

Renewable Natural Gas Project Economics

Renewable Natural Gas Issue Brief • Part IV of IV • July 2019



Introduction

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

Compared to conventional natural gas, RNG offers greenhouse gas, health and air quality benefits. However, costs of RNG projects often exceed those of conventional gas projects, resulting in a cost premium for consumers. RNG project costs can vary depending on feedstock and location, as well as on unique site characteristics like distance from existing natural gas pipeline infrastructure, interconnection requirements including upgrading the gas to pipeline quality standards, the need for customized engineering and design. Projects can also deliver a wide range of lifecycle greenhouse gas benefits. As such, generalizing cost assessments from one project to another is challenging. However, as is the case in the renewable electricity market, policies and spread of technology are expected to reduce the cost of RNG projects over time.

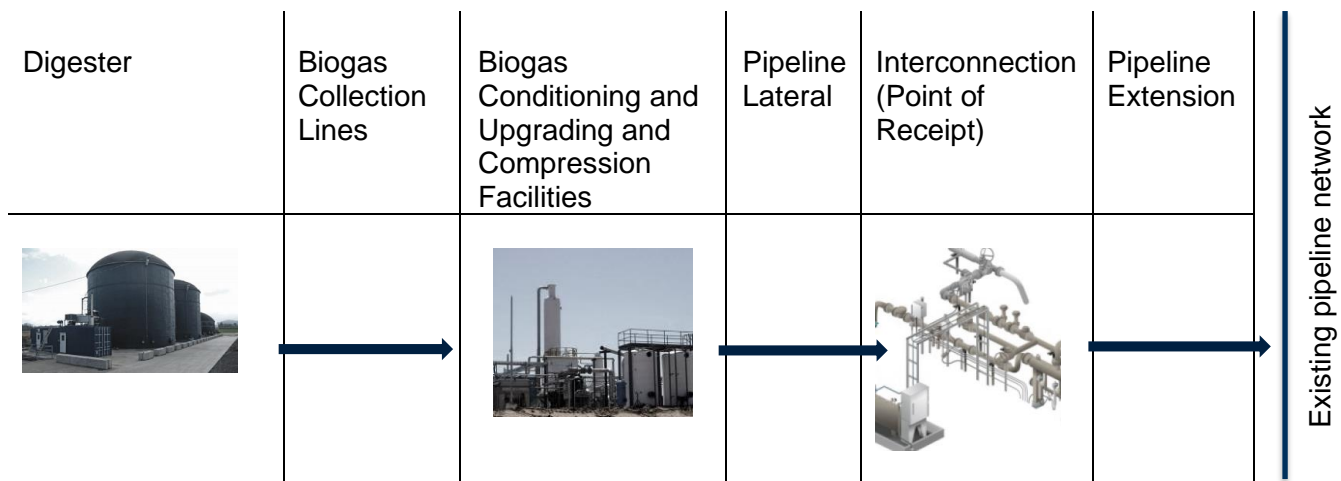
This Issue Brief first provides an overview of RNG project cost. It then reviews incentive programs in place for RNG dedicated to transportation end uses that reduce project developer risk and promote RNG project development. Then, it evaluates the economics of a landfill project and a dairy digester RNG project. Finally, it looks ahead to the future of RNG and the potential for upfront costs or payback periods to decrease.

RNG Project Cost Overview

Biogas produced from waste (i.e., animal manure, wastewater, food waste) through anaerobic digestion is typically comprised of 40-60 percent methane (CH_4), with the remainder comprised mostly of carbon dioxide (CO_2). This raw biogas can often be used locally to produce on-site electricity or heat with minimal processing. However, it must be processed or “upgraded” to meet pipeline quality standards, so that it can be injected into distribution pipelines as RNG and used interchangeably with conventional natural gas. The primary upgrading step is to remove most of the CO_2 .

