THE COALITION FOR RENEWABLE NATURAL GAS

Guidehouse

USING RNG TO MEET VOLUNTARY GHG TARGETS

A PRIMER FOR SUSTAINABILITY DIRECTORS

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Introduction

Renewable natural gas (RNG), also known as biomethane, is a commercially available, low-carbon fuel that has many applications in today's energy transition and a role to play in corporate decarbonization strategies. Produced by capturing methane released by decomposing organic wastes, it is currently the cheapest and most scalable form of renewable gas available. Use of RNG can reduce carbon emissions from assets that use natural gas as a fuel source with few or no equipment upgrades, making it a reliable alternative, carbon-neutral fuel. In fact, depending on the feedstock from which it's derived, RNG can be a *carbon negative* fuel, preventing more emissions than it produces.[1]

Methane is a potent greenhouse gas (GHG) having a significantly greater negative impact on the climate than carbon dioxide. Capturing this methane, which would otherwise escape into the atmosphere, and using it for beneficial purposes reduces its climate impact. Beyond its ability to eliminate fossil CO_2 emissions from energy and other industrial processes, RNG also promotes fuel security, local economic benefits, air and water quality improvements, and broader application of circular economy solutions.[2]

As your company pursues its sustainability journey, it's important to understand how RNG can contribute to your decarbonization goals. This white paper will cover some of the basics, such as how RNG is produced, its climate and sustainability impacts, how it can be utilized in day-to-day operations, and how it can be procured.

What is RNG?

RNG is a carbon neutral, renewable alternative to conventional natural gas that can reduce emissions from transportation, space and water heating, natural gas distribution systems, thermally intensive industrial processes, and where conventional natural gas is used as a chemical feedstock.

When organic materials decay in the absence of oxygen, they release a *biogas* that consists of methane, CO_2, and some other trace gases; this biochemical process is called *anaerobic digestion*. Upgrading that biogas to 95%+ biomethane yields a renewable form of natural gas.

RNG feedstocks include organic materials such as food waste, dairy manure, sewage, and green waste (park and garden clippings). In the instance of food waste, dairy manure or green waste, the feedstock is processed in an *anaerobic digester* to capture the biogas[i], which is then upgraded to RNG. Landfills and wastewater treatment plants are also sources for RNG; landfills use gas collection wells to capture the biogas created from decomposing organic waste, while many wastewater treatment facilities have anaerobic digesters that treat the biosolids.

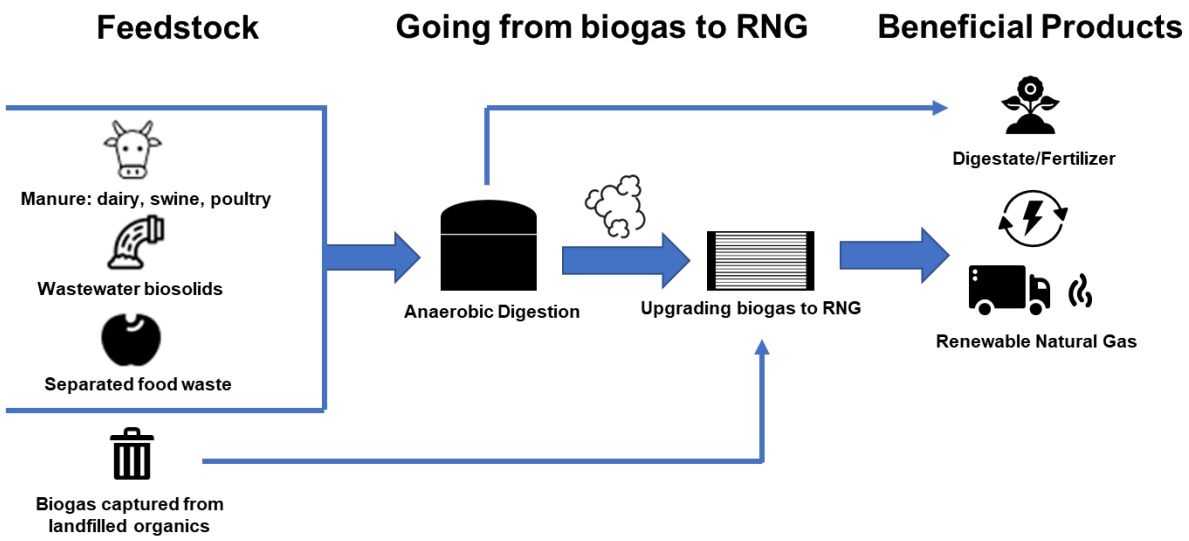
In short, by using RNG, companies are helping reduce methane emissions and improving the broader management and reuse of waste.[3]

