October 14, 2022

Sarah A. Smegal, Hearing Officer
Massachusetts Department of Public Utilities
One South Station, 5th Floor
Boston, Massachusetts 02110

Re: Investigation by the Department of Public Utilities on its own Motion into the role of gas local distribution companies as the Commonwealth achieves its target 2050 climate goals; DPU 20-80, Comments of Coalition for Renewable Natural Gas

Dear Hearing Officer Smegal,

The Coalition for Renewable Natural Gas (RNG Coalition) submits the following comments for consideration by the Massachusetts Department of Public Utilities (DPU) and other stakeholders of the ongoing 20-80 proceeding, aimed at assessing the role of gas local distribution companies (LCD) given the Commonwealth's greenhouse gas (GHG) reduction goals.[1]

We commend Massachusetts' extensive work in establishing ambitious climate and environmental goals,[2] the recognition under this proceeding that the state's energy regulations and infrastructure must undergo changes to achieve those goals, and the thoughtful comments put forth by all stakeholders as part of this process.

The decarbonization strategies submitted to DPU by the LDCs contain several key strategies related to the use of renewable gases (e.g., biomethane and renewable hydrogen) to decarbonize a portion of existing gas infrastructure. Importantly, the increased use of waste-derived renewable gases would serve as a climate change mitigation tool for use across all sectors by increasing clean fuel supply; capture and utilization of methane emissions from organic waste streams; and circularity in Massachusetts' economy through recycling, the creation of bioproducts, and carbon sequestration.

RNG Coalition's goal in this filing is to provide missing context around the long-standing, science-based conclusions regarding the impact of biogas and RNG; aggregate and describe the role of renewable gas as concluded by jurisdictions and organizations leading on climate change policy; and to outline a fact-based role for RNG based on these conclusions. We hope that the following comments from our Coalition will support Massachusetts' efforts in going further in outlining a comprehensive vision for the near- and long-term sustainable production and use of renewable gases as a key tool toward the Commonwealth's climate and other environmental goals.

[1] https://eeaonline.eea.state.ma.us/DPU/Fileroom/dockets/bynumber/20-80
[2] https://www.mass.gov/service-details/global-warming-solutions-act-background

Sincerely,

/s/

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Renewable Gas is a Fundamental Part of the Solution to Climate Change

The Role of Renewable Gas in Decarbonization

Renewable gases, including renewable natural gas[3] (RNG) and renewable hydrogen, are an important near-term decarbonization strategy for all applications which currently utilize fossil-derived fuels and, in the long-term, renewable gas use will be necessary in applications that have certain reliability requirements, or which are not well-suited to electrification.[4]

Incorporating the use of renewable gases as part of Massachusetts' climate change mitigation strategy will result in compound benefits through (1) the displacement of anthropogenic carbon dioxide (CO_2) emissions from the combustion of fossil fuels, (2) the critical near-term greenhouse gas (GHG) benefits of increased methane capture and destruction, and (3) additional environmental benefits that result from the improved management of organic waste.

To achieve these outcomes, Massachusetts should target the development of renewable gases in tandem with the other technologies that will be required to fully decarbonize the Commonwealth.[5] RNG should be given significant attention in the near-term, based on both the well-proven technology readiness level of various methods of making RNG today—such as Anerobic Digestion (AD)—and the flexibility provided by RNG's fungibility with all conventional gas applications.

In the mid- to long-term, hydrogen produced from renewable feedstocks such as clean electricity and waste biomass should also be viewed as an essential part of Massachusetts' renewable gas mix. In a similar manner to RNG, waste-biomass-derived hydrogen is poised to contribute to Massachusetts' circular bioeconomy as a pathway for recycling resources which are not suitable for AD. Furthermore, the use of carbon capture and sequestration (CCS) technologies such as geologic storage or biochar will produce negative-GHG outcomes when paired with RNG and hydrogen derived from waste biomass. These technologies will provide a necessary pathway to *remove* emissions from the atmosphere,[6] creating an important pathway to carbon neutrality and, ultimately, carbon negativity.

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[3] Sometimes called biomethane or refined biogas.

[4] Bataille et al., *A Review of Technology and Policy Deep Decarbonization Pathway Options for Making Energy-Intensive Industry Production Consistent with the Paris Agreement.* https://www.sciencedirect.com/science/article/abs/pii/S0959652618307686

[5] Including, for example, end-use electrification and geothermal resources. RNG Coalition does not oppose electrification or deployment of any other low-GHG technology.

[6] Sequestration of the biogenic carbon contained in waste feedstocks from RNG and biomass-derived renewable hydrogen can be a carbon-negative process that removes carbon from the atmosphere. This benefit is separate from the methane destruction potential of RNG, which can lead to additional carbon-negative outcomes on a lifecycle basis relative to existing environmental control baselines.

Over time, these resources can be directed toward the end-uses which are best served by the use of gaseous fuels, serving in tandem with technologies that require time to scale and achieve production cost reductions (e.g., electrolytic hydrogen, heavy duty electric vehicles) or that involve the turnover of long-lived capital stock (e.g., electrification of building space and water heating).

The portion of renewable gas serving Massachusetts' gas system will increase even as total system throughput declines, eventually leading to a smaller gas system which transports only 100% clean fuels[7] to targeted end uses. Given expected declines in gas system throughput, the use of renewable gas need not lead to net pipeline expansion, beyond connecting these new supply sources to existing load.

Further, many long-term studies of decarbonization agree that the use of renewable gases is essential but disagree about which sector will most need RNG to decarbonize in the long run.[8] Because of these facts, in these comments we attempt to articulate a nimble vision of how RNG in Massachusetts can best help with decarbonization in the near-, mid-, and long-terms as shown in Figure 1.

Figure 1. Priorities for RNG Deployment Will Likely (and Should) Shift Over Time

Navigating these complex but necessary changes will require state agencies, utilities, and other stakeholders to fully consider all possible renewable gas end-uses in the near-term, and to develop a framework to determine what end-uses may be most appropriate in the mid- to long-term. As outlined below, based on existing policies and consensus surrounding gas decarbonization strategy in other jurisdictions, we believe that Massachusetts should

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[7] https://www.nationalgrid.com/document/146251/download

[8] WRI 2020, Renewable Natural Gas as a Climate Strategy: Guidance for State Policymakers https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/60ad57a35aaa6563fbc3e508/1621972901032/2020_Dec+World+Resources+Institute_Renewable-natural-gas-climate-strategy.pdf

incorporate a Renewable Gas Standard (RGS) or Clean Heat Standard (CHS) as part of a broad gas decarbonization strategy.

