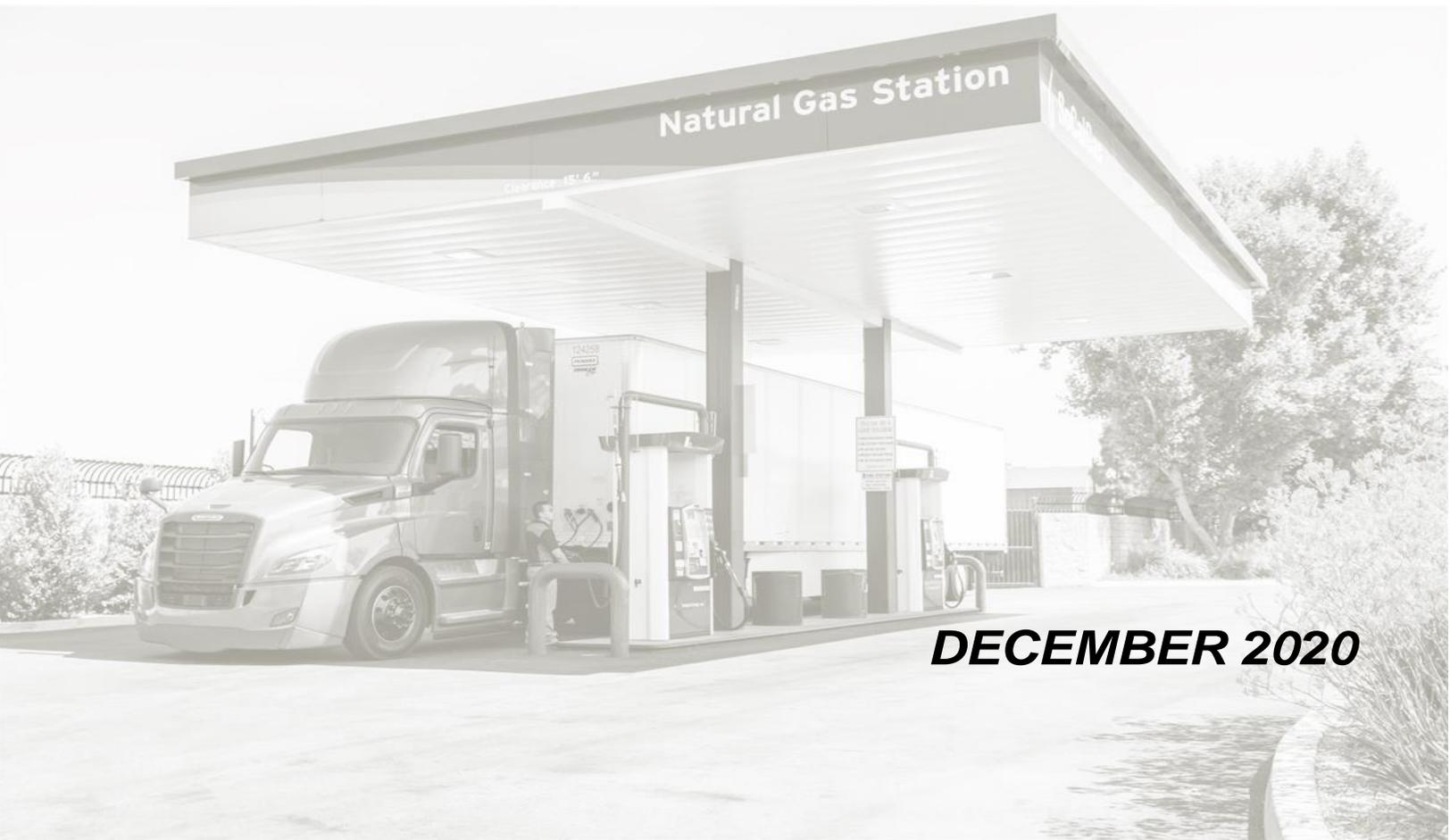




WHITE PAPER

Opportunities for Renewable Natural Gas as a “Green” Fueling Option



DECEMBER 2020

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INTRODUCTION

The use of renewable fuel sources for transportation will be gaining increasing traction in coming years. Tailwinds include both economic incentives and regulatory pressures that fleet owners/managers and corporate sustainability officers should consider in decision making regarding “green fuels”. [While renewable diesel is increasing in supply and availability](#), other “green” sources of energy including compressed natural gas (CNG), renewable natural gas (RNG), electric vehicles (EV) and hydrogen are on the rise.

