ANALYZING THE GAS SYSTEM: A FRAMEWORK TO REDUCE CONSUMER COSTS AND RISKS

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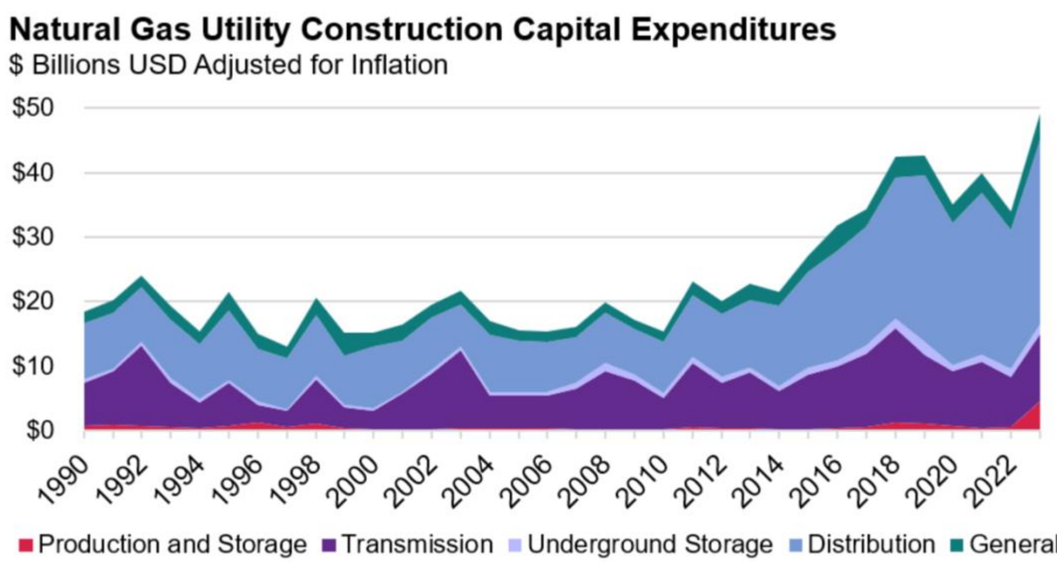
EXECUTIVE SUMMARY

Every month, hundreds of millions of American households and businesses allocate a percentage of their income to utility companies—to keep their lights on, their machines humming, and their water hot. Across the residential, commercial, and industrial sectors, nearly 164 million electricity consumers[1] and nearly 72 million fossil gas (aka natural gas) consumers pay energy bills.[i,2] These two large energy systems—separate but intertwined—have a disproportionate impact on the approximately 43 percent[ii] of customers paying for both electric and gas service.

In most states, electric utilities and gas distribution utilities are simultaneously pursuing massive infrastructure investments. Total spending by investor-owned electric utilities is projected to reach $207.9 billion in 2025 (up from $139.8 billion in 2020—a nearly 50 percent increase), with more than $1.1 trillion planned through 2030.[3] Gas utility construction-related expenditures increased from $32.7 billion in 2022 to $49.1 billion in 2023[4] (see Figure ES-1), and gas utilities may spend more than $1.4 trillion by 2050[5] to replace existing distribution pipelines, expand their systems, and make other capital investments.

Figure ES-1. Graph from the American Gas Association showing U.S. natural gas utility capital expenditures over time (1990 – 2023).[6]



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[i] This total includes only customers served by local distribution companies, not those designated as transport customers.
[ii] This number assumes the nearly 72 million gas utility customers served by local distribution companies are also served by electric utilities. In some cases, the same utility may provide electricity and gas to a single customer.

Unfortunately, as a result, America's households and businesses already feeling the pinch from higher energy bills face exacerbated affordability challenges. Center for American Progress analysis estimates at least 210 U.S. gas and electric utilities have either already raised rates or proposed higher rates to go into effect within the next two years, which will increase consumers' electricity and gas bills by $71.2 billion and $18.7 billion, respectively, by 2028.[7]

It's no wonder an increasing number of homes, businesses, and communities are asking what can be done to counter this troubling trend. These large-scale infrastructure investments take time to plan, approve, and build. In the context of policy, technology, and economic shifts, proper oversight is necessary to avoid expensive long-lived assets that may be redundant or irrelevant in a not-too-distant future.

Decision-makers overseeing gas and electric utilities[iii] are responsible for determining the fiscal prudence of proposed utility infrastructure investments, while also directing utilities to pursue solutions and innovations that contain costs and minimize risks to consumers.

Many states and utilities have implemented an array of electric utility solutions to support affordability goals and minimize consumer risks—such as integrated resource planning, distribution system planning, demand response and energy efficiency measures, flexible grid solutions, grid enhancing technologies, performance-based ratemaking, and other regulatory reforms.[8] In addition, deploying electrification technologies like electric vehicles and heat pumps has untapped potential to support the more efficient utilization of the electric grid and could put downward pressure on electric rates over time. While more can be done to ensure affordable electric rates going forward, we have a full toolbox of proven approaches to use.

Gas utility solutions, however, are more nascent and uncharted. In addition, the long-standing presumption of ever-expanding dual energy systems is only now being called into question.

But evaluating a gas utility's system is not a straightforward exercise. First, not only is most gas infrastructure invisible to the eye—distribution pipelines are buried up to three feet below the surface, often under roads and sidewalks—but not all gas utilities are required to submit detailed information about their systems.[9] Second, pipeline safety and compliance staff may not interface with those evaluating system economics and customer impacts. And third, decision-makers may lack the technical background to comprehensively evaluate the merits of gas utility proposals.

Evaluating gas system investments requires new approaches, relevant technical information, and updated frameworks. A gas system analysis (GSA) is an integral tool that can provide regulators, municipal gas utility boards, and non-utility stakeholders

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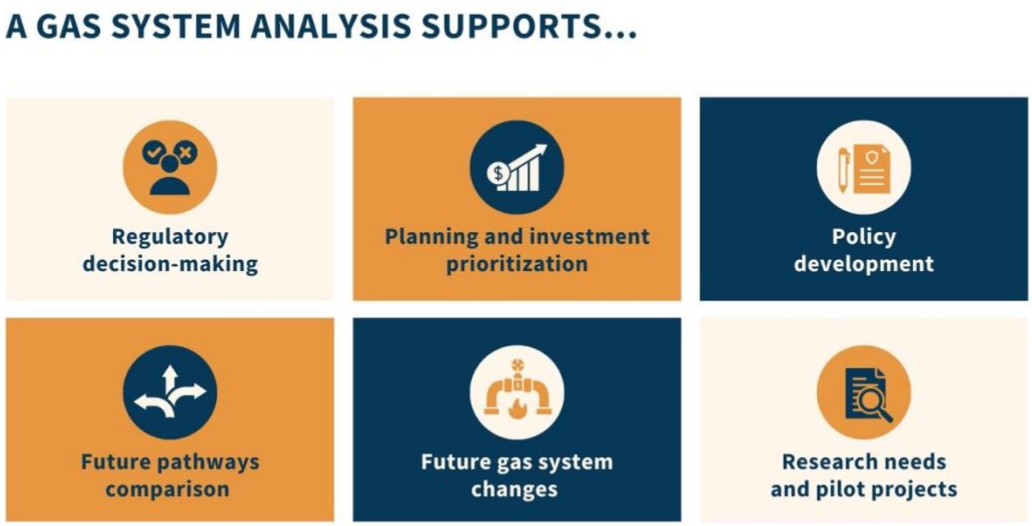
[iii] Appointed or elected utility commissioners oversee and regulate investor-owned natural gas utilities, whereas municipal governments oversee publicly owned natural gas local distribution companies.

with foundational information about gas utility distribution, transmission, and storage systems to help make more informed decisions.

A GSA can be part of gas utility planning proceedings or joint gas-electric utility coordination efforts. It can also be a foundational element to more comprehensive dockets on the future of gas or clean heat, or function as a stand-alone evaluation. A GSA can support numerous objectives, including:

- Providing timely and transparent information about the current state of a gas system and helping utility regulators and stakeholders compare alternative futures side by side, reflecting costs and benefits to consumers and society
- Informing planning and investment priorities
- Catalyzing future gas system changes
- Informing development of legislative or regulatory solutions, new programs, pilot projects, and research needs to achieve state and local policy goals.



Energy Innovation and Collaborative Climate LLC offer this framework to assist gas utility regulators and decision-makers tasked with maintaining energy affordability and evaluating gas utility investments—whether they are commissioning a GSA for the first time and establishing the scope of work, refining existing gas planning efforts or relevant proceedings, or making recommendations to achieve policy objectives.

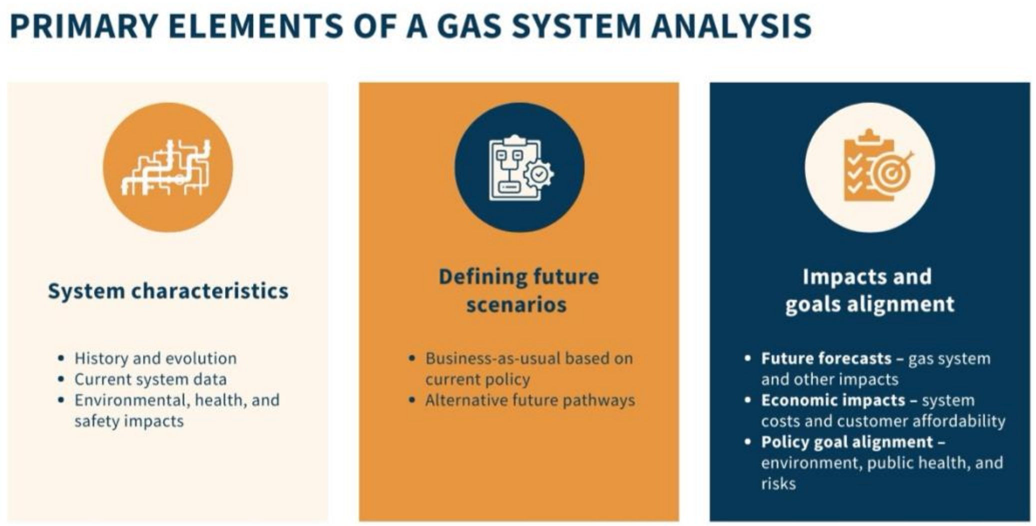
The primary elements that should be included in a GSA are:

- **System characteristics and attributes:** This section should provide historical and current data on the gas utility system, including details on existing infrastructure, investment metrics, ratepayer profiles, regulatory and market dynamics, GHG emissions, social and environmental impacts, and other relevant attributes to provide a holistic snapshot of the current gas system.

- **Future scenarios, including business-as-usual and alternative pathways:** A GSA should clearly define an array of possible future scenarios, including the underlying assumptions for each scenario, using non-proprietary data. A starting point should be the business-as-usual (BAU), or reference case, based on current policy. From there, the GSA should define additional alternative pathways that offer various future scenarios for the gas system, optimizing for different variables and accounting for relevant policy and market drivers. For example, future scenarios could reflect high-electrification outcomes, ramped demand-side efficiency program solutions, or deployment of other non-pipeline alternatives (NPAs) such as thermal energy networks, as well as other solutions for infrastructure repurposing or decommissioning. Scenarios should also define environmental and social metrics, such as future system-wide GHG emissions, public health impacts from indoor and outdoor air pollution attributable to gas combustion, and risks to the utility, shareholders, and ratepayers.

