Biomethane Production Facility

Pipeline Interconnection in Wisconsin

--- Issues and Strategies ---

A White Paper

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www.WisconsinDR.org

Final Report – Phase 1

June 2011

Related concepts: renewable natural gas (RNG), customer-owned gas, customer-produced gas, distributed gas, biothane, renewable methane, BioCNG

Disclaimer

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ABSTRACT

This paper develops a strategy framework for the interconnection of biomethane production facilities to the transmission and distribution pipelines of Wisconsin's natural gas companies. A brief review of the following topics is provided: 1) biogas production technologies, 2) methane separation technologies, 3) examples of operational biomethane systems, 4) natural gas processing, transmission and distribution, 5) natural gas pipelines, 6) gas quality and interchangeability standards applicable to biomethane and 7) the generic biomethane interconnection.

The paper's framework identifies many interconnection related general and technical issues and suggests potential strategies to address them. A set of examples are provided for technical standards, interconnection procedures and uniform applications/agreements. An appendix delineates an *Outline of Model Interconnection Guidelines.* The paper discusses that for biomethane adoption, the right balance of implementation requirements and market development must be found. The effectiveness of overall approaches for addressing general and technical issues is scored according to technology adoption effectiveness and perceived level of risk to gas providers.

The paper concludes that biomethane provides a compelling means to turn the liability of bio-based waste streams into an economic asset. In summary, even though there are still unresolved issues about biomethane injection into pipeline systems, there are no unsolvable technical reasons for creating obstacles to interconnection.

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PREFACE

This white paper is primarily concerned with the technical interconnection issues and related general issues (procedures, liability, interconnection application/agreements) for biomethane production facilities in Wisconsin. The paper is not about specific tariff language or gas purchase agreements for customer-owned gas. The reader will not find here a complete review of biogas/biomethane potential, project economics, end-uses, production technologies, case studies, biogas treatment technologies or an exhaustive review of gas quality standards. Available in-depth reports on many of these topics are listed in Appendix III. This paper is envisioned as a type of blueprint and prelude to collaborative efforts, between the Wisconsin natural gas providers and interested stakeholders to develop interconnection guidelines.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the following organizations and individuals for assistance in reviewing this white paper and providing constructive suggestions. Please note, assistance with review of this paper does not imply endorsement by any of the individuals or the organizations listed.

- Dairyland Power Cooperative (John McWilliams)
- Energy Center of Wisconsin (Joe Kramer)
- Madison College (Ken Walz)
- Madison Gas & Electric Company (Dave Toso)
- Public Service Commission of Wisconsin (Deborah Erwin, Tom Reisdorf, Dan Sage and Tom Stemrich)
- We Energies / Wisconsin Gas (Richard Quick, Dave Schigoda and Steve Schoening)
- Wisconsin Department of Agriculture, Trade and Consumer Protection (Roger Kasper)
- Wisconsin Public Service Corporation - Integrys Energy Group (Rhonda Ferguson, Philip Mauermann and Merlin Raab)
- Xcel Energy (Rosemarie Halchuk, Richard Hosch and Joni Zich)

Biomethane Production Facility Interconnection: Issues and Strategies

INTRODUCTION

The purpose of this paper is to develop a strategy framework for the interconnection of biomethane production facilities to the transmission and distribution pipelines of Wisconsin's natural gas companies. The framework identifies the issues of interconnection and suggests potential solutions to address them from a technical and business perspective. Although gas providers and the gas industry have extensive pipeline experience with geologically-sourced natural gas, they have little or no experience with biomethane produced from distributed facilities. The key to acceptance of biomethane for pipeline distribution is a clear delineation of the potential technical solutions for making its use safely interchangeable with conventional natural gas. This must be accomplished without unduly increasing the maintenance burden on pipeline systems and end-use gas equipment. This strategy paper is envisioned to be valuable to biomethane producers, gas utilities, regulators and other interested parties as a means of creating a framework for interconnection - with the ultimate goal of developing a consensus-based guidelines document in a later project.

The use of biomethane, as a supplement to natural gas, may bring substantial reductions in greenhouse gases, while creating flexibility in gas supplies. Although methane can be derived from numerous sources, the environmental benefits are gained from using renewable feedstocks in its production. In some cases, it may be more economically advantageous to utilize a blend of biomethane and conventional natural gas, within the existing gas pipeline and end-use infrastructure, than to build facilities dedicated to operating exclusively on biogas.

The Public Service Commission of Wisconsin (PSCW) opened a docket titled "Renewable Resource Credit Rule Revisions after 2009 Wisconsin Act 406" (1-AC-234). This docket concerns rules that allow an electric provider to create a renewable resource credit (RRC). The PSCW sought input to several questions in this docket relating to biogas and renewable fuels introduced into the pipeline infrastructure. One PSCW question seems to portend the eventual use of renewable natural gas in pipelines.

> *"Some of the renewable fuels specified in the statute, for example biogas, can potentially be scrubbed and introduced into a natural gas pipeline, making it impractical or impossible to distinguish the renewable fuel from the conventional resource and therefore impractical or impossible to physically verify where or by whom the renewable fuel is ultimately used. However, it is certainly possible that some or all of the renewable fuel in such a scenario would be used by Wisconsin electric providers or their customers or members, and might therefore be eligible for creating RRCs. How should the Commission verify and measure the amount of renewable fuel that is used by any given electric provider, or customer or member of and electric provider, to account for* ***circumstances where a renewable fuel has been blended with natural gas*** *(emphasis added) in such a way that a physical link*

between the producer of the renewable fuel and the ultimate user of the renewable fuel cannot be firmly established?"

Given the interest in gaseous renewable pipeline fuels and the prospect of creating corresponding RRCs, this seems to be a reasonable time to develop a technical guidance document to allow for confidence building in developing an interconnection process.

BACKGROUND

Since about 2000, there has been developing a growing market of biogas production facilities in Wisconsin. Although anaerobic digestion (a biological process) and landfill gas recovery are currently the established biogas production technologies, biomass gasification (a thermal process) may additionally produce gases of similar compositions. Biogas is the raw gas from which biomethane may be extracted. Biogas is a mixture of several gases, predominantly methane, with secondary amounts of carbon dioxide and other small percentages of constituent gases.

Most of the biogas currently produced in Wisconsin is used as fuel for combined heat and power (CHP) applications at customer-owned facilities. With today's biogas-fueled technology, an engine-generator may typically be about 35% efficient at producing electricity and up to 40% efficient at producing utilizable heat (from water jacket and exhaust). However, there has been field experience with biogas-fueled CHP, in Wisconsin, that shows low application demand for the heat produced at installations. Examples: 1) There typically are no buildings to heat or processes requiring heat at a landfill and 2) at farms, except for heating dairy parlor water - a minor heat use - buildings do not require heating in warmer weather. Low application heat demand results in poor utilization of the thermal energy available from biogas[1]. Given the underutilized heat demand of many CHP applications, pipeline biomethane appears to be a more efficient use of biogas than electricity generation - on a thermal basis. **Figure 1** shows the biogas thermal utilization efficiency pathways for methane and electricity.

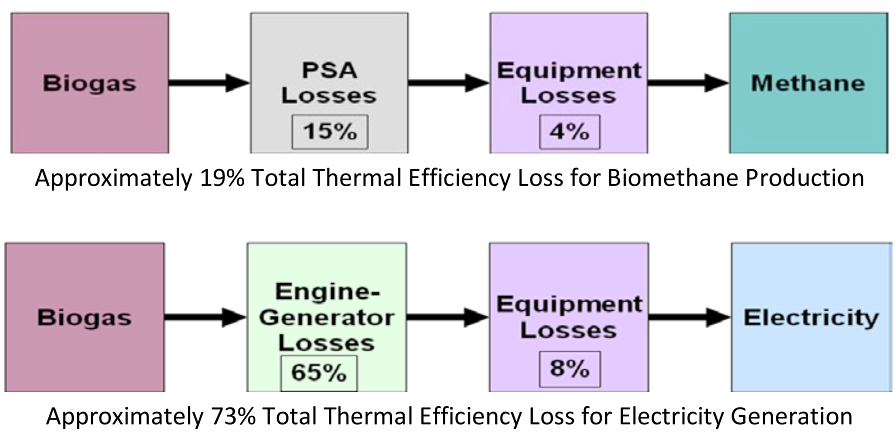

Figure 1. Biogas Thermal Utilization Efficiency Pathways

[1] Author's observation from the Focus on Energy Program as manager of Biogas Technologies.

There is also evolving interest in extracting biomethane from biogas with the goal of selling it into the natural gas infrastructure. Biomethane is almost exclusively composed of methane, the major constituent of geologically-sourced natural gas. Biomethane is also known by other terms including renewable natural gas (RNG), biothane, renewable methane, customer-owned manufactured methane and biologically sourced methane.

Pipeline biomethane takes advantage of the existing gas distribution and transmission pipeline infrastructure and contributes to a diversified and reliable natural gas supply. And importantly, pipeline methane use provides a reduction of greenhouse gas emissions in two ways: 1) directly by avoiding an amount of un-controlled production and emission of methane by the decomposition of organic material 2) indirectly by utilizing methane as fuel, thereby, lessening the proportionate need for fossil fuel. Methane is at least 21 times as harmful to the atmosphere as carbon dioxide as a greenhouse gas. [**ref: 17, ref: 18**]

Biogas Production Facilities

Biogas production can be broadly classified according to the type of gas production process used and the feedstocks utilized.

Anaerobic Digesters

An anaerobic digester is a process that breaks down organic materials using bacteria in the absence of oxygen. The products of anaerobic digestion are biogas and effluent that has been reduced in volume and strength (on a chemical & biological oxygen demand basis). Biogas consists primarily of methane, secondarily of carbon dioxide and, additionally, gases of much smaller percentage: water vapor, hydrogen sulfide, nitrogen and hydrogen.

Typical feedstocks for anaerobic digestion are from renewable biomass sources that include animal wastes, sludge from municipal wastewater treatment plants, crop waste, dedicated crops and food processing wastes.

Landfill Gas Recovery Systems

Landfill gas recovery systems utilize a series of extraction wells or trenches and collection headers to gather the gas emissions from solid waste landfills. The systems include a gas flare to burn off excess methane and various monitoring systems to gauge the volume of gas collected.

Landfill gas is produced from the breakdown of municipal solid wastes by bacterial and chemical reactions in a landfill. Landfill gas is primarily composed of methane and carbon dioxide, with various amounts of nitrogen, oxygen, water vapor, hydrogen sulfide, siloxanes and other contaminant gases known as non-methane organic compounds (NMOCs). NMOCs include, but are not limited to, benzene, vinyl chloride, chloroform, toluene, carbon tetrachloride and halogens. The NMOCs typically comprise less than 1% of landfill gas.

Biomass Gasifiers

A biomass gasifier is a chemical processing unit that principally converts biomass into carbon monoxide and hydrogen by high temperature (> 700 degrees C) with a controlled amount of oxygen and/or steam. The resulting gas is called synthesis gas or syngas. Other contaminant gases are also present; the exact composition is dependent on the feedstocks types that are used in the gasification process. The next step to produce methane is called methanation or methane synthesis. Methanation utilizes an exothermic reaction to combine the carbon monoxide and hydrogen from syngas to yield methane and water. A biomass to methane conversion efficiency of 50% is possible. **Table 1** shows the compositional ranges of biogas, syngas and landfill gas.

Table 1. Compositional Ranges of Biogas, Syngas and Landfill Gas

Composition	**Biogas –** ***dairy cow waste, % (or as stated)***	**Syngas –** ***wood chips, % [a.]***	**Landfill Gas,** ***% [c.]***
Methane	50 – 75	3.0	45 - 60
Carbon Dioxide	25 – 50	6.0	40 – 60
Hydrogen Sulfide	0 – 3	0	
Water, relative measure	80 ppm	0	Saturated
Nitrogen	0 – 10	48.6	2 – 5
Oxygen	0 – 2	0.4	0.1 – 1
Hydrogen	0 – 1	18	0 – 0.2
Carbon Monoxide		24.0	
Ammonia	< 1,000 ppm		0.1 – 1
Trace Compounds	Approx. 4,000 ppm		< 0.6 *[b.]*
HHV (Btu/scf)	500 – 600	135	450 - 550

a. Reference: HMI International. Data derived from a fixed bed updraft gasifier design. Steam – Babcock and Wilcox, p. 5-19.

b. Trace compounds: sulfur dioxide, benzene, toluene, methylene chloride, perchlorelthylene, halogenated hydrocarbons, siloxanes, and other compounds.

c. D. Augenstein, J. Pacey, Landfill Gas Energy Utilization: Technology Options and Case Studies, EPA-600-R-92-116, U.S. environmental Protection Agency, Research Triangle Park, 1992.

Methane Separation Technologies

Several technologies are now commercially available to process biogas to yield methane that is virtually indistinguishable from natural gas. Biogas processing usually takes place with several technologies, in stages or series operation, that each have advantages in removing specific contaminants. Some contaminant gases can be removed by adjusting certain characteristics of biogas production. For example, sulfur can be removed from anaerobic digesters by micro-organisms. The micro-organism family *Thiobacillus* oxidizes sulfides and sublimates elemental sulfur that is retained in the digester tank. Small amounts of oxygen are added to the biogas in the digester tank to aid this process. However, excess oxygen must be removed by a later technology stage to meet pipeline specifications.