Capital costs for RNG projects can exceed tens of millions of dollars. These project costs include: feedstock gathering and handling (landfill) or anaerobic digestion (dairy), gas upgrading and conditioning, gas compression and injection, interconnection, and pipeline extension. Figure 1 provides a schematic of a typical dairy digester project showing these major components.

Figure 1: RNG Project Components



The costs of the first three project elements (collection/digestion, conditioning/upgrading, and compression) are generally proportional to the amount of biogas produced but do exhibit limited economies of scale. These costs do not vary significantly based on project location, but could vary based on the choice of upgrading technology.

Interconnection costs are typically fixed over a wide range of injection volumes and thus exhibit very strong economies of scale, as larger projects can amortize these costs over greater throughput volumes and result in lower cost per unit of produced gas (\$/MMBtu). Interconnection costs can also vary significantly by location.

The cost of pipeline extensions to connect a given RNG supply to the existing utility distribution system is primarily a function of distance, not volume. As such, pipeline extension costs also exhibit strong economies of scale, with larger projects resulting in lower unit costs. Pipeline extension costs also exhibit the greatest variability from project to project, based on the actual distance of the RNG source from the nearest transmission or distribution pipelines.

Due to the interconnection and pipeline extension costs, total costs of RNG production in terms of \$/MMBtu generally exhibit very strong economies of scale, favoring large projects over smaller ones. To illustrate, a study conducted by Amy Jaffe at UC Davis' Institute of Transportation Studies estimated the average cost of RNG production for California projects. The results show that RNG upgrade and injection costs fall from more than \$30/MMBtu to less than \$10/MMBtu as project size increases from 10 MMBtu/hour to 100 MMBtu/hour.¹

¹ Amy Myers Jaffe, Principal Investigator, STEPS Program, Institute of Transportation Studies, UC Davis, The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute, Prepared for the California Air Resources Board and the California Environmental Protection Agency.

Transportation Fuel Market Incentives

While RNG derived from raw biogas can be used in a variety of applications, incentives associated with transportation fuel markets currently drive investment in RNG projects. RNG has significantly higher value when used as a transportation fuel than when used for space or process heating because of its eligibility to generate credits under the California Low Carbon Fuel Standard (LCFS) and the federal Renewable Fuel Standard (RFS). These credit programs help project developers and investors recoup project costs, reducing financial risk and payback timelines. Both programs are targeted exclusively to transportation fuels; there are currently no state or federal programs that provide equivalent incentives for non-transportation uses of RNG.

The Federal Renewable Fuel Standard

The federal RFS requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel in the U.S. each year. Mandated volumes are set annually for four renewable fuel categories: biomass-based diesel, cellulosic biofuel, advanced biofuel, and total renewable fuel. These eligible fuels generate Renewable Identification Numbers (RINs) that can be bought and sold separately from the fuel.² Refineries and fuel suppliers comply by either blending quantities of renewable fuel into the transportation fuel supply or by obtaining enough RINs to meet specified volume obligations. RINs generated by RNG used in transportation can be sold to refiners and fuel suppliers to meet their annual obligations, thus earning revenue for the RNG project developer.

