Renewable Natural Gas: Potential Supply and Benefits

Renewable Natural Gas Issue Brief ▪ Part III of IV ▪ July 2019

Introduction

This MJB&A Issue Brief is part of a series on renewable natural gas (RNG). This document summarizes RNG benefits and supply. Additional issue briefs provide an overview of natural gas utility business models, policies to support RNG use beyond the transportation and electric sectors, and the economics of RNG projects.

Renewable natural gas (RNG) production in the U.S. is increasing every year, but RNG continues to comprise a small percentage of overall natural gas supply. Due to challenging economics and supply constraints, investment in RNG is often overlooked as a strategy to decarbonize certain end uses currently fueled by natural gas, including space and water heating. However, sources of renewable electricity once faced similar challenges. State programs, such as renewable portfolio standards and federal and state tax incentives, created a supporting policy environment to make investments in renewable electricity economically viable. This drove technology development that further reduced costs and increased demand. RNG has the potential to follow a similar path. The right policies can increase demand and financial support for RNG, and research can support the development of cost-effective technologies that will significantly increase RNG supply.

As with renewable generation technologies, the development of RNG resources provides substantial environmental and economic benefits. The primary benefit is decarbonization of the natural gas grid. Without any changes to existing natural gas infrastructure or home appliances, RNG allows customers to reduce GHG emissions from space and water heating. In many regions, RNG provides greater immediate GHG reductions at lower cost when compared to electrification of oil and conventional natural gas-fired appliances. At the same time, RNG production can lower emissions of health-related pollutants associated with on-site use of biogas, provide co-benefits like water quality improvements, and generate local economic development.

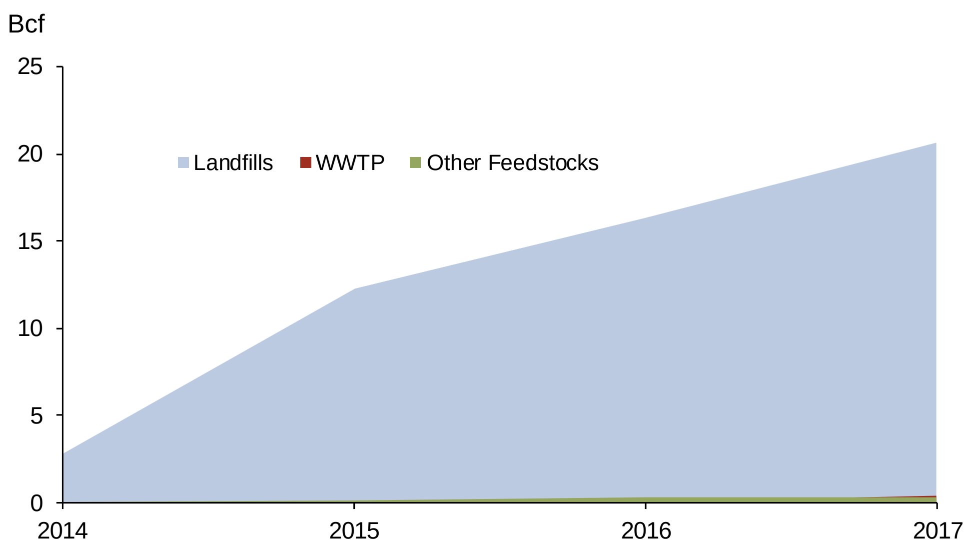
This Issue Brief first reviews existing RNG supply sources and potential national and regional levels of future RNG production. It then discusses technologies that could dramatically increase the supply of RNG and renewable hydrogen. The final section discusses the environmental and economic benefits of RNG.

RNG Supply

While there is no central source of data on U.S. RNG production, information collected and reported by EPA can be used to estimate U.S. supply. EPA publicly reports data related to the Renewable Fuels Standard (RFS), including renewable fuel production by feedstock. Because of the economic incentive provided by the RFS, the majority of U.S. RNG produced is supplied through the program to the transportation sector. While not capturing all RNG, the RFS data provides a rough estimate of RNG production and sources.

Figure 1 shows that RNG registered under the RFS grew 638 percent from 2014 to 2017. Nearly all the gas came from landfills, with small contributions from wastewater treatment plants and other feedstocks (e.g., dairy waste digesters). Additional information on RNG production and potential is available from EPA's Landfill Methane Outreach Program[1] and AgSTAR[2], which maintain databases of biogas projects at U.S. landfills and livestock manure digesters. These data provide information on landfills and digesters without biogas collection infrastructure and show that additional biogas could be recovered from several existing projects. Development of these resources could increase RNG production from existing feedstocks.

