Policy Brief – Renewable Natural Gas Provides Viable Commercial Pathway for Sustainable Freight

September 2017

Abstract

California has a large resource base of non-farmed biomass resources that can be converted to renewable natural gas fuel (RNG). RNG fuel can be a cost-effective option to meet California's Low Carbon Fuel Standard (LCFS) in some circumstances and with some waste biomass sources. Geography, scale, and intensity of clean up requirements are key variables that need to be considered. In this policy brief, we look at the location and scale of resources to consider commercial viability. Our analysis projects that with California's LCFS credits at (current) levels of $120 per metric ton of CO_2, RNG can achieve significant market penetration of 14 bcf by the 2020s. This volume would replace roughly 85% of the 16.4 bcf of fossil natural gas used in transportation in California in 2015 (Figure 1),[i] with roughly 6.3 bcf of this total from southern California landfill gas, 4.3 bcf from dairy manure from clustered farms, 1.75 bcf from municipal solid waste (MSW), and 1.5 bcf from wastewater treatment. But this quantity is small: fossil NG only accounts for 5 percent of diesel transportation fuel in California. If costs of RNG production are reduced through innovation, or the LCFS credit prices are higher (the current credit price cap is $200 per ton of CO2), then the cost-effective volumes would be greater.

Except in a few unique locations, RNG from dairy manure represents the costlier option for producing RNG because sources are dispersed geographically and volumes are small in most locations.

With that caveat understood, our study finds that an LCFS credit price of as low as $90 would enable landfills located in Los Angeles, San Diego, Irvine, Sacramento, and Livermore to provide significant volumes of low-carbon, RNG-based transportation fuel for California.

In practice, cost-effectiveness is probably not good enough to motivate RNG investments and use in trucks not currently using NG. Truck fleet owners are reluctant to switch from diesel to natural gas fuel (whether renewable or fossil) because the vehicles are currently more expensive and could potentially have less resale value.

Introduction

California's proactive policies to reduce greenhouse gases across all segments of its economy are leading to new opportunities for alternative-fuel businesses. The state will need high volumes of low-carbon alternative fuels to be able to meet its climate-change and air-quality goals.

In 2016, California Governor Jerry Brown signed into law California Senate Bill (SB) 1383, directing aggressive action on short-lived climate pollutants. SB 1383 requires dairies, livestock production, and landfills to reduce methane emissions by 40 percent relative to 2013 levels by 2030. The legislation also provides incentives for greater conversion of biomass resources to renewable natural gas (RNG) fuel. The anaerobic digestion of biogas produces a mix of various gases but primarily carbon dioxide and biomethane. When carbon dioxide is separated the resulting biomethane (and trace amounts of other gases) is referred to as renewable natural gas (RNG) or biomethane, which is similar in composition to fossil natural gas and can thus be blended with it or entirely substitute for it. SB 1383 directs gas companies to complete at least five pilot biomethane projects that demonstrate interconnection with the existing gas pipeline network by 2018, and calls on the California Air Resources Board to establish development and procurement policies for energy infrastructure needed to encourage dairy bio-methane projects. Together, these measures will help realize California's significant untapped RNG resources.

In this policy brief, we (researchers at the University of California, Davis, Institute of Transportation Studies) examine the potential of RNG in California's transportation sector. We discuss both the opportunities that RNG presents and the barriers to its wide-spread adoption. We argue that RNG could be a cost-effective commercial pathway for energy companies to meet California's Low Carbon Fuel Standard (LCSF) and for non-attainment (e.g., exceeding levels of air pollution) regions to address air-quality targets. RNG's adoption will be helped by a recent series of bills passed in September 2017 by the California legislature to provide $895 million towards programs that mitigate air pollution from mobile sources, including $250 million to the Carl Moyer program that subsidizes alternative fuel trucks and $180 million towards the Clean Bus and Truck program that targets adoption of low NOx natural gas engines that can run on RNG.

This ITS-Davis study suggests RNG is a promising low carbon alternative to diesel fuel in freight applications. Our models indicate that existing credit-market programs such as the LCFS can mitigate some or all of the higher capital costs for certain kinds of RNG in key locations around the state, rendering RNG one of the more commercially feasible ways for fuel producers to comply with California's environmental performance restrictions.