Reducing Methane Emissions and Improving Organic Waste Management

Complementary to their role as a method of zero-fossil-carbon energy supply, RNG and other waste-derived resources are unique in their near-term ability to reduce methane—a short-lived climate pollutant that, when assessed over a 20-year timeframe, is up to 80 times as potent as a greenhouse gas as carbon dioxide[9]—and to serve as a catalyst for improving organic waste management practices.

Society's waste streams create significant methane that must be dealt with quickly. Using this methane from organic wastes productively as a resource, rather than flaring it, provides greater impetus toward implementing and improving methane capture and organic waste management systems. The need to target methane emissions immediately as part of any GHG reduction strategy is substantiated by leading organizations focused on climate change mitigation, including the Intergovernmental Panel on Climate Change (IPCC), as described below.

As shown in Figure 2, comparing the International Energy Agency's (IEA) estimated cost of reducing methane emissions through the creation of RNG[10] to the Social Cost of Carbon (SCC) assessed by New York,[11] RNG is likely to be a cost-effective GHG reduction strategy. In this example, New York serves as a helpful comparison for Massachusetts being the only neighboring state with similar diversity in urban and rural areas that has developed a SCC.[12] However, there is reason to believe that New York's SCC estimate may undervalue the benefits of GHG reduction. A recent article published in *Nature* provides a preferred mean estimate of $185 per ton of CO_2, which takes into account recommendations from the National Academies of Sciences, Engineering, and Medicine.[13]

Inclusion of methane reduction benefits in such a calculation is important. Factoring methane capture and destruction into the lifecycle GHG impact shows the true cost-effectiveness of RNG facilities, even using a 100-year GWP. Comparatively, using a 20-year GWP, which is more consistent with the timeframe under which we must reduce GHG emissions to address climate

[9] The Global Warming Potential for non-fossil methane is 27 on a 100-year basis and 80 on a 20-year basis according to the most recent IPCC assessment. See Table 7.15 directly from Chapter 7.6 of the Sixth Assessment Report (Working Group 1: The Physical Science Basis). https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf

[10] https://iea.blob.core.windows.net/assets/03aeb10c-c38c-4d10-bcec-de92e9ab815f/Outlook_for_biogas_and_biomethane.pdf

[11] New York estimates that the societal benefit of reducing one ton of carbon dioxide is $125 per ton (lower central discount rate, for a 2020 reduction): https://www.dec.ny.gov/regulations/56552.html

[12] https://costofcarbon.org/states

[13] Rennert et Al, *Comprehensive Evidence Implies a Higher Social Cost of* CO_2 https://www.nature.com/articles/s41586-022-05224-9

change,[14] would further and significantly increase this cost effectiveness given the outsized impact of addressing methane emissions.

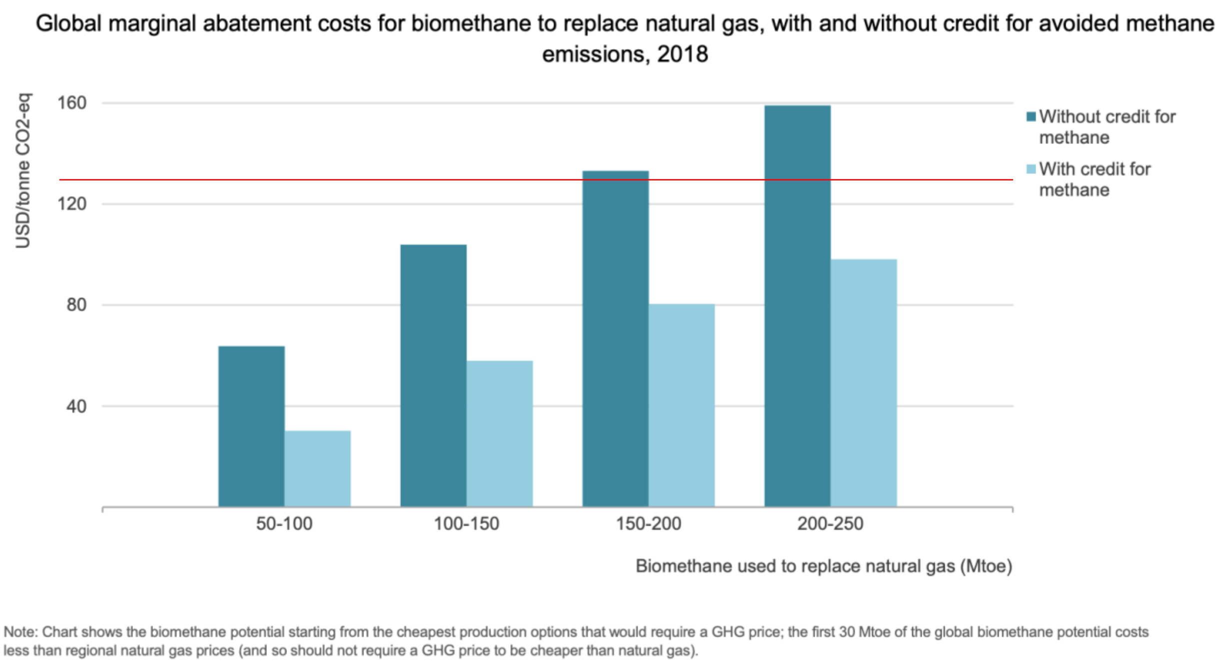

Figure 2. Comparing the IEA's Biomethane Abatement Costs to New York's Social Cost of Carbon (red line), most RNG is cost effective even using 100-year GWPs. Recognizing methane benefits (especially if using 20-year GWP) helps improve cost effectiveness further.

In creating a policy framework designed to improve the GHG performance of the organic waste sector it is important to consider that, globally, municipal solid waste is expected to grow 69% from 2.01 billion metric tons (BT) in 2018 to 3.4 BT in 2050 (around 50% of which is organic waste).[15] Moreover, these trends are underpinned by an expected 25% population increase of 2 billion people between now and 2050.[16] Considering the Commonwealth's ambitious GHG reduction goals, Massachusetts needs to help pioneer the development and commercial deployment of viable technologies to address these challenges.

