NARUC
National Association of Regulatory Utility Commissioners

Potential State Regulatory Pathways to Facilitate Low-Carbon Fuels

A Product of the National Association of Regulatory Utility Commissioners (NARUC) in Partnership with the U.S. Department of Energy

Kiera Zitelman
Technical Manager, NARUC Center for Partnerships & Innovation

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Disclaimer

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Executive Summary

Hon. Diane X. Burman, New York State Public Service Commission
Chair, DOE-NARUC Natural Gas Partnership

Hon. D. Ethan Kimbrel, Illinois Commerce Commission
Chair, NARUC Committee on Gas

Andreas Thanos, Gas Policy Specialist, Massachusetts Department of Public Service
Chair, NARUC Staff Subcommittee on Gas

States and the federal government are increasingly engaged in the challenges around decarbonizing the electric grid. In particular, regulators, consumers, stakeholders, and utilities recognize the need to carefully consider the role natural gas will play in a decarbonized future. A variety of technology and policy options to reduce greenhouse gas emissions associated with natural gas use are available, including energy efficiency programs, demand reduction tools, strategic electrification, and strategies to reduce emissions from natural gas production, transportation, and consumption.

Low-carbon fuels – mainly renewable natural gas (RNG) and clean hydrogen – are being considered an important component of decarbonization goals. RNG and hydrogen may be able to meaningfully reduce emissions from processes independent of geologic natural gas, displacing emissions of methane, a powerful greenhouse gas. Although RNG and hydrogen are not cost-competitive today with geologic natural gas and are smaller in scale and potential than other decarbonization options, they can be explored as potential critical tools to decarbonize sectors that are difficult to electrify or shift off of natural gas entirely, such as air travel, industrial processes, maritime transport, long-distance trucking, space heating on cold days, and railroads (Nadel, 2022). The role of this report is to provide informational context for state utility regulators to understand the impacts of and challenges associated with broader integration of low-carbon fuels, followed by examples of state regulatory actions taken to date to facilitate the development of low-carbon fuels.

Setting clear guidance to calculate the environmental benefits of low-carbon fuels and continuing federal and state investments in research and development to reduce costs relative to fossil fuels will be important steps to take to signal the desire to grow the market for these fuels. State public utility commissions may play a key role in setting regulatory frameworks for low-carbon fuels and ensuring that ratepayer funds, if utilized, are done so to further the public interest.

This report is intended to summarize decisions that states have made to date on low-carbon fuels. In the spirit of understanding the current market and sharing information, this report provides success stories, and lessons learned across states as regulators implement varying strategies to achieve decarbonization objectives while maintaining their focus on affordability, safety, and reliability of the energy system. The report begins with an introduction of the role of natural gas in the U.S. economy (Section I) and background information on natural gas use, decarbonization, and low-carbon fuels (Section II). Next, the report describes the current market by discussing the scale of current production, emissions intensity, resource potential, and costs of low-carbon fuels compared to geologic natural gas (Section III). Following these sections, the report describes four strategies states have employed to facilitate low-carbon fuels: opening exploratory dockets, approving voluntary tariffs for customers, approving interconnection tariffs for producers, and considering portfolio-wide procurement targets (Section IV). This section lists states that have taken actions in each category, citing utility filings, commission decisions, stakeholder comments, and other relevant sources. Finally, the report concludes with suggested questions regulators may wish to consider regarding low-carbon fuels, in the interest of preparing to make decisions in the future (Section V). These questions include:

A. Are there existing regulatory or technical barriers to voluntary purchases of low-carbon fuels? Can customers work with utilities to procure low-carbon fuels; are producers able to interconnect projects without significant barriers to entry?

B. Should the infrastructure and/or commodity costs of low-carbon fuels be socialized among all ratepayers, or borne solely by the large commercial and industrial (C&I) customers currently driving the market? Should regulated natural gas and/or electric utilities own and operate low-carbon fuel production?

C. How should regulators consider the unique decarbonization potential of low-carbon fuels, particularly for hard-to-abate sectors, in decision-making? Is additional direction or clarity from state policymakers needed?

D. What no-regrets approaches can help facilitate both near-term RNG development and long-term development of hydrogen and other zero-carbon fuels?

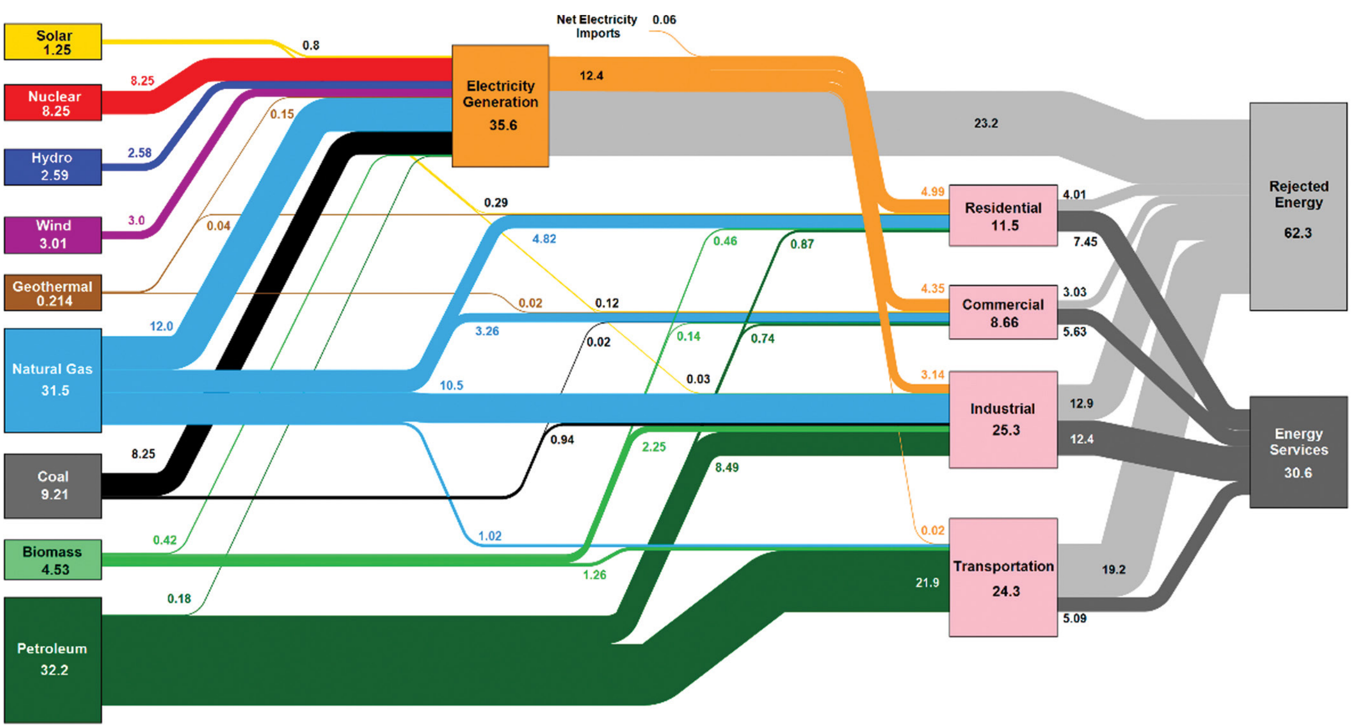
We collectively wish to express our gratitude to the U.S. Department of Energy, Office of Fossil Energy and Carbon Management, for supporting this report and other technical assistance resources for state regulators on natural gas topics. State regulators operate under a variety of policy environments, and states have vastly different types of energy resources, infrastructure, and customers. While there is no optimal regulatory, policy, or technological solution that will be successful in every state, state regulators can benefit by exchanging lessons learned with their peers across the country. We look forward to continued engagement with our fellow commissioners, commission staff, NARUC, the U.S. Department of Energy, and other stakeholders to develop sound regulation in the public interest.

I. Introduction

Over the past 15 years, the emergence of cost-competitive wind, solar, and energy storage technologies have led to a gradual increase in the portion of electricity generated by zero-carbon resources.[1] Growth in domestic natural gas production because of the "shale revolution" in the late 2000s led to natural gas steadily overtaking the share of electricity produced by coal, which provided almost half of generation in 2007. Last year, natural gas provided nearly 40 percent of U.S. electricity, followed by coal at 22 percent, renewables at 20 percent, and nuclear at 19 percent (U.S. EIA, July 15, 2022). More recently, numerous states and the Biden administration are pursuing decarbonization goals. Increasingly, these goals apply to multiple sectors or the entire economy, with major implications for the future operations of natural gas utilities and choices and costs for customers in the residential, commercial, industrial, and transportation sectors.

In this policy environment, policymakers and regulators are considering low-carbon fuels as one potential enabler of economy-wide decarbonization alongside other pathways. Low-carbon fuels are defined as liquid or gaseous fuels that can replace conventional or geologic fossil fuels, such as natural gas, coal, and petroleum, while producing lower greenhouse gas (GHG) emissions. Natural gas is a critical fuel for the U.S. economy (see **Figure 1**), accounting for one-third of total energy consumption in 2020. Of the 31.5 quadrillion (1015) British thermal units (BTUs) of natural gas that was consumed that year, 12 quads went to electricity generation, while 18.6 quads went directly to residential (4.82 quads), commercial (3.26 quads), and industrial (10.5 quads) customers that use natural gas for space and water heating, cooking, combined heat and power, and other industrial processes. The remaining 1.02 quads were used in the transportation sector, mainly for vehicles using compressed natural gas (CNG) as a fuel (LLNL, n.d.).

Figure 1: Estimated U.S. Energy Consumption in 2020 (Lawrence Livermore National Laboratory)



Source: LLNL March, 2021. Data is based on DOE/EIA MER (2020). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

1 Zero-carbon resources also include hydropower and nuclear energy. Both resources have contributed a consistent share of electricity over the past two decades, with hydropower accounting for approximately 6 percent of total electricity generation and nuclear energy accounting for approximately 19 percent.

II. Background Information

A. Natural Gas and Decarbonization

Numerous state-level decarbonization goals require the reduction or elimination[2] of GHG emissions associated with uses of all conventional fuels, including natural gas, whether through replacing natural gas with alternative fuel sources that produce lower GHG emissions or reducing the overall use of natural gas for electricity, heating, and/or industrial processes. Electrification from natural gas power generation fitted with carbon dioxide capture technology, depending on the level of carbon dioxide captured and stored, will have lower lifecycle GHG emissions. This approach is seen as a key pathway to decarbonization, paired with increasing electricity production from zero-carbon sources, such as wind, solar, nuclear, and energy storage (Steinberg et al., 2017). New, high-efficiency heat pumps, electric induction ovens and ranges, heat pump water heaters, and other more efficient energy technologies offer customers alternatives to natural gas-powered devices.

Some stakeholders have pointed to electrification as an option for meeting GHG reduction goals. In a study of building electrification in varying climates using data from Houston and Oakland as moderate climates and Chicago and Providence as cold climates, RMI found that retrofit costs and energy consumption made electrification a more expensive option for existing natural gas customers than continued reliance on natural gas. However, electrification was a cheaper long-term option for new construction:

> "In many scenarios, notably for most new home construction, we find electrification reduces costs over the lifetime of the appliances when compared with fossil fuels. However, for the many existing homes currently heated with natural gas, electrification will increase costs at today's prices… Customers with existing gas service face higher upfront costs to retrofit to electric space and water heating compared with new gas devices, and either pay more for energy with electric devices [in cold climates] or save too little in energy costs to make up the additional capital cost [in moderate climates]" (Billimoria, Guccione, Henchen, and Louis-Prescott, 2018).

The Electric Power Research Institute (EPRI) has noted the lack of a broadly accepted cost-effective framework to quantify the value of electrification, pointing to particular challenges obtaining data and using established methodologies to estimate risks of electrification to the utility, impacts on wholesale electricity prices, and impacts to participants and society (EPRI, 2019).

As technologies and valuation methodologies for electrification continue to evolve, strategies to reduce emissions from natural gas infrastructure remain one of multiple potential pathways to achieving important to decarbonization goals. In a 2022 paper, ICF analysts stated:

> "Particularly since the electricity sector is already making strong progress towards decarbonization through the use of zero-carbon power generation and distributed energy resources—and continued electric vehicle growth seems likely in the transportation sector—some policies have begun to focus on 'electrifying' natural gas and other non-electric energy end uses with the idea that, once the grid is decarbonized, the energy sector will then reach net-zero. However, it's also possible for other technologies, such as those offered by gas utilities, to support deep decarbonization or even net-zero emissions targets by directly reducing their emissions and helping their customers reduce emissions as well. In some regions, decarbonization pathways that maintain a role for gas in the energy system may help improve the likelihood of meeting climate goals on the basis of such

2 20 states (California, Colorado, Hawaii, Illinois, Louisiana, Maine, Maryland, Massachusetts, Michigan, Nebraska, Nevada, New Jersey, New Mexico, New York, North Carolina, Oregon, Rhode Island, Virginia, Washington, and Wisconsin), the District of Columbia, and Puerto Rico have set goals of 100 percent carbon-free or net-zero electricity by between 2033 and 2050. Of this group, Louisiana, Maryland, Massachusetts, Michigan, and Oregon have economy-wide goals; other state goals apply only to energy or electricity generation (Clean Energy States Alliance, n.d.).

considerations as feasibility, reliability and resilience, flexibility, customer impacts, and energy equity" (Snell and Narbaitz, 2022).

Methane, the largest component of geologic natural gas, has a global warming potential of 81 – 83 times that of carbon dioxide on a 20-year timescale, making the natural gas sector an important area for policymakers and regulators to address to mitigate climate change (Cyrs, Feldmann, and Gasper, 2020 and U.S. EPA, 2022). The next section explores the potential for hydrogen and renewable natural gas (RNG) to mitigate methane emissions from the natural gas sector.