Low Carbon Fuel Standard (“LCFS”) programs in California, Oregon and British Columbia are providing incentive and growth of the production of RNG in North America. These LCFS programs are setting examples for similar programs in other regions/states/provinces including but not limited to Washington state, Colorado, Minnesota, and the U.S. Northeast.

Particularly for medium to heavy duty tethered fleets or within specific regions with established CNG fueling infrastructure, Renewable Natural Gas (“RNG”) is a reliable, economically viable, domestic, and proven source of fuel. From a sustainability perspective, RNG has a low carbon intensity with some sources being “ultra-low”. While the supply of RNG is still in the early innings of growth, new projects are scheduled to come online in the coming years that will add to the availability of this resource.

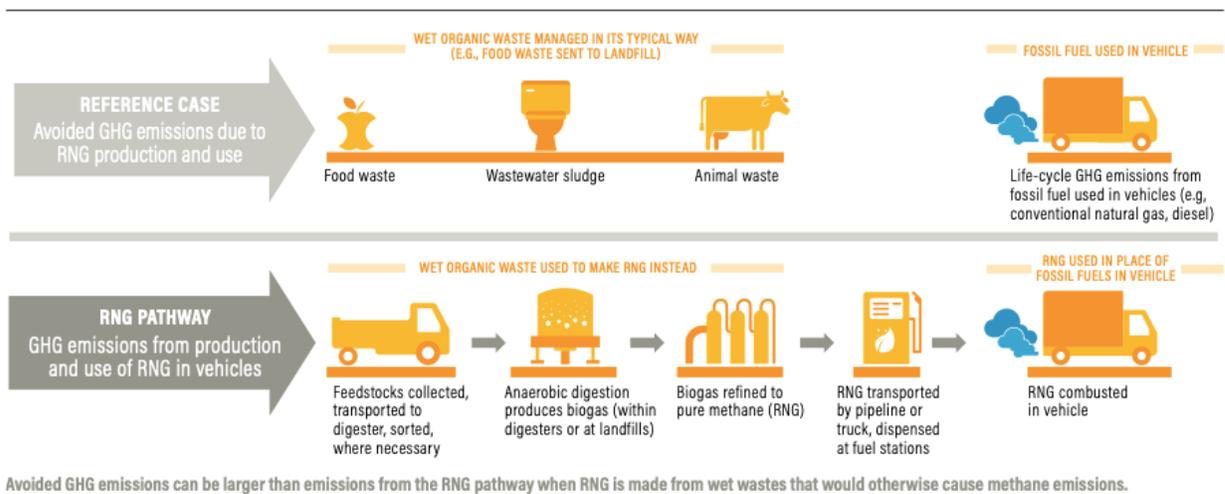
WHAT IS RNG?

RNG, or biomethane, is derived through the decomposition of organic matter in an anaerobic environment, most often at landfills, wastewater treatment facilities, or dedicated anaerobic digester units. Traditionally, biogas from these sources has been combusted in generator sets to produce green electricity. In recent years, the trend has been toward cleaning and upgrading biogas into biomethane or RNG for use as vehicle fuel. Properly upgraded RNG is suitable for injection into tube trailers for local delivery or the natural gas grid for direct delivery to end users as a low-carbon vehicle fuel for consumers, including operators of municipal fleets or medium to large trucks.

What is the Difference Between CNG & RNG?

RNG (aka “biomethane”) and CNG (aka “natural gas” or “methane”), share the same molecule: CH₄. When transported through the natural gas grid, both CNG and RNG are conditioned to meet pipeline company transmission standards. Once in the pipeline, RNG utilizes the same infrastructure network as CNG.