Resource potential

California contains a substantial amount of RNG that, under existing policies and programs,[ii] could be cost-competitive with fossil fuels in the state's transportation energy market. However, not all of the state's physical RNG resources are suitable for commercial exploitation as transport fuels. The commercial viability of an individual RNG resource depends on several factors, including the size of the resource, the proximity to infrastructure and markets, and the costs of biogas to biomethane conversion or clean up.

In California, the economics of RNG exploitation and development are best for large resources close to Los Angeles. Furthermore, certain sources of bio-methane can be developed more cost-effectively into RNG fuel than others. Landfill gas is a particularly promising source, while dairy waste is particularly costly.

In RNG analyses, it is important to understand the difference between the absolute size of an RNG resource and the volume of the resource that is commercially exploitable: that is, the volume of the resource that can profitably be converted to a transportation fuel and injected into the existing network. Failing to distinguish between these two metrics will yield apparently wide variation in estimates of RNG resource potential.

Researchers at UC Davis's California Biomass Collaborative (CBC) have produced estimates of RNG resource that is technically available (possible to obtain even if costs are high) and researchers at the Institute of Transportation Studies estimated how much of this resource is commercially available, that is to be competitive with fossil natural gas which trades at around $3/mmBtu.

California contains up to 90.6 billion cubic feet (bcf), or 750 million gasoline gallon equivalents (gge), per year of technically producible RNG but very little of it is commercially recoverable without accounting for externalities.

The largest technically recoverable source by far is landfill gas. The CBC estimates that 106 bcf/year of biogas ('unclean' RNG), which would translate into about 53 bcf/year of biomethane, can be technically produced from California landfills[iii]. About three fourths of these (82 bcf/year) are already being produced in California[iv]. And 55% of this production (~45 bcf of biogas) is currently converted to electricity, while the majority of the remainder biogas is collected and flared. Very little is currently converted into biomethane and injected into the pipeline, and that is due to the high costs of upgrading to pipeline quality standards and the capital costs of interconnections to pipelines. Based on our analysis, we estimate that only 6.3 bcf/yr RNG could be commercially be produced and injected into the pipeline, once LCFS carbon credits of $120/mmBtu are included, and 50.1 if both LCFS and RIN credits are included. Some companies are bypassing these added costs of injecting into the pipeline by using the RNG in their own fleets that are capable of refueling on-site.

The second largest technically recoverable resource is manure. The CBC estimates that California produces 11.9 million bone dry tons (bdt) of manure per year from the agricultural animal population. The majority of this resource is not available for RNG production as collection of manures deposited in fields is economically infeasible. The commercially exploitable fraction of agricultural animal manures for RNG is approximately 4.3 bcf/yr, of which more than 80% derives from dairies, once LCFS credits are included, and 10.1 bcf/yr if including LCFS and RIN credits.

Food and green wastes and animal wastes represent additional sources of RNG. The CBC estimates that 1.2 million billion dry ton (bdt/yr) of currently landfilled food and green wastes in California could produce 8 bcf/yr of technically recoverable RNG, if it could be economically separated from the waste stream and processed in an anaerobic digester.[v] The commercially exploitable fraction of food and green waste RNG is, however, only, 1.75 bcf/yr (LCFS credits or and 16.3 (LCFS credits+RINs).

Market opportunities and challenges

Our analysis projects that with California's LCFS credits at current levels of $120 per metric ton of CO_2, RNG can achieve significant market penetration in California's transportation-fuel sector of 14 bcf by the 2020s. This volume would replace roughly 85% of the 16.4 bcf of natural gas used in transportation in California in 2015 (Figure 1), .[vi] 6.3 bcf of this total would come from landfill gas, 4.3 bcf from dairy manure, 1.75 bcf from municipal solid waste (MSW), and 1.5 bcf from wastewater treatment (Figure 1)

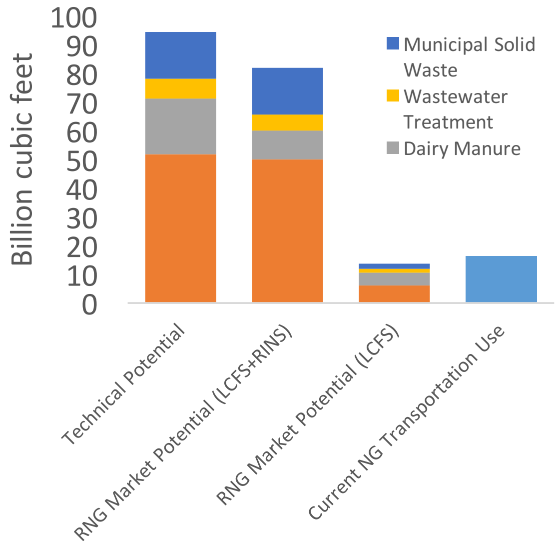

Figure 1. Technical potential, economic potential with LCFS and RFS credit revenue, economic potential with only LCFS revenue, with the total natural gas use in transportation for context.