Water in the liquid phase is usually removed by a gravity sump, followed by dehumidification and drying. The removal of water is important since it can combine with several gases to form corrosive compounds that are detrimental to metal pipelines and components.

Siloxanes are chemical compounds of the class organosilicon, composed of silicon, oxygen and hydrogen or alkane groups. Products like deodorants, shampoos, cosmetics and some soaps contain siloxanes. They are found in landfill gas and biogas from municipal wastewater treatment plants that handle these products. Siloxanes can be removed by absorption in a liquid mixture of hydrocarbons with an ability to absorb the silicon compounds. The absorbent is regenerated by heating the hydrocarbon mixture in a regeneration cycle.

Most of the other contaminant gases are removed from biogas by process stages of one or more of the following technologies. The resultant gas is about 99% methane in composition.

Conventional Pressure Swing Adsorption (PSA)

Pressure swing adsorption takes advantage of the property that allows one chemical to be deposited on the surface of another chemical. The adsorptive process is used to remove carbon dioxide, and other gases having highly adsorptive properties, from methane which is less adsorptive. The process takes place in a tank under pressure (approximately 100 psig) with zeolite or activated carbon typically used as the adsorbing material. Contaminant gases are removed (desorbed) by depressurizing the tank in a recycling sequence.

Water Scrubbing (with and without regeneration)

Water scrubbing (also known as water column) takes advantage of the absorption property that permits one material to be transferred into another material (or from one phase into another phase). In water scrubbing, the higher solubility of carbon dioxide and other gases with polar molecules, allows separation from the less soluble methane. The absorption process of carbon dioxide and other gases takes place within a tank under low pressure (approximately 3 or 4 psig) leaving relatively pure methane. The removed gases are driven from solution in second vessel under high pressure (approximately 120 to 150 psig) in a recycling process.

Membrane Separation

Methane can be separated from the other constituents of biogas by multiple passes, under pressure, through a membrane that has selective permeability. Methane of 94% to 96% purity can be obtained with membrane separation systems.

Chemical Absorption

The chemical absorption process is similar to water scrubbing but utilize a chemical solution (typically amine solution) to remove carbon dioxide and other gases from methane. Chemical removal solutions are used that have a greater capacity for absorption of unwanted gases than water. Elevated temperatures are utilized to remove the absorbed gases from the chemical solutions, thereby, recycling the solutions so they can be reused.

A biogas production facility and methane separation process(s) are necessary to create biomethane. The biogas production facility and methane separation process(s) may not necessarily be located at the same place. It is the methane separation process(s) to extract biomethane from biogas that are interconnected to a gas provider's pipeline system. Therefore, a Biomethane Production Facility is defined as a manufacturing plant for the production of biomethane that is located near the point where biomethane will be used or is at a location that will provide biomethane to a gas provider's pipeline system.

Examples of Operational Biomethane Systems

Scenic View Dairy - Fennville, Michigan; developer is Biogas Direct, LLC; biogas production 324,000 ft^3/day; biomethane used for pipeline gas and cogeneration; utility(s) are Consumers Energy, Michigan Gas Utilities Corp.

Huckabay Ridge - Stephenville, Texas; developer is Microgy (currently Element Markets, LLC); biogas production is 2,739,726 ft^3/day; biomethane used for pipeline gas; utility is Pacific Gas and Electric.

Shafter Cluster (C&R Vanderham Dairy, Inc., Whiteside Dairy and Vermeer and Goedhart Dairy) – Kern County, California; developer is BioEnergy Solutions; biomethane production is 615,000 ft^3/day; biomethane used for pipeline gas; utility is Pacific Gas and Electric.

Vintage Dairy Project – Riverdale, western Fresno County; California; developer is BioEnergy Solutions; biomethane production is 175,000 ft^3/day; biomethane used for pipeline gas; utility is Pacific Gas and Electric.

Fort St. Vrain Generating Station Biomethane Project – near Platteville, Colorado; developer is Microgy, Inc. (currently Element Markets, LLC); biomethane production is estimated to be 915,000 MMBtu/year; biomethane used for generation of carbon neutral electricity generating station; utility Xcel Energy; This announced project has Element Market, LLC under a 10-year contract and will assist Xcel energy in meeting its Colorado Renewable Energy Standard.

Rumpke Landfill Biogas to Pipeline Grade Natural Gas Project – Cincinnati, Ohio; developer is Xebec Adsorption, Inc.; biomethane production is 6.0 million standard cubic feet per day (mmSCFD); biomethane used for pipeline gas to 25,000 utility gas customers; utility is Duke Energy. [**ref: 13**]

Trident BioFuels Energy Gas Processing Facility – Point Loma Wastewater Treatment Plant in San Diego County, California; developers are BioFuels Energy, LLC, SCS. Inc. and New Energy Capital Partners, LLC; biomethane production is estimated to commence by October 2011; biomethane will be used in utility distribution pipeline system; utility is San Diego Gas & Electric Company.

Natural gas provider Integrys Energy Services is offering its Ohio customers a blend of natural gas and "biogas" at no extra charge[2]. The product, ecoVations Renewable Gas, is a blend of 92 percent conventional natural gas and 8 percent methane from manure digesters, sewage treatment plants and landfill gas wells. The gas is pipeline quality, matching the energy potential of conventional gas, the company said. "We think this is the future," said Susanne Buckley, Columbus-based director of regional

[2] Cleveland.Com, Friday, August 29, 2008 and Columbus Business Journal, Monday, September 29, 2008.

sales for Integrys. "Green is where the market is going to expand." Integrys surveyed its customers, In 2008, Buckley said, and found that 72 percent would buy renewable gas if the cost were the same as conventional fossil-based gas. A full 25 percent said they would switch to biogas even if it cost more. 2008.

Other Landfill Gas Pipeline Biomethane Projects in the U.S.
City of Ft. Smith Landfill; Arkansas Oklahoma Gas (Oklahoma)
Fresh Kills Landfill; KeySpan Energy (New York)
Greentree Landfill; Conectiv Energy Supply (Pennsylvania)
Johnson County Landfill; Enbridge Energy (Kansas)
McCarty Road Landfill; CenterPoint Energy (Texas)
McCommas Bluff Landfill; Atmos Energy (Texas)
Monroeville Landfill; Equitable Gas (Pennsylvania)
Pinnancle Road Landfill; Proliance Energy (Ohio)
Valley Landfill; Equitrans Interstate Pipeline (Pennsylvania)

Natural Gas Processing, Transmission and Distribution

Geologically sourced raw natural gas, from crude oil wells, gas wells, or condensate wells, contains considerable quantities of contaminants and must be processed to meet the gas quality standards specified by the pipeline transmission and distribution companies.

Raw natural gas flows by way of compressor stations from the producing wells through gathering lines to raw gas transmission pipelines. This raw gas is sent to a processing plant where it is processed by multiple contaminant removal stages to yield pipeline quality natural gas prior to entering a long-haul transmission pipeline system.

Raw natural gas typically consists of methane but also contains varying amounts of heavier hydrocarbons (ethane, butane, propane, pentanes, etc.), liquid hydrocarbons, carbon dioxide, hydrogen sulfide, nitrogen, helium, oxygen, water vapor, liquid water, dissolved salts, mercury, chlorides and other traces compounds.

Raw natural gas is typically processed in roughly the following stages:

1. Gas is separated from oil.
2. Condensate removal.
3. Water vapor is removed from the gas by regenerative absorption, membranes or pressure swing adsorption.
4. Carbon dioxide and hydrogen sulfide are removed by chemical absorption (amine treatment) or membrane processes.
5. Hydrogen sulfide is recovered as elemental sulfur or recovered as sulfuric acid.
6. Mercury is removed by an adsorption process typically on activated carbon.
7. Nitrogen is removed by solvent absorption or activated carbon adsorption.
8. Methane is separated.
9. Gas liquids are removed using low temperature distillation.

Natural gas that is not within specified quality standards, pressures, heating value, or moisture levels will cause pipeline deterioration and operational problems. The following table lists the average natural gas composition supplied by U.S. gas providers. It should be noted that actual natural gas composition must be determined for each specific pipeline system in order to set the required gas composition requirements for interconnection. **Table 2** delineates the average U.S. gas provider supplied natural gas composition.

Table 2. Average U.S. Gas Provider Supplied Natural Gas Composition

Composition / Property	% (by volume)
Methane	93.4
Ethane	3.20
Propane	0.69
Butane	0.25
Pentane	0.10
Hexane	0.06
N_2	1.50
H_2	0.00
CO_2	0.80
H_2O	0.00
Air	0.00
HHV (Btu/scf)	1032
LHV (Btu/scf)	931.0
Specific Gravity	0.5971
Wobbe Number (HHV)	1336.0
Wobbe Number (LHV)	1204.9
Molecular Weight	17.292

Reference: DOE/NETL-2007/1290

The relevance of raw gas processing to biomethane is to demonstrate that processing technologies are already in widespread use, for removing the considerable contaminants found in raw gas, to produce supplied natural gas.

Natural Gas Pipelines

Rigid steel is the traditional material that makes up many distribution pipelines. Flexible plastic and corrugated stainless steel tubing are materials that newer pipelines may use. Pipelines are sized for a particular flow rate (ft^3/day) and the pressure (psi) required to transport a given volume of gas. There are several engineering equations used for calculating flow rates in natural gas pipelines: Panhandle equations, Weymouth equation and IGT. Simulation programs are also available to calculate pipeline pressures[3].

Natural gas in transmission pipelines may be compressed up to 1,500 psi. in pipelines that typically have diameters of 16 inches to 48 inches. Distribution pipelines, on a national basis, are typically 1 inch to 24

[3] GASMOD and GPIPE, Systek Technologies, Inc., www.systek.us

inches in diameter and may have pressures as low as 0.25 psi to 100 psi. In Wisconsin, the maximum allowable pressure reported for gas provider-owned pipelines is typically below 400 psi. However, the maximum allowable pressure for most gas distribution pipelines is 60 psi (PSC 135.621).

The current practice is for natural gas rates to be based on a heat content basis ($/mmBtu or therm or dekatherm) rather than on a volumetric basis ($/per thousand cubic feet). Gas meters measure the volume of gas used in standard cubic feet (scf) or thousand cubic feet (Mcf). A natural gas provider knows, by periodic measurement, the heat content of the local natural gas supply. The heat content of natural gas varies up to 10% (950 Btu/scf – 1050 Btu/scf) over time. Gas providers use recording calorimeters to determine the heating value of the gas being distributed to customers. A heat content-based quantity of natural gas is calculated by multiplying the volume of gas used (scf), in the current period, by the heat content of the gas (Btu/scf).

Gas Quality and Interchangeability Standards Applicable to Biomethane

Gas Quality

Gas quality is the compositional makeup of the gas. Out-of-specification biomethane contains various amounts of potentially harmful constituents that can cause substantial problems if not removed. For instance, contaminants such as water, carbon dioxide, and hydrogen sulfide - even in small amounts - can have a corrosive effect on steel pipe, thus, degrading the safety and integrity of a pipeline system and end-use appliances. A clear gas specification will include appropriate limits on the potentially damaging components of biomethane. American Gas Association (AGA) Report No. 4A – Natural Gas Contract Measurement and Quality Clauses [**ref: 1**], provides considerations for gas measurement and analysis, gas quality and potential impacts, ranges of gas quality values found in tariffs and a measurement/gas quality checklist.

A specification for gas composition typically involves some or all of the following components:

> *hydrocarbons, water vapor, hydrogen sulfide, mercaptans (organic sulfides), total sulfur, carbon dioxide, nitrogen, total inerts, oxygen, other trace constituents, pharmaceuticals and microbes.*

A specification for gas composition typically involves some or all of the following parameters:

> *heating value, specific gravity, temperature and hydrocarbon dew point.*

The addition of an adjustment gas, like propane, has been used by the gas industry to increase the heating value of natural gas in order to meet pipeline quality specifications. Propane, as an adjustment gas, could be used to raise the heating value of biomethane.

The Wisconsin Administrative Code specifies the purity of gas requirements for natural gas supplied to customers [PSC 134.22]. The sulfur content is to be no more than 30 grains per 100 standard cubic feet. The ammonia content is to be no more than 5 grains per 100 standard cubic feet. The hydrogen sulfide content is to be no more than 0.1 grain per 100 standard cubic feet.

Interchangeability

Interchangeability is the ability to substitute one gaseous fuel for another without materially changing safety, efficiency, performance or air pollutant emissions. Interchangeability can be described with quantitative measures so that it can have broad application to end-uses. Heating value is used in many gas specifications but, used alone, is not a good indicator of interchangeability.

The Wobbe Index is a gas interchangeability index utilizing the gross heating value of the gas and the relative density of the gas. ($W \cong HV / \sqrt{G}$, where HV is the gross heating value of the gas (btu/scf) and G is the relative density defined according to ISO6976 as the ratio of the density of a gas to the density of air under the same temperature and pressure.)

The Weaver Indexes are a series of interchangeability indexes developed to augment AGA tests for flash back, lifting and yellow tipping. Weaver indexes: J_A for air supply, J_F for flashback, J_A for burner load (same as Wobbe Index); J_I for incomplete combustion, J_L for lifting, J_Y for yellow tipping.

The Methane Number is an index that represents the anti-knock property of a methane-based fuel as it relates to usage in a combustion engine (analogous to octane rating for gasoline).