The Food Recovery Hierarchy developed by the United States Environmental Protection Agency (U.S. EPA), which ranks industrial use—inclusive of conversion to energy through anaerobic digestion—as the 4th highest use after source reduction and repurposing edible food to humans and animals.[17]

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[14] Sam Abernethy and Robert B Jackson, *Global Temperature Goals Should Determine the*

Time Horizons for Greenhouse Gas Emission Metrics, 2022 Environ. Res. Lett. 17 024019 https://iopscience.iop.org/article/10.1088/1748-9326/ac4940/pdf

[15] https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

[16] https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html

[17] https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy

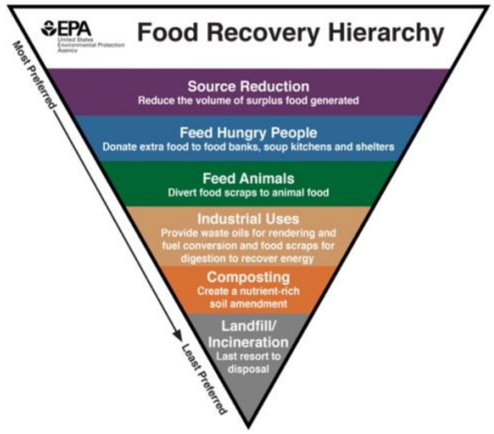

Figure 3. U.S. EPA Food Recovery Hierarchy

RNG production through anaerobic digestion of materials such as food waste, animal manure, and wastewater also yields valuable by-products. After the elimination of pathogens, digested solids can be recycled for productive uses such as animal bedding,[18] and AD converts nutrients into a form more accessible by plants than raw manure, allowing for an effective organic fertilizer.[19] Processing digestate using pyrolysis and other technologies to create biochar is also an option, resulting in a soil amendment which supports plant growth, can eliminate harmful perfluoroalkyl and polyfluoroalkyl substances (PFAS), and can achieve carbon-negative outcomes. Overall, recycling and using the by-products of waste through AD for RNG production processes creates a more environmentally responsible and sustainable circular economy.

Massachusetts should develop a plan with accounts for the benefits of replacing geologic natural gas, utilizing existing natural gas infrastructure, and the long-term need for gaseous thermal resources in certain sectors. Furthermore, stakeholders must be clear as to what policies or strategies will be used to promote methane capture from these sources if RNG is not incented. Simply requiring organic waste aggregators to capture and flare emissions is not a good outcome from a local criteria pollutant perspective, and will not incent methane capture to the fullest extent possible. Studies from both U.S. EPA[20] and the California Air Resources Board (CARB)[21] have shown that pipeline injection of biomethane reduces criteria air pollutants both on site (relative to a case where the biogas is flared or used in most on-site power generation equipment) and on a lifecycle basis (with additional emission reductions possible depending on end use).[22]

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[18] U.S. EPA. *The Benefits of Anaerobic Digestion* (2020, August 18) https://www.epa.gov/agstar/benefits-anaerobic-digestion

[19] Id.

[20] https://nepis.epa.gov/Exe/ZyPDF.cgi/P100QCXZ.PDF?Dockey=P100QCXZ.PDF

[21] https://ww2.arb.ca.gov/sites/default/files/2020-07/dairy-emissions-matrix-113018.pdf

[22] For example, when low-NOx natural gas vehicles displace emissions from diesel vehicles.

As described in further detail below, Massachusetts stakeholders should incorporate a RGS or CHS as part of the Commonwealth's decarbonization strategy. Jurisdictions leading the way[23] on GHG reduction have implemented such programs as part of their strategy for simultaneously decarbonizing the energy and organic waste sectors.

RNG Supply Potential

Based on a 2019 study conducted by ICF which outlines the supply potential for RNG in the United States,[24] we estimate that RNG from AD feedstocks will be able to supply at least 1,425.3 tBtu/year by 2040.[25] Based on U.S. natural gas consumption in 2021, this would cover approximately 30.6% of residential demand, 43.7% of commercial demand, or 17.4% of industrial demand nationally.[26]

Extensive capital stock exists in Massachusetts that is designed to transport and consume gaseous fuels, and which possesses a significant remaining useful life. Conventional natural gas is currently Massachusetts' largest single source of energy, accounting for 31.3% of total energy consumption in the state—including 30% of commercial sector use, 33% of industrial sector use, and 29% of residential use.[27] ICF estimates that Massachusetts' potential to produce RNG from anaerobic digestion sources (landfills, animal manure, wastewater treatment, and food waste) is on the order of 7.2-11.824 tBtu/year.[28] This supply potential could satisfy 10% of residential demand, 11% of commercial demand, or 26% of industrial demand.

Although the RNG industry's focus has traditionally been limited to feedstocks which are well-suited to AD, it is also important to consider the additional potential of RNG produced via gasification of feedstocks such as agricultural residue, forestry and forest product residue, and

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[23] Jurisdictions which have historically been leaders in climate and environmental policy—such as California, Oregon, Washington, Canada, and the EU—have policies in place to promote renewable gases as part of their waste management and GHG reduction strategies.

[24] ICF, *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment.*

https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf

[25] Based conservatively on the "High" production scenario, using landfill gas, animal manure, wastewater, and food waste feedstocks.

[26] https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm

[27] EIA estimates Massachusetts' 2020 total energy consumption by type here, 2020 commercial and industrial energy consumption here, and 2020 total natural gas use by sector here. Note that values are approximate due to variations between data sets.

[28] American Gas Foundation, *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment*, 2019 https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf

energy crops. According to the ICF study, New England's gasification feedstocks (excluding MSW) have the potential to add 7.9 tBtu/yr to RNG supply.[29]

Although gasification/pyrolysis feedstocks do not have the benefit of capturing and reducing methane emissions, potential benefits incentivizing the improved management of these feedstock streams deserves additional attention. In California, for example, the recently enacted RNG mandate requires the development of pilot gasification facilities for forestry waste as a wildfire control mechanism. Furthermore, potential energy crops should not be dismissed without additional analysis on a feedstock-by-feedstock basis. Research by the Climate and Applied Forest Research Institute at the State University of New York's College of Environmental Science and Forestry,[30] suggests that feedstocks such as willow can sequester more carbon in the soil than emitted over the plants' lifetime, potentially leading to carbon-negative outcomes even before the employment of CCS. Despite the need for more caution with gasification/pyrolysis feedstocks,[31] if incentivized carefully these resources have the potential to drive numerous environmentally beneficial outcomes throughout Massachusetts' and New England's bioeconomy.