- **System and impact forecasts based on future scenarios:** Using the defined future scenarios, a GSA should then provide a comprehensive forecast of future natural gas use (both average and peak demands) under each scenario along with the relative impact of alternative technologies such as electrification and other NPAs. The analysis should model the full suite of options to meet energy demand, outline different infrastructure requirements, and detail accompanying costs to ratepayers over defined time horizons, often five to 20 years. Forecasts for all scenarios should reflect varying assumptions for customer growth, energy efficiency, gas markets and pricing, climate and weather trends, policy and regulatory developments, technological advancements, and other relevant goals. More comprehensive analyses may go one step further to include forecasts for revenue requirements, which can then inform customer class bill impacts (though in some places this economic analysis may be reserved for a gas utility rate case). [iv]

[iv] We provide illustrative examples of the GSA components listed above from a sample of existing state and utility analyses, which are featured in Appendix A and summarized in Appendix B. We also provide additional resources, reports, and analyses in Appendix C. Our reference of other reports and case studies is not necessarily an endorsement of their findings or methodological approaches; we provide them as illustrative examples.



Energy regulators charged with maintaining affordability can use the findings from a GSA in other relevant regulatory proceedings or new investigations to explore possible future gas system changes. Potential regulatory actions may include:

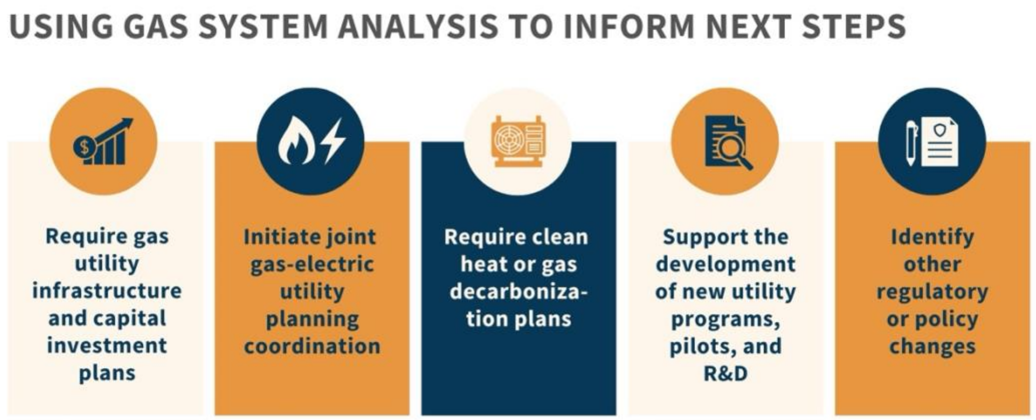
Requiring (or updating) gas utility infrastructure and capital investment plans, filed regularly to help regulators make informed decisions about the prudent use of ratepayer dollars as well as manage changes to the gas system in an equitable manner.

Initiating joint gas-electric utility planning coordination to reveal redundancies in gas and electric infrastructure plans, reduce consumer costs and risks.

Requiring clean heat or gas decarbonization plans to inform the transition of the natural gas system toward a low- or zero-carbon future and align the gas utility with relevant state or local climate goals. These plans could also reveal opportunities for non-gas and non-pipeline investments, as well as other strategies to reduce gas demand.

Supporting the development of new utility programs, pilots, and R&D on technology feasibility, customer uptake, and system impacts. Regulators should prioritize no- to low-regret actions in the near term that provide clear benefits to customers or the system.

Identify other regulatory or policy changes, such as revisions to gas pipeline extension policies, amortization or depreciation reforms, updates pipeline replacement programs, or other legislation to overcome barriers.



WHAT IS A GAS SYSTEM ANALYSIS?

Beneath our feet, 2.8 million miles of local utility distribution and transmission pipelines[10,v]—enough to encircle the Earth more than 110 times—deliver fossil gas to more than 72 million residential, commercial, and industrial customers across the U.S. Gas utilities in nearly every state have spent or are planning to spend billions to both replace existing pipes and build new pipelines,[11] forcing nearly 60 percent of gas utility customers to pay an additional $18.7 billion by 2028 (assuming these investments are approved).[12] If this trend continues, cumulative gas utility spending could total $1.4 trillion by 2050.[13]

Not only are gas customers paying more than ever for energy bills today, but they will also be paying for long-life gas infrastructure assets for decades to come, and all while the gas utility companies earn a return on their investments.

The combination of costly infrastructure and gas price volatility is prompting decision-makers tasked with overseeing gas utility spending to ask what can be done to protect households and businesses from ever-increasing costs, driven largely by utility spending.

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[v] According to the American Gas Association, there are 2.4 million miles of local utility distribution pipelines and 400,000 miles of transmission pipelines.

A growing number of households and businesses are taking steps to insulate themselves from price shocks and gas volatility by choosing all-electric technologies like highly efficient heat pumps for water heating and space heating-plus-cooling, along with cleaner cooking options like induction stoves instead of gas-burning appliances.

In 2024, Americans bought 32 percent more air-source heat pumps than gas furnaces, continuing a year-over-year trend.[14] Residential electric storage water heaters and heat pump water heaters have outsold gas counterparts for three years running, with 11 percent growth between 2022 and 2024.[15] Commercial and industrial customers are investing in state-of-the-art industrial heat pumps and boilers, uncovering huge untapped potential for all-electric technologies in these sectors.[16] And more than a dozen states and hundreds of local governments have leveraged stronger building codes, electrification incentives, and policies to cut economy-wide emissions of greenhouse gases (GHGs) and other air pollutants from burning gas.

Across the U.S., more than 1,000 gas distribution utilities build and maintain gas infrastructure.[vi] Approximately 80 percent of them are governed by municipal governments, and the remaining 20 percent are investor-owned utilities subject to regulatory oversight by appointed or elected state utility regulatory commissions.[17]

To date, over a dozen state utility regulatory commissions (California, Colorado, Illinois, Maine, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New York, Oregon, Rhode Island, Washington, and the District of Columbia) have initiated regulatory proceedings to align gas utility regulation with relevant state GHG emissions goals,

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[vi] Approximately 1,136 gas distribution utilities.

electrification policies, customer affordability objectives, or clean heat standard legislation.[18] Their approaches and frameworks vary, though common features of these efforts include identifying impacts on utility investments, operations, rates, financial health, and the workforce; evaluating customer affordability and equity impact; identifying potential changes to utility business models; and exploring decarbonization pathways or plans. Other states (e.g., Georgia, Idaho, Michigan, Missouri, New Mexico, and Utah) require their regulated utilities to file integrated resource plans (IRPs) or similar gas plans.[vii]

No matter which approach states take, they should ideally all be useful and informative for regulators and decision-makers tasked with determining whether investments are necessary and in the public interest. The information, data, analysis, and ensuing reports or filed plans should reflect clear regulatory guidance, incorporate non-utility stakeholder input, and rely on transparent and accessible assumptions, data, and models.

The GSA can inform utility regulators, governing bodies, and other stakeholders as they assess the prudence of billion-dollar gas infrastructure proposals.

As outlined in this paper, a GSA consists of detailed data and inputs that provide information about existing gas utility system components, along with future scenarios and pathways for gas system investment. A GSA can provide a useful starting point for decision-makers wanting to better understand the current gas utility system and evaluate how it should evolve going forward. Where existing related efforts are underway, this framework may help identify areas for refinement or improvement. A GSA can also serve as a foundational resource to guide regulatory actions, future research, gas transition plans, compliance filings, and program design.

Motivations for a gas system analysis

Gas utility regulators or governing bodies may have different motivations to direct a utility or third party to conduct a GSA—whether as a stand-alone analysis, one undertaken to inform gas system planning or gas-electric joint planning, or as part of a dedicated future-of-gas or clean-heat proceeding. A GSA may also be helpful for those entities not ready or authorized to require more comprehensive gas planning or for those seeking an initial scoping analysis to gather information as a first step.

Ideally, a GSA should help inform new or ongoing regulatory processes and allow for future updates as market and policy conditions evolve. A GSA could also provide a natural nexus to inform joint gas-electricity system planning and objectives. GSA motivations will vary by state and local context, but may include:

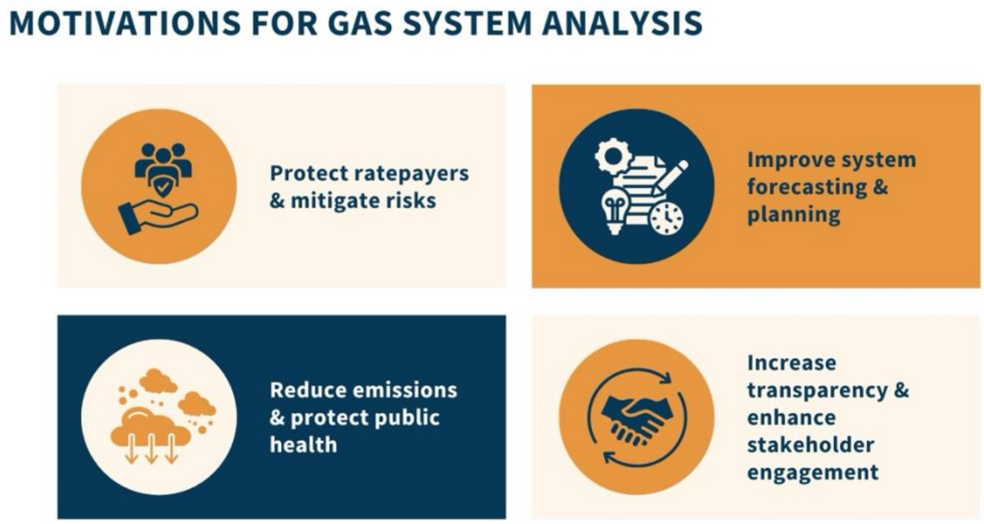
[vii] For example, Atlanta Gas Light files an integrated capacity development plan in Georgia, Intermountain Gas Company files an IRP in Idaho, Consumers Energy and DTE file Gas Delivery Plans in Michigan, Spire files an IRP in Missouri, New Mexico Gas Company files an IRP in New Mexico, and Enbridge files an IRP in Utah.

Protecting ratepayers, mitigating risks, and ensuring "used and useful" investments: A GSA can help articulate the costs and risks associated with different gas utility infrastructure investment choices (perhaps informing least-cost investments), allowing a side-by-side comparison of various future scenarios to inform decision-making. Decision-makers can use a GSA to evaluate how proposed infrastructure investments will impact energy rates for all customer classes and ideally avoid investments in costly long-life assets that may quickly become stranded. In addition to protecting all ratepayers from economic harm, a GSA can help inform strategies to mitigate future risks.