B. Production of Low-Carbon Fuels

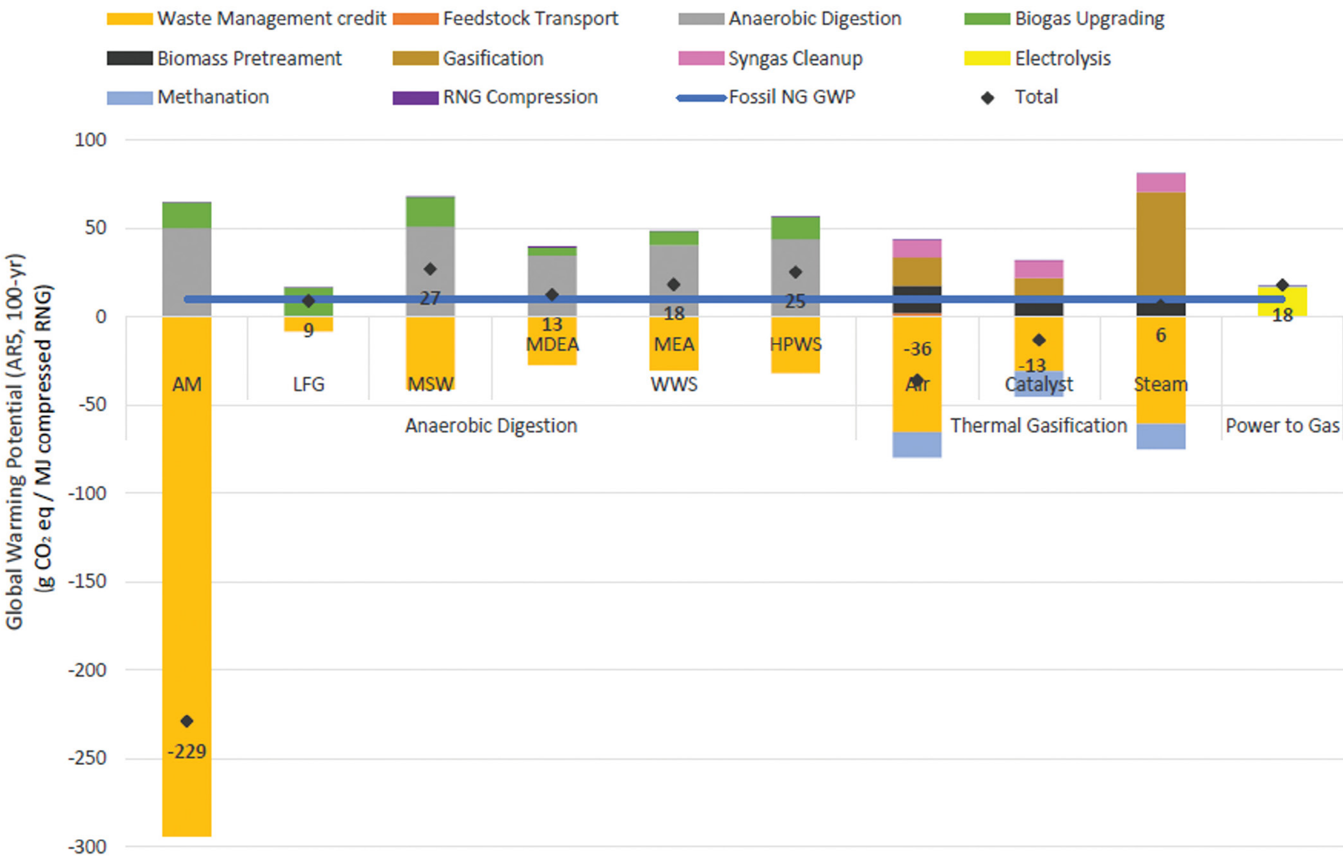
Hydrogen (H2) and RNG have emerged as the most promising low-carbon replacement options for conventional natural gas (Snell and Narbaitz, 2022). Hydrogen, while a different molecule from RNG or conventional natural gas, can be burned to generate heat, similar to methane. Hydrogen can be produced from diverse domestic feedstocks, including fossil fuels, biomass, and water via electrolysis, or other methods to isolate H2 molecules (U.S. DOE, n.d.). RNG is defined by the U.S. Department of Energy as "pipeline-quality gas that is fully interchangeable with conventional natural gas," generated from processed gaseous products of the decomposition of organic matter (U.S. DOE, EERE, n.d.).

Depending on feedstocks and production processes, hydrogen and RNG can be produced with lower life-cycle greenhouse gas emissions than conventional natural gas, helping to drive the decarbonization of end uses dependent on natural gas. Currently, 95 percent of U.S. hydrogen production comes from natural gas via steam methane reforming, a process often categorized as "grey hydrogen" in which methane reacts with steam under high pressure to produce hydrogen, carbon monoxide (CO), and carbon dioxide (CO_2). The hydrogen is separated; the carbon monoxide is combined with water in a water-gas shift reaction to produce additional hydrogen, carbon dioxide, and heat (U.S. DOE, EERE, n.d.). "Blue hydrogen" refers to the application of carbon capture technologies to grey hydrogen production, whereby, the CO_2 is captured and permanent stored in geologic reservoir (also referred to as CO_2 sequestration) or is utilized for another purpose, such as building products, rather than releasing it to the atmosphere. Hydrogen can also be produced by water electrolysis using renewable or nuclear energy, from the gasification of coal, methane pyrolysis (the thermal splitting of methane), or as a byproduct of industrial chemical processes (NARUC, 2021).

RNG can be produced from sources such as landfills, organic waste, water treatment plants, and agricultural processes. RNG production methods include anaerobic digestion, thermal gasification, pyrolysis, and power-to-gas. Anaerobic digestion, in which microorganisms break down organic material in an environment without oxygen, accounts for the majority of RNG production. Thermal gasification applies high-temperature gases to feedstocks to separate and capture methane (DOE AFDC, n.d.).

The National Energy Technology Laboratory (NETL) released an evaluation of RNG life cycle global warming potential (GWP) impacts for RNG produced through anaerobic digestion, thermal gasification, and power-to-gas. The study found impacts ranging from -229 to 27 grams of CO_2 equivalent per megajoule (gCO_2e/MJ), shown below in **Figure 2**. Anaerobic digestion of animal manure was cited as the most beneficial pathway from a global warming perspective, with net GWP ranging from -229 to -188 gCO_2e/MJ. However, the authors conclude: "the process of RNG production in itself is not always carbon neutral or carbon negative. The GWP impact of RNG production is highly dependent on the production pathway and feedstock" (Rai et al., 2022).

Figure 2: Consequential LCA of RNG Pathways (NETL, 2022)



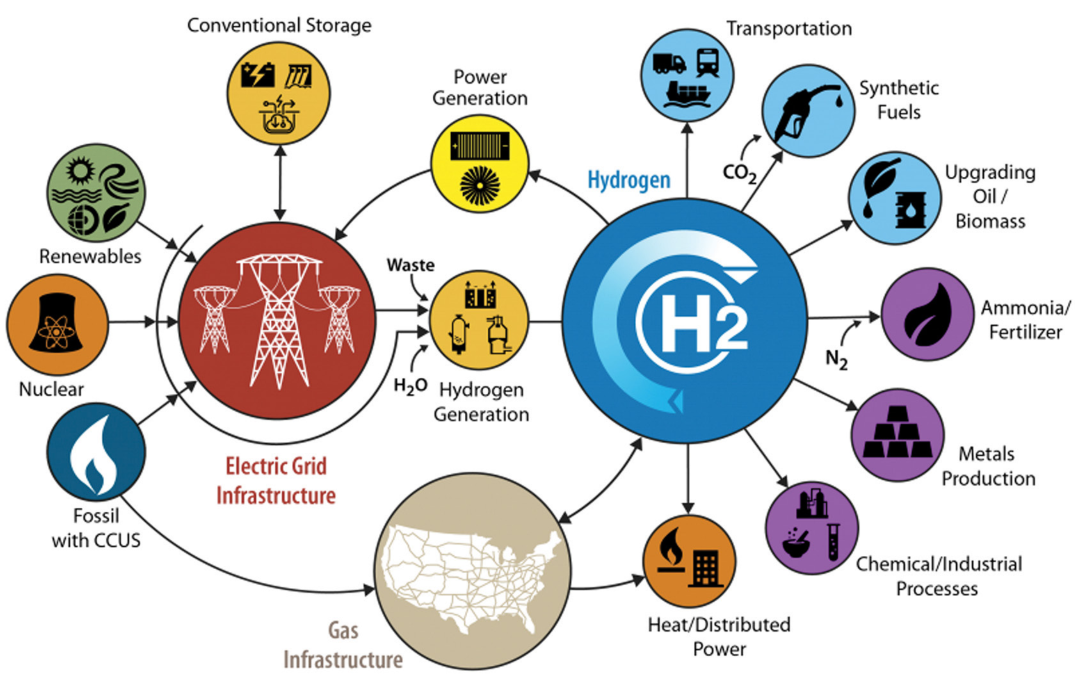
As low-carbon fuels, hydrogen and RNG have the potential to be used in place of geologic natural gas for electricity generation, transportation, and direct uses by residential, commercial, and industrial customers. Gas turbines that currently use natural gas to generate electricity can run on varying percentages of hydrogen-natural gas blends, although it is important to note that modifications to fuel accessories, bottoming cycle components, and plant safety systems may be needed (GE, 2021). Hydrogen can play a role in decarbonizing the transportation sector by powering fuel cell vehicles, which produce zero emissions (DOE AFDC, n.d.). Hydrogen can also support decarbonization in the buildings sector by powering on-site fuel cells. Hydrogen-natural gas blends can satisfy direct uses that are currently entirely reliant on geologic natural gas, although higher blends of hydrogen bring up safety considerations (see next section) and may require investments in retrofitted or new appliances. Hydrogen is a highly versatile energy carrier capable of meeting needs across diverse industries, shown in **Figure 3**.

Figure 3: Existing and Emerging Demands for Hydrogen (DOE Hydrogen Program Plan, 2020)

	Transportation Applications	Chemicals and Industrial Applications	Stationary and Power Generation Applications	Integrated/Hybrid Energy Systems
Existing Growing Demands	• Material-Handling Equipment • Buses • Light-Duty Vehicles	• Oil Refining • Ammonia • Methanol	• Distrubuted Generation: Primary and Backup Power	• Renewable Grid Integration (with storage and other ancillary services)
Emerging Future Demands	• Medium-and Heavy-Duty Vehicles • Rail • Maritime • Aviation • Contruction Equipment	• Steel and Cement Manufacturing • Industrial Heat • Bio/Synthetic Fuels	• Reversible Fuel Cells • Hydrogen Combustion • Long-Duration Energy Storage	• Nuclear/Hydrogen Hybrids • Gas/Coal/Hydrogen Hybrids with CCUS • Hydrogen Blending

Hydrogen and RNG offer other benefits in addition to advancing decarbonization. The use of low-carbon fuels diversifies domestic energy production, increases sustainability of waste management practices, leverages existing infrastructure, and provides local economic and air quality benefits, particularly if hydrogen or RNG replaces the use of diesel or gasoline in transportation (EPA, n.d. and Cyrs, Feldmann, and Gasper, 2020). RNG production takes products that would otherwise be wasted, producing methane emissions in the process, to create valuable fuel supplies. The wide variety of feedstocks and production methods for both hydrogen and RNG make both fuels suitable for production in various environments, depending on local availability of feedstocks. In addition to substituting for geologic natural gas, hydrogen can be used as an input to various processes, shown in **Figure 4**. Natural gas infrastructure is an important enabler of hydrogen use, as seen in the bottom of the figure. On the other hand, both hydrogen and RNG face obstacles to utilization, including higher costs in comparison to conventional natural gas, safety questions, operational concerns, and other issues discussed in forthcoming sections.

Figure 4: DOE's Vision of the Hydrogen Economy (DOE EERE)



C. Transportation of Low-Carbon Fuels

Following production and processing, low-carbon fuels must be transported to customers, whether to electric generators or residential, commercial, industrial, or transportation users. The U.S. has an extensive natural gas pipeline distribution system consisting of approximately three million miles of mainline and other pipelines that transported 27.7 trillion cubic feet of natural gas to 77.3 million customers in 2020 (EIA, 2021 Nov). State utility regulatory commissions oversee local distribution company (LDC) programs to replace aging cast iron and bare steel pipelines with modern materials less prone to leaks or damage (Thanos and Zitelman, 2020). The existing gas distribution network can help enable the transportation of low-carbon fuels to customers, although infrastructure investments and appliance upgrades may also be needed.

Estimates of how much methane leaks from natural gas distribution pipelines vary. According to the U.S. Environmental Protection Agency (EPA), between 50 and 65 percent of global methane emissions originate from anthropogenic sources, including oil and gas production, transportation, and end use; landfills; agricultural activities; coal mining; wastewater treatment; and industrial processes. The EPA's Greenhouse Gas Emissions and Sinks database estimates that the oil and gas sector accounts for 30 percent of anthropogenic methane emissions in the U.S. Within the sector, distribution pipelines account for 7 percent of methane emissions, with gas production accounting for 48 percent, oil production 20 percent, transmission and storage 19 percent, and processing 6 percent (EPA, 2021). A study in *Environmental Science & Technology* estimated methane leakage from natural gas distribution pipeline mains at 690,000 metric tons of methane per year (Weller, Hamburg, and von Fischer, 2020).

Utilities, pipeline operators, and regulators must carefully consider the environmental and safety implications of blending low-carbon fuels into existing pipelines made for the transport of geologic natural gas. Because it is the same molecule as geologic natural gas – methane (CH_4) – RNG can be injected into existing gas pipelines and transported and used in the same way as geologic natural gas. Pipeline operators define and maintain gas quality standards that apply to any material injected into their pipelines, and RNG, like geologic natural gas, must meet those standards (GTI, 2012). Depending on the feedstock and production method, RNG may contain trace elements of non-methane molecules, such as carbon dioxide, nitrogen, oxygen, hydrogen sulfide, and total sulfur, as well as trace organics, including aromatic hydrocarbons, aldehydes, and ketones, but these elements are often found in geologic natural gas (EPA, 2020). RNG can be conditioned or upgraded to remove some of these nonmethane molecules.

When first recovered, both geologic natural gas and landfill-derived RNG require processing to meet the gas quality standards of pipeline transporters. Indeed, the gas treatment processes for landfill-derived RNG are similar to and derived from the processes used to remove contaminants from geologic natural gas (Coalition for Renewable Natural Gas, 2016). Additional cleaning or processing (e.g., membranes, pressure swing adsorption, solvent scrubbing, and water scrubbing) may be required by a gas producer prior to pipeline injection. The Coalition for Renewable Natural Gas, a public policy organization and educational platform for RNG use, maintains a database of major transmission pipeline tariffs (Coalition for Renewable Natural Gas, n.d.). The Northeast Gas Association developed an interconnection guide for RNG in 2019 for New York, (discussed in more detail in Section IV.B). The guide is currently being updated to include considerations for hydrogen.

> In 2012, GTI Energy compared pipeline gas quality standards against samples of landfill gas-derived RNG and geologic natural gas and found that the RNG samples satisfied gas quality standards for almost all parameters, but noted that some RNG samples could fall outside certain specification ranges, such as Wobbe number (an indicator of the energy of gas within a given volume, measured as the ratio between calorific value and specific gravity or relative density), diluents and inerts, and nitrogen (GTI Energy, 2012).

Hydrogen is a completely different molecule than methane, presenting more significant considerations related to safe transportation and end use. The U.S. has only 1,600 miles of dedicated hydrogen pipeline (DOE HFTO), meaning that transportation methods of bringing hydrogen to end use customers are limited. In recognition of the challenges of siting and constructing new dedicated hydrogen pipelines, blending hydrogen into the three million miles of natural gas pipelines may be a readier option in the near term to distribute hydrogen to customers. Given the lack of dedicated hydrogen distribution infrastructure, most hydrogen is produced at or close to where it is ultimately used. Steam methane reforming powered by natural gas accounts for almost all domestic production; landfill gas / biogas can be used as an input, but geologic natural gas dominates the market due to its much lower cost (U.S. EIA, 2021). The degree to which hydrogen can be safely blended with natural gas in distribution pipelines without risking damage to pipes and other related gas network infrastructure and/or appliances, as well as leaks or explosions that could threaten human health and safety, is currently under review by many research institutions; this research is reviewed in more detail below.

Hydrogen is a smaller molecule than methane, making its leakage rate[3] through pipe walls and joints about three times higher, and it is extremely flammable (Blanton, Lott, and Smith, 2021). Hydrogen embrittlement, in which interactions between hydrogen molecules and pipeline materials lead to hydrogen-assisted fractures and degraded mechanical properties of metals in pipelines, is a threat to pipeline integrity. Hydrogen embrittlement correlates with hydrogen blend levels to a degree, although pipeline materials, environmental characteristics, and stress / mechanics also influence embrittlement (Ronevich and San Marchi, 2019). A 2013 NREL study found that hydrogen blending at 5 – 20 percent of total volume of gas appeared to be viable "without significantly increasing risks associated with utilization of the gas blend in end-use devices (such as household appliances), overall public safety, or the durability and integrity of the existing natural gas pipeline network" (Melaina, Antonia, and Penev, 2013).

In addition to concerns about the ability of natural gas distribution pipelines to carry hydrogen at levels beyond 20 percent, end use device requirements pose a major constraint to higher hydrogen blend levels. Appliances are optimized for use with pure natural gas, and increased hydrogen concentrations could lead to potentially dangerous malfunctions (Blanton, Lott, and Smith, 2021).