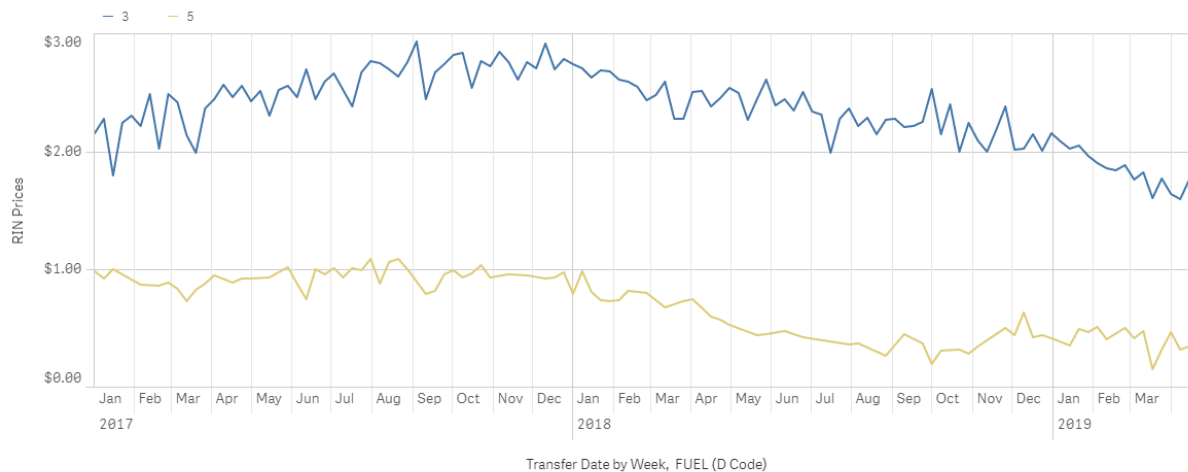
Market prices for RINs under RFS vary depending on generation fuel category. RINs generated by primarily cellulosic biofuel (D3) have historically had the highest value. To qualify to generate D3 RINs, the average cellulosic content of the biofuel must be greater than or equal to 75 percent. If average cellulosic content is less than 75 percent, the RINs are apportioned based on the cellulosic content of each feedstock; EPA test methods are required to be used in order to determine the cellulosic content of the feedstock.

RINs generated by advanced biofuel (D5) have historically had the lowest value. As illustrated in Figure 2, in April 2019, D3 RINs were selling for \$1.85/RIN while D5 RINs were selling for only \$0.34/RIN. Based on this current market value of D3 RINs, RNG from qualifying sources can generate RINs worth approximately \$21/MMBtu of delivered RNG. Since 2017, the average D3 RIN price has been \$2.39 (minimum \$1.04, maximum \$2.95) while the average D5 RIN price has been \$0.70 (minimum \$0.28, maximum \$1.05). The minimum RIN price set by the federal government is \$0.05/RIN for both D3 and D5 RINs, while the maximum prices are \$3.50/RIN and \$2.00/RIN, respectively.

Based on EPA analysis, RNG from landfills, municipal wastewater treatment facility digesters, agricultural digesters, and separated municipal solid waste (MSW) digesters qualifies for D3 RINs. Some portion of RNG produced in other waste digesters could qualify as D3 fuel depending on the biofuel's cellulosic composition. RNG from waste digesters qualifies as an advanced biofuel and generates D5 RINs. Although D3/D5 combined production is permissible, EPA has yet to approve a feedstock-to-biogas derivation methodology.

² Under RFS, a quantity of fuel with energy content of 85,324 btu, equivalent to the energy content of one gallon of ethanol, can generate one RIN if it replaces a petroleum-based fuel. One MMBTU of RNG has the same energy content as 11.72 gallons of ethanol, so could generate 11.72 RINs under RFS.

Figure 2: Weekly D3 and D5 RINs Prices (2017-2019)



Source: EPA, Fuels Registration, Reporting and Compliance Help; Available at <https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information>.

The California Low Carbon Fuel Standard

In California, the LCFS requires in-state refineries and fuel suppliers to reduce the carbon intensity of transportation fuels ten percent from 2010 levels by 2020 and twenty percent by 2030. Additionally, transportation fuels must meet an annual carbon intensity (CI) target that decreases each year.³ Refineries and fuel suppliers can meet these targets either by mixing fuels with lower CI into the overall supply or by purchasing credits.

To generate credits, each source of RNG must have a CI value approved by the California Air Resources Board (ARB) based on the details of the “pathway” between production and transportation use in California. Individual RNG pathways have different CIs based on the details of the pathway (e.g. the energy inputs required for biogas upgrading, the distance between the source and end-use sites). LCFS credits are calculated



³ The carbon intensity of all fuels is expressed as grams of CO₂-equivalent GHG emissions per mega-joule of delivered energy (g CO₂-e/MJ), to include all life-cycle emissions of CO₂, CH₄, and N₂O. Life-cycle emissions include those associated with fuel production, transportation, and end-use combustion.

based on the difference between the target CI for the total fuel pool and the actual approved CI of the fuel in question, based on a life cycle analysis. The lower a fuel's CI, the greater number of credits it will earn for a given sales volume. Credits are expressed as metric tons of carbon dioxide-equivalent emissions (MT CO₂-e). Like RINs, these credits can then be bought and sold.

