* should include medium- and long-term emissions reduction targets for New York State’s gas distribution system in the greenhouse gas emissions regulation it is to adopt pursuant to section 75-0109 of the Environmental Conservation Law.

In addition to these four sections, this report also contains an appendix on pathways studies, which can provide helpful insights but are also susceptible to model design flaws, inaccurate data, and are limited in their ability to make sense of technological change. This report cautions that any pathways development exercise—including the studies the Commission has directed gas utilities to conduct—should adhere to core analytical principles including transparency about sources of inputs and degrees of certainty about outputs.

# New York's Gas Distribution System

Since the laying of the first cast iron gas pipe beneath New York's streets over two centuries ago, the construction and operation of gas networks in the state has been a costly endeavor. However, ratepayers have been willing to bear the costs because gas has historically been cheaper and preferable to alternatives of the time, from wood, coal, and whale oil in the 1800s, to fuel oil in the 20th and 21st centuries. Today, nearly 5 million gas ratepayers in New York receive service from a gas utility, subject to regulatory oversight from the Public Service Commission (PSC) pursuant to the state's Public Service Law.

This section provides a detailed account of the growth of gas networks in New York and how the companies that own and operate them have transformed over time in the face of competition and technological change. It addresses the economics of the gas distribution system and how expansion has historically been paid for. It concludes by highlighting the rising expenditures undertaken by gas utilities to maintain the gas network and the subsequent rising costs that they will seek to recover from ratepayers.

## Growth

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Over a 200-year history, New York's gas networks have grown steadily despite competition from other energy sources.<sup>22</sup> Today, these networks include nearly 50,000 miles of gas mains and serve ap-

proximately 5 million ratepayers across the state.<sup>23</sup> Looking back at the industry's history of responding to competition and its growth strategies can provide valuable insights for regulators and legislators who are grappling with the future of gas.

In 1823, the New York Gas Light Co. began installing the first gas system in the state, providing an alternative to whale oil lamp lighting.<sup>24</sup> Within decades, thousands of miles of cast iron gas lines were constructed to illuminate the streets and homes of New York's largest cities with gas manufactured from coal at nearby plants, commonly referred to as "manufactured gas" or "MG" Manufactured gas was a mixture of methane, hydrogen, carbon monoxide, and ethylene derived from the local combustion—or gasification—of biomass or coal in the absence of oxygen.

Despite its early success, the gas industry faced a significant competitive threat from electricity at the turn of the 20th century. The mere mention of Thomas Edison in the newspapers caused a decline in gas company stock prices.<sup>25</sup> To meet this challenge, New York's gas companies took three actions. First, the six largest gas providers in New York City ceased competing and consolidated into one entity, Consolidated Gas Co.<sup>26</sup> Second, Consolidated Gas purchased a controlling stake in Edison Electric.<sup>27</sup> And third, utility gas was repositioned for the heating and cooking markets.<sup>28</sup> As a result, when electricity adoption took off, the decline in gas consumption for lighting was more than offset by the

increase in use for heating and cooking, an outcome that Thomas Edison himself predicted.<sup>29,30</sup>

Not long after electricity replaced gas for lighting, New York's gas companies faced another threat to their business model. This threat came in the form of fossil methane gas, commonly referred to as "natural gas," or "NG" for short. Natural gas was a cleaner-burning and gas companies produced. Despite companies in other states making the transition, the dominant gas providers in New York held out on switching to natural gas for several decades. This was partially due to their distance from the major supply of natural gas in the Southwest, as well as financial concerns regarding undepreciated manufactured gas assets (e.g., gasification plants), which ConEd estimated their share of to be over \$250 million at the time, close to \$3 billion in today's dollars.<sup>31,32</sup> Moreover, the transition from the less energy-dense MG to NG would necessitate modifications to nearly every gas consuming appliance.

In 1951, the completion of a 1,840-mile natural gas pipeline to Manhattan led to a swift transition of customers from MG to the newly imported NG. By 1960, the number of NG customers in New York State had surged from 703,862 to 3,786,000.<sup>33</sup> ConEd and Brooklyn Union Gas in New York City converted all their ratepayers from manufactured to natural gas in less than a decade. In 1952, Brooklyn Union Gas mobilized over 3,000 technicians to convert each of their 925,000 customers with their 2 million appliances to the use of NG.<sup>34</sup> The shift from

**“In 1952, Brooklyn Union Gas mobilized over 3,000 technicians to convert each of their 925,000 customers with their 2 million appliances to the use of NG.”**



A Brooklyn Union Gas employee converts a gas stove to enable the switch from MG to NG, 1951.

Source: Brooklyn Daily Eagle photographs, Brooklyn Public Library, Center for Brooklyn History

MG to NG demonstrates how established industries can resist technological change that benefits their customers, as well as how companies can overcome perceived barriers to adoption when it serves their business interests.

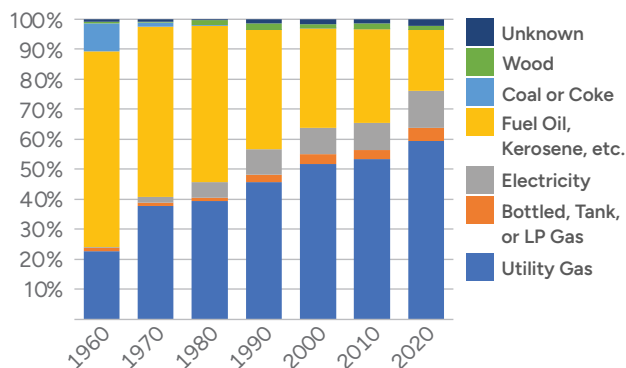
The transition to NG brought about 70 years of continuous expansion to the gas distribution system, financed by investors who expected to earn a stable, fair return on their investments. Although large capital investments were required for network expansions in the 1950s and 60s, customers did not experience a proportionate increase in their bills.<sup>35</sup> This was possible because gas utilities spread the costs of capital investments across a growing number of customers who were using an increasing volume of gas. Costs were also spread out over many decades, as the Commission approved then, as it does now, the use of an age-life, straight-line method of depreciation on gas utility assets, approving some service lives up to 85 years.<sup>36</sup> This method, still in use today, allows for the costs of gas infrastructure to be spread not just across more customers and units sold but also across many decades under the assumption of continued system use.

In the last 30 years, the growth of gas networks has been driven by advancements in high-efficiency gas appliances, low commodity costs due to advancements in hydraulic fracturing and gas processing, and policy measures that encouraged conversion from oil to gas for home heating. The fuel oil industry has borne the brunt of the resulting competition, with gas overtaking fuel oil as the most common source of energy for household heating in the 1990s.

Supporting this growth are the provisions of New York’s Public Service Law and Transportation Corporations Law that establish utilities’ “obligation to serve” and the “100-foot rule.” The first of these has long imposed an obligation on energy utilities to extend service to any potential ratepayers in their service territory who want service and can pay for it, and to continue providing service to existing ratepayers. The law frames that “obligation to serve” in a fuel-specific way: utilities are not obliged to provide just energy but the particular form of energy sought by a potential customer, whether gas, electricity, or steam. <sup>37</sup> The law all but guarantees the con-

\* Public Service Law section 30(1) states: It is hereby declared to be the policy of this state that the continued provision of all or any part of such gas, electric and steam service to all residential customers without

**Figure 1. Per-decade share of house heating fuel by energy source**



Source: US Census

tinued delivery of fossil methane gas to residential and commercial ratepayers in New York. As for the “100-foot rule,” it is a form of cross-subsidy for new residential gas ratepayers, who do not pay the costs of extending a gas main or service line by up to 100 feet from existing mains in order to reach their building.<sup>38</sup> Instead, that cost is added to the other capital costs that a gas utility recovers from all of its ratepayers. The 100-foot rule is a meaningful incentive: from 2017 to 2021 it shifted just over \$1 billion of costs off of roughly 170,000 new ratepayers—an average of about \$5,880 for each new ratepayer.<sup>39</sup>

## Present Costs


Today, ratepayers’ gas bills are increasing and will continue to do so in the coming years, irrespective of the influence of climate policies and building electrification efforts. The primary reason for rising costs is the continuous replacement of old cast iron and unprotected steel pipes that are considered “leak-prone.”

From 2011 to 2021, 72% of the gas mains installed were for the purpose of replacing existing lines. In 2020 and 2021, the proportion was even higher, with 89% of all gas mains installed serving as replacements for leak-prone pipes.<sup>40</sup> The removal of leak-

unreasonable qualifications or lengthy delays is necessary for the preservation of the health and general welfare and is in the public interest. And Section 31(1) states: “Every gas corporation, electric corporation or municipality shall provide residential service upon the oral or written request of an applicant.”

**Definition**

### Leak Prone Pipe (LPP)



Leak Prone Pipe (LPP) consists of unprotected steel pipe, cast iron pipe and some vintages of plastic pipe that can become brittle. To determine the amount of LPP remaining for each utility, the Commission relies on annual data supplied by utilities to the Federal Pipeline and Hazardous Materials Safety Administration (PHMSA). As of 2021, 8,177 miles of leak-prone pipe remain in New York, more than any other state in the country.



**Table 1. Changes to the book value of distribution plant-in-service of New York gas utilities in relation to miles of distribution mains installed, 2011-2021.**

	Distribution Plant in Service		Distribution Main (Miles)			
	2011	2021	2011	2021	Miles (expansion)	Miles (replacement)
<b>NYSEG</b>	\$272,698,675	\$1,223,464,465	4,723	4,852	129	284
<b>ConEd</b>	\$3,610,877,973	\$9,633,754,138	4,310	4,408	98	876
<b>RGE</b>	\$655,293,317	\$1,218,502,017	4,740	4,925	184	362
<b>KEDNY</b>	\$3,006,225,867	\$6,506,158,144	4,109	4,190	81	632
<b>KEDLI</b>	\$2,335,450,205	\$4,458,052,808	7,822	8,399	577	864
<b>National Fuel</b>	\$1,134,593,507	\$2,043,724,419	9,567	9,785	217	1012
<b>NiMo</b>	\$1,680,788,330	\$2,468,426,815	8,528	8,902	373	493
<b>CHGE</b>	\$252,699,057	\$670,438,086	1,185	1,313	128	125
<b>ORU</b>	\$460,606,205	\$868,986,946	1,834	1,880	46	159
<b>Total</b>	<b>\$13,409,233,136</b>	<b>\$29,091,507,838</b>	<b>46,818</b>	<b>48,653</b>	<b>1,833</b>	<b>4807</b>

Source(s): LDC filings to the Commission; PHMSA  
 Note: Fractional miles removed, not all columns and rows will sum exact.

prone pipe helps to reduce fugitive emissions and improve the safety of the gas distribution system. However, unlike during the early years of the expansion of gas networks, these costs are no longer being absorbed by a rapidly growing customer base.

Table 1 illustrates the substantial increase in the book value of gas distribution plant-in-service reported on gas utility balance sheets over the past decade. The book value of gas distribution plant is the primary component of the gas utility rate base, which in turn, drives what ratepayers eventually pay. The larger the undepreciated balance of plant, the greater the amount ratepayers will be expected to pay for delivery of gas. As shown in Table 1, between 2011 and 2021, New York gas utilities installed 5,640 miles of gas distribution mains at a cost of approximately \$15.7 billion, or \$2.78 million per mile.<sup>41</sup> Because the book value reflects the cost of assets at the time of installation, retiring old gas pipes has little impact on the rate base, while the cost of installing new gas pipes has a substantial impact.

As of the end of 2021, there are still 8,177 miles of distribution mains and over 350,000 service lines that are classified as “leak prone,” and targeted for replacement.<sup>42</sup> With an average installation cost-per-mile in 2022 that is now over \$3 million for distribution mains and over \$10,500 per individual service line, the total cost to gas utilities for replacing remaining leak prone pipe, if it were possible to do all at once, would be just over \$28 billion.<sup>43</sup> However,

**“Between 2011 and 2021, New York gas utilities installed 5,640 miles of gas distribution mains at a cost of approximately \$15.7 billion, or \$2.78 million per mile.”**

this number is not close to the full cost that ratepayers will be asked to cover. Additional costs such as operations and maintenance, taxes, and more also go into calculating the revenue requirement or “cost of service” that gas utilities seek permission from the PSC to recover from ratepayers.

The revenue requirement of a gas utility can be disaggregated into various components, including plant-in-service, depreciation, operations and maintenance expenses, taxes, and the allowed rate of return. One crucial determinant of depreciation calculation is the asset’s net salvage value, which is a negative amount for distribution mains. This negative value arises because the cost of removing the pipe at the end of its useful life exceeds the scrap or “salvage value” that the utility can recover. To account for this, the Public Service Commission

(PSC) authorizes depreciation plans that incorporate these negative salvage values. For example, Niagara Mohawk’s net salvage is 65%, which means that for every \$1 million spent on capital costs, the utility will seek to recover \$1,650,000. The total costs that gas utilities seek to recover may exceed twice the capital cost once taxes and O&M expenses are included. (Table 2) These costs increase as the asset’s service life lengthens, a point that will be elaborated on further in Section 2’s subsection on depreciation.

**Table 2. Simplified breakdown of a present-value revenue requirement for a representative 1-mile gas main replacement project**

Item	Cost	% of Installation Cost
<b>Main Installation</b>	\$3,000,000	100%
<b>Net Salvage</b>	\$1,950,000	65%
<b>Taxes</b>	\$949,500	31.65%
<b>Operations &amp; Maintenance (annual)</b>	\$67,500	2.25%
<b>Regulated Rate of Return</b>	\$210,000	7%
<b>Total Cost</b>	<b>\$6,177,000</b>	<b>206%</b>

Data Source(s): LDC filings to the commission; PHMSA. Analysis: Groundwork Data

Half a century ago, investments in gas networks on a large scale and at high cost may have been justified, as there were limited alternative options available, and public awareness of the health and climate impacts of fossil fuels was just emerging. At that time, these investments were relatively affordable due to growing customer bases and increasing consumption.

However, today, both the PSC and the majority of gas utilities in New York have acknowledged that the number of gas ratepayers and consumption of fossil methane gas will decline due to increasing competition from electric alternatives and climate policy measures. Despite this reality, gas utilities continue to install distribution mains with proposed service lives exceeding 75 years, which are projected to cost ratepayers over \$150 billion over their lifetime.<sup>44</sup>

## Gas planning does not need to wait for formal ratepayer impact studies

There have been calls for New York to defer decisions regarding its approach to a clean energy transition until the state completes a formal analysis of the costs of transition to individual ratepayers. While it remains important to ensure that the ratepayer impacts of decarbonizing buildings are manageable and allocated equitably, it is unnecessary to delay development or adoption of a decarbonization strategy for the building sector and gas distribution system pending a ratepayer impact analysis.

The first reason for this is that using forecasts of ratepayer impacts to dictate the decarbonization strategy puts the analytical cart before the horse. A utility does not begin its planning process for capital projects by examining how particular ratepayers might be affected should those projects be undertaken. Instead, it first decides what investments are required to provide adequate service to ratepayers by examining different portfolios of investments and determining how well and cost-effectively particular options would satisfy the utility's service obligations. This determination reveals a utility's "revenue requirement," or the aggregated costs of providing safe and reliable service to all ratepayers in its service territory. Only after determining how to provide service to *all* ratepayers most cost-effectively do utilities figure out how the costs and benefits of deploying and operating those assets should be distributed across categories of ratepayers. This order of operations makes good sense given that the aggregate cost of providing safe and reliable energy does not depend on how that cost is distributed—and because tools to ensure that the distribution is fair cannot lower the aggregate cost. The same logic applies to the task of determining which solutions would most cost-effectively meet the demand for energy in buildings in compliance with the Climate Law.

***Will the most cost-effective of those solutions result in different levels of cost and benefit for different ratepayers?***

**Almost certainly**

***Should a ratepayer analysis be conducted to help ensure that the resulting cost burden does not rise above a low threshold for any ratepayer?***

**Absolutely**

***Should that analysis precede the determination of which solution is feasible and most cost-effective in the aggregate?***

**It should not**

Another reason not to wait for a ratepayer impact analysis before determining a basic strategy for transition is that traditional ratepayer analysis is an inappropriate tool for comparing scenarios that involve significant changes to the gas and electric distribution systems. A typical ratepayer impact analysis requires holding fixed several analytical parameters, so that it is possible to see how the costs of a given investment or policy measure propagate and affect various categories of ratepayer. But, as the scenarios described in Section 3 show, nearly all versions of the impending gas transition involve multiple changes to basic parameters, such as the number of gas ratepayers, gas consumption, and the useful life of different components of gas distribution infrastructure. They also involve changes to the electricity system—and all gas ratepayers are also electricity ratepayers. Consequently, at least some of the key parameters that will actually be dynamic over the coming years must be assumed to be static in a ratepayer impact analysis. This mismatch effectively ensures that such an analysis of costs to individual ratepayers will fail to reflect reality and so be of limited accuracy and utility.

# New York's Gas Utilities Must Transform

There is a broad consensus among gas system stakeholders—reflected in the Scoping Plan—that continued reliance on fossil methane gas is incompatible with the emissions reduction requirements codified in the Climate Law.<sup>45</sup> This incompatibility, and the availability of non-emitting alternatives that do not rely on pipeline gas, spells unavoidable disruption for gas utilities' current business model. Arguments that this disruption can be avoided or even substantially mitigated by substituting renewable natural gas (RNG) for fossil methane gas rest on faulty assumptions. Biofuels derived from waste streams and other feedstocks have important applications in a decarbonized New York economy, but refinement into RNG is not one of them. The following subsections explain, in turn, the coming disruption for gas utilities and why RNG cannot prevent it.

## The Coming Disruption to Gas Utilities' Business Model

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The business model of gas utilities is facing mounting pressure and impending disruption. Electrification, energy efficiency, flexible energy demand management, and non-pipeline fuels are increasingly able to compete with utility gas at, among other things, delivering significant energy to buildings during peak demand periods. Climate laws in New York State, as well as in localities such as New

York City, promise to restrict the distribution and consumption of fossil methane gas with growing stringency. As competition intensifies and climate policies are implemented, gas utilities will face reduced ratepayer counts and decreased demand for pipeline gas from those that remain. To offset declining demand and revenues, gas utilities will need to raise rates for their remaining ratepayers. These higher prices will incentivize ratepayers to pursue alternative energy sources and seek disconnection from the gas network. This process creates a negative feedback loop that gas utilities cannot halt.

In addition, the declining use of gas lines affects the calculation of depreciation for those assets. Gas utilities will likely seek approval from the PSC for the use of accelerated depreciation methods on assets with costs that were originally intended

**“As competition intensifies and climate policies are implemented, gas utilities will face reduced ratepayer counts and decreased demand for pipeline gas from those that remain.”**

**Table 3. Opportunities for value creation in the gas transition.**

<b>Electrification</b>		
End-Use	Improved Electric Alternative	Value Propositions
<b>Heating</b>	Heat pumps in various arrangements	Efficient heating and cooling and enhanced comfort through room-by-room control of heating and cooling
<b>Hot Water</b>	Heat pump water heaters	Flexible and efficient operation with demand response
<b>Cooking</b>	Induction cooktops	Faster boil times, precise cooking, easier to clean, improved indoor air quality
<b>Clothes Drying</b>	Hybrid heat pump, electric resistance	Ventless and gentle on fabrics
<b>Building Efficiency Upgrades</b>		
Strategy	Actions	Value Propositions
<b>Shell upgrades</b>	Insulation, weatherstripping	Reduced energy consumption, increased comfort, resilience, improved air quality
<b>HVAC system upgrades</b>	Retro-commissioning, controls, zoning, improved duct performance, air filtration	Reduced energy consumption, increased comfort, resilience, improved air quality
<b>Non-Pipeline Fuels</b>		
End-Use	Strategy	Value Propositions
<b>Cooking</b>	Propane	Maintain customer cooking preference, e.g., for grilling
<b>Heating</b>	Auxiliary propane or wood heating	Meet auxiliary heating needs if barriers to full electrification exist
<b>Fireplaces</b>	Propane, wood or electric	Maintain customer aesthetic preferences

to be recovered over seven or eight decades but are now at risk of sooner obsolescence. The result is even greater near-term costs to the ratepayer. In anticipation of this risk, the PSC directed gas utilities in a May 2022 order to study the consequences of accelerating their assets’ depreciation amid falling ratepayer counts. The recently filed studies by the gas utilities provide the commission with estimates of the ratepayer impact of declining gas use, declining consumption, and accelerated depreciation, the causes and consequences of which are further discussed below.

## Competition

From the perspective of consumers, energy system operators, and policymakers, gas is facing increasing competition from alternatives, most of them electric.

New technologies, information, and priorities are eroding the appeal of gas for use in residential and commercial buildings. The suite of technologies includes cold-climate heat pumps that can provide space heating even when outdoor temperatures drop well below freezing, demand-responsive heat pump water heaters, and induction cooktops. New

information on the negative effects of gas equipment and appliances, particularly gas ranges<sup>46</sup>, on indoor air quality undermines industry claims that gas is a clean and safe option. Consumer priorities increasingly include comfort, efficiency, flexibility, and tailored control of humidity and temperature, which are more easily achieved with electric options than gas. Analyses and pathways studies conducted on building electrification tend to fixate on consumer costs, overlooking comfort, health and preferences.

Table 3 lists ways in which alternatives to pipeline gas offer value that challenges the historical role and appeal of the gas system. Some of these alternatives have higher upfront and operating costs, while others may have practical barriers and challenges. However, all of these gas-reducing strategies have the potential to create sources of customer value that are not available from gas.

In addition to these customer-centric value propositions, non-pipeline alternatives can also enhance energy system reliability and operations. Electric appliances and equipment can operate more flexibly. For example, most heat pumps can operate at variable speeds to ensure precise temperature control, providing better thermal comfort with less energy use. Smart heat pump and thermostat sys-

tems can be programmed to pre-condition (warm or cool) buildings in response to time-variant electric rates to reduce costs and emissions. Batteries can serve many backup needs. Non-pipeline fuels, such as propane, can provide hourly and multi-day reliability. An increase in cooling from accelerated heat pump deployment can alleviate heat stress in at-risk homes and avoid the expense of less efficient air conditioning units. Electric distribution systems can become more resilient via undergrounding, micro-grids, storage and other distributed strategies that counter claims that the gas distribution system is inherently more reliable. Furthermore, more efficient buildings will be able to keep warm or cool longer.

## Climate Policy

The Scoping Plan calls on agencies to achieve two building electrification targets by 2030: electrifying heating in one to two million homes by installing heat pumps, and electrifying space heating and cooling in 10% to 20% of commercial buildings.<sup>47</sup> Policy measures can support progress toward these targets in at least two ways. One involves constraining access to gas, whether by restricting its consumption or making that consumption more expensive over time. Another involves supporting investments in alternative means of energy consumption that allow end-users to reduce or even eliminate their reliance on gas. Examples of each are described below. The examples include federal, state, and local policies.

### Constraints on gas consumption

The Scoping Plan recommends that New York State agencies adopt several measures to limit or constrain emitting activity, including regulations,<sup>48</sup> performance standards,<sup>49</sup> and a cap-and-invest program.<sup>50</sup> Local governments have also adopted laws to restrict or eliminate fossil methane gas use in buildings.<sup>51</sup> These constraints will necessarily tighten as New York and its localities draw closer to the emissions deadlines codified in the Climate Law and local laws like New York City's Climate Mobilization Act. And the tightening of those constraints will put steady downward pressure on both the number of gas ratepayers served by gas utilities and the level of consumption by remaining ratepayers. Three initia-

tives help to illustrate how different measures will lead to reduced demand for gas and the adoption of non-fossil alternatives.

**New York City's Local Law 154.** Late in 2021, New York City adopted a law imposing carbon dioxide emissions limits on new construction and gut renovations of buildings under seven stories starting in 2024 and for taller buildings starting in 2027.<sup>52</sup> Those limits were carefully calculated to fall just below the level of emissions resulting from fossil methane gas combustion, effectively excluding gas lines, as well as systems that might rely on fuel oil, from new buildings.<sup>53</sup> The rate of turnover of New York City's building stock is slow: the city's one million buildings generally stand for multiple decades.<sup>54</sup> Relying on a requirement for new construction could mean waiting nearly a century for all of the city's buildings to move away from reliance on gas. Even so, as new, all-electric buildings replace older ones, they will put downward pressure on the number of gas ratepayers in the city. Notably, as of this writing, New York State's legislature is considering a similar measure consistent with the Scoping Plan.<sup>55</sup>

**Phase-outs.** The Scoping Plan recommends that DEC and NYSERDA adopt regulations requiring residential and commercial tenants to replace gas-fired appliances, at the end of their useful lives, with zero emission (presumably electric) appliances beginning on certain dates.<sup>56</sup> Whereas a mandate for all-electric new construction causes energy system turnover to move at the slow pace of the turnover of building stock, this sort of measure would shorten that timeframe to the useful life of a range, furnace, boiler, or hot water heater.

**Cap-and-invest.** As noted in the introduction, the Climate Law directs the Department of Environmental Conservation (DEC) to adopt detailed emissions regulations that specify how various sectors and emissions sources shall comply with the Climate Law's overarching emissions reduction targets.<sup>57</sup> Governor Hochul has announced a plan, consistent with a recommendation in the Scoping Plan, to meet that directive by adopting a cap-and-invest program.<sup>58</sup> Such programs set a cap on permissible emissions and require the purchase of emissions allowances by entities directly or indirectly responsible for emitting activity. Because it would be

impractical to require all retail consumers to purchase allowances commensurate with the emissions expected to result from the consumption of fossil fuels, the program would instead require upstream entities like gasoline wholesalers or gas utilities to do so. The added cost of the allowances would then be reflected in the price paid by retail consumers, giving those consumers added incentive to seek non-emitting alternatives. Climate Law requires that DEC's implementing regulation must apply to emissions from small sources with cumulatively large impacts, like oil or gas-fired furnaces.<sup>59</sup> Over time, the volume of available allowances would be reduced, driving the price of each allowance steadily higher, and with it the price of consuming greenhouse gas-emitting fuels.

## Support for adopting alternatives to gas

Several New York State programs that support energy efficiency and electrification measures predate the adoption of the Scoping Plan.<sup>60</sup> The Scoping Plan recommends that still more be done.<sup>61</sup> In addition, federal programs established by the Inflation Reduction Act of 2022 promise to direct substantial additional support toward electrification as well. The examples below help to illustrate the scale of support available to building owners and tenants in New York who want to electrify.

**Ground Source Heat Pump Tax Credit.** In 2022, New York's legislature adopted a tax credit for up to \$5,000 toward the costs of a GSHP's installation.<sup>62</sup> GSHPs, compared to ASHPs, do not experience as much of a decline in their efficiency or capacity when outdoor air temperatures drop extremely low, but GSHPs also require installation of an underground thermal loop, which means they require adequate space and drilling or trenching services. Thus, GSHPs are an advantageous solution for sparsely developed areas in very cold regions, but their acquisition entails a substantial up-front cost. The tax credit program allows a homeowner who installs a GSHP to reduce their tax bill, effectively recouping up to 25% of that cost or \$5,000.