Evaluating the impact of technology uptake on gas and electric load forecasts and supporting forward-looking systems planning: A GSA can reveal the impact of policies, programs, and technologies on forecasted customer demand for gas. This in turn enhances transparency for stakeholders (serving as a repository of information for public benefit) and can inform more accurate system planning scenarios and investment priorities. A GSA can help regulators better determine where a gas utility may need to make near-term investments in existing or new pipelines and where non-pipeline alternatives, such as electrification, are preferable to support long-term policy goals.

Reducing gas system emissions and pollutants to achieve environmental and health policies: Tackling fossil fuel combustion in buildings and industry is a top priority for governments with policy goals and plans to reduce emissions. A GSA can quantify the current emissions impact from gas utilities, which can then be compared against gas decarbonization pathways. A GSA can inform development of a more comprehensive gas transition plan and identify additional legislative or regulatory actions necessary to reduce emissions inherent in gas utility infrastructure. State air regulators may also find value in a GSA for determining how gas system pollution impacts airsheds and public health.

Improving transparency, aiding oversight, and enhancing stakeholder engagement: Regulators should also ensure the process underpinning development of a GSA allows for transparency and equitable information sharing among non-utility participants. Regulators should allow ample opportunity to solicit and incorporate review and feedback from non-utility stakeholders—a transparent and public process is necessary for instilling trust and buy-in. This could combine approaches, such as posting information about the analysis online in multiple languages, offering opportunities for public input through written comments, and hosting virtual and in-person sessions, including meetings after business hours to allow community members to be involved. Ensuring sufficient input from all stakeholders impacted by gas utility system build-out will support greater buy-in for future system changes, needed investments, and identified alternative future pathways.



It is important to note the entity tasked with developing a GSA and is responsible for conducting any relevant analysis or report—such as a third-party consultant, a nonprofit organization, or even a gas utility—may have inherent biases toward a particular outcome, which may skew the analysis and outcomes. Gas utility regulators and governing bodies overseeing a GSA should be mindful of this and take steps to ensure the efforts support stated objectives or policy goals while verifying that stakeholder input is incorporated and well-documented throughout the process.

The following sections discuss the primary functions of a GSA and provide an overview of the technical system modeling components therein. We then offer recommendations for next steps to better align gas utilities with policy goals, affordability objectives, emissions reductions, and modified approaches to doing business. Each section includes subsections with detailed guidance for regulators, relevant state and utility examples, and additional resources.

PRIMARY FUNCTIONS AND MODELING COMPONENTS OF A GAS SYSTEM ANALYSIS

The three primary functions of a GSA are to:

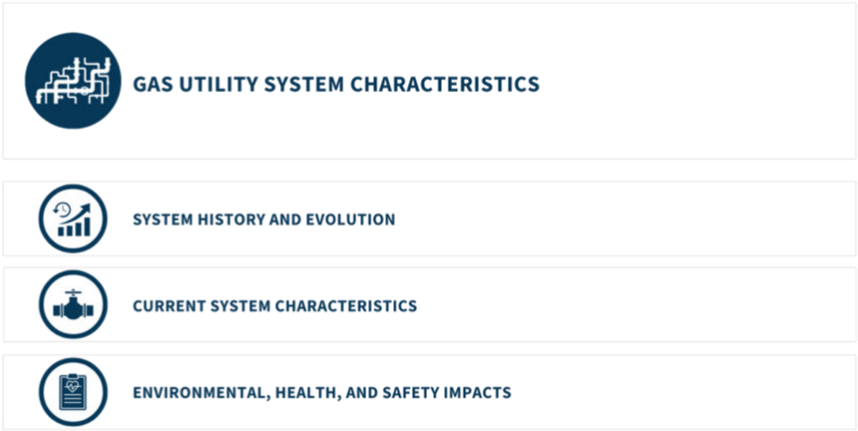
1) Accurately depict current system conditions, including any relevant history, to provide a common baseline of understanding about the gas utility's infrastructure and customer base.

2) Explore and articulate assumptions for different future scenarios, including a BAU or reference case and other alternative future pathways such as different forms of a decarbonized gas system.
3) Forecast gas demand and infrastructure needs under various defined future scenarios, allowing for side-by-side comparison of costs, benefits, and other impacts.

Below we describe each of the modeling components to support these functions.

Gas utility system characteristics

A GSA should offer a baseline context prior to detailing system forecasts and future scenarios so that regulators and other stakeholders gain shared familiarity with how the current system is configured and its impacts.



System history and evolution

Before describing current system characteristics, a GSA should provide a brief history of the gas system, noting any important legislative and regulatory actions that led to different phases of development and system evolution. This section should also mention applicable climate, clean energy, electrification, and emissions reduction goals or policies, including both state and local government objectives, to ground analysis in prevailing targets and requirements. A chronological list of policies is helpful to include for quick reference.

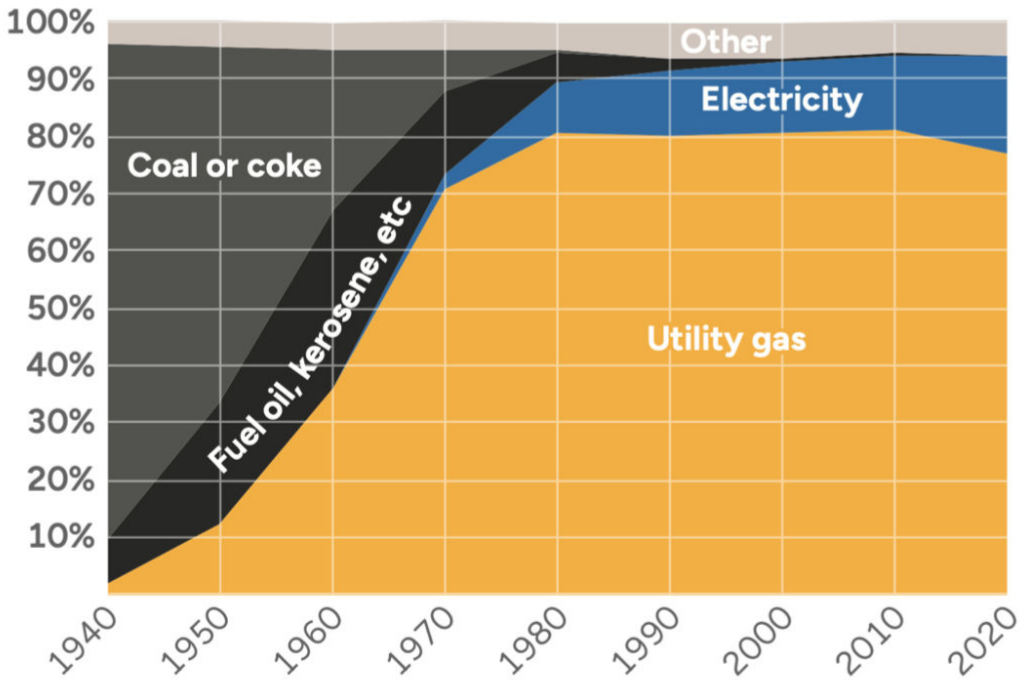
This section should also include a discussion of technoeconomic trends impacting the historic build-out of the system, including catalysts for growth or replacement of gas transmission and distribution pipelines based on population changes and customer types, as well as descriptions of customer rate designs and how utilities recover costs and earn revenue. This section should not be a lengthy history lesson, but a concise recap of the most salient elements impacting the gas utility system.

Information to include:

- Relevant legislative and regulatory history
- Regulatory oversight and governance structure
- Historic system build-out and replacement
- Utility ownership structure and compensation mechanisms

- Customer details and growth trajectory
- Utility revenue history and customer rates

Figure 1. Illinois example of gas system history and evolution showing the share of home heating fuel by energy source over time (1940 – 2020).[19]



Source: For 1940-2000, U.S. Census Bureau, Historical Census of Housing Tables (House Heating Fuel); for 2010 and 2020, U.S. Census Bureau, American Community Survey, 5-year data. https://www.census.gov/data/tables/time-series/dec/coh-fuels.html.

Current system characteristics

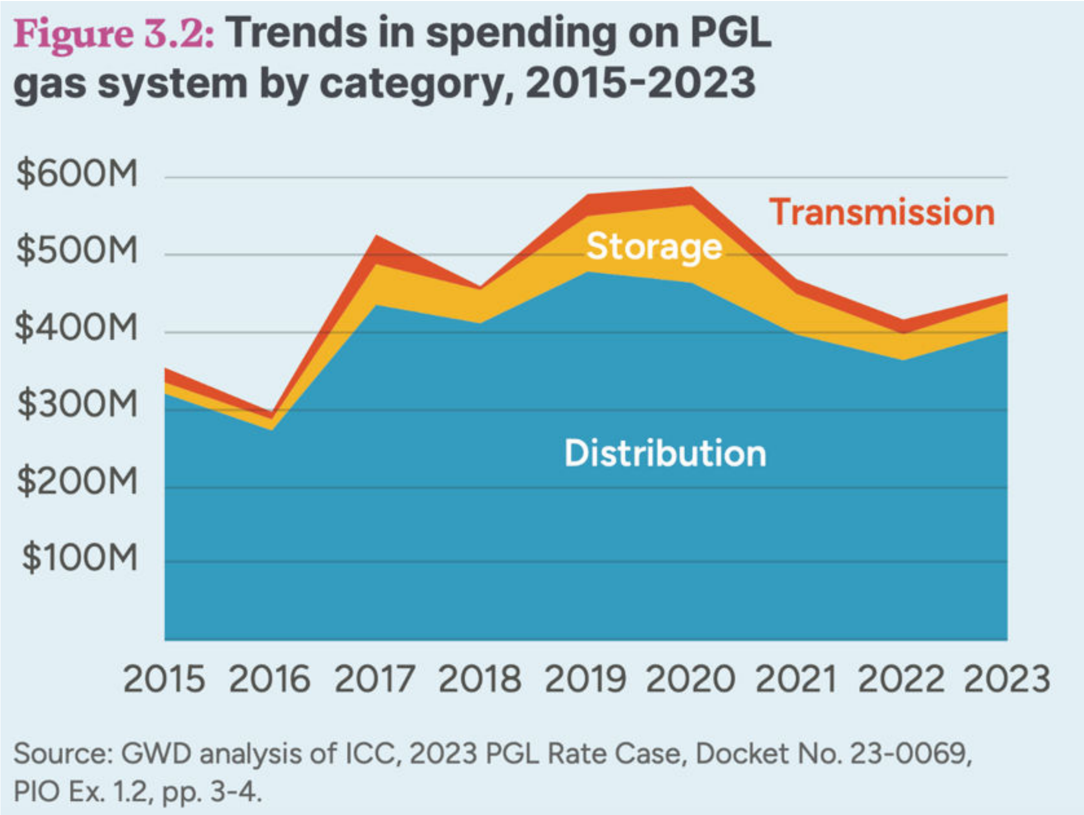
This section of the GSA should provide details on the physical and economic characteristics of the gas utility system, including total customer base, customer classes, miles of gas distribution (and any applicable transmission) pipelines, gas storage infrastructure, fuel sources and markets, recently approved capital expenses for new infrastructure or replacements, operating expenses, customer meters and replacement protocols, and a pipeline safety synopsis. Additional information on the workforce and customer energy burdens can help provide a holistic picture of the current gas system. Regulators should work closely with the utilities or third parties conducting the GSA to ensure that data is accurate and that information-sharing occurs in a streamlined and efficient manner. This process could start by creating an inventory of existing data sources, such as the gas distribution annual report form