Figure 1. Typical RNG Pathway

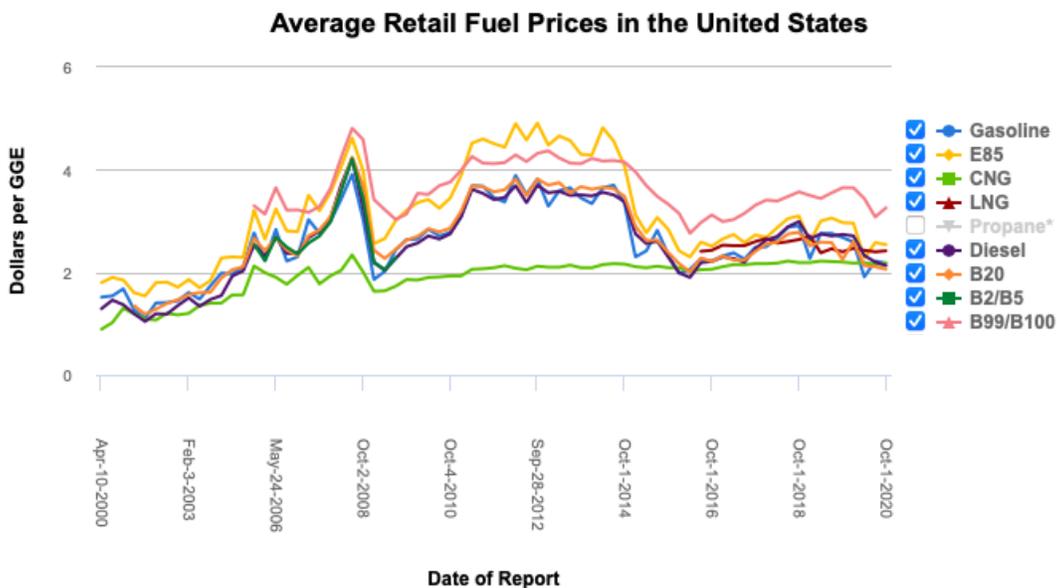


Source: World Resource Institute

WHY UTILIZE RNG?

- Economics = vehicle or fleet owners often save about \$1/gallon when compared to diesel, depending upon location and market conditions
- RNG pricing is relatively stable and can act a hedge against diesel price fluctuations. It is domestically sourced and generally insulated from international tensions. The graph below depicts historical pricing over the last twenty years of common vehicle fuel options. CNG shows a comparatively steady pricing trend. Environmental credits associated with **RNG** described later in this white paper can serve to lower the cost of CNG.

Figure 2.



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Source: [Clean Cities Alternative Fuel Price Reports](#) | Electricity prices are from EIA's [Real Prices Viewer](#).

- Supply = Increasing & Available:

[The American Biogas Council](#) lists **2,200 sites producing biogas in all 50 states**: 253 anaerobic digesters on farms, 1,269 water resource recovery facilities utilizing anaerobic digesters, 68 stand-alone systems that digest food waste, and 652 landfill gas projects. For comparison, Europe has over 10,000 operating digesters, with some communities essentially fossil fuel free because of these systems. In 2018, investment in new biogas

systems totaled \$1 billion. Over the last five years, total investment in the U.S. biogas industry has been growing at an annual rate of 12%.

The advent of the Low Carbon Fuel Standard (“LCFS”) by the California Air Resources Board (“CARB”) has only served to stoke further growth in RNG supply and demand. A concise description of the LCFS program may be found [here](#).

This program initiated by the Schwarzenegger Administration in 2014, was amended in 2018 to extend at least through 2030. This program extension is providing market stability and assurance to developers and investors of RNG projects.

While to claim LCFS credits, RNG must be consumed by vehicles (including forklifts and warehouse equipment) within California, RNG producers nationwide can participate in this program if they can demonstrate interconnection to California via the national natural gas pipeline network. Developers of RNG projects are emerging to take advantage of this “gold rush”. While the California RNG market is robust, other LCFS similar programs in other states are likely to offer a reliable and bankable market for project developer/producers, investors, fuel purchasers, and other stakeholders.