**Clean Heat Program.** This program provides funds and resources to utilities and contractors rather than to the ratepayers whose home or business has an air or ground source heat pump installed. By pro-

viding those entities with an incentive, rather than end users, it encourages contractors to become familiar with the technologies and their installation and maintenance, makes use of utilities' relationships with their ratepayers, and helps to keep the search costs between would-be heat pump users and a capable contractor low. The recent experiences of ConEd and Central Hudson with this program reflect the enormous popularity of subsidized heat pump installation with residential customers in parts of New York State where gas distribution system density is highest: both utilities exhausted their authorized funds years ahead of schedule and have sought authorization to increase the funds available to them to keep up with unexpectedly high levels of demand.<sup>63,64</sup>

**Inflation Reduction Act's High Efficiency Electric Home Rebate Program (HEEHR).** Several federal programs were established with passage of the Inflation Reduction Act in 2022. The New York State Energy Research and Development Authority estimated that the tax credits and programs created by the Inflation Reduction Act would result in a \$7 to \$11 billion boost to New York's building energy efficiency and electrification efforts.<sup>65</sup> HEEHR is just one of the programs established by the act. It makes available point-of-sale rebates for consumers who purchase one of several types of electric appliances for their home, such as heat pumps for space and water heating or induction stoves. Those rebates can defray the cost of a heat pump for space heating and cooling by up to \$8,000.<sup>66</sup> The success of federal programs in supporting clean energy transitions depends heavily on state and local institutions that can manage or guide federal support effectively. Fortunately, New York State is particularly well-equipped to take advantage of these opportunities, thanks to its Climate Law and various institutions dedicated to its implementation.

The climate policy measures discussed above are just a few examples from a long list. Given that gas utilities' competitive position relies on fossil methane gas being priced competitively relative to other readily available alternatives, the combination of policy constraints on gas access and incentives for alternative adoption will directly reduce the value proposition of gas services delivered through pipelines.

## Effects of Competition and Climate Policy on Gas Consumption and Ratepayer Counts

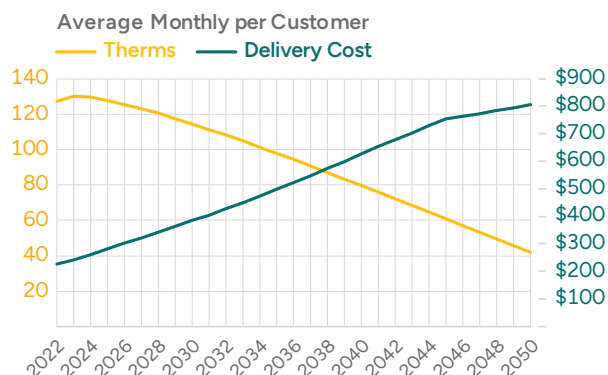
As discussed in Section 1, the affordability of the gas network relies on its ability to outcompete alternative energy sources, as well as ongoing growth in the number of ratepayers and their consumption. However, the rise of competitive substitutes and the continued downward pressure on fossil methane gas consumption due to shifting customer preferences and regulatory compliance will result in an increase in the rates for delivered gas. This, in turn, will encourage more ratepayers to leave the gas system, but any reduction in gas system costs will be far short of proportional. Fixed costs will remain high, leaving remaining ratepayers with higher bills. Many of the ratepayers remaining on the gas network are likely to be renters, low-income households, and others who are least able to shoulder the larger energy bills.

The subsections below lay out the potential impact of reduced consumption and ratepayers disconnection using data submitted to the PSC by National Grid for its KEDNY territory in Brooklyn and Queens. They then discuss the impact that reduced gas use has on gas utilities' accounting for depreciation and the subsequent consequences for investors and ratepayers. These subsections conclude by illustrating how a combined decline in gas ratepayers and consumption, coupled with the availability of competitive substitutes, can create a negative feedback loop, accelerating gas system decline.

### Reduced Gas Consumption Does Not Reduce Gas Distribution Costs Proportionally

As highlighted in Section 1, utilities spread the costs of gas distribution infrastructure across the total volume of gas sold. In New York, the commodity supply price of gas has been unbundled from delivery costs since the restructuring of gas markets in the 1990s. However, the volume of gas consumed across the network, measured in therms, still significantly impacts the rate paid for gas delivery. This approach

**Figure 2. Impact of Reduced Consumption on Gas Delivery Costs—KEDNY (Brooklyn and Queens)**



Data Source: National Grid Gas Projections Model, National Grid PSC Supplemental Filing to Annual Report. Analysis: Groundwork Data

has enabled many ratepayers who would otherwise have been unable to afford to connect to the gas network to do so. Once connected, new ratepayers begin paying back the fixed costs of extending service to them through their own consumption, with higher consumption ratepayers subsidizing lower consumption ones.\* However, in the event that total consumption declines relative to the fixed costs of the distribution network, the cost per therm of gas will increase. The more consumption declines, the higher rates will go, incentivizing those who can afford it to leave the gas system altogether.\*

Figure 2 illustrates the expected monthly cost impact of reduced consumption on a ratepayer using data submitted by National Grid to the PSC for their KEDNY territory.<sup>67</sup> The chart holds the number of ratepayers constant at 2022 through 2050 and reduces annual consumption according to National Grid's High Electrification Scenario, declining to 34% of 2022 levels by 2050. The chart demonstrates how even in a zero-ratepayer departure scenario, with declining gas use, the monthly bill for a ratepayer would nearly quadruple despite using one third of the gas they do today.

The reduction in consumption shown in Figure 2 would be highly unlikely to be spread evenly across

\* Higher consumption ratepayers subsidize low consumption ratepayers insofar as the fixed costs of gas infrastructure required to serve them is of similar cost. A higher consumption ratepayer who requires more fixed infrastructure to connect to the network may actually be subsidized by a lower consumption ratepayer.



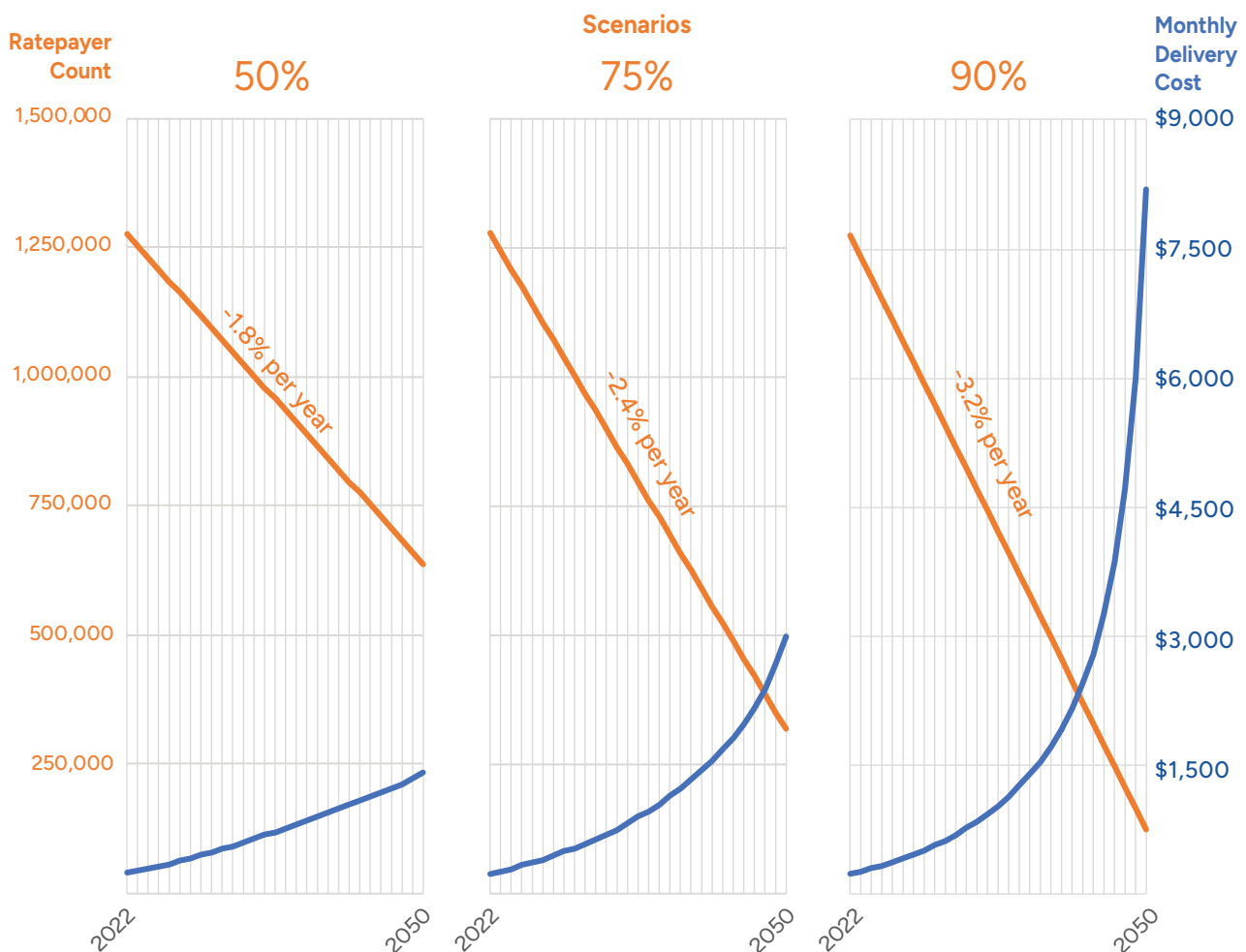
the months of the year. Instead, under current rate design and usage patterns, the average annual cost of gas delivery per ratepayer of \$9,653 in 2050 would be incurred almost entirely in winter months.

### Reduction in Ratepayers

As the number of a gas utility’s ratepayers decline, the strain on its solvency grows. With fewer ratepayers, the revenue required to maintain and operate the network must be spread across the smaller ratepayer base. Gas utilities have some flexibility to shift cost burdens across ratepayer classes (e.g., from residential to industrial), but this becomes increasingly challenging as costs grow. While gas utilities can try to reduce variable costs such as ratepayer service and billing support, these cost-cutting

measures are limited by the need to maintain safe and reliable service for ratepayers who remain, and therefore fall short of making up for ratepayer loss.<sup>68</sup> Figure 3 utilizes data supplied by National Grid for its KEDNY territory to demonstrate the potential financial impact, in the form of increased delivery costs, that declining ratepayer count and consumption would have on remaining ratepayers.

**Figure 3. Effect of Ratepayer and Consumption Decline on Monthly Delivery Costs by 2050**



Data Source: National Grid Gas Projections Model, National Grid PSC Supplemental Filing to Annual Report. Analysis: Groundwork Data

## Effect of Falling Consumption and Ratepayer Counts on Asset Depreciation

Amid the shifts in competition and policy described above, depreciation functions as another conduit for delivering pressure to gas utilities' business model. Depreciation measures the decrease in the value or worth of a fixed asset that occurs throughout its useful life. In the context of rate regulation, depreciation is also an expense that a regulated entity is allowed to recover from ratepayers.<sup>69</sup> It is distinct from the rate of return on capital assets. While the rate of return compensates investors for risk—a return on capital—depreciation is meant to ensure the return to investors of the capital they invested. As such, gas utilities seek to use as accurate as depreciation methods as possible to attract investor capital and allocate costs to their ratepayers accordingly.

The calculation of gas asset depreciation for gas utilities includes three key components: asset service life, net salvage value, and the method of depreciation. Gas mains are New York gas utilities' largest depreciable asset.<sup>70</sup> Distribution main service lives tend to range from 60 to 80-plus years. Their net salvage value, which represents the expected cost recovery needed to remove pipeline at the end of their service lives, frequently range from 30% to 85% of the cost to install each pipe.<sup>71</sup> Gas utilities in New York use the "straight-line method" to calculate mains' rate of depreciation—meaning that they assign an equal value for each year of a gas main's expected service life. The service life in the context of depreciation is not determined by an asset's physical condition but by its utilization. If all ratepayers were to disconnect from a gas line, it would be at the end of its service life and would not be included in the gas utilities' rate base. The PSC, and potentially a court, would determine whether gas utility investors can recoup their investments in assets whose service lives end prematurely.<sup>72</sup>

Gas utilities may try to mitigate or wholly avoid financial and legal problems from reduced asset use by requesting permission from the Commission to use alternative depreciation methods. For instance, gas utilities might seek to switch from the "age-life" to the "units-of-production" cost allocation method. Doing so would allow gas utilities to depreciate

pipeline assets based on the volume or number of units of gas passing through those assets. Another option is to set a retirement date, as is done for electric production facilities, and to calibrate the level of depreciation in a given year in order to fully depreciate an asset by its designated retirement date. While this strategy ensures recovery of all costs by a specific date, it also tends to increase short-term costs to ratepayers because it recovers more of the asset's value sooner than would occur otherwise.

Pursuant to instructions from the Commission, New York's gas utilities recently explored "both the structure of accelerated depreciation and its potential impact on ratepayers."<sup>73</sup> The study that each gas utility prepared indicates how costs to ratepayers would change in different circumstances and depending on what method and timeframes gas utilities use to depreciate their assets. The parameters for the "High Electrification" scenario, for instance, includes the departure of 90% of gas ratepayers and a 66% reduction in gas consumption by 2050. One method of depreciation the gas utilities explored for this scenario was to "recover all by 2050," meaning to set 2050 as the retirement date for all assets and, accordingly, to depreciate them fully by that year.

National Grid's study for its KEDNY service territory considered the effect of a "recover all by 2050" approach under a High Electrification scenario, but a decision was made to omit operations, maintenance (O&M), and taxes from the projected ratepayer impact of each depreciation scenario.<sup>74</sup> Omitting taxes and O&M has the effect of suggesting that a "recover all by 2050" method, in accordance with which all of National Grid's KEDNY assets would retire by 2050, would result in *higher* costs to ratepayers than other methods of depreciation. However, the inclusion of O&M and taxes reveals that in a "High Electrification scenario," retiring all gas distribution assets by 2050 would be considerably cheaper for ratepayers than maintaining gas assets beyond 2050. National Grid's submission inadvertently highlights the potential risks associated with continuing to assume a service life of 70 plus years for newly installed gas assets, underscoring the need for a more prudent approach.

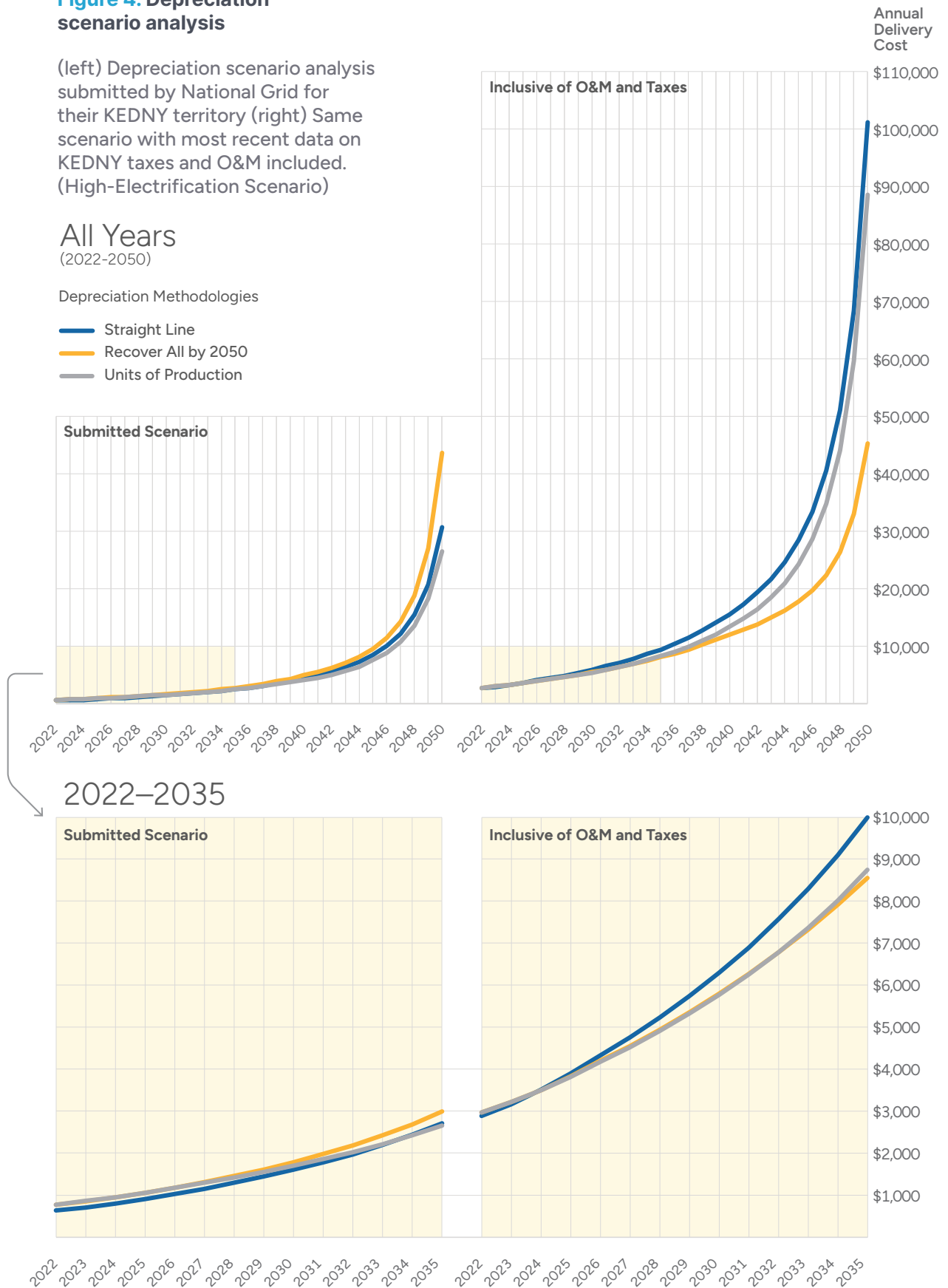
**Figure 4. Depreciation scenario analysis**

(left) Depreciation scenario analysis submitted by National Grid for their KEDNY territory (right) Same scenario with most recent data on KEDNY taxes and O&M included. (High-Electrification Scenario)

All Years  
(2022-2050)

Depreciation Methodologies

- Straight Line
- Recover All by 2050
- Units of Production



Source: National Grid Gas Projections Model, National Grid PSC Supplemental Filing to Annual Report

**“the inclusion of O&M and taxes reveals that in a “High Electrification scenario,” retiring all gas distribution assets by 2050 would be considerably cheaper for ratepayers than maintaining gas assets beyond 2050.”**

### **Consequences for the Gas Utility Business Model**

As the preceding sections lay out, fewer ratepayers and lower consumption would lead to less revenue for gas utilities. However, gas utilities must continue recovering the costs of their capital assets and operations, and so they would have little choice but to charge their remaining ratepayers more for the same service. This would drive more ratepayers to avoid the cost of consuming gas, initially by reducing their consumption and eventually by exiting. Because gas utilities do not have many options for alleviating costs to their ratepayers, the effect would worsen, leaving many ratepayers unable to afford the cost of gas service and leaving gas utilities unable to continue providing safe and reliable service to their remaining ratepayers. Together, these outcomes combine to create a self-reinforcing feedback mechanism.

If gas utilities are permitted to make another 10 to 20 years of capital expenditures in a context characterized by increasing competition from alternative sources to meet buildings’ energy needs and climate policies that limit emissions and promote non-emitting alternatives, then the future of gas appears especially bleak.

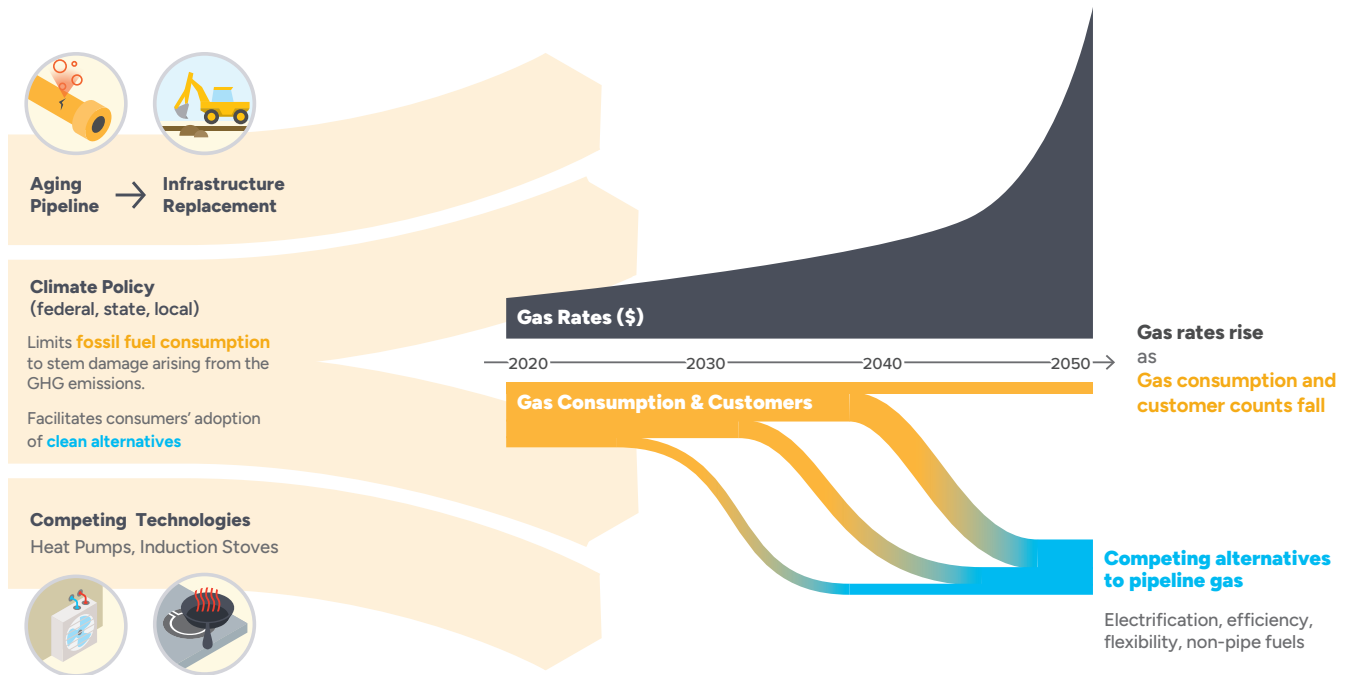
### **Consequences for Vulnerable Ratepayers**

This feedback mechanism of rising disconnections and rates will disproportionately affect those ratepayers who are least able to bear the rising costs of gas service. This is because exiting gas service generally requires *investing* in energy efficiency, energy management, and electrification measures and then only recouping some or all of that investment over subsequent years. Long-term cost savings from ceasing gas service cannot make up for the limited budget of a renter and lower-income home or business owner who cannot afford the measures required to do so.<sup>75</sup>

New York State has recognized the potentially crushing burden of utility bills, particularly in the midst and the aftermath of the Covid-19 pandemic, which caused many to lose their jobs and, for many months, to have few if any opportunities to get back to work. In 2022, the Commission approved \$567 million of relief to qualifying ratepayers; and in January 2023, the Commission approved \$672 million more.<sup>76</sup> The potential to trap some ratepayers with increasingly high-cost gas service that they might not even want should be recognized as a serious risk to those ratepayers’ wellbeing and to the Commission’s ability to ensure that utilities provide their ratepayers with service at “just and reasonable rates.”<sup>77</sup>

The effects of upward-ratcheting gas rates on those least able to afford or escape them have two further forms of potential legal significance under the Climate Law. Section 7(3) of the Climate Law directs the Commission and other agencies to “prioritize reductions of greenhouse gas emissions and co-pollutants in disadvantaged communities.” Failing to address the foreseeable pattern of falling gas ratepayer counts and rising gas rates will cause members of disadvantaged communities to lag behind others in avoiding the emissions from con-

**Figure 5. Causes and effects of the self-reinforcing negative feedback loop on gas utilities and their ratepayers**



suming pipeline gas,<sup>78</sup> contravening § 7(3). A second potentially applicable provision of the Climate Law is codified in Environmental Conservation Law § 75-0117, which states that “disadvantaged communities shall receive no less than 35% of the overall benefits of spending on clean energy and energy efficiency programs, projects or investments...” While the precise scope of this provision remains subject to interpretation, particularly as it applies to gas distribution system transition, it clearly *cannot* mean that the Commission allows gas utilities’ approach to transition to leave members of disadvantaged communities burdened with mounting gas rates as others are able to avoid those rates by electrifying.

“ This feedback mechanism of rising disconnections and rates will disproportionately affect those ratepayers who are least able to bear the rising costs of gas service.”

## Neither RNG nor Hydrogen Will Enable Gas Utilities to Avoid this Disruption

Gas utilities in New York and elsewhere have argued that renewable natural gas (RNG) and hydrogen could serve as a climate-friendly, cost-effective substitute for the fossil methane gas currently delivered through gas distribution systems.<sup>79,80</sup> But RNG is not a practical or cost-effective substitute for fossil methane gas. It is costly to produce, and those costs are likely to increase if it scales up—compared to the declines experienced by other renewable energy technologies such as solar or batteries. This is because the bioenergy-feedstocks from which RNG is derived are limited<sup>81,82,83,84</sup> and if RNG production were scaled up it would compete for access to those limited bioenergy feedstocks with other, higher-value applications.<sup>85,86,87,88</sup> RNG production and delivery is also a risky strategy for methane management.<sup>89</sup>

Before describing each of these reasons in greater detail, it is helpful to first note several differences between RNG and the fossil methane gas that it would, in theory, replace.

### Hydraulic Fracturing

The explosion in gas production via hydraulic fracturing over the last decade has created a number of environmental and social externalities that are largely not reflected in the price of gas.<sup>90</sup> Such impacts include land changes including deforestation, increased traffic, water quality, air quality, displacement, and even minor earthquakes.<sup>91</sup> Many of these impacts have been tolerated by local communities due to transfer payments to landowners and local communities, however such payments may not equitably address all the costs of fracking.<sup>92</sup>

## Fossil methane gas vs RNG

Raw fossil methane gas is sourced from geological reserves that would otherwise lie undisturbed. It generally requires modest processing to remove impurities and separate high-value natural gas liquids (e.g., propane, ethane) from some raw “wet” fossil methane gas reserves. Recent technological innovation in extraction and processing has largely kept the commodity price of this gas low over the past decade with gas production and processing economical at less than \$2 per MMBtu.<sup>93</sup>

RNG, by contrast, can be sourced from any of several feedstocks, including methane-generating waste streams such as landfill gas, livestock waste, and wastewater sludge. Alternatively, RNG can be produced using high temperature processes, similar to those first put in use 200 years ago for the production of manufactured gas.