F7100.1-1 required by the U.S. Pipeline and Hazardous Materials Safety Administration, and other regulatory information filed by the utility.[20]

Information to include:

- Capital expenses (CapEx) by infrastructure type and project category (e.g., safety and integrity, new business, capacity expansion, mandatory relocations), operating expenditures (OpEx), operations and maintenance (O&M), and corporate earnings
- Customer totals and revenue by customer class
- Customer energy usage totals and profiles by customer class; more comprehensive GSAs could include a granular breakdown by customer class for each year over the past 10 years (annual demand and peak demand) and a comparison with historical forecasts
- Gas pipeline and service line details: length (miles), diameter, type (distribution versus transmission), material (e.g., cast iron, plastic), age, and average fully loaded cost to replace a distribution main per mile or service line per foot
- Gas system safety metrics (including annual leaks by grade, pipeline material, and leak rate per mile); a summary of the utility's Gas Distribution Integrity Management Program, a summary of the utility's Transmission Integrity Management Program, and details on safety or other issues related to customer-owned yard lines
- Maps with major gas pipelines and other infrastructure details
- Utility workforce overview (e.g., number and types of jobs supported, unionized labor details)
- Customer energy burden metrics, if known

Figure 2. Example of gas system characteristics for a gas-only utility in Chicago, Illinois (People's Gas, or PGL) showing trends in spending on transmission, storage, and distribution over time.[21]



Environmental, health, and safety impacts

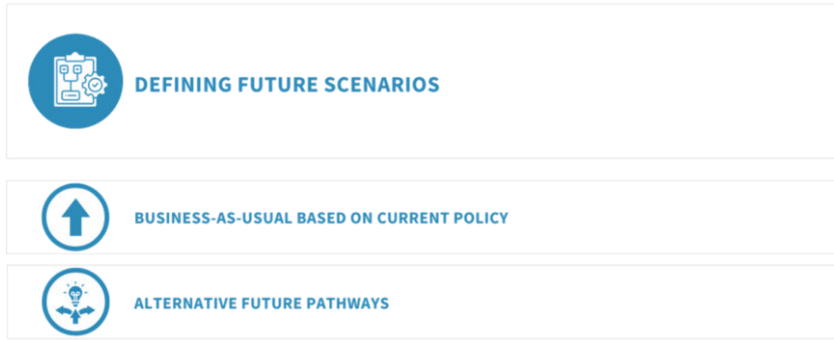
In addition to providing details on the physical and economic traits of the system, a GSA should identify and quantify social and environmental impacts of the gas utility system, using specific and agreed-upon metrics. These elements will provide a thorough picture of how the gas utility system affects the health of the environment, communities, and customers, and will also help inform priorities for gas system decarbonization.

Information to include:

- GHG emissions, including both Scope 1 and Scope 3
- Social cost of carbon
- Fugitive methane emissions and leak mitigation efforts
- Local air pollution (e.g., nitrogen oxides and volatile organic compounds) and details regarding public health impacts
- Indoor air quality impacts of fossil fuel combustion (e.g., research on mortality, morbidity, asthma rates)

- Pipeline safety and hazards data, including leaks by grade on each system type (e.g., transmission versus distribution)

Defining future scenarios



A GSA should clearly define various future gas system scenarios and detail the assumptions for each. Regulators and stakeholders may choose to request certain scenarios based on their specific policy context, but in general the GSA should include a BAU scenario and a few alternative future pathways. To minimize analysis paralysis or unwieldy evaluation processes, regulators should home in on the most important scenarios to inform their future decision-making.

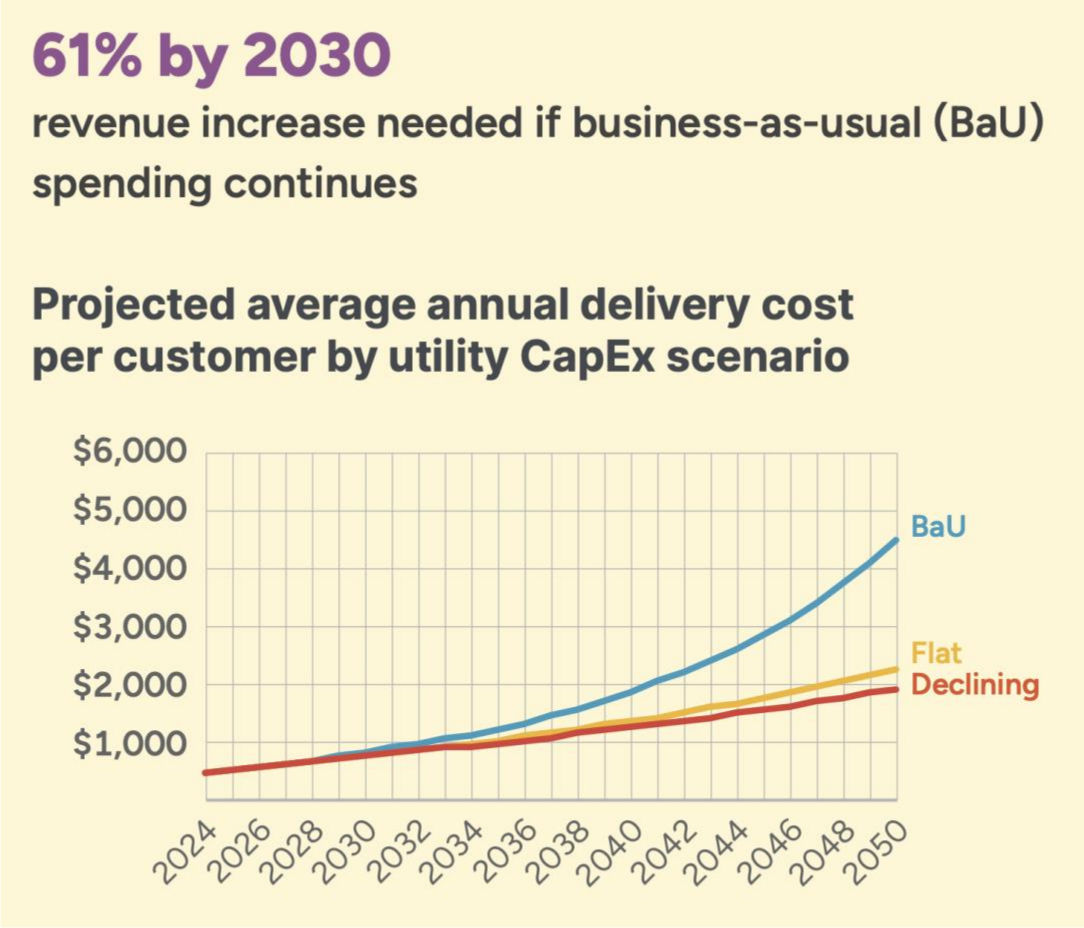
Business-as-usual based on current policy

Building off the previously described current system characteristics of a gas utility system, a GSA should first provide a BAU, or reference case, scenario based on current policies, which will inform the forecast for an established time frame (often 10 to 20+ years). The assumptions should include system and customer attributes, financial investments and recovery, and potential unrecovered investments (or stranded assets) that are incurred over the lifetime of capital infrastructure. The BAU forecast provides an important baseline scenario that can be compared against when evaluating alternative future scenarios, including the introduction of new technologies and revised investment priorities.

Information to include:

- Customer energy usage totals and profiles by customer class
- Customer totals and revenue by customer class
- Gas transmission and distribution pipelines plus gas storage facilities to be installed, refurbished, or replaced
- OpEx and CapEx spending related to the gas utility
- Fuel costs and implications for customer affordability
- GHG emissions or other environmental, health, or safety impacts
- Quantity and investment totals for NPAs to serve customers
- Potentially unrecovered gas system investments, including sensitivity analysis in regard to state and local climate goals
- Annual revenue requirement per customer based on the load forecast

Figure 3. Example of a BAU scenario for a gas utility in Illinois, showing projected average annual costs per customer.[22]



Alternative future pathways

The alternative future scenarios for gas utilities and their customers should reflect a range of technologies and programmatic solutions—such as high efficiency and demand response, full electrification, hybrid electrification with fossil fuel backup, renewable natural gas (RNG), and networked geothermal. Technical experts and stakeholders not associated with the gas utility should help inform and review assumptions regarding technologies, customer demand, costs, decarbonization solutions, and NPAs. Careful consideration should be given to future market dynamics, such as technology performance (e.g., advances in cold climate heat pumps), improved economic factors (e.g., up-front and operating costs, price differentials between gas and electricity for different customer classes, and availability of incentives), and external factors such as new policies (e.g., improvements to building energy codes and other policies).

Scenarios can mix and match different technology packages, for instance relying on a blend of demand- and supply-side solutions to meet customer energy needs, while striving for alignment with GHG reduction goals and even early achievement of these targets.

Importantly, if current laws and regulations restrict or dampen the viability of alternative future scenarios, the GSA should still define and model associated alternative scenarios, which may require policy or regulatory changes, to inform meaningful discussion of future pathways. Scenario assumptions for all three customer classes—residential, commercial, and industrial—should be ambitious and forward-looking, rather than reflecting historical trends. This is especially important for commercial and industrial customers, who have not yet widely adopted electric technologies due to pervasive market and policy barriers, but who may shift their demand profiles in response to improved economics, internal decarbonization goals, or other factors.