The Wisconsin Administrative Code specifies heating and specific gravity requirements for natural gas supplied to customers [PSC 134.21]. The heating values are to be no more than 5% above or 4% below the heating value that each gas provider has on file with the PSCW. The code specifies the specific gravity of natural gas supplied to customers. The specific gravity is to be within 10% of the specific gravity that each gas provider has on file with the PSCW. “Dry gas”, as specified in PSC 134, means a gas having a moisture and hydrocarbon dew point below any normal temperature to which the gas piping is exposed. As applied to determination of heating value or specific gravity, dry gas means the complete absence of moisture or water vapor. The heating value and specific gravity essentially provide the necessary information to calculate the Wobbe Index of the supplied gas.

Instrumentation for Monitoring Gas Quality and Interchangeability

Gas quality monitoring may be performed by various instruments to detect the chemical signatures of specified contaminant gases and provide a quantitative assessment of them. On-line sampling and detection requires a responsive gas composition sensor for real-time assessment and control of gas injection, especially with potential composition variations that may result from feedstock changes at gas production facilities.

There are many useful types of instruments used to determine gas quality as determined in a 2007 report from the U.S. Department of Energy and the National Energy Technology Laboratory [**ref: 9**]. Many of the instruments identified in the report are for use in laboratories and are unsuitable or not yet available as on-line sensors.

Continuous gas chromatographs are extremely versatile and can be used to measure a wide range of chemical components, including methane, carbon dioxide, oxygen and hydrogen sulfide. However, the analysis is usually slow and requires considerable maintenance.

Since 2007, infrared (IR) spectrometers have been developed that demonstrate versatility as analytical instruments when used to identify types of organic and many inorganic compounds. IR spectroscopy can be a powerful tool to determine the constituents of biomethane. It is impossible to determine the composition of biomethane directly from its IR spectrum. Software is utilized to derive the compositional analysis from the IR spectrum data using various algorithms. IR spectrometer systems are commercially available and are in use by the natural gas industry. Several use a tunable diode laser as the light source for absorption spectroscopy. They excel at the detection of moisture, carbon dioxide, hydrogen sulfide, ammonia, oxygen and other gases.

The Generic Biomethane Interconnection

A biomethane interconnection is the physical connection of a biomethane production facility to a gas provider's pipeline system so that gas injection can occur. **Figure 2** shows a diagram of a generic biomethane interconnection. The main components include at least the following: 1) methane separation unit, 2) controller-interfaced three-way valve to divert gas either to the gas analyzer instrument or a flare, 3) controller-interfaced gas analyzer instrument, 4) buffer tank, 5) controller-interfaced compressor, 6) gas cooler, 7) gas pressure regulator and overpressure relief, 8) controller-interfaced flowmeter, 9) controller-interfaced calorimeter, 10) controller-interfaced moisture meter, 11) odorization injection system, 12) gas sampling port, 13) controller-interfaced main disconnect valve, 14) gas meter, 15) system controller and 12) communication link.

The point of interconnection is the point where the pipes of the gas provider's pipeline system are connected to the biomethane producer's pipes and where any transfer of gas between the biomethane producer and the gas provider's pipeline system takes place. The point of interconnection is usually at the gas meter.

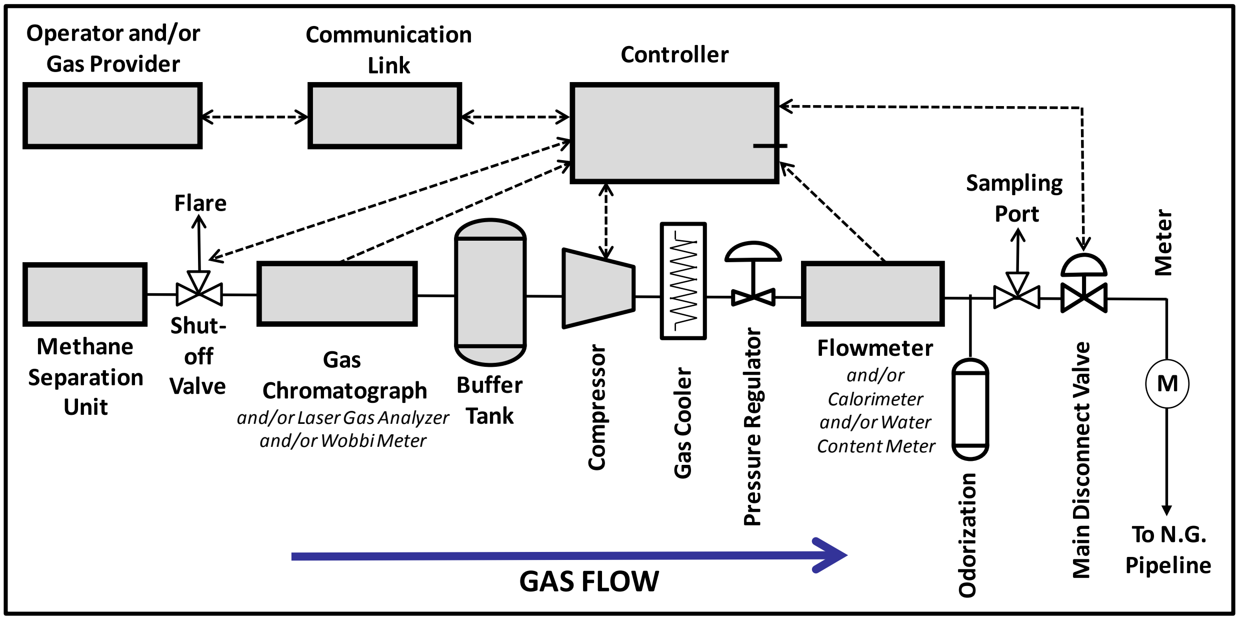

Figure 2. Generic Biomethane Interconnection Components

For the purposes of this white paper, the source of raw biogas is not included as part of a biomethane interconnection. The reasoning for not including the source of biogas as part of the interconnection is two-part: 1) the methane separation unit has considerably more influence on gas quality and 2) a gas provider will likely not wish to become involved in biogas production design issues. What the gas provider is most likely interested in is the means of controlling gas quality/parameters, control of gas injection and safety issues.

At a biomethane interconnection, data that are typically collected and sent to a controller (microcomputer) are: 1) the on/off state of the shutoff valve between the methane separation unit and the compressor, 2) the gas chromatograph data and/or laser gas analyzer data and/or Wobbi meter data, 3) the on/off state of the compressor, the flowmeter and/or calorimeter and/or water content meter data and 4) the on/off state of the main disconnect valve.

The typical control signals sent by microcomputer are: a) on/off control of the shutoff valve between the methane separation unit and the compressor, b) on/off control of the compressor, c) on/off control of the main disconnect valve and d) control signals to various alarms.

All or some of these data and control signals may be sent to the gas provider via a communication link. The communication link can be any of the following: telephone line, satellite link, T1 line, packet radio link, microwave link or fiber-optic cable.

INTERCONNECTION ISSUES AND POTENTIAL STRATEGIES

Biomethane production facility interconnections raise concerns that can be grouped into the following issue categories: 1) general (procedural/legal) and 2) technical. This section provides a description of each interconnection issue and provides some potential strategies for addressing them. The issues are based on exchanges and discussions with the technical staff of Wisconsin's gas providers and other stakeholders. The resolution of these issues will provide stepping stones to an overall strategy for the acceptance of biomethane in the pipeline infrastructure of Wisconsin's natural gas providers. A strategically implemented interconnection will ensure that biomethane is safely interchangeable with conventional natural gas - without unduly increasing the maintenance burden on pipeline systems and end-use gas equipment.

General Issues:

➢ General Issue 1: Biogas Source Technology Eligibility for Interconnection

Should all biogas source technologies be allowed for biomethane to pipeline interconnection? As shown in the background section of this paper, the potential contaminants from various sources of biogas vary. Some of these contaminants are more egregious than others. This is potentially of concern to a gas provider since equipment failure, or lack of maintenance from a source of biogas containing more onerous contaminants, could transfer the contaminants through with the biomethane. These contaminants could potentially damage a pipeline or customer equipment before the situation is rectified.

On the other hand, once a biomethane specification is set, the design and operation of the production facility should be fully capable of effectively detecting out-of-specification gas, shutdown injection and set an alarm indicating equipment failure. The decision about which biogas source technologies are eligible for interconnection should be based upon sound technical, engineering and scientific considerations, not arbitrary policy. If a biomethane production facility fully complies with the gas quality specification and other guidelines in effect, there should be no safety or operational reason to disallow an interconnection.

Potential Strategy: Technical Requirements Set According to Biomethane Production Facility Categories

A case can be made for setting the general and technical requirements of biomethane production facilities according to the potential impacts they may have on pipeline systems. Categories can be used to set specific requirements according to the feedstock and gas production technology used, thereby, taking into consideration the potential contaminants from the various production technologies. **Table 3** lists example biomethane production categories.

Table 3. Example Biomethane Production Facility Categories

Category	Biomethane Production Facility Type
Category 1: Anaerobic Digestion	Feedstocks: animal waste, food processing waste, municipal wastewater Gas producing technology: anaerobic digestion
Category 2: Biomass Gasification	Feedstocks: wood, and non-treated wood waste, crops Gas producing technology: biomass gasification
Category 3: Landfill Gas	Feedstocks: allowed municipal solid waste Gas producing technology: landfill gas recovery system

➢ General Issue 2: Volume Restrictions for Individual Production Facilities

Concerns have been raised about biomethane injection into pipelines that do not have the capacity to safely accept the gas volumes that a facility can produce. Overcapacity issues may be found on pipelines that have low volume capacity at their rated pressure. Situations of overcapacity can also occur on pipelines that have low seasonal natural gas usage, especially during summer months. Low seasonal gas usage situations can cause difficulty when forcing injected biomethane volumes toward higher capacity pipelines, without changing flow regulators or check valves. There is also concern about having a large enough buffer of natural gas, in some low pressure pipelines, to dilute any accidental out-of-specification biomethane resulting from protection system failure at a production facility. Another related issue is that certain production facilities, depending on the local pipeline capacity, may supply nearly 100% biomethane to some customers.

Potential Strategy: Limit Quantities of Biomethane Injected into Pipelines on a Site Specific Basis

Limiting the quantities of biomethane at specific points in the pipeline system will mitigate many potential effects of over-injection or accidental out-of-specification gas. A demarcation point for determining the allowable amount of biomethane injected could be related to the flow rates (scf/day) of various sizes of pipelines. In Wisconsin, the maximum allowable pressures for gas distribution pipelines are typically 60 psi, but some operate at higher pressures. The volumes of gas transported by similar sized pipelines are proportional to the flow rates (scf/day) and the pressures required to transport the gas over the required distance. It is possible to limit the amount of biomethane injected based on some percentage relationship to gas volumes transported in various sized pipes. This situation is of somewhat less concern for transmission pipelines since they transport larger volumes of gas at pressures up to 1,500 psi.

➢ General Issue 3: Graduated Technical Requirements for Biomethane Production Facilities

A case can be made for having technical requirements to be set according to the potential impacts production facilities may have. Larger production facilities produce more biomethane and, therefore, will have a larger impact on pipeline systems if, by accident, gas quality fails to meet the required quality specification.

There are several questions that still need resolution on this issue. Should technical requirements be set for sizes of biomethane production facilities (the total biomethane processed at the facility) or for sizes of biomethane interconnections (the amount of gas allowed to be injected)? There are cases where the gas is not only injected into the pipeline system but also used on-site. This is somewhat analogous to inside-the-fence electricity generation.

Potential Strategy: Increased Contractual Requirements for Production Facilities of Increasing Size

Many contractual interconnection requirements do not necessarily have to be the same for all sizes of biomethane production facilities. Smaller production facilities, with less gas available for injection, may have less impacts on pipeline systems than larger facilities. Smaller production facilities will inject a smaller percentage of biomethane volume as a function of the average natural gas pipeline volume carried - depending on the specifics of a particular pipeline. The key is to determine a relevant method to calculate the average natural gas pipeline volume capacities. Since the volume of gas transported by a pipeline is proportional to the flow rate (scf/day) and the pressure (psi), these two factors could be utilized in a methodology for determining average volumes carried by a pipeline. This value would have to be determined on a case-by-case basis since each pipeline would likely carry different average volumes. Once the average volume carried by a pipeline is determined, not-to-exceed percentage thresholds can be set for different levels of relaxed contractual requirements - except for gas quality and interchangeability. In several ways, this issue has similarities with General Issue 2. Provided that the fraction of biomethane volume injected is less than the natural gas volumes carried by the pipeline, any impacts should be lessened. The technical requirements could be graduated according to the example values in **Table 4**.

Table 4. Example of Graduated Contractual Requirements

Volume of Biomethane Injected (scf/day) as a Percentage of Average Pipeline Carried Volume (scf/day)	Contractual Requirements (except gas quality and interchangeability)
25% and less	Level 1 (least requirements)
greater than 25% to 50%	Level 2 (medium requirements)
greater than 50% to 75%	Level 3 (most requirements)

Contractual requirements that can be reduced for smaller production facilities can be grouped into two types – general and technical. Examples of general requirements that could be reduced include, but are not limited to: 1) minimum liability insurance coverage, 2) application review fees and 3) engineering review fees. Examples of technical requirements that could be reduced include, but are not limited to: 1) types of instrumentation, 2) SCADA communication link types, 3) protection device characteristics and 4) commissioning tests.