Not only can RNG be used as a substitute for natural gas across many applications, its production results in beneficial byproducts, such as *digestate*, the residual organic materials left

[i] For instance, livestock manures that aren't used to produce biogas or RNG are often stored in large open lagoons before being spread on land, releasing methane.

over from the digestion process. Digestate liquids can be used as agricultural fertilizer; the solids can be used as a compost-like soil amendment, as bedding for farm animals, and can even be mixed into construction materials or converted to biochar as a form of carbon sequestration.[4]

Figure 1. RNG Process Flow Example



The Sustainability Impact of RNG

Climate Impact

Conventional natural gas has been buried for millions of years, and using it reintroduces the carbon it contains into today's environment. RNG, on the other hand, represents a closed-loop system, capturing CO_2 recently sequestered by plants as part of the current carbon cycle. By capturing methane from different sources, RNG plays an important role in meeting the Global Methane Pledge.[5]

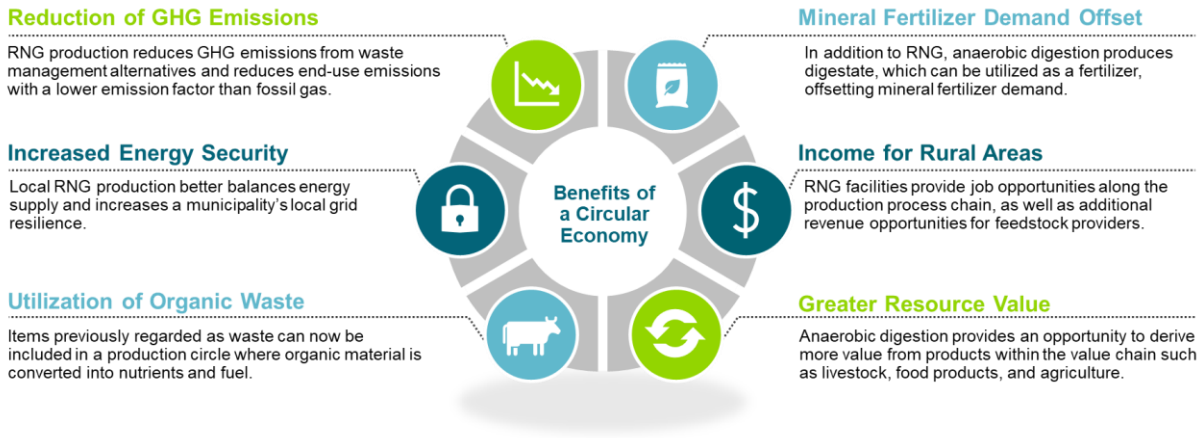
Switching from fossil fuel use to RNG reduces direct operational (Scope 1) emissions for most companies. For example, using RNG instead of diesel to run heavy duty vehicles or using RNG instead of conventional natural gas to power industrial processes are all Scope 1 reductions. The contribution of RNG to an organization's emissions inventory can be considered near zero for reporting purposes;[6] in standard corporate emissions accounting methodologies, CO_2 from RNG is considered biogenic and therefore neutral, while CO_2 from fossil fuels counts toward Scope emissions.

Circular Economy

Anaerobic digestion plays an important role in creating a circular economy for organic waste (Figure 2) by promoting its proper management and reuse. By converting organic materials with little or no value (i.e., manure, food waste, municipal solid waste and wastewater residues) into RNG, the value of the organic resources remains in the economy for longer. In addition to the beneficial products from the anaerobic digestion process (energy and digestate), RNG

production also provides positive economic and non-climate environmental impacts for local communities and increases energy security.

Figure 2. Circular Economy



Beneficial Byproducts

RNG feedstocks (excluding landfilled municipal solid waste) yield digestate, the residual organic material left over from the anaerobic digestion process, as a byproduct. Solid and liquid digestate both represent nutrient-rich soil health enhancers that fertilize soil and improve the ability of degraded agricultural land to sequester carbon. Recycling the nutrients from the organic feedstocks used in the anaerobic digestion process back into agricultural soil reduces the need for fossil-derived synthetic fertilizer (and the GHG emissions associated with its production).[7] Application of liquid digestate has also been shown to improve soil structure leading to less runoff,[8] and decreasing the potential for eutrophication[ii] in local water sources.[9]

Economic Benefits

RNG development projects have a major positive impact on regional economics. In 2022, 91 trillion BTUs (91 million MMBTUs) of RNG were produced across 254 facilities in North America, a 23% increase in capacity and a 44% increase in the number of facilities from 2021.[10] On average, for every new RNG facility commissioned, 98 jobs associated with the build and seven jobs associated with operations and maintenance are created.[11] Notably, these jobs tend to be concentrated in rural communities, with more than half (51%) of operational facilities and more than two-thirds (68%) of those under construction focused on using agricultural residues to produce RNG.