Figure 4. Massachusetts example of a comparison of defined alternative future pathways (*continued gas*, *dual fuel – pipeline*, *unmanaged electrification*, *dual fuel – tank*, and *accelerated electrification*) and their respective cost test impacts (e.g., utility ratepayer cost, utility cost, customer cost, system cost and climate target risks).[23]

Scenario	Gas Network (Utility/Ratepayer Costs)	Building (Customer Costs)	Electric Network (Utility/Ratepayer Costs)	System Capital Investment (Total: Gas + Building + Electric Costs)	Climate Target Risk (Leaks & Emissions)
Continued Gas	Gas pipeline replaced in 2025* Total Capital: $642K Per Home: $34K	At its end-of-life, gas equipment is replaced with similar equipment. Total Capital: $407K Per Home: $21K	No upgrades. All heating loads remain on the gas system.	*Gas System Reinvestment + Low Heating Reinvestment* Total: $1,049K Per Home: $55K	*Highest* Inconsistent with climate targets.
Dual Fuel - Pipeline		Gas furnaces are replaced with hybrid systems at end-of-life. Total Capital: $684K Per Home: $36K	No upgrades. Peak heating loads remain on the gas system.	*Gas System Reinvestment + Medium Heating Reinvestment* Total: $1,326K Per Home: $70K	*Medium* Partial reduction in combustion and leaks. Requires additional intervention.
Unmanaged Electrification		Buildings to be fully electrified when existing systems reach their end of life. Total Capital: $886K ($1,105 w/EE) Per Home: $47K ($58K w/EE)	Steady electrification requires preemptive transformer upgrades over time. Total Capital: $80K ($60K w/EE) Per Home: $4.2K* ($3.2K w/EE)	Gas System Reinvestment + High Heating Reinvestment + Additional Elec. Capacity Total: $1,608K ($1,827K w/EE) Per Home: $85K ($96K w/EE)	*Low* Buildings will be fully electrified by 2050
Dual Fuel - Tank	Gas service ended in 2025. Pipes are capped at a modest cost. Total Capital: $20K Per Home: $1.05K	Buildings are to be retrofitted in 2025 with a heat pump and supplemental tank propane. Total Capital: $429K Per Home: $26.8K	No upgrades. Peak heating loads shift from the gas system to tanked propane.	Medium Heating Reinvestment Total: $530K Per Home: $23.6K	*Medium* Partial reduction in combustion. Leaks eliminated in 2025 Requires additional intervention.
Accelerated Electrification		Buildings will be completely electrified in 2025. Total Capital: $703K ($878 w EE) Per Home: $37K ($46Kw/EE)	Steady electrification requires preemptive transformer upgrades over time. Total Capital: $80K ($60K w/EE) Per Home: $4.2K* ($3.2K w/EE)	High Heating Investment With Early Retirements + Additional Elec. Capacity Total: $783K ($958K w/EE) Per Home: $41K ($50K w/EE)	*Lowest* Leaks and combustion emissions are eliminated in 2025.

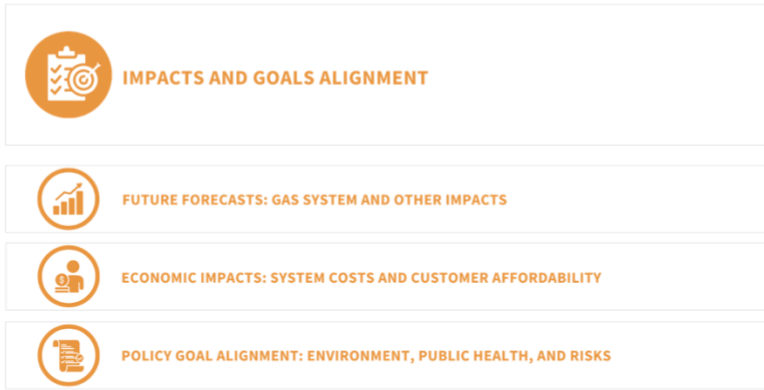
***Cost is borne by all ratepayers with additional revenue needed to cover rate of return, taxes, O&M | EE = Enhanced Envelope Energy Efficiency**

Information to include—in addition to the details from the BAU scenario section:

- Overview information on technologies and potential grouping of technologies into different modeling categories (e.g., high electrification scenario)
- Market readiness, deployment rates, growth potential, and anticipated improvements for each technology

- Limitations, feasibility, and scalability of alternative fuels, such as green hydrogen and RNG, if included in alternative pathways[viii]
- Customer and situational applicability of each technology or programmatic solution
- Technology costs and customer affordability details
- Environmental, public health, safety, and other attributes associated with specific technologies

Impacts and goals alignment



Documenting anticipated impacts of future scenarios is fundamental to a GSA and allows stakeholders to understand the infrastructure, financial, environmental, and social implications of differing gas utility approaches and investment decisions. Clear understanding of policy objectives, such as reducing emissions to reach climate goals by target dates, should inform the aforementioned scenario creation process and be reflected in quantified future impacts for customers and investment approaches. To ensure goal alignment, an iterative process that revisits and refines scenario creation as future impacts come into focus during analysis may be necessary and should be factored into the approach for creating a GSA.

Future forecasts: gas system and other impacts

A robust and credible gas system forecast should document the modeling approach and key assumptions that drive outcomes under each of the alternative future pathway scenarios. Technical credibility of the forecast hinges on the GSA providing increased transparency for regulators and other stakeholders, such that all interested parties understand how the forecast supports long-term planning and policy alignment. The most important elements to include are listed in Table 1 below.

[viii] Some GSAs may consider alternative fuels, like hydrogen or renewable natural gas, as part of their alternative future scenarios. If so, the GSA should clearly document their limitations, feasibility, and scalability. For example, a meta-review of 54 peer-reviewed studies on hydrogen heating (available at https://doi.org/10.1016/j.crsus.2023.100010) concludes hydrogen for heat in buildings does not make sense, given the physical characteristics of hydrogen and gas services lines, limited climate impact, and safety, public health, and cost concerns. For more information, see Hydrogen Policy's Narrow Path: Delusions and Solutions (Energy Innovation). Similarly, numerous RNG studies conclude that feedstocks are limited and costly, for example The Four Fatal Flaws of Renewable Natural Gas (Sightline Institute).

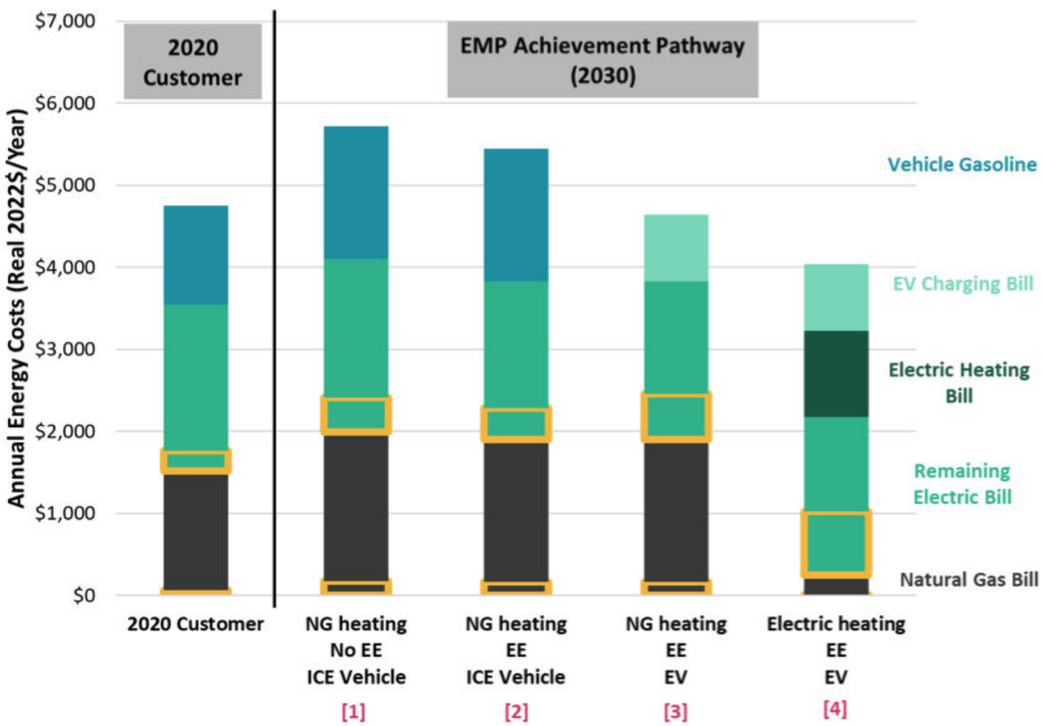
Table 1. Gas system forecast assumptions, inputs, and data needs.

Forecast assumption category	Inputs and data needs
Customer and load growth variability	√ Population and housing trends √ Economic growth projections √ Updated design day assumptions for gas utilization based on rolling 30-year outdoor temperature averages √ Customer technology adoption rates and usage patterns by customer class, including peak and annual demand
Energy efficiency and demand reduction	√ Assumed impacts of efficiency programs, building codes, and appliance standards √ Electrification assumptions (e.g., for space and water heating)
Emissions reduction policies and regulations	√ State and local climate goals, emissions caps, legislation and regulations √ Pollution restrictions or moratoriums on new service connections, including the potential for new policies √ Potential for gas pipeline repair and relining efforts to address leaks without full replacement √ GHG emissions √ Other environmental or health indicators
Fuel supply and pricing	√ Gas price forecasts (wholesale and retail) and price elasticity of demand √ Availability and cost of alternative fuels (e.g., RNG, green hydrogen) √ Commodity market assumptions and volatility
Technologies	√ Adoption of new heating and cooling technologies (e.g., heat pumps) √ Differences across geographic areas based on local policies or other factors √ Feasibility of hydrogen or RNG integration
Economic factors	√ Capital and O&M costs for infrastructure projects and technologies √ Utility investor returns plus capital depreciation rates and methods √ Costs and cost-effectiveness thresholds for non-pipeline alternatives √ Discount rates and inflation √ Sensitivity analyses (e.g., technology breakthroughs, fuel price swings, high electrification, low gas demand)

Forecasts should consider technology applicability, adoption timelines, and feasibility by customer types, while acknowledging variances across residential, commercial, and industrial customers. Forecasts can mix and match options within each scenario.

Figure 5. New Jersey example comparing alternative future scenarios based on different forecasts for technology adoption: natural gas (NG) heating, electric heating, energy efficiency (EE), internal combustion (ICE) vehicle, and electric vehicle (EV). The graph shows how different combinations of technologies would impact annual energy costs for non-low-income customers under the Energy Master Plan Achievement (EMP) Pathway, designed to meet the state's policy goal of a 100 percent clean energy economy by 2050.[24]

FIGURE ES.1: ANNUAL ENERGY COSTS FOR RESIDENTIAL NON-LOW-INCOME CUSTOMERS UNDER THE EMP ACHIEVEMENT PATHWAY[5]