Figure 1. RNG Registered Under the RFS Program by Feedstock



Source: EPA, MJB&A analysis

[1] U.S. EPA Landfill Methane Outreach Program https://www.epa.gov/lmop
[2] U.S. EPA AgSTAR https://www.epa.gov/agstar

National RNG Potential

Technical potential of RNG volumes can be estimated using information on the availability of the feedstocks used to produce RNG, but the current costs associated with producing RNG and getting it to market prevent the realization of this potential. Future production will depend on the policies and incentives implemented to support RNG. The development of new technologies will also reduce costs for existing feedstocks and open new pathways for cost-effective RNG production.

Table 1 shows total U.S. RNG potential estimates as reported in studies conducted over the last decade, which find that RNG could be used to satisfy meaningful portions of total U.S. natural gas demand. For example, the American Gas Foundation's maximum scenario RNG estimate is enough to meet ten percent of annual U.S. gas consumption. In the residential sector specifically, the largest estimate of technical RNG potential would be enough to meet more than twice the annual natural gas demand, and even the smallest estimate is enough to meet the needs of about one in five households. While the technical potential of RNG is quite high, actual RNG production will be lower than the estimates provided below due to costs and feedstock competition for other fuel types.

Table 1. Estimates of National RNG Potential

Report	RNG Potential (Bcf/year)*	Percent of 2017 U.S. Residential Natural Gas Deliveries**
American Gas Foundation (2011)[3]	932 – 2,397	21%-54%
DOE Billion Ton Study (2011)[4]	1,212 – 9,230	27%-209%
National Petroleum Council (2012)[5]	4,667	101%
NREL (2014)[6]	756†	17%

* All estimates are as presented in ICF's report, *Design Principles for a Renewable Gas Standard*, with the exception of NREL's estimate.
** From EIA Form 176 Natural Gas Deliveries.
† NREL's estimate does not include potential for feedstocks captured in other reports, including lignocellulosic biomass (e.g., forest materials, crop residuals, energy crops).

[3] https://www.eesi.org/files/agf-renewable-gas-assessment-report-110901.pdf
[4] https://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf
[5] https://www.npc.org/FTF_Topic_papers/22-RNG.pdf
[6] https://www.nrel.gov/docs/fy14osti/60283.pdf

Regional RNG Potential

Estimates of RNG potential have also been calculated at the state and regional levels. Table 2 shows that, at a regional level, RNG could meet significant portions of both local residential and total natural gas demand. In each region, RNG could supply, at minimum, roughly half of residential demand; in Oregon, there are adequate feedstocks to produce enough RNG to meet the needs of every household. The range of RNG potential as a percentage of total supply estimates indicates that RNG could replace large volumes of conventional natural gas, substantially reducing the carbon intensity of the natural gas that utilities deliver to their customers.

Table 2. Estimates of Regional RNG Potential

Region	RNG Potential (Bcf)	Percent of 2017 Regional Residential Deliveries	Percent of 2017 Regional Total Deliveries
California[7]*	104.9-208.3	24%-48%	5%-11%
Northeast U.S. States[8]	267.3	46%	15%
Oregon[9]	50	105%	21%
Washington[10]	51.9	57%	17%

*California estimate is from ICF analysis. The ICF report includes a summary table with California RNG production potential estimates from four additional studies.
Note: All regional estimates include both anaerobic digestion and thermal gasification potential.

Future Supply

Nearly all RNG in the U.S. is produced through anaerobic digestion (AD), where organic matter is broken down in a sealed, oxygen-free environment to produce biogas. RNG produced through thermal gasification (TG), included in most of the potential estimates above, is only produced in small quantities by pilot and demonstration projects. In the TG process, biomass is broken down into combustible gas in an enclosed reactor called a gasifier in the presence of air or another externally supplied oxidizing agent. While AD and TG have the potential to generate large RNG volumes, a third technology, power-to-gas (P2G), could significantly increase RNG production.