Another spur toward development of RNG projects is by the natural gas network. Utilities and pipeline operators who receive, transport, and deliver natural gas are coming under increasing regulatory and stakeholder pressure to include RNG into their pipelines. In 2019, SoCalGas adopted goals and targets for percentages of RNG into their pipelines. [SoCalGas is committed to replacing 20 percent of its traditional natural gas supply with renewable gas by 2030](#). This is just one example. PLG’s consultants are working with pipeline operators and utilities on RNG injection projects throughout the nation and are seeing the growing trend toward accepting renewables in their portfolios.

- RNG is a Clean-Burning Fuel

In areas where air quality is an issue, displacing diesel fuels with RNG can serve to reduce air pollution. RNG is low NOx, low PM which are precursors to ozone. It is also ultra-low in sulfur content.

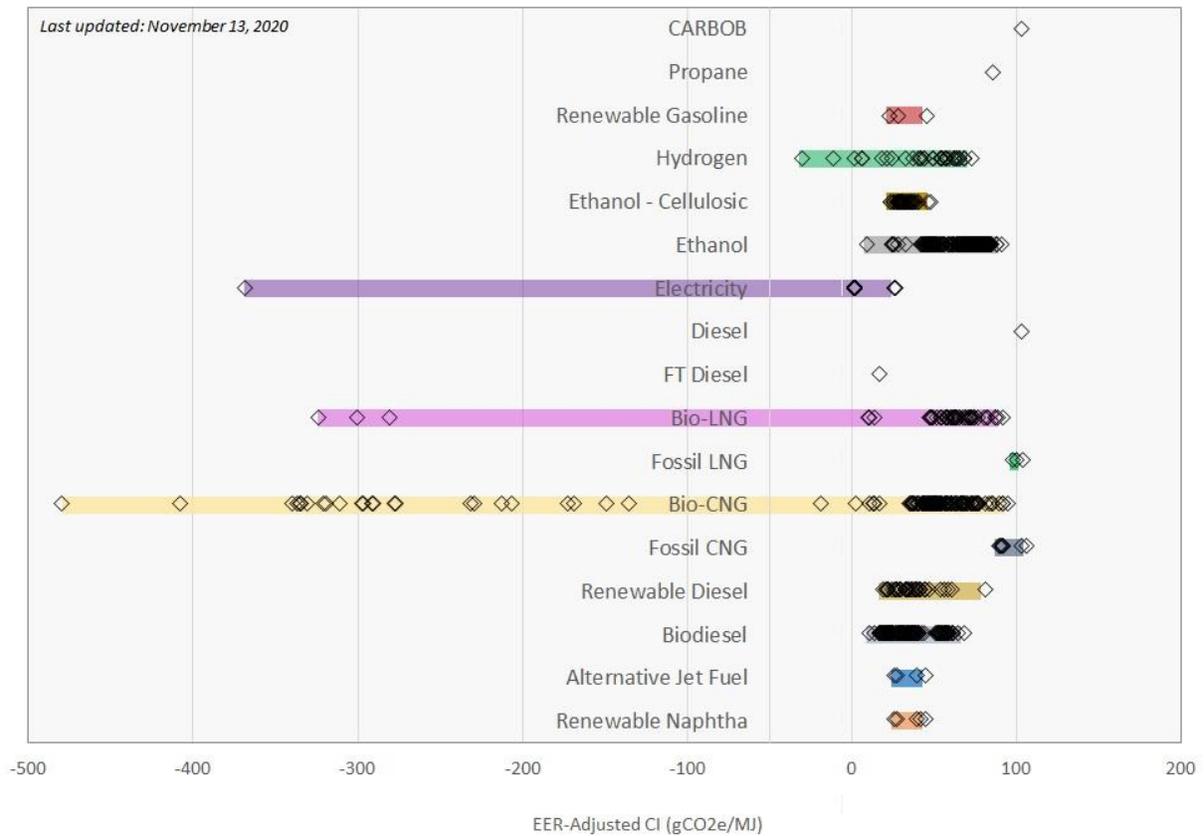
- Regulatory/Sustainability Target Achievement: The use of RNG as fuel can help users hit net neutral carbon targets more easily.