Numerous public and private research efforts are underway to facilitate the safe integration of hydrogen into existing gas distribution pipelines and appliances (Blanton, Lott, and Smith, 2021). DOE's HyBlend initiative is funding research to test pipeline materials under varying concentrations of hydrogen. Data will feed into two publicly available tools to (a) characterize the costs of hydrogen blending and its potential for emissions reductions, and (b) assess the risks of blending to a pipeline system given the pipe materials, age, and blend concentration (DOE HFTO). In addition, DOE funds a consortium of National Laboratories called the Hydrogen Materials Compatibility Consortium (H-Mat), led by Sandia National Laboratories and Pacific Northwest National Laboratory, which conducts research on the compatibility of various pipeline materials with hydrogen blends. Outside of the U.S., demonstration projects in Europe have successfully blended hydrogen at concentrations of up to 20 percent (Ronevich and San Marchi, 2019). Overall, the safe or acceptable level of hydrogen blending is dictated by pipeline materials and end uses and is dependent on operating conditions. These research efforts can help pipeline operators better understand constraints and opportunities for blending hydrogen into existing gas distribution networks.

Regulating the safety of gas pipelines is a shared responsibility between state and federal regulators. Federal statutes grant states the ability to assume safety authority over intrastate gas pipelines; states must adopt minimum federal pipeline safety regulations to assume authority. In states that do not adopt minimum federal regulations, PHMSA takes responsibility for inspection and enforcement (PHMSA, n.d.).

3 Newer polyethylene plastic pipes have been shown to be compatible with hydrogen, with an estimated annual leakage rate of between 0.0005 and 0.0001 percent of the total transported volume (Blanton, Lott, and Smith, 2021).

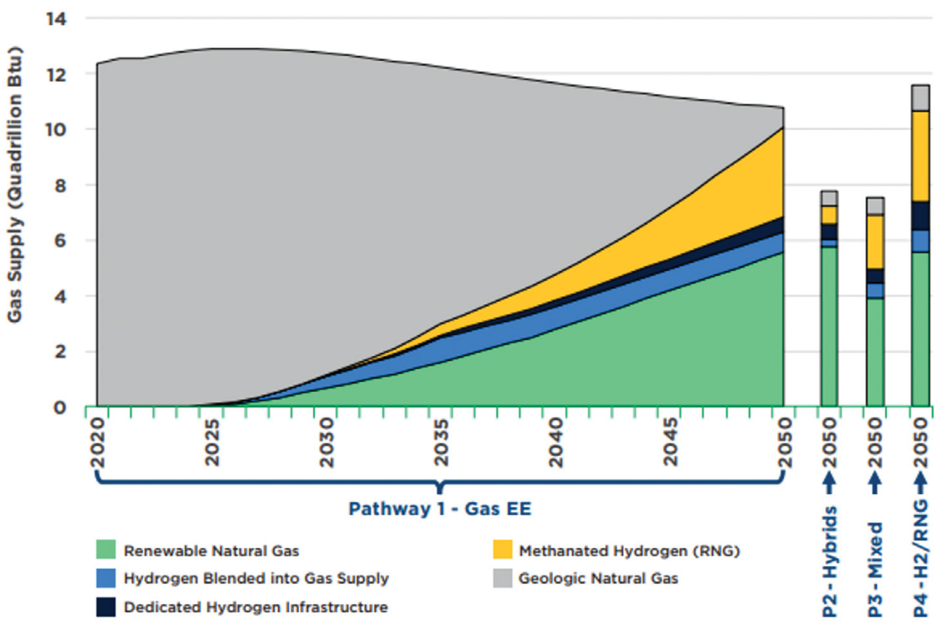
III. Current Market for Low-Carbon Fuels

With a foundational understanding of two of the low-carbon fuels being considered in many decarbonization discussions, this section provides data on the market and potential for these fuels, as well as methods for tracking attributes and currently available incentive programs.

A. Measuring the Decarbonization Potential and Quantifying the Contributions of Low-Carbon Fuels

Low-carbon fuels are one of four pathways available for gas utilities to reduce GHG emissions, alongside reducing consumption through efficiency and/or electrification, reducing utility system and upstream emissions from methane leaks, and using negative emissions technologies to offset emissions (Snell and Narbaitz, 2022). The EIA projects increasing natural gas consumption through 2050, driven by higher demand in the electric power and industrial sectors (U.S. EIA, March 2022). In a 2022 study for the American Gas Association, consultancy ICF compared four decarbonization scenarios[4] and calculated the reductions in emissions compared to a business-as-usual scenario by 2050 for three strategies: gas demand reductions; low-carbon fuels (defined as renewable natural gas, hydrogen blended into gas supply, and methanated hydrogen[5]); and carbon capture, offsets, and negative emissions technology. Across the scenarios, low-carbon fuels were responsible for between 39 and 59 percent of emissions reductions through 2050 (AGA, 2022). The ICF report estimated that by 2050, low-carbon fuels would account for nearly all gas demand in all scenarios (**Figure 5**). It is important to note that ICF's forecast includes only residential, commercial, LDC industrial, and transportation demand for natural gas and incorporates more conservative assumptions for demand growth, while EIA's annual energy outlook also incorporates gas exports and other industrial processes and projects more optimistic growth through 2050.

Figure 5: Utility Customer Gas Supply Mix (AGA, 2022)



4 The four decarbonization scenarios included:

1. Gas energy efficiency focus: leveraging existing infrastructure, demand-side management programs, and regulatory structures by expanding utility energy efficiency programs and incentivizing efficient natural gas technologies.
2. Hybrid gas-electric heating focus: focusing on coordinated gas and electric infrastructure planning through hybrid gas-electric heating systems and selective electrification of certain end uses.
3. Mixed technology approach: enabling customers' choice of efficient technologies, electrification, utility efficiency programs, and hybrid heating.
4. Renewable and low-carbon gas focus: prioritizing the decarbonization of the supply of gas in order to limit the need for major changes in energy infrastructure and equipment. Also includes gas energy efficiency improvements.

5 Methanated hydrogen is defined as renewable natural gas produced by methanating clean hydrogen with biogenic CO_2.

State-level clean fuels programs, such as California's Low Carbon Fuel Standard (LCFS), and the federal Renewable Fuel Standard (RFS) are the biggest drivers for the RNG market, incentivizing the production of RNG as a transportation fuel. Recent RNG projects intend to generate credits under the LCFS and/or RFS programs. Oregon's Clean Fuels Program began in 2016 and has reduced nearly six million tons of GHG emissions (Oregon Department of Environmental Quality, n.d.). In 2021, the state of Washington passed a clean fuels standard law, with the program expected to begin in January 2023 (Washington Department of Ecology, n.d.). There are no state- or federal-level programs providing similar incentives for non-transportation uses of RNG (M.J. Bradley & Associates,[6] 2019), meaning that RNG purchases outside of the transportation sector are driven entirely by voluntary customer demand for low-carbon fuels. It is worth mentioning that California has taken steps towards encouraging the use of low-carbon fuels outside of the transportation sector with the California Public Utilities Commission's February 2022 decision adopting a renewable natural gas standard, discussed in more detail in Section IV.D.1. The incentives available to RNG producers through the LCFS and RFS programs have resulted in more than three-quarters of RNG production dedicated to transportation customers (Patel, 2021).

As discussed in Section II, renewable natural gas and hydrogen can be produced from a variety of feedstocks, underscoring the importance of developing carbon intensity methodologies that account for where and how the fuel was produced, as well as the counterfactual of what would happen to the feedstock if it were not used in RNG production and to what extent that use would release GHG emissions. Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model is a broadly accepted method of calculating lifecycle emissions for RNG. California's LCFS program uses a California-specific variation of the GREET model, known as CA-GREET, to calculate lifecycle emissions (**Figure 6**).

Figure 6: California LCFS Carbon Intensities
(M.J. Bradley & Associates, 2017)

Gas Source	Carbon Intensity ($g\ CO_2e/MJ$)
California Natural Gas (Traditional)	78.37
Landfill Gas	46.42
Dairy Digester Gas	-276.24
Wastewater Treatment	19.34
Municipal Solid Waste (MSW)	-22.93
Source: California Air Resources Board	

More recently, ICF used California Air Resources Board (CARB) models to illustrate the emission intensities of current RNG supplies in the U.S. Compared to geologic natural gas, ICF found that RNG produced from anaerobic digestion ranges from net negative to approximately 60 percent of the emissions released by geologic natural gas, estimated at 63.9 kg CO_2e per million Btu (MMBtu) (**Figure 7**).[7] Notably, energy use associated with the digestion and gas processing steps produces the vast majority of emissions that occur during the RNG production and use life cycle. These values have the potential to, in the future, approach zero as increasing amounts of clean power and renewable gases are used in the RNG production process. Furthermore, the use of carbon capture in tandem with biologically derived RNG and hydrogen can achieve negative emissions beyond the avoidance of methane emissions.

As discussed in Section II.B, hydrogen can be produced from a variety of feedstocks using different production methods, underscoring that methods to calculate the carbon intensity of hydrogen must account for where and how it was produced. Steam methane reforming, the dominant method of producing hydrogen today,

Figure 7: Example of Current GHG Emission Factors in the RNG Supply Chain from Anaerobic Digestion of Feedstocks, Compared to Geologic Natural Gas (in kgCO_2e/MMBtu) (AGA, 2022)

6 In March 2020, M.J. Bradley & Associates was acquired by ERM Group.

7 RNG produced by thermal gasification (i.e., from agricultural residue, forest residue, energy crops, and municipal solid waste) releases between 53.2 to 55.0 kg CO_2e per MMBtu. See Section III.D for a discussion of the technical maturity of these production methods compared to anaerobic digestion, which accounts for the vast majority of RNG produced today.

emits approximately 10 kg CO_2 per kg H_2 (Bartlett and Krupnick, 2020).[8] Additionally, similar to RNG, methods for calculating the emissions benefits of hydrogen should account for not only the carbon intensity of the

RNG Production Process Anaerobic Digestion		Dairy Manure	Food Waste	Landfill Gas	WRRFs	Geologic Natural Gas
Collection & Processing	Feedstock Collection	–	2.0	–	–	7.8
	Digestion & Gas Processing	49.8	38.2	35.2	34.5	
	Avoided Emissions	-239.5	-109.8	–	–	–
Pipeline/ Transmission	Transmission[127]	3.0	3.0	3.0	3.0	3.0
End-Uses	Combustion	< 0.1	< 0.1	< 0.1	< 0.1	53.1
Total		**-186.7**	**-66.6**	**38.2**	**37.5**	**63.9**

production method but also the carbon intensity of the fuel displaced by the hydrogen.

Developing standards to measure the GHG emissions and, if desired by policymakers, other environmental attributes of hydrogen and RNG compared to geologic natural gas is a critical step towards expanding the market for low-carbon fuels as a decarbonization strategy. The emissions benefits of RNG depend on the feedstock (i.e., what would be released into the atmosphere if not captured for RNG production) and ultimate end use of the fuel (i.e., the fossil fuels that RNG displaces in power generation, transportation, or another use). Accounting for lifecycle emissions – "both positive and negative emissions impacts over a specific RNG production and use pathway, including avoided methane emissions at the feedstock source, emissions from energy consumption for fuel upgrading, methane leakage, and end-use emissions" – is the best method to evaluate the full emissions impacts of RNG (Cyrs, Feldmann, and Gasper, 2020). NETL's 2022 study, discussed in Section II.B, underscores this point and provides a potential path forward.

B. Scale of Current Hydrogen and RNG Markets

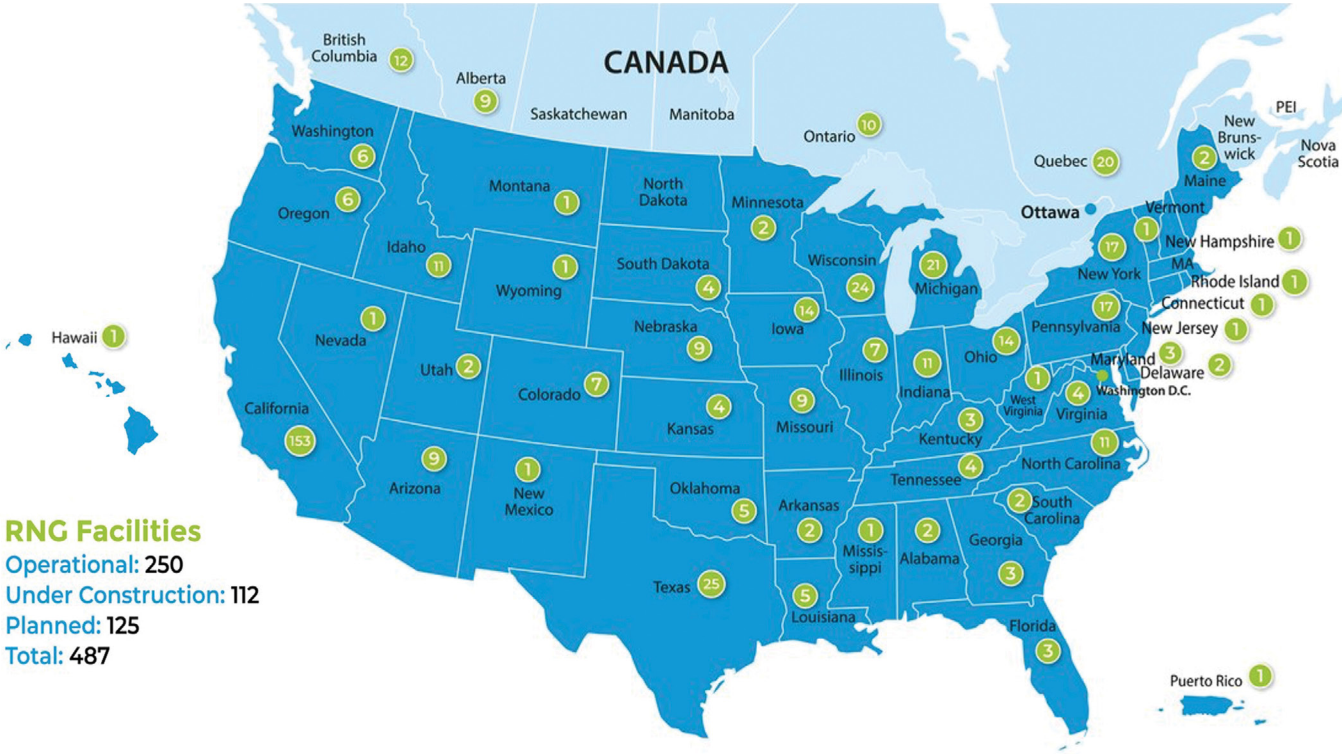
Policies to reduce carbon emissions in the electricity and, mainly, transportation sectors are the main drivers of RNG (Russell, Lowell, and Jones, 2017). There are some industrial and transportation customers that purchase hydrogen, but U.S. hydrogen production amounts to approximately 10 million metric tons annually, equivalent to 1 percent of total energy used in the U.S. each year. Current hydrogen production is mainly used for petroleum refining and ammonia production (DOE EERE, n.d.). In addition to decarbonization policies, large commercial and industrial customers voluntarily procure low-carbon fuels to reach corporate decarbonization targets.

Currently, 250 RNG facilities are operational across the U.S. and Canada, as shown in **Figure 8.** Another 112 facilities are under construction, and another 125 are earlier in the planning process. In 2019, U.S. RNG production totaled approximately 78 million cubic feet per day (Patel, 2021). Most RNG production originates from landfills, animal manure, and wastewater treatment plants. Landfills over a certain size threshold are required under Clean Air Act regulations to install systems to capture and route gas to energy recovery or flares,

8 Carbon intensity of hydrogen production ranges from zero, for renewable or nuclear electrolysis, up to 19 kg CO_2 per kg H_2 for the most carbon-intensive method of coal gasification. The former accounts for less than 1 percent of U.S. supply; the latter accounts for slightly under 5 percent.

resulting in landfills dominating the RNG market today (Cyrs, Feldmann, and Gasper, 2020). RNG supplies 40 percent of the fuel used by natural gas vehicles (Cyrs, Feldmann, and Gasper, 2020).