While hydrogen combustion does not generate GHG emissions[11], the steam methane reforming process used to produce most hydrogen today is GHG-intensive. As a result, hydrogen can have greater lifecycle emissions than conventional natural gas. P2G technology uses electricity in a process known as electrolysis to split water

[7] https://www.icf.com/-/media/files/icf/white-paper/2017/icf_whitepaper_design_principles.pdf
[8] Information on Massachusetts, New Hampshire, New York, Rhode Island is available here: https://www9.nationalgridus.com/non_html/NG_renewable_WP.pdf
[9] https://www.oregon.gov/energy/Data-and-Reports/Documents/2018-RNG-Inventory-Report.pdf
[10] http://www.commerce.wa.gov/wp-content/uploads/2018/02/Energy-RNG-Roadmap-for-Washington-Jan-2018.pdf
[11] Hydrogen combustion produces water vapor. For more information on water vapor as a greenhouse gas, see https://www.ncdc.noaa.gov/monitoring-references/faq/greenhouse-gases.php?section=watervapor

into hydrogen and oxygen. This hydrogen can then be used as a fuel itself or be combined with CO_2 through methanation to create methane. If renewable electricity is used to power the electrolyzer, the process yields renewable hydrogen, which in turn can be used to produce RNG. The GHG emissions associated with RNG generated through P2G are lower than those from conventional natural gas and can be further reduced if the methanation process utilizes CO_2 from a waste stream.

P2G is also a promising technology because it provides a means of storing excess renewable electricity. Curtailment of renewable resources like wind and solar due to oversupply is already a problem in some regions and will increase as additional renewable energy resources are built. Rather than curtailing these resources, P2G could be used to convert renewable electricity into RNG that can be stored in existing natural gas infrastructure for future use. For example, nighttime generation (when winds are strongest and electricity demand lowest) from offshore wind projects under development in the Northeast and Mid-Atlantic could be used to produce RNG delivered to homes, businesses, and power plants.

P2G is currently in the initial stages of development in the U.S. Southern California Gas Company helped develop two pilot projects – one that uses solar power to generate hydrogen that is blended into the fuel supply of a natural gas-fired co-generation plant and another that converts hydrogen into methane using bacteria.[12] Europe invested in P2G earlier than the U.S. and is already implementing the technology at commercial scale. The Energiepark Mainz project in Germany began operating in 2015 and utilizes a 6 MW electrolyzer connected to a wind farm to produce up to 1,000 cubic meters/hour of renewable hydrogen.[13] Another project, Jupiter1000, plans to use a 1 MW electrolyzer to produce renewable hydrogen and RNG for injection into the natural gas pipeline system.[14] Even larger 50 and 100 MW projects are currently under development in Germany.[15]

RNG Benefits

Natural gas utilities, policymakers, customers, and other stakeholders are primarily interested in RNG as a means to reduce GHG emissions associated with conventional natural gas. However, RNG can also provide environmental and economic benefits beyond those related to climate change.

Greenhouse Gases

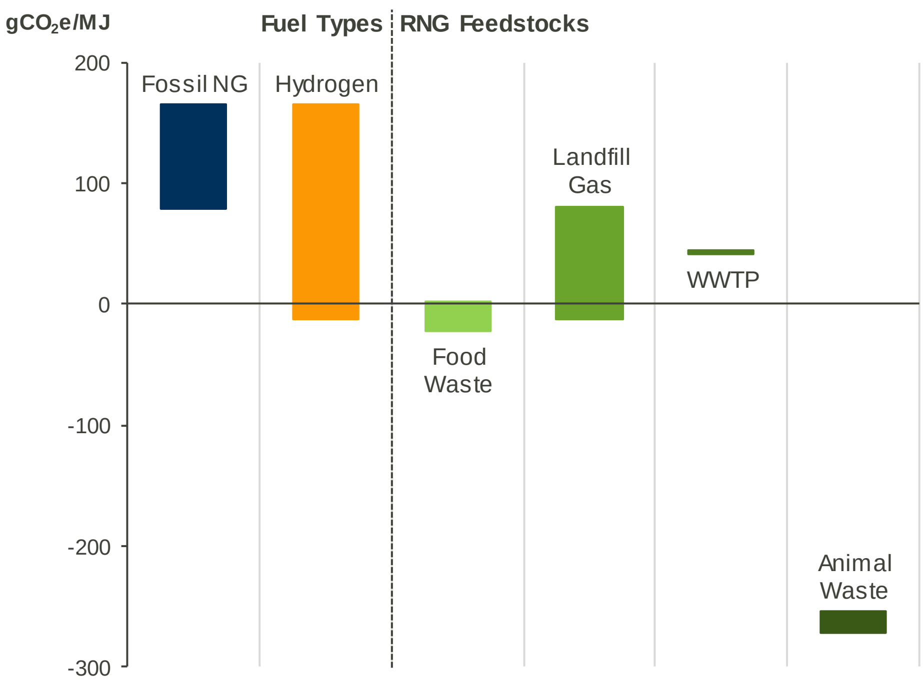
All natural gas of similar composition, whether renewable or conventional, emits the same amount of GHG emissions when combusted in identical processes. However, RNG reduces methane from waste streams that would otherwise be emitted to the atmosphere or otherwise not put to beneficial use (i.e., combusted in a flare). Because methane has a greater global warming potential (GWP) and therefore a greater short-term impact on the climate than CO_2, these upstream GHG reductions make RNG a lower carbon fuel option compared to conventional natural gas.