Energy Security

RNG also provides energy security[12] by increasing the diversity of energy supplies, with production and distribution dispersed geographically around the country.[13] Today there are RNG projects operating or under construction in more than 40 U.S. states; by contrast, 70% of conventional natural gas production is concentrated in just five states.[14] In situations where

[ii] An overabundance of nutrients—primarily nitrogen and phosphorus—in water starts a process called *eutrophication*. Algae feed on the nutrients, growing, spreading, and turning the water green. Algae blooms can smell bad, block sunlight, and even release toxins in some cases. (USGS Nutrients and Eutrophication)

natural gas is transported over long distances, locally produced biomethane can be connected directly to the local distribution pipeline or end user from the production source.

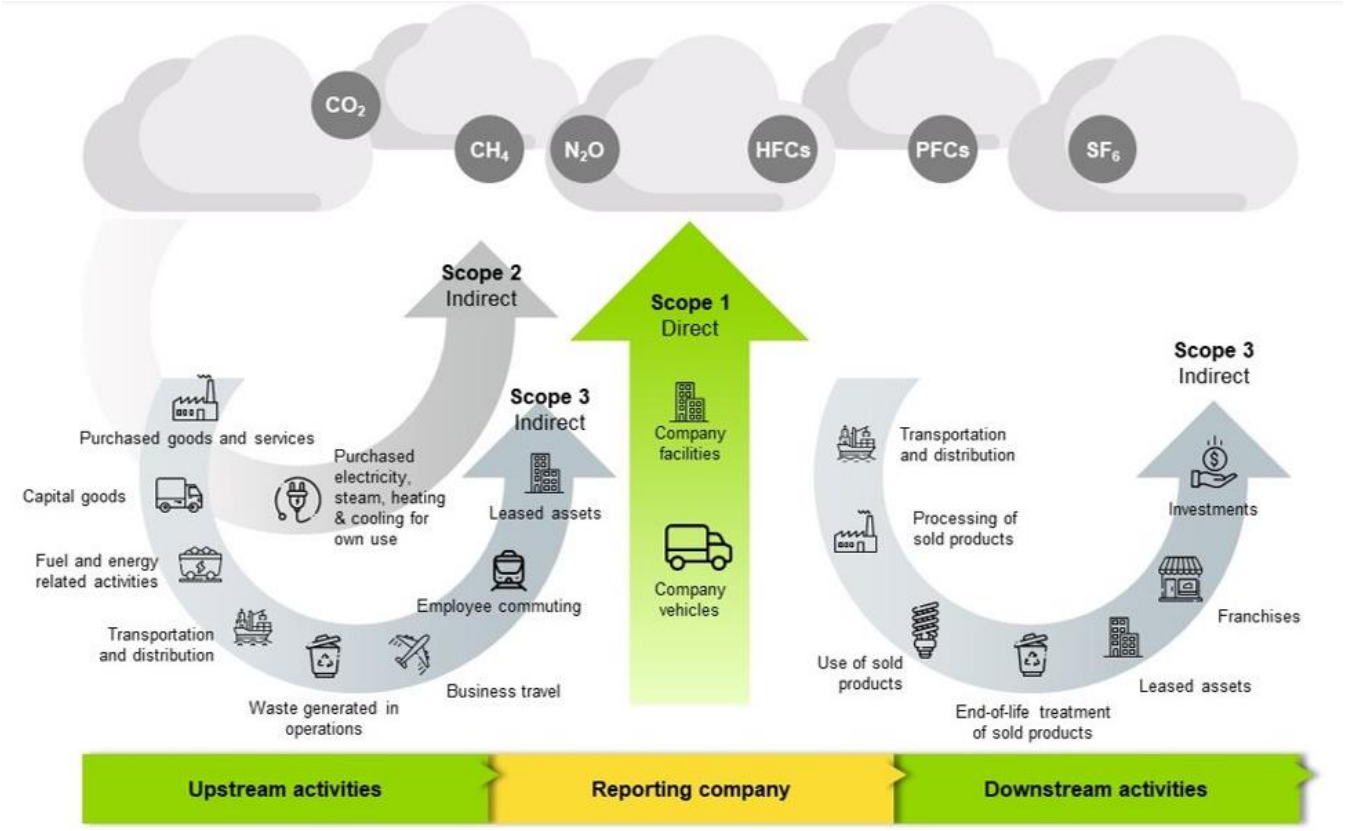
ESG Story

RNG plays a role beyond the energy commodity by providing positive environmental and economic impacts. It offers a solution for reducing carbon emissions, developing economic opportunities for rural communities, and mitigating energy dependency risk. These additional benefits help a company tell investors a positive ESG story that embraces but goes beyond standard metrics, and takes a multifaceted view of sustainability and social goals.