Finally, when determining the total potential for RNG in Massachusetts, DPU should consider using the Commonwealth's population-weighted share of regional RNG resources that could be imported. Massachusetts' gas demand is currently served by pipelines which transport conventional natural gas, extracted in other states, many miles. While some parts of the gas infrastructure are slated to decline, these larger transport arteries will need to be maintained to support fossil natural gas use for some time, and could eventually transport 100% clean fuels as part of a smaller gas system. For example, ICF estimates that nationally, in a "High" production scenario, states east of the Mississippi River[32] could produce 756.1 tBtu/y from AD feedstocks and 582.1 tBtu/y from gasification feedstocks (excluding MSW) in 2040.

Studies and Existing Programs Highlighting Capturing Methane from Organic Wastes Streams with Productive Energy Use as a Key Near-term Climate Strategy

The complementarity of RNG and renewable hydrogen with other decarbonization strategies—such as electrification and energy efficiency—is well-substantiated by climate change mitigation studies and strategies conducted in various states, as well as by leading universities, government entities, and environmental organizations.

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[29] In the "High" scenario, representing the middle resource availability case, pg. 20.

[30] http://cafri-ny.org/wp-content/uploads/2021/01/Greenhouse-Gas-Balance-of-Willow.pdf

[31] We understand and appreciate the concerns of environmental groups related to intentionally creating methane through biomass gasification and agree that it is especially important to employ strong lifecycle accounting for such projects to guard against pathways that would produce a high-carbon outcome.

[32] Including the New England, Middle Atlantic, South Atlantic, East North Central, and East South Central regions.

Massachusetts' broader energy and waste decarbonization strategies should include renewable gases in a manner that reflects the most current thinking and best modeling of pathways to reach carbon neutrality by 2050 while also remaining focused on the need to drive substantial near-term GHG reductions. The following are leading examples of studies outlining the role of RNG in economywide decarbonization, all of which substantiate the necessity of including renewable gases in strategies that reach deep GHG cuts.

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) calls methane capture and recovery from solid waste management "a short-term 'win-win' policy that simultaneously improves air quality and limits climate change."[33] Furthermore, the 2021 IPCC Working Group I report recommends that "strong, rapid, and sustained reductions in CH_4 emissions" should be a first priority for policymakers.[34]

In its most recent approved draft report on GHG mitigation, entitled *Climate Change 2022, Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,*[35] the IPCC states that:

> *"Because some applications (e.g., aviation) are not currently amenable to electrification, it is anticipated that 100% renewable energy systems will need to include alternative fuels such as hydrogen or biofuels."* Page TS-54
>
> *"Several biomass conversion technologies can generate co-benefits for land and water. Anaerobic digestion of organic wastes (e.g., food waste, manure) produces a nutrient-rich digestate and biogas that can be utilised for heating and cooking or upgraded for use in electricity generation, industrial processes, or as transportation fuel. The digestate is a rich source of nitrogen, phosphorus and other plant nutrients, and its application to farmland returns exported nutrients as well as carbon."* Page 12-102, line 36 (citations removed)
>
> *"Scaling up bioenergy use will require advanced technologies such as gasification, Fischer-Tropsch processing, hydrothermal liquefaction (HTL), and pyrolysis. These pathways could deliver several final energy carriers starting from multiple feedstocks, including forest biomass, dedicated cellulosic feedstocks, crop residues, and wastes."* Page 6-40, line 7

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[33] See page 6-91 of: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_06.pdf

[34] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf, pg. 27

[35] https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

"Most production routes for biofuels, biochemicals and biogas generate large side streams of concentrated CO_2 which is easily captured, and which could become a source of negative emissions." Page 11-32, line 12

Environmental Protection Agency

The U.S. EPA has long supported biogas recovery for use as RNG under programs such as the Landfill Methane Outreach Program (LMOP),[36] AgSTAR,[37] and the Renewable Fuel Standard.[38] The LMOP website, for example, notes the benefits of RNG as a resource which utilizes existing infrastructure, supports local economies, provides local air quality benefits compared to fossil fuel resources such as diesel and conventional natural gas, and reduces GHG emissions through methane destruction and fossil fuel displacement. In the agricultural sector AgSTAR has, for more than 20 years, promoted covered lagoons and digesters as the top solutions for manure management.[39] More recently, EPA added Renewable Natural Gas as an explicit opportunity within the Methane Challenge program, noting that, "as a substitute for natural gas, RNG has many end-uses, including in thermal applications, to generate electricity, for vehicle fuel, or as a bio-product feedstock."[40]

Canada

Canada has made several climate commitments backed by concrete plans and policies. They have stated that:

"To meet our new 2030 and 2050 net-zero goals, Canada's economy will need to be powered by two equally important energy sources—clean power and clean fuels. Electrification—clean power—provides a near-term pathway for emissions reductions in many sectors including personal transport and the built environment. But clean fuels (low-carbon fuels that typically consist of clean hydrogen, advanced biofuels, liquid synthetic fuels, and renewable natural gas) are expected to play a critical role in 'hard-to-decarbonize' sectors such as industry and medium- and heavy-duty freight.

[36] https://www.epa.gov/lmop/renewable-natural-gas

[37] https://www.epa.gov/agstar

[38] https://www.epa.gov/renewable-fuel-standard-program

[39] https://www.epa.gov/sites/default/files/2019-09/documents/epa_non-co2_greenhouse_gases_rpt-epa430r19010.pdf

[40] https://www.epa.gov/system/files/documents/2022-05/MC_BMP_TechnicalDocument_2022-05.pdf

Even in a scenario with ambitious electrification, it is estimated that 60 percent or more of national energy demand in 2050 could need to be met with clean fuels to meet a net-zero goal."[41]

In its 2030 Emissions Reduction Plan released on March 29, 2022, the Government of Canada adds that economy-wide strategies to reduce GHG emissions, inclusive of clean fuels and methane emissions reduction, will enable Canada to meet its climate targets in the most flexible and cost-effective way.[42]

Canada also has strong methane emission reduction targets. In November 2021, Canada joined the Global Methane Pledge, which has been signed by over 100 countries, to reduce anthropogenic methane emissions across all sectors by at least 30% below 2020 levels by 2030. The measures outlined in the 2030 Emissions Reduction Plan may result in a reduction in waste-sector GHG emissions of 49% by 2030 against 2005 levels.[43]

European Union

Europe has long supported RNG under the broad Renewable Energy Directive (RED) framework.[44] Recent revisions known as the "Hydrogen and Decarbonized Gas Package"[45] reinforce support for renewable gases as a key greenhouse gas reduction strategy in the context of RED updates and the "Fit for 55"[46] strategy, which is essentially the EU's Scoping Plan analogous process.