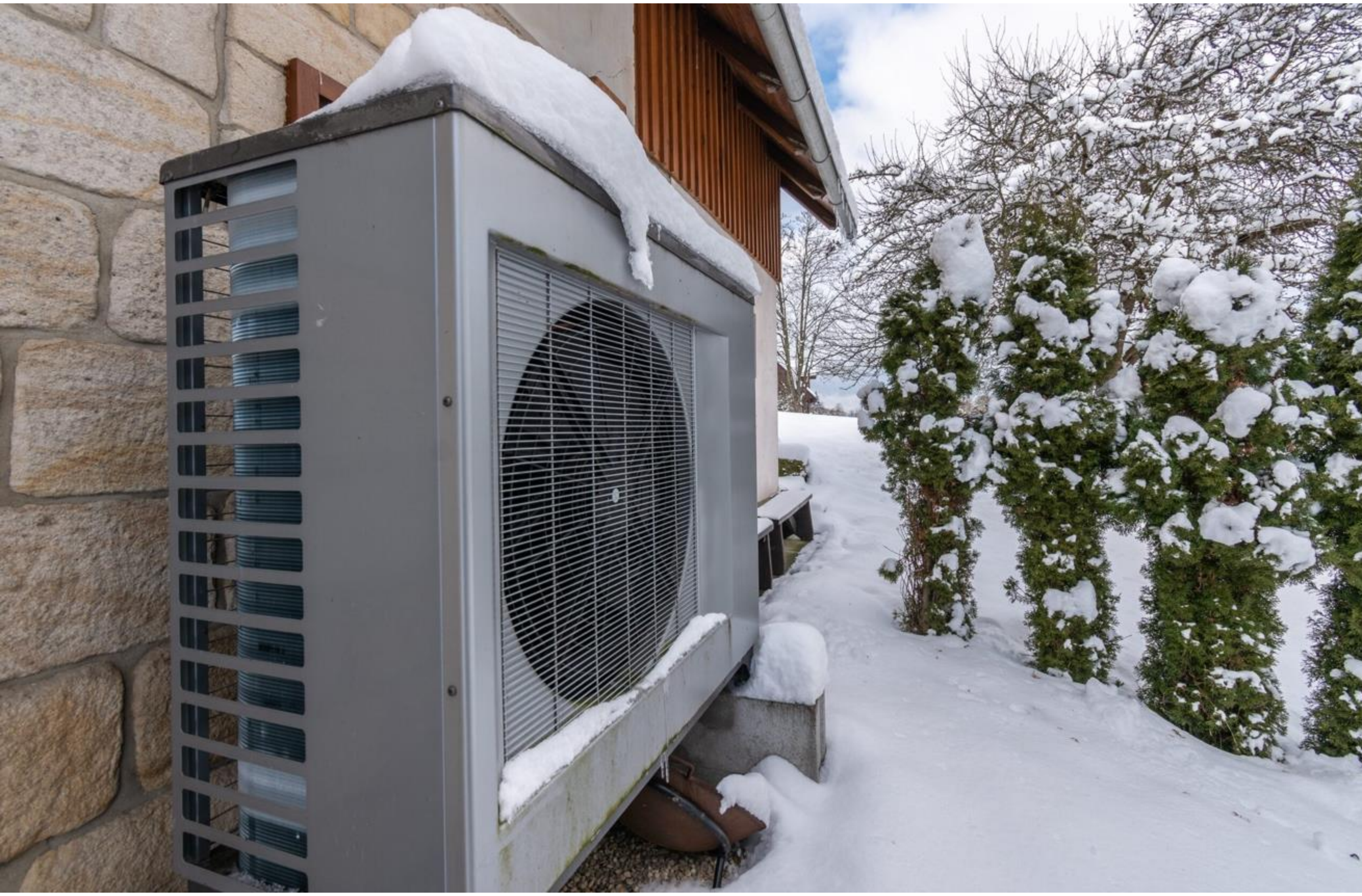
Scenario forecasts: alternative pathways—possible options to forecast and model

- Energy efficiency: Demand-side interventions to reduce energy consumption and complement other solutions for decarbonization
- Full electrification: Full electrification of customer end uses and disconnection from the gas system
- Thermal energy networks: Networks of heating systems such as ground-source heat pumps to provide heating and cooling services
- Hybrid electrification: Primary use of electrification technologies such as heat pumps, but with use of gas or other fossil fuel technologies as backup

- Gas alternatives: Biogases (aka RNG), blended hydrogen, or others
- Diverse: A combination of various approaches
- Varying time horizons: Reflecting modeling outcomes for numerous future milestone dates will provide the most useful and actionable information

Economic impacts: system costs and customer affordability

Understanding the nuances of different economic impacts associated with each modeled future scenario will inform the feasibility of achieving policy goals and timelines for decarbonization. CapEx and OpEx should be considered to provide an estimate of the utility's revenue requirement in future years. Stranded asset risks may be uniquely profiled in a system cost evaluation, quantifying the total amount of prior or upcoming investments that may not be useful or fully covered by utility bill collections. Assessing the potential for stranded assets can provide motivation to



evaluate alternatives, such as NPAs, rather than sustaining capital expenditures and increasing risks to customers associated with gas infrastructure investments. An evaluation of economic impacts should also consider alternative depreciation methods to assess impacts and potential benefits of modifications to the current approach.

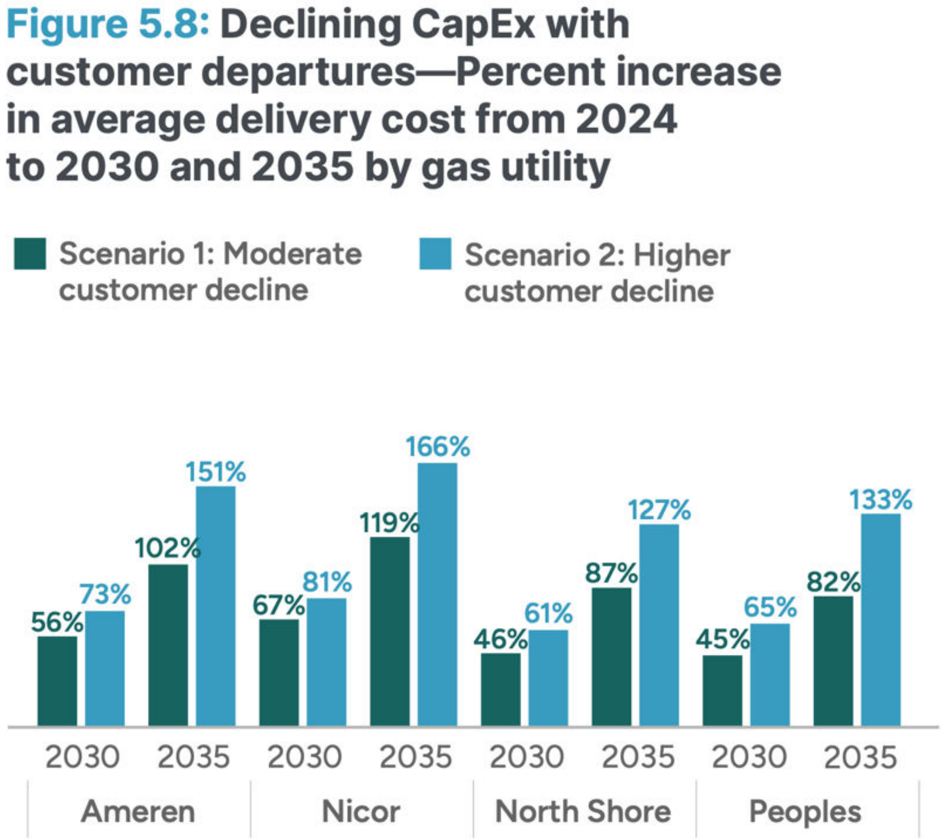
Customer costs should be evaluated in several ways to reflect a holistic picture of affordability outcomes and differing experiences, including the impact on average customer rates, energy costs for participating versus non-participating customers (e.g., those that electrify or not), or energy bill impacts by customer type (e.g., residential and non-residential customers).

Estimating customer costs is a dynamic exercise that must reflect ratepayer departures from the system, such as under electrification scenarios, and consider how that will impact utility bills for remaining customers. As with utility system costs, customer costs should consider the full range of energy expenditures, inclusive of gas utility bills, electricity bills, and expenses for any delivered fuels such as fuel oil and propane. Analyses will ideally consider economic impacts by individual key technology (e.g., HVAC heat pumps versus fossil alternatives) along with full and partial electrification scenarios by customer type. Some analyses have quantified household transportation costs and savings, particularly if electrification scenarios are developed to include adoption of electric vehicles. Studies have also estimated customer energy burden under future scenarios, which includes details on the percentage of household income that is spent on utility bills and energy needs depending on technology adoption (e.g., electrified or not).

Information to include:

- CapEx, OpEx, and utility revenue requirement, all characterized by asset class and subcategories
- Stranded asset risk and potential unrecovered costs and balances
- Analysis of alternative asset depreciation methods
- Customer cost and saving implications, detailed by customer class, inclusive of all utility bills and other energy expenses
- Equity metrics such as energy burden estimates tailored to differing technology adoption assumptions

Figure 6. Illinois example of economic and customer impacts under different modeled scenarios—moderate gas customer decline (scenario 1) and higher customer decline (scenario 2)—across four gas utilities (2024-2035).[25]



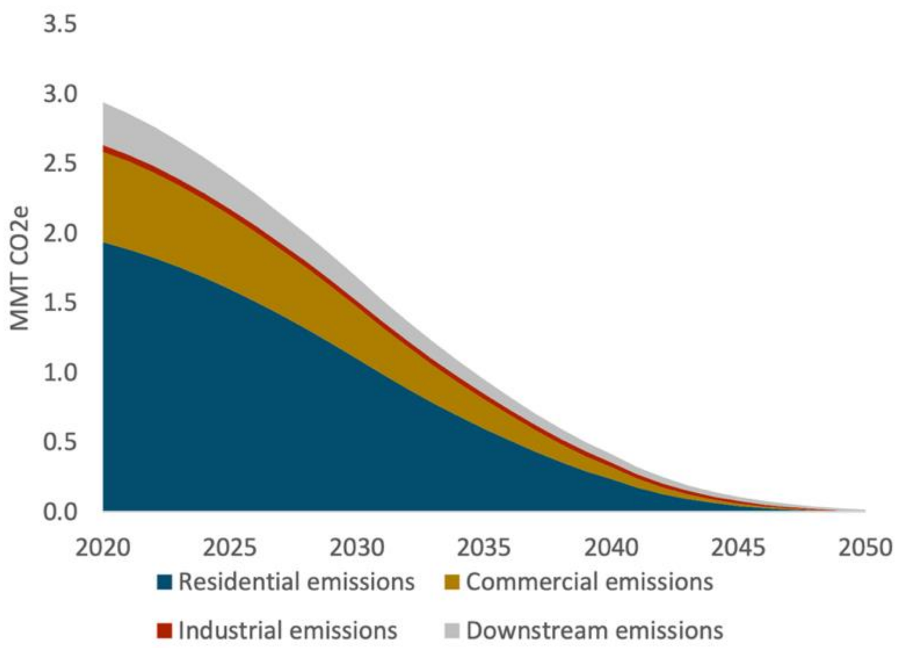
Policy goal alignment: environment, public health, and risks

All GSAs, as well as gas utility plans and investments, should be informed by prevailing policy goals related to the environment, public health, customer affordability, risk tolerance, and other priorities. A GSA can support both quantitative and qualitative details that characterize the alignment of each modeled scenario with stated ambitions. In places where a policy requires gas utilities to reduce GHG emissions, the GSA should clearly and transparently quantify the emissions impacts of the gas system along with emissions of alternative technologies and future scenarios, including electrification technologies.

An accurate GHG forecast must be dynamic and consider changing electric grid conditions, including the introduction of renewable energy technologies over time and how this impacts the emissions intensity of electrification compared to use of the gas utility system. The most accurate GHG analyses will consider emissions at the point of gas combustion plus upstream impacts such as fugitive emissions associated with methane leaks to more accurately depict outcomes and potential emissions savings of alternatives. It is also important to apply at least one method that aligns with any GHG inventory protocols used for goal setting in the state or jurisdiction.

Quantifying the social cost of carbon will translate emissions metrics into financial costs and allow for a more direct comparison with system costs and customer economics of various scenarios. Other policy goals that may need to be incorporated into the GSA include those related to public health such as mitigating air quality pollutants, aspirations to minimize future regulatory and infrastructure risks, plus workforce opportunities and impacts.

