Renewable Natural Gas To The Natural Gas Pipeline — The Basics

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Interest in supplying RNG to local gas distribution and transmission pipeline companies is increasing. Key factors about how the process works are reviewed.

Diane L. Saber

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LOCAL gas distribution and transmission pipeline companies are increasingly being approached to purchase and/or take delivery of renewable natural gas (RNG) into their existing lines for general distribution. RNG is derived from anaerobic decomposition of a wide variety of organic materials, including dairy and agricultural waste and wastewater and landfill sources. Within the natural gas industry, the term "biogas" refers to gas produced directly from digesters or landfills; it is often burned on- or off-site in generators for conversion to electricity or simply flared. Cleaned biogas or biomethane, more commonly referred to today as RNG, is the target product for inclusion in the natural gas pipeline grid.

Natural gas companies may be motivated to bring RNG into the pipeline for several reasons: 1) The wish to fulfill their Renewable Portfolio Standard using this "green" product; 2) Their customers request green products; 3) Specific industries within their system want to use green products and green gas; and/or 4) Specific markets, such as the compressed natural gas (CNG)/vehicle fuel market in their territory or state are increasing and RNG provides an additional "green bonus."

Supplying RNG to the pipeline requires meeting specifications that primarily revolve around biogas cleanup. There are a numerous approaches to cleaning the biogas, and each has its advantage. The key questions to guide the approach are: "To what specification does the gas need to be cleaned?" and "How do I get the gas into the natural gas pipeline grid near the production site?"

How Clean is Clean?
The answer is not so straight-forward. Natural gas quality is a complex and highly technical issue. The required quality of geologically-derived natural gas is documented in existing Federal Energy Regulatory Commission (FERC) guidelines, under Gas Quality, for specific producers and transmission companies (see www.ferc.gov). Within the natural gas industry, there is little consistency on particular natural gas quality specifications among pipeline tariffs, even within corporate pipeline families. Within the context of the natural gas industry and specific to transmission of natural gas, a tariff is a set of conditions and requirements that a specific, individual company petitions/negotiates with FERC in order to transport gas within their designated distribution area. Among these conditions are specifications for natural gas quality.

Tariffs vary in degrees of specificity between companies. Some tariffs are quite stringent, including a wide variety of parameters for compliance. Others are less encompassing. The natural gas industry and FERC are working together to bridge these gaps and explore specifications or methodologies other than those traditionally used. Presently, exceptions or language specific to RNG are not included under current FERC tariffs. This is often why the requirements for cleanup of biogas to RNG and pipeline injection specifications vary between pipeline networks located even closely to each other. But it may not be the only reason.

Are RNG And Natural Gas The Same?
The answer is: sort of. Are they, in fact, interchangeable? This topic is surely one of hot debate among many in the industry. Natural gas is refined, purified or "cleaned up" prior to introduction to the grid, just like RNG. Natural gas is comprised of mostly methane, as is RNG. But, there are important differences. Natural gas has components that impart particular burn characteristics and desirable quality. Small but significant quantities of gases such as ethane, propane, butane, pentane, hexane and others supply the characteristic burn-power of the gas (or "combustion energy output," otherwise known as the Wobbe Index). RNG does not contain these compounds. Thus, and not surprisingly, the Wobbe Index for even highly cleaned RNG may be lower. Other sources of natural gas, such as liquid natural gas, shale gas, gasification gas and other sources may also possess different Wobbe Index numbers and profiles, depending upon source.

Other discussions focus on constituents sometimes found in RNG and absent in natural gas. Depending upon the source of biogas and cleanup technology, small quantities of volatile and semivolatile compounds (particularly chlorinated compounds), metals and siloxanes may be present in the resulting RNG product. These constituents are captured under the category, "Other Trace Constituents and Objectionable Matter" in the FERC tariff for each natural gas company. Previous testing of RNG/biomethane by research groups such as the Gas Technology Institute has shown that trace constituents are indeed present, but at very low levels. Natural gas companies are faced with deciding the suitability of a new gas for their pipeline network based upon a profile that reveals differences from natural gas supplies. Such deliberation is not without cause.

Some Constituents Cause Pipe Corrosion
Natural gas companies work diligently to ensure that their pipeline networks retain their integrity and that their customers receive a consistent and high-quality product. Integrity of the pipeline network throughout North America is

a primary concern, so that gas can be carried safely into homes and businesses. Approximately 95 percent of all pipelines in the U.S. support the low-pressure, small diameter local distribution company (LDC) network; increasingly, this network is being dominated by plastic materials. In general, the transmission pipeline grid (high volume, high pressure) feeds into the local distribution network (low volume, low pressure) prior to exit off the grid to customers or industries. However, there are exceptions. Some LDCs are able to purchase locally produced gas, if specifications are met and the system demands are accommodated.