How RNG Can Help You Meet Your Sustainability Goals

Anthropogenic emissions are a main driver for recent changes in global temperatures.[15] A company's operational impact on climate change can be measured through its direct and indirect emissions. Direct emissions are those emitted directly by the company's operations, and which it has the greatest ability to control; indirect are those generated upstream and downstream of the core business. These GHG emissions are classified into three categories, known as Scope 1, 2, and 3 emissions,[16] as depicted in Figure 3[17] and explained below.

Figure 3. Overview of Scope 1, Scope 2, and Scope 3 Emissions



Understanding the magnitude of Scope 1, 2 and 3 emissions is key to reducing the climate impact of a company's operations.[18] By accurately measuring and reporting their emissions, companies can identify opportunities for emission reduction, such as improving energy efficiency, transitioning to renewable energy sources, and optimizing supply chains.

SCOPE 1

Emissions from sources owned or controlled by a company, also referred to as "direct emissions". Sources include but are not limited to fuel combustion, industrial processes, and company-owned vehicles.[19] **Organizations can use RNG as a direct substitute for conventional natural gas operations** such as heating buildings, fueling on-site power generation, or operating compatible company vehicles. RNG's biogenic origin means its CO_2 emissions are carbon neutral.

SCOPE 2

Scope 2 emissions are indirect emissions associated with the generation of purchased electricity, steam, heating, and cooling consumed by a company.[19] These emissions occur at the facility where energy is produced, rather than at the company's premises. **Purchasing Renewable Energy Credits (RECs) that represent power produced from RNG can reduce Scope 2 emissions** while helping to displace fossil-fuel based grid electricity.

SCOPE 3

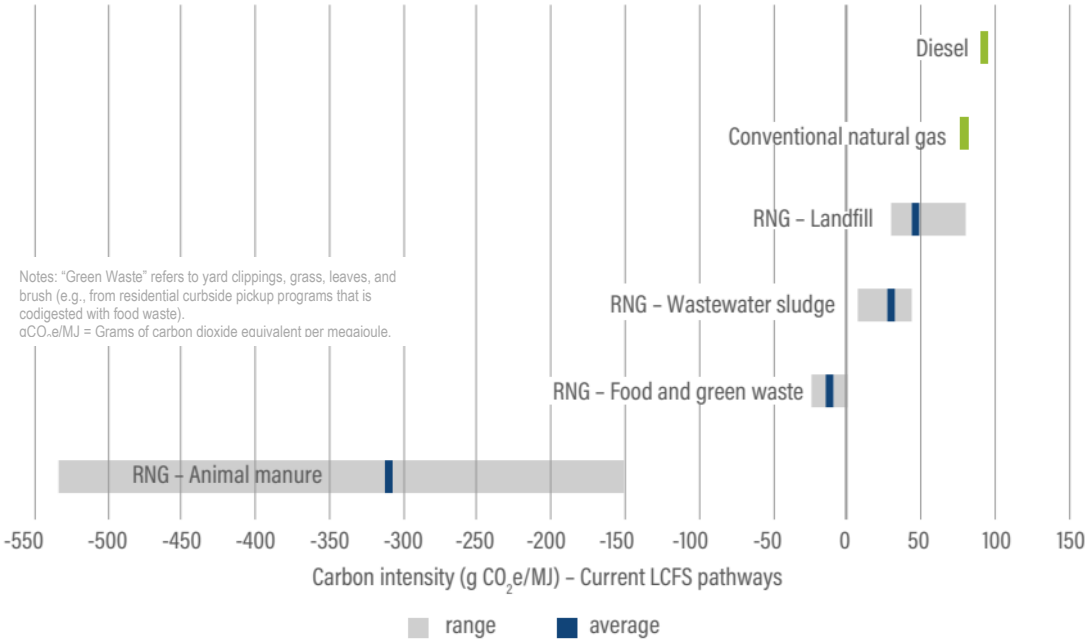
Scope 3 emissions encompass all other indirect emissions that occur throughout a company's value chain, not included in Scope 2 emissions.[19] These emissions can be both upstream (e.g., raw material extraction, manufacturing, and transportation) and downstream (e.g., product use, end-of-life treatment, and disposal). Scope 3 emissions can be lowered by **selecting suppliers that utilize RNG in their operations, lowering emissions from upstream and downstream activities.**

Carbon Negative/Neutral Fuels

RNG that's *carbon negative* or *carbon neutral* can provide companies that use natural gas as a fuel source the option of reducing their carbon emissions with few or no equipment upgrades.