Figure 7. Example of environmental impacts of different future scenarios for a municipal gas utility (Philadelphia Gas Works), showing the decline in emissions across residential, commercial, and industrial customers and downstream emissions under a high electrification scenario.[26]



Information to include:

- Overview of state and local goals and targets related to gas utility operations
- GHG emissions for each scenario, including upstream emissions impacts
- Public health goals plus quantitative and qualitative commentary on issues such as air quality
- Financial estimates of the social cost of carbon or other public health or environmental goals
- System safety or other risk characteristics associated with each scenario
- Other goal categories such as equity, workforce, and system safety

USING A GAS SYSTEM ANALYSIS TO INFORM NEXT STEPS

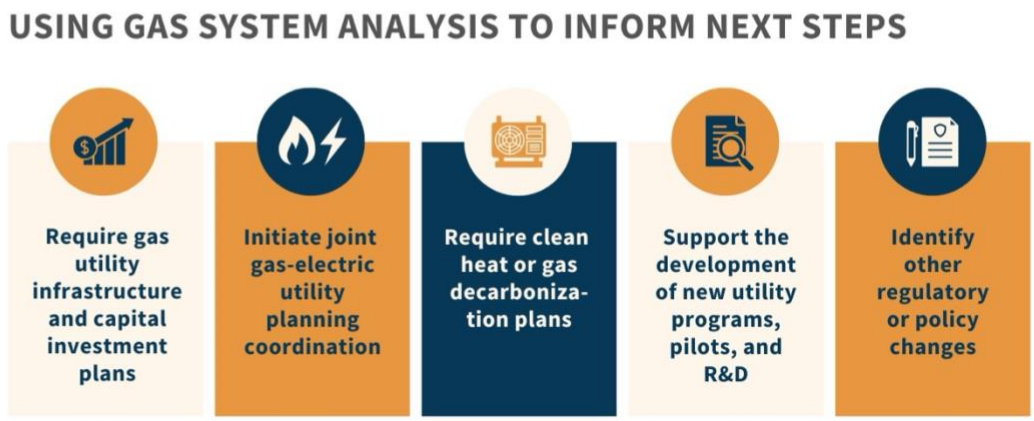
A GSA should serve as a foundational tool that informs, advances, and even streamlines other regulatory processes. Following the completion of a GSA,inclusive of review and vetting by stakeholders, state and local gas utility regulators will need to determine the next steps most appropriate for their jurisdiction. Regulators should facilitate an efficient but inclusive stakeholder process to solicit input on barriers and solutions along with prioritization of near-term, mid-term, and long-term actions that are responsive to policy goals and timelines.

Regulatory steps should be based on the alternative future scenarios from the GSA and should reflect state and utility context plus market conditions. Next step options range from straightforward fixes to identified barriers, to more comprehensive approaches, to shifting gas utilities away from the sale of fossil gas with revenues and profits based on their capital infrastructure investments. A GSA should also provide a strong nexus to any traditional and ongoing gas planning regime and allow for iteration and future use to meaningfully inform those processes and plans.

States and municipal governments will want to invite input from their gas utilities and non-utility stakeholders but may also want to consult with other policymakers and agencies on the needs and gaps. Energy regulators charged with maintaining affordability can use the findings from a GSA in other relevant regulatory proceedings or initiate new investigations, to catalyze needed discussions about possible future gas system changes. Potential regulatory actions may include:

- **Require gas utility infrastructure and capital investment plans:** Utility regulators can establish new or revised gas planning requirements for all regulated gas utilities. These plans can build on the work done as part of a GSA and can be filed regularly to help regulators make informed decisions about the prudent use of ratepayer dollars as well as manage changes to the gas system in an equitable manner. GSAs could be filed in advance of or as part of a gas plan.
- **Initiate joint gas-electric utility planning coordination:** Ideally, any requirements for gas planning should account for how gas and electric utilities operate in overlapping service territories and consider solutions that address the need to overcome competing interests while also reflecting costs and benefits of proposed investments across the entire energy system. GSAs and related activities should act as a catalyst for coordination and collaboration among utilities and across regulatory staff. The GSA could serve as a useful starting point for such efforts.
- **Require clean heat or gas decarbonization plans:** A gas decarbonization plan is a strategic framework developed by governments, utilities, or regulators to transition the natural gas system toward a low-carbon or zero-carbon future and align the gas utility with relevant state or local climate goals. These plans could also articulate opportunities for non-gas and non-pipeline investments, as well as other strategies to reduce gas demand. As part of this effort, regulators should specify early in the process which alternatives to gas are eligible to meet decarbonization objectives, with justification for their inclusion or exclusion (and accounting for stakeholder input).

- **Support the development of new utility programs, pilots, and R&D:** Regulators may also use a GSA to consider new proposals for programs, pilots, and additional research priorities, including new data collection and analysis, needed to support the continued understanding of technology feasibility, customer uptake, and system impacts. The GSA could catalyze no- to low-regret actions in the near term that provide clear benefits to customers or the system. The analysis might also justify new feasibility studies for capital projects such as geothermal networks or other infrastructure essential to decarbonizing the gas system. The scenario analyses and forecasts should inform which programs, pilots, and additional research are catalyzed in the near and medium terms.
- **Identify other regulatory or policy changes:** A GSA could also be used to inform additional actions, including revisions to gas pipeline extension policies, amortization or depreciation reforms, update pipeline replacement programs, or new legislation necessary to address identified challenges to evolving gas utilities away from BAU and toward future alternative pathways.



Policymakers concerned with rising energy costs and affordability challenges should use all the tools in their toolbox to scrutinize proposals for billion dollar investments to replace or expand gas utility systems. Analyzing the gas system should not be an exercise in futility. Regulators should ask more of their gas utilities and seek to better understand the vast gas systems hidden underground and the assumptions used to rationalize their expansion and replacement. By taking stock of the gas system and the myriad factors impacting its future, decision-makers can avoid unneccesary investments in overlapping (and possibly redundant) gas and electricity systems, and identify future pathways that minimize costs and risks to all energy consumers.

APPENDIX A – CASE STUDIES

Case studies from five gas system analyses

The following case studies are examples of studies commissioned to analyze gas utility systems. The inclusion of these examples is not necessarily an endorsement of their findings or methodological approaches, but rather an illustration of different components that should be included in a gas system analysis. Appendix B provides a summary of the evaluation elements and page references.

CASE STUDY 1: Peoples Gas: Escalating business risk in a changing energy landscape (2024) - Led by Groundwork Data (Prepared for Citizens Utility Board – Illinois)

This report examined risks and uncertainties associated with Peoples Gas (aka PGL), a utility serving Chicago and operating one of the oldest gas delivery systems in the country. The study featured a detailed look at the history and evolution of this gas system, analysis of the utility's System Modernization Program, and the position of Peoples Gas on key topics affecting investments and operations. The report concludes with a section on managing risks along with top-line findings relevant to future regulatory and policy decisions. Key study elements include:

Utility business model reflections: Documents historical context and recent evolutions in market conditions, gas delivery totals, infrastructure investments, utility profits, and third-party audits of plans and investments made by Peoples Gas.

Systemic threats to the gas utility: Provides detailed metrics and analysis on key threats to the operating approach of Peoples Gas, including rising gas delivery costs, state and local clean energy policies, and adoption trends for technology alternatives such as electrified space and water heating.

Position of Peoples Gas on key issues: Reflects on the position of the utility on key issues related to the gas system and energy transition, including safety and reliability, customer electrification feasibility and economics, GHG emissions, and the potential role of hydrogen and RNG. The study also includes context on financial and other metrics related to these issues.

Risk management analysis and priorities: Scrutinizes key risks to the utility in a changing regulatory environment with details on recent regulatory decisions and associated financial impacts plus potential gas transition efforts. The report concludes with a series of findings related to system attributes, potential investments, and risks, along with investor implications.

"The long-term sustainability of PGL's operations in Chicago is in question, with potential repercussions that extend beyond Peoples Gas to the broader financial health and creditworthiness of the parent company…."

CASE STUDY 2: The future of gas in Illinois (2024)- Led by Building Decarbonization Coalition and Groundwork Data

This study highlights the history and evolution of the gas system in Illinois, including infrastructure and investment trends that led to the state being one of the most gas-reliant in the U.S. The analysis considers gas alternatives such as hydrogen, RNG, and other alternative fuels along with potential unrecovered costs and stranded asset risks associated with ongoing gas system investment. The report frames current regulatory approaches to cost recovery and a possible evolution in system planning that results in a managed transition less dependent on gas transmission and distribution pipelines along with gas storage infrastructure. Key study elements include:

Historical context: Details on gas system costs and recent trends, such as the investment of more than $1 billion annually in the system by the largest four gas utilities in the state. The report features summary profiles for each of these gas utilities, with details on infrastructure, spending, customers, and revenues.

Current regulatory environment: Background on how gas planning and investment decisions are currently evaluated and approved along with recent policy commitments and new regulatory proceedings in Illinois that are set to reshape system planning approaches and priorities.

Alternative fuels: Descriptions of traditional gas fuel alternatives such as hydrogen and RNG and associated cost premium estimates, GHG emissions implications, and technical feasibility.

Cost analysis: Forecasts of potential future capital expenditures and estimates of associated revenue requirements and ratepayer impacts for three infrastructure investment scenarios. This section also includes detailed commentary and calculations for potentially unrecovered costs and associated stranded asset risks.

Managed transition: Recommendations to mitigate risk and promote a managed gas system transition using best available technologies aligned with climate goals. Beneficial electrification, neighborhood-scale decarbonization, gas system decommissioning frameworks, and regulatory innovation are among the topics described in detail.

"The four largest Illinois gas utilities have been investing more than $1 billion annually, largely to replace aging gas infrastructure, and thereby locking in capital spending that gets repaid with a rate of return over 40 to 70 years."

CASE STUDY 3: New Jersey energy master plan: Ratepayer impact study (2022) - Led by Brattle Group (prepared for New Jersey Board of Public Utilities)

This study was commissioned by the New Jersey Board of Public Utilities to evaluate future scenarios and energy utility cost impacts of pursuing policies and strategies reflected in the state's 2019 Energy Master Plan (EMP). The EMP was developed in response to adopted state legislation with mandates to address climate change and achieve a 100 percent clean energy economy by 2050. The report features impacts for both electric and gas utilities, including residential, commercial, and industrial customer types. Key study elements include:

Scenario evaluation: Analyzes the costs and benefits of three separate pathways related to the EMP, including a *current policy pathway*, *EMP achievement pathway*, and an *ambitious pathway*. The report breaks down total annual energy costs, including electric bills, gas bills, and vehicle fuel, for all three pathways for both a low-income and a non-low-income residential customer. The analysis also calculated annual energy cost impacts for commercial and industrial customers under each pathway.

Customer rate and energy cost forecasts: Reveals forecasts of customer rate and energy cost impacts associated with achieving the 2019 EMP in New Jersey. All forecasts are broken down by customer class for each electric and gas utility studied.