At the same time, the GHG emission benefits of RNG are project- and source-specific, varying based on feedstocks used and how those feedstocks are processed. For example, producing RNG at a large dairy operation that previously used uncovered manure lagoons would yield major GHG emission reductions. RNG from a landfill generally provides fewer GHG reductions because many landfills already capture and flare landfill gas; landfill RNG therefore puts to beneficial use a fuel that would otherwise be wasted but does not

[12] See SoCalGas demonstration projects, https://www.socalgas.com/smart-energy/renewable-gas/power-to-gas
[13] http://www.energiepark-mainz.de/en/
[14] See https://www.jupiter1000.eu/english
[15] See https://www.hysyngas.de/ and https://www.amprion.net/Presse/Presse-Detailseite_18113.html

dramatically reduce upstream emissions. Figure 2 shows the range of carbon intensities (CI) for conventional natural gas and RNG produced from various feedstocks under California's Low Carbon Fuel Standard (LCFS). Under the LCFS, the California Air Resources Board develops lifecycle GHG CIs for fuels used in the transportation sector.[16] Compared to conventional natural gas, most RNG used in the LCFS program has significantly lower lifecycle emissions and in some cases generates negative emissions.

Figure 2. Range of Certified LCFS Pathway Carbon Intensities



Source: California LCFS Approved Pathways[17], MJB&A analysis

For every dekatherm of RNG injected into the natural gas network, a dekatherm of conventional natural gas is displaced. Assessing the climate benefits on a full lifecycle basis for both conventional natural gas and RNG is the most transparent approach available. It is also important to compare the climate benefits of RNG to those from electrification. Though electrification of oil and natural gas space and water heating equipment results in zero end-use emissions, the lifecycle GHG benefit of electrification is dependent on the carbon intensity of the electric grid. As shown in Figure 3, using RNG to heat a home and fuel residential appliances provides GHG benefits compared to using electricity, even if the grid is 75 percent zero-emitting. Further, RNG allows natural gas utilities to deliver a low-carbon fuel through existing pipeline infrastructure that has been the focus of extensive investment and modernization over the last several decades. In fact, natural gas LDCs continue to invest in upgrades to their distribution networks to improve safety and reliability and reduce methane emissions through pipeline replacement programs and other efforts.

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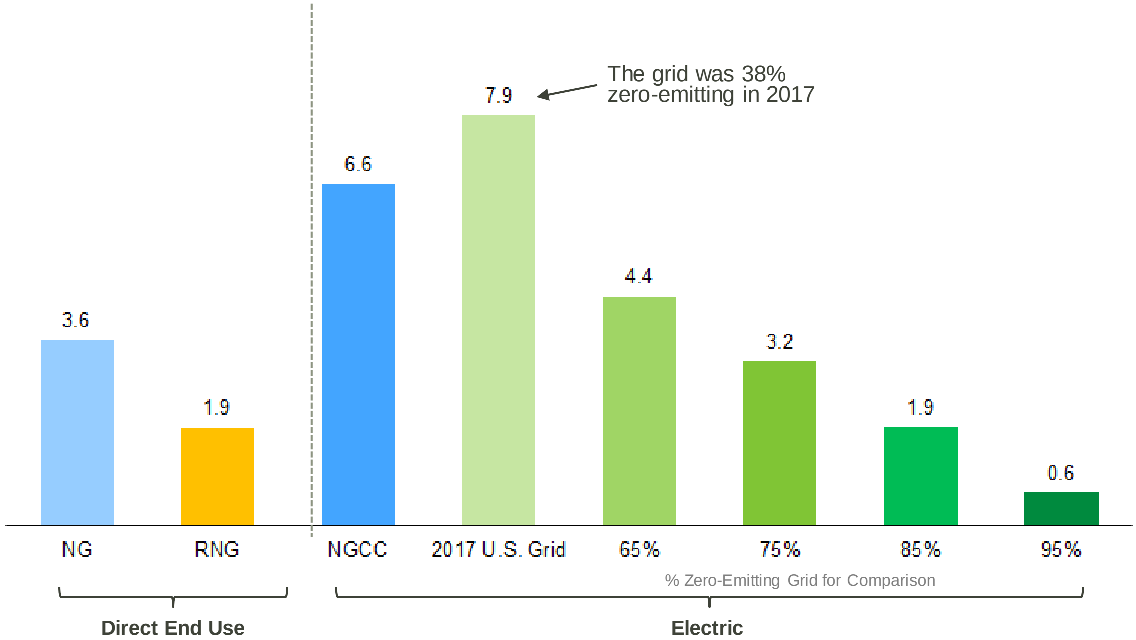
[16] While these CIs are for fuel used in vehicles, they provide a means of comparing the GHG-impact of fuels used in other sectors as well. LCFS CI information is available at: https://www.arb.ca.gov/fuels/lcfs/fuelpathways/fuelpathways.htm