Figure 8: RNG Projects in the U.S. and Canada (Coalition for Renewable Natural Gas, 2022)



The EPA, through the Landfill Methane Outreach Program (LMOP), maintains a database tracking landfills accepting municipal solid waste. LMOP includes data on landfill gas energy projects, separated into categories for electricity, direct use, RNG for pipeline injection, and RNG for local use (EPA LMOP, 2022). The database included 119 RNG projects at landfills in 23 states and territories as of August 2022.

Animal manure is another major source of current RNG production. The EPA maintains a Livestock Anaerobic Digester Database under the AgSTAR program (EPA AgSTAR, 2021). According to the database, as of May 2022, 416 U.S. farms produce biogas using anaerobic digesters. Biogas contains methane and other products and must be upgraded to produce pipeline-quality RNG for consumption by vehicles or other end uses, according to Argonne National Laboratory's Renewable Natural Gas Database (Argonne, 2021).

Of the approximately 15,000 wastewater resource recovery facilities currently serving the U.S., 1,269 have on-site anaerobic digesters. The majority of facilities with digesters produce biogas for on-site energy needs. Fifteen facilities upgrade biogas to RNG, with twenty more in the construction or late development phases of implementing RNG projects (Cyrs, Feldmann, and Gasper, 2020).

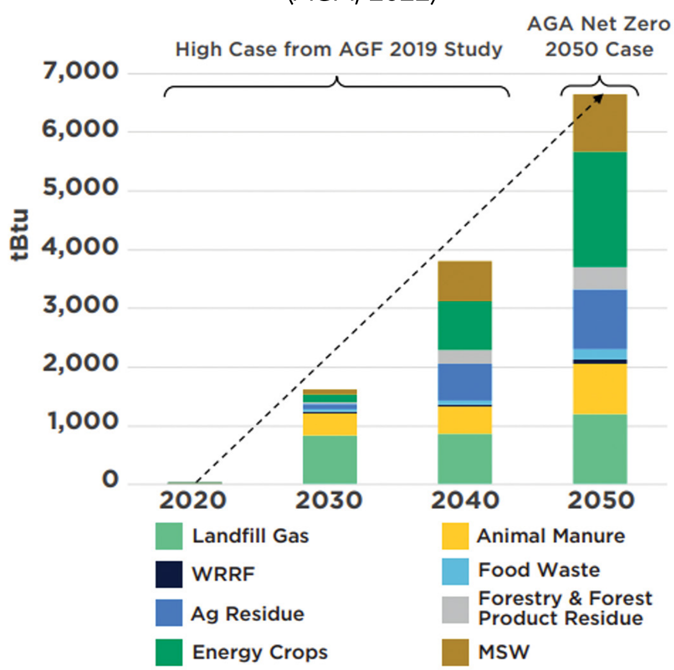
Looking towards the future, the American Council for an Energy-Efficient Economy (ACEEE) estimates a need for approximately nine quadrillion BTUs of alternative fuels by 2040 to support difficult-to-electrify sectors of the economy (ACEEE, June 2021). The largest projected needs will be for industrial high-temperature processes (projected to make up 36 percent of this need) and long-distance planes (defined as planes traveling more than 500 miles) which are projected to make up 34 percent of total projected need.

C. Resource Potential

A 2018 U.S. Department of Energy national assessment indicated that existing organic waste streams in the U.S. could produce enough RNG to displace 1,300 billion cubic feet (bcf) per year of natural gas, equivalent to 7 percent of geologic natural gas consumption (Milbrandt, Seiple, Heimiller, Skaggs, and Coleman, 2018). This estimated amount is large enough to play an important complementary role along with other decarbonization policies and technologies (Cyrs, Feldmann, and Gasper, 2020). While these potential assessments do not account for the economic barriers of bringing additional production online, they emphasize the ability of RNG to contribute to local climate and energy goals in any state with landfills, agricultural facilities, wastewater treatment plants, or other sources of organic matter – virtually the entire country. Additionally, these potential studies focus on the "wet-waste" feedstocks of landfills, food waste, animal manure, and wastewater, which rely on abundant feedstocks and commercially available production technologies. Including dry feedstocks (agriculture and forestry residues) increases the size of the potential RNG market to up to 2,200 bcf per year or 11 percent of natural gas use annually. RNG production from dry feedstocks, however, relies on thermal technologies that are not yet commercially mature, and climate benefits are not well quantified and highly variable by region (Cyrs, Feldmann, and Gasper, 2020).

The AGA's 2022 report discusses available RNG supply to support various decarbonization pathways. To achieve net-zero emissions in 2050, AGA estimates approximately 6,700 bcf of RNG will be produced from, in descending order, energy crops, landfill gas, agricultural residue, municipal solid waste, animal manure, forestry and forest product residue, food waste, and wastewater resource recovery facilities (**Figure 9**).

Figure 9: Projected RNG Supply by Feedstock
(AGA, 2022)



RNG and hydrogen are not cost-competitive with geologic natural gas today. RNG commodity costs average five times those of geologic natural gas. Interconnection costs are a significant contributor to overall RNG project costs and vary widely (ICF, 2019), making it difficult to specify a standard cost for delivered RNG. **Figure 10** below reproduces ICF's estimates of RNG costs for all feedstocks. For comparison, the average price of natural gas to residential, commercial, and industrial users in 2021 was $5.47/MMBtu, according to the EIA's 2021 energy outlook (EIA, 2021) – well below the cheapest low-cost estimate of $7/MMBtu for landfill gas and water resource recovery facilities. Significant volatility in natural gas markets throughout 2022 led EIA to raise its forecasts in the June 2022 short-term energy outlook, to an average of $8.71/MMBtu throughout summer 2022 and above $8 until a projected decline below $4 after winter 2023 (U.S. EIA, June 2022).

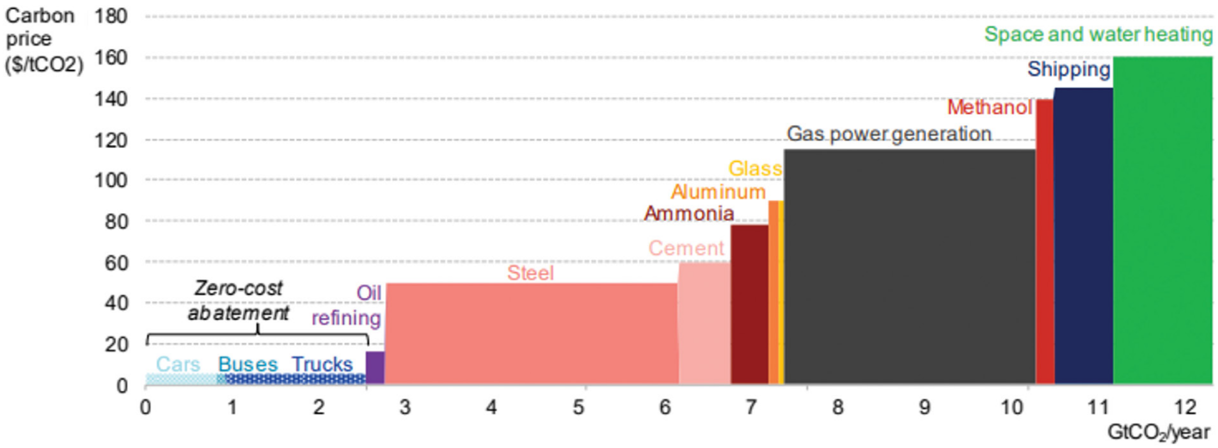
RNG producers face economic barriers to bring gas to market due to the need to not only capture and produce RNG from feedstocks but also process it to meet pipeline standards and physically connect to a pipeline for distribution, either directly via pipeline or by transporting RNG by truck from the production source to a pipeline, known as "virtual pipelining" (Russell, Lowell, and Jones, 2017). For this reason, larger, more concentrated sources of organic waste, such as large landfills, generally dominate RNG production today, as these facilities can take advantage of economies of scale to produce RNG at lower marginal costs than smaller facilities. Large landfills located close to pipeline infrastructure have an even greater cost advantage for RNG production (Cyrs, Feldmann, and Gasper, 2020).

Figure 10: Estimated RNG Costs (ICF, 2019)

Production method	Feedstock	Low-cost estimate ($/MMBtu)	High-cost estimate ($/MMBtu)
Anaerobic digestion	Landfill gas	$ 7	$19
	Animal manure	$18	$32
	Water resource recovery facilities	$ 7	$26
	Food waste	$19	$28
Thermal gasification	Agricultural residues	$18	$27
	Forestry and forest residues	$17	$29
	Energy crops	$18	$31
	Municipal solid waste	$17	$44
P2G	Renewable electricity	$23	$52

Low-carbon hydrogen production costs anywhere from approximately double the cost of geologic natural gas on a per MMBtu basis (for low-cost steam methane reformation with carbon capture technology) to three to six times the cost of geologic natural gas (for renewable electrolysis) (Bloomberg New Energy Finance, 2020). DOE's Hydrogen Energy Earthshot initiative has set a goal of reducing the cost of clean hydrogen by 80 percent to $1 per kilogram[9] by 2030.[10] Widely available clean hydrogen at DOE's aspirational $1 per kilogram cost would unlock massive emissions reductions, shown in **Figure 11**. Notably, gas power generation and space and water heating fall towards the end of the cost curve, indicating that low-cost clean hydrogen has greater potential to displace carbon emissions in transportation, oil refining, and the production of steel, cement, ammonia, aluminum, and glass – all industries with severely limited potential for electrification due to needs for high-temperature heat as an input to industrial processes.

Figure 11: Marginal Abatement Cost Curve from Using $1/kg Hydrogen for Emission Reductions, by Sector in 2050 (Bloomberg New Energy Finance, 2020)



9 Hydrogen has the highest energy content of any common fuel by weight, but the lowest energy content by volume. Approximately 30 percent of the energy content of natural gas, meaning that one kilogram of hydrogen (equal to 423 cubic feet) has the same energy content as 0.3 kilograms (equal to 127 cubic feet) of natural gas. See U.S. EIA's hydrogen explanation at https://www.eia.gov/energyexplained/hydrogen/ and the U.S. DOE Hydrogen Program's hydrogen conversion factors and fact card at https://www.nrel.gov/docs/gen/fy08/43061.pdf.

10 The Bipartisan Infrastructure Investment and Jobs Act of 2021 provided DOE with $8 billion in funding for clean hydrogen demonstration projects and $1.5 billion for clean hydrogen manufacturing (Shah, Witteman, Baumann, and Davis, 2021).

IV. Potential State Regulatory Pathways to Facilitate Low-Carbon Fuels

State utility regulatory commissions set just and reasonable rates for natural gas service, and oversee the safety, reliability, and affordability of the natural gas distribution system. Natural gas utilities have a duty to procure gas supplies at least cost to customers and, absent state or federal policy, cannot purchase RNG or hydrogen unless customers specifically request a low-carbon fuel instead of some portion of geologic natural gas (M.J. Bradley & Associates, 2019). As economic regulators, state regulatory commissions approve the rates paid by customers for natural gas, and thus play a key role in facilitating markets for low-carbon fuels. State commissions are already implementing several approaches to hydrogen and RNG, generally falling into four categories:

1. Opening exploratory dockets on clean heat, covering the use of low-carbon fuels to achieve decarbonization goals;
2. Approving voluntary tariffs for utility customers to purchase carbon offsets and/or RNG credits proportionate to their consumption of natural gas;
3. Approving tariffs for RNG suppliers to interconnect to a gas utility distribution system to transport gas to customers; and
4. Allowing or disallowing procurement targets for RNG as a portion of the total gas supply portfolio, with costs recovered from customers via rates; or allowing the recovery of infrastructure costs related to RNG production and interconnection as capital expenses from general rate base.

This section will provide examples of states pursuing each approach. It is important to note that some states are pursuing multiple regulatory pathways to facilitate low-carbon fuels, and none of these methods are mutually exclusive. Additionally, as independent regulators, state commissions operate under the authority granted to them by legislative and executive branches of state government. Many of the examples discussed below resulted from or required explicit statutory authority or executive order for the commission to take a particular action or open a docket to consider actions in line with statutory intent and public interest. These examples are shared to help inform state commissions as to how their peers are proceeding with regards to low-carbon fuels, not to recommend a particular regulatory action or policy outcome.

A. Exploratory Dockets on Clean Heat / Low-Carbon Fuels

Colorado

In 2019, House Bill 19-1261 set statewide GHG targets based on 2005 emissions, requiring 26 percent reductions by 2025, 50 percent by 2030, and 90 percent by 2050 (Colorado General Assembly, 2019). The Colorado Energy Office produced a roadmap in January 2021 showing intended pathways for each sector of the economy, with one sector being residential, commercial, and industrial fuel use, including gas distribution utilities (Colorado Energy Office, 2021). The roadmap clarified that Colorado does not have requirements for the state's gas distribution utilities to reduce GHG emissions but concluded that a 20 percent reduction from 2005 levels was "achievable by 2030." Biogas and hydrogen from renewable energy were specifically mentioned as options to replace gas sales and reduce emissions from transportation. The Energy Office had previously completed a study on RNG potential in Colorado, indicating that RNG could replace up to 10 percent of current gas use and noted the emissions benefits of capturing methane and putting it to productive use rather than releasing it into the atmosphere (Colorado Energy Office, 2019).

In October 2020, the Public Utilities Commission (PUC) opened an investigatory docket looking at whether changes in gas utilities could help meet the HB 19-1261 goals and what impacts those changes would have on utilities and customers. The docket gathered information about emissions from various segments of gas utility operations, expectations for reduced GHG emissions from methane use, options to decarbonize retail gas sales, impacts on low- to moderate-income customers, and the potential for electrification of current gas loads (Colorado PUC, 2020). The PUC organized a series of public meetings between November 2020 and May 2021 seeking broad input from utilities and stakeholders, with a March 2021 meeting dedicated to biomethane and hydrogen (Gilman, 2021).

In June 2021, the legislature clarified the responsibility of gas distribution utilities to contribute to the state's GHG goals with SB 21-264, implementing a performance standard allowing utilities to use a variety of approaches, including biomethane, hydrogen, and recovered methane, to reduce emissions. The statute required utilities to file clean heat plans reducing emissions by 4 percent by 2025 and 22 percent by 2030, based on a 2015 baseline. The legislation defined "recovered methane" as biomethane derived from municipal solid waste, pyrolysis, enzymatic biomass, or wastewater treatment; methane from active or inactive coal mines; or methane leaking from gas distribution pipelines. The PUC was granted authority to set targets for 2035 and beyond (Colorado General Assembly, 2021). Directed by the 2021 legislation, the PUC opened a rulemaking in September 2021 on clean heat plans and broader gas planning. Commissioner Megan Gilman noted that Colorado's clean heat legislation was "among the first in the country, so we're trying very hard to ensure that we have the proper rules in place to implement [SB 21-264]." The PUC expects utilities to submit multiple scenarios for clean heat plans similar to how Colorado conducts energy resource and clean energy plans for electric utilities, noting the costs, benefits, and emissions reduction contributions of the use of different technology options at different levels of deployment (Colorado PUC, 2021).

