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WHITE PAPER / **RNG TECHNOLOGY AND APPLICATIONS**

ENVIRONMENTAL AND ECONOMIC BENEFITS OF RENEWABLE NATURAL GAS

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Developing renewable natural gas (RNG) resources can enhance waste management practices, create job opportunities and increase energy production. Additionally, it can build new revenue sources and safeguard the environment by drastically reducing greenhouse gas emissions.

Protecting the environment while maintaining economic growth has been challenging for the government as well as utilities. Considering this, government policies and private investments have focused on developing technology to integrate renewable sources into the existing power grid and increase their usage. In the last few decades, RNG has garnered a lot of attention because it can play a vital role in attaining the critical objectives of a decarbonized economy. Sources of RNG are all around us; for example, the local landfill, sewage treatment facilities or the farm up the road are all sources of RNG. The key is to capture it, clean it and use it in combination with standard natural gas. By leveraging proven and emerging technologies, we can seize opportunities to develop RNG and improve the diversity of our energy supply.

In September 2020, the Coalition for Renewable Natural Gas, a public policy advocate led by industry members, estimated there were 119 operational liquefied natural gas facilities in the U.S. with 98 under construction or in substantial development stage.

EXPLORING THE BENEFITS OF RNG

There are potential benefits of leveraging RNG as a substitute for some fossil fuels. For that reason, several states, including California, Colorado, Nevada, New Hampshire, New Jersey, Oregon and Washington, have proposed legislation related to RNG. Much of the proposed legislation is focused on financial incentives for building new pipeline infrastructure and equipment.

The benefits of RNG take a variety of forms.

STORED AND TRANSPORTED THROUGH EXISTING NATURAL GAS PIPELINE NETWORKS

Unlike many renewable power generation sources, RNG can be stored by using existing field-proven processes and commercially ready technologies for later on-site usage or to transport it to other locations through pipelines.

The pipeline network offers storage and distribution for RNG. However, as these pipelines are usually owned by private or municipal gas utilities, the RNG developers must sign an agreement with the pipeline owner to supply RNG through the natural gas pipelines. The most important requirement of this agreement is to see that the RNG infused into the pipeline meets the local gas utility's guidelines and criteria.

After the RNG is infused into the pipeline network, it can be used as a fuel for domestic as well as commercial and industrial purposes.

REDUCTION IN GREENHOUSE GAS EMISSIONS

RNG offers the same low-carbon properties of natural gas but produces 4% of the greenhouse gas emissions when burned. It qualifies as a renewable fuel under the federal Renewable Fuels Standard (RFS) and as a low-carbon fuel within California's Low Carbon Fuel Standard (LCFS).

From a greenhouse gas emissions perspective, RNG demonstrates tremendous benefits. Methane from animal waste and other biomass sources, which otherwise would have directly entered the atmosphere, can be captured for conversion and combustion as RNG. The greenhouse gases released from that combustion are approximately 21 times less potent than methane released directly into the atmosphere. The use of RNG represents

the recycling of carbon that is already circulating in the environment, whereas burning a fossil fuel represents the release of new carbon emissions that were previously sequestered in the earth.

RNG projects capture and recover methane produced at a landfill or agriculture facility. Why does this matter? Methane has an impact that is 25 times greater than carbon dioxide (CO_2). Thus, by reducing methane emissions, environmental impacts can be significantly reduced.

INCREASED DOMESTIC ENERGY TO POWER COMMUNITIES

From running commercial and industrial facilities to cooking dinner at home, we depend on energy supplies. RNG provides security by increasing the domestic production of renewable non-fossil fuel energy that could supplement foreign-produced transportation fuels.

According to the EPA, RNG is also more cost-effective than some alternatives. For example, it is estimated to be three times more cost-effective than any electrification project.

Additionally, the EPA estimated there is enough growing supply of RNG in the U.S. to meet many states' greenhouse gas emission goals by replacing a portion of other, higher-emission fossil fuels.

IMPROVED WASTE MANAGEMENT

According to the EPA, municipal solid waste landfills are the third-largest human-generated source of methane emissions in the U.S. With landfills generating a large amount of methane, opportunities abound to improve waste management practices. Many communities, residents and organizations are coming together to create partnerships to leverage landfill gas (LFG) to generate energy and reduce methane emissions.

It is estimated these LFG-to-energy facilities can capture nearly 60% to 90% of methane from landfills. Emissions into the environment are decreased and the methane is transformed into a viable electricity source. In 2020, a typical 3-megawatt LFG-to-energy plant is estimated to generate enough electricity to power approximately 1,900 homes.

REVENUE SOURCE FOR FARMERS

In 2017, California adopted legislation that will require reducing methane emissions by 40% by 2030. As a result, the state has provided many incentives for creating and using RNG. The California Department of Food and Agriculture created the Dairy Digester Research and Development Program, which awards competitive grants to implement projects that result in methane emission reductions and minimize environmental impacts.

For example, biogas produced at existing facilities is actively being injected as RNG into pipelines. At the facilities, cow manure is collected from local dairy farms and processed into an anaerobic digester to accelerate the natural decomposition process. Methane is captured and converted to make renewable fuels for vehicles.