The determination of which specific contractual requirements should be reduced in this graduated arrangement is best left to a collaborative process for developing an interconnection guidelines document.

➢ General Issue 4: Standardized Interconnection Application Forms and Agreements

Standardized interconnection application forms and agreements provide a reasonable level of certainty as to the general and technical requirements for a wide range of project participants. These participants include the supply chain of equipment manufacturers to installation contractors, project engineers, system owners/operators, financial service providers, regulators and others. Without standardized interconnection application forms and agreements, the process of meeting a gas provider's requirements becomes more complex, varying from one gas provider to gas provider.

Potential Strategy: Standardize the Application Forms and Agreements for Wisconsin's Gas Providers.
Standardized application forms and agreements can be developed that are similar to those adopted for distributed generation interconnection in PSC 119 (Rules for Interconnecting Distributed Generation Facilities).

➢ General Issue 5: Streamlined Application Process

The application process for a biomethane production facility involves specifying: 1) the allowable timeline for application process step approval, 2) engineering reviews and 3) application/engineering review fees. It is important for all involved in a biomethane interconnection project to know the time length that each step in the application approval process will take. A standardized application form should require the applicant to specify sufficient information to make an engineering review a straight-forward process, one that does not involve an excessive amount of back-and-forth between the project developer and the gas provider's engineering staff. It is also helpful to project developers to have any fees for the application or engineering review to be predetermined and standardized. Delineating and streamlining all of these factors helps reduce the frustration level, uncertainty and costs for a biomethane interconnection.

Potential Strategy: Utilize a Streamlined Application Process Timeline, Clearly Specified Information Requirements for an Engineering Review and Standardized Application/Engineering Fees.
A specified application process timeline, clearly specified information requirements (in the application agreement) for an engineering review and standardized application/engineering fees can be developed that are similar to those adopted for distributed generation interconnection in PSC 119 (Rules for Interconnecting Distributed Generation Facilities).

➢ General Issue 6: Scope of Interconnection Guidance Applicability

Any interconnection process for biomethane production facilities becomes more user-friendly if it applies to all gas providers within Wisconsin. Interconnection application forms/agreements, defined application process, defined technical requirements and defined general requirements only provide a reasonable level of certainty and cost containment if they are standardized across all gas providers. Standardization makes the process of meeting a gas provider's interconnection requirements less complex and does not vary from one gas provider to another.

Potential Strategy: The Scope of Interconnection Guidance Applicability should be developed as part of a collaborative process between the gas providers and other stakeholders.

➢ General Issue 7: Liability

How will biomethane production facilities be held liable for their operations and product? Even with the best design, construction and operation of biomethane production facilities, things can go wrong. If production facility equipment fails, gas providers will want to know if the owners and operators of facilities will hold the utility harmless for any problems with their gas pipeline system or with their gas customer's equipment. For example, will the owners and operators of a biomethane production facility bear the cost of replacing gas provider and gas customer equipment if there are problems? What about legal challenges from out-of-specification biomethane?

Potential Strategy: Indemnification

The interconnection agreement can require the owners and operators of the biomethane production facility to indemnify and hold harmless the gas provider, its officers, agents and employees against all loss, damage, expense, and liability, resulting from injury to or death of any person, arising out of or in any way connected with the biomethane injected into the gas provider's pipeline system. This provision could include, but not be limited to, employees of the gas provider, gas customers or any third party for the loss, destruction, damage to property, including but not limited to property of the gas provider, gas customer, or any third party, arising out of or in any way connected with the biomethane injected into the gas provider's pipeline system.

Indemnification would not be extended to that events caused by the active negligence or willful misconduct of the gas provider, its officers, agents and employees. The owners and operators of the production facility can be required to defend any suit asserting a claim covered by this indemnity.

The following language is adapted from PSC 119 – "*Each party to the standard interconnection agreement shall indemnify, hold harmless and defend the other party, its officers, directors, employees and agents from and against any and all claims, suits, liabilities, damages, costs and expenses resulting from the installation, operation, modification, maintenance or removal of the biomethane production facility. The liability of each party shall be limited to direct actual damages, and all other damages at law or in equity shall be waived.*"

Potential Strategy: Graduated Liability Insurance Requirements

Using the graduated requirements from distributed electric generation as an example, an applicant seeking to interconnect a biomethane production facility to the pipeline system of a gas provider can be required to maintain liability insurance similar to the amounts stipulated in Table 119.05-1, per occurrence, or prove financial responsibility by another means mutually agreeable to the applicant and the gas provider. A biomethane production facility in certain categories could also be required to name the public utility as an additional insured party in the liability insurance policy. As an example, **Table 5** lists the minimum liability insurance coverage requirements from PSC 119.

Table 5. Minimum Liability Insurance Coverage for Categories of Distributed Generation

Table 119.05–1		
Category	**Generation Capacity**	**Minimum Liability Insurance Coverage**
1	20 kW or less	$300,000
2	Greater than 20 kW to 200 kW	$1,000,000
3	Greater than 200 kW to 1 MW	$2,000,000
4	Greater than 1 MW to 15 MW	Negotiated

Biomethane Interconnection equipment designed and installed in compliance with well designed interconnection guidelines can go a long way in preventing potential liability issues.

➢ General Issue 8: Natural Gas Pipeline Extensions and Upgrades

The following example, from distributed electric generation, illustrates the related importance of careful consideration of issues related to pipeline extension and upgrades in the biomethane interconnection process.

> *A conscious decision was made when PSC 119 (Rules for Interconnecting Distributed Generation Facilities) was written that issues relating to electric line extensions and distribution system upgrades should not be included in the rule. This decision was made because rules for line extensions already existed in PSC 112 (Construction by Electric Public Utilities and Extensions of Electric Service) and PSC 113 (Service Rules for Electrical Utilities). Sometime after PSC 119 went into effect, the decision not to include line extension issues in PSC 119 was seen by some as a source of confusion and difficulty in completing projects. This situation was largely due to the many challenges distributed generation poses that are not encountered in ordinary electric line extensions. Of the many analogous examples of the difficulties encountered in distributed generation projects involving distribution line upgrades, the following topics are indicative:*
>
> - *communication links – what is the minimum adequate link: dedicated telephone line, satellite link, T1 line, fiber-optic cable?*
> - *substation upgrades – new regulators, control house communications circuits, new breakers*
> - *distribution line recloser coordination – relays, user interfaces and wireless encrypting transceivers*
> - *measurement equipment – possibly redundant potential transformers*

There is a process similarity between natural gas pipeline extensions and electric line extensions. Although pipeline extensions are generally handled under tariffs, rather than administrative rules in Wisconsin, some guidance on pipeline extensions should be made in the biomethane interconnection process.

Potential Strategy: Include Topics Related to Natural Gas Pipeline Extensions and Upgrades in Biomethane Interconnection Guidelines.
In developing a biomethane interconnection guidelines document, it is important to consider the relationship between biomethane interconnection and pipeline extension issues. Some level of guidance should be provided in coordinating the interconnection process with the pipeline extension process at the time an application is made for interconnection. A guidance document should provide a means to streamline the process for making pipeline extension and upgrades clear and cost considerate for both project developers and gas provider staff. PSC 133 (Construction, Installation, and Placing in Operation of Facilities by Gas Utilities) and PSC 134 (Standards for Gas Service) are the administrative rules for gas pipeline extensions. Aspects of these two administrative rules, as well as future tariffs, should be made part of the biomethane interconnection process.

➢ General Issue 9: Dispute Resolution

Without doubt, over time there will be disputes regarding the interpretation of some biomethane interconnection procedures. A process for resolving disputes is essential.

Potential Strategy: Utilizing the Public Service Commission to Resolve Disputes
The standard route of dispute resolution is within the gas provider's company. However, this means of resolving disputes may not solve every dispute. The results of outside dispute mediation are only as useful as the impartiality of a selected mediator. If mediation is selected, there should be thoughtful consideration given to selecting a mediator prior to signing an interconnection agreement. Mediator selection should not be made in the wake of a dispute.

The Federal Energy Regulatory Commission (FERC) has jurisdiction over interstate transmission pipelines while State agencies have jurisdiction over local distribution companies (LDCs) and intrastate distribution. The State agency that is pertinent for gas interconnection in Wisconsin is the PSCW. The PSCW should be the body that resolves disputes. Taking problems through litigation should be reserved as a last resort, to be used only when all other means do not result in a resolution of the dispute.

Technical Issues:

➢ Technical Issue A: Design Requirements for Biomethane Interconnections

Producing biomethane that conforms to a specific gas composition and interchangeability index is part of a series of steps that are necessary to achieve overall production facility performance. It is also important to be assured that a production facility interconnection will be designed to standards that reflect appropriate engineering design principles, best practices and regulatory requirements. A production facility interconnection must be designed to protect natural gas pipeline systems, avoid gas equipment combustion problems, ensure the safety of customers, gas provider employees and the general public and maintain overall pipeline system reliability.

Potential Strategy: Clearly Specify Design Requirements for Biomethane Interconnection

Owners and operators must be responsible for the design of a biomethane production facility interconnection so they are in conformance with the requirements of Wisconsin Administrative Codes (e.g. PSC 134), relevant laws, applicable codes, regulations (local, state, and federal) and the requirements of a gas provider's interconnection agreement (see example below).

For example, the following listing provides categorical design requirements that would be useful in a guidance document.

General Design Requirements

- *Regulatory Requirements and Standards*

Biomethane Interconnection Specifications

- *Permitted Quantities and Blending*
- *Interconnection Equipment and Minimum Pipeline Protection Functions*
- *Automatic Shutoff Valve*
- *System Purging*
- *Metering Requirements*
- *Labeling Requirements*
- *Test Valves and Test Bypasses*
- *Monitoring Instrumentation for Gas Quality & Calibration*
- *Telemetry / SCADA*

Gas Delivery Specifications

- *Gas Quality*
- *Monitoring Instrument Calibration*
- *Gas Interchangeability*
- *Odorization*

Example Design Specification and Guidance (for gas odorization):

An approved odorant shall be added to the biomethane prior to injection into the pipeline system in conformance with 192.625, of Title 49 Code of the Federal Regulations and local gas provider requirements. *Several odorant injection systems, utilizing mercaptan-based agents (typically tertiary butyl mercaptan), are commercially available – including, but not limited to, OdorEyes and NJEX*[4].

[4] Welker Company, www.odoreyes.com and YZ Systems Milton Roy, www.yzsystems.com

Biomethane interconnection design can be specified explicitly in a guidelines document that is the template for an interconnection agreement. The ***Outline of Model Interconnection Guidelines for Biomethane Production Facilities**,* listed in **Appendix II**, provides a proposed framework for the topics that need to be addressed to assure sound design of biomethane interconnections.

➢ Technical Issue B-1: Specification of Biomethane Gas Quality / Interchangeability

Metal pipeline systems are susceptible to corrosion which can be caused or accelerated with acidic solutions. Corrosive solutions can be largely eliminated from biomethane by removing the compounds that combine with water to form acids (e.g. hydrogen sulfide, carbon dioxide, etc.) Water itself is detrimental to pipeline systems, so removal of liquid water and water vapor by dehumidification of biomethane is essential. Combustion appliances, engines, gas turbines, natural gas vehicles and boilers will have degraded operation when fueled with out-of-specification fuel gas. Gas quality and interchangeability both affect the gas provider's pipeline systems and customer's end-use systems/appliances.

Potential Strategy: Specification of Biomethane Gas Quality and Interchangeability Should Be Made With Regard to at Least the Following Guidance Documents.

- *White Paper on Natural Gas Interchangeability and Non-Combustion End Use*, A reference for interim guidance on natural gas interchangeability (heating values and Wobbe index values) can be found in a white paper by NGC+ Interchangeability Work Group (for FERC) [**ref: 5**]

- *AGA Report No. 4A - Natural Gas Contract Measurement and Quality Clauses. 2009*. American Gas Association. This report provides general definitions, language and criteria to consider when specifying measurement & gas quality parameters typically found in contracts & tariffs. [**ref: 1**]

- *AGA Research Bulletin No. 36, Interchangeability of Other Fuel Gases with Natural Gases.* [**ref: 2**]

- *Policy Statement on Provisions Governing Natural Gas Quality and Interchangeability in Interstate Natural Gas Pipeline Company Tariffs*. Federal Energy Regulatory Commission [**ref: 15**]

- *Rule 30 – Biomethane Guidance*. Southern California Gas Company [**ref: 14**]

- A reference for typical tariff gas composition/parameter specifications (including several European tariffs) is found in a Gas Technology Institute report Task 1 [**ref: 4**]

- A reference listing the constituents of anaerobic digester produced biogas is found in a Gas Technology Institute report Task 2 [**ref: 4**]

Potential Strategy: Utilize "Rule 30 – Transportation of Customer-Owned Gas - Gas Delivery Specifications" (Southern California Gas Company) as a Starting Point for a Wisconsin Biomethane Specification.