[17] California Air Resource Board, LCFS CI data. Available at: https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm

Figure 3: Annual CO_2 Emissions for an Average U.S. Home (MT/year)



Source: MJB&A analysis

A 2018 report by Navigant Consulting prepared for SoCalGas, "Analysis of the Role of Gas for a Low-Carbon California Future," compares the GHG and economic impacts of RNG and electrification in California.[18] The report compares GHG emissions reductions across multiple scenarios in which California electrifies commercial and residential end-uses with scenarios in which RNG replaces natural gas in the same end-use appliances. The report models the share of natural gas that would need to be converted to RNG in order to reach the same GHG emissions reductions from electrification and decarbonization of electricity. The report found that 46 percent of the gas SoCalGas supplies to residential and commercial buildings, or only 16 percent of its total throughput, would need to be RNG to provide the same GHG benefits as a 100 percent electric appliance conversion scenario by 2030.[19] Further, the cumulative costs of each RNG scenario were found to be lower than the cumulative costs of each electrification scenario. While the GHG and economic benefits of RNG and electrification strategies will vary across states and regions based on a number of factors, policymakers should carefully evaluate both options to ensure that decarbonization pathways optimize GHG reduction potential while protecting the interests of utility customers.

Other Benefits

RNG can contribute to local air quality improvements and economic development as well as provide natural gas utilities with alternative fuel supply sources. While combustion of biogas at landfills, manure digesters, and WWTPs reduces GHG emissions, it results in the emission of pollutants that affect health and contribute

[18] See https://www.socalgas.com/1443741887279/SoCalGas_Renewable_Gas_Final-Report.pdf
[19] In the 100 percent conversion scenario, 87 percent of gas-fired appliances are replaced with electric appliances by 2030.