These production strategies involve processing that is more energy and capital intensive than what is generally required to turn raw fossil methane gas into pipeline-quality methane. Greater energy demands, capital costs, and input requirements explain the gap in price between the two fuels: the wholesale price of fossil methane gas ranged from \$3.5 to \$5 per MMBtu between 2016 and 2021 at the city gate in New York;<sup>94</sup> VGS (formerly Vermont Gas) has established the only voluntary RNG rate in the region at \$19 per MMBtu.<sup>95</sup> Projected production costs for RNG produced in New York State range from \$10 to over \$50 per MMBtu,<sup>96</sup> although as discussed below, New York cannot anticipate low prices due to competition for bioenergy resources from which RNG is derived.

## Hydrogen is unsuitable for use in gas distribution networks and severely limited in its ability to support gas system decarbonization

As with RNG, gas utilities and others have put forward hydrogen as a potential solution to avoid the disruption described in the previous subsection. But the large-scale delivery of hydrogen to buildings through the gas distribution network is implausible due to high cost, competing demand, and barriers to blending pipeline gas in existing pipeline networks.<sup>97</sup>

Historically, hydrogen production has involved steam reforming of methane, requiring 50% more fossil methane gas energy input than the energy stored in the hydrogen product. This energy penalty, along with the capital and other costs, results in conventional hydrogen costing three times as much as fossil methane gas (Table 4). Capturing and sequestering the carbon emissions generated in this process requires additional capital and energy leading to higher costs.

Costs for generating hydrogen from electrolysis are currently higher than using steam reformation with CCS but are expected to decline and become competitive with fossil-derived hydrogen by the decade's end.<sup>98</sup> Still, this hydrogen requires low cost renewable electricity to be cost competitive—electricity that is necessary for decarbonizing other sectors and not constantly available at low cost. There is also substantial demand for hydrogen in existing applications (chemical feedstocks, fertilizer, steel production)<sup>99</sup> along with potential growing demand from hard to electrify sectors such as aviation or industrial heat. Decarbonization imperatives in these competing sectors will keep costs relatively high—especially relative to fossil methane gas.

**Table 4. Current estimates for the cost of hydrogen.**

Type	Cost
<b>Fossil Methane Gas (typical New England city-gate price)</b>	\$5 per MMBtu
<b>Fossil-Derived Hydrogen (Grey)</b>	\$15 per MMBtu
<b>Fossil-Derived Hydrogen w/Carbon Capture (Blue)</b>	\$25 per MMBtu
<b>Hydrogen Produced via Electrolysis using Wind &amp; Solar (Green)</b>	\$30 per MMBtu

Source: RMI<sup>100</sup>

National Grid has suggested transitioning 20% of its non-residential customers to 100% hydrogen pipelines.<sup>101</sup> A pure hydrogen strategy would require extensive upgrades to replace incompatible distribution pipe and equipment—beyond current leak-prone pipe replacement efforts—replace incompatible pipe in buildings and retrofit or replace nearly all end use equipment. This is because hydrogen embrittles cast iron pipes, degrades some plastic pipes, and is incompatible with most current end use equipment.<sup>102</sup>

This would be prohibitively costly and disruptive while delivering most customers little novel value, whereas the previous transition from manufactured to natural gas resulted in customers receiving lower cost and cleaner burning gas with broad-but-modest changes to equipment and limited distribution system upgrades.

Alternatively, gas utilities<sup>103</sup> and industry organizations<sup>104</sup> have proposed blending renewable hydrogen to modest levels (<10%) in New York's gas distribution system to achieve some emissions reductions. Despite these levels being relatively small the National Renewable Energy Laboratory observed that “numerous challenges and uncertainties complicate” even modest blending, such as hydrogen's harm to pipeline materials. Further, leaks continue to be an issue: as a small molecule hydrogen is more likely to leak than methane and has a global warming potential approximately 11 times higher than CO<sub>2</sub>.<sup>105</sup>

Due to hydrogen's lower energy density—approximately 1/3rd that of methane gas—a 5% blend would correspond to a less than 2% contribution in energy. As such, a modest blend of hydrogen would have a minimal impact on overall emissions.<sup>106</sup> In addition other sectors, such as aviation, will place

higher value on green hydrogen than gas utilities or their ratepayers. Whatever amount of hydrogen might be available to gas utility ratepayers would have to be purchased at great cost.

The production of low carbon hydrogen is essential for decarbonizing fertilizers, chemicals, and high temperature energy needs. These sectors, which lack electric alternatives, will out-compete hydrogen for heat, keeping prices high. Renewable energy resources deployed for hydrogen could be put to more efficient use in directly displacing fossil fuels in electricity generation or supporting electric heating. Like RNG the high cost of hydrogen makes electrification and efficiency more competitive. Given these limitations, efforts to incorporate hydrogen into the gas system are a misallocation of resources.

## RNG is costly to produce, and its feedstocks are limited

Producing RNG by upgrading biogas or landfill gas requires energy and capital equipment—for CO<sub>2</sub> separation, removal of impurities, and interconnection to a pipeline or some other form of transport.<sup>107</sup> Biomass gasification, another way to produce RNG, is also capital-intensive and requires the acquisition of feedstock from agricultural or forest sources at a cost. The amount of energy required for RNG

production ranges from 5% to 10% of the energy embodied in the RNG produced, though this value and indirect emissions can be higher if offsite fuels are used to generate the electricity necessary to power compressors.<sup>108,109</sup> Table 5 shows how different waste streams and other sources of bioenergy feedstocks in New York State compare in terms of their available supply, their production cost, how cost-effectively their use as RNG would abate greenhouse gas emissions, and the technology used to derive RNG from each of them.

The sum of the values in the “Supply” row of Table 5 is New York’s aggregate annual economic resource potential for RNG, which amounts to approximately 90 TBtu in total. That number is not how much RNG is currently produced, but how much could theoretically be produced given the volume and costs of available feedstocks in and around New York—and ignoring institutional and practical constraints as well as potential higher value competing uses. This 90 TBtu volume is a fraction of the nearly 1000 TBtu of annual gas consumption across all sectors in New York today.

The “Production Cost” row shows the costs of producing RNG, which are usefully compared with that of fossil methane gas, which can be produced for often less than \$3 per MMBtu and has been supplied to New York at rates between \$2 and \$9 per

**Table 5. Summary of New York State’s RNG resources.**

Feedstock	Wet wastes				Dry Material			
	Food Waste	Landfill Gas	Animal Manure	Wastewater Sludge	Ag. Residues	Wood Residues	Energy Crops	MSW**
<b>Supply (TBtu/yr)</b>	3.4	19.3*	9.1	2.4	7.3	4.8	4.8	24.9
<b>Production Cost \$/MMBtu</b>	\$23.86	\$11.29	\$34.56	\$27.68		\$25.67		
<b>Implied annual increase to a typical household gas bill</b>	\$1,961	\$704	\$3,031	\$2,343		\$2142		
<b>Abatement cost \$/tCO<sub>2</sub></b>	\$370	\$133	\$572	\$442		\$404		
<b>RNG Technology</b>	Anaerobic digestion with biogas upgrading and purification and pipeline injection					Gasification		

Source: *Potential of Renewable Natural Gas in New York State Achievable Deployment Scenario excluding gasified MSW.*<sup>152</sup> Household bill and abatement cost estimates are based off of an assumption of 100 MMBtu annual usage and a typical gas city-gate supply price of \$4.25 per MMBtu.

\*Landfill gas generation declines as organic waste decomposes and has the potential to be practically exhausted as an energy resource several decades after a landfill stops accepting methane-producing waste.<sup>153</sup> Future generation of landfill gas depends on the level of organics in future waste streams which can be anticipated to decline due to more effective, less emissions intensive (and Climate Law-aligned) treatment energy recovery strategies. If such diversion occurs in the immediate future, available landfill gas resource may start to become exhausted past 2050.

\*\*Combustion of an MSW-derived fuel results in a mixture of biogenic and fossil CO<sub>2</sub> emissions



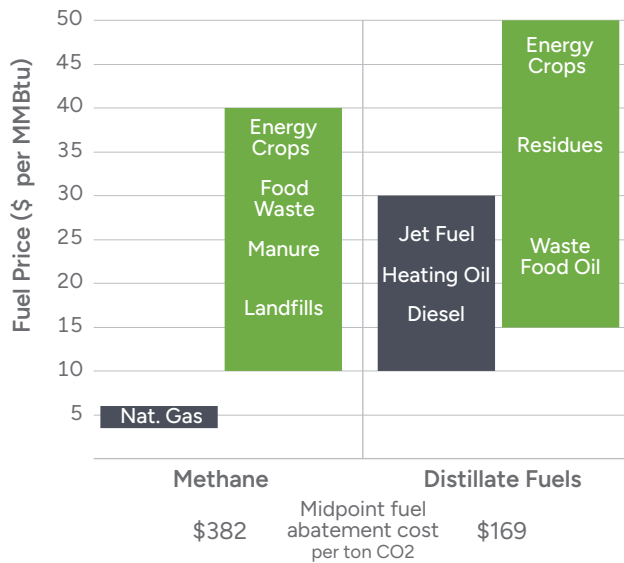
MMBtu in recent years.<sup>110</sup> Notably, even landfill gas, the lowest-cost resource on offer, would require a doubling of gas supply costs in order to be economically viable.

The next row down on household gas bills indicates how those RNG production costs would increase retail costs for a typical residential gas ratepayer if RNG replaced fossil methane gas.

The values in the “Abatement Cost” row indicate the cost of avoiding the emissions of fossil carbon by substituting fossil methane gas with RNG. It is calculated from the difference between the RNG and fossil price divided by the carbon intensity of the fuels, here assumed to be 53 kg CO<sub>2</sub>eq/MMBtu in the case of fossil methane gas.<sup>111</sup>

Figure 6 illustrates the relative cost differences between fossil fuels and biofuels like RNG that might serve as substitutes. A larger difference indicates a higher cost of substituting for the fossil fuel and thereby abating the greenhouse gas emissions arising from that fossil fuels use. The high cost of substituting RNG for fossil methane gas means that it would be a relatively high-cost use of limited bio-energy resources. For comparison, the abatement cost of electricity, assuming gas as the marginal fuel at (\$30 per MWh), with electricity generated from anaerobic digestion (\$100 per MWh<sup>116</sup>) is approximately \$200 per ton CO<sub>2</sub>.

**Figure 6. The cost of replacing fossil methane (left black) with RNG (left green) is greater than replacing fossil distillate fuels (right black) with renewable distillates.**



Source: Fossil prices are obtained from EIA wholesale prices from 2019-2021. RNG price estimates are based on those in Potential of Renewable Natural Gas in New York State.<sup>112</sup> The low price of liquid fuels is based on estimates of production of biodiesel from food waste.<sup>113</sup> The high values align with estimates from other studies of renewable fuel prices<sup>114</sup> including pathways to supply the Port Authority with sustainable aviation fuel.<sup>115</sup>

## RNG's high costs are unlikely to fall quickly

RNG proponents sometimes argue that RNG's production costs will decline because of scale economies and learning effects. But for cost declines to follow from scale economies and learning effects, several features must be present, including high degrees of modularity<sup>117</sup>, scalability, competition<sup>118</sup>, and supporting policy.<sup>119</sup> These features help to explain, for example, the drastic drop in solar panel production costs, but they are generally not part of the context in which RNG production might develop. As described below, the one exception is supporting policy, which is available to RNG, thanks to federal and California programs aimed at stimulating the production of alternative fuels for transportation.

RNG costs will not follow the sharp downward slope that solar costs did. RNG biorefineries are generally large-scale plants, while solar is a manufactured modular technology: fewer biorefinery plants are built compared to the large number of solar panels. This means there will be fewer units produced and so fewer opportunities to identify and implement cost reductions. Solar manufacturing is also more flexibly scalable than RNG biorefinery facilities, which are limited in size by resource availability in a given area. Further, regulated incorporation of RNG into pipeline gas through long-term contracts is less of a competitive crucible than the fierce markets solar manufacturers and installers have experienced for decades as they have chased market share.

Finally, the cost of produced RNG will never be competitive with fossil methane gas in the way that solar electricity has become cost-competitive with conventional electricity generation. RNG requires a feedstock, and the collection and transportation of that feedstock incurs a cost. At best, the cost of collection is likely more expensive than the cost of extracting fossil methane gas. The 2016 Department of Energy Billion Ton Report's forecast of available bioenergy feedstocks started with those that could be sourced at \$30 per ton, which would contribute \$3.3 per MMBtu to the cost of RNG produced from gasification of that biomass<sup>120</sup> before any capital or operational costs are accounted for. It is likely that given competition for such resources the feedstock

price could be at least double this. Processing any RNG feedstock to pipeline quality gas will always be more equipment or energy intensive than processing raw fossil methane gas.

## RNG would compete with higher-value applications for limited bioenergy feedstocks

"Future of gas" studies often discuss the use of biological feedstocks as though no application other than RNG would compete for them.<sup>121</sup> In this way, they generally fail to recognize that RNG production to replace gas is likely to be just one of several uses of organic wastes and residues that could deliver climate and energy benefits, and fail to analyze RNG's relative costs and value in comparison to potential alternatives that are more prevalent in national and international pathway studies.<sup>122</sup>

Generally, any carbon-rich compound ("feedstock") can be converted to a gas, liquid, or solid fuel. The production of fuels from such feedstocks involves varying levels of costs and energy demands that affect the overall lifecycle performance of such fuels.<sup>123</sup> But, relative to other potential outputs of biological feedstock processing, RNG is a high-cost and low-value product (Table 6). RNG is produced from the upgrading of biogas created by high-moisture organic waste decomposing in an anaerobic environment or the gasification of dry biomass. Similar biological and thermo-chemical processes can yield higher-value liquid fuels (e.g., sustainable aviation fuels) and chemical feedstocks (e.g., hydrogen, ammonia, polymers, pharmaceuticals).

Raw biogas or landfill gas can also be used to generate electricity and on-site heat with relatively low levels of processing or pretreatment. This electricity is generally competitive with other sources, though barriers to interconnection or sub-optimal tariff designs can hinder adoption. Here, improved policy can incentivize electricity pathways that provide both locational and grid-firming value if integrated with biogas storage.<sup>124,125</sup> Such resources could provide significant locational value to rural communities. Because of the high costs associated with biogas upgrading, generation of electricity from raw biogas is generally more cost effective than

**Table 6. Comparison of alternative bioenergy pathways**

	RNG	Electricity	Liquid Fuels	Sequestration
<b>Wet waste pathway(s)</b>	Anaerobic digestion with biogas upgrading and purification and pipeline injection	Anaerobic digestion with direct combustion; biogas storage to support grid firming; <sup>154,155</sup> hydrothermal carbonization <sup>156</sup>	Hydrothermal liquefaction with upgrading <sup>157,158</sup> arrested digestion <sup>159</sup>	Hydrothermal liquefaction or wet pyrolysis
<b>Dry material pathway(s)</b>	Gasification	Combustion of pelletized biomass	Gasification & Pyrolysis	Pyrolysis to intermediate biooil <sup>160</sup> or biochar
<b>Production Cost</b>	\$\$ - \$\$\$	\$	\$\$\$	\$\$
<b>Energy Market Revenue</b>	\$	\$ - \$\$	\$\$\$	\$\$
<b>Leak Risk</b>	High	Low	None	None

producing RNG. As a result, biogas upgrading and pipeline injection projects have historically been in the minority nationally.<sup>126,127</sup> However, policy in these sectors can place a thumb on the scale and favor one strategy over another.

In addition to higher-value fuels or electricity generation, the feedstocks needed to produce RNG could also be used to facilitate carbon dioxide removal with the co-generation of energy—often called bioenergy with carbon capture and storage or BECCS. Or, in a similar vein, the energy production step of BECCS can be skipped, and biogenic carbon can be directly sequestered.<sup>128</sup> It is conceivable that such a strategy could be bundled with the use of fossil methane gas to deliver the same emissions reduction as RNG using the same biomass feedstock.

Excessive reliance on bioenergy, and in particular energy crops, for RNG can conflict with efforts to sequester carbon in natural lands and ecosystems.<sup>129</sup> Thus, the use of bioenergy resources for RNG would come at an opportunity cost of carbon dioxide removal or higher value energy applications.

## Does producing RNG reduce or contribute to methane emissions?

Proponents of RNG often claim that its production mitigates fugitive methane emissions, which would otherwise be released into the atmosphere from landfills, wastewater sludge, food waste or manure. Such claims neglect that fact that RNG production from such wastes is just one of many potential methane management strategies.

Best practices in methane management start with avoided waste generation. When waste is unavoidable, pathways that avoid methane generation from wastes reduce the risk of fugitive emissions. Such non-methane pathways include the aerobic composting of food,<sup>130</sup> daily spread of manure on to crops,<sup>131</sup> or energy recovery via liquid fuel pathways<sup>132</sup> listed in Table 6 above. In cases where methane use is unavoidable, such as existing landfills, as-soon-as-possible on-site destruction via flaring or electricity and heat production minimizes the potential for fugitive emissions.

The intentional cultivation of methane for RNG raises the risk of fugitive emissions. Such risk arises from the production of biogas from wet wastes, the equipment used to upgrade that gas into RNG, the gasification of dry biomass—that never would have decomposed into methane—into RNG, and downstream leaks from the use of that gas. Many of these risks are similar in magnitude to those associated with the production of fossil methane gas.<sup>133</sup> While RNG proponents have acknowledged the importance of reducing such leaks, regulators should question such claims recognizing that sufficiently reducing leaks across the entire pipeline gas value chain is a tall order.

RNG is upgraded biogas. Its production does not eliminate or even reduce methane emissions but is part of a value chain that instead tends to increase them. Even so, some proponents argue that RNG is a “negative emissions” solution.<sup>134</sup> This claim is based on an extreme counterfactual scenario and assumptions adopted by California Air Resources Board for the accounting of transportation fuels

under its Low Carbon Fuel Standard (LCFS). Under this approach, electric, hydrogen, and compressed or liquefied natural gas pathways are credited with avoided methane emissions from manure and landfilling.<sup>135</sup> Given the high potency of methane, this credit can be large, sometimes multiples of emissions associated with the displaced fossil fuel. Crediting avoided methane emissions is premised on the flawed assumption that such methane emissions are unavoidable by other means. The specific amount of avoided methane emissions in the case of manure assumes that the manure used in such a pathway would have been otherwise lagooned—a methane-intensive manure management practice that is typically used at concentrated animal feeding operations (CAFOs).<sup>136,137</sup>

Reliance on this counterfactual by proponents of RNG, who argue it reduces emissions, is problematic for two reasons. The first is that lagooning is far from universal practice, and many farms use other manure management strategies (e.g., daily spreading or dry low storage) which are less likely to generate fugitive methane emissions than anaerobic digestion.<sup>138</sup> While lagooning has grown in New York State as a low-cost CAFO manure management strategy, it is not universal. And second, it supports nonsensical results. For instance, because a new cow could generate enteric emissions and manure, an RNG producer would receive a credit for adding a cow to its herd and then “avoiding” methane emissions from that cow by contributing its waste to a digester. That is, under this policy framework, a farmer is credited for engaging in additional emission-intensive activities.<sup>139</sup>

These logical errors have been widely embraced by industry. The American Gas Association, for example, uses this emissions factor in its studies to forecast the upstream emissions reductions associated with RNG.<sup>140</sup> Industry regularly cites this factor in presentations, incorrectly calling it a “negative emission.”<sup>141</sup>

## If RNG is so expensive to produce, why is it being produced?

Gas utilities have been exploring RNG for over a decade. A long-delayed National Grid pilot project at the Newtown Creek wastewater treatment facility has yet to be launched.<sup>142,143</sup> Given the high cost and shifting regulatory outlook, there has been significant uncertainty surrounding the role of RNG in pipeline decarbonization.

Several RNG projects in New York State<sup>144</sup> are incentivized by programs aimed at increasing the production of renewable transportation fuels, such as the Federal Renewable Fuel Standard (RFS) and California’s LCFS. The RFS currently provides a market subsidy equivalent to \$40 per MMBtu for RNG produced for transportation fuels.<sup>145</sup> And the California LCFS offers an additional astonishingly high subsidy of \$81.50 per MMBtu on average—equivalent to over \$11 per gallon of gasoline.<sup>146</sup> Researchers at the University of California at Davis observed that, as a result of these policies, a cow that produces \$5,000 of milk in a year, gets a subsidy of nearly \$3,000 for its manure. Gas utilities are seeking to take advantage of these distortive credit systems as they pursue opportunities to develop RNG for building heat.<sup>147</sup>

The role of the LCFS and RFS in promoting transportation biofuels has been contentious on several fronts. Most notably, these programs were largely formed over 15 years ago to incentivize the production of drop-in transportation fuels from bioenergy feedstocks. Since then, there has been growing concern about the impact of such programs on food prices and land use change.<sup>148</sup>

The rapid growth in electrification has disrupted the foundational construct of these programs by rapidly displacing biofuels as the core sector decarbonization strategy. The LCFS has adapted by allowing for renewable electricity consumed by EVs to be eligible for credits. Electric credits are the LCFS’s fastest growing source of emissions reductions.<sup>149</sup> The EPA has also proposed<sup>150</sup> creating a renewable electric credit (“eRIN” in the parlance of the RFS) alongside its conventional corn ethanol, biodiesel, and compressed RNG vehicle fuel credits. By just proposing placing renewable electricity on more equal footing

with compressed RNG, the EPA's rulemaking has already prompted some anaerobic digester project developers to pursue a lower cost and more efficient biogas to electricity pathway rather than producing RNG for vehicle fuel.<sup>151</sup>

Such impacts emphasize how influential, and distortive, policy can be. It also underscores the complicated multi-sector role that bioenergy will play in supporting climate goals. This underscores the importance of crafting a sound, cross sector policy regime to ensure that limited, precious bioenergy resources are used in applications where they create the greatest amount of value.

# Four Futures for Gas: What are the Risks and How Are They Managed?

The looming disruption of the gas utility business model described in Section 2 presents an unprecedented challenge for the PSC in fulfilling its historical cost, safety, and reliability mandates alongside its new climate and equity mandates. Pathway studies conducted by several states with similar climate goals to New York provide helpful information but little clarity. For example, such studies have illuminated both the high costs of substituting fossil fuels with bioenergy on the one hand, and the challenges of abandoning all combustion on the other.

This Section steps away from the sometimes-misleading precision of such studies and instead focuses on the tangible objectives sought for New York's gas distribution system and its stakeholders. It also explores available strategies as the state increases its oversight of the disruption and transition that awaits its gas utilities. To reduce dependence on fossil fuels, extensive and intensive efforts will be required at the local, neighborhood, and household levels. Although state-level projections are helpful in setting goals, local planning and implementation is essential to effect change while maximizing outcomes for stakeholders.

This section starts by identifying objectives for New York's gas distribution system stakeholders that have been established by the Climate Law, other state laws, or follow logically from the pursuit of statutorily defined objectives. These are listed in the left column of Table 7.

Advancing these objectives can involve trade-offs. Strategies that are lower cost for the energy system as a whole may be experienced as higher cost by individual consumers, depending on decisions about cost allocation. Employment, for instance, may increase in renewable energy industries but decline in fossil fuels. Equity issues are complex, as decisions can lead to intergenerational, cross-population, and spatial tradeoffs among impacted communities. Even though the costs and benefits of the clean energy transition will not fall evenly across communities and individuals, that transition still has the potential to deliver positive outcomes on all objectives—if implemented strategically.