Table 6 lists the gas delivery specifications for Rule 30 - Southern California Gas Company. [**ref: 19**]

Table 6. Rule 30 – Gas Delivery Specifications

Heating Value: The minimum heating value is nine hundred and ninety (990) Btu (gross) per standard cubic foot on a dry basis. The maximum heating value is one thousand one hundred fifty (1150) Btu (gross) per standard cubic foot on a dry basis.
Moisture Content or Water Content: For gas delivered at or below a pressure of eight hundred (800) psig, the gas shall have a water content not in excess of seven (7) pounds per million standard cubic feet. For gas delivered at a pressure exceeding of eight hundred (800) psig, the gas shall have a water dew point not exceeding 20 degrees F at delivery pressure.
Hydrogen Sulfide: The gas shall not contain more than twenty-five hundredths (0.25) of one (1) grain of hydrogen sulfide, measured as hydrogen sulfide, per one hundred (100) standard cubic feet (4 ppm). The gas shall not contain any entrained hydrogen sulfide treatment chemical (solvent) or its by-products in the gas stream.
Mercaptan Sulfur: The gas shall not contain more than three tenths (0.3) grains of mercaptan sulfur, measured as sulfur, per hundred standard cubic feet (5 ppm).
Total Sulfur: The gas shall not contain more than seventy-five hundredths (0.75) of a grain of total sulfur compounds, measured as sulfur, per one hundred (100) standard cubic feet (12.6 ppm). This includes COS and CS2, hydrogen sulfide, mercaptans and mono, di and poly sulfides.
Carbon Dioxide: The gas shall not have a total carbon dioxide content in excess of three percent (3%) by volume.
Oxygen: The gas shall not have an oxygen content in excess of two-tenths of one percent (0.2%) by volume, and customer will make every reasonable effort to keep the gas free of oxygen.
Inerts: The gas shall not contain in excess of four percent (4%) total inerts (the total combined carbon dioxide, nitrogen, oxygen and any other inert compound) by volume.
Hydrocarbons: For gas delivered at a pressure of 800 psig or less, the gas hydrocarbon dew point is not to exceed 45 degrees F at 400 psig or at the delivery pressure if the delivery pressure is below 400 psig. For gas delivered at a pressure higher than 800 psig, the gas hydrocarbon dew point is not to exceed 20 degrees F measured at a pressure of 400 psig.
Merchantability: The gas shall not contain dust, sand, dirt, gums, oils and other substances injurious to Utility facilities or that would cause gas to be unmarketable.
Hazardous Substances: The gas must not contain hazardous substances (including but not limited to toxic and/or carcinogenic substances and/or reproductive toxins) concentrations which would prevent or restrict the normal marketing of gas, be injurious to pipeline facilities, or which would present a health and/or safety hazard to Utility employees and/or the general public.
Delivery Temperature: The gas delivery temperature is not to be below 50 degrees F or above 105 degrees F.
Interchangeability: The gas shall have a minimum Wobbe Number of 1279 and shall not have a maximum Wobbe Number greater than 1385. The gas shall meet American Gas Association's Lifting Index, Flashback Index and Yellow Tip Index interchangeability indices for high methane gas relative to a typical composition of gas in the Utility system serving the area. Acceptable specification ranges are: * Lifting Index (IL) IL <= 1.06 * Flashback Index (IF) IF <= 1.2 * Yellow Tip Index (IY) IY >= 0.8
Liquids: The gas shall contain no liquids at or immediately downstream of the receipt point.
Biogas: Biogas refers to a gas derived from renewable organic sources. The gas is primarily a mixture of methane and carbon dioxide. Biogas must be free from bacteria, pathogens and any other substances injurious to Utility

facilities or that would cause the gas to be unmarketable and it shall conform to all gas quality specifications identified in this Rule.

Table 7 is a short listing of test methods for major components and parameters of pertinence to biomethane.

Table 7. Test Methods for Major Components and Parameters of Biomethane.

Parameter	**Test Method**
Heating Value Wobbe Number Major Components: (C_1 to C_6+, CO_2. N_2. O_2, CO, H_2)	• American Society for Testing and Materials - ASTM D1945/D7164, • Gas Processors Association -GPA 2261
Water Vapor Content	• Gas Processors Association -GPA 2261, • American Society for Testing and Materials – ASTM D1142/D5454/D3588
Hydrocarbon Dew Point	• American Society for Testing and Materials – ASTM D1142, • Gas Processors Association -GPA 2286
Hydrogen Sulfide, Mercaptan and Total Sulfur	• American Society for Testing and Materials - ASTM D4084/D6228/D4468/D5504/D7166
Oxygen	• Electrochemical
Carbon Dioxide	• Laser, Fourier Transform Infrared Spectroscopy (FTIR)
Dust and Gum	• Environmental Protection Agency - EPA Method 5, 0.1µm filters
Temperature	• Thermocouple

Source: ASTM International; www.astm.org

Potential Strategy: Utilize the Guidance from "Rule 30 Biomethane Gas Delivery Specifications - Limits and Action Levels" (Southern California Gas Company) as an Example for a Wisconsin Guidance Document. **[ref: 14]**

Although Southern California Gas Company gas specifications are a reasonable starting point for a guidance document, many of the specifications would need to be adjusted for Wisconsin's climate. Examples of specification adjustments for Wisconsin include:

- Water vapor dew point: 0° F
- Hydrocarbon dew point: 15-20° F
- Carbon dioxide: 0.5% - 1%

Potential Strategy: Characterize Current Natural Gas Composition

The composition of Wisconsin's natural gas supply can be characterized in order to set a gas quality / interchangeability index. This characterization can be used to set the gas quality specification for a particular production facility. If biomethane has insufficient heating value, it may be spiked with limited amounts of propane to advantage. Spiking is the process of adding a higher heating value gas to another fuel gas to boost the heating value of the composite fuel gas.

Potential Strategy: Awareness of Legacy Equipment Sensitivities on Distribution Pipeline

Some legacy gas equipment may not have burner geometry or controls that are adjusted properly for small variances of natural gas characteristics. If this equipment is located on the same distribution pipeline and is in proximity to the biomethane production facility, there is a chance that it may not function optimally due to any gas variances. By being aware of these sensitivities, a production facility can make adjustments to the composition of the biomethane to assure proper operation of any legacy equipment at specific pipeline locations. The gas provider's customer representative will likely be aware of potentially sensitive legacy equipment and can communicate this to the production facility designers/operators.

> *PSC 134.10 (1) sets the appliance service requirements for gas utilities for several conditions including when changes in the heating value standard, all changes in pressure and specific gravity greater than the allowable variation, and changes in the composition of the gas which would materially affect the operation of the customer's appliances must be accompanied by a general inspection and adjustment of all appliances that would be affected by the changes. "Appliance" means any device which utilizes gas fuel to produce light, heat, or power. PSC 134.10 (3)(a) also requires each utility shall adopt and file with the commission a policy for inspection of customer's appliances. The filed rule need not include the inspection and adjustment of special industrial equipment, which should be checked by persons more familiar with the equipment.*

➢ Technical Issue B-2: Trace Gas Components

Biomethane may also potentially contain trace gas components, in unknown quantities, that may not be normally investigated in gas testing. Various levels of trace components may lead to problems in the pipeline system and with end-use equipment. Gas providers in Wisconsin have indicated concern about the effects of trace gas components in their pipeline systems.

Gas chromatography, with a thermal conductivity detector, is typically used to test the major component composition of natural gas. Gas chromatography testing is usually valid down to 0.01 mole percent concentration for each trace component. There are, however, a multitude of trace components with less than 0.01 mole percentage concentration. For natural gas, these trace components include aromatic hydrocarbons, organic sulfur compounds and paraffinic hydrocarbons. There are a number of advanced tests that can be utilized to identify these trace components. **Table 8** is a short listing of possible trace components, which can be found in biomethane, and some methods used to test for them.

Table 8. Short Listing of Possible Trace Components of Biomethane and Pertinent Testing Methods

Trace Component	Test Method
Aldehydes and Ketones, Formaldehyde	• Environmental Protection Agency - EPA TO-11, • High Performance Liquid Chromatography (HPLC)
Ammonia	• Gas Chromatography (GC), • Nitrogen Chemiluminescence Detector (NCD), • Occupational Safety Health Administration (OSHA) ID 164 Modified
Biologicals	• Most Probable Number Determination of Total Live Bacteria (MPN), • Quantitative Polymerase Chain Reaction (qPCR), • Spore Enumeration – NASA Handbook 5340.1D and id, 2µm, 0.2µm filters
Halocarbons	• Environmental Protection Agency - EPA TO-14, • Gas Chromatography /Electrolytic Conductivity Detector(GC/ELCD)
Hydrogen	• American Society for Testing and Materials - ASTM D1945/D7164
Mercury	• Atomic Absorption (AA), • Atomic Fluorescence Spectrometry (AFS), • American Society for Testing and Materials – ASTM D5954/D6350
Pesticides	• Gas Chromatography /Electron Capture Detector (GC/ECD), • Gas Chromatography/ Mass Spectrometry (GC/MS), • Environmental Protection Agency - EPA 8081
Pharmaceuticals Animal Care Products	• Liquid Chromatography/ Mass Spectrometry (LC/MS), • Gas Chromatography/ Mass Spectrometry (GC/MS)
Polychlorinated Biphenyls (PCB's)	• Gas Chromatography /Electron Capture Detector (GC/ECD), • Gas Chromatography/ Mass Spectrometry (GC/MS), • Gas Chromatography/ Atomic Emissions Detector (GC/AED), • Environmental Protection Agency - EPA 8082
Siloxanes	• Environmental Protection Agency - EPA TO-14.15, • Gas Chromatography /Electrolytic Conductivity Detector(GC/ELCD), • Gas Chromatography/ Atomic Emissions Detector (GC/AED), • Gas Chromatography/ Mass Spectrometry (GC/MS)
Volatile Metals	• Inductively Coupled Plasma (IPC),

	• Atomic Absorption Spectrometry (AAS)
Volatile Organic Compounds (VOC's) Semi-Volatile Organic Compounds (SVOC's) Polycyclic Aromatic Hydrocarbons (PAH's)	• Gas Chromatography/ Mass Spectrometry (GC/MS), • Environmental Protection Agency - EPA 8270C,B, • Environmental Protection Agency - EPA TO-14.15, • Environmental Protection Agency - EPA TO-13A
Volatile Fatty Acids (VFA's)	• Environmental Protection Agency - EPA TO-17, • Gas Chromatography/ Mass Spectrometry (GC/MS)
Vinyl Chloride	• Gas Chromatography/ Mass Spectrometry (GC/MS), • Environmental Protection Agency - EPA 8270C,B, • Environmental Protection Agency - EPA TO-14.15

Source: ASTM International; www.astm.org

It is important to remember that a trace component, present at any arbitrarily small detection level, may not necessarily be problematic for a pipeline system, health or end-use equipment. There is a good probability that natural gas itself contains trace components that are not normally investigated in gas analysis.

Potential Strategy: Initially Allow Interconnection to Anaerobic Digestion-Based Biomethane Production Facilities.

As mentioned in General Issue 1, **b**iomethane production facility categories can be used to set specific requirements according to the feedstock and gas production technology used. The proposed biomethane facility categories have technical requirements set according to the potential contaminants from the various gas producing technologies. Perhaps, biomethane interconnections should be initially limited to category 1 production facilities (anaerobic digestion facilities utilizing dairy waste feedstocks) until more experience and confidence is gained. Of the three proposed production facility categories, anaerobic digestion will likely have fewer trace components than synthesis gas or landfill gas.

A Gas Technology Institute (GTI) report concluded that undesirable components can be effectively removed from biomethane derived from dairy farm wastes, using available gas treatment equipment, to meet typical natural gas pipeline tariffs. [**ref: 4 – Task 2**].

> *"Overall, the data resulting from testing of biomethane samples demonstrates that this type of renewable gas can exhibit a chemical profile which is consistent with typical tariff and contract constituent considerations cited in AGA Report 4A. In addition, the other target compounds, specifically those not commonly found in natural gas, that were detected in the biomethane samples were present in very low concentrations (parts per billion). These concentrations were compared against NIOSH and OSHA exposure limits as well as other reference concentrations. When compared against NIOSH and OSHA exposure limits, it may be concluded that specific trace concentrations of the compounds in biomethane generated from the digestion of dairy waste and from the systems tested by GTI are far below actionable levels. The data from the biomethane samples demonstrates that the gas treatment technologies used can effectively treat biodigestion outputs to remove undesirable components to levels within the bounds of typical natural gas pipeline tariffs and specific contract values assigned to the biomethane supplier."* [**ref: 4, Task 2, page 88**]

To bolster this approach, Technical Issue C suggests a potential gas quality verification period, and continuing gas quality verification schedule, for production facilities. The question is whether biomethane should be subject to more stringent trace component level thresholds than natural gas and, if so, which trace components should be identified for testing. This is a subject that needs additional investigation.

➢ Technical Issue C: Biomethane Interconnection Commissioning

Interconnection commissioning is the initial process of documenting and verifying the performance of a biomethane production facility so that it operates in conformity with design specifications. Several types of commissioning tests can be performed including gas quality verification, anti-islanding tests and on-line gas monitoring instrument calibration.

Potential Strategy: Gas Quality Verification

A trial evaluation period of laboratory testing of biomethane gas quality can be instituted prior to interconnecting the production facility. Biomethane gas quality verification should alleviate concerns about the gas composition being within the required specification. Gas quality monitoring can be broadly divided into two types: 1) periodic field sampling with laboratory analysis and 2) on-line gas quality monitoring.