Figure 2 shows the locations of California's potential RNG resources and their proximity to pipelines and end-use markets. Additionally, we find that an LCFS credit price of as low as $90 would enable landfills located in Los Angeles, San Diego, Irvine, Sacramento, and Livermore to provide significant volumes of low-carbon, RNG-based transportation fuel for California. The problem has been that some sort of additional targeted incentives may be needed to overcome reluctance on the part of truck fleet owners, who have tended to be risk averse, to switch to natural gas fuel vehicles which are currently more expensive and could potentially have a less liquid resale market.

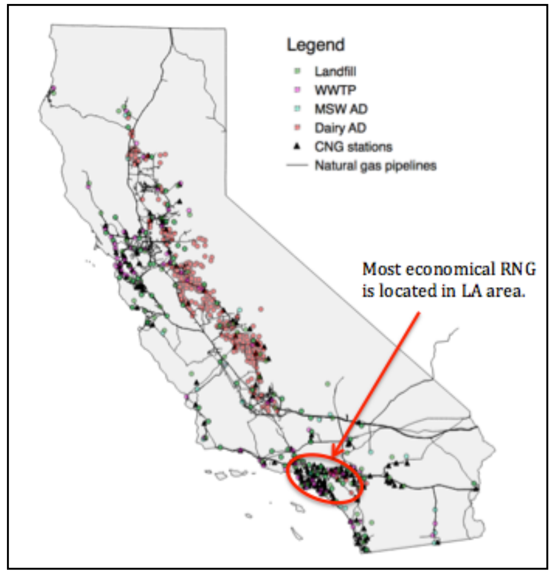

Figure 2. Locations of California's potential RNG resources and their proximity to pipelines and end-use markets. RNG production is most economically viable at sites within the red oval.

If additional credits granted under the U.S. Environmental Protection Agency's Renewable Fuels Standard (RFS) are taken into account, the projected market penetration rises from 14 to 82.2 bcf by the 2020s. A caveat of this projection is that RNGs recently qualified to generate cellulosic biofuel D3 renewable identification numbers (RINs, the credits used for RFS compliance), the most expensive RIN category. The price of D3 RINs has been extremely volatile as rule-making has evolved. Higher volumes of RNG production will be possible as LCFS, RFS, and other credits become more valuable and technological learning and scale economies lower upfront capital costs. As discussed above, the level of price incentives that are needed vary from source to source for RNG and by location. Table 1 below provides some comparative examples of price support that is needed per production pathway:

Table 1. Levels of price support required to incentivize production by pathway

RNG Production Pathway	*$ per mmBTU*	*$ per gasoline gallon equivalent*
Municipal solid waste	$11.50	$1.38
Landfill	$3.75	$0.45
Wastewater	$5.90	$0.71
Dairy	$26.00	$3.15

Recent growth of California's fueling infrastructure for natural gas has improved the prospects for the development of a commercially viable RNG industry in the state, particularly with regard to the transportation sector. Natural gas is a popular fuel for medium-duty work trucks and delivery vehicles, and it is increasingly being used for long-distance, heavy-duty freight applications. About 25% of all liquefied natural gas (LNG) truck refueling facilities in the United States are in California, and about 200,000 gge/day of LNG were trucked into California in the mid-2000s. LNG fueling stations for heavy trucks now exist in over a dozen locations around the state and continue to expand, especially in and around the ports of Los Angeles and Long Beach. California is also home to 20% of all compressed natural gas stations in the United States, and roughly 25,000 natural gas vehicles are registered in the state.