Massachusetts

In June 2020, the Massachusetts Department of Public Utilities (DPU) opened an investigation into the role of gas local distribution companies in the state's 2050 climate goals, as requested by a petition from the Massachusetts Office of the Attorney General (AGO) (Massachusetts DPU, 2021). In the AGO's petition, renewable natural gas was mentioned as a consideration in two ways: (a) to meet future gas demand and deliver verifiable GHG emissions reductions, and (b) as a feedstock for power-to-gas with hydrogen (Massachusetts AGO, 2020). Massachusetts local distribution utilities selected E3 and ScottMadden to develop a report analyzing decarbonization pathways to achieve emissions reduction goals. In March 2022, E3 and ScottMadden submitted the report, which found that "strategies that use both the gas and electric systems to deliver low-carbon heat to a portion of the buildings in Massachusetts show lower levels of challenge across a range of evaluation criteria" (E3 and ScottMadden, 2022, p. 11). The report also found that despite long-term uncertainty regarding decarbonization, blending of between 5 – 10 percent of renewable fuels into gas distribution systems was a low-regret decarbonization technology that should be pursued, along with energy efficiency, building electrification, and renewable electricity.

Regulated gas utilities filed operating plans utilizing the decarbonization pathways report to describe the role of clean fuels in decarbonization targets. Eversource's plan noted that because Eversource serves more commercial and industrial customers that face barriers to electrification, the utility expects to pursue decarbonized fuels, including hydrogen and RNG (Eversource, 2022). National Grid's plan affirmed a commitment to transitioning to 100 percent fossil-free gas (RNG and renewable hydrogen) by 2050 (National Grid, 2022). Liberty discussed monitoring the results of hydrogen and synthetic natural gas pilots to determine the role of renewable gas for its Massachusetts customers (Liberty, 2022). Unitil mentioned dedicated hydrogen pipelines for industrial customers (Unitil, 2022). Berkshire Gas Company recognized that hydrogen and RNG might be necessary in the long run to decarbonize buildings, electricity generation, and transportation (Berkshire Gas Company, 2022).

New York

In March 2020, the New York State Public Service Commission (PSC) opened a proceeding to consider issues related to gas utilities' planning procedures which, among other things, is broadly viewed as a first step toward LDCs' alignment with the Climate Leadership and Community Protection Act (CLCPA) (New York PSC, 2020). The CLCPA requires New York to reduce GHG emissions 40 percent by 2030 and at least 85 percent by 2050, based on a 1990 baseline. The law also established New York's Climate Action Council, which is currently finalizing a scoping plan of recommendations for meeting these targets, including the role of renewable gas (New York State Legislature, 2019).

Oklahoma

Oklahoma House Bill 3970, which was introduced in January 2020 but was not signed into law, specified RNG as "a complement to our state's vast natural gas and renewable energy resources" and declared the legislature's intent to "ensure renewable natural gas is allowable in the portfolio of natural gas utilities on behalf of Oklahoma energy consumers." The proposed law would have required the Oklahoma Corporation Commission (OCC) to issue a report to the legislature including recommended adjustments to Oklahoma's renewable fuel standard "to more proactively promote biogas, renewable natural gas and hydrogen as solutions for reducing methane emissions and other environmental problems" (Oklahoma State Legislature, 2020) and recommendations on cost recovery methods for infrastructure and commodity costs. Although the law did not pass, the OCC elected to open an exploratory docket in August 2020 to "identify and examine issues regarding maximizing available or developing resources in Oklahoma, including… renewable natural gas and related infrastructure" (OCC, 2020). The inquiry sought comments from stakeholders on support for RNG mandates or goals for LDCs, issues the OCC should address, technological barriers, RNG infrastructure issues, and additional statutory provisions that would assist in resolving the areas named in the inquiry (OCC, 2020). The OCC closed the inquiry on October 21, 2021.

By April 2021, HB 1815 was signed into law, containing similar provisions to the bill proposed in 2020: declaring RNG is a complement to in-state energy resources, expressing support to allow utilities to procure RNG, and asking the OCC to issue a report and recommendations to the legislature by December 1, 2021 (Oklahoma State Legislature, 2021).

Oregon

Senate Bill 334, passed in 2017, directed the Oregon Department of Energy to develop and periodically update an inventory of in-state RNG resources (Oregon Legislative Assembly, 2017). The subsequent DOE report to the Oregon legislature recommended that the Public Utility Commission:

1. "Allow the natural gas companies to buy and sell RNG to and for their customers.
2. Allow local gas distribution companies to recover pipeline interconnection costs through their rates.
3. Study how best to expand natural gas transportation fueling infrastructure.
4. Explore development of voluntary gas quality standards for injection of RNG into the natural gas pipeline.
5. Explore financial incentives to help drive the nascent industry forward.
6. Coordinate with RNG stakeholders and state agencies to develop a tracking and accounting protocol for production and use of RNG" (Oregon DOE, 2018).

Washington

House Bill 1257, passed in May 2019, defined RNG as "a gas consisting largely of methane and other hydrocarbons derived from the decomposition of organic material in landfills,

Quebec

In May of 2022, the Quebec Régie de l'énergie approved a plan by Hydro-Québec and Energir to launch a dual-fuel building decarbonization strategy utilizing a residential dual-fuel rate (Hydro-Québec, May 2022). Under this plan, natural gas-heated buildings would be electrified through hybrid systems, which would reduce about three-quarters of a building's gas consumption, without increasing the strain on Hydro-Québec's winter peak (Electrifying Canada, May 2022). This dual-energy scenario was estimated to have a much lower impact on Hydro-Québec's electricity rates when compared with a total electrification scenario (Hydro-Québec, May 2022). The first phase of this program is focused on residential customers, with commercial and institutional customer offerings coming online during phase two.

wastewater treatment facilities, and anaerobic digesters." The statute encouraged natural gas utilities to develop programs for purchasing RNG, with section 13 allowing utilities to propose programs to replace a portion of conventional gas with RNG for all retail customers, and section 14 requiring utilities to offer voluntary RNG tariffs to enable customer purchases (Washington Legislature, 2019).

In September 2019, the Washington Utilities and Transportation Commission (UTC) opened investigatory docket U-190818 to examine program design and pipeline safety standards for RNG programs required or allowed by HB 1257. The UTC held a workshop and accepted public comments as part of the investigation and issued a policy statement in December 2020 covering five areas for RNG: program design, quality standards and pipeline safety requirements, environmental attributes, attribute tracking and verification, and banking criteria for RNG attributes (Washington UTC, 2020). In issuing the policy statement, the UTC cited the "nascent state" of RNG use by retail customers and the desire to provide regulatory flexibility as reasons for the UTC to issue policy guidance rather than formal rules, although the statement clarifies that the UTC may later promulgate additional guidance or formal rules for the RNG marketplace if and when appropriate.

The policy statement offered more clarity on cost caps for RNG procurement programs for all retail customers, specifying that utilities should not exceed 5 percent of their total approved revenue requirement from the most recent rate case for RNG purchases inclusive of commodity, acquisition, and delivery costs of RNG compared to conventional gas. For voluntary RNG tariffs, the UTC called for utilities to provide separate, clearly identifiable RNG charges for customers who choose to participate. The UTC also specified that voluntary tariffs should include all costs associated with RNG so that no costs are shifted to customers who do not choose RNG programs.

Regarding RNG quality and pipeline safety standards, the UTC puts the burden on pipeline operators and utilities, citing recommended biomethane quality standards from the Northwest Gas Association (on behalf of Avista, Puget Sound Energy, Northwest Natural Gas, and Cascade Natural Gas), as well as the RNG Coalition. On environmental attributes, the UTC endorsed lifecycle carbon intensity accounting as a way to compare the environmental attributes of different sources of RNG, as well as comparing RNG to conventional gas. The UTC expects utilities to calculate and verify the carbon intensity of any purchased RNG. The UTC also clarified that environmental attributes could be unbundled and sold independently of the physical gas in third-party tracking systems, anticipating a future renewable thermal credit market program in Washington. Utilities identified M-RETS as their preferred RNG tracking and verification system. The UTC agreed and required utilities to track environmental attributes with Renewable Thermal Credits equivalent to one dekatherm of RNG; credits can be traded through M-RETS or a comparable system.

B. Voluntary Customer-Facing Tariffs to Purchase RNG and/or Carbon Offsets

California

In February 2019, Southern California Gas Company (SoCal Gas) and San Diego Gas & Electric (SDG&E) filed an application with the California Public Utilities Commission (PUC) seeking approval of an RNG tariff for customers. The utilities requested approval to offer a voluntary RNG program to residential and small commercial and industrial customers to set an amount of their monthly natural gas usage to be replaced by RNG. Residential customers could identify a set dollar amount ($10, $25, or $50) to purchase RNG; small commercial and industrial customers could either identify the same dollar amounts or request a percentage of their monthly usage to be converted to RNG, in 25 percent increments going up to 100 percent of usage. In April 2020, the utilities submitted a joint agreement with the Public Advocates Office at the PUC, Environmental Defense Fund, Bioenergy Association of California, Renewable Natural Gas Coalition, Agricultural Energy Consumers Association, and SFE Energy California Inc. In the course of negotiating the settlement, SoCal Gas and SDG&E changed the duration of the proposed program from indefinite to a three-year pilot; specified that at least half of the RNG procured under the program must come from in-state sources, with at least half of in-state procurement coming from sources other than landfill gas; and created an advisory group of stakeholders to review proposed RNG procurements. In December 2020, the PUC approved a voluntary pilot program based on the proposed settlement agreement with modifications relating to reporting requirements and public disclosure (CPUC, 2020). In February 2022, the PUC released a decision implementing a biomethane procurement program under Senate Bill 1440.

Illinois

In a January 2021 general rate case filing, Northern Illinois Gas Company d/b/a Nicor Gas Company (Nicor) requested Illinois Commerce Commission (ICC) approval of a "TotalGreen" voluntary rider program allowing customers interested in reducing their carbon footprint to purchase combinations of carbon offsets and RNG credits. Costs would show up as a separate line item in customer bills for those who opt into the program. Although commenters brought up concerns about Nicor discouraging competition in the market for carbon offsets and RNG credits, the ICC approved TotalGreen, stating that the program is entirely voluntary, does not affect non-participating customers, and gives Nicor the chance to gain information about customers' interest in RNG and low-carbon fuels (ICC, 2021b).

Maine

Summit Utilities filed requests with the Maine Public Utilities Commission (PUC) in May 2019 to (a) establish a company called NewCo to develop, construct, and operate an anaerobic digester in Clinton, Maine to produce RNG from dairy farms and (b) create a voluntary RNG attribute program. Summit plans to utilize the anaerobic digester in a renewable power-to-gas pilot project, with funding from the U.S. Department of Energy's Bioenergy Technologies Office. The project would assess the feasibility of pairing renewable hydrogen production and biomethanation to produce RNG for injection into Summit's gas pipeline system (Summit Utilities Inc., 2021).

Under the voluntary program, residential and small commercial customers could purchase RNG attributes to offset 10, 25, 50, or 100 percent of average monthly natural gas usage of a customer in their respective class. For residential customers, participation in the program would amount to a monthly charge of $7.44, $18.60, $37.20, or $74.40 for the respective tiers. Small commercial customers would pay $31,79, $79.47, $158.95, or $317.90, respectively (Summit, 2019). Summit was not seeking to sell RNG as a commodity to its customers, solely the environmental attributes by enabling customers to purchase RNG credits.

In an October 2019 order, the PUC approved Summit's proposed voluntary RNG attribute program, noting it was entirely voluntary and included measures to protect customers (Maine PUC, 2019). The PUC supported the reorganization and establishment of NewCo by approving a stipulation between Summit Natural Gas of Maine, its parent company Summit Utilities, Inc., and the Office of the Public Advocate in a January 2020 order (Maine PUC, 2020).

Michigan

In 2012, the Michigan Public Service Commission (PSC) approved a proposal from DTE Gas Company to create a BioGreenGas pilot program. The program was deemed successful in attracting enough customers to continue permanently, which DTE requested and the PSC approved in 2015. The BioGreenGas program charges participating customers a flat rate of $2.50 per month to offset RNG purchases (DTE, 2020).

In June 2020, DTE applied for approval of a modified BioGreenGas program and a new voluntary RNG pilot with the PSC. The voluntary RNG pilot would allow customers to offset carbon emissions in $4 increments of carbon offsets and RNG purchases equivalent to 25% of average residential use. The voluntary RNG pilot would be in place for 36 months, after which point DTE would seek approval from the PSC to implement it permanently. DTE sought to transfer the 2,200 existing BioGreenGas customers to the voluntary RNG program at the existing $2.50 rate. In its filing, DTE cited a 300 percent increase in RNG costs between 2012 to 2019 as a reason for pivoting from a monthly flat rate that failed to keep up with growing RNG costs to a new structure allowing customers to choose from incremental levels of carbon offsets and RNG credits. Additionally, DTE cited a similarly designed MIGreenPower carbon offset program for DTE Electric customers. DTE expected 20,000 customers to enroll in the voluntary RNG program over the three-year pilot period (DTE, 2020).

In August 2020, the PSC requested update from DTE to address issues with the June proposal, including renaming the program, providing detailed marketing cost breakdowns, and filing annual reports on the program. In October 2020, DTE filed an updated proposal to the PSC, which the PSC approved. DTE does not expect the voluntary RNG program to be cost neutral until 2024 at the earliest but confirmed that it would not recover program costs from base rates. The PSC noted the program was voluntary and would not raise rates for non-participating customers (Michigan PSC, 2020).

New York

In January 2019, Consolidated Edison Company of New York (Con Edison) filed a rate case seeking cost recovery for RNG interconnection and supplies (Con Edison, 2019). Con Edison also proposed to implement the 2019 Northeast Gas Association / GTI interconnection guidance. In January 2020, the New York State Public Service Commission (PSC) approved Con Edison's proposal, noting that the RNG proposals could provide health and safety benefits to customers and the public (New York PSC, 2020).

In 2019, National Grid proposed three R&D projects: first, the Newtown Creek RNG pilot project, which would directly inject RNG from a wastewater treatment plant and food waste into local gas distribution pipelines. Second, the utility proposed collaboration with the National Renewable Energy Laboratory on a power-to-gas demonstration project to convert excess renewable electricity to RNG, showing the potential for natural gas infrastructure to offer long-term storage for renewable energy supplies. And third, National Grid proposed a study with Stony Brook University on opportunities and challenges blending hydrogen into the gas distribution system, eliminating barriers to RNG interconnections, and incentivizing RNG projects through National Grid ownership of portions of RNG interconnection equipment (National Grid, 2019). In May 2021, National Grid submitted a joint proposal for PSC approval based on discussions with Department of Public Service (DPS) staff and other parties (National Grid, 2021). DPS staff and parties had raised concerns about the green gas tariff and recommended against its implementation. In August 2021, the PSC approved the joint proposal, which excluded the green gas tariff (PSC, 2021).

North Carolina

In March 2021, Piedmont Natural Gas Company (PNG) filed a proposal for a green energy program allowing customers to purchase a block of environmental attributes mitigating the carbon impact of 12.5 therms of natural gas use. Four blocks equated to the average monthly residential customer's use. Blocks were priced at $3 and contained nature-based carbon offsets and RNG attributes (PNG, 2021). On March 30, 2022, the North Caroline Utilities Commission (NCUC) approved Piedmont's proposal, granting NCUC Public Staff the ability to recommend to the commission whether to continue or modify the program based on reviewing reports and data provided by Piedmont (NCUC, 2022).

PSNC filed a similar proposal with the NCUC in April 2021 for a GreenTherm program, allowing customers to purchase half-dekatherm blocks of RNG attributes. The NCUC approved a joint agreement between PSNC, NCUC Public Staff, Carolina Utility Customers Association, and Evergreen Packaging, LLC in December 2021 that included the GreenTherm program as proposed (NCUC, 2021).

Utah

In March 2019, Dominion Energy Utah filed an application with the Utah Public Service Commission to approve a voluntary RNG program called GreenTherm. The modified proposal set a block of RNG as equal to five therms at a $5 customer cost; customers can procure multiple blocks of RNG depending on their preferences. The PSC approved the proposal in July 2019, finding that the program would not shift costs to non-participating customers but would enable participating customers to voluntarily support RNG.