Equipped with this list of objectives, this section evaluates how four scenarios for the future of the gas distribution system are likely to fare. Some quantitative values are presented, but this is mainly

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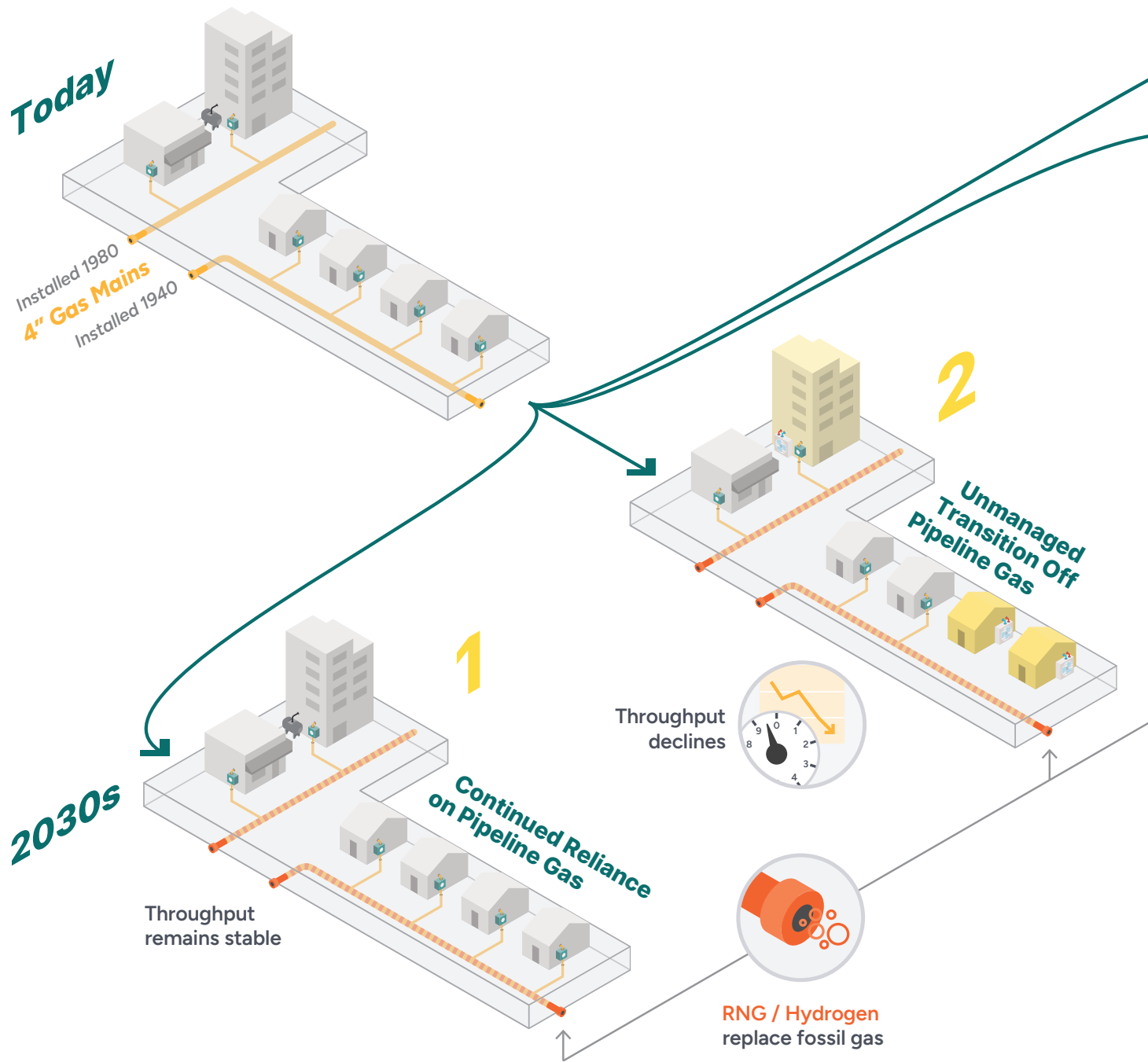
**Table 7. Objectives of current New York State energy and climate regulatory policy.**

Objective	... which depends upon ...	Law prescribing the objective
<b>Minimize cost</b>	Costs of gas consumption, pipelines, electricity generation, electric grid, buildings	Public Service Law §§ 65(1), (2), (6); Environmental Conservation Law § 75-0103(14)(b)(ii)
<b>Ensure customer convenience</b>	Retrofit hassle, building value and comfort	N/A
<b>Improve health</b>	Indoor and outdoor air quality, safety vis-a-vis extreme temperatures	Climate Law preamble; Environmental Conservation Law § 75-0103(14)(b)(i)
<b>Expand employment opportunities</b>	Electrification workforce, gas workforce	Environmental Conservation Law §§ 75-0103(8)
<b>Advance equity</b>	Overall energy burden, maintaining energy security and access	Climate Law § 7(3), Environmental Conservation Law § 75-0117
<b>Eliminate emissions</b>	Combustion emissions, fugitive emissions	Environmental Conservation Law §§ 75-0107, -0109
<b>Enhance energy reliability</b>	Electricity generation, transmission and distribution systems	Public Service Law §§ 65, 66
<b>Improve resilience</b>	Need for and availability of backup power, building thermal performance	Climate Law § 9, updating Climate Risk & Resiliency Act §§ 17-a, 17-b
<b>Preserve system safety</b>	Pipeline pressure and integrity; storage and combustion of hydrogen	Public Service Law §§ 65, 66, 66-s

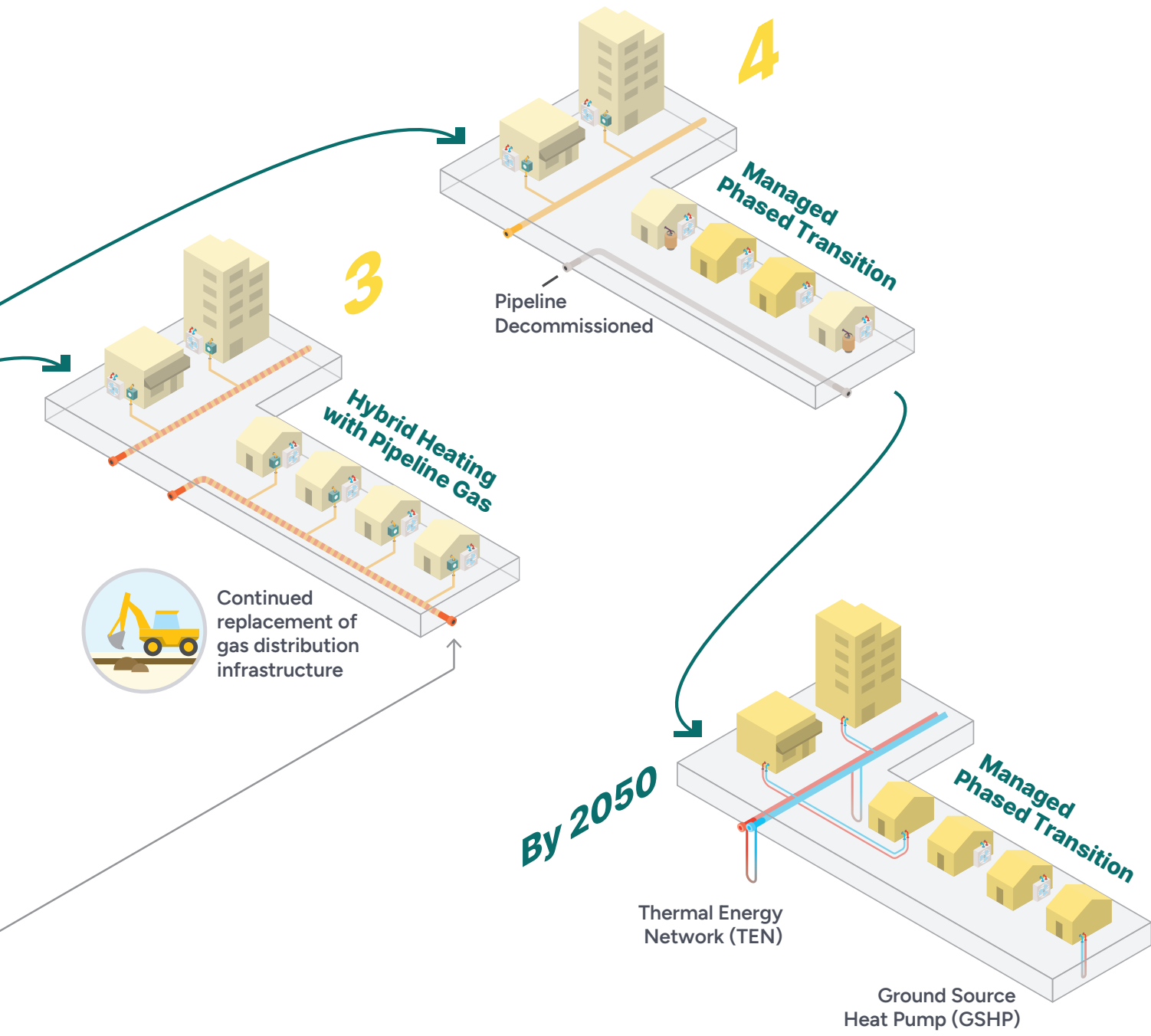
a qualitative exercise. Each scenario is assessed with respect to each objective; the degree and nature of risks it entails for each; and the availability of mitigation measures for those risks.

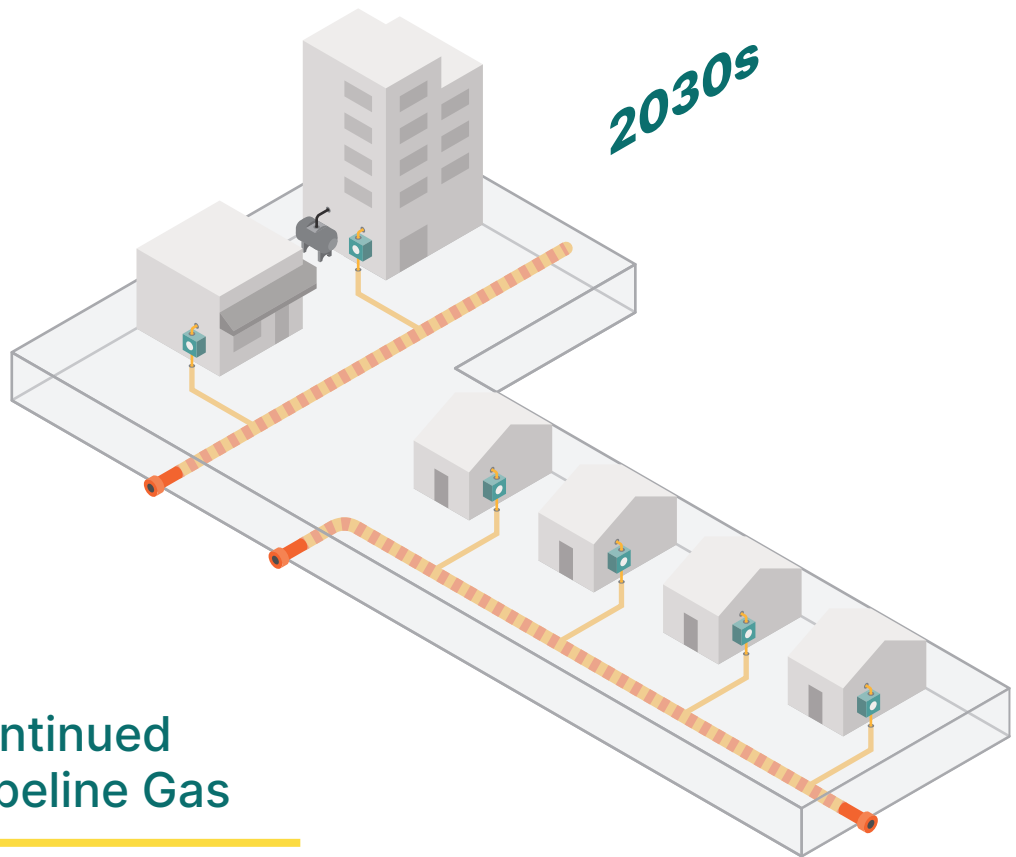
The first of the four scenarios assumes continued reliance on pipeline gas without electrification. The second is an unmanaged, unsubsidized transition away from gas toward non-combustion alternatives. The third is a hybrid future that preserves gas distribution system service to buildings even as they electrify. The challenges of these scenarios are then discussed before presenting a fourth scenario describing a managed phased transition. With each successive scenario, the number of risks decreases and the potential actions to mitigate those risks become less invasive and less costly.

**Figure 7. Four scenarios for the future of gas (Illustrated)**









## Scenario 1: Continued Reliance on Pipeline Gas

### Comparable analyses

- ▶ National Fuel 2022 Climate Report, “High Fuels” scenario<sup>161</sup>
- ▶ American Gas Association Net-Zero Opportunities for Gas Utilities, “Renewable and Low-Carbon Gas Focus” scenario<sup>162</sup>

### Description

The state remains reliant on pipeline gas at current scales. To comply with the emissions reduction mandates of the Climate Law, it must decarbonize the energy supply via RNG or alternative compliance mechanisms (e.g., a carbon tax, durable carbon offset, or compliance fee). No major changes to building heating systems or the gas distribution system are pursued. High-efficiency furnaces (e.g. 95% efficient) replace older equipment per currently proposed federal standards,<sup>163</sup> but the market for heat pumps fails to scale due to various customer and industry barriers despite recently-implemented federal and state incentives. Gas consumption and number of ratepayers levels off. Accelerated leak-prone pipe replacement reduces

but does not eliminate methane leaks. Investment in duplicative energy delivery systems—electricity and gas—continues.

### Major Outcomes

**High Fuel Costs:** The cost of RNG is substantial. Continued reliance on pipeline gas at current scale would require gasification of collected residues and cultivated energy crops, which are expensive forms of RNG production. Proposals to use RNG in the building sector must also address competing and more strategic uses for landfill gas, manure, food waste, biosolids and residues. Energy crops are needed for production at this scale. This results in a high cost of RNG: \$30 per MMBtu in 2050. Replacing all fossil methane currently supplying residential, commercial, and industrial demand in New York with RNG at this price would cost \$25 billion annually on top of current gas expenses. This is 1.25% of New York’s GDP, largely spent on fuel sourced from out of state, while failing to create any new customer value or improvements in health outcomes.

**Significant Footprint from RNG Use:** Further, meeting the state’s current gas heating demands using RNG would require an area of cropland roughly equivalent to twice New York’s currently harvested cropland: 7 million acres or 11,000 square miles.<sup>164</sup> While most of this energy could be sourced from outside New York’s borders, there are significant opportunity costs associated with tying up this amount of land in RNG production wherever it is located. For example, this land can be used for food, wine, higher value fuels, carbon sequestration, recreation, or reforestation. There are also potential adverse environmental and climate impacts to many of these forms of RNG production.

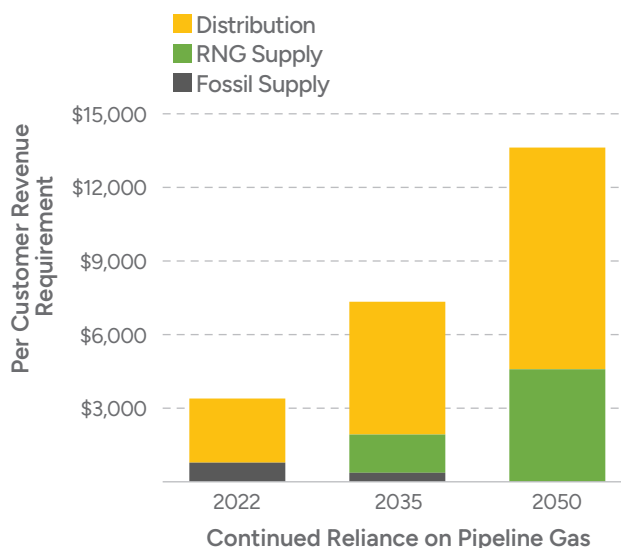
**Gas Distribution System Costs:** The largest cost the customer experiences is maintaining and paying off prior investments in the gas distribution system. These costs, like RNG, and unlike electrification, provide little novel value for customers.

**Infrastructure and Emissions Lock-in Risk:** Going down this pathway—as many building owners are currently proceeding—creates *lock-in and emissions abatement risk*: Combustion at the point of final consumption for end uses will be “locked in” for the life of new appliances. Because decarbonization is primarily achieved in this scenario through substituting RNG for fossil methane, if RNG fails to scale, then the bulk of emissions allowances available in 2050 (15% of 1990 levels) are now demanded by the buildings sector, increasing the cost of decarbonizing other sectors.

**Increasingly High Revenue Requirements:** The combination of high fuel costs and high distribution systems costs lead to rising revenue requirements and ballooning heating bills under today’s ratemaking practices (Figure 8).

**Inequitable Outcomes:** Finally, continued reliance on pipeline gas creates an unacceptable and inequitable burden on those whose energy bills are a large fraction of their income due to the significantly increased commodity and delivery cost.

**Figure 8. Revenue requirement per ratepayer for continued reliance on gas heat.**



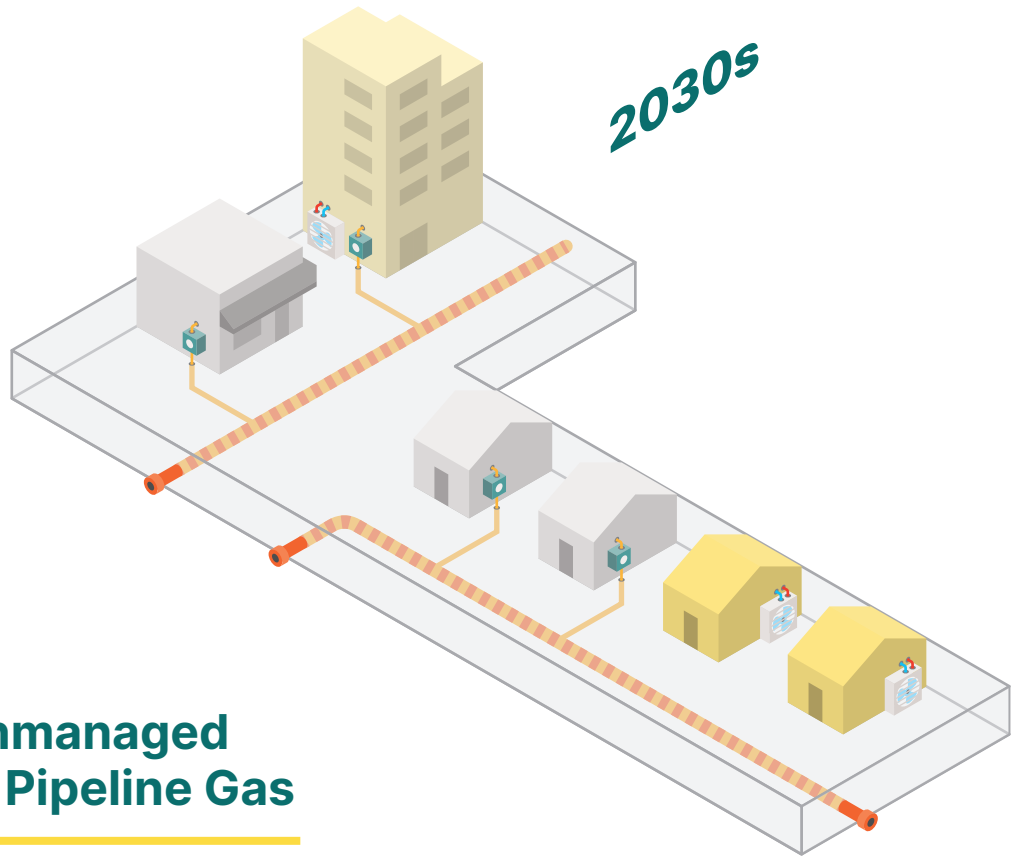
Assumptions: Demand of 150 MMBtu per year (Costs for a typical single-family home, demanding 100 MMBtu of heat per year, are approximately two-thirds the values presented). Cost estimates assume the gas distribution system maintains its current size and consumption levels but RNG replaces 50% of fossil methane gas in 2035 and 100% in 2050. Distribution revenue requirement based off revenue requirement analysis above.

## Analysis

Evaluating these outcomes using the objectives matrix demonstrates a high degree of risk with very challenging risk mitigation strategies. This ultimately makes this scenario untenable. If New York fails to scale heating electrification, the costs of complying with the Climate Law via RNG and a pipeline gas system are large, and the risk of failure is high. The untenable nature of this “pipeline gas as usual” future would prompt customers to reduce or eliminate their reliance on pipeline gas due to this high cost. Given historical trends, those with the most agency and access to resources will be able to reduce their gas use, leaving behind those with less agency and less access to resources—an unmanaged transition with inequitable consequences.

**Table 8. Objective and risk assessment matrix for Continued Reliance on Pipeline Gas scenario**

Scenario 1	Advantages	Disadvantages	Degree and nature of risk	Actions to mitigate the risk
<b>Cost</b>	Low need for capital investment in buildings.	High emissions compliance cost: (RNG or credits)  High cost of maintaining the gas distribution system.	<b>Significant &amp; Possibly Prohibitive</b> —Costs are too high for this scenario to be viable.	<b>Significant</b> —Social subsidization of compliance costs; development of negative emissions technologies to offset gas emissions.
<b>Convenience</b>	Avoid the hassle of complicated building upgrades.	No new customer value is created despite high costs.	<b>Significant</b> —See cost implications above.	<b>Significant</b> —See cost implications above.
<b>Health</b>	None	Forgoes major opportunities for improving health outcomes by reducing household fuel combustion.	<b>Significant</b> —Health damages from gas combustion are unaddressed.	<b>Significant</b> —Improve building ventilation and efficiency of gas appliances.
<b>Employment</b>	Maintains current employment paradigm.	Higher dependence on energy imports is a lost opportunity for local investment.	<b>Significant</b> —Large increase in out-of-state spending creates economic drag.	N/A—Risk is likely unavoidable.
<b>Equity</b>	Avoids near-term cost challenges of electrification.	High emissions compliance costs burden low-income households. Fails to reduce the cumulative burden on consumers.	<b>Significant</b> —Creates a direct and unacceptable burden on low-income households	<b>Significant</b> —Substantial expansion of heating and weatherization assistance programs.
<b>Emissions</b>	Dubious potential to reduce emissions by substituting fossil gas with RNG if leaks and land use change are avoided.	Exclusively reliant on the development and scaling of decarbonized gas.  High amount of fugitive methane.	<b>Significant</b> —Decarbonized gas fails to scale or is out-competed by other bioenergy. Methane leaks are difficult to eliminate.	<b>Significant</b> —Investment in replacing leak-prone pipes and equipment, including those inside buildings—increases cost.  A price on carbon that reflects the social costs of unabated emissions.
<b>Reliability</b>	Fossil methane gas maintains current reliability paradigm	RNG resources could be exposed to extreme weather and volatile market fluctuations	<b>Moderate</b>	<b>Moderate</b> —Maintain a diverse supply portfolio, including fossil methane gas.
<b>Resilience</b>	Maintains current resilience paradigm	No specific opportunity to improve resilience.	N/A	N/A
<b>Safety</b>	Maintains current safety paradigm.	No specific opportunity for improving safety outcomes.	Possibly <b>Significant</b> —The continued risk of gas explosion disasters (e.g., 2014 East Harlem gas explosion).	Investment in replacing leak-prone pipes and equipment, including those inside buildings, increases cost.



## Scenario 2: Unmanaged Transition Off Pipeline Gas

### Comparable analysis:

- ▶ New York State Integration Analysis<sup>165</sup>, “Accelerated Transition Away from Combustion” scenario.
- ▶ Plans for cities like Menlo Park, California<sup>166</sup> and Ithaca, New York<sup>167</sup>

### Description

Decarbonization occurs as a result of customer decisions to electrify their homes and appliances based on a mix of climate (reducing GHG emissions), financial (avoiding long-term costs), health (eliminating indoor air pollution), and regulatory (complying with appliance emissions standards) motivations. Combustion-based heating appliances and equipment will be phased out as replacements by 2030 for residential and 2035 for commercial applications consistent with the final Climate Action Council Scoping Plan and New York’s pending equipment emissions standards. Homes are relied upon to individually and fully electrify around key intervention points (e.g., end of equipment life, major renovations, point of sale). The Inflation Reduction Act and state incentives partially bridge financing

gaps, but low to moderate income households—because of cost and other barriers—lag in migrating to whole home electrification and remain connected to the gas distribution system.

Without a concrete transition plan, the gas distribution system is maintained at its current scale to serve remaining ratepayers, requiring reinvestment in increasingly underutilized gas assets and significant ongoing operational expense.

This scenario aspires to achieve compliance with emissions reduction targets by steadily reducing combustible fuel use in buildings, but some buildings may remain on gas while being subject to increasing compliance costs. Purchasing emissions allowances may be less expensive than RNG, but this mechanism still increases the cost of gas.

Homes remaining connected to the gas distribution system also bear the burden of paying for decisions made in decades prior to reinvest in the system. By 2040, the delay in action has resulted in a political impasse where the early electrifiers do not want to pay for these mistakes, and the gas companies are forced to raise rates higher on those with less agency to leave.

Notably, this scenario is the only readily available option to cities that commit to building electrification but do not own and operate municipal utilities, because those cities lack the regulatory authority required to manage transition for local gas and electric networks. These city-level efforts yield important pilot projects, the ratepayer impacts of which can be blunted by state and federal subsidies. They are difficult—and maybe impossible—to scale up without utility cooperation. Consequently, while city-scale action can yield good outcomes for select participants and insights that could serve others, such action also risks shifting the costs of ongoing gas utility service to cities and towns that rely on the same gas distribution network.

## Major Outcomes

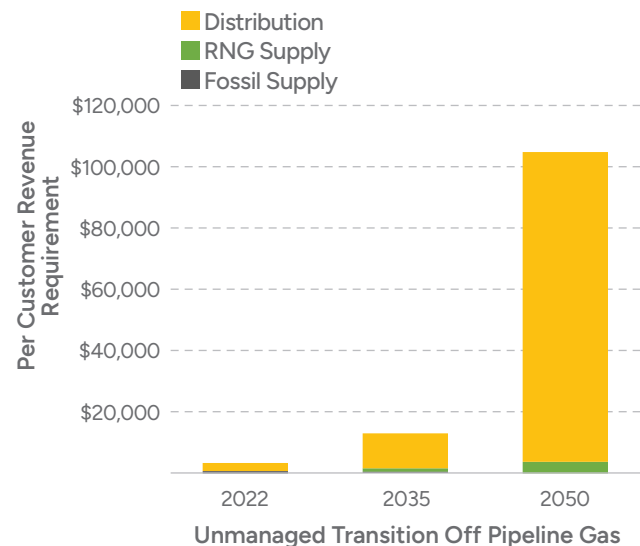
**High Cost of Infrastructure Lock-in:** Like Scenario 1, this scenario also requires continued reinvestment in gas distribution networks to support remaining ratepayers. However, it differs in the fact that those networks become largely underutilized relative to today as other customers electrify and leave the gas system.

**Gas Utilities Spiral Toward Insolvency While Gas Ratepayers are Increasingly Burdened:** The consequence of this lock-in amid declining consumption and unorganized ratepayer exits is spiraling utility bills for remaining ratepayers, driving further exits and eventually disrupting gas utilities’ ability to provide safe and reliable service.

**Emissions Reductions:** This scenario promises durable emissions reductions at the building level, but without state and local incentives and assistance to leave the gas distribution system, emissions reductions may be delayed and relatively costly. Because, as explained below, this scenario will tend to boost electric system costs, it potentially adds to the challenge of New York’s power sector continuing its present progress toward compliance with the Climate Law’s target of 100% clean electricity by 2040 in a way that keeps power costs affordable.

**Electric System Costs Rise:** Simultaneously, scattershot electrification drives rapid and costly but uncoordinated upgrades to distribution systems. An aging electric distribution system may allow only

**Figure 9. Revenue requirement per remaining ratepayer for an Unmanaged Transition Off Pipeline Gas scenario.**



Assumptions: Demand of 150 MMBtu per year (Costs for a typical single-family home at 100 MMBtu per year are approximately two-thirds the values presented). Distribution revenue requirement based off of revenue requirement analysis above assuming a 90% reduction in customers and throughput. Remaining ratepayers comply with emissions reductions through purchases of allowances which are lower cost than RNG, but are insignificant to distribution costs.

for some of the homes connected to a given electric distribution grid feeder to be electrified before upgrades to local distribution infrastructure (e.g., conductors, transformers, or even substations) are necessary. At scale, a workforce that is still becoming familiar with key technologies and techniques, nascent supply chains, and a lack of supporting rate design may create cost barriers and hassle. If these features fail to take shape in the ways required to support electrification, then the transition away from gas will proceed slowly, partially, and in inequitable and fragmented ways across communities.

**Inequities:** The spiral toward gas utility insolvency places disproportionate burdens on ratepayers least able to avoid growing gas bills. Without a targeted effort to migrate ratepayers, exit remains out of reach for many even as the burden of the gas bill becomes severe.