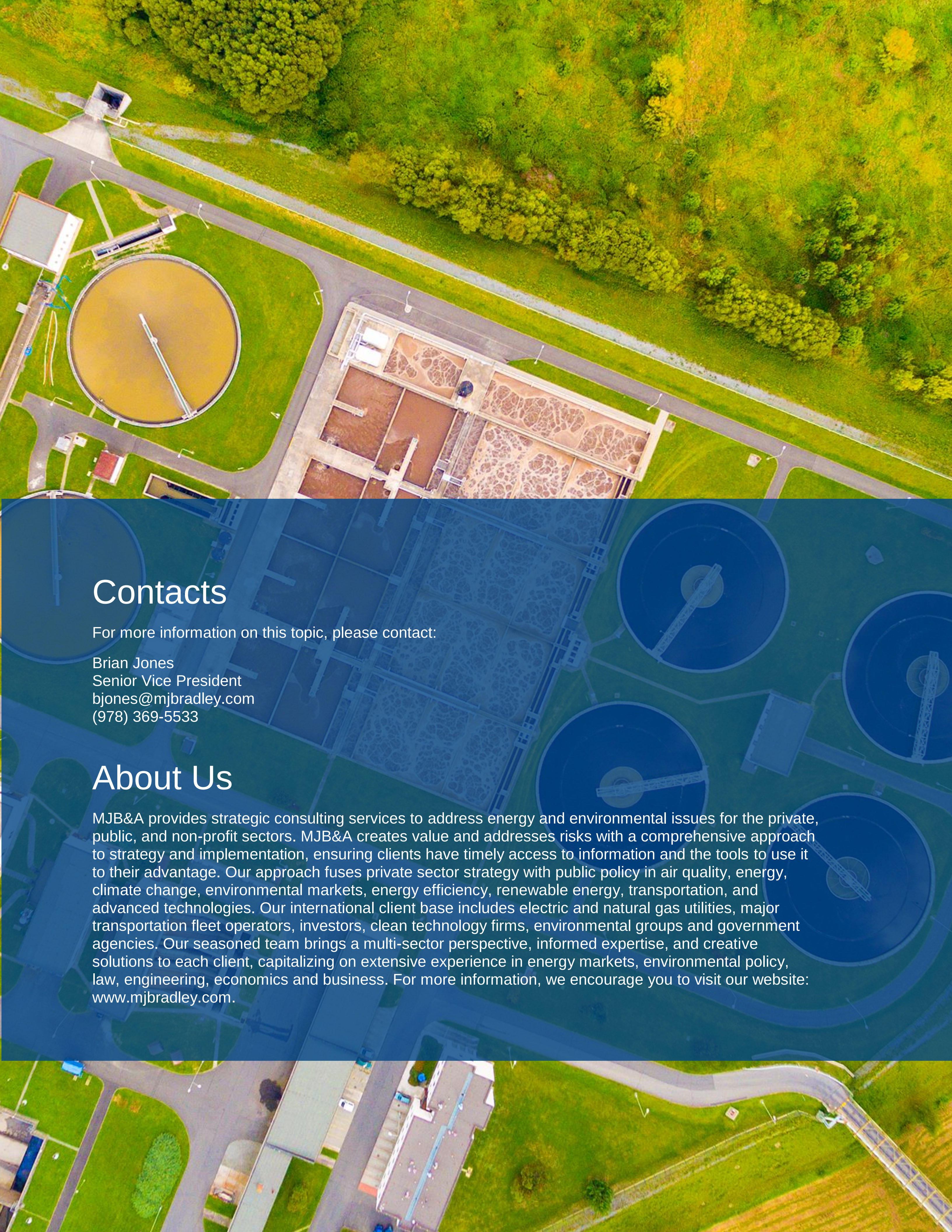
to ozone formation. Compared to on-site combustion, upgrading biogas to RNG can reduce criteria pollutant emissions. A 2016 study by the University of California Davis and EPA on biogas sources in California found that upgrading biogas to RNG, when compared to biogas flaring, reduced local, on-site emissions of health-related pollutants by 90 percent or more.[20]

RNG projects require local economic investment and provide local jobs. National Grid's 2010 analysis of RNG found that developing the Northeast's RNG potential would result in $6.75 billion in capital investment and create 2,500 to 8,900 jobs. While RNG is generally more expensive than conventional natural gas, it provides a local source of natural gas supply that can at times be less expensive than conventional supply. This was exemplified by Consolidated Edison's recent Non-Pipeline Solutions proposal to the New York Public Service Commission, which seeks to lower natural gas demand during peak winter demand periods. Proposed projects included energy efficiency, air-source and ground-source heat pumps, CNG and LNG supplies, and RNG supplies. Con Edison proposed to invest approximately $70 million toward the construction of several RNG projects, interconnection and related work from 2019 through 2024. While the gas from these projects is more expensive than conventional gas for most of the year, the savings their fixed-priced supply provides on peak demand days when prices increase dramatically yield net positive price benefits.[21]

NW Natural has also found that RNG can reduce costs. The utility justified RNG supply requirements in its 2018 Integrated Resource Plan (IRP) by applying avoided cost analysis to low-carbon gas supply resources like RNG and P2G. Total avoided cost is an estimate of the cost to serve the marginal unit of demand with conventional supply-side resources. This incremental cost represents cost avoided if a unit of gas were not demanded due to improved energy efficiency or use of locally-sourced RNG. Based on this approach, NW Natural found on-system dairy RNG to be a least-cost capacity resource when replacing conventional natural gas, with off-system dairy RNG becoming cost-effective in 2036-2037 relative to conventional natural gas. The utility also notes that carbon reduction benefits – along with avoided marginal capacity costs, avoided system reinforcement costs, and emissions policies – strengthen the industry and have contributed to increased RNG availability.

[20] https://nepis.epa.gov/Exe/ZyPDF.cgi/P100QCXZ.PDF?Dockey=P100QCXZ.PDF see Table 32 on p. 43.

[21] The NY PSC issued an order on February 7, 2019 approving, with modification, Con Edison's proposed NPA Portfolio but did not explicitly approve the supply portions, including RNG.



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