Vermont

Vermont was among the first states to take regulatory action on RNG. In October 2015, Vermont Gas filed a petition with the Vermont Public Service Board to approve an RNG program and optional RNG tariff service for customers. Customers could voluntarily purchase RNG in amounts equal to 10, 25, 50, or 100 percent of their total monthly use. The Board opened an investigation that extended through September 2017, at which point a final order was issued approving the RNG program and directing Vermont Gas to file a formal tariff including proposed rates for RNG for approval in the future. The order required Vermont Gas to file a separate Renewable Vehicle Fuel Tariff for customers using RNG as a fuel for transportation. Vermont Gas was authorized to sell RINs associated with RNG used in transportation under the RFS program; revenue from the sale of RINS would be used to offset the price of RNG for transportation customers (Vermont PUC, 2017).

D. RNG Supplier-Facing Tariffs to Enable Standardized RNG Interconnection and Transportation via LDC Distribution Systems

Arizona

In 2018, the Arizona Corporation Commission (ACC) approved a request from Southwest Gas Corporation to offer RNG producers access to interconnection for RNG that meets gas quality specifications (Southwest Gas Corporation, 2018).

Connecticut

In July 2019, Public Act 19-35 was signed into law. The statute directed the Connecticut Public Utilities Regulatory Authority (PURA) to "initiate a docket to define and adopt gas quality interconnection standards for biogas derived from the decomposition of farm-generated organic waste or source-separated organic material that will ensure its suitability for injection into the LDCs natural gas distribution system" (Connecticut General Assembly, 2019). The deadline for PURA to open a docket was October 1, 2019, with a final decision required by September 1, 2021. The law required PURA to consider biogas cleanliness standards as well as a process for biogas producers to request and be approved for interconnection.

Figure 12: Connecticut Renewable Natural Gas Quality Standards

PURA subsequently opened docket 19-07-04 on July 3, 2019, and sought comments from LDCs and stakeholders. LDCs and stakeholders generally submitted comments in favor of RNG and supporting PURA's approval of the

#	Natural Gas Property Specification	Unit	Range	Guidance
1	Gross Heating Value	Btu/scf	(Min. - Max.)	970-1110
2	Wobbe Number		(Min. - Max.)	1270-1400
3	Cabon Dioxide	% by Volume	Not to exceed	2.0%
4	Oxygen	% by Volume	Not to exceed	0.2%
5	Combined Oxygen and Nitrogen	% by Volume	Not to exceed	4.0%
6	Total Inerts (Diluents)	% by Volume	Not to exceed	4.0%
7	Non- Methane C2+ Hydrocarbons	% by Volume	Not to exceed	12.0%
8	Heavier Hydrocarbons C4+ Hydrocarbons	% by Volume	Not to exceed	1.5%
9	Hydrocarbon Dewpoint	°F	Less than	15
10	H2S	grain/100 scf	Not to exceed	0.25
11	Total Sulfur	grain/100 scf	Not to exceed	1
12	Water Vapor	lbs./Mcf	Not to exceed	7
13	Siloxanes, Si	ppm(v)	Not to exceed	1
14	* "Standard Cubic Foot" or "SCF" means a volume of Gas that occupies one (1) cubic foot of volume at a temperature of 60 degrees Fahrenheit and an absolute pressure of 14.73 pounds per square inch.			
15	**Flowing temperature should be adequate to prevent interference with the proper operation of lines, regulators, meters and other equipment of Yankee. Yankee may impose restrictions on the temperature of the flowing gas that it receives when, in Yankee's easonable judgment, these restrictions are necessary to insure the proper operation of Yankee's facilities.			
16	***Commercially free of all objectionable matter: Biologicals, objectionable odors, dust, or other solid or liquid matters.			

biogas tariffs proposed by Yankee Gas Service Company, Connecticut Natural Gas Corporation, and Southern Connecticut Gas Company, Connecticut's three major LDCs. On June 2, 2021, PURA approved the LDCs' proposed tariffs for gas quality (see **Figure 12**) and measurement and pressure. Regarding interconnection, the LDCs proposed that RNG suppliers enter into Gas Sale and Interconnection Agreements (GSIAs) with the appropriate LDC. The GSIA would then be subject to PURA approval. The potential supplier would complete an Interconnection Feasibility Analysis and Engineering Agreement (IFAE) study and would bear all costs associated with interconnecting facilities and compliance with interconnection standards, consistent with practices around the interconnection of distributed electric generation resources (PURA, 2021).

Florida

The Florida Public Service Commission has approved RNG tariffs for gas quality and interconnection from two regulated LDCs. Peoples Gas was the first utility in Florida to file a tariff to deliver RNG via gas distribution pipes; Peoples Gas did not intend to sell RNG to customers and clarified the intent of the petition to the PSC was to allow their system to be used to transport RNG that meets quality standards on behalf of the biogas producer (Florida PSC, 2017). In January 2021, the PSC approved a similar request from Florida City Gas (FCG) to provide conditioning services to convert biogas into RNG and receive and transport RNG through the utility's distribution system on behalf of the biogas producer. Both LDCs said they had received interest in RNG from potential producers and customers and developed the proposed tariffs in response, also pointing out safeguards to prevent cost-shifting from biogas customers to non-biogas customers. While neither tariff was intended to enable customer purchases of RNG, FCG stated it could also purchase RNG as part of its system supply, with costs to be recovered through the annual Purchased Gas Adjustment proceeding, subject to PSC approval: "it is anticipated that the cost of the RNG would be higher compared to the current cost of fossil natural gas; however, the location of the biogas producer could mitigate pipeline capacity costs FCG incurs to transport natural gas into its service territory" (Florida PSC, 2021).

In June 2021, Senate Bill 896 was signed into law, defining RNG as "anaerobically generated biogas, landfill gas, or wastewater treatment gas refined to a methane content of 90 percent or greater which may be used as a transportation fuel or for electric generation or is of a quality capable of being injected into a natural gas pipeline" (Florida House of Representatives, 2021). The statute granted the PSC authority to approve cost recovery for gas utilities to purchase RNG in excess of current natural gas market prices if the PSC deems the costs to be "reasonable and prudent." The statute also amended Florida's definition of renewable energy to include RNG.

Idaho

In June 2020, the Idaho Public Utilities Commission approved an application from Intermountain Gas Company (Intermountain) to transport RNG to buyers using the utility's gas distribution system. Prior to filing with the PUC in May 2020, Intermountain had negotiated agreements with three RNG producers but sought PUC approval of an RNG access program that would apply to all future producers seeking to transport gas in Intermountain's service territory. Similar to filings in other states, Intermountain clarified its intent to "completely insulate utility customers from all potential impacts of RNG production" by having producers bear all costs associated with RNG interconnection. PUC staff reviewed Intermountain's proposal and found it would appropriately protect customers from bearing the risk of stranded assets and costs of RNG assets, noting, "If market conditions or incentive structures change for RNG production, the industry may become unprofitable… utility customers need to be shielded from potential negative cost impacts of RNG production" (Idaho PUC, 2020).

Maryland

In June 2021, Baltimore Gas and Electric Company (BGE) filed a proposal with the Maryland Public Service Commission seeking to offer RNG interconnection service. BGE's proposal included gas quality standards to be met by RNG producers, terms and conditions of interconnection, steps producers must take to interconnect to BGE's distribution system, and rates to be charged for interconnection. The PSC approved the request in

August 2021 (Maryland PSC, 2021). Bioenergy DevCo became the first producer to utilize the interconnection tariff, constructing an anaerobic digestion facility at the Maryland Food Center campus in Jessup, MD. The facility began operations in July 2021 (Miller, 2022).

Minnesota

In April 2020, CenterPoint filed a request to introduce an RNG interconnection tariff allowing producers to interconnect to CenterPoint's distribution system. CenterPoint emphasized its proposal would not affect costs borne by existing gas customers and would only introduce RNG interchangeable with conventional natural gas; similar to other proposals, all costs would be covered by RNG producers (CenterPoint, 2020). In January 2021, the PUC approved CenterPoint's request but declined to adopt specific gas quality standards, instead obligating CenterPoint to regulate the quality of gas in its system. The PUC also responded to comments from the Minnesota Department of Commerce by requiring CenterPoint to charge an exit fee to providers that suspend RNG production. The PUC further directed CenterPoint to propose a framework for evaluating and verifying the carbon intensity of RNG sources to assess whether a new interconnection for an RNG producer would reduce GHG emissions (Minnesota PUC, 2021).

CenterPoint filed a proposed framework to satisfy the latter condition in May 2021. The utility engaged EcoEngineers, one of three third-party auditors for the RFS program, to develop a carbon accounting framework and threshold carbon intensity requirement. EcoEngineers developed a proposal using the GREET model as a starting point. The resulting "MN-GREET" model calculates lifecycle carbon intensity using inputs and assumptions specific to RNG feedstocks and RNG lifecycle stages (clean up, transportation, and end use). The PUC opened docket G999/CI-21-566 (Minnesota PUC, 2021). In June 2022, the PUC released an order establishing frameworks for implementing Minnesota's Natural Gas Innovation Act, which allows natural gas utilities to file innovation plans for the development of innovative resources such as RNG and power-to-hydrogen to achieve Minnesota's clean energy goals. The order instructed utilities to use the GREET model to calculate the greenhouse gas intensity of RNG in innovation plans, although a related docket G-008/M-21-324 remains open to consider comments on CenterPoint's proposed MN-GREET framework (Minnesota PUC, 2022).

New York

In July 2019, gas distribution utilities operating in New York collaborated via the Northeast Gas Association with GTI to produce an interconnection guide for RNG in New York state. The utilities collectively recognized that "processes, requirements, and agreements to enable connecting these valuable [RNG] supplies are not uniform, resulting in commercial and technical uncertainties for both parties that inhibit maximum recovery and utilization of this valuable resource." The guidance includes four components: (1) an interconnect agreement evaluation process flow diagram, (2) producer/developer and pipeline operator assessment checklists, (3) a gas quality and interchangeability management program matrix, and (4) a raw biogas and upgraded RNG trace constituents measurement matrix and proposed sampling plans (Northeast Gas Association and GTI, 2019).

North Carolina

In December 2016, Piedmont Natural Gas Company (PNG) submitted a filing to the North Carolina Utilities Commission describing a pilot program to accept "alternative gas," including RNG into its distribution system for delivery to PNG customers (PNG, 2016). PNG stated that numerous RNG developers had approached the utility requesting interconnection to PNG's distribution system in order to sell RNG to existing transportation customers. PNG noted that injecting RNG was "a relatively new phenomenon and there is comparatively little experience or data to support the conclusion that it will not harm or disrupt the facilities of Piedmont or its customers or threaten the public health."

The NCUC initiated an investigation to consider service quality and operational issues raised by the introduction of alternative gas. Citing ongoing concerns in these areas, in a June 2018 order, the NCUC approved PNG's request as a three-year pilot program, during which PNG would report to the commission on the impacts of alternative gas on system operations and customers. The NCUC required modifications to several of PNG's proposed gas quality standards in its order (NCUC, 2018). Public Service Company of North Carolina (PSNC) made a similar filing to PNG, which the NCUC combined to address jointly.

In May 2021, NCUC Public Staff recommended that the NCUC continue authorizing RNG pilot programs for Piedmont and PSNC for three years. Staff recommended that the commission classify swine manure and swine processing wastewater as viable feedstocks for meeting pipeline gas quality standards and remove them from the pilot program, noting that PNG's two existing RNG projects had successfully used those feedstocks for the initial three-year pilot period. Staff recommended that the NCUC require PNG and PSNC to consider interconnection requests from RNG developers using swine manure and swine processing wastewater feedstocks (Public Staff, 2021). In September 2021, the NCUC issued an order extending the pilot program for an additional three years for PNG and PSNC. The NCUC did not adopt the Public Staff's recommendations regarding swine manure and swine processing wastewater, stating that an additional three-year pilot term would allow the utilities to obtain sufficient data to ensure RNG delivery met safety and quality standards and was in the best interest of ratepayers (NCUC, 2021).

Oregon

In March 2019, the Oregon legislature passed SB 98. The statute required the PUC to adopt rules for RNG programs for retail customers by July 31, 2020. Utilities participating in RNG programs can procure increasing amounts of RNG as a percentage of total gas purchases for retail customers: up to 5 percent through 2024, increasing by 5 percent every 5 years up to 30 percent by 2050 (Oregon Legislative Assembly, 2019).

In response, the PUC opened a rulemaking and issued an order on July 16, 2020 (Oregon PUC, 2020). During the rulemaking, the PUC held four workshops and accepted written comments at three opportunities. The order adopted a March 2020 staff proposal with two modifications. The Oregon PUC proposed the use of renewable thermal credits, separate from the RNG commodity itself, to track environmental attributes based on lifecycle carbon intensity accounting. The PUC selected M-RETS to issue, track, trade, and retire RTCs, but reserved the right to consider alternative renewable thermal credit (RTC) tracking systems in future rulemakings. Like the Washington UTC, the PUC specified a methodology to calculate annual incremental costs of RNG procurement. The PUC noted that utilities could recover RNG costs through a purchased gas adjustment (PGA) mechanisms (for commodity costs) and general rate cases (for capital expenses). In the final section of the order, the PUC dealt with the legislative mandate for competitive bidding on upstream biogas production, deciding that projects under $25 million do not need to go through commission review and approval, consistent with electric utility resource procurement.

Virginia

In June 2020, Virginia Natural Gas (VNG) filed a rate case with the State Corporation Commission (SCC). The utility proposed an interconnection tariff for RNG suppliers to deliver RNG to VNG's distribution system (Virginia Natural Gas, 2020). SCC staff questioned the need for commission approval of a tariff for RNG suppliers as opposed to VNG customers, instead supporting the inclusion of RNG suppliers in VNG's gas supply portfolio for future SCC review. In July 2021, VNG withdrew its proposed RNG schedule without prejudice, requesting that the SCC determine a date at which the company would file for approval of an RNG tariff (SCC, 2021).

D. Portfolio-Wide Procurement Targets; Recovery of Infrastructure Costs

1. Allowed

California

Two statutes have guided California's regulatory activity on renewable natural gas. In 2016, Senate Bill 1383 called for the state to reduce short-lived climate pollutants to decrease methane emissions by 40 percent of 2013 levels by 2030 (California Legislative Information, 2016). In 2018, Senate Bill 1440 encouraged state agencies to adopt policies and incentives to increase the production and use of renewable gas (California Legislative Information, 2018).

In February 2022, the California Public Utilities Commission concluded a two-year rulemaking by setting procurement targets for renewable natural gas as one of the steps in implementing the statutes. In its decision, the PUC set goals for regulated utilities of procuring 17.6 bcf of biomethane by 2025 and 72.8 bcf by 2030, corresponding to approximately 12 percent of annual residential and small business gas usage as of 2020. To maximize the program's impact on statewide methane emissions, the procurement target instructs utilities to procure biomethane sourced from organic waste diverted from landfills as a primary source. The decision also called for utilities to develop a cost-effectiveness methodology for biomethane procurement, subject to PUC approval, as well as biomethane procurement plans submitted to the PUC that include bill and rate impacts (California PUC, 2022).

Illinois

In September 2020, Nicor filed an application for an RNG interconnection pilot with the ICC. Nicor's intent with the filing was to analyze the benefits of interconnecting RNG production facilities to customers, the utility, the environment, and economic development in Illinois. Nicor did not include gas quality standards in its application, writing that RNG can be used in existing pipelines without system upgrades. Nicor cited the lack of an existing RNG tariff for RNG producers and interconnection costs as the two main barriers to RNG development in Illinois. Nicor proposed spending up to $20 million in capital expenditures to interconnect RNG production facilities at up to $4 million per project. Producers would be responsible for any non-interconnection costs as well as interconnection costs in excess of $4 million. The proposal sought to spread these costs among all Nicor ratepayers in the rate base (Nicor, 2020). In July 2021, the ICC approved Nicor's petition with modifications, including reducing the total capital spending to a maximum of $16 million at no more than $3.2 million per project. The ICC also requested data from Nicor to help quantify the benefits of the RNG interconnection pilot (ICC, 2021a).