Some pipelines are subject to corrosion, including metallic LDC lines (particularly in the Northeast), high pressure steel transmission lines that carry gas through the U.S., and cast iron mains that service LDCs mainly in large cities. Some of this piping dates to the early 20th century. Corrosion in these high-pressure pipes can be dangerous and costly to all. The FERC tariff requirements are crafted to mitigate corrosion through control of constituents that initiate or exacerbate corrosion in metallic pipes. Corrosion control is not formulaic and pipeline conditions vary widely, making each parameter the potential "culprit of concern" under certain circumstances. The most noteworthy parameters are as follows:

Water: Perhaps the greatest instigator of corrosion in metallic pipe is water vapor entrained with the natural gas or RNG. Water combined with other trace compounds, such as carbon dioxide (CO2) or hydrogen sulfide (H2S), under certain conditions can form acidic mixtures that are highly corrosive to pipeline systems. Water vapor is also limited in the gas to prevent condensation and reduce hydrate formation. Hydrates are an ice-like mixture of water and hydrocarbons formed at high pressures where high water vapor is present. Some natural gas companies consider this parameter the most important factor in accepting RNG to the pipeline grid, as water vapor plays a key role in initiating corrosion in the presence of a variety of trace constituents.

Total Sulfur and Hydrogen Sulfide: Total sulfur is the sum of the contribution by all sulfur-containing compounds in the gas. The primary sulfur compound found in biogas is H2S but sulfur is also found natively in natural gas. Both gases require sulfur cleanup for pipeline inclusion. Sulfur-containing compounds are regulated because of their potential corrosive and destructive nature to pipeline materials, with or without the presence of water. In the presence of water, sulfur compounds can eventually form sulfuric acid, a strong acid with an aggressive corrosion potential. Sulfur corrosion is also synergistic or enhanced if other compounds are present, especially carbon dioxide (CO2) and oxygen (O2.)

Diluent Gases: Oxygen and Carbon Dioxide: The presence of O2 is problematic because it increases both the effect and rate of corrosion mechanisms. In combination with free water and/or with other constituents such as CO2, H2S and sometimes bacteria, enhanced corrosion can result. Therefore, dry gas is desired. Carbon dioxide is noncorrosive in the absence of water, but if water is present and under certain conditions, it can form carbonic acid. Additionally, CO2 can act synergistically with H2S and O2, thereby enhancing the corrosion of pipeline materials further.

Chlorides: The word chloride refers to a chemical compound in which one or more chlorine atoms are bonded to the molecule. Chloride-containing compounds are typically absent from natural gas, but they can be found in trace quantities in RNG, depending upon the source of the digested material. Feedstock source and the types of biomass digested greatly affect overall gas quality. Most chlorinated compounds are found in trace quantities in biogas originating from landfills or even wastewater treatment facilities. Unless used on the farm, chlorinated compounds rarely make their way into biomass destined for digestion. Quality conditioning systems have been shown to greatly reduce or remove these compounds from the cleaned RNG. As always, the quality of the biogas and the extent to which it will require aggressive or advanced cleaning to meet RNG specifications depends on the quality of the biomass used for digestion. In the presence of water, chlorides are rapidly converted to hydrochloric acid, which aggressively causes pitting and corrosion of the pipes.

It is clear from that no single parameter or agent is solely responsible for corrosion within metallic pipes. Environments and constituent combinations blend and vary throughout North America. Sometimes, gas companies have noticed upsets or transient aberrations within their system without a specific and identifiable cause. Many research dollars are being spent to understand the complex nature of pipeline interactions with natural gas sources. It is often believed that what is not in the gas, especially with a new gas source, may be as important as what is consistently present in the conventional source. Therefore, FERC (and subsequently the natural gas industry) has stringently limited qualities of certain constituents that are known to cause problems. Nothing personal! In this business, it is all about the pipes!

End Users Don't Like Surprises

Another aspect of gas quality that is of high concern to the natural gas industry is the impact of gas variation on end user equipment. Most residential customers would not notice small changes in natural gas characteristics, but large consumers, users and producers of specialty equipment, engines, and products and specific industries rely on consistent gas profiles. In fact, some gas companies may engage in contracts with sensitive end users for guarantee of natural gas quality within specified boundaries.

Although not found in natural gas, siloxanes are compounds of concern in RNG, potentially found in wastewater and landfill biogas. Siloxanes are not problematic to the pipeline network. Rather, upon combustion, silicon is released and can combine with free oxygen or various other elements in the combustion gas to form silica or silicates that deposit at the site of combustion, forming a powdery to glassy coating. These deposits can ultimately build to a surface thickness of several millimeters and are difficult to remove by chemical or mechanical means. The damage inflicted by siloxane combustion can be profound. Reciprocating piston engines, gas turbines and especially catalysts can experience fouling, erosion, a sharp drop in efficiency and outright equipment failure. Engine overhauls can be very costly. Therefore, the natural gas industry has carefully examined limitations in siloxane concentrations in RNG and most are quite stringent.