CI values of existing approved RNG pathways vary from 7.39 to 66.55 g CO₂-e/MJ for RNG produced from landfills, and from -272.97 to -254.94 g CO₂-e/MJ for RNG produced from digestion of livestock waste at dairies. This compares to a CI of 100.82 g CO₂-e/MJ for gasoline and 80.59 g CO₂-e/MJ for fossil natural gas.⁴ Dairy pathways have negative CI values because it is assumed that, absent the RNG project, the biogas produced by manure would be released directly to the atmosphere. Because the methane in the biogas has 25 times the warming potential of CO₂, on a CO₂-equivalent basis the life cycle "credit" for not allowing this gas to escape is greater than that of the CO₂ produced by end-use RNG combustion. RNG produced from landfills does not have a negative CI because virtually all landfills large enough to be targets for RNG production are required by EPA regulations to capture the landfill gas they produce and either use or flare that gas. As such, landfill RNG projects only get credit for reducing CO₂ emissions from flaring, not the much higher credit for reducing methane emissions to the atmosphere.

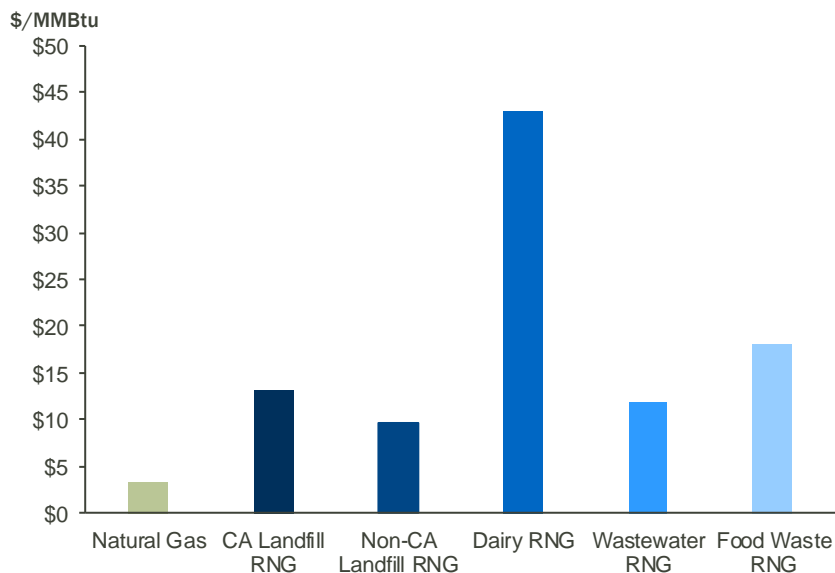
LCFS credit transaction volumes and prices are required to be reported to the ARB, which provides weekly, monthly, and annual LCFS credit transaction information publicly on its website. During the week of May 3, 2019, the average sale price of LCFS credits was \$189/MT, with prices ranging from \$175/MT to \$198/MT. Since 2017, the simple average LCFS credit value has been \$128.16/MT, with prices ranging from \$46.14/MT to \$202/MT.⁵

Figure 3 shows the estimated average LCFS credit (\$/MMBtu) that could be generated by eligible RNG, based on 2018 market data (average 2018 LCFS credit value of \$155/MTCO₂-e) and the average CI values of existing approved RNG pathways. As shown, RNG from landfills, wastewater treatment plants, and digestion of separated food waste can earn LCFS credits of \$10-\$20/MMBtu, while RNG from a dairy digester could earn more than \$45/MMBTU in LCFS credits. RNG used for transportation in California can both generate RINs under RFS and generate LCFS credits.