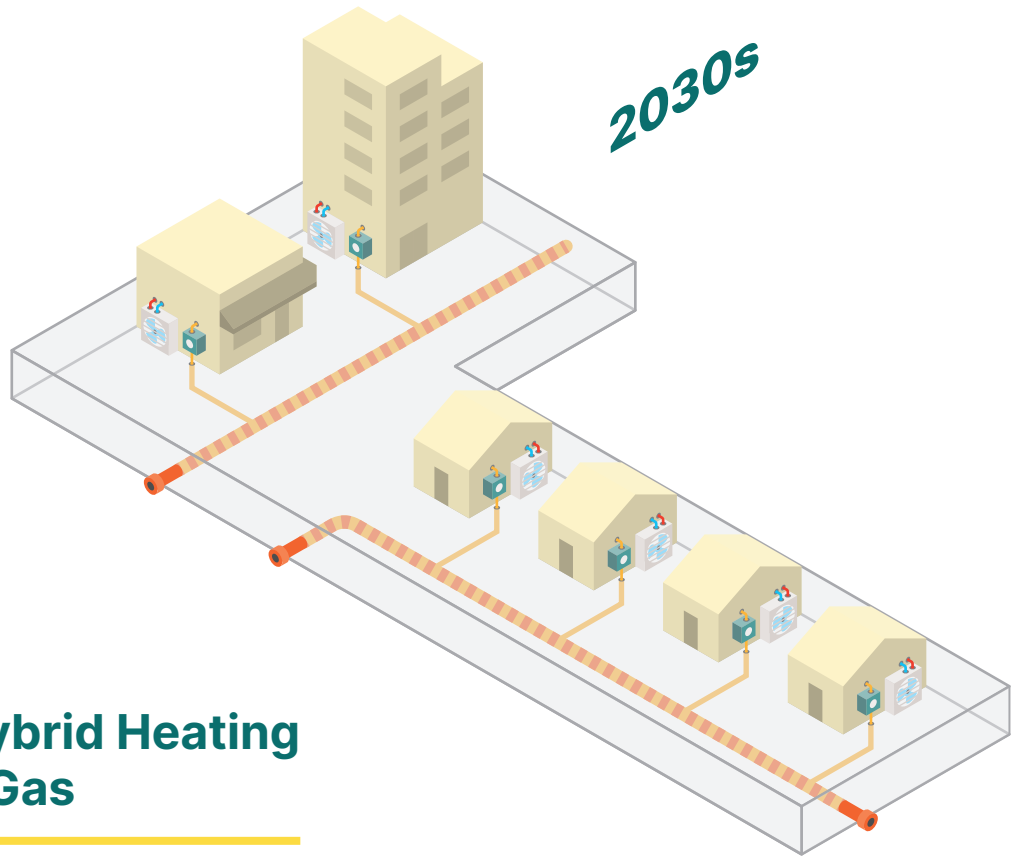
## Analysis

This combination of overinvestment in underutilized gas assets, rising gas system costs, patchwork electrification, and inequitable energy burdens fails

**Table 9. Objective and risk assessment matrix for Unmanaged Transition Off Pipeline Gas scenario**

Scenario 2	Advantages	Disadvantages	Degree and nature of risk	Policy to mitigate the risk
<b>Cost</b>	Substantially lower cost than relying on decarbonized gas at current levels of demands.	High upfront costs in both buildings and electric infrastructure, continued investments in the gas distribution system.	<b>Significant &amp; Possibly Prohibitive</b> —Costs are likely to create <b>significant</b> barriers to the adoption of heat pumps. Limited options to recoup costs leading to negative feedback loop.	<b>Significant</b> —Adequate retrofit subsidies. Flexible rate design. High social subsidy in the 2040s to pay off gas distribution system investments made today.
<b>Customer</b>	Increased comfort and value created by electric appliances.	Required retrofits, possibly on an accelerated timeline. Customers who prefer gas-cooking may be resistant.	<b>Significant</b> —Public pushback from gas bans, costs, retrofit hassles.	<b>Significant</b> —Increase customer education.  Develop and scale electrification workforce.
<b>Health</b>	Improved indoor air quality from the removal of combustion appliances.	N/A	N/A	N/A
<b>Employment</b>	Substantial local job creation opportunity for building retrofits at scale.	A tight labor market challenges the ability to scale. Need to transition gas workforce.	<b>Significant</b> —A sizable well-trained workforce may not materialize.	<b>Significant</b> —Aggressively develop and scale electrification workforce.
<b>Equity</b>	Steady reduction in cumulative burden from pollution.	Lower income households that remain on the gas system will be burdened by costs.	<b>Significant</b> —Inequitable realization of cost burden.	<b>Significant</b> —Income-based subsidies and discounts.
<b>Emissions</b>	Steady and concrete reduction in building emissions.	Leaks evolve from the distribution system and buildings still using gas. Electric heating during coldest hours remains emissions intensive as long as gas remains the marginal fuel.	<b>Moderate</b> challenge as electric systems decarbonize.	<b>Moderate</b> —Accelerate deployment of renewables and to-be-identified clean firming technology.
<b>Reliability</b>		Requires significant and accelerated grid upgrades to support increased loads.	<b>Significant</b> —Requires most aggressive distribution and supply system upgrades.	<b>Significant</b> —Accelerate distribution and supply system upgrades.
<b>Resilience</b>	Air-tight, well-insulated homes maintain comfortable temperatures during extreme events. Expands access to cooling.	Reduces potential back-up energy options.	<b>Moderate</b> compared to current conditions where many homes are reliant on electricity for heating.	<b>Moderate</b> —Couple heating electrification with DERs, microgrids. Underground utility infrastructure.
<b>Safety</b>	Reduces risk of gas explosions in exited buildings.	Remaining older buildings may be the most at-risk of gas explosion due to older and neglected infrastructure. Likely low-income households.	<b>Moderate</b> safety risks from neglected action may create long-term costs.	<b>Moderate</b> —Monitor remaining customers to ensure that risks are not neglected.

to achieve the objectives stipulated by the State’s climate and consumer protection laws. The potential cost increases to both gas service and electrification that arise in this scenario would create pressures that push customers away from gas but make it hard for them to electrify. As a result, an unmanaged gas transition is likely to be **rife with inefficiencies and inequities**.



## Scenario 3: Hybrid Heating with Pipeline Gas

### Comparable pathways & policies:

- ▶ New York Clean Energy Vision Scenario (National Grid)<sup>168</sup>
- ▶ Diversified Strategy of Pathways to Carbon-Neutral NYC (National Grid and Con Edison)<sup>169</sup>
- ▶ Fuel and Electrification Scenario (National Fuel)<sup>170</sup>
- ▶ Hybrid Gas-Electric Heating Focus (AGA Net-Zero Emissions Opportunities)<sup>171</sup>

### Description

Another strategy for managing the challenges described above is to maintain the gas distribution system at roughly its current physical size, in terms of customer connections and miles of pipe, but reduce consumption in a managed fashion.

Here, despite the ability to fully electrify most heat with extensive upgrades, combustion heating — and a pipeline supplying fuel — is retained. Heat pump installation is often done expediently and does not prioritize complete coverage of heating needs. Accompanying energy efficiency retrofits are, similarly, often less comprehensive than what would support

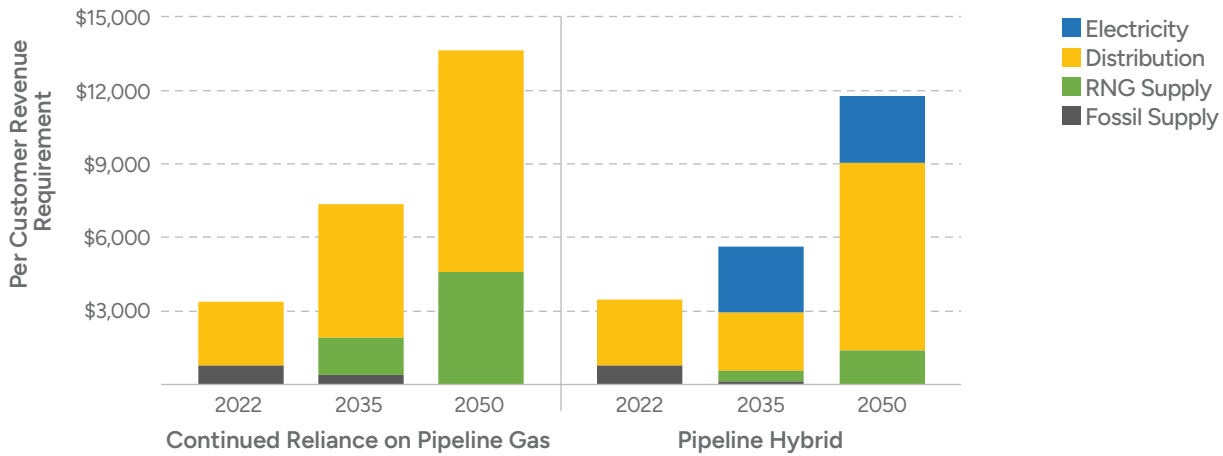
complete electrification. While the heat pump is used during many heating hours, combustion heating is used at times when the building tenant prefers it, potentially due to perceived cost savings.

This arrangement allows for a lower level of intervention on the building side than full electrification because access to auxiliary combustion means that heat pumps and energy efficiency improvements do not need to stand on their own against exceptionally cold weather. Customers therefore generally acquire smaller-sized heat pumps and undertake less-intensive building retrofits. Some other appliances are electrified based on practicality and customer preferences, but customers might also retain, for instance, gas cooking equipment or fireplaces.

Onsite fuel consumption complies with emissions limits either by drawing RNG from a service line or by purchasing emissions credits commensurate with the volume of fossil methane gas consumed. Even though the volume of fuel consumed onsite in this way is relatively low, customers still experience cost increases because RNG and emissions allowances are both extremely expensive and increasingly so.



**Figure 10. Comparison of revenue requirements for the Continued Reliance on Pipeline Gas and Hybrid Heat with Pipeline Gas scenarios.**



Assumptions: Demand of 150 MMBtu per year (Costs for a typical single-family home at 100 MMBtu per year are approximately two-thirds the values presented). Hybrid costs are based off revenue requirement analysis above assuming a 70% reduction. Electric costs are included to illustrate approximate impact of electricity demand from heat pumps in this scenario.

Substantial emissions continue to flow from the system even as leak-prone pipe is replaced, and partial electrification reduces leaks from equipment and ignition cycling. This is because leaks remain a significant source of emissions relative to the volume of gas consumed.

## Key outcomes

**Partial Electrification Reduces Fuel Demand:** Gas utility hybrid heating proposals suggest that hybridization reduces gas demand by 50%-75%. This makes decarbonizing the remainder of gas use by RNG or emissions allowances more feasible from a cost perspective. If RNG is used, its scalability and land use demands are still considerable — possibly an area equivalent to half to all of New York’s cultivated cropland would be needed to produce the feedstock to meet the state’s demand. If RNG cannot meet this demand, using fossil methane gas with emissions offsets becomes more practical at lower levels of fuel demand.

**Partial Electrification Avoids Challenges from Rapid and Large Increases in Electricity Demand:** Using combustion during periods of peak heating needs avoids costly distribution system upgrades from the panel to the substation. It also avoids the need for additional renewable and low-carbon firm generation resources.

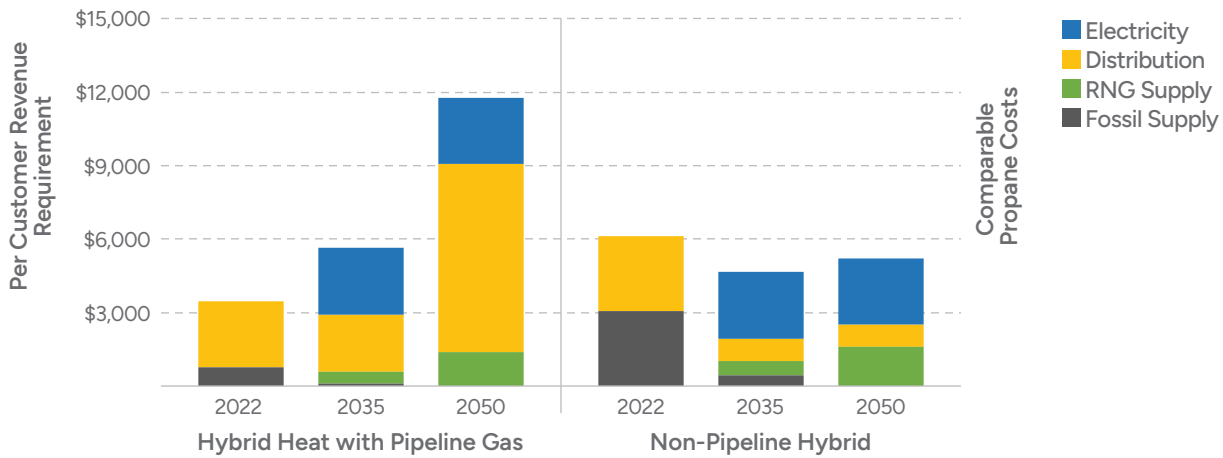
**Pipeline Costs Remain High:** Like the previous scenarios, this scenario is still reliant on the pipeline—and reinvesting in the pipeline over the coming years. The customer’s contribution to distribution costs is comparable to the continued use of gas at current rates described in Scenario 1. Despite lower consumption, the full pipeline network is maintained, and the pipeline still needs to be paid for.

## Analysis

Despite some of these impacts still being significant at this scale, there is attractiveness to such proposals given challenges associated with electrification—notably the deep building interventions required and the impacts to the electric grid from peak heating demand. However, the increasing cost of the gas network creates a tenuous situation.

There remain significant, difficult-to-mitigate risks associated with ensuring that this scenario achieves the state’s multiple objectives. Partial electrification of gas-supplied buildings is not likely to result in a manageable equilibrium for gas utilities because customers will eventually opt to avoid the high costs of maintaining gas access. Indeed, as Figure 10 above illustrates, the per-customer revenue requirement escalates similarly in the scenario to the continued gas scenario (Scenario 1). Regulators and utilities should therefore expect that partial electrification of gas-heated homes would avoid

**Figure 11. Comparison of revenue requirement from the Hybrid Heat with Pipeline Gas scenarios with equivalent costs of a Non-Pipeline Hybrid strategy.**



Assumptions: Demand of 150 MMBtu per year (Costs for a typical single-family home at 100 MMBtu per year are approximately two-thirds the values presented).

some short-term costs while continued reinvestment in the pipeline networks incur large long-term costs. The pipeline hybrid case fails to lessen gas customers' incentives to eventually disconnect and thereby leave costly gas distribution system assets stranded. In sum, the pipeline is valuable in the near term, but continued reinvestment in it is not a viable long-term strategy.

To make this scenario viable, gas utilities would need to impose high customer exit fees, which deter customer exit by making it more expensive, and the PSC would need to allow gas utilities to recoup the costs of maintaining their networks if customers decide to exit nonetheless. Measures like this would run counter to the recommendations in the Scoping Plan, which urges electrification, and would also constrain consumer choice in a direct and concerning fashion.

The problem facing New York's future of heat is that the costs of its gas pipeline networks have become unsustainable in any future arrangement. The networks are both exposed to increasing competition and in need of management to avoid stranded assets and achieve New York's climate, energy, and social objectives.

## Non-Pipeline Fuels Become Competitive with High Cost, Hybrid Gas Systems and Can Serve as a Mechanism for Removing Dependency on the Pipeline

As illustrated above in Section 2, Figure 6, propane and its analogues (e.g., dimethyl ether, or synthetic liquified petroleum gases), with modest interventions, can substitute for pipeline gas to support both peak heating needs and customer preferences (e.g., cooking). This non-pipeline hybridization approach delivers the same benefits as a pipeline-hybrid approach in reducing the level of intervention in buildings and electric systems.

Today, pipeline gas has lower delivery and commodity costs than propane (Figure 11). However, commodity costs of RNG and renewable propane or its analogues are more on par with each other than fossil methane gas and fossil propane. Any premium that propane commodity costs have over methane or hydrogen are small relative to future costs associated with pipeline delivery of methane or hydrogen.

Pipeline networks depend on economies of scale of both customers and throughput to deliver gas at low cost. The analysis so far in this report has demonstrated that the gas system, in the absence of regulatory intervention, will fail to achieve the

economies of scale necessary to deliver pipeline gas at its historic competitive low cost.

Comparatively, trucked delivery of propane has been relatively expensive, but its costs are far less dependent on scale economies. While a hybrid-propane arrangement has notably higher costs than today's pipeline gas delivery, it is able to control future costs far better for the customer.

A typical single-family home using a 125-gallon propane tank would only need two fill-ups a year, assuming a heat pump takes 80% of the demand for heating fuel. While this strategy may not be suitable for high-density buildings that lack sufficient space to host propane storage, it may be applicable in medium to low-density neighborhoods where gas infrastructure sprawls and infrastructure costs per ratepayer are high. A conversion from pipeline gas to propane will likely cost around \$1,000 for a 125-gallon propane tank and adjustments to burner tips.

Currently, propane and natural gas markets are linked as liquid propane is often extracted from raw "wet" natural gas. It is important to acknowledge that declining natural gas production will lead to declining fossil propane production. However, there are several existing pathways for producing propane or propane analogues such as dimethyl-ether (DME)<sup>82</sup>

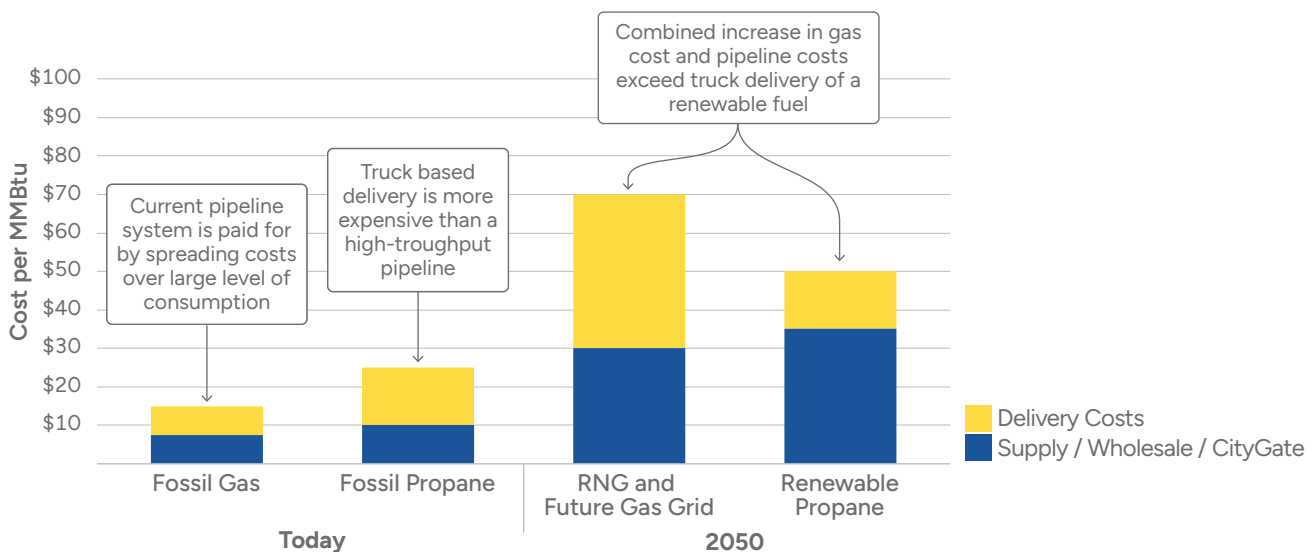
from fossil and biological feedstocks—including those proposed for conversion to RNG. It can be assumed that its production at scale is as feasible as RNG but may incur a slightly higher production cost depending on the pathway involved. Still, as noted above, supply and delivery prices may be sufficiently low enough to be competitive with increasingly costly delivery of pipeline gas.

Propane is used here as an example because of its high substitutability for pipeline gas. However, distillate fuels, biomass, or even compressed or liquified natural gas can play a similar role depending on the application. Indeed, such hybrid approaches may be an important cost saving strategy in transitioning more rural buildings not currently served by gas.

In all these cases, historical cost advantages have favored pipeline gas for its ability to deliver large volumes of energy at low cost. With electrification slashing the volume of fuel demand, truck-delivery and onsite storage of fuels—where practical—can feasibly deliver energy at a lower cost per unit of energy than a low throughput pipeline gas system. (Figure 12)

Such an approach is not a panacea. Any large-scale use of renewable fuels will face land use and ecological tradeoffs similar to that of RNG. Some of

**Figure 12. Changes in supply and delivery costs eliminate the historical cost advantage of pipeline gas.**



Source: Today's cost estimates are approximated from current prices (EIA). Future supply prices are based off estimates of renewable fuel costs. Future pipeline gas delivery costs are based on the above section analysis. Future propane delivery costs are assumed to be equivalent to today's costs.

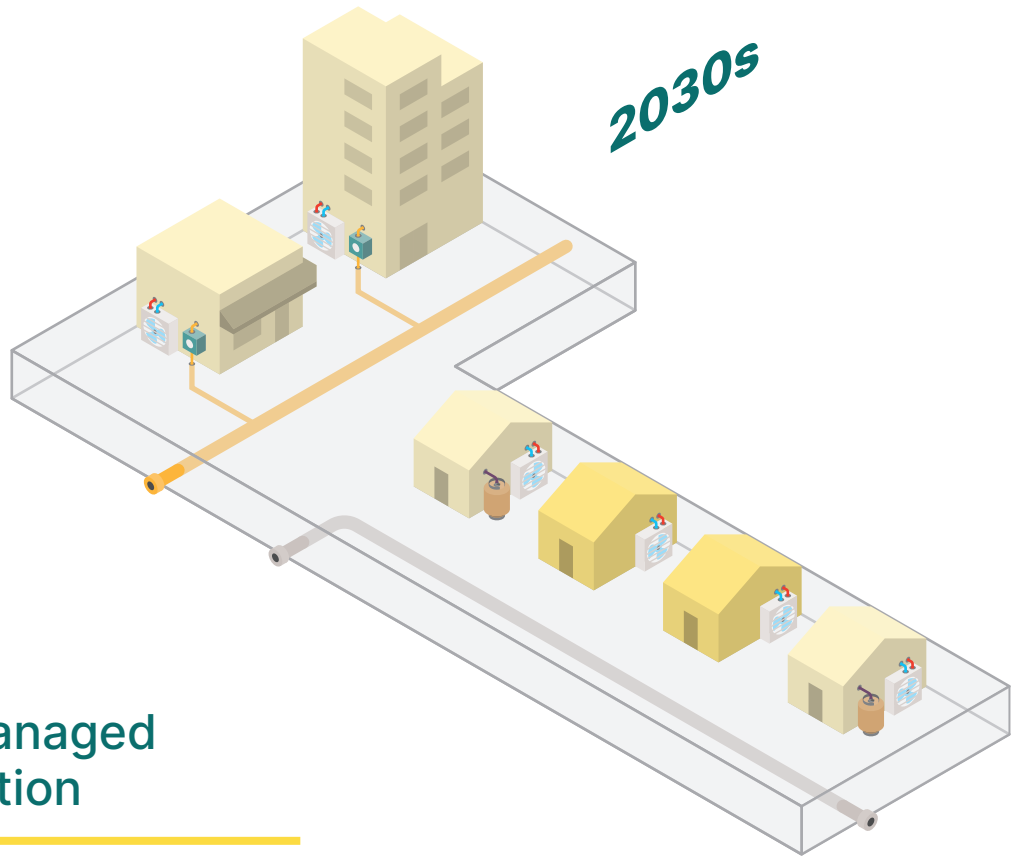
**Table 10. Objective and risk assessment matrix for Hybrid Heating with Pipeline Gas scenario**

Scenario 3	Advantages	Disadvantages	Degree and nature of risk	Policy to mitigate the risk
<b>Cost</b>	Leverages existing assets as an energy resource to support other elements of decarbonization.	The cost of managing and maintaining a gas distribution system with low consumption is precarious due to potential for departures; requires continued investment in the gas system.	<b>Significant</b> —High likelihood of ratepayer departures due to competition from non-pipeline alternatives. Limited options to recoup costs leading to negative feedback loop.	<b>Significant</b> —Regulation to maintain ratepayer use of distribution system (e.g., exit fees)
<b>Customer</b>	A manageable amount of intervention provides customers with new technologies while avoiding the challenges of full electrification.	Does not fully improve buildings for comfort and consumer value.	<b>Significant</b> —Customers may seek out non-pipeline alternatives.	<b>Significant</b> —Same as in the above cell
<b>Health</b>	Some benefits from reduced combustion where end-uses have been electrified.	Missed opportunity for comprehensive health-improving building improvements	<b>Moderate</b> —Missed opportunity for benefits.	N/A
<b>Employment</b>	Accelerated deployment of heat pumps is a significant and relatively practical mode of job creation.	Reduces but maintains reliance on energy imports which may be a missed opportunity for local job creation.	<b>Moderate</b> —A sizeable and well trained workforce may not materialize, but risk is lower than more aggressive scenarios	<b>Significant</b> —Workforce development programs and investment
<b>Equity</b>	Least-cost near-term strategy provides low-risk electrification for vulnerable populations.	Long-term risk for those with reduced agency or capability to transition.	<b>Significant</b> —Due to precarious nature of the scenario.	<b>Significant</b> —Stabilize the scenario by keeping ratepayers on the gas distribution system.
<b>Emissions</b>	High potential for near-term emissions reduction.	Reduces but maintains leaks in both gas equipment and pipes.	<b>Moderate</b> —Leaks continue to be a pernicious problem challenging emissions targets	<b>Significant</b> —Intensified effort to reduce gas system leaks, including those from equipment and building pipes.
<b>Reliability</b>	Dual fuel approach at the building scale avoids accelerated hardening of the grid.	No major disadvantages	None	N/A
<b>Resilience</b>	Provides cooling	No updates for enhancing building thermal resiliency.	<b>Minimal</b> —Missed opportunity for benefits.	N/A
<b>Safety</b>	No major improvements to the current safety paradigm	Older buildings may be the most at-risk of gas explosion due to older and neglected infrastructure. Likely low-income households.	<b>Minimal</b> —Missed opportunity for benefits.	N/A

these fuels will even be synthesized using hydrogen. Combustion and its burdens remain—especially for biomass and distillate fuels. Early adoption of this cost-effective strategy will be pursued by those with the means and agency to do so, leaving disadvantaged communities behind.

However, the option for non-pipeline fuels to play a transitional strategy raises two important points. First, it demonstrates that gas networks are severe-

ly exposed to competition as their costs rise. This underscores the urgent need for intentional, active management of the gas transition to minimize transitional burdens. Second, non-pipeline strategies can be used to right size the gas system by allowing for the transitional use of useful undepreciated gas equipment and moderating the challenges associated with electrification.