[According to recent data from the California Air Resources Board \(CARB\), the energy weighted carbon intensity \(CI\) value of California’s natural gas vehicle fuel portfolio in the Low Carbon Fuel Standard \(LCFS\) program was below zero.](#) How is that possible? It is through methane (aka RNG or CH₄) emission avoidance. Methane is a

greenhouse gas that has a global warming potential approximately 28 to 36 times more aggressive than carbon dioxide [according to the US EPA](#). By avoiding the release of the fugitive methane into the atmosphere by capturing and using it as a renewable vehicle fuel results in a net benefit from an emissions perspective.

Figure 3

Carbon Intensity Values of EER-Adjusted Certified Pathways (2020)



Source: California Air Resources Board: <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>

Why is the look into the California LCFS approach and valuation relevant? It is being used as a paradigm for programs in other states/provinces/regions. It may be often observed that incentives and subsidies such as the LCFS program often lead to lasting changes – even when lowered or removed.

RNG MARKET CHANNEL STRUCTURE

Within the typical RNG transaction chain, there are:

- **Producers**
- **Brokers/Marketers** - generally dominated by energy majors such as Chevron, BP and Shell and other fuel distributors who not only market the fuel most often to fleet-buying customers but may be [LCFS or RIN-obligated parties](#).
- **CNG Fueling Stations** – among the larger owner/operators include CleanFuels, Trillium and US Gain.
- **Fleet Purchasers** – including municipalities and other buyers who may have established CNG fueling infrastructure that may be available to other consumers of RNG.



Brokers/Marketers are a good point of contact for fleet owners to source RNG under long-term purchasing arrangements. They are in direct contact with Producers and can utilize their market channels to distribute RNG effectively and share environmental credits. Methods of delivery of RNG to market are the natural gas pipeline network and/or direct tube trailer deliveries by truck. PLG consultants have direct experience with and can provide expertise on RNG fueling options.

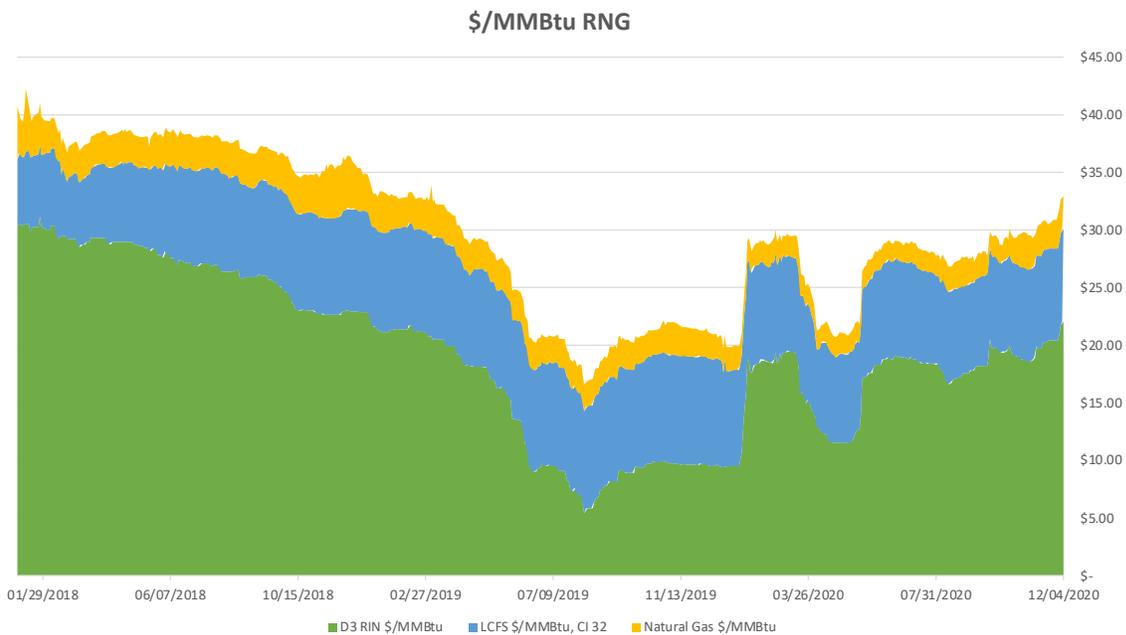
Read our [case study](#) on how an international leader in biofuel technology teamed up with PLG Consulting to bring CNG - made from recycled landfill gases - to the energy and transportation markets cost-effectively.