Individual European Union member states have very high biomethane blend rates. For example, Denmark's proportion of RNG injected into its system was almost 25% of total demand as of the end of 2021. Denmark hopes to be able to meet 75% of its gas demand from RNG by 2030. By 2034, RNG production is expected to cover all Danish gas consumption on an annual basis.[47]

Russia's recent military aggression against Ukraine has massively disrupted Europe (and the world's) energy system. It has caused hardship due to high energy prices and it has heightened energy security concerns, bringing to the fore the EU's over-dependence on gas, oil, and coal

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[41] Natural Resources Canada, "Clean fuels – fueling the future," 2022. https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/clean-fuels-fueling-the-future/23735

[42] Environment and Climate Change Canada, *2030 Emissions Reduction Plan: Canada's Next Steps for Clean Air and a Strong Economy* (2022), page 23 (pdf page 25). https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/erp/Canada-2030-Emissions-Reduction-Plan-eng.pdf

[43] Ibid, page 90 (pdf page 92)

[44] https://www.europeanbiogas.eu/renewable-energy-legislation/#:~:text=In%20general%2C%20the%20Directive%20is,border%20trade%20of%20biomethane%20easier

[45] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6682

[46] https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/

[47] https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/011022-denmark-hikes-proportion-of-biogas-in-grid-to-25-grid-operator

imports from Russia. As a result, on March 8, 2022, the European Commission called for a rapid phase out of Russian fossil fuels and an acceleration of the European Green Deal in its Communication "REPowerEU: Joint European Action for More Affordable, Secure and Sustainable Energy".[48] This action plan calls for Europe achieving 35 billion cubic meters (bcm) of annual RNG production by 2030. The European Biogas Association states that this target represents over 20% of the current EU gas imports from Russia and that by 2050, this potential can triple, growing to well over 100 bcm and covering 30-50% of the future EU gas demand.[49] The EU has also joined the Methane Pledge targeting a 30% reduction by 2030.[50]

International Energy Agency

The International Energy Agency's (IEA) *Net Zero by 2050* report from May 2021 projects that, to reach carbon neutrality, global RNG use needs to increase seven times from 2020 levels by 2030 and over 27 times 2020 levels by 2050, leading to a blend rate in gas networks of above 80%. The report also notes that a key advantage of RNG is ability to "use existing natural gas pipelines and end-user equipment",[51] continuing that "[t]he share of low-carbon gases (hydrogen, biomethane, synthetic methane) in gas distributed to buildings rises from almost zero to 10% by 2030 to above 75% by 2050",[52] and that "[g]overnments should prioritise the co-development of biogas upgrading facilities and biomethane injection sites by 2030, ensuring that particular attention is paid to minimizing fugitive biomethane emissions from the supply chain."[53] These statements surrounding the timeline and trajectory for RNG development and use align with our vision for the future of the RNG industry in Massachusetts and North America.

California

In May 2022 the California Air Resources Board (CARB) released their Draft 2022 Scoping Plan,[54] which outlines the state's pathway to carbon neutrality by 2045—one of the most ambitious GHG reduction targets put forth by any jurisdiction in the world. The plan identifies increasing methane capture at landfills and dairy digesters as a key GHG abatement strategy. Specifically, strategies for the dairy and livestock sector include, "[Installing] state of the art anaerobic digesters that maximize air and water quality protection, [maximizing] biomethane capture,

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[48] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_3132

[49] https://www.bioenergy-news.com/news/biomethane-will-deliver-20-of-current-eu-gas-imports-from-russia-by-2030/

[50] https://www.state.gov/joint-u-s-eu-statement-on-the-global-methane-pledge/

[51] Id., pg. 78

[52] Id., pg. 146

[53] Id., pg. 112

[54] https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

and [directing] biomethane to sectors that are hard to decarbonize or as a feedstock for energy".[55] Strategies for reducing methane emissions include, "[maximizing] existing infrastructure and [expanding] it to reduce landfill disposal, with strategies including composting, anaerobic digestion, co-digestion at wastewater treatment plants, and other non-combustion conversion technologies."[56]

California's strategy also includes the use of RNG across different sectors. In the buildings sector, for example, "This transition must include the goal of trimming back the existing gas infrastructure so pockets of gas-fueled residential and commercial buildings do not require ongoing maintenance of the entire limb for gas delivery. Blending low-carbon fuels, such as hydrogen and biomethane, into the pipeline further displaces fossil gas".[57] In the industrial sector, "Decarbonizing industrial facilities depends upon displacing fossil fuel use with a mix of electrification, solar thermal heat, biomethane, low- or zero-carbon hydrogen, and other low-carbon fuels to provide energy for heat and reduce combustion emissions".[58] And finally, in the transportation sector, "In addition to building the production and distribution infrastructure for zero-carbon fuels, the state must continue to support low-carbon liquid fuels during this period of transition and for much harder sectors for ZEV technology such as aviation, locomotives, and marine applications. Biomethane currently displaces fossil fuels in transportation and will largely be needed for hard-to-decarbonize sectors but will likely continue to play a targeted role in some fleets while the transportation sector transitions to ZEVs".[59]

California's Integrated Energy Policy Report (IEPR) is the California Energy Commission's (CEC) leading document aimed at comprehensively addressing the state's evolving energy trends in the context of climate change and other environmental issues. CEC 2021 IEPR Volume III was entitled *Decarbonizing the State's Gas System*.[60] This document recognizes the role renewable gas can play in decarbonization of the gas system and encourages the use of renewable gases to achieve a variety of important environmental benefits. Notably, the report states that "there is increasing awareness that to fully decarbonize the gas system, there is a need for clean fuels or molecules in addition to clean electricity." The hydrogen section of the report also acknowledges that renewable organic waste feedstocks can be used to produce renewable hydrogen in a beneficial manner.