## Scenario 4: Managed Phased Transition

### Comparable analysis and frameworks:

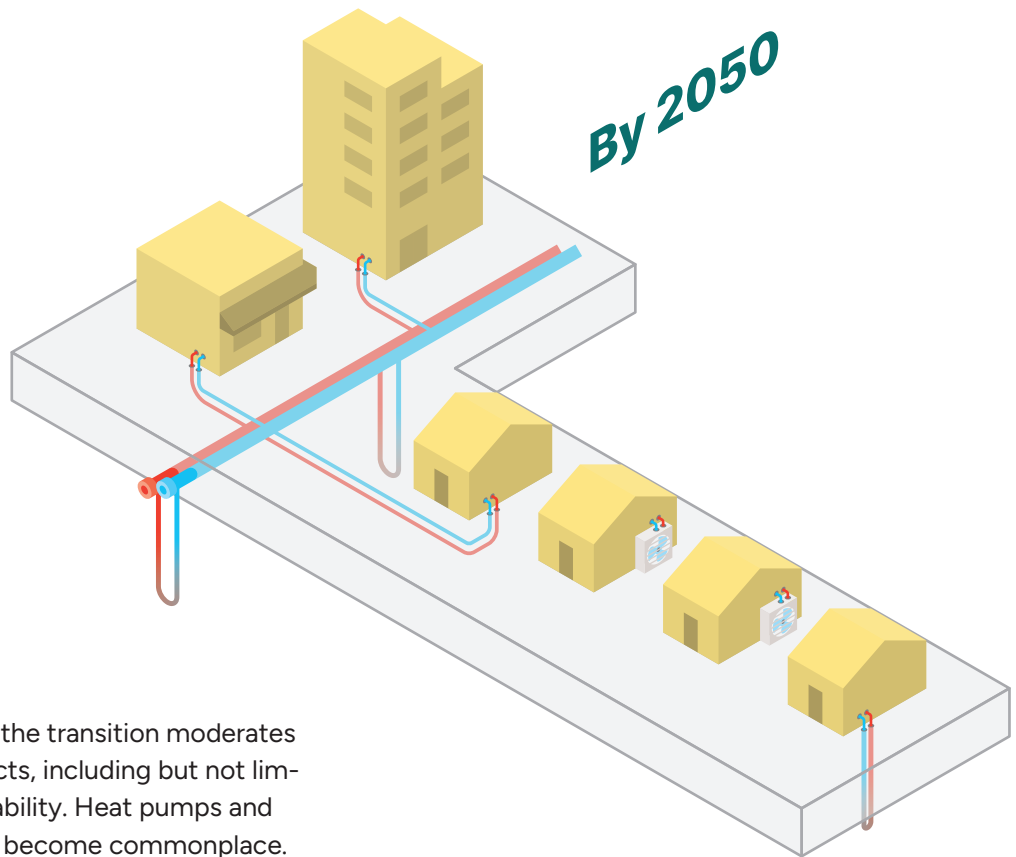
- ▶ Massachusetts 2025/2030 Clean Energy and Climate Plan: Phased Electrification Scenario<sup>172</sup>
- ▶ California Public Utilities Commission: Gas Planning and Reliability in California<sup>173,174</sup>
- ▶ Gridworks for California Public Utilities Commission; Gas Resource and Infrastructure Planning for California<sup>175</sup>
- ▶ EDF: Managing the Transition—Proactive Solutions for Stranded Gas Asset Risk in California<sup>176</sup>
- ▶ None conducted for New York but the application concept on large buildings has been illustrated with NYSERDA’s Resource Efficient Electrification.<sup>177</sup>

### Description

In this scenario, gas utilities, electric utilities, localities, and other stakeholders, all led by the PSC, actively coordinate on electrification and the right-sizing of the gas distribution system. This proceeds

through successive phases of targeted branch pruning and zonal transitions, organized to facilitate safe, equitable, and cost-effective gas network contraction, while supporting continued safe and reliable access to energy. A major part of this effort involves a hyperlocal or neighborhood-level focus that uses a standard toolkit of solutions to deal with diverse situations. It is complemented by regulatory financial policy that manages the costs of the transition.

**Defined Gas Network Rightsizing Objectives:** This proactive, phased process builds on system-level planning and begins with an end to gas distribution system expansion and to avoidable investments in existing gas networks. Opportunities to safely retire leak prone pipe are identified and taken advantage of. Transition away from reliance on gas is undertaken wherever possible in a zonal fashion rather than house-by-house, building-by-building. This yields efficiencies and creates opportunities for coordinated investments by several stakeholders in solutions like thermal energy networks.



**Phased Approach:** Phasing the transition moderates its impacts in several respects, including but not limited to cost and energy reliability. Heat pumps and energy efficiency upgrades become commonplace. Emphasis in the 2020s is on making basic, prerequisite energy efficiency improvements and replacing key appliances and devices with heat pumps. Buildings with partially depreciated gas-fired equipment might, for instance, have heat pumps installed incrementally, replacing water heaters and HVAC equipment when old equipment fails or approaches its end of useful life. By the 2030s, and beyond, whole building electrification becomes the norm. NYSERDA has described this approach with large complex buildings as Resource Efficient Electrification. (Figure 13)<sup>178</sup>

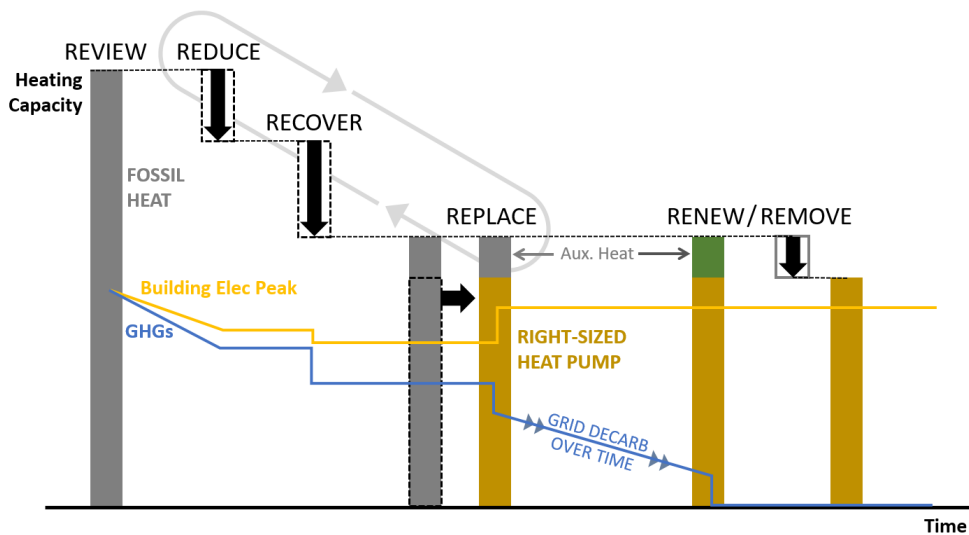
**Prioritization of Low to Moderate Income Housing:** A managed transition prioritizes low to moderate income housing for both this cohort’s large potential energy and emissions savings and for the broader economic, health, and social benefits such improvements will bring. Prioritization is necessary to mitigate issues associated with late adoption of electrification in this cohort such as risk of higher cost pipeline gas and delayed realization of electrification’s benefits.

**Local energy asset planning**<sup>179</sup> provides critical support for the process at the system, zonal, and individual levels. This planning maps out local energy resources comprehensively. Those resources

### Three Network Rightsizing Objectives of a Managed Transition

1. Halt new investment in the growth of gas networks
2. Avoid reinvestment in gas networks by repairing or decommissioning leak prone pipe rather than replacing it
3. Plan for zonal transitions based on local needs and opportunities

**Figure 13. Illustration of the concept of Resource Efficient Electrification.**



Source: NYSERDA

include: regional and local electric capacity; energy storage capabilities; loads and their degrees of flexibility; ambient thermal resources, such as geothermal reservoirs, water bodies, large sources of waste heat, and consistent thermal loads; and fuels, including more and less feasible pipeline and non-pipeline fuels and feedstocks, such as wastewater and food waste. Crucially, this mapping out will involve the collection and organization of information at the level of individual buildings and energy distribution systems, for the benefit of the utilities, municipalities, and other stakeholders, all of whom will have to make plans and decisions in coordination as part of the process.

These planning efforts and their implementation will require clear and firm policy foundations. As noted in Section 1, New York’s Public Service Law currently impedes the PSC’s ability to implement the sort of plans contemplated here. In addition to potential legislative changes, other important measures will include thorough and thoughtful updates to rate design, as well as policy support for the investments and upgrades that various stakeholders will have to undertake. Finally, gas utilities will require guidance and support with respect to managing the financial and operational aspects of this transitional process, so that they avoid the disruption described in Section 2 and their service to remaining gas ratepayers is not compromised as right-sizing efforts incrementally shrink gas networks over time.

## Elements of Local Energy Asset Planning

- ▶ Focus on location-specific elements of building stock and energy distribution systems
- ▶ Identification of potential energy resources
- ▶ Coordination between utilities, consumers, municipalities and regulators
- ▶ Improved data collection, management and sharing

## Major outcomes

**Solutions are Applied in Strategic Manner.** Mature strategies are aggressively implemented over the next decade. Central heat pump units replace AC condensers in as old units retire. Mini-splits are aggressively promoted in non-ducted arrangements. Larger buildings adopt suitable hybrid heating equipment. Basic energy efficiency upgrades are broadly applied alongside other practical measures such as improved control, electric appliances, and heat pump water heaters.

**Simultaneously, emerging strategies are cultivated for broad and aggressive implementation after 2030.** These include whole building strategies such as ground source heat pumps or comprehensive retrofits (e.g., Enegiesprong approach<sup>180</sup>). Thermal energy networks (TENs) are piloted by gas utilities and private entities (e.g. universities) in locations most suitable to their application. Learnings from these early deployments are used to develop the markets for these technologies over the long run.

**Where practical, propane or other delivered fuels are used to transition pipeline segments and zones off of gas when:** there is a need for auxiliary combustion; or, to meet specific customer preferences such as combustion-based cooking.

**Bioenergy Demands are Minimized and its Application to Building Heat is Secondary.** Ongoing and substantial reductions in combustion, as well as gas distribution system downsizing are the prime drivers of emissions savings. Remaining modest uses of combustion come into compliance using emissions allowances or qualified bioenergy pathways. Any bioenergy use in building heat largely results from excess capacity, if any, from growth of bioenergy strategies in other sectors (e.g., renewable propane is a byproduct of sustainable aviation pathways<sup>181</sup>) or from location-specific opportunities (e.g., district combined heat and power from wastewater treatment plant's anaerobic digester). Intentional generation and pipeline use of RNG is avoided to minimize leaks.

**Electric System Upgrades are Adequately Planned and Implemented for a Deeply Electrified and Efficient Future.** A managed, phased strategy ensures that electric system upgrades from the panel

to the substation can be implemented at the most cost-effective time point. Near term partial electrification followed by long-term efficiency-maximizing strategies lowers the need for accelerated and more aggressive upgrades. Distribution system costs are spread across growing heat sales and flexible EV charging demands.

**Gas Network Planning Leads to Cost Savings that Would Otherwise Be Unrealized.** Avoided new investment and replacement reduces the long-term costs of the gas distribution system, limiting substantial rate increases and the risk of stranded assets.

**Steady Reduction in Emissions as Growth of the Gas Distribution System Halts and Consumption Begins to Fall.** Retirement of leak prone pipe segments leads to measurable reductions in fugitive methane emissions.

**Burdens to Consumers are Minimized while Maximizing Benefits.** Near-term hybrid strategies and electrification of appliances provide consumers cost savings and other tangible benefits with little implementation hassle. Federal incentives and state rebates cover most of the cost associated with these strategies. Avoided gas distribution system costs and a steady pace of electric system upgrades—not that much different than historical growth—keep revenue requirements and rates low.

## Analysis

This scenario recognizes that approaches described in the previous three scenarios above cannot restore New York's gas networks and gas utilities to a stable equilibrium and instead aims to manage, in phases across geographies, the transition of gas ratepayers to competing energy resources. The proactive approach described here hinges on extensive and intensive coordinated planning among key stakeholders at the state and local levels. It also requires creating and organizing a large amount of information about energy systems and consumption.

The prior three scenarios all largely defer action to later dates. A managed, phased electrification requires intentional action now. It requires making harder choices and galvanizing support today. However, by intentionally building momentum it reduces



**Table 11. Objective and risk assessment matrix for the Managed Phased Transition scenario**

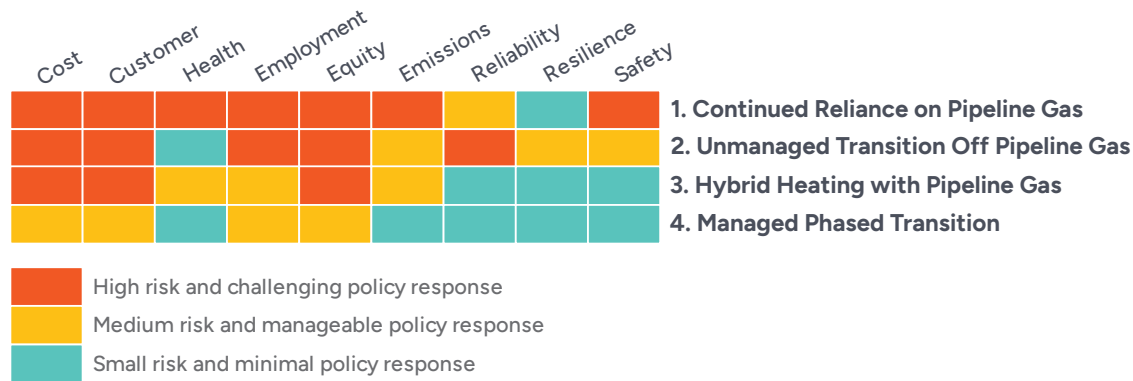
Scenario 4	Advantages	Disadvantages	Degree and nature of risk	Policy to mitigate the risk
<b>Cost</b>	Avoids costs of installing or maintaining parts of the gas distribution system that are redundant in the face of lower cost non-pipeline alternatives. Electric system costs are managed.	High upfront costs for building retrofits. Electrification of gas-heated homes likely to result in a near-term increase in heating costs (though long-term reduction)	<b>Moderate</b> —Cost barriers will slow down adoption of electric alternatives,	<b>Moderate</b> —Leverage IRA incentives and resources to keep upfront costs low. Develop heat pump-friendly rate design.
<b>Customer</b>	A manageable amount of intervention provides customers with new technologies while avoiding challenges from full electrification.	Consumers need to adapt to a new technological and energy paradigm.	<b>Moderate</b> —Customer knowledge poses a potential hindrance to growth.	<b>Minimal</b> —Create streamlined pathways for improving building stock. Support and develop work force and supply chains.
<b>Health</b>	Significant benefits from reduced combustion.	None	None	N/A
<b>Employment</b>	Accelerated deployment of heat pumps is a significant and relatively practical mode of job creation.	Workforce needs are considerable even for this scenario.	<b>Moderate to significant</b> —Phasing helps with challenge of scaling workforce, but challenge still remains.	<b>Moderate</b> —Workforce development programs and investment for an ongoing transition.
<b>Equity</b>	Least cost near term strategy, provides low-risk electrification for vulnerable populations.	Upfront costs and split incentives are still a challenge in a managed transition	<b>Moderate to significant</b> —Institutionalized practices continue to leave behind disadvantaged populations	<b>Moderate</b> —Intentional program design to ensure that disadvantaged populations do not get left behind in the transition.
<b>Emissions</b>	High potential for near-term emissions reduction. Elimination of fugitive methane emissions from leak-prone segments.	Reliance on non-pipeline bridge fuels may prolong or exacerbate some emissions-generating activities	<b>Minimal</b> —Emissions reductions are pursued across the system.	<b>Minimal</b> —Ensure electrification, deep efficiency and systems integration are prioritized in implementation.
<b>Reliability</b>	Dual fuel approach at the building scale avoids accelerated hardening of the grid.	Rapid promulgation of various strategies may create reliability challenges.	<b>Minimal</b> —On net, reliability is maximized by multiple strategies.	<b>Minimal</b> —Encourage a diverse portfolio of non-pipeline strategies.
<b>Resilience</b>	Onsite stored fuels can create resilience value. Buildings are improved on practical time scales. Provides cooling.	Removal of existing pipeline system may create some situational resiliency challenges	<b>Minimal</b> —Depends locational situation	<b>Minimal</b> —Various strategies exist to enhance resilience following pipeline removal.
<b>Safety</b>	Reduction in leak prone pipe segments mitigate risks of hazardous events.	No major safety disadvantages if implemented properly.	None	N/A

the long term burdens and risks associated with the prior scenarios.

Policy measures will be necessary to support information gathering, planning, and implementation. Some of those measures will remove barriers: most importantly, present statutory language fetters the PSC’s ability to pursue this approach. Other measures will be needed to enable agencies, utilities, and localities to gather and share the full array of information needed to navigate through the process of

transition. And implementation measures will require devoted attention from state agencies and utilities to ensure that equity and affordability get due priority, as well as safety and reliability.

**Figure 14. Summary of the degree of risk and level of intervention needed in each future of gas scenarios.**



## Summary of Scenarios

Figure 14 summarizes the assessments of risk and intervention in each of the above scenarios. Its findings are clear: an intentional effort to strategically manage the gas transition through a phasing in of electric and other non-pipeline strategies is the best pathway for achieving the state’s multiple climate, energy, and equity objectives.

Across the scenarios there are some notable trends and evolutions:

**Costs** are challenging in all scenarios, but differ between high operating costs for RNG and high capital costs for value-generating building retrofits. A managed transition maximizes **customer** benefits, however it still requires customers to participate in a coordinated transition. Greater electrification and less combustion of gas in homes results in improved **health**.

Developing a building retrofit **workforce** will be a challenge for all scenarios—even if New York pursues an RNG strategy, the high cost of that fuel would still necessitate intensive efficiency-improving building retrofits for its use to be economical.

Ensuring **equitable outcomes** requires ensuring that disadvantaged communities are not left behind in this transition and receive sufficient transitional support.

Less combustion means **fewer emissions**. However, **fugitive emissions** are a risk for all scenarios that

rely on pipeline gas: at point of production for RNG; in aged pipe, including plastic; and in homes with older pipe and gas equipment.

**Reliability, resiliency and safety** are a function of how well the transition is managed. Lack of action will miss opportunities for better meeting these objectives.

Pursuing all of these multiple objectives at once is an ambitious task that requires coordinated action. The ordering of scenarios above largely reflects an increasing degree of coordinated action among agencies, energy consumers, utilities, and municipalities. The degree, scale, and needed pace of such coordinated action is significant but so is the disruption that will occur if such action is not undertaken.

As this report describes in its history of the gas system, this coordinated action is of similar ambition to the laying of the first pipes, the creation of the utility framework, gas’s competitive response to early electrification, and the transition from manufactured to natural gas.

The sooner such action is pursued, the lower the cost and the greater the benefits. With nearly 500 miles of distribution mains being replaced each year, future generations are burdened with the financial and climate costs of such systems. Such burdens are not inevitable and can be avoided via proactive regulatory action.

# Recommendations

New York’s gas system and its rate-payers’ access to affordable gas service face impending disruption. It is imperative that several leading institutions take action to prevent that disruption from harming rate-payers and impeding the clean energy transition called for by the state’s Climate Law. The recommendations below would help to steer away from harmful disruption, and toward a managed, phased transition—a result consistent with the vision articulated in the Climate Action Council’s Scoping Plan.

Legislature



## 1 Update utility laws that impede Climate Law implementation

Entity: **Legislature**

Timing: **Immediately**

Update utility laws that impede the Commission and the utilities it regulates in implementing the Climate Law. The update should be enacted as soon as possible. Provisions requiring amendment include but are not limited to:

- ▶ Public Service Law sections 30 and 31 (imposing a utility obligation to provide gas service upon request to residential would-be ratepayers and establishing a “100-foot rule” that incentivizes connection and shifts its costs to other ratepayers)
- ▶ Transportation Corporations Law section 12 (similar but for commercial ratepayers)



## 2 Adopt an overarching gas planning framework to govern filings in both the Gas Planning docket (20-G-0131) and Climate Law Compliance docket (22-M-0149)

Entity: **Public Service Commission**

Timing: **By the end of 2023**

That framework should:

- ▶ Specify emission reduction obligations for gas utilities under the Climate Law for both 2030 and 2050 and direct utilities to meet those obligations.
- ▶ Avoid unnecessary carbon and cost lock-ins by requiring that near-term LDC investments be consistent with longer-term plans for deep decarbonization to meet Climate Law emissions mandates.
- ▶ Implement concrete recommendations from the Scoping Plan, including halting the expansion of gas networks and requiring zero emission appliance replacements by specified dates.
- ▶ Accurately account for the lifetime costs of pipe replacement projects for comparison with non-pipeline alternatives and otherwise.
- ▶ Identify and direct stakeholders to act on opportunities for zonal phase-out and decommissioning of gas network segments based on potential cost savings, emissions reductions, and improved outcomes for end-users' health and comfort.

## 3 Clarify issues related to RNG and hydrogen

Entity: **Public Service Commission**

Timing: **As soon as practicable**

- ▶ Direct the Department of Public Service, in collaboration with the New York State Energy Research and Development Authority, to issue assessments of the viability of RNG or hydrogen as decarbonization solutions for New York's buildings in light of constraints on cost, availability, climate impacts, and competition with other sectors also needing to decarbonize.
- ▶ Require any gas utility's plans or proposals involving RNG or hydrogen, whether submitted to the Commission in the context of a rate case or non-adjudicatory docket, to carry the burden of proof that those resources are: (1) are cost-effective relative to more readily available alternatives such as electrification, (2) deliver additional and directly attributable emissions reductions—including accounting for fugitive emissions, and (3) represent a clear best use case from a cost and emissions perspective for RNG and hydrogen feedstocks relative to their potential use in other sectors such as electricity, liquid fuels or chemical feedstocks.
- ▶ Scrutinize assumptions embedded in filings in planning proceedings or rate cases about demand for RNG and hydrogen from other sectors.

## 4 Steer gas utilities' development of their Climate Law Compliance Pathways Studies

Entity: **Public Service Commission**

Timing: **In response to March 2023 submissions of study proposals**

- ▶ Give direction to gas utilities regarding:
  - decarbonization strategies to model;
  - how they should model energy efficiency retrofits;
  - assumptions gas utilities should make regarding firming resources in the electric sector;

- required disclosure of assumptions about RNG feedstocks and emissions; and
- how gas utilities should incorporate thermal energy networks into their modeling.

► Engage an independent consultant

- direct the consultant to review utility pathways analyses for consistency with Climate Law emission mandates and recommendations in the final Scoping Plan; and

authorize the consultant to request changes to these analyses where deficiencies are identified.



## 5 Medium- and long-term sector-specific emissions reduction targets

Entity: **Department of Environmental Conservation**

Timing: **As part of January 1, 2024 regulation issuance**

Include medium- and long-term sector-specific emissions reduction targets for the gas system in the emissions regulation to be adopted pursuant to Environmental Conservation Law section 75-0109. The price signals sent by a cap-and-invest program, such as the one New York plans to adopt, are unlikely to produce an optimal decarbonization strategy in the buildings sector. Gas utilities have a higher tolerance for emissions allowance costs because they can pass those costs through to ratepayers. And ratepayers will have both limited information about what is affecting their bills and limited options to respond. Because gas utilities and ratepayers are less likely to be responsive to price signals, an additional mechanism should further encourage the adoption of measures that reduce emissions from the gas system in line with the Climate Law's overarching target.

# Appendix: Guidance on Pathways Analysis

Pathway studies are informative exercises that use complex systems modeling to help understand the broad implications of specific decisions. However, many pathway studies involving the gas system lack the analytical rigor to yield externally valid insights. This appendix identifies the primary elements of gas system pathways analyses and considerations around developing these elements. It offers recommendations for improving the value of gas system pathways analysis and for contextualizing the interpretation of the results.

## Elements of Gas System Pathways Analyses

The purpose of a pathways study is to understand how the decisions made in a given sector impact energy and infrastructure needs in other sectors. In the context of a gas distribution-focused pathways analysis, this usually involves decisions surrounding building interventions and management of the gas distribution system, but understanding the implications of certain constraints in the energy supply sectors (e.g., the inability to scale bioenergy) may also be valuable. Forecasting the gas transition typically involves examining changes in cost and energy—along with other derived indicators—over four distinct energy sectors:

- a. Building energy demand
- b. Electricity supply
- c. Bioenergy supply
- d. Distribution systems

Representation of each of these sectors varies by modeling approach and practitioner. Building energy demands are modeled with some level of disaggregation by building type and end-use segmentation using standardized building energy use assumptions developed by the Energy Information Agency and U.S. Department of Energy.<sup>182,183</sup> Scenario-defining assumptions on equipment efficiency, adoption, and load shapes produce aggregate hourly energy demands. A capacity expansion model is often used to match this demand with the deployment of energy resources based upon fundamental assumptions (e.g., equipment cost and performance) and scenario assumptions (e.g., RPS mandate for a certain level of solar). Depending on certain assumptions, bioenergy resources can fill the demand for remaining fuels, but this may not be climate or cost optimal.

Unfortunately, the state of the practice is such that analysis of the dynamics of gas, electric and novel thermal energy networks is less developed than those of the other sectors. Simulating the distribution systems in the context of pathway studies is an emerging concept. Most pathway studies are conducted at a macro level. Distribution assets can be, but are often not, represented in vintage cohorts and replaced using system-wide historical trends in

capital expenses. Operating expenses are based on historical trends. A limited number of reports have looked at some systems management (e.g., decommissioning segments on leak-prone pipe) but with little analytical granularity.

There is no common practice evaluating relative differences in decarbonization strategies across distribution systems. For example, the cost and applicability of strategies will likely vary considerably in urban, suburban, and exurban areas. The failure of many gas system pathways studies to accurately capture these differences is unfortunate, as strategic management of gas, electric, and novel energy distribution systems (e.g., shared-loop thermal energy networks) may be a significant source of cost savings as systems decarbonize. Management of such systems falls more within the PSC's authority than the implications on the electric supply, building infrastructure, and bioenergy systems.

The ideal gas system pathway study would appropriately use its modeling platform to evaluate distinct alternative strategies for decarbonizing the system. Scenario design would maintain "internal consistency" by ensuring that scenarios are logically distinguishable from one another and would avoid varying multiple decisions between scenarios in a way that obscures the impact of individual decisional choices.

By varying individual decisions incrementally, hypotheses can be more rigorously tested. For example, a practitioner may hypothesize that coordinated building and transportation electrification is lower cost than the combined costs of separate electrification because of the ability to more optimally use the electric distribution at different hours due to the flexible nature of EV charging. The practitioner would subsequently model a building electrification scenario, a transportation electrification scenario, and a combined electrification scenario. The hypothesis would be supported if the results showed cost benefits of a certain size from simultaneously electrifying both sectors.

While some scenarios may be impractical (e.g., building electrification without EVs), uninformative in isolation, or undesirable (e.g., non-compliant scenarios), they may be useful for illustrating the dynamics of the energy transition and relative impacts of some strategies compared to others.

The following subsections review and provide recommendations in each of the four areas noted above, as well as in general, to ensure that such studies provide maximum insight for the PSC and its stakeholder deliberations. Finally, utility plans should not be over-reliant on pathways studies and should instead use them only as part of a number of assessments to critically develop an effective approach to energy transition that reduces risks to climate.

Given uncertainties and differences across sectors, pathway analyses should focus on primary indicators such as loads, capacity by resource, amount of fuel consumption, miles of gas-served pipeline, number of ratepayers, and number of building interventions. Comparing costs across sectors can be helpful for identifying major drivers, however given the high degree of uncertainty—particularly as strategies scale—a parochial focus on cost can obscure important findings regarding implementation and risk.