RNG has a key advantage over many alternative near-zero emission fuels in that it can be distributed via existing natural-gas pipelines and fueling stations. This is in contrast to hydrogen, ethanol, and methanol, all of which require special, separate transport, storage, handling, and fuel-dispensing equipment. RNG deployment is often associated with steep costs of removing inpurities to upgrade biogas to methane-rich RNG. The costs added to meet the required quality standards of California's natural gas industry vary depending on the biomass source used to develop the gas, but have generally proven a barrier to entry for commercial development. Another commercial barrier is the cost of interconnection for feeder pipelines from RNG sources. California has restrictive quality standards for RNG injection and high interconnection costs for RNG feeder pipelines, relative to other states. Much of the RNG currently being used in California consequently comes from out-of-state suppliers. The California Public Utility Commission (CPUC) recently instituted a biomethane monetary incentive program to help offset interconnection costs, which is expected to improve commercial viability of some kinds of locally sourced RNG.

RNG is not the only fuel that can be made from biomass feedstocks. Production of biodiesel, dimethyl ether (DME), and even compost, are competing uses for RNG feedstocks. Carreras-Sospedra (2013) suggests that conversion of biomass to RNG for vehicle use may achieve lower impacts on air quality and climate protection than some competing uses.[vii] Value for RNG derived from landfill or municipal solid waste collection can be derived from waste by three primary mechanisms: tipping fees, recycling and generating energy from waste. Because of the high demand for energy and fuel, converting biomaterials to fuel presents a high value potential, allowing for capture of both lucrative tipping fees and revenues from the sales of fuels. Zero waste initiatives that arise from governments, environmental and civic groups encourage reduction of waste through recycling, or reuse.

Large-scale injection of RNG into the existing natural-gas fueling infrastructure system can improve the environmental performance of the natural-gas fuel currently used in California. In transportation, natural gas has traditionally appealed to commercial applications such as taxis and buses. Natural gas is increasing a popular fuel for medium-duty work trucks and delivery vehicles, and it is increasingly being used for long-distance, heavy-duty freight applications, due to high fuel savings potential and local pollution control. Our analysis finds that converting trucks from conventional fuels to RNG can lower the carbon intensity of trucking, although the magnitude of environmental benefits achieved depends on the energy needed to convert biomass feedstocks to RNG, the rate of methane leakage along pipeline networks, the distance that RNG must be transported from production site to end user, and carbon savings from avoided emissions. Some trucking companies have been reluctant to convert fleets to natural gas, worrying that volatility in natural-gas prices will affect payback times and profitability. Some California air districts are addressing this latter barrier by providing vehicle incentives in order to attain federal health-based air quality standards. Pollutants of concern are particulate matter (PM) and oxides of nitrogen (NOx). Natural gas and RNG produce virtually no PM and diesel truck will use filters, which greatly reduce PM emissions from diesel engines but require maintenance. All new diesel trucks (2010 or later) can use selective catalytic reduction to reduce their NOx emissions and thus certify as low NOx (0.2 g/bph-hr), about 90% reduction with respect to older diesel trucks. However, the extent of emissions will depend on drive cycle, with local and near-dock operating diesel trucks have a harder time producing low levels of NOx than higher speed regional applications. On the contrary, natural gas and RNG consistently produce low NOx across all applications and can certify as ultra-low NOX (0.02 g/bph-hr) engines, a further 90% below the current standard[viii]. Natural gas and RNG are less stellar in other categories of pollutants. For example, natural gas and RNG vehicles have been found to emit ammonia. The potential for natural gas to produce lower than diesel carbon emissions is uncertain, due to the relative lower efficiency of natural gas vehicles, but the carbon intensity of operating a natural gas vehicle can be reduced if fossil natural gas is blended, or eliminated if substituted by RNG.

Policy analysis and conclusion

Natural gas is already a popular fuel in California for heavy trucks and medium duty work fleets. There has been speculation that natural gas can serve a bridge to lower carbon fuels in the state. This prospect is looking more promising as California agencies adopt policies to promote the development of a low carbon, renewable natural gas industry that can eventually replace fossil natural gas fuel and still utilize the same transport and fueling infrastructure as today's fossil natural gas.

As discussed above, California has extensive biomass resources—including manure, food waste, landfill gas, wastewater-treatment sludge, organic municipal solid waste, and forest and agricultural residues—that can help companies meet California's regulations to lower greenhouse gases and criteria pollutant emissions by 2020 and beyond. Because biomass-based fuels are readily available and well-aligned with existing infrastructure, they provide a particularly promising pathway for accomplishing these goals.