Nevada

In June 2019, the Nevada Public Utilities Commission opened a docket to adopt RNG regulations, as directed under Senate Bill 154. The statute required the PUC to "recovery all reasonable and prudent costs associated with [a] public utility's participation in a renewable natural gas activity, which provides certain environmental benefits and has been approved by the Commission." The statute also directed gas utilities to "attempt to incorporate renewable natural gas" into gas supply portfolios at a level of 1 percent or more by 2025, 2 percent by 2030, and 3 percent by 2035 (Nevada State Legislature, 2019).

In December 2019, the PUC issued draft RNG regulations requiring gas utilities to file applications for any RNG activities. Applications must contain a description of the proposed RNG activity, an estimate of costs, proposed contracts if applicable, an explanation of environmental benefits, a proposed cost recovery mechanism and an explanation of impacts to utility rates as a result of the proposed RNG activity (Nevada PUC, 2019). The PUC specified that approval of an RNG activity application is not a determination of prudency, which should be considered in a separate utility application to the PUC. The draft regulations were finalized in an April 2020 order (Nevada PUC, 2020).

In January 2021, Southwest Gas Corporation requested authority to purchase RNG as part of its gas supply portfolio up to 3 percent of total gas supply by 2035, in accordance with SB 154. Southwest calculated that procuring 3 percent of supply from RNG would reduce GHG emissions by 107,000 to 604,000 MT CO2e by 2025, depending on weather conditions and natural gas demand and the carbon intensity of RNG production (Southwest, 2021). Costs for procuring RNG would be recovered from ratepayers via the Deferred Energy Accounting Adjustment/Base Tariff Energy Rate (DEAA/BTER) mechanism, similar to how Southwest recovers costs to purchase conventional natural gas. Southwest estimated the incremental costs of 3 percent RNG supply at $0.095/therm for northern Nevada and $0.065/therm for southern Nevada. In October 2021, the PUC approved Southwest's application in part, permitting Southwest to attempt to procure between 1 and 2 percent or more of total gas supply from RNG through 2029 to adhere to the staged volumetric goals in SB 154, noting the "regulatory goal of gradualism." The PUC noted uncertainties forecasting RNG costs, gas demand, and emissions benefits into the future and decided to approve a lower, more near-term target in lieu of approving Southwest's more aggressive request. The PUC disallowed Southwest's request to engage in other markets for RNG such as the California LCFS program or the federal RFS program (PUC, 2021).

New York

In January 2019, Consolidated Edison Company of New York (Con Edison) filed a rate case seeking cost recovery for RNG interconnection and supplies (Con Edison, 2019). Con Edison also proposed to implement the 2019 Northeast Gas Association / GTI interconnection guidance discussed in Section IV.C. In January 2020, the New York State Public Service Commission approved Con Edison's proposal, noting that the RNG proposals could provide health and safety benefits to customers and the public (New York PSC, 2020).

In August 2021, National Grid received approval for their rate case covering Downstate New York subsidiaries Brooklyn Union Gas Company and Keyspan Gas East Corporation, which authorized a 20-year cost recovery for the Newtown Creek RNG facility; Brooklyn Union Gas Company to spend $900,000 per year for RNG interconnection between 2021 and 2023, increasing to $5.9 million in 2024; and Keyspan Gas East Corporation $450,000 per year for RNG interconnection between 2021 and 2023, increasing to $5.45 million in 2024. The Order also authorizes the companies and the New York State Energy Research and Development Authority (NYSERDA) to proceed with a hydrogen blending study (New York PSC, 2021).

In January 2022, National Grid received approval for their rate case covering Upstate New York subsidiary Niagara Mohawk Power Corporation, which allows them to contract and procure RNG generated locally to New York, initially capped at 1 percent of total supply, and increasing to five percent over time. The utility will not purchase environmental attributes as part of this supply. The plan also provides $2 million for interconnection costs and the ability to petition the Commission for additional interconnection relief, and includes additional provisions for hydrogen (New York PSC, 2020).

Oklahoma

In May 2021, ONE Gas filed a rate case with the OCC seeking authority to spend up to $10 million to procure RNG for customers, with costs recovered via a purchased gas cost mechanism and an additional $10 million on supporting infrastructure. In a proposed settlement agreement between ONE Gas, the Public Utility Division of the OCC, the Attorney General, Oklahoma Industrial Energy Consumers, and the American Association of Retired Persons, parties agreed to ONE Gas recovering up to $5 million for RNG purchases and that ONE Gas would file an application by the end of 2022 seeking approval of an RNG pilot program with a voluntary tariff allowing the utility "to allocate costs and benefits of renewable natural gas to those customers who specifically choose the service" (OCC, 2021a). In November 2021, the OCC issued an order approving the settlement (OCC, 2021b).

2. Disallowed

Arizona

Approximately one year after receiving approval for interconnection access, Southwest sought authority from the Arizona Corporation (ACC) to take a larger step towards low-carbon fuels by incorporating RNG into its gas supply portfolio in a general rate case filed in May 2019. The company's request would have effectively socialized RNG costs among all gas ratepayers via the Purchased Gas Cost Adjustment Provision. Southwest defined RNG as "biogas that is cleaned or upgraded to pipeline quality gas and can be injected into and distributed through an existing natural gas delivery system," noting that RNG is considered to be a carbon-neutral fuel that offers added benefits by putting organic waste to beneficial use. Southwest stated that many wastewater treatment plants and landfills in Arizona were currently producing RNG for sale in California's LCFS market and/or the federal RFS program. Southwest sought authority from the ACC to procure up to 1 percent of retail natural gas sales with RNG by 2025, increasing to 2 percent by 2030 and 3 percent by 2035 (Southwest Gas Corporation, 2019).

The ACC issued a decision in December 2020 denying Southwest's RNG program. Arizona Grain, a supplier of agricultural supplies, and the Residential Utility Consumer Office, Arizona's consumer advocate, both submitted comments to the ACC expressing opposition to Southwest's request, citing the "infancy" of Arizona's RNG market and unknown (but generally high) costs for RNG. ACC staff agreed with the commenters, recommending that Southwest continue its practice of acquiring and selling RNG on a case-by-case basis in accordance with the ACC's 2018 decision. The ACC concurred, writing: "We find that there are too many unknown variables associated with RNG to support the adoption of the proposed RNG program at this time. We note that the proposed RNG program involves a high-risk, speculative activity, and we do not believe it would be appropriate to pass the associated risks and costs on to ratepayers… it is not in the public interest to adopt the Company's proposed RNG program" (ACC, 2020).

In its decision on the rate case, the ACC ordered commission staff to hold a workshop to explore the role of RNG in Arizona by June 1, 2021. The workshop was held on May 18, 2021, under docket G-00000A-21-0045. As of the publication of this report, the docket remains open, but no comments have been filed since September 2021, no further workshops have been convened, and no decisions have been proposed or adopted (Abinah, 2021).

Minnesota

In August 2018, CenterPoint Energy requested Minnesota Public Utilities Commission approval of a voluntary RNG pilot program allowing customers to purchase all or a portion of their natural gas from RNG sources by paying an extra fee. CenterPoint proposed a five-year pilot period, during which it would purchase RNG for its general gas supply portfolio with costs recovered from all customers through gas commodity charges, up to a cap of $1 million per year or approximately $0.70 per year for an average residential customer. Program participants who opted in would pay an additional program charge (CenterPoint, 2018). At the time it was proposed, the pilot was one of the first green tariffs for RNG in the U.S. (Minnesota PUC, 2019). The PUC denied the request without prejudice in an August 2019 order, citing unanswered questions about tracking and verifying the RNG, using local sources of RNG, and scaling the program beyond the pilot level. In its denial, the PUC explicitly encouraged CenterPoint to bring forward a modified proposal addressing regulatory concerns in the future, which it did in 2020 (See Section IV.C).

3. Not Yet Decided

Arkansas

Arkansas has seen comparatively little regulatory activity on low-carbon fuels. In March 2021, Senate Bill 136 was signed into law, which allowed the Public Service Commission to approve utility purchases of "natural gas alternatives," including RNG and hydrogen as operating expenses, "if the purchase of natural gas or natural gas alternatives is in the public interest" (Arkansas General Assembly, 2021).

New Hampshire

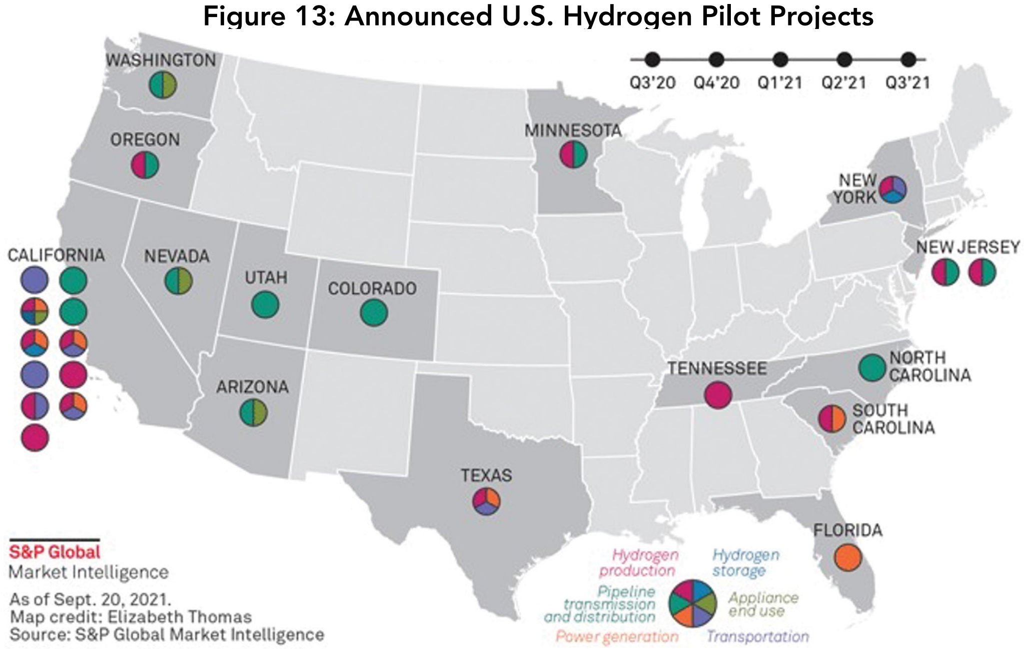
In September 2018, Liberty Utilities requested approval from the New Hampshire Public Utilities Commission (PUC) for a landfill RNG supply and transportation contract, under which Liberty would reduce customer costs by selling thermal RECs, with other costs to be recovered in rate base (Liberty Utilities, 2018). Liberty stated that the contractual RNG pricing exceeded conventional natural gas prices in the summer, but was actually lower than incremental winter supplies, and only slightly higher on an annual basis. Liberty proposed procuring approximately 6 percent of its annual gas sales with the proposed RNG contract. PUC staff raised concerns about gas reliability, quality, and costs to customers (Frink, 2019, Eckberg, 2019, and Knepper, 2019). In February 2020, Liberty requested that the PUC close the docket without prejudice, allowing the company to submit a new filing to address concerns from commission staff. The PUC did so, and Liberty submitted a new filing in March 2021 (Liberty, 2021).

Similar to the initial request, Liberty proposed in its new filing to buy the entirety of RNG output from a landfill over a 17-year term, with an option to extend. Three large customers signed letters of intent to purchase 65 percent of the projected RNG output from the project, with the remainder going to serve CNG customers in Keene, New Hampshire or injected into the distribution system (Liberty, 2021). In December 2021, Liberty requested the PUC suspend the current docket due to a bill under consideration in the state legislature that would substantially impact the RNG market in New Hampshire (Liberty Utilities, 2021). Specifically, SB 424-FN encouraged gas utility procurement of and investment in RNG supplies and infrastructure, provided that the PUC finds it to be in the public interest. Because the statute affected how the PUC considers procurement of gas that exceeds the straightforward least cost to customers, Liberty requested to pause the docket until there was more certainty with SB 424-FN, which was adopted in June 2022. The docket was reactivated at Liberty's request in July 2022 but closed the following month to allow Liberty to conduct a competitive bidding process to procure RNG as required under the adopted legislation (New Hampshire PUC, 2022).

E. Hydrogen

Decisions related to hydrogen infrastructure and commodity costs are beginning to come before state regulatory commissions. Two regulated utilities – Arizona Public Service and Public Service Company of New Mexico – have included hydrogen technologies in integrated resource planning scenarios, demonstrating interest in incorporating hydrogen into generation portfolios (Green Hydrogen Coalition, 2022). S&P Global counted 26 pilot projects announced by U.S. natural gas utilities as of October 2021, as shown below in **Figure 13**.

Figure 13: Announced U.S. Hydrogen Pilot Projects



Eleven of these projects are being developed by California utilities, mainly Sempra companies San Diego Gas & Electric (SDG&E) and Southern California Gas (SoCal). SoCal Gas is also participating in a hydrogen production, transportation, and storage project to use hydrogen for vehicle fueling and powering a data center in Texas. New Jersey Resources, the parent company of local distribution company New Jersey Natural Gas, became the first gas utility to blend green hydrogen into its distribution system in October 2021, starting with a less than 1 percent blend (DiChristopher, 2021). CenterPoint Energy has announced a demonstration project in Minnesota to produce hydrogen from renewable electricity generation and blend it into limited, low-pressure sections of CenterPoint's gas distribution network at concentrations of 5 percent of volume or less (CenterPoint Energy, n.d.). In December 2021, National Grid and the town of Hempstead on Long Island, New York announced the HyGrid Project (National Grid, 2021). The project will blend green hydrogen produced from wind and solar generation into National Grid's distribution system. The hydrogen will fuel 10 municipal vehicles and heat 800 homes. Hempstead built a hydrogen fueling station in 2009 (Town of Hempstead, 2021). National Grid noted Long Island as uniquely well situated for clean hydrogen development due to its excellent offshore wind resources and limited transmission connections to mainland New York. As Long Island is likely to frequently experience conditions of excess wind generation compared to electricity demand, using surplus wind energy to produce clean hydrogen for future use in heating, transportation, or power generation can be a cost-effective way to reliably decarbonize the state's economy, consistent with the CLCPA.

Not all announced pilot projects have come before regulatory commissions for approval; decisions by regulators in Arizona and California offer examples of regulatory approaches to hydrogen proposals and are described below.

Arizona

In January 2021, the Arizona Corporation Commission approved an application from Arizona Public Service (APS) to create special rates in place for four years for electricity sold to Nikola, a company seeking to use electricity to generate hydrogen via electrolysis for use at planned zero-emissions truck fueling stations in Arizona (ACC, 2021). APS proposed the rates under a special contract supporting economic development opportunities in Arizona, which the ACC had previously encouraged in a 2012 decision (ACC, 2012). ACC staff noted that Nikola's hydrogen production facilities would require a high load factor of above 92 percent but fit the definition of flexible load, with the potential to respond to demand response events, and recommended ACC approval of APS's proposal (ACC Utilities Division, 2021), which the commission did in a subsequent decision. Nikola praised the approval, noting that the rate structure "reflects value that results from the curtailment flexibility that Nikola's hydrogen production facilities are expected to provide to the electrical grid. These facilities will be configured to respond to the needs of the grid, for example, by reducing Nikola's energy consumption from the electric grid during heatwaves" (Nikola Corporation, 2021).