## Buildings & Demand Side

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There are two broad sets of strategies for decarbonizing buildings: strategies that decarbonize the energy consumed by buildings and strategies that reduce the energy consumed by buildings. To decarbonize the energy used in buildings, there are four overarching approaches:

- ▶ continued use of pipeline gas with reduced GHG intensity
- ▶ hybrid heating with peak heating needs to be served by the pipeline gas system using gas possibly with reduced GHG intensity
- ▶ hybrid heating with peak heating demands met by non-pipeline fuels possibly with reduced GHG intensity
- ▶ whole-building electrification

Hybrid strategies may leverage existing equipment for auxiliary heat and be either an end state or a step toward whole-building electrification.

To reduce energy demand from buildings, forecasts include a range of building energy efficien-

cy measures typically categorized into two levels of intervention:

1. “Standard” or “basic” energy efficiency measures are generally considered cost-effective at household and systems levels under conventional cost-benefit tests. These typically reduce energy demand by 10% to 25% depending on the building type and can include: drill & fill insulation, attic insulation, weatherstripping
2. “Deep” or “enhanced” energy efficiency measures which achieve higher levels of performance (30% to >50% reduction in energy demand) but at higher upfront cost and with longer-payback periods: triple pane windows, prefabricated envelope retrofits, high-efficiency equipment, ground source heat pumps.

Higher levels of efficiency are justifiable and possibly necessary in the case of whole-building electrification to moderate its costs and impacts. Basic efficiency measures are assumed to be applied to any level of intervention, and their universal application to lower-performing buildings should be a policy priority in any future scenario.

## Modeling Considerations

Modeling these packages must show the impact of energy efficiency measures on load profiles and not assume that energy reductions are averaged across the year.

Models should represent flexible loads in both buildings and EV charging. Flexible building loads (e.g., water heating or space heating in high-performing buildings) provide modest benefits. Most important is a strong representation of future EV charging loads, forecasted based on New York State’s Zero Emissions Vehicle timeline. Forecasts should represent the ability to shift charging to night, thus increasing the load factor of both generation and distribution. Such flexibility provides significant system benefits at a very low cost.<sup>184</sup> The lack of such representation may result in a bias for the analysis to simulate higher peak energy demand.

Costs are a significant uncertainty due to limited tracking of building costs. A hybrid heat pump in a ducted home replacing a partially depreciated

central air conditioning system will have lower costs than the installation of mini-splits in a home with a hot-water distribution system. More granular representation of buildings may provide more detail, but such precision can create a false sense of accuracy. Depending on the scale modeled, practitioners may choose to use a range of building cost estimates in a sensitivity analysis approximated from bulk cost estimates. While costs are influenced by macro-economic factors such as labor and materials costs, downward pressure on costs can also come from industrial policy.

Consideration should be given to the application of the above strategies to different parts of the building stock. In the Massachusetts 20-80 Gas Docket, the LDC’s consultant modeled a hybrid heating scenario in which all buildings (gas, oil, propane) were hybridized.<sup>185,186</sup> In other scenarios non-pipeline fuels were transitioned to be fully electric. This gas system-agnostic decision violated the principal of internal consistency with respect to the study’s goal of understanding the dynamics of the gas transition. The inclusion of oil and propane heated homes in the hybridized cohort resulted in additional net cost savings (from less intensive building electrification and grid investment) that were outside the frame of the gas system. This led to the scenario emerging as the most cost-effective. Had a better control been used, it is likely that the study’s hybrid heating scenario would have looked similar in magnitude to a targeted-retirement scenario.

**Recommendation:** LDC pathway studies should evaluate all four of the strategies for decarbonizing building energy listed above on gas-served buildings. Each scenario should be conducted using a “basic” and “deep” efficiency sensitivity. The study should also conduct a sensitivity analysis of cost estimates. For simplicity, non-pipeline buildings should be retrofitted with a mix of whole building and partial electrification in a manner that is consistent across all scenarios.



## Electric Sector

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The purpose of modeling the electric supply sector is to evaluate and contextualize the costs of additional electricity resource capacity needed to support increasing demand from building electrification relative to strategies with lower levels electrification or increased management of electrification (e.g., efficiency and flexibility). Such analysis is performed in the context of a rapidly decarbonizing electricity supply—largely the growth of variable renewable energy.

The amount of capacity by resource type required under each scenario is a primary indicator of the implications of alternative demand-side strategies. Capacity expansion models will deploy the least-cost resource mix under specified emissions caps. Solar and wind are generally deployed at a low cost but require more expensive firming resources.

The cost of firm generation can vary depending on the type. In addition, because the Climate Law mandates zero emissions electricity generation by 2040 with no allowance for offset, fossil fuel generation resources are assumed to be unavailable beyond that date.

The Scoping Plan's Integration Analysis conducted a sensitivity exploring the cost differential between RNG, H2 combustion and H2 fuel cell grid firming. RNG was the lowest cost strategy but still resulted in a significant cost increase relative to the use of fossil methane gas. Given issues raised in this report regarding the impracticalities of production, it may be more climate and cost optimal to allow for the use of fossil methane gas to be bundled with an offset, however this strategy currently conflicts with the CLCPA. Alternatively, some in-state biogas resources could be designed with integrated gas storage to provide grid firming without the need for costly RNG upgrading. Such resources may provide locational value to electricity systems.

The Climate Law and Scoping Plan recognize the current cost, scalability, climate and broader impacts of putative zero emissions firm generation technologies are not yet fully understood.<sup>187</sup> The PSC is granted sufficient leeway to ensure reliability and avoid significant cost burdens.

Uncertainty presents a fundamental challenge in assessing the impacts as such costs can contribute significantly to cost differentials between pathways. This can have implications for not only high electrification pathways but also pathways that are overly reliant on electrolyzed hydrogen or other renewable or synthetic fuels that have significant electric demands in their production. As a result, cost contributions from the electric sector should be viewed critically and secondarily to primary indicators such as changes in loads.

**Recommendation:** The PSC should establish guidance on what firming resources and what the costs of such resources should be in any integrated pathways study. Since the choice of firming resources is an outstanding policy and technology decision with implications outside the gas sector, it is advisable that the lowest-cost Climate Law-compliant firm resource be used as the base assumption.

Other assumptions and model-specific features will also influence costs. For example, the ability to share resources across regions via increased transmission helps to keep costs low. Different models operated by different practitioners have varying levels of transmission representation. Other features such as choice of weather year, allowed technology portfolio, and cost assumptions can also lead to divergent results.<sup>188</sup> Such model design aspects can have a significant impact on results.

**Recommendation:** Pathway analyses should provide a methodological description of their electricity sector model. The practitioner should provide sufficient context for the results in the model's capabilities. For example, if their model fails to simulate dynamic transmission with neighboring regions, the practitioner should acknowledge that capacity needs may be overestimated.

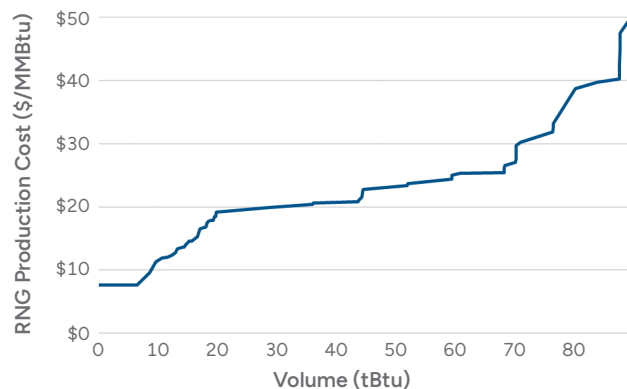
## Representation of RNG and Remaining Fuel Use

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Models have different treatments for renewable fuels. Some approaches, such as those employed by E3 (MA future of Gas docket<sup>189</sup>), ICF (e.g., NYS RNG Assessment<sup>190</sup> & AGA National RNG Potential<sup>191</sup>), and

Net Zero America,<sup>192</sup> generate renewable fuel prices and availability based on a supply curve representing the number of resources available at a given price (Figure 15) and adding bio-refining costs. These are often based on resource assessments of wastes, residues, and energy crops conducted in the U.S. Department of Energy’s 2016 Billion Ton Report<sup>193</sup>, along with supplemental data on landfills<sup>194</sup> and wastewater treatment facilities. Such supply curves may generate some insight, but imply high precision in resource availability and cost when actual supplies and costs can be quite uncertain—most notably due to competition for resources.

**Figure 15. New York RNG Production Supply Curve**



Source: NYSERDA’s Potential of Renewable Natural Gas in New York State.<sup>195</sup>

Often such supply curves are locally calibrated to reflect a “fair share” of national or regional resources based on historical population or energy use within a given region or state. Additionally, some studies will make adjustments for allocating these resources to other sectors (see Section 3) The Net Zero America study assumes a total available supply of 6 Qbtus of bio-derived resources and subsequently allocates 4 Qbtus of these resources to chemical feedstocks before allocating resources among the states. This modeling decision shifts New York’s “fair share” of bioenergy resources from 364 TBtus to 121 TBtus—an amount roughly equivalent to the state’s consumption of jet fuel in 2020.<sup>196</sup>

Some models will optimize the production and allocation of bioderived fuels and electro- or synthetic fuels across the energy sector. For example, Evolved Energy Research’s proprietary RIO model optimizes

across the entire energy supply sector, allowing for a more robust analysis of the applicability of renewable or synthetic fuels. Applied in both the Net Zero America Study<sup>197</sup> and studies in Massachusetts,<sup>198</sup> this model demonstrated that RNG is the lowest value use of bioenergy resources leading to it being one of the last decarbonization tools applied. This methodology contrasts those of other studies that exogenously assume that RNG is blended to bring the system into compliance with an emissions target. The former method assumes that expensive-to-decarbonize residual fuel use will purchase an allowance when such allowances are cost effective relative to RNG, while the latter assumes that it will be decarbonized despite the potential higher cost of RNG relative to an allowance or tax.

**Recommendation:** Pathways studies should not exhaustively focus on the supply of RNG and need not assume that all pipeline gas is decarbonized. Instead, the analysis should evaluate residual fuel used in scenarios as a primary indicator in the following context:

1. Residual building sector fuel use should be evaluated in the context of the state’s net zero allowance: *How large is the residual gas use compared to the gross emissions target’s allowances?* This will establish the emissions at risk associated with dependence on the continued use of pipeline gas if RNG becomes challenging to scale.
2. The PSC should provide guidance to the LDC’s on how to account for future fossil methane gas and RNG combustion and production given New York’s greenhouse gas accounting methodology.<sup>199,200</sup> This includes upstream emissions (lifecycle leaks and production emissions) and how upstream emissions intensities evolve over time. New York’s accounting approach creates a layer of complexity given inherent uncertainties, variabilities and long-term changes in upstream emissions. The PSC should not allow LDCs to claim emissions reductions from avoided methane unless the LDCs clearly demonstrate that such methane emissions cannot be avoided by any other strategy than the production of RNG.
3. If residual fuel demand is a small fraction of remaining gross emissions (e.g., <5% of 1990 emissions), then it can be reasonable to assume

that the cost of such gas may incur a compliance cost rather than assume the use of RNG. A cap-and-trade program would determine such compliance cost, but a reasonable proxy for such a cost is the recent federal estimates of the social cost of carbon<sup>201</sup> or New York's estimates of the value of carbon<sup>202</sup> with reasonable assumptions for escalation.

4. If RNG is a proposed strategy, the analysis should acknowledge the need to prioritize bioenergy resources for other sectors. Because of this, the cost of RNG should reflect the higher-cost RNG-production pathways and resources (e.g., gasification of biomass). Ideally pathway analyses should represent competition for RNG such that fossil methane gas or electrification is pursued under high levels of competition for bioenergy feedstocks. Further, high levels of RNG will likely necessitate the use of energy crops that conflict with using those crops or land for carbon sequestration. Such consequences should be quantified acknowledged as an impact of high-RNG pathways.
5. If RNG is a proposed strategy, the LDCs should evaluate challenges and opportunities in the incorporation of RNG to the LDC's supply portfolio given that RNG has different predictability of supply profile.
6. If RNG or hydrogen are a proposed strategy, LDCs should incorporate the energy demand associated with the production of those fuels into their models and describe a framework for how energy used to produce those fuels are procured in a manner that ensures that those fuels do not generate indirect emissions in state or out of state.
7. Gas system studies should not assume that the development of RNG influences waste and agricultural sector emissions. Such emissions could also be managed by other non-energy and energy strategies, and the development of such strategies will be driven to a greater extent by higher value pathways.

## Distribution System

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There are several strategies for managing the gas distribution system as electrification proceeds:

1. Incorporation of non-pipeline strategies to avoid new investment in the system.
2. Decommissioning gas-served segments that require pipe replacement to avoid reinvestment in the system. This strategy is relevant to pending near-term decisions.
3. Zonal transitioning and decommissioning of networks of that will experience declining gas consumption that leads to such zones being uneconomical or impractical for continued gas use. This is a long-term strategy designed to manage and sunset underutilized assets and promote electrification in a given zone. Zonal transitions seek to find the best decarbonization strategy for a given location. For example, medium density zones with access to suitable and sufficient thermal sources and sinks are likely to be strong candidates for thermal energy networks. Low density zones, previously served by pipeline gas with high costs of electric upgrading may be suitable for near term non-pipeline hybridization and guided transition to independent geothermal heat pumps over the long-term at practical installation points.

All of these strategies are likely necessary for aligning and rightsizing the gas distribution system to be compliant with Climate Law objectives at lowest cost. However, the application of these strategies will require interventions on the building and electric system. The failure to implement the above strategies would contribute to an *unmanaged transition*.

The primary indicator for evaluation of gas distribution system implications are the relative costs of different strategies driven by capital expenses, level of depreciation, and operational expenses. Ideally, LDCs should segment their systems into groupings that reflect a varying degree of opportunity for decommissioning. Ultimately cross sector planning is needed to ensure that buildings and the electric distribution system is well positioned for the transition of a segment off of gas.

Electric distribution investment needs will be influenced by the level of electrification. Peak loads and calculated investment needs should be used to evaluate the implications on the distribution system.

**Recommendation:** LDCs should estimate opportunities for avoided new and reinvestment and forecast the implications of these strategies on future revenue requirements relative to scenarios that presume continued use of the gas distribution system at current scale. Further, the LDCs should identify opportunities for cost-effective zonal decommissioning in the 2040s under scenarios with high levels of customer electrification. Finally the LDCs should model an unmanaged transition in which the above strategies are not implemented and use this scenario to contextualize the managed transition scenarios as well assess the needs of unmanaged transition.

## Thermal Energy Networks

Representation of thermal energy networks (TENs) presents challenges in the low-resolution state or utility-level analyses. TENs are analytically similar to building energy efficiency in that they offer higher levels of energy use efficiency at higher costs. Their scalability is also likely in distinct situations where other distribution system cost dynamics may evolve: they may be best in semi-dense environments where avoided electric infrastructure costs may be significant.

**Recommendation:** LDCs should identify specific potential thermal energy network zones and estimate their potential costs and energy usage. These assessments should represent tiers of networks that progressively include more buildings up to the point where such networks become impractical. LDCs may then use these assessments to inform their pathways analysis. Conducting a utility-scale analysis without a sufficiently thorough assessment of potential sites and implementation strategies is generally uninformative. The PSC would be best served by thorough and thoughtful analyses of actual potential network sites than unrepresentative approximations in a utility-scale pathway. LDCs are encouraged to discuss how they would implement TENs in their respective territories.

## General Considerations

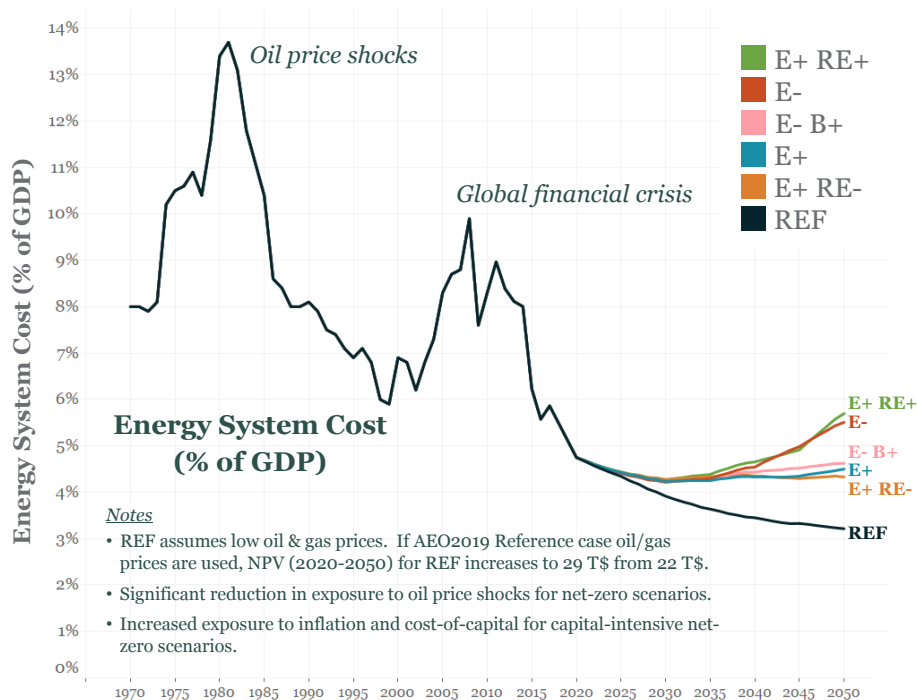
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LDC Pathway studies and planning efforts should prioritize evaluating strategies for managing the gas system as consumption declines and customers leave the system. Analysis of other sectors such as bioenergy supply is less likely to provide novel insight. Comparing costs and tradeoffs across these sectors is prone to high levels of uncertainty particularly when considering extreme scenarios. The PSC needs to start understanding how gas utilities can best manage a downsizing of their system.

Pathway studies illustrate “book-end” cases that may show the directional implications of given strategies such as complete electrification or substituting current fuels with biofuels. The deficiency of this assessment of extreme scenarios is that many strategies exhibit rapid cost escalation past a certain threshold: decarbonizing the last 10% of electricity supplies (e.g., low-carbon firm resources) will likely cost more than the first 90% (low-cost wind and solar). Pathway analyses typically obscure this effect.

Pathway studies should be transparent and describe the tools, assumptions, and underlying data used in the forecasting. Practitioners should state the name of any open source or proprietary software used in the process (e.g., LEAP, SWITCH, GenX, AURORA, PLEXOS). The PSC should encourage transparency and discourage the practice of firms rebranding these tools as their own proprietary tool. A spreadsheet workbook of assumptions should be included with any report, and such assumptions should provide sources or justification.

**Figure 16. Cost of national net zero pathways**



Source: Princeton Net Zero America Study<sup>203</sup>

Regional and national studies demonstrate that though decarbonization costs vary, the impact of a range of decarbonization strategies on energy costs is small relative to historical energy costs. Figure 16 shows energy cost discrepancies using results from the Net Zero America study but is also a conclusion of the New York State Integration Analysis.<sup>204</sup> The costs implications of decarbonization scenarios are not on net excessive. Cost changes across sectors may be large and will need to be managed to protect consumers, and cost differentials between scenarios should be evaluated with this in mind.

Further, indirect costs and benefits of decarbonization (health, employment) can be high but exhibit high levels of uncertainty. However, the benefits from reduced combustion, a shift from reliance on imported fuels to local wind, solar, ambient heat, and energy efficiency, and the mitigation of past social injustices will bring monumental health, social and customer benefits. The integration analysis showed that the health benefits alone, largely from reduced combustion, can result in a benefit greater than half of the transition costs before accounting for the monetized benefit of avoided CO<sub>2</sub> emissions which, when added, deliver net cost savings.<sup>205</sup>

The benefits of climate action via reduced combustion are now undisputed. LDCs, the PSC and process stakeholders should not overly center systems costs calculated using coupled-together models based on highly uncertain assumptions. This risks a number-slugging exercise among stakeholders in which nuance is lost and time is wasted.

Instead, gas planning and pathways studies need to focus on integrated, locally-focused planning that seeks to right-size the gas distribution system to be compliant with the CLCPA’s objectives. Such analysis should focus largely on identifying opportunities to avoid additional investment in the gas distribution system and deploy integrated strategies to responsibly transition swaths of the system off of a dependency on pipeline delivered fuels.

# References and Endnotes

- 1 N.Y. Laws of 2019 c.106.
- 2 CLCPA § 7(2); *see also* Order Approving Joint Proposal, as Modified, and Imposing Additional Requirements, Case 19-G-0309/10 (Aug. 12, 2021), pp. 69-70 (deciding that CLCPA § 7 applies to rate cases as well as more general proceedings).
- 3 Statewide Greenhouse Gas Emissions Report—NYS Dept. of Environmental Conservation. <https://www.dec.ny.gov/energy/99223.html>.
- 4 Individually Filed LDC Annual Reports filed with the PSC. *Annual Report*. 60–62 <https://documents.dps.ny.gov/public/Common/AdvanceSearch.aspx> (2021).
- 5 Aug. 2021 Order, Case 19-G-0309/10, p. 72.
- 6 CLCPA § 2, N.Y. Env't Conserv. L. § 75-0103(11).
- 7 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 2 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 8 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 176–177, 180. [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 9 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 188–190 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 10 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 350, 353 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 11 Climate Law section 2; Environmental Conservation Law section 75-0103(11).
- 12 *See* N.Y. Energy L. 6-104(5)(b).
- 13 CLCPA § 2, N.Y. Env't Conserv. L. § 75-0109(1).
- 14 CLCPA § 2, N.Y. Env't Conserv. L. § 75-0109(2).
- 15 CLCPA § 2, N.Y. Env't Conserv. L. § 75-0109(2).
- 16 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 352, [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 17 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 360, [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 18 Gas Planning Proceeding, Case 20-G-0131; Proceeding on Compliance with the Climate Leadership and Community Protection Act, Case 22-M-0149.
- 19 Order Adopting Gas System Planning Process, 20-G-0131 (May 12, 2022), p. 21.
- 20 Order on Implementation of Climate Leadership and Community Protection Act, 22-M-0149 (May 12, 2022), p. 26.
- 21 Order on Implementation of Climate Leadership and Community Protection Act, 22-M-0149 (May 12, 2022), pp. 26-27.
- 22 Pipeline and Hazardous Materials Safety Administration (PHMSA). *Gas Distribution Annual Data*. (2021).
- 23 U.S. Energy Information Administration. New York Natural Gas Number of Residential Consumers (Number of Elements). [eia.gov https://www.eia.gov/dnav/ng/hist/na1501\\_sny\\_8a.htm](https://www.eia.gov/dnav/ng/hist/na1501_sny_8a.htm) (2023).
- 24 I.N. Phelps Stokes. *The iconography of Manhattan Island*. 1629 (Robert H. Dodd, 1915).
- 25 The New York Times. Gas Stocks and Light. *The New York Times* 6 (1878).
- 26 Wells, B. A. & Wells, K. L. History of Con Edison. *American Oil & Gas Historical Society* <https://aoghs.org/stocks/con-edison-american-utility-company> (2013).
- 27 Jones, P. A *Power History of the Consolidated Edison System, 1878-1900*. (Consolidated Edison Company of New York, 1940).
- 28 Mark H. Rose, *Cities of Light and Heat: Domesticating Gas and Electricity in Urban America* (Penn State Press, 1995).
- 29 United States Geological Survey. *Mineral Resources of the United States*. 1175 (United States—Department of the Interior, 1912).
- 30 Frank Lewis Dyer & Thomas Commerford Martin. *Edison: His Life and Inventions*. (Harper & Brothers, 1910).
- 31 Pratt, J. A *Managerial History of Consolidated Edison, 1936-1981*. 163 (Consolidated Edison of New York, 1988).
- 32 Christopher James Castaneda. *Invisible Fuel*. 140–142 (Macmillan Reference USA, 1999).
- 33 Bureau of Mines. *Minerals Yearbook 1960, Volume II*. 317–329 <https://search.library.wisc.edu/digital/ASCYBICDM7QGZD8B> (1960).
- 34 The New York Times. GAS MAN COMETH, AND SO EARLY TOO. *The New York Times* (1952).
- 35 Bureau of Mines. *Minerals Yearbook 1960, Volume II*. 317–329 <https://search.library.wisc.edu/digital/ASCYBICDM7QGZD8B> (1960).
- 36 Depreciation Panel Testimony, 22-G-0065, Exhibit DP-2 pg. 3
- 37 For a discussion of the obligation to serve and its interaction with New York's Climate Law, see Justin Gundlach and Elizabeth Stein (2020).
- 38 Public Service Law § 31(4).