⁴ https://www.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx

⁵ <https://www.arb.ca.gov/fuels/lcfs/credit/lrtweeklycreditreports.htm>

FIGURE 3: ESTIMATED LCFS CREDIT VALUE OF NATURAL GAS V. ELIGIBLE RNG TYPES



Source: California ARB LCFS credit price and CI values, MJB&A analysis. LCFS credit price \$155/MT. CI values: NG 74.1, CA Landfill 11.3, Non-CA Landfill 33.5, Dairy -178.6, WWTP 19.3, Food waste -19.1.

Implications for Future RNG Projects

Since 2011, 60 RNG projects have been developed and more than 50 new RNG projects are under construction or are in development. Virtually all of these recent projects plan to market the resulting RNG for transportation use and therefore generate credits under the LCFS and the RFS. Inherently, these credit programs apply an economic value for the benefits of RNG compared to conventional gas. Though RNG projects are currently more expensive than conventional natural gas supply, they contribute to reducing the carbon intensity of fuels burned, capture methane emissions that would otherwise escape to atmosphere, and leverage existing waste streams, all of which positively impact public health, climate and air quality. Without credits, many of these projects would have unfavorable economics and likely would not be proceeding. The case studies in the following section offer a glimpse into costs of two illustrative projects and the potential impact that LCFS or RFS credits could have in recouping investment costs in a timely manner.

While the incentives provided by LCFS and RFS have been instrumental in spurring development of new RNG supplies, there are limitations. First, without a significant expansion, the natural gas transportation market will eventually be saturated. In addition, financing RNG projects based on the projected revenue stream from selling credits is a strategy not always well received by financial institutions, given the inherent regulatory and market risks of these revenue streams. Potential investors are likely to discount the value of RFS and LCFS credits due to this uncertainty, thus reducing the number of financially attractive project opportunities. Nonetheless, RNG project developers focus on the transportation market because no other markets provide comparable returns. This could change as demand from large end users for renewable thermal product offerings increases and innovative approaches emerge.

Innovative Project Financing Approaches

In addition to natural gas LDCs, large energy users like manufacturers and industrial companies are increasingly interested in RNG. This interest stems from corporate climate change goals to reduce GHG emissions, with some companies aspiring to become carbon neutral.

In 2018, L'Oréal USA announced plans to achieve carbon neutrality in 2019 for all 19 of its U.S. manufacturing and distribution facilities across 12 states using a financially sustainable approach that could serve as a model for future RNG projects. The company signed a 15-year agreement to purchase approximately 40 percent of the RNG produced from the Big Run Landfill in Ashland, Kentucky. To offset the cost differential between RNG and conventional natural gas, L'Oréal USA will sell the RNG into the transportation fuels market for approximately five years and purchase carbon offsets. After the five-year period, L'Oréal USA plans to use the RNG to maintain its carbon neutrality for its manufacturing and distribution facilities.

This approach could represent a transition point for the market, where long-term purchase agreements for RNG could result in more attractive pricing for large users and for natural gas LDCs. Coupled with short-term payback on the capital investment through sale of RNG into the transportation fuels market, end users could potentially build RNG supplies at more reasonable cost.

See L'Oréal USA's announcement here <https://www.lorealusa.com/media/press-releases/2018/march/carbon-neutrality>

Evaluation of Representative Landfill Project and Dairy Digester Projects

To provide a closer look at potential project costs and payback timelines, MJB&A conducted two analyses on representative RNG projects from two feedstocks: a landfill and a large dairy (2,000 cows). Landfills are generally the lowest cost RNG resource available today – gas collection systems are already in place at many landfills due to federal air quality requirements to capture and flare gas.⁶ Some landfill projects may require additional investments to upgrade the existing gas collection systems or to maximize gas collection, but these costs are typically nominal compared to other project costs. By comparison, dairy projects require construction of a digester to collect the biogas and enhance its production.