The costs of developing and deploying RNG resources can vary widely. The small scale and scattered nature of dairy manure feedstocks makes this resource the most challenging to develop. Achieving commercial viability will likely require clustering multiple suppliers into a shared, coordinated, and potentially subsidized system. For other sources, such as landfill and wastewater-treatment sludge, resource collection and upgrading necessary equipment is less capital intensive, and so the level of carbon credits available will be a primary commercial driver. We find that an LCFS credit price of as low as $90 a ton is sufficient to give developers a commercial return for converting landfill gas located in Los Angeles, San Diego, Irvine, Sacramento and Livermore for injections into the natural gas transportation fuel network in California.

Local and state policies regarding landfill tipping fees will be highly salient to the successful exploitation of RNG from MSW for transportation uses. Higher tipping fees, combined with carbon credits, will increase incentives to produce RNG from MSW. Policies can be designed to encourage the production of RNG from MSW in optimal locations: for instance, by imposing limits on the amount of MSW that can be accepted at landfills on sites that could easily house anaerobic digesters and/or that are close to end-user markets for RNG.

California Senate Bill (SB) 1383 proposes a fifty percent reduction in organic-waste contributions to landfill by 2020 and a 75 percent reduction by 2025, calculated from 2014 levels. This legislation will significantly improve the economics of RNG production from dedicated MSW digesters by driving up the cost of landfilling organic waste. If SB 1383 fails to stimulate sufficient conversion of MSW to renewable natural gas, California should also consider imposing a statewide fixed tipping fee for MSW that would increase diversion of MSW to digesters for RNG production.

State government's efforts to stimulate the development of a large-scale RNG market in California can be successful by ensuring that carbon credit markets and other subsidies for RNG will be sustained for a number of years, giving private sector investors the confidence that they can earn a sufficient return to develop new projects. The private sector is best positioned to choose among the wide variations in costs for various sources for RNG at different locations and applications and to decide which specific resources will carry the most attractive return on private capital in light of carbon market credit values and other state incentive structures such as support for truck purchases and elimination of onerous quality control regulations that are currently barriers to development of in-state resources.

Investments in renewable natural gas projects are taking place slowly in California, with the relatively more commercially oriented developments coming on line first. Over time, RNG businesses will be helped by scale economies and learning by doing, potentially bringing down costs and permitting a rise in RNG production and use in California.

Authors
Amy Myers Jaffe, Rosa Dominguez-Faus, Nathan Parker, Daniel Scheitrum, Justin Wilcock and Marshall Miller.

Learn more

Renewable Natural Gas as a Solution to Climate Goals: Response to California's Low Carbon Fuel Standard By Daniel Scheitrum October 2016

The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute By Amy Myers Jaffe, Rosa Dominguez-Faus, Nathan C. Parker, Daniel Scheitrum, Justin Wilcock, Marshall Miller June, 2016

STEPS White Paper: Exploring the Role of Natural Gas in U.S. Trucking (Revised Version) By Amy Myers Jaffe, Rosa Dominguez-Faus, Allen Lee, Kenneth Medlock, Nathan Parker, Daniel Scheitrum, Andrew Burke, Hengbing Zhao and Yueyue Fan 2016

[i] EIA 2015 Natural Gas Consumption by End Use. Available at http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm
[ii] Specifically, policies and programs designed to support fuels that are less carbon intensive. These include California's LCSF and the U.S. Environmental Protection Agency's Renewable Fuel Standard (RFS), among others.
[iii] Assuming 50% biomethane in biogas
[iv] Based on estimates from from 147 of the existing 314 landfills in California. The 147 landfills contain 92% of the reported waste in place in California landfills.
[v] Kaffka, Stephen, Tyler Barzee, Hamed El-Mashad, Rob Williams, Steve Zicari, and Ruihong Zhange. Evaluation of Dairy Manure Management Practices for Greenhouse Gas Emissions Mitigation in California. Draft report to the State of California Air Resources Board.
[vi] EIA 2015 Natural Gas Consumption by End Use. Available at http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm
[vii] Carreras-Sospedra, M., Williams, R., & Dabdub, D. Assessment of the Emissions and Air Quality Impacts of Biomass and Biogas Use in California. Journal of the Air & Waste Management Association, (2015).
[viii] https://cleancities-stage.nrel.gov/files/u/news_events/document/document_url/93/ngvtf14oct_hogo.pdf