When one such dairy farm was completed in 2019, it was believed to be the largest dairy biogas operation in the U.S. In 2020, the operation was expanded to add four dairy farms, doubling the amount of RNG produced.

GREEN JOBS CREATION

Green jobs can be defined as opportunities in the fields of energy and agriculture that aim to significantly safeguard and restore environmental quality.

The energy from waste aids in creating thousands of jobs, such as for renewable energy engineers, recycling workers, environmental consultants and more. According to the RNG Coalition, by 2030 there are expected to be 24 million jobs in the global renewable energy sector. Also, each new RNG production facility has the potential to create five to seven times more jobs than an equivalent-sized petroleum refinery.

TECHNOLOGIES FOR PROCESSING RNG

For decades, hazardous waste has been collected from landfills, sewage plants, farms and more. Now, this not-so-new approach is generating a new wave of business as waste is leveraged to generate diverse energy sources that have environmental and economic benefits. Despite the relative maturity of RNG, it is being leveraged more now thanks to its transportability and improved technologies.

Technology	Description	Status
RNG technologies	Raw gas is cleaned to remove impurities and create pipeline-quality gas. The feedstocks used for each process are sustainable, generally readily available and are often otherwise considered waste.	Many proven technologies and processes exist to produce RNG.
Landfill biogas technologies: • Water scrubbing • Amine scrubbing • Gas membranes • Pressure swing adsorption	Instead of a pollutant, landfill gas and biogas from municipal and industrial wastewater treatment plants can serve as feedstock to create RNG. These gas mixtures require removal of impurities and CO_2 to create RNG from biogas.	Many technologies are commercially available to perform processes. More than 75% of RNG production is sourced from landfills, according to a 2021 estimate from Argonne National Laboratory.
Anaerobic digestion	Anaerobic digestion is a bacterial fermentation process in which microorganisms naturally break down organic matter to produce biogas. Anaerobic digestion thrives in waterlogged soils, lagoons, marshes and wetlands, as well as in bodies of water. Anaerobic digestion is also the main decomposition process occurring in landfills.	The relative value of natural gas in the U.S. is a challenge in adopting this approach to make RNG production financially viable. The technology is already available.
Dry biomass	Dry biomass cannot be converted to RNG by anaerobic digestion; instead, it must be treated thermally to produce gas. When dry biomass is gasified, synthetic gas or syngas is produced, which contains carbon monoxide (CO), CO_2, hydrogen (H_2) and methane (CH_4), along with other components. Through synthesis processes, it is possible to produce different final products, such as CH_4, from the syngas.	While the technology and process are proven from the coal and refining industries, cost reductions are required to help adoption using biomass feedstock. Also, operators must consider feedstock logistics to provide sufficient quantity and accessibility.
Solar hydrothermal gasification	Solar thermal collectors can be established to continuously provide high-temperature heat using solar troughs, plus serve as a thermal energy storage system. While the technology requires further development, potential exists for this technology to supplement and enhance RNG production.	This is in relatively early stages of development. Promising areas are being explored for broad commercialization.
Power to renewable hydrogen (P_2H) and power to renewable natural gas (P_2G)	This process involves capable technologies for renewable energy storage where excess or low-cost electricity is converted to a chemical form of energy that can be stored for later use.	According to the Hydrogen Council, the cost to produce and distribute hydrogen from clean energy sources will fall by as much as 50% over the next several years. Power to gas is often considered when there is an energy surplus.

FIGURE 1: *Technologies for processing RNG.*

As discussed earlier, the network of natural gas pipelines is steadily expanding, and it can be utilized for storing and transporting RNG. New technology solutions can be deployed to capture the feedstock or gas itself and transport it from multiple sources to a single place for processing of larger quantities. Alternatively, there can be processing facilities distributed near every source, so that cleaned RNG can be infused back into the natural gas system at each respective site.

Many emerging technologies are already being tested and enhanced to enable the production of RNG. Figure 1 highlights different technologies that can be used for processing and storing RNG.

POWER SOURCE ON THE RISE

- **The EPA estimates LFG facilities can capture nearly 60% to 90% of methane from landfills.**
- **According to the RNG Coalition, RNG is expected to be three times more cost-effective than any electrification project. From 2015 to 2019, the number of operating RNG facilities in North America more than doubled.**

CONCLUSION

In addition to creating revenue for municipalities and farmers and providing employment and economic benefits, there are numerous advantages to developing RNG infrastructure. It reduces harmful carbon emissions, improves air quality, enhances energy security and provides compliant and reliable power generation opportunities, helping to protect the environment and foster healthy living conditions. There is no one-size-fits-all solution, and it's important to consider economic and technical barriers in determining which RNG technologies are appropriate to a given scenario.

BIOGRAPHY

CHRIS McCALL, PE, P.ENG, PMP, is a program and project manager focused on managing and executing complex transmission and distribution projects for utilities and developers at all scales. He has more than a decade of experience overseeing and designing transmission line projects from start to finish, incorporating all aspects of licensing, testimony, estimating, scheduling, permitting, engineering, construction and everything in between. In his current role, he coordinates and oversees execution planning, scope management, budgeting, scheduling, contract negotiation, proposal development, subcontractor and purchase order management, procurement management, and construction management.

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