As discussed in the first section of this brief, the high capital costs of utility interconnection and pipeline expansion also result in significant economies of scale for RNG projects, further improving the economics of landfill RNG projects as compared to dairy RNG projects. A mid-to-large sized landfill might produce 700,000 MMBtu/year of RNG, while a large dairy would produce only about 47,000 MMBtu/year of RNG. Estimated total RNG project costs for this landfill would be on the order of \$21.5 million⁷, resulting in RNG production costs of approximately \$8.70/MMBtu.⁸ By comparison, estimated RNG project costs for a 2,000-head dairy would be on the order of \$8 million dollars for on-site digestion and \$6 million for centralized digestion⁹, resulting in RNG production costs of \$28-\$35/MMBtu.¹⁰ These are the underlying assumptions used in the analyses below.



⁶ Based on total cost of production (\$/MMBtu), not including RFS or LCFS credits. Total cost of production includes amortized capital costs and annual operating costs.

⁷ Project costs include the following: gas clean up 37 percent, balance of plant 37 percent, interconnection 21 percent and gas collection 5 percent.

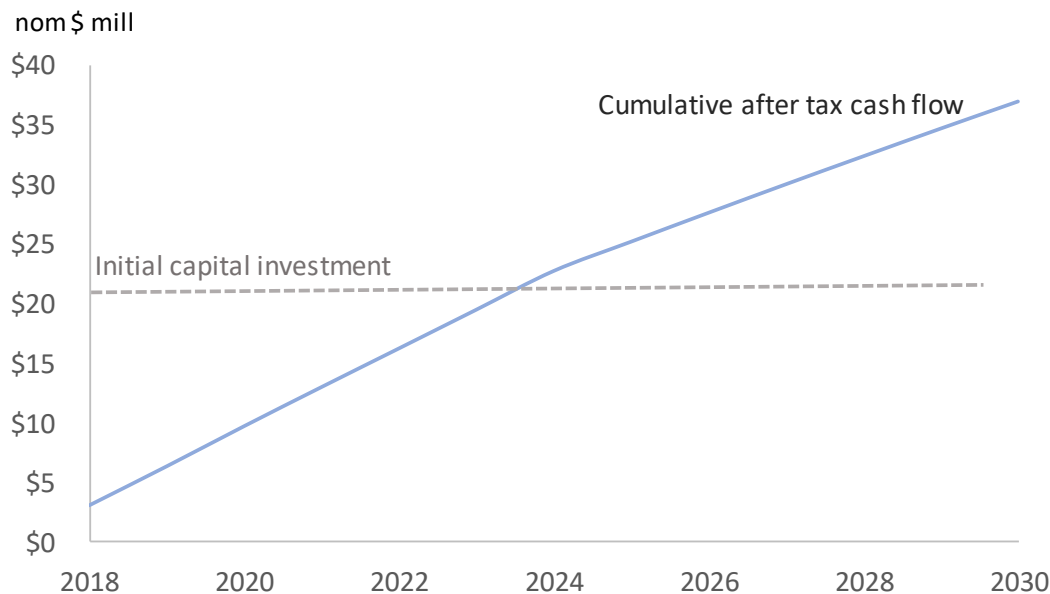
⁸ This assumes 10-year capital amortization and a 10 percent annual return on capital.

⁹ Centralized digestion consolidates manure from multiple farms to a centralized digestion facility which can increase economies of scale, but also adds operating costs for transportation and results in a lower net GHG reduction (higher CI).

¹⁰ This assumes 10-year capital amortization and a 10 percent annual return on capital.

Figure 4 below illustrates the cumulative cash flow for the landfill project producing 700,000 MMBtu/year of RNG, assuming the project could sell RNG at market price (\$4/MMBtu) and earn an incentive of \$100/MT CO₂-e reduced.¹¹ Figure 4 plots cumulative net cash flow after subtracting out all operating expenses and taxes.