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[55] Id., pg. 214

[56] Id., pg. 216

[57] Id., pg. 197

[58] Id., 192

[59] Id, 179

[60] California Energy Commission, *2021 Integrated Energy Policy Report, Volume III: Decarbonizing the State's Gas System*

https://efiling.energy.ca.gov/GetDocument.aspx?tn=242233

Columbia University

Columbia University's School of International and Public Affairs Center on Global Energy Policy conducted a study[61] focused on the use of the existing gas system in a carbon neutral world. Notably, the authors state that:

> *"[R]etrofitting and otherwise improving the existing pipeline system are not a choice between natural gas and electrification or between fossil fuels and zero-carbon fuels. Rather, these investments in existing infrastructure can support a pathway toward wider storage and delivery of cleaner and increasingly low-carbon gases while lowering the overall cost of the transition and ensuring reliability across the energy system. In the same way that the electric grid allows for increasingly low-carbon electrons to be transported, the natural gas grid should be viewed as a way to enable increasingly low-carbon molecules to be transported."*

World Resources Institute

The role of RNG as a decarbonization strategy was also recently examined by the World Resources Institute, who published a paper illustrating how RNG fills an important niche as part of a broader low-carbon technology portfolio.[62] The authors state that:

> *"RNG has the potential to reduce methane emissions from organic wastes and provide fuel for applications that lack other low-carbon alternatives, such as heavy-duty freight or existing building and industrial heat sources."*

> *"The report emphasizes the importance of considering RNG as a complementary fuel in applications where natural gas or other energy sources are currently used. In this way, RNG can be seen as a flexible, low-carbon fuel source that can potentially be deployed in a variety of applications, even as other vital strategies such as electrification are pursued in parallel."*

Furthermore, WRI's analysis *How Methane Emissions Contribute to Climate Change* identifies "improving efficiency [in agricultural production practices, including manure management]",

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[61] Blanton et. Al, *Investing in the US Natural Gas Pipeline System to Support Net-Zero Targets* https://www.energypolicy.columbia.edu/research/report/investing-us-natural-gas-pipeline-system-support-net-zero-targets?utm_source=Center+on+Global+Energy+Policy+Mailing+List&utm_campaign=38d4ab05a7-EMAIL_CAMPAIGN_2019_09_24_06_19_COPY_01&utm_medium=email&utm_term=0_0773077aac-38d4ab05a7-102456873

[62] World Resources Institute, *Renewable Natural Gas as a Climate Strategy: Guidance for State Policymakers.*

https://www.wri.org/publication/renewable-natural-gas-guidance "separating organics and recycling", and "capturing landfill gas and reducing energy" as key methane abatement strategies. [63]

Modeling of Pathways to Carbon Neutrality

At this time, we believe New York to be the best example of a nearby state which is considering similar changes to its energy delivery system in the context of climate change. The analysis conducted for New York by the consulting firm Energy and Environmental Economics' (E3) in June of 2020 identified switching to low-carbon fuels as one of the four pillars of decarbonization "critical to achieving carbon neutrality" in New York State, with scenarios including an 8-18% pipeline blend of RNG,[64] showing widespread RNG use across sectors. This is consistent with E3's high-electrification scenarios conducted in other jurisdictions, which show significant demand for gaseous fuels remaining in 2050.[65]

The New York City Mayor's Office of Sustainability, in collaboration with Con Edison and National Grid, published a study outlining three pathways by which New York City can achieve carbon neutrality by 2050.[66] All three pathways in the report—including the pathway with highest electrification—outlined the use of renewable gases as an essential part of this goal. Even in the case where it is possible to convert approximately 60% of New York City's building stock to all-electric applications by 2050, this study shows that RNG has a role to play. A key finding applicable to all scenarios was that, "in addition to providing a solution for buildings that do not electrify, a low carbon gas network improves overall system reliability by offering optionality and flexibility within the energy system."[67]

This key framing of the role of RNG in the above New York analyses is consistent with studies conducted for other jurisdictions—including California,[68] Minnesota,[69] Oregon and

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[63] https://www.wri.org/insights/methane-gas-emissions-climate-change

[64] See slide 5 of E3's "New York State Decarbonization Pathways Analysis," presented to the Climate Action Council on June 24, 2020. https://climate.ny.gov/-/media/Project/Climate/Files/2020-06-24-NYS-Decarbonization-Pathways-CAC-Presentation.pdf

[65] For an example from other similar E3 work, see pg. 35 of the California Energy Commission report entitled *The Challenge of Retail Gas in California's Low Carbon Future,* which finds that natural gas in California's residential, commercial, and industrial sectors is still ~1,000 tBtu in 2050 in the high-building-electrification case: https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/CEC-500-2019-055-F.pdf

[66] New York City Mayor's Office of Sustainability, *Pathways to Carbon-Neutral NYC: Modernize, Reimagine, Reach.* https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf

[67] Id., xvii

[68] *Achieving Carbon Neutrality in California.* https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf

[69] Great Plains Institute & Center for Energy and Environment, *Decarbonizing Minnesota's Natural Gas End Uses.* https://e21initiative.org/wp-content/uploads/2021/07/Decarbonizing-NG-End-Uses-Stakeholder-Process-Summary.pdf

Washington,[70] Colorado,[71] and Maryland,[72] among others. Simply put, RNG is a necessary decarbonization strategy, even in high-electrification scenarios.

Building RNG Supply Quickly to Capture Methane from Organic Wastes is More Important in the Near-term than Debating the Sector that is the Long-Run Best Use

We believe the body of literature presented above shows that renewable gas has a clear role within any of Massachusetts' GHG reduction scenarios. However, the same literature also shows that there is diversity of opinion about the best targeted long-term uses of RNG. The RNG industry does not claim to be able to solve the daunting challenge of eliminating all organic waste methane emissions and decarbonizing the entire gas system alone, however, we believe that deciding on the best long-run end use is less important in the near term relative to ensuring that renewable gas represents a key component of Massachusetts' GHG strategy to reduce methane and begin to decarbonize gas supply.

As well stated by the World Resources Institute work referenced above:

> *"The viability of RNG as a decarbonization strategy will vary depending on regional context, and ultimately the role that it plays in decarbonization and how it complements other key strategies may shift over time. However, through careful consideration of the factors included in the preceding discussion, policymakers can explore and identify opportunities for targeted RNG production and use that can meaningfully contribute to GHG reduction goals. Overall, the flexibility of RNG, along with the methane emissions reductions associated with its production, mean that it can play a dynamic and complementary role in decarbonization in the long term."*[73]

Therefore, as summarized above in Figure 1, in the near-term Massachusetts should focus on new policy to deploy RNG quickly. Doing so does not preclude adjustments to its end use as the gas system transition takes place—an effort which will take significant time and require thoughtful infrastructure planning to determine the targeted long-run applications best served by clean gaseous fuels. Our industry remains open minded to those varying possibilities, and we

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[70] *Pacific Northwest Pathways to 2050*. https://www.ethree.com/wp-content/uploads/2018/11/E3_Pacific_Northwest_Pathways_to_2050.pdf

[71] *Colorado GHG Reduction Roadmap Technical Appendix.* https://drive.google.com/file/d/1215j7zfCsgE50msF_ZJt6ZUj0iG7Th3V/view

[72] *Maryland Building Decarbonization Study.* https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG_Buildings%20Ad%20Hoc%20Group/E3%20Maryland%20Building%20Decarbonization%20Study%20-%20Final%20Report.pdf

[73] World Resources Institute, *Renewable Natural Gas as a Climate Strategy: Guidance for State Policymakers. (*See page 37).

https://www.wri.org/publication/renewable-natural-gas-guidance look forward to working with DPU and other stakeholders as the long-term vision for RNG use in Massachusetts evolves.