California

The California Public Utilities Commission (CPUC) has also taken action on hydrogen. The CPUC issued a rulemaking scoping memo in November 2019 addressing hydrogen injection standards in 2018 as part of an ongoing rulemaking on biomethane opened in 2013 (CPUC, 2013) and to align with Senate Bill 1440. The memo directed gas utilities to file an application with the PUC to revise renewable gas tariffs defining renewable hydrogen, putting forth a preliminary renewable hydrogen injection standard, and modifying the hydrogen standard for biomethane or modifications to interconnection agreements.

In November 2020, SoCal Gas, SDG&E, Pacific Gas and Electric (PG&E), and Southwest Gas proposed a definition of renewable hydrogen, but declined to address the other areas in the scoping memo, claiming that they needed to conduct additional research on safety and reliability before proposing a hydrogen injection standard (CPUC, 2021a). The joint utilities requested regulatory approval for a three-phase hydrogen research program consisting of: (1) hydrogen injection in a small portion of SoCal Gas's plastic distribution system, increasing over five years; (2) testing hydrogen injection into mixed plastic and steel distribution pipelines;

and (3) testing and demonstrating hydrogen injection into steel transmission pipelines. The utilities estimated the program would cost $31.8 million, of which $24.5 million was classified as capital costs recoverable from ratepayers. In June 2021, an administrative law judge rejected the application, noting that it failed to discuss how the research program would overlap or interact with similar R&D projects already underway by the California Energy Commission (CEC) and University of California (UC) Riverside. The decision asked the utilities to submit a new application discussing collaboration with the CEC and UC Riverside, scaling to PG&E's and Southwest Gas's gas transmission and distribution systems, the potential to leverage PUC-authorized or federal funding for gas safety and reliability research, total costs and cost recovery, detailed annual reporting, and research on specific topics, including pipeline materials and hydrogen embrittlement, gas storage facilities, distribution system pressure, and transmission constraints (CPUC, 2021a). In July 2021, the CPUC issued an order dismissing the application (CPUC, 2021b).

In July 2022, the CPUC released a study conducted by UC Riverside on the feasibility and safety implications of injecting hydrogen into the natural gas system. The study found that hydrogen blends of up to 5 percent are generally safe, but higher blend levels can result in a greater chance of pipeline leaks and steel pipeline embrittlement. Other key findings included that blends above 5 percent may require modifications to appliances, blends of more than 20 percent present a higher likelihood of permeating plastic pipes, and more hydrogen-blended natural gas will be needed to deliver an equivalent amount of energy compared to geologic natural gas due to hydrogen's lower energy content (University of California Riverside, 2022).

On September 8, 2022, Southern California Gas Company, San Diego Gas & Electric Company, and Southwest Gas Corporation submitted a joint application to establish hydrogen blending demonstration projects (Southern California Gas Company, San Diego Gas & Electric Company, and Southwest Gas Corporation, 2022). The petitioning utilities proposed a phased approach to blending hydrogen into utility distribution infrastructure at and above a 5 percent level to generate information and knowledge to inform a safe hydrogen injection standard for California (Southern California Gas Company et. al., 2022). The application requests permission from the PUC to set up a balancing account for each utility so that they can record the costs related to these pilot projects (Southern California Gas Company et. al., 2022). This application is currently under consideration, and no commission action has been taken as of October 2022 as stakeholders continue to file comments in support and opposition of the proposal.

The CEC supports two pathways to research into and envision the role of hydrogen in California's clean energy economy. The Electric Program Investment Charge (EPIC) program collects funding from electric ratepayers to advance precommercial clean energy technologies that have a public interest benefit. The CEC develops five-year plans setting forth priority EPIC investment areas. In the current 2021 – 2025 plan, published in November 2021, multiple proposed investments aim to advance hydrogen, including research into low-carbon power generation fueled by green hydrogen through a green hydrogen roadmap and methods to evaluate the air pollutant emissions, wildfire risk, and climate resilience impacts of green hydrogen projects (CEC, 2021). In addition, the CEC prepares a biennial Integrated Energy Policy Report (IEPR) assessing major energy trends and issues for electricity, natural gas, and transportation, and providing policy recommendations to California officials. The 2021 IEPR included a volume on decarbonizing the state's gas system, with substantial discussion on the role of renewable gas and hydrogen in California and recommendations for how gas infrastructure can enable the deployment of low-carbon fuels. Notably, the report recognizes that renewable hydrogen can be produced by splitting water using renewable electricity and from organic waste feedstocks, and that carbon intensity will be a critical metric in determining the eligibility of resources from a GHG perspective (CEC, 2022).

V. Questions for Regulators

State commissions have several options to facilitate low-carbon fuels, assuming they possess the relevant statutory authority to act. This report offers questions for exploration by state commissions so regulators can gain access to high quality information upon which to base their regulatory decisions in the public interest, balancing reliability, safety, and affordability with decarbonization and other policy objectives.

Many commissions have opened the conversation about low-carbon fuels by requesting or completing impartial studies of the potential for in-state low-carbon fuel production and demand, often spurred by statutory or executive action. These resource assessment and demand studies can account for locally available and economically feasible feedstocks for hydrogen or RNG production, GHG emissions benefits, and other energy and environmental benefits, as well as how low-carbon fuels can be used to displace fossil fuels or encourage in-state economic growth (Cyrs, Feldmann, and Gasper, 2020). Previously completed studies in West Coast states and the Northeast region provide examples of questions that can be answered with currently available data (**Figure 14**). However, because RNG can be easily transported in gas pipelines across state lines, encouraging in-state production may be a question better suited to policymakers than regulators, with regulators being primarily concerned with affordability and overseeing the costs of RNG that are passed on to utility customers in their states.

Figure 14: The Role of RNG in Deep Decarbonization Studies (Cyrs, Feldmann, and Gasper, 2020)

REGION	STUDY	FINDINGS AND ASSUMPTIONS RELATED TO ROLE OF RNG IN DEEP DECARBONIZATION BY MIDCENTURY OR EARLIER
California	Deep Decarbonization in a High Renewables Future (Mahone et al. 2018)	**Transport**: Light-duty vehicles move toward 100% electrification. Medium- and heavy-duty vehicles use biomethane alongside mix of CNG, hydrogen, and other biofuel options. **Stationary end uses:** Alongside large-scale building electrification, RNG displaces additional building gas demand.
California	Getting to Neutral: Options for Negative Emissions in California (Baker et al. 2020)	**Cross-cutting**: Reaching net-zero emissions will require scaling of net-negative decarbonization strategies. RNG and hydrogen from organic wastes can play a role if coupled with emerging CCS technologies to achieve added carbon removal.
Oregon/ Washington	Pacific Northwest Pathways to 2050 (Aas et al. 2018)	**Stationary end uses**: Alongside electrification efforts, RNG and hydrogen may be used in existing gas distribution networks to help decarbonize hard-to-abate end uses and meet peak heating demand.
Northeast	Northeastern Regional Assessment of Strategic Electrification (Hopkins et al. 2017)	**Cross-cutting**: Alongside rapid electrification, RNG and other low-carbon fuel supply can be deployed to further lower emissions.
Northeast	Northeast 80x50 Pathway (National Grid 2018)	**Stationary end uses**: Region can reduce emissions through rapid transition away from liquid fuels in building heating and conversion to electric heat pumps, natural gas, and renewable natural gas from local feedstocks.
Northeast	The Role of Renewable Biofuels in a Low Carbon Economy (Lowell and Saha 2020)	**Cross-cutting**: Complementary deployment of biofuels may be viable for decarbonization. **Transport**: Alongside significant electrification of heavy-duty vehicles (with the exception of combination trucks), RNG fuels 80–100% of NG vehicles in 2030. **Stationary end uses**: Alongside electrification, RNG may be used to meet 5–10% of residential and commercial heating demand in 2030.

After assessing in-state supply and demand for low-carbon fuels, state regulatory commissions can proceed to more challenging questions regarding actions they might take.

A. Barriers to Voluntary Low-Carbon Fuel Transactions

Are there existing regulatory or technical barriers to voluntary purchases of low-carbon fuels? Are customers able to work with utilities to procure low-carbon fuels; are producers able to interconnect projects without significant barriers to entry?

Commissions can begin by considering the existing barriers for low-carbon fuels: whether projects can interconnect to distribution pipelines or if they face high costs and lengthy timelines, whether RNG sources are located in close proximity to distribution pipelines, and whether supplies can connect to customers. Commissions have generally accepted proposals from utilities to initiate voluntary RNG programs allowing customers to purchase RNG credits and/or carbon offsets as long as appropriate protections are in place to avoid non-participating customers subsidizing costs for participating customers.

For utilities that do not have voluntary tariffs in place, commissions may consider requesting information on whether customers are asking for such programs, why the utility does not have an existing program, and the benefits and drawbacks of initiating a program.

Likewise, supplier-facing tariffs can be a proactive step towards standardizing rules for gas quality and interconnection to reduce uncertainty and costs for low-carbon fuel producers. Commissions can similarly request information on whether suppliers have inquired with gas distribution utilities to clarify rules and responsibilities to interconnect low-carbon fuels to the distribution network, and if a standardized tariff would be a more beneficial approach than individual negotiations between distribution utilities and fuel suppliers.

B. Allocating Costs for Low-Carbon Fuels

Should the infrastructure and/or commodity costs of low-carbon fuels be socialized among all ratepayers, or borne solely by the large C&I customers currently driving the market? Should regulated natural gas and/or electric utilities own and operate low-carbon fuel production?

Among the most important questions public utility commissions will need to consider is how to allocate costs for low-carbon fuels among ratepayers as a whole, individual customers, utility shareholders, and project developers as regulated utilities begin to invest in RNG or hydrogen production. As discussed in Section III.D, commissions have taken different approaches to enabling the recovery of RNG commodity and infrastructure costs from all ratepayers. In states that have done so (Nevada, Oklahoma, and Illinois), commissions have placed clear constraints around spending of ratepayer funds, setting limits on overall spending, favoring gradual increases in spending rather than major infusions of funds, and requiring utilities to provide data and reports to the commission. Commissions have also specified whether ratepayer funds may be spent on RNG as a commodity versus infrastructure and interconnection costs.

This evidence demonstrates regulators' skepticism of allowing utilities to spend ratepayer funds on low-carbon fuels without strong guardrails to ensure ratepayers are benefiting. As commissions begin to consider equity implications of regulatory decisions, the implications of low-carbon fuels on low- to moderate-income ratepayers and disadvantaged communities will surely factor into decision-making.

When thinking about cost allocation, commissions can reflect on the experience many states have had with renewable portfolio standards (RPS). RPS policies have been implemented in 30 states as well as Washington, DC, Guam, and Puerto Rico, and are credited with spurring approximately half of the growth in renewable generation in the past two decades (NCSL, 2021). RPS programs essentially socialize the cost of renewable power across ratepayers by requiring utilities to procure a given percentage of generation from renewable sources, as defined by statute or commission rules. RPS programs typically set low initial targets, increasing to higher levels in future decades – up to 100 percent requirements between 2032 and 2050 in eight states and Washington, DC, Guam, and Puerto Rico. RPS programs have coincided with massive public and private investment in decreasing the costs of renewable energy and energy storage, enabling utilities to achieve targets without increasing energy costs for customers.

Notably, RPS programs are authorized by statute, with commissions responsible for (in some cases) defining which resources are eligible as clean or renewable generation and ensuring utilities' compliance with the statutes as they oversee resource and capital investment plans. As with RPS programs, commissions will require clear statutory direction to spread low-carbon fuel costs across the rate base and may wish to proceed in a gradual manner. Given the higher costs of low-carbon fuels compared to geologic natural gas, continued investment in R&D to bring down the production costs of low-carbon fuels would help broaden the market for low-carbon fuels.

C. Accounting for the Decarbonization Potential of Low-Carbon Fuels in Decision-Making

How should regulators consider the unique decarbonization potential of low-carbon fuels, particularly for hard-to-abate sectors, in decision-making? Is additional direction or clarity from state policymakers needed?

Public utility commissions function as economic regulators of investor-owned utilities. They generally lack regulatory oversight of other sectors that are major contributors to GHG emissions, such as transportation and heavy industry, although some commissions regulate transportation to varying extents. The question of the extent to which regulated entities should be required to decarbonize is under active discussion in many states. Low-carbon fuels offer decarbonization benefits to multiple sectors. Transportation is by far the largest market for RNG at present, with industrial processes comprising most of the demand for hydrogen. While low-carbon fuels can contribute to decarbonization for regulated utilities, public utility commissions will need to collaborate with other state regulatory agencies and policymakers to build a common understanding of the potential for low-carbon fuels to contribute to economy-wide decarbonization. Learning from the European Commission's approach to decarbonization across the European Union (EU), which involves integrated network planning, expanded consumer choice, certification for low-carbon gases, and creating dedicated hydrogen infrastructure to foster a strong market for renewable and low-carbon fuels, may be helpful to U.S. regulators. The EU's goals – to reduce economy-wide GHG emissions by 55 percent by 2030 and achieve climate neutrality by 2050 – are comparable to several state decarbonization targets (European Commission, 2021).

Several states are also actively considering methodologies to document the carbon intensity and GHG emissions reduction benefits of RNG and hydrogen. Developing robust methodologies that can be applied across state lines will provide certainty to utilities and project developers. With the GREET model in use in California's LCFS market and under consideration in Minnesota, this tool can be a helpful starting point for state public utility commissions to adapt to state conditions. As an example, Minnesota is considering slight modifications to the GREET model to reflect local RNG feedstocks.

D. Decision-Making in Uncertain Conditions

What no-regrets approaches can help facilitate both near-term RNG development and long-term development of hydrogen and other zero-carbon fuels alongside other cost-effective and technically feasible pathways to decarbonization?

Gathering additional data on existing gas distribution pipeline infrastructure and its readiness to accommodate low-carbon fuels would be a good starting point for many states. States may also consider the availability, cost, and likelihood of RNG production from in-state feedstocks, as these data could inform potential interconnection and transportation tariffs in the future.

Assessing multiple pathways to reach decarbonization goals both in the gas and electric utility sectors – and comparing costs and benefits of different strategies – is also an important area for commissions to lead (Snell and Narbaitz, 2022). Several state public utility commissions discussed above acted based on initial assessments from state departments of energy, air quality or environmental agencies, or other offices. A high-level, economy-wide assessment of decarbonization pathways conducted by either a capable state agency or a neutral third party will illuminate the magnitude of the need – or lack of need – to develop low-carbon fuels alongside renewable electricity, electrification, or other decarbonization policies. Additionally, state regulators can learn from approaches in other jurisdictions, such as a dual-fuel program offered by Hydro-Quebec and Energir promoting complementary use of both electricity and gas for heating to reduce emissions while managing peak demand, rates, and societal costs (Hardy and Dunsky, 2022).

VI. Conclusion

Utilities, customers, and regulators are actively considering and exploring various decarbonization options. RNG and hydrogen are expanding across the country, with substantial resources from the November 2021 Bipartisan Infrastructure Law and August 2022 Inflation Reduction Act available to incentivize the development of markets for low-carbon fuels (DOE, June 2022, Webster, 2022, and Kirkwood et al., 2022). State regulators must make decisions in the public interest, weighing costs and risks to customers with reliability and resilience, emissions reduction, affordability, and societal benefits in their role as economic regulators. Towards that end, this report provides background information, relevant state regulatory decisions, and questions for regulators to keep in mind as they consider proposals to pilot or deploy low-carbon fuel options to customers. NARUC will continue to monitor developments in the growing low-carbon fuels arena with the objective of sharing best practices and lessons learned across jurisdictions.

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1101 Vermont Ave, NW • Suite 200 • Washington, DC 20005
www.naruc.org • (202) 898-2200