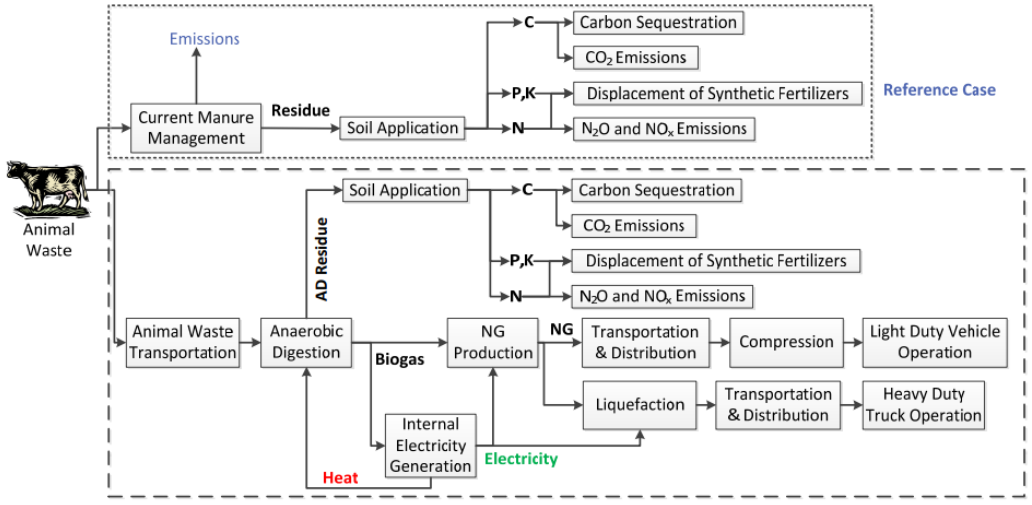
The "carbon intensity" (CI) of fuels is often measured on a *life cycle basis*. This takes into account all emissions (and avoided emissions) associated with a fuel, including its initial production, transportation to the user and final end use. Depending on the feedstock used, RNG's CI score — measured in grams of CO_2-equivalent per unit of energy — can be above or well below zero (see Figure 4).

Figure 4. Carbon Intensities of Different RNG Production Pathways



The CI score of fuels can be measured with life cycle analysis tools, such as the GREET model (**G**reenhouse gases, **R**egulated **E**missions, and **E**nergy use in **T**echnologies), a publicly available tool sponsored by the Department of Energy's Argonne National Laboratory.[19] As seen in Figure 5,[20] which shows an example of RNG from dairy manure used for transportation, GREET takes all parts of the value chain into consideration to generate an overall CI score. The tool is accepted by regulators and GHG disclosure companies for measuring the CI of a fuel used for transportation, but can also be used for bioproducts, and stationary energy systems. Preventing more emissions than they produce, carbon-negative fuels offer the considerable benefit of helping to counterbalance emissions from transportation fleets, space and water heating for buildings, and industrial facilities.

Figure 5. GREET Life Cycle Analysis Sample



How RNG Fits into the Decarbonization Taxonomy

RNG can effectively support the reduction of Scope 1 and 2 emissions while providing additional carbon offsets through methane intervention, and additional non-climate environmental benefits through organic waste processing. RNG is often considered first for a direct replacement to natural gas because it can often be fully interchangeable, but RNG can be even more impactful when substituted for more carbon-intensive fossil fuels, such as diesel.

Transportation

Transportation is currently the primary application of RNG in the US.[21] Driven by federal renewable fuel policies and by state-level emission reduction policies for the transportation sector,[iii] in 2022 69% of all on-road fuel used in natural gas vehicles was RNG.[22]

Producers either inject RNG into pipelines for supplying off-site transportation users or use it on-site to fuel vehicles themselves.[23] Major waste collection companies have converted refuse collection vehicles to natural gas engines and are using the RNG generated at their landfills to power them.[24] In some municipalities, RNG produced at wastewater treatment plants is used to power municipal vehicles. Other fleet users, particularly those with heavy-duty vehicles, source their RNG by contract from producers.[25]