Periodic field sampling with laboratory analysis can provide a good baseline of gas composition for biomethane gas quality assessment. Gas samples would be taken from the system sampling port and sent to a testing laboratory to check for conformance with the required gas delivery specification. The laboratory analysis can determine the general gas composition and be fine tuned to detect any types of contaminants of concern associated with a particular category of production facility. Sampling may take place over several weeks of operation. This type of analysis can also provide a snapshot of gas composition for setting the detection thresholds of any real-time on-line sampling equipment. Passing periodic gas sampling and analysis tests can be made a requirement prior to giving final written approval for interconnection.

On-line gas quality monitoring, utilizing advanced gas analysis instruments, can provide an almost continuous assurance of the composition of biomethane. The on-line gas analysis instrumentation can inform the system controller if the biomethane becomes out-of-specification or if other system emergency situations occur. Upon receiving a fault signal, the system controller can respond by shutting down the compressor and closing the main shutoff isolation valve, thereby, discontinuing gas injection into a pipeline system.

An acceptable range for gas specification settings are typically programmed into the interconnection system controller, by the production facility operators, which determine the conditions of when automatic shutdown of injection occurs. The biomethane interconnection design would require an interconnection shutdown upon sensing out-of-specification biomethane, within the range of gas specification settings. This can be simulated in a commissioning test by either programming a “trip” or injecting out-of-specification gas into a sample port to check for proper shutdown.

Potential Strategy: Anti-Islanding Test

One type of commissioning test is an Anti-Islanding Test. Islanding is the condition in which a biomethane production facility delivers gas to customers using a portion of the gas provider's pipeline system that is isolated from the remainder of the pipeline system. The anti-islanding test requires that the unit shut down upon sensing a drop in flow rate and/or pressure within the natural gas pipeline system below an acceptable level. This can be simulated by either programming a "trip" or closing the isolation valve, thereby, effectively shutting off the gas injection valve. The gas provider could require observation of the automatic shutdown before giving final written approval for interconnection of the biomethane facility.

Potential Strategy: On-line Gas Monitoring Instrument Calibration

On-line gas quality monitoring is only effective if the gas analysis instruments are calibrated to the appropriate referenced standards of calibration. Operators of production facilities can be required to confirm instrument calibration in their operational logs. These operational logs would be available to gas provider staff for inspection.

Potential Strategy: A Gas Quality Verification Schedule Can Be Developed that is Based on the Adopted Guidance Used by Other Gas Providers

Rule 30 – Biomethane Gas Quality Review Flow Chart Guidance, Southern California Gas Company (Southern California Gas company), provides a starting template for building a verification schedule [**ref: 14**].

➢ Technical Issue D: Maintenance Requirements of Biomethane Interconnections

Biomethane interconnection design is only the first step necessary to achieve overall biomethane interconnection safety. The responsibility of protecting production facilities, pipeline systems and customers should be accomplished through the proper installation, operation and maintenance of various protective devices.

Potential Strategy: Specify Biomethane Interconnection Maintenance Requirements

Owners and operators must be responsible for the installation, operation, and maintenance of biomethane production facilities so they are in conformance with the requirements of Wisconsin Administrative Codes (e.g. PSC 134), relevant laws, applicable codes, regulations (local, state, and federal) and a gas provider's interconnection agreement. Operators of biomethane interconnections must properly maintain protective systems so that out-of-specification gas is not injected into the pipeline system. Operators of production facilities can be required to enter maintenance activities in their operational logs. These operational logs would be available to gas provider staff for inspection.

Interconnection maintenance can be specified explicitly in a guidelines document that is the template for an interconnection agreement. The ***Outline of Model Interconnection Guidelines for Biomethane Production Facilities****,* listed in **Appendix II**, provides a proposed framework for the topics that need to be addressed to assure proper maintenance of biomethane production facilities.

Additional References

- A reference for pipeline safety requirements is found in a Title 49, Part 192 of the Code of Federal Regulations [**ref: 3**].
- A reference for standards for gas service in Wisconsin is found in Wisconsin Administrative Code PSC 134 [**ref: 6**].
- A reference for Natural Gas Transmission Pipeline's General Terms and Conditions on Gas Quality is found in a University of Texas – Austin report [**ref: 12**].

➢ Technical Issue E: Biomethane and Natural Gas Mixing

Out-of-specification biomethane injected into the natural gas pipeline system may produce equipment instabilities, flashbacks, or flameout conditions. These potentially dangerous combustion conditions can be mitigated or checked if the contaminants are either insignificant in percentage or pipeline biomethane injection is immediately discontinued when out-of-specification conditions are first detected. A major concern appears to be related to out-of-specification biomethane being accidentally injected into the pipeline system due to a systems failure at the production facility. A systems failure can be attributed to malfunctioning gas quality monitoring sensors and/or injection shutoff equipment not responding to a gas monitoring alarm signal. Under a systems failure, out-of-specification biomethane may be delivered to the pipeline system. The resulting contaminated gas flow could potentially affect nearby natural gas users on the same pipeline. The degree of effect contaminated gas will have on the pipeline system will be mitigated by the degree of dilution that takes place as a result of incidental gas stream mixing. The following excerpt from a U.S. Department of Energy study report sums up two scenarios where different composition gases mix at a pipeline. [**ref: 9**]

> *"A combination of numerical models and mathematical analysis was used to assess two scenarios where different composition gases mix at a pipeline junction.*
>
> *First, it was shown that steady injection of a gas into a flowing main would mix to an average composition in a relatively short distance; typically within 100 pipe diameters.*
>
> *Second, it was shown that during transient injection, (e.g., when a branch supply is activated) the interface between the new and old average composition would flow well-defined in the pipeline for very large distances (> 100 km). Thus, gases with different composition appear to move as "packets" though the pipeline. Abrupt changes in gas composition will be delivered through the pipeline with only modest attenuation." DOE/NETL [**ref: 9**]*

Potential Strategy: Gas Blending

Blending is the mixing of gas streams that yields a volume-weighted average of the concentrations of each constituent. There are two specific types of blending: physical and contractual. Physical blending is when two or more gas streams are mixed together prior to being introduced into a pipeline. Contractual blending takes place when two gas streams enter a pipeline at different points in the pipe. Pipelines and gas end-users have benefited from blending for years to make a combined gas stream from individual gas streams that meets gas quality specifications.

Physical blending is the process of mixing one gas with another gas to achieve a blend outside of a pipeline system. Physical blending, prior to injection, may bring some contaminants in biomethane into specification to meet pipeline quality standards. The percentage volume of biomethane to natural gas can be set to make a blend to meet the required site specific pipeline specification. Several types of gas blenders are commercially available - venture flow (feed-forward and feedback), proportional (feedback only) and piston mixer type. Physical blending is not a solution for removing contaminates from a gas stream but may be one of the techniques used. The main solution to bringing biomethane into specification is to make sure that gas conditioning equipment (methane separation technologies) is appropriately designed, tuned for the required gas quality and properly maintained.

➢ Technical Issue F: Interaction of Biomethane with Natural Gas Pipeline Systems

Will the interaction of biomethane with the natural gas pipeline components increase the deterioration of an aging system (older pipe)? Rigid steel is the traditional material that makes up many distribution pipelines. Flexible plastic tubing and corrugated stainless steel tubing are materials used in many newer pipelines.

It is well know that pipeline steel is sensitive to corrosion due dilute acids formed from carbon dioxide and oxygen interacting with water. Hydrogen sulfide will also combine with water to form an acid. Making sure that biomethane is within specification should contain this problem. If biomethane production adheres to the gas quality specifications and parameters set in a properly designed guideline document, steel pipeline systems will experience corrosion risks similar to that from natural gas.

Nationwide, more than fifty percent of natural gas distribution pipeline is plastic pipe, most of which is plastic PE (polyethylene) pipe. Much of the biogas production plant piping is either plastic or stainless steel. These materials seem to hold up well when exposed to raw biogas, which is considerably more corrosive than biomethane – especially that which is allowed to be injected into the pipeline system.

A Gas Technology Institute (GTI) report lists microbial-induced corrosion (MIC), caused by bacteria, to be one of the major causes of pipe failure in natural gas systems [**ref: 4 – Task 3**]. The report states that this corrosion is exacerbated by moisture but does not explicitly state which pipeline materials are most susceptible to corrosion. The GTI report cites a study from the Swedish Institute of Infectious Diseases that concludes *"Although the study was not exhaustive and the results are preliminary, it showed the densities of microorganisms found in biomethane were in a similar range as those found in natural gas."*

Potential Strategy: The Need for Additional Research

As new material are used in pipelines and the natural gas supply changes (biomethane included), there is a need for additional research in this area. As a starting point, the *White Paper on Natural Gas Interchangeability and Non-Combustion End Use* provides a good reference on pipe and component corrosion in appendix B [**ref: 5**].

➢ Technical Issue G: Telemetry/SCADA and Communication Links

Supervisory Control and Data Acquisition (SCADA) is a combination of telemetry and data acquisition (hardware and software) that enables the collecting of process information, communicating it to a receiving site, carrying out any data analysis and sending control signals back to the process. The process information is typically collected by Remote Terminal Units (RTU) that communicate data back to the receiving site where the data analysis takes place. Data analysis is typically carried out by one or more microcomputers as a type of distributed control system. Other approaches to achieve similar results to SCADA are Distributed Control Systems (DCS) and Programmable Logic Controllers (PLC).

At a biomethane interface, the data that typically will be collected and sent to the microcomputer are: 1) the on/off state of the shutoff valve between the methane separation unit and the compressor, 2) the gas chromatograph and/or laser gas analyzer and/or Wobbi meter data, 3) the on/off state of the compressor, 4) the flowmeter and/or calorimeter and/or water content meter data and 5) the on/off state of the main disconnect valve. The typical control signals sent by microcomputer are: a) on/off control of the shutoff valve between the methane separation unit and the compressor, b) on/off control of the compressor, c) on/off control of the main disconnect valve and d) control signals to various alarms.

Data signals in a SCADA, DCS or PLC will be originated at various locations in the production facility. Control signals can be operated on autonomously by the controller system, by the facility operator or by the gas provider's control center (if so equipped). One of the issues to be resolved is the type of communication link used between the biomethane production facility and the gas provider's control center. The question of the minimum adequate communications link is important on both a practical and an economic basis.

- A decision will have to be made about what information and control signals need to be sent to the gas provider.
- A decision will have to be made about whether the minimum adequate link is a dedicated telephone line, satellite link, T1 line, packet radio link or fiber-optic cable.

Potential Strategy: The decision about SCADA/Telemetry/DCS should be developed as part of a collaborative process between the gas providers and other stakeholders.
The decision should be based on technically sound solutions.

➢ Technical Issue H: Accuracy of Heat Content-Based Gas Metering and Billing

There is an important question to be resolved about the accuracy of heat content-based customer metering (therm billing) on pipelines that are interconnected to a biomethane production facility. Even if biomethane is injected within-specification for heat value, it may be different than the heat value of the natural gas that also flows in a pipeline.

As mentioned in the background section of this paper, the Wisconsin Administrative Code specifies heating and specific gravity requirements for natural gas supplied to customers [PSC 134.21]. The heating values are to be no more than 5% above or 4% below the heating value that each gas provider has on file with the PSCW. A natural gas provider knows, by periodic measurement, the heat content of the local natural gas supply. The heat content of natural gas varies up to approximately 10% (950 Btu/scf – 1050 Btu/scf) over various time periods. Gas providers use recording calorimeters to determine the heat value of the gas being distributed to customers. The heat content-based quantity of natural gas (therm billing) is calculated by multiplying the volume of gas used (scf), in the current period, by the heat content of the gas (Btu/scf).

PSC 134.251 requires the use of recording calorimeter for therm billing. In the application of gas rates based on the therm billing, a recording calorimeter is be used to determine the heat value of the gas being distributed to utility customers. These calorimeters have such accuracy characteristics as to be able to measure the heating value of the gas to within + or −2 Btu.

How are customers billed for the correct heat content-based (therm billing) quantity of natural gas given a potential disparity in the heating values obtained from various biomethane and natural gas mixtures within their service area's pipelines? Possible ways to address this issue include, but are not limited to the following strategies.

Potential Strategy: Require the Biomethane Production Facility to Provide the Real-Time Heat Value and/or Wobbi Number of the Biomethane Injected

A production facility can be required to provide the real-time heat value (and/or Wobbi Number) of the biomethane to the gas provider. With this information, an adjustment to the heating value of the composite gas conveyed in the local pipeline can be made for billing purposes. This can be accomplished by using a weighted averaging calculation of the respective heat values of the gas volumes of the local natural gas supply and from the biomethane facility. The Background Section of this paper describes the generic biomethane interconnection major components in a block diagram. A calorimeter and/or Wobbi meter is a part of this diagram. Calorimeter and/or Wobbi meter readings are sent to the system controller via a SCADA system, through a communications channel, to the gas provider.

Potential Strategy: Require the Biomethane Production Facility to Inject Biomethane that Matches the Heat Value and/or Wobbi Number of the Natural Gas at Their Location on the Pipeline

Rule 30 – Transportation of Customer-Owned Gas – Southern California Gas Company, uses an Electronic Bulletin Board (EBB) for periodic posting of the Wobbe Number of gas at identified locations on the Pipeline System. This value can be used by the production facility to adjust the heat value of the biomethane to that of the pipeline.

Potential Strategy: Specify a Fixed Biomethane Heat Value

Biomethane heat value can be specified within a fairly narrow range, as gas quality parameters, to provide a known value for composite gas heat value determination . Gas volumes from the natural gas supply and from the biomethane facility can be used with their respective heat values, in a weighted averaging calculation, to determine the composite heating value of the gas in the interconnected pipeline.