Figure 4: Landfill Project Payback (with \$100/MT CO₂e incentive)



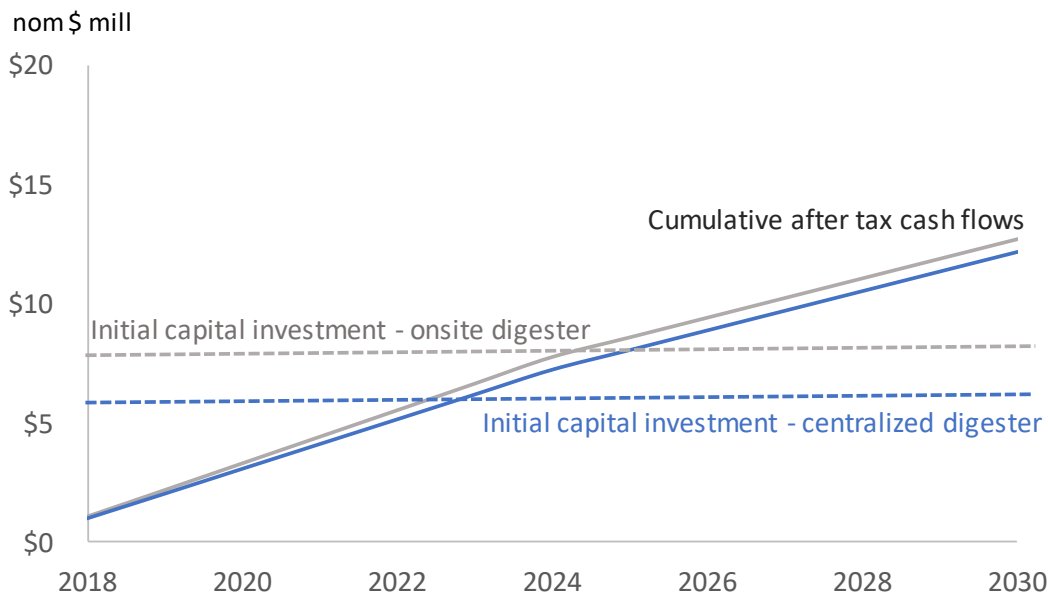
Source: MJB&A Analysis, landfill producing 700,000 MMBtu/year of RNG. Includes operating costs.

As shown, the landfill project would earn back its \$21.5 million in up-front capital costs after approximately five years (5-year simple payback), at which point it would start to earn significant returns on the initial investment. With wholesale natural gas prices around \$4/MMBtu, the cost premium for RNG supplied from a landfill would be approximately \$4.70/MMBtu.

For the dairy digester project producing 47,000 MMBtu/year of RNG, Figure 5 similarly illustrates the cumulative cash flow assuming the project could sell RNG at the same market price (\$4/MMBtu) and would earn the same incentive per MT CO₂-e reduced as the landfill project (\$100/MT CO₂-e). Despite higher costs inherent to dairy projects, as discussed above, the payback periods for dairy onsite digester and dairy centralized digester projects would be similar—just over four years for the centralized digester and around seven years for the onsite digester. In contrast to the landfill project, the initial returns on investment would not be nearly as robust. With wholesale natural gas prices around \$4/MMBtu, the cost premium for RNG supplied from a dairy would be in excess of \$24/MMBtu.

¹¹ The \$100/MT incentive does not represent any specific program or policy. The value that accrues to the project is based on the lifecycle carbon intensity values of LFG and dairy RNG relative to conventional natural gas.

Figure 5: Dairy Digester Project Payback (with \$100/MT CO₂e incentive)



Source: MJB&A Analysis, 2,000 cow dairies, onsite digester and centralized digester. Includes operating costs.