RNG VALUE CHAIN

Purchasers of RNG should be aware of factors, including environmental credits, that affect RNG pricing. These credits include:

1. Product value of the natural gas: examples = Henry Hub, CityGate, etc.
2. D-RINs: environmental credits administered by the US EPA
3. LCFS: environmental credits for RNG consumed in California as vehicle fuel and administered by CARB

Figure 4. Biomethane Value per Dekatherm (MMBtu)



- All pricing is indicative and intended for illustrative purposes only
- Natural gas value is the Henry Hub natural gas spot market price as reported by U.S. EIS
- LCFS and D3 RIN Value are the daily average settlement prices as reported by OPIS
- Carbon Intensity (CI) is the average from all fuel sources during the period

Source: Element Markets – www.elementmarkets.com

RIN Valuations:

RINs are administered by the US EPA. To validate RINs, they must be ultimately used as transportation fuel.

Factors that affect RIN pricing vary by source and use. “RIN” is an acronym for “Renewable Identification Number”. Each RIN carries a unique number as a means of tracking and tracing from origin to end use. The most valuable are cellulosic D3 RINs

that are derived from manures, organics, and landfill gas. RIN values for the different RIN types, or D-Codes are listed in Figure 5.

Figure 5.

D-Code	Current Value *	Description
D3	\$1.83	Cellulosic: Produced from energy-purposed crops/ag residues, manures, landfill gas
D4	\$0.88	Advanced Biofuel: Produced from non-corn starch, renewable biomass
D5	\$0.87	Biodiesel
D6	\$0.70	Corn-based Ethanol

* Source: EcoEngineers RIN Daily Pricing Update 12/7/20 – 2021 RIN trading values

Using data from Figure 4, the average valuation per MMBtu for RINs in late 2018 was about \$25.00. [Utilizing a figure of 137,381 MMBtu/DGE](#) yields a total value of \$-3.43 per DGE (diesel gallon equivalent).

LCFS Valuation:

To the uninitiated, assessing LCFS values can be challenging. Determining the value of the LCFS credits in a particular transaction can be determined by the following influencing factors:

- Carbon Intensity from a given waste stream (see Figure 3)
- Reference Fuel: Carbon Intensity of fuel being replaced by RNG: (diesel, gasoline, other)
- Price of carbon (based upon negotiated transactions on a \$/MT CO_{2e} value, an index for which is published daily)
- Energy Efficiency Ratio of the end use (heavy duty trucks is typically 0.9)

A program into which this data may be inserted to determine value by energy end use (DGE, GGE, electricity) may be found on the CARB website [here](#).

By way of a headline-inducing example, dairy-derived RNG (Bio-CNG) used in California as vehicle fuel offers a net negative carbon intensity with some projects up

to well below -400 gCO_{2e}/MJ. This translates not only into helping to realize sustainability targets, but also potentially to economic benefits as total value of this gas can be in the \$60 to \$100 per MMBtu range, which translates to between -\$8.00 and -\$13.50 per DGE. However, what may be more realistic is the average per-MMBtu credit value for LFCS across all sources (landfill, wastewater treatment, animal manures) that in 2019 yielded an average CI score of +32 and shows a value of closer to \$10/MMBtu in Figure 4. Using the same valuation approach as the DGE calculation for RINs shows a value of about \$-1.40 per DGE.

After production, transportation, and delivery costs, with properly negotiated multi-year purchase contracts, fleet owners can enjoy a portion of these valuations. PLG's consultants have direct experience in determining these values and what may be considered fair market value for RNG purchasers.