Case Study: Decarbonizing UPS Transportation with RNG

United Parcel Service (UPS) has a goal of reaching 40% alternative fuel use in their fleet by 2025. Today they operate a global fleet of 13,300 trucks that use alternate fuel and advanced technology. As part of their efforts to decarbonize, UPS has purchased 155 million gallon-equivalents of RNG since 2014, and last year used 63 million gallon-equivalents of RNG.[26] To date they have invested more than $1 billion in alternative fuel and advanced technology. In addition to their ground transportation, they have joined the Sustainable Aviation Buyers Alliance with the goal of decarbonizing flight by 2050.[27]

Heating

RNG can also be used to provide heat, hot water and cooking gas for buildings. RNG only displaces a small proportion of conventional natural gas used to supply (mostly institutional and commercial) buildings across the country today. The proportion of RNG used for such thermal applications has the potential to increase as cities look to decarbonize energy use in buildings and organizations with sustainability goals seek to get emissions under control. In some buildings, replacing natural gas heating systems with electric systems may not be physically or economically feasible, making RNG a good alternative.[28]

[iii] States such as California, Oregon, and Washington have low-carbon fuel standards providing incentives for the production and use of RNG in transportation.

Case Study: Port of Seattle Utilizing RNG for Building Heat

In 2020 the Port of Seattle entered a 10-year supply contract with US Gain to purchase RNG, enabling the Port to reach its 2030 goal a decade early by reducing carbon emissions by 50% compared to its 2005 baseline.[29] The RNG, coming from a landfill, will be used to power 100% of the Port's airport bus fleet and heat 55% of the Seattle-Tacoma International Airport (SEA).

Prior to this deal, natural gas made up 75% of the Port's annual GHG emissions. With the substitution of RNG the Port will reduce 11,000 tons of its Scope 1 and Scope 2 GHG emissions annually. SEA has also set a goal of providing 10% of all flights with sustainable aviation fuel (SAF) by 2028 and operating a carbon neutral airport by 2050.

How RNG Can Decarbonize Hard-to-Decarbonize Sectors

As the world seeks to reduce GHG emissions and transition to cleaner energy sources, some sectors remain hard to electrify due to technological limitations and the need for high energy density. RNG is a promising option for these sectors, as it is chemically identical to conventional natural gas and can be utilized without major modifications to existing infrastructure. Hard-to-electrify sectors where RNG can play a role in decarbonization include direct use in industrial applications, companies under compliance programs, and maritime shipping fuel. Additionally, RNG has a potential role as an intermediate component in SAF and hydrogen production.

Industrial Applications

Some industrial applications with high carbon emissions require high temperature, high energy density, or have specific process requirements that make electrification challenging. RNG can be deployed as a direct replacement for conventional natural gas in these situations, with few or no infrastructure and process modifications. Primary applications for this transition are in aluminum, glass, and ceramics manufacturing, with applicability in other processes, including steel production and high temperature furnaces and kilns.

RNG also has the potential to displace conventional natural gas in making chemicals that are subsequently used in the production of plastics, fabrics, cosmetics, and an array of other consumer goods.[30]

Utilities and RNG

RNG can help utilities meet mandated emissions reduction targets and can help their customers reduce emissions at the same time. For example, utilities in Washington state are mandated to provide voluntary RNG programs to their customers, and in California gas utilities are required to have a percentage of their fuel supply made up of RNG. In these cases, RNG reduces GHG emissions, and supports the broader integration of renewable energy sources. Renewable Portfolio Standards require utilities to procure a certain percentage of their electricity from renewable energy sources; some jurisdictions include RNG as an eligible energy source, particularly for combined heat and power systems for electricity production.[31]

Maritime Shipping Fuel

While the shipping sector plays a critical role in global trade and economic growth, it is also a significant contributor to GHG emissions, responsible for up to 3% of global CO_2 emissions and consuming 330 million metric tons of marine fuel per year.[32] Liquified RNG (or "bio-LNG") can be used as a shipping fuel. Trials of blending 10% bio-LNG with fossil fuel-derived LNG in Rotterdam and the Netherlands have proven to be successful, demonstrating feasibility of bio-LNG blending for maritime shipping fuel. When taking into consideration avoided emissions for the production and use of bio-LNG against the oil baseline, an estimated 47%-72% emissions reductions can be achieved.[33]

Methanol is also getting a great deal of attention as a greener maritime fuel.[34] Methanol is commonly produced using natural gas,[35] but producers have been blending biomethane and conventional natural gas, achieving reductions in GHG emissions of over 50%.[36] "Biomethanol" can be produced exclusively with biomethane, and a Danish biofuels manufacturer expects to begin production at a new facility in 2024.[37]

Intermediate Component (RNG as a feedstock)