RNG Quality – Where To Start?
The natural gas industries in the U.S. and Canada have been working diligently to prepare Guidance Documents to establish a common framework for introduction of RNG into their networks. As mentioned above, each natural gas company is faced with unique considerations. For this reason, common Guidance has been constructed, rather than prescriptive standard language. Industry-prepared Guidance needs to accommodate the wide variety of situations and forces that impact gas receipt. Therefore, specific "cleanup standards" or conditions for introduction of RNG to the pipeline network are avoided. Natural gas companies are able to accept RNG of varying qualities, depending upon the situation. Therefore, the natural gas industry considers each situation on an individual basis, company to company. Guidance Documents serve as industry-wide references covering basic RNG quality parameters, characteristics, and analytical techniques that may be used in contracts.

The Canadian Gas Association (CGA) recently produced a Guidance Document for RNG to the pipeline, titled Biomethane Guidelines for the Introduction of Biomethane into Existing Natural Gas Distribution & Transmission System. It was vetted with the RNG industry earlier this year and was created through exhaustive review of required tariffs, etc. throughout Canada, as well as input from other Guidance and specifications gathered from Europe.

The Gas Technology Institute (GTI) had produced two Guidance Documents pertaining to RNG to the pipe, titled Pipeline Quality Biomethane: North American Guidance Document for Introduction of Dairy Waste Derived Biomethane into Existing Natural Gas Networks (2009, collaborative natural gas research) and Pipeline Quality Biogas: Guidance Document for Dairy Waste, Wastewater Treatment Sludge and Landfill Conversion (2010, DOT/PHMSA). Included in these lengthy documents are procedures, analytical data, overview information and Guidance language. As with the CGA document, the GTI Guidance Documents present overviews of basic gas quality parameters for RNG, analytical ranges typical to pipeline tariffs for the parameters and representative analytical tests. Also added to the documents are sample gas verification testing programs. At this time, each natural gas company is responsible for its own specific requirements and contract language.

Injecting RNG to the Network
Factors cited above are specific to RNG quality, but these are not the only parameters of consideration to the natural gas industry. Location of RNG introduction also may depend on gas volumes, consistency and pipeline accessibility. Often, the first question asked is: "Is the RNG destined for the LDC network or the transmission pipes?" The difference is substantial.

LDCs deal with gas volumes that go directly to customers and industries. These LDC lines may be very full of natural gas during times of high demand (winter heating, etc.) but low during other months. Pipeline capacity is very important. The LDC will consider these seasonal variations, pipeline pressures, flow capacity, pipeline materials, the customer base and sensitive end users. If the RNG plant is producing great quantities year round, an alternative line may be the best option, but it may be far away. Injecting RNG into suitable pipes may directly impact specific end users, as they are "first off the pipe." The LDCs are well equipped to assess their own networks.

Transmission companies deal with high volumes of gas, traveling long distances, at high pressure. These may be a more attractive option for gas injection, but the RNG will require pressurization to meet the demands of pipeline conditions. However, there are generally fewer transmission lines available for local access.

Connection to a distribution and/or transmission system is similar to the connection of a traditional natural gas source in that it requires careful planning and project execution; a systematic assessment of feasibility and design of the receiving facility is most likely required by the natural gas company. Typical of natural gas receipt, the RNG receipt facility needs to install analytical instrumentation to measure the gas basics: quantity and quality (BTU, etc.). RNG suppliers are not "singled out" for additional instrumentation — it is required for all gas receipt! Costs for connection to the network vary between companies, and "who pays for it" is also a point of negotiation between all parties. Depending upon the required instrumentation, location of the receipt site, pressurization requirements and other considerations, the cost can be moderate to high. However, most natural gas companies will invest in the connection as impact to and safety of their pipeline is of upmost concern.

Summary
It is important to remember that each RNG to pipeline project is different. Tariffs, end-use base, pipe constraints and other parameters discussed vary across the U.S. and Canada. What works in one place may not suffice at another. Success stories, qualifying analytical data, continued dialog and patience are required by all. The natural gas company should be involved early in discussions. Even if the buyer is located in a distant state, the gas will be injected locally

and local considerations apply. With more experience, natural gas companies and RNG producers will gain knowledge that will smooth the path to increased RNG introduction to the pipeline grid.

Diane L. Saber, Ph.D. is President of REEthink, Inc. in Kildeer, Illinois. She is a nationally recognized expert in the area of production and characterization of biomethane. Prior to starting REEthink, Dr. Saber was a Director at the Gas Technology Institute (Des Plaines, IL) and responsible for a portfolio of projects and research specific to this industry in the areas of environmental science and forensic chemistry. All cited Guidance Documents in this article can be found at www.reethink.net *under Reports.*