Despite the higher cost of production for dairy RNG projects, these projects can still be economically viable if they can earn some type of incentive based on their net GHG reduction. As discussed above, RNG from dairies has lower life cycle carbon intensity than RNG from landfills, so it would earn greater credits per unit of delivered gas under a program like LCFS that would at least partially offset higher production cost and improve cost competitiveness of dairy projects. Though the dairy and landfill analyses assume that incentives earned by RNG would be \$100/MT CO₂-e of net life cycle GHG reduction, this is significantly lower than the incentive amount that can currently be generated under RFS and LCFS for RNG sold into California for transportation use. Our hypothetical projects would have even shorter payback periods if earning RFS and LCFS credits.

RNG Economics Going Forward

As the analyses and discussion above show, there is currently a cost premium on RNG even when incentives are considered, and those incentives are often limited to RNG used in transportation. RNG directed to other uses (e.g. space heating, process heat) still comes at a significant premium to market price.

Despite this cost premium, RNG projects continue to launch because of the societal benefits that RNG provides as compared to conventional natural gas. First, RNG is often derived from an existing waste feedstock. Methane that could be released directly to atmosphere or flared on site is repurposed to provide an energy source. RNG production therefore helps reduce the direct release of a high global warming potential (GWP) gas, gives waste productive value, and can improve health and safety outcomes in surrounding communities. Second, RNG production can give the agricultural sector a new, reliable revenue stream. Additionally, RNG can help to reduce the environmental impact of hard-to-abate industrial sectors unable to electrify. Finally, the negative environmental and health externalities of conventional natural gas use have historically not been endowed with specific economic value.

As states and jurisdictions increasingly account for and value these externalities, cost could be added to conventional natural gas prices, allowing RNG the potential to become a comparatively-priced resource offering health and safety benefits. In its latest Integrated Resource Plan, NW Natural claims that RNG, derived from dairy specifically, could soon be considered a least-cost resource because use of dairy-derived RNG can provide a net negative impact to carbon emissions and result in net negative carbon compliance costs. After considering the on-system benefits and emissions compliance benefits of dairy RNG, NW Natural predicts that the all-in cost for on-system dairy in 2037 will be just over \$2/MMBtu.

It is also possible that, over time, the RNG price premium will continue to fall and perhaps reach the conventional natural gas market price due to market forces. In the renewable electricity market, for example, incentives for solar technologies when those technologies were still nascent spurred innovation in the sector, contributing to a precipitous price decline. While some segments of the RNG cost structure are not as flexible as those comprising solar cost, it is likely that there will be innovation in the sector as the technology is used on larger scales, applied to different feedstocks, and implemented across a variety of jurisdictions.

Conclusion

RNG is a more expensive gas supply resource than conventional gas. The higher RNG costs are due to high capital costs for gas collection and processing, and the small scale of most individual supply projects. However, given the focus by states and by many large companies on decarbonizing all sectors of the economy and the broader benefits of RNG projects, supportive public policies that value the greenhouse gas reduction benefits and the renewable attributes of RNG are necessary, especially at this stage of the market. Market incentives that reward the use of RNG for in heating will continue to drive public and private sector investments in RNG projects. At the same time, future cost reductions are possible as technologies mature, project designs are advanced and resources are brought to market at scale.

Contacts

For more information on this topic, please contact:

Dana Lowell
Senior Vice President-Technical Director
dlowell@mjbradley.com
(978) 369-5533

Brian Jones
Senior Vice President
bjones@mjbradley.com
(978) 369-5533

About Us

MJB&A provides strategic consulting services to address energy and environmental issues for the private, public, and non-profit sectors. MJB&A creates value and addresses risks with a comprehensive approach to strategy and implementation, ensuring clients have timely access to information and the tools to use it to their advantage. Our approach fuses private sector strategy with public policy in air quality, energy, climate change, environmental markets, energy efficiency, renewable energy, transportation, and advanced technologies. Our international client base includes electric and natural gas utilities, major transportation fleet operators, investors, clean technology firms, environmental groups and government agencies. Our seasoned team brings a multi-sector perspective, informed expertise, and creative solutions to each client, capitalizing on extensive experience in energy markets, environmental policy, law, engineering, economics and business. For more information, we encourage you to visit our website: www.mjbradley.com.