THE RIGHT BALANCE OF IMPLEMENTATION REQUIREMENTS AND MARKET DEVELOPMENT

New technologies typically undergo a period of resistance to their implementation until there is either: 1) definitively convincing analysis showing the advantages, 2) enough actual application experience to feel comfortable with the technology or 3) sufficient information and experience by others to offer assurances against risk, thus reducing concerns.

It is important to balance overly cautious technical requirements with an understanding that unfamiliarity can lead to onerous impediments to the deployment of any new technology. Finding a balance between caution and best current technical practices will provide an avenue to move forward.

The Federal Energy Regulatory Commission (FERC) issued a *Policy Statement on Provisions Governing Natural Gas Quality and Interchangeability in Interstate Natural Gas Pipeline Company Tariffs* in the Natural Gas Interchangeability Docket No. PL04-3-000. [**ref: 15**] In this proceeding, the FERC had been exploring natural gas quality and interchangeability issues and the impact of those issues on the natural gas companies subject to the FERC's jurisdiction, as well as on natural gas producers, shippers and end-users. The guidance issued by FERC has relevance to developing guidance for biomethane pipeline interconnection in Wisconsin. The five FERC principles for gas interconnections follow:

> First, only natural gas quality and interchangeability specifications contained in a Commission-approved (FERC) gas tariff can be enforced. Unless these specifications are stated in the tariff, the Commission (FERC) will not be able to address gas quality and interchangeability concerns. Where gas quality and interchangeability issues are of concern to the transporting pipeline, tariff standards are essential terms and conditions of service.
>
> Second, pipeline tariff provisions on gas quality and interchangeability need to be flexible. Pipelines operate in dynamic environments that frequently require quick responses to rapidly changing situations. For example, a pipeline may be asked to transport gas that does not meet a particular gas quality or interchangeability specification in the pipeline's tariff. Nevertheless, if the pipeline has the ability to transport such out-of-specification gas without jeopardizing system operations, its tariff should be flexible enough to allow it to do so. The Commission (FERC) believes that flexible tariff provisions on natural gas quality and interchangeability will allow pipelines to balance safety and reliability concerns with the importance of maximizing supply, while recognizing the evolving nature of the science underlying gas quality and interchangeability specifications.

Third, pipelines and their customers should develop gas quality and interchangeability specifications. The Commission (FERC) expects that specifications for natural gas quality and interchangeability will be based upon sound technical, engineering and scientific considerations.

Fourth, in negotiating technically based solutions, pipelines and their customers are strongly encouraged to use the NGC + interim guidelines as a common scientific reference point for resolving gas quality and interchangeability issues [**ref: 5**].

Fifth, to the extent pipelines and their customers cannot resolve disputes over gas quality and interchangeability, those disputes can be brought before the Commission (FERC) to be resolved on a case-by-case basis, on a record of fact and technical review.

The FERC policy statement achieves a balanced approach by providing reasonable interconnection expectations while ensuring the safety and reliability of gas provider's pipeline systems. The policy recognizes concerns about natural gas quality and interchangeability, while providing the flexibility necessary to maximize the introduction of new sources of gas into the pipeline system.

A major objective of a biomethane interconnection guideline should be to strike a balance between biomethane market development and appropriate implementation requirements. The previous section identified major implementation issues and delineated selected potential implementation strategies. **Table 9** matches the general and technical issues with overall approaches for solving them. Each overall approach is then scored according to the effectiveness of the market traction gained in biomethane technology adoption and the perceived level of risk involved to the gas provider (legal, business and technical).

Table 9. Effectiveness of Overall Approaches for Addressing Biomethane Issues:
Technology Adoption and Perceived Level of Risk to Gas Providers

Issues	Overall Approaches	Biomethane Technology Adoption	Perceived Level of Risk *(n/a = not applicable)*
General Issues			
1: Biogas Source Technology Eligibility for Interconnection	Anaerobic digesters only	Facilitating **-**	Low
	Anaerobic digesters and syngas	Facilitating	Medium
	Anaerobic digesters, syngas and landfill gas	Facilitating **+**	High
2: Volume Restrictions for Individual Biomethane Interconnections	Restrictions based on customers gas usage	Hindering	n/a
	Restrictions based on sound technical considerations	Facilitating	n/a
3: Graduated Technical Requirements for Biomethane Interconnections (except gas quality)	Same requirements for all sizes	Hindering	Low
	Requirements based on limited technical considerations	Neutral	Medium
	Graduated requirements	Facilitating	Medium

4: Standardized Interconnection Application Forms and Agreements	Highly complex standard forms and agreements	Hindering	n/a
	No standardized applications and forms	Hindering	n/a
	Standardized applications and forms	Facilitating	n/a
5: Streamlined Application Process	No standardization of timelines, forms or fee structures	Hindering	n/a
	Limited standardization of timelines, forms or fee structures	Neutral	n/a
	Standardized application process	Facilitating	n/a
6: Scope of Interconnection Guidance Applicability	Applicable to only to one or two gas providers	Neutral	n/a
	Applicable to many gas providers	Facilitating	n/a
	Applicable to all gas providers	Facilitating **+**	n/a
7: Liability	High liability insurance and one-sided indemnification terms	Hindering	Low
	Negotiated liability insurance and indemnification terms	Hindering	Low
	Lower liability insurance and mutual indemnification terms	Facilitating	Medium
8: Natural Gas Pipeline Extensions and Upgrades	Provisions not included in guidelines	Hindering	n/a
	Provisions made overly complex in guidelines	Hindering	n/a
	Provisions included in guidelines based on admin. rules	Facilitating	n/a
9: Dispute Resolution	No specified means of resolving disputes	Hindering	Low
	Mediation specified to resolve disputes	Neutral	Medium
	PSCW specified to resolve disputes	Facilitating	Medium
Issues	**Overall Approaches**	**Biomethane Technology Adoption**	**Perceived Level of Risk**
Technical Issues			
A: Design Requirements for Biomethane Interconnections	Design requirements made on a case-by-case basis	Hindering	Medium
	Standardized but onerous design requirements	Hindering	Low
	Design requirements standardized through collaboration	Facilitating	Low
B-1: Specification of Biomethane Gas Quality / Interchangeability	Specification made on a case-by-case basis	Hindering	n/a
	Specification not tied to other state's adopted guidance	Hindering	n/a
	Specification tied to other state's adopted guidance	Facilitating	n/a
B-2: Trace Gas Components	Clear delineation of trace gas components in specification	Facilitating	Low
	Setting trace component concentration thresholds too low	Hindering	Low
	Vagueness about allowing any level of trace components	Hindering	High
C: Biomethane Interconnection Commissioning	Onerous commissioning requirements	Hindering	Low
	Commissioning performed on a case-by-case basis	Hindering	Low
	Standardized commissioning for all interconnections	Facilitating	Low
D: Maintenance Requirements of Biomethane Interconnections	Initial sampling period too long	Hindering	n/a
	Too many commissioning tests required	Hindering	Low
	Standardized commissioned tests	Facilitating	Low
E: Biomethane and Natural Gas Mixing	Biomethane volume set too low for distribution pipelines	Hindering	Low
	Standardized biomethane volumes set for various flow rates	Facilitating	Low
F: Interaction of Biomethane with Natural Gas Pipeline Systems	Biomethane OK in metal pipelines with onerous restrictions	Hindering	Low
	Allowing gas quality specification to protect pipelines	Facilitating	Medium
G: Telemetry/SCADA and Communication Links	Always requiring fiber optic links	Hindering	Low
	Communication links determined on a case-by-case basis	Hindering	Low

	Allowing dedicated telephone lines and T1 lines as links	Facilitating	Medium
H: Accuracy of Heat Content-Based Gas Metering and Billing	Biomethane to match Wobbi Number of pipeline gas	Hindering	Low
	Communicate Wobbi Number to gas provider	Facilitating	Low
	Assume biomethane always has same Wobbi Number	Facilitating	Medium
	NOTE: n/a = not applicable		

The Technology Adoption and Perceived Level of Risk factor scoring in the above table was made by the author. It would be informative to conduct a survey of the effectiveness of these overall approaches for addressing the identified issues of biomethane interconnection. Respondents would score these factors for each approach. This task could be part of a related project involving developing a guidelines document.

NEXT STEPS FOR BIOMETHANE PRODUCTION FACILITY INTERCONNECTIONS

This paper recommends that a set of interconnection technical standards, interconnection procedures and uniform interconnection applications/agreements be developed for biomethane production facilities in Wisconsin. These procedures would be useful where biomethane is sold to the local gas provider or where it is transported to a third-party customer via a bi-lateral purchase agreement. This paper also suggests that Wisconsin's gas providers work collaboratively with other stakeholders to develop an interconnection guidance document with the goal of voluntary adoption among all gas providers.

A good place to begin is to use the *Outline of Model Interconnection Guidelines for Biomethane Production Facilities*, found in Appendix II, as a framework for a guidelines document. This work can be carried out by the Wisconsin Distributed Resources Collaborative (www.WisconsinDR.org), an organization already in place with the needed stakeholders.

At some point in time, administrative rules or PSCW directives on biomethane interconnection guidance may be appropriate. A guidelines document on biomethane production facility interconnection will be valuable to biomethane producers, gas utilities, regulators, engineering contractors, equipment manufacturers and other stakeholders. The use of a guidelines document will cut down on the soft costs associated with developing projects.

However interconnection guidelines are utilized, biomethane production facilities will require authorization from the PSCW before commencing construction. Wisconsin State Statute 196 is the governing law on obtaining this authorization. The following is an extract from State Statute 196 related to this issue.

> **196.49 Authorization from commission before transacting business; extensions and improvements to be approved; enforcement of orders; natural gas.**
>
> **196.49 (5)** (a) No public utility furnishing gas to the public in this state may construct, install or place in operation any new plant, equipment, property or facility, or construct or install any extension, improvement, addition or alteration to its existing plant, equipment, property or facilities for the purpose of connecting its properties and system to a source of supply of gaseous fuel for sale to the public which is different from that which has been sold previously, or for the purpose of adapting its facilities to use the different kind of gaseous fuel unless the commission certifies that the general public interest and public convenience and necessity require the connection to or use of the different fuel. No public utility may substitute natural gas or a mixture of natural and manufactured gas in lieu of manufactured gas for distribution and sale to the public unless it has obtained from the commission a certificate that the general public interest and public convenience and necessity require the substitution.

The following is an extract from Wisconsin Administrative Rule PSC 133 related to this issue.

> PSC 133.03 When commission authorization or notification is required. (1) CONSTRUCTION, INSTALLATION, OR USE. A gas public utility shall obtain a certificate of authority before constructing, installing, or placing in operation any of the following:

(b) A production, mixing, standby, peak shaving, or storage plant or a principal gas manufacturing or mixing unit or any equipment designed to materially change the rated or nominal output characteristics of such a plant or unit.
(d) A new or altered existing plant for the purpose of bringing in a new type of gas or to supply a different type of gas to the public, as described in s. 196.49 (5) (a), Stats.
(e) A single gas pipeline project and associated plant, or any plant or addition to plant the cost of which exceeds $1,500,000 or 4% of the utility's gross gas operating revenue received during the previous calendar year, whichever is less, except for any of the following:
1. Plant installed in accordance with filed extension rules and rates.
2. Plant installed in compliance with commission orders.
(f) A gas pipeline or plant in a newly created municipality or newly annexed or consolidated area, unless the utility already owns service facilities in the area and the exclusive right to serve a specified part or area has been established.
(2) CHANGE IN GAS. Except as provided in par. (b), a gas public utility shall obtain a certificate of authority before doing any of the following:
(a) 1. Substituting one kind of gas for another, as described in s. 196.49 (5) (a), Stats.
2. Changing the heating value or specific gravity of the gas normally supplied to customers in excess of variation permitted in s. PSC 134.21.

Pipeline biomethane provides a great opportunity to bring substantial reductions in greenhouse gases, while utilizing the existing natural gas infrastructure to create flexibility in gas supplies. Biomethane provides a compelling means to turn the liability of bio-based waste streams into an economic asset that enhances energy security and creates jobs. Even though there are still unresolved issues, there seem to be no unsolvable technical reasons for creating obstacles to interconnection. Although natural gas market prices and financing availability will largely determine the rate at which biomethane production facilities are built, this is a good time to lay the interconnection groundwork.

APPENDIX I - Definitions

Absolute Pressure – A pressure measurement referenced to a perfect vacuum. Absolute pressure = gauge pressure + atmospheric pressure.

Alkanes – Chemical compound consisting of only carbon and hydrogen linked together with single bonds, e.g. methane, ethane, propane, butane, etc.

AGA - American Gas Association.

Anaerobic Digestion - An anaerobic digester is a process that breaks down organic materials using bacteria in the absence of oxygen. The products of anaerobic digestion are biogas and effluent that has been reduced in volume and strength (on a chemical & biological oxygen demand basis). Biogas consists primarily of methane, secondarily of carbon dioxide and, additionally gases of much smaller percentage of nitrogen, hydrogen sulfide, hydrogen and water vapor.

ASME – American Society of Mechanical Engineers.

ANSI - American National Standards Institute.

Applicant - The legally responsible person applying to a gas provider to interconnect a biomethane production facility to the gas provider's distribution system.

Application Review - A review by the gas provider of the completed standard interconnection application form for interconnection, to determine if an engineering review or distribution system study is needed.