FACTORS THAT INFLUENCE RNG SELECTION

Important factors to consider when evaluating an RNG program:

Traditionally, RNG works well for tethered fleets:

- Garbage industry
- Municipal bus fleets
- Fleets or equipment operating in regions with air quality issues such as Ports of Los Angeles and Oakland
- Industry-focused transportation networks such as distribution centers or milk truck fleets

Decision Factors on Whether to Convert Existing Gasoline or Diesel-Fueled Vehicles to RNG:

- Fuel cost effects (typically savings + price stability)
- Vehicle Purchase Cost Incentives (grants, or other incentives that tend to be state or local government-specific are often available to offset vehicle purchase costs)
- Maintenance – what capabilities and resources are available/may be required?
- Fuel dispensing design – do vehicles need to be filled quickly or are multi-hour windows an option? [CNG/RNG fueling facilities](#) can be designed and operated with fast fuel, time fuel, or a combination of the two.
- Fueling infrastructure – are fueling stations with fast fuel nearby or would a corporation yard RNG dispensing system be optimal?
- [Advancements in engine design by Cummings Westport and their 12-liter CNG-fueled engines](#) offer increased horsepower and performance for larger trucks.
- Environmental compliance – both air quality and carbon offset requirements

Electrification is on the Horizon:

Another pending trend is for increased electrification of trucks and cargo handling equipment (EV). In California, the LCFS program has been extended to offer environmental credits (eLCFS) for electricity used for vehicle charging and for electrified warehouse or cargo handling equipment such as forklifts. In California, the Air Resources Board is now offering vouchers and other incentives for EV conversions.

However, electrification of medium to heavy duty truck fleets is still in the early stages of development. EV trucks are just now beginning to enter the market and, as with many new technologies, the costs are comparatively high against CNG/RNG or biodiesel options. EV charging stations for tethered fleets require infrastructure

updates at corporation yards and by utilities. Time to charge (re-fuel) and range anxiety should be considered. Yet another factor is outside air temperatures - heating and cooling systems require energy that can reduce range. A recent report by [NGV Americas](#) describes many of these issues.

From an environmental impact perspective, corporate sustainability managers may consider carbon intensity. The CI score identified in the LCFS calculator for grid power is currently +81.5. Compared to the CI for energy derived from digested organics listed in Figure 3, there are other sources of environmentally friendly energy. By using this comparison, dairy manure-derived RNG (CI of -250 to -400) is among the most carbon friendly fuel sources known.

Based upon these factors, conversion of medium to heavy duty fleets to EV is presently challenging.

HYDROGEN

While nascent, hydrogen is also on the horizon as a renewable resource. It is a readily abundant molecule, fueling time is similar to gasoline or diesel, and the emissions when consumed is water.

Current headwinds are cost and availability of medium to heavy hydrogen-fueled vehicles and the lack of a fueling infrastructure.

CONCLUSION

Fleet owners/operators, transportation executives and sustainability officers have an increasing set of fueling alternatives that can offer savings, while meeting environmental obligations. Different incentives that vary by jurisdiction are now in place with more options foreseeable. Supply, infrastructure, and marketing channels are becoming ever more established and reliable.

In summary, the information contained in this white paper includes influencing factors to help key transportation decision makers to make more informed decisions about RNG as a fuel source. When evaluating renewable fuels, PLG's consultants are well-versed and have direct experience with the myriad of contributing factors to allow transporters to make the most informed decisions.

About the Author | Bill Graham



Bill has over 20 years of business development experience in the environmental services industry – specializing in renewable fuel production and distribution, transportation logistics, energy production, solid waste management, and site remediation. Bill's additional areas of expertise and direct experience are in large-scale facility siting, permitting and development, and project finance.

Most recently, he has been involved in anaerobic digestion of organic wastes to produce transportation fuel and green energy. As a PLG project manager, he has coordinated an engineering and logistics team to design and configure a transport system, including a rail yard on the largest wind energy project in North America.

About PLG Consulting

[PLG Consulting](#) has been involved in market analysis, operations, network design, procurement, site selection, and innovation for renewable energy and the circular economy for more than ten years. We have helped our clients bring logistics solutions as innovative as the mission itself – capturing and repurposing the 90+% of post-consumer waste plastics that currently end up in landfills, oceans, waterways, beaches, and elsewhere. For more information on PLG Consulting's [industries](#) and [services](#), [contact us](#) today.