Renewable Gas and Clean Heat Standards

In determining which policies and programs are most appropriate, Massachusetts should look to other jurisdictions which have made considerable progress toward similar decarbonization goals. We believe that Tradeable Performance Standards (TPS) have proven to be very effective tools in motivating RNG buildout specifically, and "fuel switching" through clean energy and infrastructure deployment more generally, toward decarbonizing the supply side of the transportation, gas, and electric sectors.

In general, a TPS sets a standard of technology performance but leaves technology choice to the program participants (e.g., clean technology companies and compliance entities). It increases the relative costs of technologies with undesirable GHG performance characteristics and lowers the costs of technologies with desirable GHG characteristics.

Jurisdictions focused on gas sector decarbonization have employed two primary types of policies aimed at incenting clean energy supply and infrastructure. Specific to gas supply only, a Renewable Gas Standard establishes targets for total renewable gas throughput, potentially including both RNG and renewable hydrogen, which increase over time.

Alternatively, a Clean Heat Standard can be used to incentivize clean heat resources more broadly, often including electrification and geothermal infrastructure alongside renewable gases. We believe that employing one of these strategies will be crucial to meeting both near- and long-term decarbonization goals in Massachusetts.

As part of California's gas sector decarbonization strategy, the California Public Utilities Commission (CPUC) voted unanimously to adopt a RGS in early 2022. Establishing a 12.2% procurement mandate for utilities' core gas customers by 2030, with a smaller mid-term target in 2025, this program is also viewed by the state as an important component of their methane reduction and landfill diversion strategies, with the near-term RNG requirement being largely based on potential from organic waste diversion projects.[74]

In addition to reducing methane emissions and replacing fossil-derived natural gas, the program is designed to facilitate the broader environmental benefits of RNG development. This is accomplished by prioritizing facilities which include carbon sequestration to further reduce emissions and achieve carbon negativity; prioritizing facilities which use their waste byproduct to create soil amendments such as a compost and biochar; requiring the buildout of pilot facilities which use wood waste feedstocks in gasification applications to reduce forest fire risk; and prioritizing facilities which use zero or near-zero emission trucks. These provisions

[74] https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-sets-biomethane-targets-for-utilities

exemplify the potential of RNG to contribute to broader environmental goals, including strengthening and circularizing the state's bioeconomy.

In May of 2022, the Minnesota Public Utilities Commission (MPUC) voted unanimously to adopt a carbon intensity (CI) and cost-benefit analysis (CBA) framework pursuant to the *Natural Gas Innovation Act*—a first-of-its-kind Clean Heat Standard in North America.[75] This program allows the state's gas utilities to propose investments in a variety of clean energy resources and infrastructure, including RNG, renewable hydrogen, electrification, geothermal, and energy efficiency, among others. Each resource mix must be compared based on cost-effectiveness, which includes lifecycle CI scoring for RNG and renewable hydrogen. Clean Heat policies such as this are significant because of their ability to incent the full spectrum of resources that are shown to be necessary for gas sector decarbonization. Jurisdictions which have adopted either a RGS or CHS include British Columbia,[76] California, Colorado,[77] Minnesota, New Hampshire,[78] Oregon,[79] and Quebec.[80]

Some stakeholders rightfully acknowledge that the transition away from fossil natural gas—particularly given the potential for electrification of many residential and commercial customers who underly current business models for gas distribution utilities—needs to be conducted deliberately and carefully to avoid an unbalanced system for remaining gas customers. Furthermore, planning for gas sector decarbonization must take into account the time required for fuel-switching, where feasible, as well as the continued need for gaseous fuels in certain applications. It is likely that this transition will require changes in rate design for gas utilities, which deserves deliberate consideration under this proceeding.

Allowing gas utilities to invest broadly in renewable thermal infrastructure such as renewable gas supply (with a goal of ultimately achieving 100% of supply from renewable sources), dedicated hydrogen infrastructure, geothermal energy, and electrification could provide a pathway for the development and maintenance of the spectrum of sustainable energy infrastructure required to serve all of Massachusetts' thermal needs in the future.

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75 https://www.revisor.mn.gov/bills/text.php?number=SF0421&session=ls92&version=latest&session_number=0&session_year=2021

76 https://news.gov.bc.ca/releases/2021EMLI0046-001286

77 https://leg.colorado.gov/sites/default/files/2021a_264_signed.pdf

78 https://legiscan.com/NH/text/SB424/id/2528713#:~:text=New%20Hampshire%20Senate%20Bill%20424&text=Bill%20Title%3A%20Relative%20to%20renewable%20energy%20and%20natural%20gas.&text=AN%20ACT%20relative%20to%20renewable%20energy%20and%20natural%20gas.&text=This%20bill%20authorizes%20the%20recovery,of%20the%20public%20utilities%20commission.

79 https://olis.oregonlegislature.gov/liz/2019R1/Measures/Overview/SB98

80 https://www.legisquebec.gouv.qc.ca/en/pdf/cr/R-6.01,%20R.%204.3.pdf

GHG Accounting Methodologies for Bioenergy

Point Source Accounting vs. Lifecycle Accounting

There are two distinct GHG emission accounting approaches commonly used in regulatory programs for bioenergy today: the "point-source biogenic CO_2 emissions are carbon neutral" approach and the "lifecycle" approach. Programs built on lifecycle analysis are more likely to produce better incentives for biofuels and bioenergy.