Customers and technology adoption: Quantifies anticipated energy costs for various residential customers, including those who adopt electrification technologies such as heat pumps and electric vehicles and those who do not. The analysis forecasts meaningful annual energy cost savings for electrified customers. Technology adoption and costs are also forecasted for commercial and industrial customers.

GHG reduction estimates and benefits: Forecasts future GHG emissions under EMP implementation scenarios and estimates a social cost of carbon benefit of $1.75 billion per year in 2030 for a pathway achieving targets in the EMP.

"In 2030, residential customers who have electric vehicles and electric heating experience cost savings (14-15%), while non-electrified customers experience cost increases (10-16%) compared to 2020 levels."

CASE STUDY 4: Baltimore gas and electric integrated decarbonization strategy (2022) – Led by E3 (prepared for Baltimore Gas and Electric)

This analysis evaluated transformations needed in Baltimore Gas and Electric (BGE) service territory to accomplish state-level climate goals in Maryland, including economy-wide net-zero GHG emissions by 2045. The study focused on three separate decarbonization scenarios with differing technology solutions and associated uses and outcomes for the BGE utility system. An update to the analysis was published in 2023 reflecting anticipated impacts of recent federal legislation and new energy incentives. Key study elements include:

Scenario evaluation: Analyzes system costs and customer economic impacts of three separate long-term scenarios, including scenarios for *limited gas* that emphasize electrification and transitioning away from the gas system, *hybrid* with an electrification focus plus a sustained role of the gas system for back-up heating, and a *diverse* scenario including a wide range of solutions such as electrification, hybrid heating systems, networked geothermal, and decarbonized fuels.

Gas and electric system futures and costs: Reflects future utilization rates and capacity needs for both the electric and gas BGE systems from 2020 through 2045 and characterizes the level of challenge related to system costs, customer affordability, equity, workforce, and other elements for each of three scenarios evaluated. Provides detailed incremental annual costs and cumulative costs for the overall gas and electric system through 2045, plus estimated monthly residential utility bills for each scenario depending on technology adoption by customers.

Regulatory and policy recommendations: Includes suggested next steps to support gas and electric system decarbonization, such as potential modifications to customer incentives and evolving cost-recovery mechanisms to support decarbonized gas, plus NPAs that reduce the need to invest in traditional gas pipeline networks.

Federal Inflation Reduction Act (IRA) impacts: E3 published a report addendum in 2023 that incorporates impacts of the 2022 IRA legislation and an updated assessment that considers revised renewable fuel production costs, electrification incentives, and several other aspects of the legislation. The new modeling with IRA impacts reflected significant cost reductions, relative to the 2022 study, for achieving decarbonization across all three scenarios.

"Consumers are central to the transformations required to achieve net-zero and achieving the scale of adoption envisioned here will require developing solutions that are affordable and work for all customers, equitably."

CASE STUDY 5: Philadelphia gas works business diversification study (2021) - Led by E3; Econsult Solutions; Portfolio Associates (prepared for City of Philadelphia)

This study evaluated system decarbonization solutions for Philadelphia Gas Works (PGW), the largest municipally owned gas utility in the U.S. The analysis considers the PGW workforce and opportunities for employees to thrive in a lower-carbon future with increased electrification and other climate solutions. Numerous stakeholders in Philadelphia informed the analysis through targeted engagement sessions, an online survey, and other input opportunities. Key study elements include:

Gas utility overview: Highlights the gas utility system history, size, and other attributes, plus details on PGW's revenue collection process and regulatory structure as a publicly owned utility.

Scenario evaluation: Features four potential decarbonization scenarios: *decarbonized gas, networked geothermal systems, hybrid electrification,* and *full electrification*. Each scenario includes forecasts of estimated revenue requirements for PGW, based on anticipated levels of infrastructure investment, for each decade through 2050.

Residential customer annual bill forecasts: Estimates annual energy utility bills for single-family homes in each scenario, including anticipated costs for customers that adopt electrification technologies and those that remain reliant on gas-combusting appliances.

GHG and air quality impacts: Analyzes GHG outcomes of each scenario and includes a forecast of combined GHG emissions for the electric and gas utility sectors from 2020 through 2050 for residential, commercial, and industrial customers. The study also comments on local air quality impacts of different scenarios.

Business model diversification and pilot projects: Details possible evolutions to the gas utility business model to accelerate decarbonization and recommends a variety of public projects for PGW to pursue, including weatherization with innovative financing, a feasibility analysis for networked geothermal systems, and a local decarbonized gas program. The study also includes commentary on PGW's potential roles as a utility supporting various decarbonization opportunities.

"…the Office of Sustainability made it a priority at the outset of the study to hear from community members in areas of the city where energy burden is highest."

APPENDIX B – CASE STUDY COMPARISON TABLE

GAS UTILITY SYSTEM ANALYSES: EXAMPLES AND SECTION DETAILS	Gas utility system characteristics			Defining future scenarios		Impacts and goals alignment		
	System history and evolution	Current system characteristics	Environmental, health, and safety impacts	Business-as-usual based on current policy	Alternative future pathways	Future forecasts: gas system and other impacts	Economic impacts: system costs and customer affordability	Policy goal alignment: environment, public health, and risks
Peoples Gas: Escalating Business Risk in a Changing Energy Landscape (2024), Groundwork Data *(Prepared for Citizens Utility Board – Illinois)*	p. 12-23	p. 17-20	p. 45-46 p. 50-53	p. 20-23 p. 27-30 p. 63-66 p. 78-79		p. 63-66	p. 27-30 p. 38-41 p. 63-66 p. 77-79	p. 45-53
The Future of Gas in Illinois (2024), Building Decarbonization Coalition and Groundwork Data	p. 15-25	p. 28-41	p. 23-24 p. 40-44	p. 30-37 p. 68-82	p. 85-90	p. 73-76	p. 68-82	p. 90-95
New Jersey Energy Master Plan: Ratepayer Impact Study (2022), Brattle Group *(Prepared for New Jersey Board of Public Utilities)*		p. 42-44	p. 56-59	p. 37-44 p. 78-111	p. 47-48	p. 45-48	p. 42-44 p. 78-100 p. 104-111	p. 56-59
Baltimore Gas and Electric Integrated Decarbonization Strategy (2022), **E3 (Prepared for Baltimore Gas and Electric)**			p. 19-20	p. 12-14	p. 16-18	p. 16-18	p. 30-36 p. 40	p. 19-25 p. 39-41
Philadelphia Gas Works Business Diversification Study (2021), E3, Econsult Solutions, Portfolio Associates *(Prepared for City of Philadelphia)*	p. 8-14	p. 11-13	p. 27-32	p. 25-26	p. 15-24	p. 25-26	p. 32-45 p. 58-60	p. 26-36

- *Page numbers indicate where featured topics are covered in each report*
- *Colored boxes indicate partial coverage in study*

APPENDIX C – ADDITIONAL READING

- Gas System Evaluations and Forecasts – Numerous Publications Groundwork Data (2021-current)
- Scoping a Future of Gas Study: In support of Massachusetts DPU Case No. 20-80 Prepared by Synapse Energy Economics for Conservation Law Foundation (2021)
- Modernizing Gas Utility Planning: New Approaches for New Challenges Regulatory Assistance Project (2022)
- A Regulator's Blueprint for 21st Century Gas Utility Planning Prepared by Strategen for Advanced Energy United (2023)
- Non-Pipeline Alternatives to Natural Gas Utility Infrastructure: An Examination of Existing Regulatory Approaches Prepared by Strategen for Lawrence Berkeley National Laboratory (2023)
- Natural Gas Delivery Plan: 4th Quarter 2024-2034 Consumers Energy (2023)
- Consumers Energy Gas Bill Impact Analysis: A Case Study of the Effects of Planned Capital Expenditures and Electrification Trends Prepared by Strategen for Advanced Energy United (2023)
- How Cities Can Mitigate the Impacts of the Gas System and Accelerate the Shift to Clean Energy Institute for Market Transformation and Groundwork Data (2024)
- Non-Pipeline Alternatives: Emerging Opportunities in Planning for U.S. Gas System Decarbonization RMI and National Grid (2024)
- Regulatory Approaches for a Cost-Effective Gas Transition: Ratemaking, Incentives, and Other Tools Prepared by Strategen for Advanced Energy United (2024)
- Decarbonizing the Obligation to Serve Building Decarbonization Coalition (2024)
- Leaked and Combusted: Strategies for reducing the hidden costs of methane emissions & transitioning off gas HEET (2024)
- Opportunities for Integrating Electric and Gas Planning Regulatory Assistance Project and Lawrence Berkeley National Laboratory (2025)
- Momentum: Quarterly Building Decarbonization Update with Link to Future of Gas Dockets Building Decarbonization Coalition (2025)

ENDNOTES

[1] "Table 2.1. Number of Ultimate Customers Served by Sector, by Provider (2014-2024)," U.S. Energy Information Administration Electric Power Annual, 2024, https://www.eia.gov/electricity/annual/table.php?t=epa_02_01.html.
[2] "U.S. EIA Natural Gas," Number of Natural Gas Consumers, 2019-2024, November 28, 2025, https://www.eia.gov/dnav/ng/ng_cons_num_dcu_nus_a.htm.
[3] Sonal Patel, "Investor-Owned Utilities to Spend $1.1T in Grid Boost as Power Demand Spirals," *Power*, October 9, 2025, https://www.powermag.com/investor-owned-utilities-to-spend-1-1t-in-grid-boost-as-power-demand-spirals/.
[4] "Gas Utility Construction Capital Expenditure," American Gas Association, 2025, https://www.aga.org/research-policy/resource-library/gas-utility-construction-capital-expenditure/.
[5] Dorie Seavey, *Leaked & Combusted: Strategies for Reducing the Hidden Costs of Methane Emissions & Transitioning off Gas* (HEET, 2024), https://assets-global.website-files.com/649aeb5aaa8188e00cea66bb/663a27270c0fa4fffcfe447d_Leaked-and-Combusted-May-2024.pdf.
[6] American Gas Association, "Gas Utility Construction Capital Expenditure."
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[8] Matthew Land et al., *US Governors Are Leading Efforts to Tackle the Cost of Electricity* (RMI, 2025), https://rmi.org/us-governors-are-leading-efforts-to-tackle-the-cost-of-electricity/; Hal Harvey and Sonia Aggarwal, *America's Power Plan Overview: Rethinking Policy to Deliver a Clean Energy Future* (Energy Innovation, 2013), https://energyinnovation.org/report/overview-rethinking-policy-to-deliver-a-clean-energy-future/.
[9] Megan Anderson et al., *Under Pressure: Gas Utility Regulation for a Time of Transition* (Regulatory Assistance Project, 2021), https://www.raponline.org/wp-content/uploads/2023/09/rap-anderson-lebel-dupuy-under-pressure-gas-utility-regulation-time-transition-2021-may.pdf.
[10] "Delivering Natural Gas," American Gas Association, accessed October 31, 2025, https://www.aga.org/natural-gas/reliable/delivering-natural-gas/.
[11] American Gas Association, "Gas Utility Construction Capital Expenditure."
[12] Marquez et al., *Residents of 49 States and Washington, D.C., Face Increasing Electric and Natural Gas Bills*.
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