- 39 RMI (2022). New York Spends Millions on Subsidized Gas Line Extensions, [https://rmi.org/wp-content/uploads/2022/12/new\\_york\\_subsidized\\_gasline\\_extensions.pdf](https://rmi.org/wp-content/uploads/2022/12/new_york_subsidized_gasline_extensions.pdf). This fact sheet collects data reported by gas utilities in response to an order by the Commission.
- 40 Pipeline and Hazardous Materials Safety Administration (PHMSA). *Gas Distribution Annual Data*. (2021).
- 41 Individually Filed LDC Annual Reports filed with the PSC. *Annual Report*. 60–62 (2021). <https://documents.dps.ny.gov/public/Common/AdvanceSearch.aspx> (2021).
- 42 Pipeline and Hazardous Materials Safety Administration (PHMSA). *Gas Distribution Annual Data*. (2021).
- 43 Average costs were determined using 2021 LPP mileage data supplied by PHMSA, and replacement cost figures submitted in utility rate filings. The differing per-utility costs were then weighted according to their share of remaining LPP miles and service lines. Where there is missing service line replacement cost data, National Fuel's average cost of \$5800 has been used, likely leading to a slight undercounting of costs. The estimated averages are \$3,004,000 for Mains and \$10,508 per service line.
- 44 Casey, C. Will New York Squander Its Opportunity for a Just Transition? *NRDC* <https://www.nrdc.org/experts/christopher-casey/will-new-york-squander-its-opportunity-just-transition> (2023).
- 45 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. Ch. 18 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 46 *Environ. Sci. Technol.* 2022, 56, 4, 2529–2539
- 47 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 176 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 48 Scoping Plan, p. 186–87.
- 49 Scoping Plan, pp. 189–90.
- 50 Scoping Plan, pp. 341–49.
- 51 New York City Climate Mobilization Act, Local Law 97 of 2019.
- 52 New York City Local Law 154 of 2021, adding New York City Admin. Code § 24-177.1.
- 53 Evan Preminger and Adam Stolorow, NYC's Natural Gas Ban Intends to Speed Up Building Electrification, Sive Paget Risel blog, Jan. 14, 2022, <https://sprlaw.com/nycs-natural-gas-ban-intends-to-speed-up-building-electrification/>.
- 54 City of New York (2015), *One City Built to Last*, pp. 24–25.
- 55 New York State Senate Bill S562A (2023-2024 session).
- 56 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 188–190 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 57 Environmental Conservation Law 75-
- 58 Press release: Governor Hochul Unveils Cap-and-Invest Program to Reduce Greenhouse Gas Emissions and Combat Climate Change, Jan. 10, 2023, <https://www.nyserda.ny.gov/About/Newsroom/2023-Announcements/2023-1-10-Governor-Hochul-Unveils-Cap-and-Invest-Program>.
- 59 Climate Law § 2, codified in Environmental Conservation Law § 75-0109(2)(d).
- 60 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 181–182 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 61 New York State Climate Action Council. *New York State Climate Action Council Scoping Plan*. 192–194 [climate.ny.gov/ScopingPlan](https://climate.ny.gov/ScopingPlan) (2022).
- 62 Dandelion Energy. Dandelion Energy Celebrates New Tax Credit for New York Homeowners. <https://www.prnewswire.com/news-releases/dandelion-energy-celebrates-new-tax-credit-for-new-york-home-owners-who-install-geothermal-systems-301525355.html> (2022).
- 63 Order Approving Funding for Clean Heat Program, Case 18-M-0084, Aug. 11, 2022, p. 2 (approving ConEd's request to transfer previously collected and unspent funds to support the acceleration of spending on heat pump installation).
- 64 Petition of Central Hudson Gas & Electric Corp. to Support Clean Heat Market Growth Through Transfer of Unspent and Previously Authorized Funding, Case 18-M-0084, Feb. 2, 2023 (seeking adjustment similar to what Commission granted ConEd in light of unexpectedly high demand for subsidized heat pump installations).
- 65 New York State Climate Action Council, Meeting 25 Presentation, Sept. 29, 2022, p. 15, <https://climate.ny.gov/-/media/project/climate/files/2022-09-29-CAC-Meeting-Presentation.pdf>.
- 66 Congressional Research Service. *The Inflation Reduction Act: Financial Incentives for Residential Energy Efficiency and Electrification Projects*. 2 [https://crsreports.congress.gov/product/pdf/IF/IF12258/2?itid=ik\\_inline\\_enhanced-template](https://crsreports.congress.gov/product/pdf/IF/IF12258/2?itid=ik_inline_enhanced-template) (2022).
- 67 KEDNY—Gas Projections Model—High Electrification, Case 19-G-0309, Jan. 31, 2023
- 68 Davis, L. & Hausman, C. Who Will Pay for Legacy Utility Costs? *SSRN Electronic Journal* (2021) doi:<https://doi.org/10.2139/ssrn.3875122>.
- 69 NARUC. Depreciation Expense: A Primer for Utility Regulators. 10–11 <https://pubs.naruc.org/pub.cfm?id=6ADEB9EF-1866-DAAC-99FB-DBB28B7DF4FB> (2021).
- 70 Individually Filed LDC Annual Reports filed with the PSC. *Depreciation Studies* <https://documents.dps.ny.gov/public/Common/AdvanceSearch.aspx> (2021).
- 71 Individually Filed LDC Annual Reports filed with the PSC. *Depreciation Studies* <https://documents.dps.ny.gov/public/Common/AdvanceSearch.aspx> (2021).
- 72 See *Abrams v. Pub. Serv. Comm'n*, 67 N.Y.2d 205, 217, 492 N.E.2d 1193, 1199 (1986) (“The PSC does have the discretion . . . to permit no more than partial recovery of investment in a subsequently abandoned facility.”).
- 73 Public Service Commission. Gas Planning Order. <https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={2BE-6F1CE-5F37-4A1A-A2C0-C01740962B3C}> (2022).
- 74 KEDNY—Gas Projections Model—High Electrification, Case 19-G-0309, Jan. 31, 2023
- 75 A recent study of 20 households in New York City Housing Authority apartments found that all those who had the chance to switch their gas stove for an induction range wanted to keep the induction range at the end of the study period, even though they could have switched back at no cost. We ACT for Environmental Justice, *Out of Gas, In with Justice: Studying the Impacts of Induction Stoves on Indoor Air Quality in Affordable Housing* (2023), <https://www.weact.org/wp-content/uploads/2023/02/Out-of-Gas-Report-FINAL.pdf>.
- 76 Office of the Governor. Governor Hochul Announces \$672 Million Electric and Gas Utility Bill Relief for New Yorkers | Governor Kathy Hochul. <https://www.governor.ny.gov/news/governor-hochul-announces-672-million-electric-and-gas-utility-bill-relief-new-yorkers#:~:text=January%2019%2C%202023-> (2023).
- 77 Public Service Law s.65(1).
- 78 Climate Law section 2; Environmental Conservation Law section 75-0101(5) defines a “disadvantaged community” as one that includes, among other things, “high-concentrations of low- and moderate- income households.”
- 79 National Fuel. *2022 Climate Report*. <https://www.nationalfuel.com/wp-content/uploads/documents/NFG-2022-Climate-Report-FINAL.pdf> (2022).

- 80 Guidehouse. *National Grid New York Climate Leadership And Community Protection Act Study*. (2022).
- 81 Calvin, K. et al. Bioenergy for climate change mitigation: Scale and sustainability. *GCB Bioenergy* 13, 1346–1371 (2021).
- 82 Xu, S. et al. Delayed use of bioenergy crops might threaten climate and food security. *Nature* 609, 299–306 (2022).
- 83 Strapasson, A. et al. On the global limits of bioenergy and land use for climate change mitigation. *GCB Bioenergy* 9, 1721–1735 (2017).
- 84 Staples, M. D., Malina, R. & Barrett, S. R. H. The limits of bioenergy for mitigating global life-cycle greenhouse gas emissions from fossil fuels. *Nat Energy* 2, 1–8 (2017).
- 85 Daioglou, V., Wicke, B., Faaij, A. P. C. & van Vuuren, D. P. Competing uses of biomass for energy and chemicals: implications for long-term global CO<sub>2</sub> mitigation potential. *GCB Bioenergy* 7, 1321–1334 (2015).
- 86 Newes, E. et al. *Biomass Resource Allocation among Competing End Uses*. NREL/TP-6A20-54217, 1041351 <http://www.osti.gov/servlets/purl/1041351/> (2012) doi:10.2172/1041351.
- 87 de Wit, M., Junginger, M., Lensink, S., Londo, M. & Faaij, A. Competition between biofuels: Modeling technological learning and cost reductions over time. *Biomass and Bioenergy* 34, 203–217 (2010).
- 88 Gerssen-Gondelach, S. J., Saygin, D., Wicke, B., Patel, M. K. & Faaij, A. P. C. Competing uses of biomass: Assessment and comparison of the performance of bio-based heat, power, fuels and materials. *Renewable and Sustainable Energy Reviews* 40, 964–998 (2014).
- 89 Grubert, E. At scale, renewable natural gas systems could be climate intensive: the influence of methane feedstock and leakage rates. *Environ. Res. Lett.* 15, 084041 (2020).
- 90 Alexander W. Bartik et al., “The Local Economic and Welfare Consequences of Hydraulic Fracturing,” *American Economic Journal: Applied Economics* 11, no. 4 (October 2019): 105–55, <https://doi.org/10.1257/app.20170487>.
- 91 Anna (Any) Phelan and Sander Jacobs, “Facing the True Cost of Fracking: Social Externalities and the Role of Integrated Valuation,” *Ecosystem Services*, Integrated valuation of ecosystem services: challenges and solutions, 22 (December 1, 2016): 348–58, <https://doi.org/10.1016/j.ecoser.2016.11.006>.
- 92 Benjamin K. Sovacool, “Cornucopia or Curse? Reviewing the Costs and Benefits of Shale Gas Hydraulic Fracturing (Fracking),” *Renewable and Sustainable Energy Reviews* 37 (September 2014): 249–64, <https://doi.org/10.1016/j.rser.2014.04.068>.
- 93 Short-Term Energy Outlook—U.S. Energy Information Administration (EIA). <https://www.eia.gov/outlooks/steo/report/natgas.php>.
- 94 U.S. Energy Information Administration (EIA). Opendata. [www.eia.gov](http://www.eia.gov) <https://www.eia.gov/opendata/index.php> (2023).
- 95 “Blended RNG Adder Calculator,” VGS, accessed November 28, 2022, <https://vgsvt.com/climate/renewable-natural-gas/calculator-blended/>
- 96 ICF, “Potential of Renewable Natural Gas in New York State” (NYSER-DA, April 1, 2022).
- 97 Rosenow, J. Is heating homes with hydrogen all but a pipe dream? An evidence review. *Joule* (2022) doi:<https://doi.org/10.1016/j.joule.2022.08.015>.
- 98 Mills, R. Green Hydrogen on an S-curve: Fast, Beneficial, and Inevitable. *RMI* <https://rmi.org/green-hydrogen-fast-beneficial-and-inevitable/> (2022).
- 99 Net-Zero America, “Net-Zero America,” Net-Zero America, accessed August 31, 2022, <https://netzeroamerica.princeton.edu/>.
- 100 Mills, R. Green Hydrogen on an S-curve: Fast, Beneficial, and Inevitable. *RMI* <https://rmi.org/green-hydrogen-fast-beneficial-and-inevitable/> (2022).
- 101 Guidehouse. *National Grid New York Climate Leadership And Community Protection Act Study*. (2022).
- 102 Topolski, K. et al. *Hydrogen Blending into Natural Gas Pipeline Infrastructure: Review of the State of Technology*. NREL/TP-5400-81704, 1893355, <https://www.osti.gov/servlets/purl/1893355/> (2022) doi:10.2172/1893355.
- 103 Pathways to Carbon-Neutral NYC. <https://www.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf> (2021).
- 104 American Gas Association. Net-Zero Emissions Opportunities for Gas Utilities. <https://www.aga.org/globalassets/research--insights/reports/aga-net-zero-emissions-opportunities-for-gas-utilities.pdf>.
- 105 Atmospheric implications of increased hydrogen use. *GOV.UK* <https://www.gov.uk/government/publications/atmospheric-implications-of-increased-hydrogen-use>.
- 106 Rosenow, J. Is heating homes with hydrogen all but a pipe dream? An evidence review. *Joule* (2022) doi:<https://doi.org/10.1016/j.joule.2022.08.015>.
- 107 ICF. *Potential of Renewable Natural Gas in New York State*. (2022).
- 108 ICF. *Potential of Renewable Natural Gas in New York State*. (2022).
- 109 GREET Models. <https://greet.es.anl.gov/greet.models>.
- 110 EIA New York State Energy Profile. <https://www.eia.gov/state/?sid=NY>
- 111 US EPA. Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM). *US EPA* <https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model> (2016).
- 112 ICF. *Potential of Renewable Natural Gas in New York State*. (2022).
- 113 Huq, N. A. et al. Toward net-zero sustainable aviation fuel with wet waste-derived volatile fatty acids. *Proceedings of the National Academy of Sciences* 118, e2023008118 (2021).
- 114 Jones, R. et al. *Massachusetts 2050 Decarbonization Roadmap: Energy Pathways to Deep Decarbonization*. <https://www.mass.gov/doc/energy-pathways-for-deep-decarbonization-report/download> (2020).
- 115 Moriarty, K., Milbrandt, A. & Tao, L. *Port Authority of New York and New Jersey Sustainable Aviation Fuel Logistics and Production Study*. NREL/TP-5400-80716, 1827314, MainId:77500 <https://www.osti.gov/servlets/purl/1827314/> (2021) doi:10.2172/1827314.
- 116 Anelia R. Milbrandt, Donna M. Heimiller, and Paul D. Schwabe, “Techno-Economic Renewable Energy Potential on Tribal Lands,” July 3, 2018, <https://doi.org/10.2172/1459502>.
- 117 Baldwin, C. Y. & Clark, K. B. *Design Rules: The Power of Modularity*. (2000). doi:10.7551/mitpress/2366.001.0001.
- 118 Technological Learning in the Energy Sector: Lessons for Policy, Industry and Science. *Technological Learning in the Energy Sector* (Edward Elgar Publishing, 2010).
- 119 International Energy Agency. *Experience Curves for Energy Technology Policy*. (OECD, 2000). doi:10.1787/9789264182165-en.
- 120 Goss, A., Thesis, T. & Rials, T. 2016 Billion-Ton Report | Department of Energy. <http://energy.gov/eere/bioenergy/2016-billion-ton-report> (2016).
- 121 Topolski, K. et al. *Hydrogen Blending into Natural Gas Pipeline Infrastructure: Review of the State of Technology*. NREL/TP-5400-81704, 1893355, MainId:82477 <https://www.osti.gov/servlets/purl/1893355/> (2022) doi:10.2172/1893355.
- 122 AR6 Climate Change 2022: Mitigation of Climate Change—IPCC. <https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/>.



- 123 Liang, Y. A Critical Review of Challenges Faced by Converting Food Waste to Bioenergy Through Anaerobic Digestion and Hydrothermal Liquefaction. *Waste and Biomass Valorization* 13, 781–796 (2022).
- 124 Hahn, H., Krautkremer, B., Hartmann, K. & Wachendorf, M. Review of concepts for a demand-driven biogas supply for flexible power generation. *Renewable and Sustainable Energy Reviews* 29, 383–393 (2014).
- 125 This allows for flexible heat and electricity generation that can be responsive to site needs and energy market conditions.
- 126 US EPA, O. LMOP Landfill and Project Database. <https://www.epa.gov/lmop/lmop-landfill-and-project-database> (2016).
- 127 Livestock Anaerobic Digester Database | US EPA. <https://www.epa.gov/agstar/livestock-anaerobic-digester-database>.
- 128 One innovative carbon removal startup is putting ‘oil’ back underground. | Grist. <https://grist.org/climate-energy/lucky-charm/>.
- 129 Strapasson, A. *et al.* On the global limits of bioenergy and land use for climate change mitigation. *GCB Bioenergy* 9, 1721–1735 (2017).
- 130 Sánchez, A. *et al.* Greenhouse Gas from Organic Waste Composting: Emissions and Measurement. in *CO2 Sequestration, Biofuels and Depollution* (eds. Lichtfouse, E., Schwarzbauer, J. & Robert, D.) 33–70 (Springer International Publishing, 2015). doi:10.1007/978-3-319-11906-9\_2.
- 131 IPCC. *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. (2019).
- 132 Liang, Y. A Critical Review of Challenges Faced by Converting Food Waste to Bioenergy Through Anaerobic Digestion and Hydrothermal Liquefaction. *Waste and Biomass Valorization* 13, 781–796 (2022).
- 133 Bakkaloglu, S., Cooper, J. & Hawkes, A. Methane emissions along biomethane and biogas supply chains are underestimated. *One Earth* 5, 724–736 (2022).
- 134 What is Renewable Natural Gas? | SoCalGas. <https://www.socalgas.com/sustainability/renewable-gas/what-is-renewable-natural-gas>.
- 135 LCFS Pathway Certified Carbon Intensities | California Air Resources Board. <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>.
- 136 Jeremy Martin. *Comment to CARB on LCFS: Manure biomethane analysis*. (2022).
- 137 Association of Irrigated Residents, Leadership Counsel for Justice & Accountability, Food & Water Watch & Animal Legal Defense Fund. Petition for Rulemaking to Exclude All Fuels Derived from Biomethane from Dairy and Swine Manure from the Low Carbon Fuel Standard Program.
- 138 IPCC. *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. (2019).
- 139 Younes, A. & Fingerman, K. *Quantification of Dairy Farm Subsidies Under California’s Low Carbon Fuel Standard: Version 1.2*. (2021).
- 140 American Gas Association. Net-Zero Emissions Opportunities for Gas Utilities. <https://www.aga.org/globalassets/research--insights/reports/aga-net-zero-emissions-opportunities-for-gas-utilities.pdf>.
- 141 As gas companies plan for a climate future, their vision: more gas—The Boston Globe. <https://www.bostonglobe.com/2022/06/16/science/gas-companies-plan-climate-future-their-vision-more-gas/>.
- 142 Dec 9, S. C. & commentsShare, 202220. Long-delayed project to convert compost, waste into gas for NYC homes slated to launch in January. *Gothamist* <https://gothamist.com/news/long-delayed-project-to-convert-compost-waste-into-gas-for-nyc-homes-slated-to-launch-in-january> (2022).
- 143 New York’s Newtown Creek Wastewater Treatment Plant Revs up Anaerobic Co-Digestion Project. *Waste360* <https://www.waste360.com/wastewater/new-yorks-newtown-creek-wastewater-treatment-plant-revs-anaerobic-co-digestion-project> (2022).
- 144 Renewable Natural Gas Database | Argonne National Laboratory. <https://www.anl.gov/esia/reference/renewable-natural-gas-database>.
- 145 US EPA, O. RIN Trades and Price Information. <https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information> (2018).
- 146 Smith, A. The Dairy Cow Manure Goldrush. *Aaron Smith* <https://asmith.ucdavis.edu/news/visiting-value-dairy-cow-manure> (2022).
- 147 Initial Brief of the office of the Attorney General. (2022)
- 148 Tyler J. Lark *et al.*, “Environmental Outcomes of the US Renewable Fuel Standard,” *Proceedings of the National Academy of Sciences* 119, no. 9 (March 2022): e2101084119, <https://doi.org/10.1073/pnas.2101084119>.
- 149 LCFS Data Dashboard | California Air Resources Board. <https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard>.
- 150 US EPA, O. Proposed Renewable Fuel Standards for 2023, 2024, and 2025. <https://www.epa.gov/renewable-fuel-standard-program/proposed-renewable-fuel-standards-2023-2024-and-2025> (2022).
- 151 How the EPA’s Renewable Fuel Standard program changes could be a boon for landfill and AD operators. *Waste Dive* <https://www.wastedive.com/news/epa-rfs-rin-biogas-rng-ev-wm-republic-anaergia/641997/>.
- 152 ICF. *Potential of Renewable Natural Gas in New York State*. (2022).
- 153 US EPA, O. Landfill Gas Energy Project Development Handbook. <https://www.epa.gov/lmop/landfill-gas-energy-project-development-handbook> (2016).
- 154 Hahn, H., Krautkremer, B., Hartmann, K. & Wachendorf, M. Review of concepts for a demand-driven biogas supply for flexible power generation. *Renewable and Sustainable Energy Reviews* 29, 383–393 (2014).
- 155 Hahn, H., Hartmann, K., Bühle, L. & Wachendorf, M. Comparative life cycle assessment of biogas plant configurations for a demand oriented biogas supply for flexible power generation. *Bioresource Technology* 179, 348–358 (2015).
- 156 Kassem, N. *et al.* Developing Decision-Making Tools for Food Waste Management via Spatially Explicit Integration of Experimental Hydrothermal Carbonization Data and Computational Models Using New York as a Case Study. *ACS Sustainable Chem. Eng.* 10, 16578–16587 (2022).
- 157 Liang, Y. A Critical Review of Challenges Faced by Converting Food Waste to Bioenergy Through Anaerobic Digestion and Hydrothermal Liquefaction. *Waste and Biomass Valorization* 13, 781–796 (2022).
- 158 Seiple, T. E., Skaggs, R. L., Fillmore, L. & Coleman, A. M. Municipal wastewater sludge as a renewable, cost-effective feedstock for transportation biofuels using hydrothermal liquefaction. *Journal of Environmental Management* 270, 110852 (2020).
- 159 Huq, N. A. *et al.* Toward net-zero sustainable aviation fuel with wet waste-derived volatile fatty acids. *Proceedings of the National Academy of Sciences* 118, e2023008118 (2021)
- 160 One innovative carbon removal startup is putting ‘oil’ back underground. | Grist. <https://grist.org/climate-energy/lucky-charm/>.
- 161 National Fuels. 2022 Climate Report. <https://www.nationalfuel.com/wp-content/uploads/documents/NFG-2022-Climate-Report-FINAL.pdf> (2022).
- 162 American Gas Association. Net-Zero Emissions Opportunities for Gas Utilities. <https://www.aga.org/globalassets/research--insights/reports/aga-net-zero-emissions-opportunities-for-gas-utilities.pdf>.
- 163 Appliance Standards Rulemakings and Notices. [https://www1.eere.energy.gov/buildings/appliance\\_standards/standards.aspx?productid=59&action=viewlive](https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=59&action=viewlive).

- 164 USDA—National Agricultural Statistics Service—2017 Census of Agriculture—Volume 1, Chapter 1: State Level Data. [https://www.nass.usda.gov/Publications/AgCensus/2017/Full\\_Report/Volume\\_1,\\_Chapter\\_1\\_State\\_Level/New\\_York/](https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/New_York/).
- 165 Wilcox, J., Hammer, H. & Patane, N. Integration Analysis Technical Supplement.
- 166 Kate Bradshaw, Menlo Park council takes steps toward 2030 climate goals, *The Almanac*, Apr. 8, 2021, <https://almanacnews.com/news/2021/04/08/menlo-park-council-takes-steps-toward-2030-climate-goals>.
- 167 Tanner Harding, Ithaca becomes first city in U.S. to try and electrify all buildings, *Ithaca.com*, Nov. 9, 2021, [https://www.ithaca.com/news/ithaca/ithaca-becomes-first-city-in-u-s-to-try-and-electrify-all-buildings/article\\_03c6e998-41bb-11ec-9a84-47a7c90ee120.html](https://www.ithaca.com/news/ithaca/ithaca-becomes-first-city-in-u-s-to-try-and-electrify-all-buildings/article_03c6e998-41bb-11ec-9a84-47a7c90ee120.html).
- 168 Guidehouse. *National Grid New York Climate Leadership And Community Protection Act Study*. (2022).
- 169 Pathways to Carbon-Neutral NYC. <https://www.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf> (2021).
- 170 National Fuels. 2022 Climate Report. <https://www.nationalfuel.com/wp-content/uploads/documents/NFG-2022-Climate-Report-FINAL.pdf> (2022).
- 171 American Gas Association. Net-Zero Emissions Opportunities for Gas Utilities. <https://www.aga.org/globalassets/research--insights/reports/aga-net-zero-emissions-opportunities-for-gas-utilities.pdf>.
- 172 Cooper, N. (EEA). Appendices to the Massachusetts Clean Energy and Climate Plan for 2025 and 2030.
- 173 Bilich, A., Colvin, M. & O'Connor, T. Managing the Transition: Proactive Solutions for Stranded Gas Asset Risk in California. *Industrial and Commercial Training* 35, 241–246 (2019).
- 174 Anna Brockway, Duncan Callaway, & Salma Elmallah. *Can Distribution Grid Infrastructure Accommodate Residential Electrification and Electric Vehicle Adoption in Northern California?* *Energy Institute WP 327* (2022).
- 175 Gridworks, “Gas Planning and Reliability in California: A Proposed Approach to Long-Term Gas Planning” 2021
- 176 Bilich, A. *et al.* Managing the Transition Proactive Solutions for Stranded Gas Asset Risk in California.
- 177 NYSERDA, “Resource Efficient Electrification,” <https://www.nyserdanyc.gov/-/media/Project/Nyserda/Files/Programs/Empire-Building-Challenge/EBC-approach.pdf>.
- 178 NYSERDA, “Resource Efficient Electrification,” <https://www.nyserdanyc.gov/-/media/Project/Nyserda/Files/Programs/Empire-Building-Challenge/EBC-approach.pdf>.
- 179 Walsh, M. *Local Energy Asset Planning*. (2022). <https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/15634293>
- 180 RMI, “Prefabricated Zero Energy Retrofit Technologies: A Market Assessment,” (2020) <https://rmi.org/wp-content/uploads/2020/04/prefabricated-zero-energy-retrofit-technologies.pdf>.
- 181 Robert Baldwin, Mark Nimlos, and Yimin Zhang, “Techno-Economic, Feasibility, and Life Cycle Analysis of Renewable Propane: Final Report,” October 3, 2022, <https://doi.org/10.2172/1891468>.
- 182 Opendata—U.S. Energy Information Administration (EIA). <https://www.eia.gov/odata/index.php>.
- 183 Residential Energy Consumption Survey (RECS)—Energy Information Administration. <https://www.eia.gov/consumption/residential/>.
- 184 Jones, R. *et al.* *Massachusetts 2050 Decarbonization Roadmap: Energy Pathways to Deep Decarbonization*. <https://www.mass.gov/doc/energy-pathways-for-deep-decarbonization-report/download> (2020).
- 185 Energy Environmental Economics (E3). *The Role of Gas Distribution Companies in Achieving the Commonwealth’s Climate Goals Independent Consultant Report*. (2022).
- 186 Walsh, M. J. How the gas system can adapt to net zero future. *CommonWealth Magazine* <https://commonwealthmagazine.org/opinion/how-the-gas-system-can-adapt-to-net-zero-future/> (2022).
- 187 source/line in one or each report needed
- 188 See the contemporary MA 2050 Roadmap Pathways 32 and New England Net Zero Energy Future86 studies which exhibited notably different levels of firm resource needs. Reasons for the differences included representation of interstate transmission, use of different weather year, and different cost assumptions.
- 189 The Role of Gas Distribution Companies in Achieving the Commonwealth’s Climate Goals Independent Consultant Report. [www.ethree.com](http://www.ethree.com) (2022).
- 190 ICF. *Potential of Renewable Natural Gas in New York State*. (2022).
- 191 Renewable Sources of Natural Gas. *American Gas Foundation* <https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/> (2019).
- 192 America, N.-Z. Net-Zero America. *Net-Zero America* <https://netzeroamerica.princeton.edu/>
- 193 Goss, A., Thesis, T. & Riels, T. 2016 Billion-Ton Report | Department of Energy. *energy.gov* 1 <http://energy.gov/eere/bioenergy/2016-billion-ton-report> (2016).
- 194 US EPA, O. LMOP Landfill and Project Database. <https://www.epa.gov/lmop/lmop-landfill-and-project-database> (2016).
- 195 ICF, “Potential of Renewable Natural Gas in New York State” (NYSERDA, April 1, 2022). <https://www.nyserdanyc.gov/-/media/Project/Nyserda/Files/EDPPP/Energy-Prices/Energy-Statistics/RNGPotentialStudyforCAC10421.pdf>
- 196 EIA New York State Energy Profile. <https://www.eia.gov/state/?sid=NY>.
- 197 America, N.-Z. Net-Zero America. *Net-Zero America* <https://netzeroamerica.princeton.edu/>.
- 198 Cooper, N. (EEA). Appendices to the Massachusetts Clean Energy and Climate Plan for 2025 and 2030. 173.
- 199 Adopted Part 496, Statewide Greenhouse Gas Emission Limits—NYS Dept. of Environmental Conservation. <https://www.dec.ny.gov/regulations/121052.html>.
- 200 Fossil and Biogenic Fuel Greenhouse Gas Emission Factors. <https://www.nyserdanyc.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-23-Fossil-and-Biogenic-Fuel-Greenhouse-Gas-Emission-Factors.pdf> (2022)
- 201 Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review”: EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.
- 202 Cuomo, A. M. & Seggos, B. Establishing a Value of Carbon.
- 203 America, N.-Z. Net-Zero America. *Net-Zero America* <https://netzeroamerica.princeton.edu/>.
- 204 Wilcox, J., Hammer, H. & Patane, N. Integration Analysis Technical Supplement.
- 205 Wilcox, J., Hammer, H. & Patane, N. Integration Analysis Technical Supplement.





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