When using a point-source approach, GHG emissions from bioenergy are assessed only at the point of use—such as in a home, business, vehicle, power plant, or industrial facility. When determining these point-source GHG emissions, the biogenic carbon dioxide produced from the combustion of a biomass-derived input is often assumed to be counteracted by the carbon dioxide that was recently removed from the atmosphere when the biogenic material was grown, and thus netted out of any final compliance obligation.[81] The use of such a point-source framework is appropriate if it is expected that the upstream emissions (e.g., pipeline leakage) and upstream GHG sinks and avoided emissions (e.g., methane emissions from organic waste) will be accounted for by other jurisdictions under analogous programs.

A lifecycle approach[82] (LCA) accounts for GHG emissions generated from a fuel's production through its end-use—the full life of the fuel.[83] The lifecycle approach for GHG emission accounting for biofuels can also be referred to as a "well-to-wheels" or "full fuel cycle" approach. This approach accounts for all of the GHG emissions produced or avoided from the production, collection and processing, transmission and delivery, and ultimate use of a fuel (including upstream sinks and final point-source emissions).

When determining the lifecycle GHG emissions factor or carbon intensity, the GHG emissions are summed across each stage, and the end user of the fuel is responsible for all emissions. A full lifecycle approach is appropriate if other jurisdictions do not have programs to account for these upstream sources and sinks, or simply if the jurisdiction's goal is to create the proper incentives to reduce global emissions across an entity's entire biofuel or bioenergy supply chain.

Fundamentally, it is appropriate to track biogenic carbon dioxide emissions from use of biomass and biofuels as a line item in any point source emission accounting, and to appropriately "net

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[81] For example, the Regional Greenhouse Gas Initiative uses this approach.

[82] Lifecycle analysis is well established as the leading way to holistically compare greenhouse gas abatement options. It is frequently used for bioenergy (inclusive of biofuels), but also has a role in comparing many other types of GHG abatement. The term "life cycle" appears 143 times in the IPCC's *Climate Change 2022, Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_Chapter10.pdf

[83] https://www.epa.gov/renewable-fuel-standard-program/lifecycle-analysis-greenhouse-gas-emissions-under-renewable-fuel

out" CO_2 biogenic emissions or sinks as a step in any accounting of such fuels. Conversely, it is not appropriate to treat biogenic CO_2 from the use of biomass and biofuels as identical to CO_2 from fossil fuels (thus ignoring the upstream sink as the biogenic material is grown).

With this in mind, analyses of RNG, hydrogen, and other energy resources under consideration by the Commonwealth should rely on proven LCA tools, such as the Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model (GREET) from Argonne National Labs, that are supported by more than 25 years[84] of research and peer review.[85]

Renewable Gas Creates Green Jobs and Provides a "Just Transition" for the Gas Sector Workforce

Ensuring a just transition away from traditional energy sources and industries should be an important consideration for Massachusetts and has been identified as a key concern for workers and community voices participating in the DPU 20-80 process. Indeed, it is likely that many of the technologies considered by the Commonwealth will lead to the eventual obsolescence of some existing oil and gas *extraction* infrastructure as fossil fuel use declines. However, stakeholders must consider how certain necessary components of the state's GHG reduction strategy, such as renewable gas and liquid biofuels, will support the long-term use of a subset of the existing *distribution* infrastructure and associated jobs in a beneficial manner, in addition to the important opportunity to promote high-quality manufacturing jobs in Massachusetts from emerging technologies.

The process of decarbonizing all sectors which currently utilize fossil natural gas will involve increasing renewable gas supply while systematically pruning portions of the gas system subject to electrification. From an employment standpoint, the utility gas industry currently provides well-paying union jobs for skilled workers across Massachusetts. Therefore, it is important to consider apprenticeship opportunities and high-road pathways to green jobs provided by renewable gases, which in turn will advance the state's goals of broadening access to middle-class jobs while resolutely addressing the climate crisis.

While gas industry jobs have historically fallen under the fossil fuel industry umbrella, those which are retained will become green jobs as the pipeline system transitions to a clean fuel system and RNG methane capture projects begin to employ this skilled labor. With this in mind, Massachusetts should study which portions of the pipeline are expected to be needed for renewable gas delivery over different timeframes, and should map employment expectations and gaps accordingly.

RNG Coalition best understands the employment benefits at the RNG facilities themselves. For example, Massachusetts should move forward with organic waste recycling mandates, which

[84] https://www.epa.gov/system/files/documents/2022-03/biofuel-ghg-model-workshop-biofuel-lifecycle-analysis-greet-model-2022-03-01.pdf
[85] https://greet.es.anl.gov/

would necessitate new facilities to process the additional quantities of organic waste, stimulating employment in the sustainable waste management and industrial building construction industries, among others. For comparison, California is projected to create 11,700 permanent jobs based at more than 80 new or expanded compost or anaerobic digestion facilities based on CalRecycle's organic waste recycling goals.[86]

The RNG industry currently has more RNG plants under construction or substantial development than in existence. Therefore, RNG contribution to jobs and the economy will inevitably increase. This represents an important opportunity for employment in Massachusetts given that RNG jobs are high paying, the vast majority of which fall well above the national average personal income. In 2021, the RNG industry contributed 22,600 Jobs and $2.6B in GDP to the U.S. economy, and could contribute 200,000 jobs by 2030 if the U.S. is on track to achieve carbon neutrality by 2050. Every $1 million spent on RNG production in 2021 created approximately 12 jobs.[87]

Conclusion

Based on extensive research, modeling, and experience from existing policies aimed at achieving carbon neutrality, RNG has demonstrated it can play a key role in reaching deep decarbonization goals in Massachusetts and globally.

To achieve methane reductions, RNG should be generally incentivized for use in any application to displace fossil fuels in the near-term, including those which may ultimately be electrified. There remains such a large demand for conventional fuels, and the RNG industry is still so nascent, that there is no need to determine the ultimate end use of the sustainable RNG resources immediately. In the long-term, renewable gases should be targeted toward applications that are not suitable for electrification. With this framework in mind, we urge the DPU to work with stakeholders in developing a strategy which sends a clear signal about Massachusetts' vision for the use of renewable gases.

Our industry stands ready to deploy renewable gas technologies which will reduce methane emissions, displace fossil fuel supply, improve organic waste management, produce useful soil amendments, and ultimately sequester carbon in Massachusetts. We commend the DPU, Massachusetts' agencies, and all stakeholders for your significant work throughout this process and look forward to continued collaboration toward the state's GHG reduction goals.

[86] https://www.nrdc.org/sites/default/files/green-jobs-ca-recycling-report.pdf

[87] https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/61ba25c889b4fb7566404e6c/1639589328432/RNG+Jobs+Study.pdf