Sustainable Aviation Fuel

Aviation fuel needs to provide high energy density and manageable weight. Fuels that provide this combination have historically been carbon-intensive, making aviation a hard-to-abate industry responsible for 9%-12% of the GHG emissions related to travel in the U.S.[38,39] Alternatives like batteries are currently unsuitable for long flights, making SAF a promising low-carbon alternative for airlines.[40] Depending on the feedstock and the technology, SAF can reduce the life cycle GHG emissions drastically. RNG can be used to produce SAF, lowering the fuel's carbon intensity while maintaining compatibility with existing airline infrastructure.[41]

RNG for Hydrogen Production[42]

There are currently two leading forms of low CI hydrogen production: reforming of natural gas with associated CO_2 emissions being captured, and electrolysis powered by carbon-free renewable electricity. Biohydrogen, on the other hand, receives far less attention, despite its considerable benefits. When produced using RNG and renewable energy, hydrogen can be nearly carbon neutral, and when paired with carbon capture and storage, it can become net carbon-negative.

Considerations for Purchase

There are several ways for a company to purchase RNG as part of its sustainability strategy – through a contract with a developer, a broker, or through a utility with a voluntary RNG program. The pathways from the production site to the end-user can vary and may depend on whether purchases are in a compliance or voluntary market. This section touches on the different procurement mechanisms, verification to track the commodity from production to consumption, and accounting in voluntary standards.

Environmental Attributes

Certificates that can facilitate the transfer of "environmental attributes" such as renewable thermal credits (RTCs) and RNG certificates are tradable commodities associated with the production of renewable fuels, including electricity. Since renewably sourced electrons and molecules cannot be distinguished from their conventional counterparts once comingled, the associated environmental attributes provide a fuel with both a stamp of authenticity as to its renewable or low carbon qualities, and a way to track ownership and claim credit for use of the fuel.

A consumer can purchase a fuel commodity together with its environmental attributes in a "bundle" (potentially allowing them to sell the attributes), or they can buy the environmental attributes without the commodity, "unbundled." The needs of the company and what makes the most business sense will drive the decision to purchase "bundled" or "unbundled." A "bundled" example is seen in the L'Oreal case study below.

Case Study: RNG Enabled L'Oréal to Become Carbon Neutral, Across All US Sites

L'Oréal achieved carbon neutrality for its Scope 1 & 2 emissions across all 21 of its US sites in 2019. The company uses RNG as a core component of reducing emissions for space and water heating, complementing L'Oréal's energy optimization efforts and renewable electricity sourcing.[43]

L'Oréal sources RNG from landfill projects in New York, Texas, and Kentucky. The Kentucky example is notable as part of the decision was to provide fuel for their Florence, Ky facility but also increase economic benefits where they operate. L'Oréal's commitment to purchase 40% of the RNG produced by the installation over a 15-year period was key to the project securing financing in 2018.[44]

By investing in long-term RNG supply L'Oréal has hedged against fluctuations in the price of heating needed for its operations.

Mechanisms for Procuring RNG

There are different mechanisms for obtaining RNG—the simplest of which is a direct pipeline connection from the RNG facility to the end use site, when the two points are in proximity.

Beyond this, other common mechanisms for procurement are **book-and-claim** and **mass balance**. Each has its own guidelines on how to acquire the RNG, with book-and-claim being the most common and convenient standard. In each mechanism the amount of RNG taken out of the pipeline must equal the amount injected into the pipeline.

- **Book-and-claim:** This procurement mechanism is used under the California Air Resources Board's low carbon fuel standard (LCFS) and the federal Renewable Fuel Standard, as well as compliance and voluntary non-transportation procurement regimes. Most entities receive their energy from large distribution systems in which specific electrons or gas molecules cannot be traced from producer to buyer, creating

a barrier to direct clean energy procurement. In a book-and-claim system, a contracted amount of clean energy (whether electricity or RNG) is introduced into a distribution system and an equal amount of energy is withdrawn at another location. The "environmental attributes" corresponding to the clean energy are transferred through an exchange of certificates (i.e., RTCs, RECs, RINs, Guarantee of Origin) between the producer and buyer to establish chain of custody and ownership of the energy and associated emissions reductions.[iv] However, the environmental attributes and the energy commodity are de-coupled in a book and claim system, meaning that certificates can be sold separately from the commodity; the buyer can then use the energy, but can no longer claim its environmental attributes.

- **Mass Balance:** Like book and claim, in a mass balance approach the RNG can be injected and mixed into a pipeline with other gases such as hydrogen and natural gas. A notable difference between the two is that in a mass balance system, the environmental attributes must remain with the commodity; they cannot be traded between parties without trading the energy commodity between the same parties. In addition (depending on the jurisdiction), tracking and documentation may be required not just for the energy, but for the feedstock used to produce it.

Green Tariff Program

A Green Tariff program provides the opportunity for utility customers to purchase RNG for their facility directly from their utility provider. This is commonly done via book-and-claim, and in some instances by direct connection from the development site. Reaching out to a local utility is the best way to understand the options a customer has for taking part in a Green Tariff program.

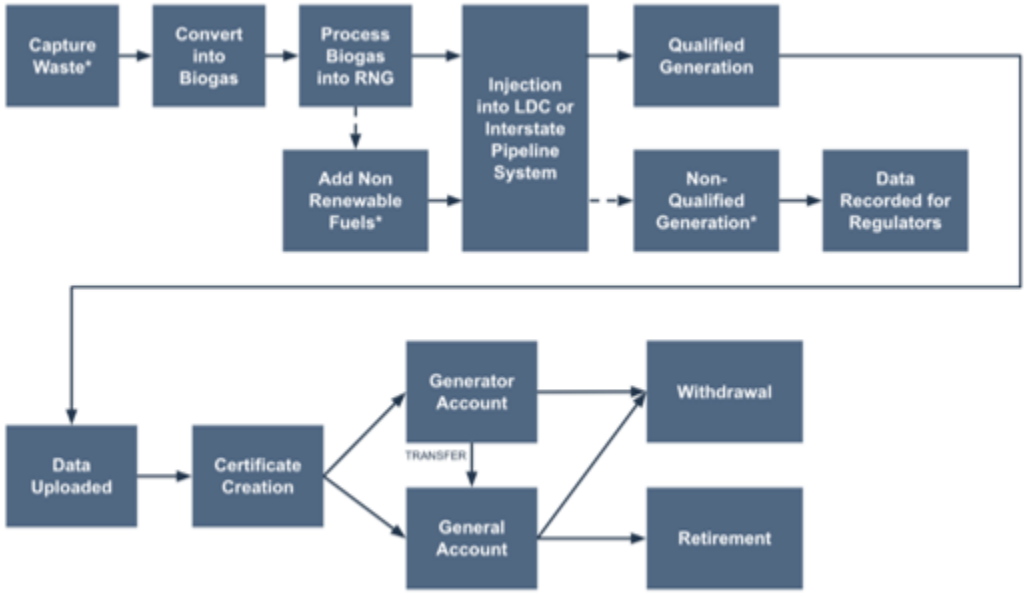
Verification of RNG Procurement

Tracking RNG from injection into a pipeline to the point of consumption (unless through a dedicated RNG pipeline) can be challenging as RNG molecules are being mixed with other gas molecules. Since the physical molecules can't be tracked, there are different verification and tracking platforms for the environmental attributes.

M-RETs is a good example of a platform that connects the producer with the end-user. It provides a trusted environmental attribute and certificate validation and tracking system where companies on the voluntary or compliance markets can track the environmental attributes from production to retirement (as seen in Figure 6).[45] Each dekatherm is assigned a serial number to generate a certificate that includes location, project, and carbon intensity pathway. Once certificates are in M-RETs they can be sold either through a broker, on an auction/exchange program, or retired.[46]

[iv] According to the California Air Resources Board, "Book-and-claim accounting refers to the chain-of-custody model in which decoupled environmental attributes are used to represent the ownership and transfer of transportation fuel under the LCFS, without regard to physical traceability."

Figure 6. M-RETs RTC Creation Schematic



Accounting for use of RNG

Once environmental attributes are in hand, they can be used to claim the environmental benefits for using RNG under leading voluntary standards such as Carbon Disclosure Project, Climate Registry, and RE100 for Scope emissions.[47] RNG's ability to support GHG reduction is also recognized by the Science Based Targets Initiative (a non-profit that verifies that emissions reduction plans align with the Paris Agreement goals).[48] Claiming the environmental attributes and what qualifies within different voluntary standards may vary, so understanding the technical criteria for each will be important.

Conclusion

RNG is a growing market, gearing up to support companies on their decarbonization journeys, as illustrated in the profiled case studies. Companies should consider RNG when they weigh-up options for decarbonizing the energy they use in transportation, heating, or industrial processes. In addition to being a carbon neutral energy source, RNG provides secondary and tertiary benefits through positive local economic impacts and improvement to air quality and agriculture that fit well in a company's sustainability goals.

While most of the demand for RNG has come from the transportation sector, there are expectations the voluntary market will drive increased demand for the product as companies look for solutions to decarbonize.[49]

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