ASTM - American Society for Testing and Materials.

Atmosphere (atm) - A measurement of pressure based upon the pressure due to the column of air above the earth's surface. One atmosphere is equal to 14.7 psi absolute.

Atmospheric Pressure - The pressure exerted by the atmosphere at a given location and time. Sea level pressure is approximately 14.7 psi absolute.

Back Pressure Check Valve – A valve that prevents the backward flow of a gas toward the supply source. This type of valve typically operates automatically.

Biomass – A resource that derives energy from wood, plant material or residue, biological waste or crops. [source: based on 196.378 WI Stat. Stat.]

Biomass Gasifier – A chemical processing unit that principally converts biomass into carbon monoxide and hydrogen by high temperature (> 700 degrees C) with a controlled amount of oxygen and/or steam. The resulting gas is called synthesis gas or syngas.

Biomethane – A gas composed principally of methane derived from biogas (produced from anaerobic digestion or landfill gas) or syngas (produced from biomass gasification) which is suitable for domestic or industrial fuel. Biomethane is also known by other terms including renewable natural gas (RNG), biothane, renewable methane, customer-owned manufactured methane and biologically sourced methane and BioCNG.

Biomethane Production Facility - A manufacturing plant for the production of biomethane that is located near the point where biomethane will be used or is at a location that will provide biomethane to a gas provider's pipeline system. This term is used synonymously with Principle Gas Manufacturing Unit (see definition).

Blending (gas) – The process of mixing one gas with another gas to achieve a blended gas that meets or exceeds a pipeline quality requirement. There are two specific types of blending: physical and contractual. Physical blending is when two or more gas streams are mixed together prior to being introduced into a pipeline. Contractual blending takes place when two gas streams enter a pipeline at different points in the pipe.

British Thermal Unit (Btu) - The quantity of heat that must be added to one avoirdupois pound of pure water to raise its temperature from 58.5° Fahrenheit to 59.5° Fahrenheit under standard pressure. [source: PSC 134]

Cathodic Protection - A procedure by which underground metallic pipe is protected against deterioration (rusting and pitting). [source: 49 CFR Part 192]

Chromatograph – An analytical device used to separate the components of a chemical mixture (such as gases) for the purposes of measuring the relative proportions of the components in the mixture.

City Gate - The transfer point at which transmission pipelines connect to the natural gas distribution system.

Commissioning Test - The initial process of documenting and verifying the performance of a biomethane production facility interconnection so that it operates in conformity with the design specifications.

Condensate – In a biogas system, the liquid formed when biogas or syngas cools in a collection or clean-up system.

Condensation - A change of state of a substance from the gas to the liquid form.

Corrosion - The degradation of metals by contact with acids or bases, causing an electrochemical reaction.

Designated Point of Contact – A single point of contact for all customer inquiries related to biomethane production facility interconnection and from which interested parties can obtain a copy of interconnection rules and specifications - which include the appropriate application forms and interconnection agreements.

Dew Point – The temperature at which a gas must be cooled for water vapor within the gas to condense as water.

Detection Limit – The minimum quantity which must be observed before it can be stated that a substance has been discerned with an acceptable probability.

Dry Calorific Value - The value of the total or net calorific value of a gas divided by the volume of dry gas in a standard cubic foot. [source: PSC 134]

Drying - The process of reducing or removing moisture from a gas supply.

Dry Gas - A gas having a moisture and hydrocarbon dew point below any normal temperature to which the gas piping is exposed. As applied to determination of heating value or specific gravity dry gas means the complete absence of moisture or water vapor. [source: PSC 134]

Engineering Review - A study that may be undertaken by a gas provider, in response to its receipt of a completed standard application form for interconnection, to determine the suitability of the installation.

Fault - An equipment failure, pipe failure, overpressure, or other condition resulting from out-of-specification operation of the biomethane production facility.

Flame Flash Back - A condition where a flame moves into the burner toward the gas supply - typically due to increased flame speed.

Flame Lifting – Flame lifting is the movement of a flame front away from a burner - typically due to a decrease in flame speed. If condition may lead to flame blow-out in extreme cases of low flame speed.

Flame Yellow Tipping - Yellow tipping is caused by soot formation in a flame - typically due to incomplete combustion, sulfur content, oxygen content, etc.

Gas - Any gas or mixtures of gases suitable for domestic or industrial fuel that is transmitted or distributed to the public through a gas pipeline system, including natural gas, manufactured gas, and liquefied petroleum gas distributed as a vapor with or without mixture of air. [source: PSC 133]

Gas Detector – Devices used to detect the presence of gases – in the context of this paper, typically gases that are combustible and toxic. Gas detectors may be associated with control systems for automatic shutdown or for leak detection.

Gas Provider - A public utility or gas transmission system company that sells natural gas in Wisconsin and is regulated by the Public Service Commission of Wisconsin.

Gas Testing Period - A trial period of testing and verifying the gas quality from a biomethane production facility.

Gauge Pressure (psig) - Gauge pressure uses the actual atmospheric pressure as the zero point to measure gas pressure. Gauge pressure = absolute pressure – atmospheric pressure.

Heating Value – see Net Calorific Value of a Gas and Total Calorific Value

High-Pressure Distribution System – A distribution system in which the gas pressure in the main is higher than the pressure provided to the customer; therefore, a pressure regulator is required on each service to control pressure to the customer. [source: 49 CFR Part 192]

Higher Heating Value – see Total Calorific Value

Interchangeability - The ability to substitute one gaseous fuel for another in a combustion application without materially changing operational safety, efficiency, performance or materially increasing air pollutant emissions.

Interconnection - The physical connection of a biomethane production facility a gas provider's pipeline system so that gas injection can occur.

Interconnection Disconnect Valve - A mechanical device used to disconnect a biomethane production facility from a gas provider pipeline system. Also known as an isolation device.

Islanding - A condition in which a biomethane production facility delivers gas to customers using a portion of the gas provider's pipeline system that is isolated from the remainder of the pipeline system.

Landfill Gas – Landfill gas is produced from the breakdown of municipal solid waste by bacterial and chemical reactions in a landfill. Landfill gas is primarily composed of methane and carbon dioxide, with various amounts of nitrogen, oxygen, water vapor, hydrogen sulfide and other contaminant gases known as non-methane organic compounds (NMOCs). NMOCs include, but are not limited to, benzene, vinyl chloride, chloroform, toluene, carbon tetrachloride and halogens). The NMOCs typically comprise less than 1% of landfill gas.

Landfill Gas Recovery Systems - Landfill gas recovery systems utilize a series of extraction wells or trenches and collection headers to gather the gas emissions from solid waste landfills. The systems include a gas flare to burn off excess methane and various monitoring systems to gauge the volume of gas collected.

Local Distribution Company (LDC) - A company which provides the distribution service from the city gate to customer premises.

Lower Heating Value (LHV) – see Net Calorific Value of a Gas

Main – A natural gas distribution pipeline that serves as a common source of supply for more than one service line. [source: 49 CFR Part 192]

Maximum Allowable Operating Pressure (MAOP) – The maximum pressure at which a pipeline may be operated in compliance with the gas pipeline safety regulations. It is established by design, past operating history, pressure testing, and pressure ratings of components. [source: 49 CFR Part 192]

Meter - An instrument installed to measure the volume of gas delivered through it. [source: PSC 134]

Mercaptan (Methanethiol) – A colorless gas with the chemical formula CH_3SH that smells somewhat like rotten cabbage. Mercaptans are added to odorless gases such as natural gas to make the gas detectable by smell.

Methanation (Methanator) – A chemical process used to generate methane from mixtures of gases resulting from gasification, principally carbon monoxide and hydrogen.

Methane – The simplest alkane class chemical compound consisting of one carbon atom and four hydrogen atoms – the principal constituent of natural gas.

Methane Number - The methane number is an index that represents the anti-knock property of a methane-based fuel as it relates to usage in a combustion engine (analogous to octane rating for gasoline).

Mixing Unit - Any apparatus designed to mix gas with air or other gas. [source: PSC 133]

NFPA – National Fire Protection Association.

Natural Gas – A non-toxic, colorless fuel, about one-third lighter than air. Natural gas burns only when mixed with air in certain proportions and ignited by a source of ignition (spark or flame: approx. 4% - 14% gas to air). Natural gas in its natural state may not have an odor. [source: 49 CFR Part 192]

Net Calorific Value of a Gas - The number of British thermal units evolved by the complete combustion, at constant pressure, of one standard cubic foot of gas with air, the temperature of the gas, air, and products of combustion being 60° Fahrenheit and all water formed by the combustion reaction remaining in the vapor state. [source: PSC 134] **Also known as the lower heating value (LHV).**

Operating and Maintenance Plan – Written procedures for operations and maintenance on natural gas pipeline systems. [source: 49 CFR Part 192] Also applies to biomethane production facilities.

Overpressure Protection Equipment – Equipment installed to protect and prevent pressure in a system from exceeding the maximum allowable operating pressure (MAOP). [source: 49 CFR Part 192]

Pipeline and Hazardous Materials safety Administration (PHMSA) – The primary federal regulatory agency, in the Office of Pipeline Safety (OPS) – U.S. department of Transportation. responsible for ensuring the safety of fuel pipelines.

Point of Interconnection - The point where the pipes of the gas provider's pipeline system are connected to the biomethane producer's pipes and where any transfer of gas between the biomethane producer's and the gas provider's pipeline system takes place.

Pressure Regulator - A device to automatically reduce and control the gas pressure in a pipeline downstream from a higher pressure source of natural gas. It includes any enclosures, relief devices, ventilating equipment, and any piping and auxiliary equipment, such as valves, regulators, control instruments, or control lines. [source: 49 CFR Part 192]

Pressure Swing Adsorption (PSA) – A process used to separate some gas species from a mixture of gases under pressure according to the molecular characteristics of the species and their interaction with an adsorbent material.

Principal Gas Manufacturing Unit - Any plant that is capable of generating or manufacturing gas with or without connection to any auxiliary apparatus. [source: PSC 133]

Producer Gas – see Syngas

Protective Function - A function of a biomethane production facility, carried out using hardware and software, designed to prevent unsafe operating conditions from occurring before, during, and after the interconnection to gas provider's pipeline system.

Relief Valve – see Overpressure Protection Equipment

Scrubber – A device used to remove specific particulates and various gas species from gas streams.

Shut-Off Valve – A valve used to stop the flow of gas. The valve may be located upstream of the service regulator or below ground at the property line or where the service line connects to the main. [source: 49 CFR Part 192]

Siloxanes - A chemical compound of the class organosilicon composed of silicon, oxygen and hydrogen or alkane groups. Siloxanes are found in products like deodorants, shampoos, cosmetics and some soaps. They are found in landfill gas and biogas from wastewater treatment plants that handle these products.

Specific Gravity of a Gas - The ratio of the molecular weight of a dry gas or gas mixture to the molecular weight of dry air. [source: PSC 134]

Spiking (gas) – The process of adding a higher heating value gas to another fuel gas to boost the heating value of the composite fuel gas.

Standard Cubic Foot of Gas - The quantity of a gas that at standard temperature and under standard pressure will fill a space of 1 cubic foot when in equilibrium with liquid water (According to Dalton's law, this is equivalent to stating that the partial pressure of the gas is: 30–0.522 = 29.478 inches of mercury column.) [source: PSC 134]

Standard Pressure - The absolute pressure of pure mercury 30 inches in height at 32 degrees Fahrenheit and under standard gravity (Standard gravity is 32.174 feet per second which results in a standard pressure of 14.735 pounds per square inch absolute) [source: PSC 134]

Standard Service Pressure - The gas pressure which a utility undertakes to maintain on the meters of all customers, except the meters of customers utilizing high–pressure service, expressed in pounds per square inch above atmospheric pressure or psig. [source: PSC 134]

Standard Temperature – 60 degrees Fahrenheit based on the international temperature scale. [source: PSC 134]

Supervisory Control and Data Acquisition (SCADA) - A system of remote control and telemetry used to monitor and control a biomethane production facility.

Synthetic Gas (Syngas) – A gas mixture that contains principally carbon monoxide and hydrogen that can be produced from a biomass gasifier.

Telemetry - The transmission of biomethane production facility operating data using telecommunications techniques.

Therm - 100,000 British thermal units

Total Calorific Value - The number of British thermal units evolved by the complete combustion, at constant pressure, of one standard cubic foot of gas with air, the temperature of the gas, air, and products of combustion being 60 degrees Fahrenheit and all water formed by the combustion reaction condensed to the liquid state. [source: PSC 134] *This use of the term "total" (in total calorific value) may have been a definitional error since most technical usage refers to this value as gross calorific value.* **This value is also known as the higher heating value (HHV)**.

Transported Gas – Natural gas that is delivered to a local gas utility but not purchased by the local gas utility. This type of transaction is for the use of the local pipeline of a gas utility for a fee.

Weaver Index
A series of interchangeability indexes developed by E.R. Weaver (U.S. Bureau of Mines), that augment AGA tests for flash back, lifting and yellow tipping. Weaver indexes: J_A for air supply, J_F for flashback, J_A for burner load (same as Wobbe Index); J_I for incomplete combustion, J_L for lifting, J_Y for yellow tipping. See Gas Engineers Handbook (1st Edition). New York: Industrial Press. 1974

Wobbe Index – A gas interchangeability index utilizing the gross heating value of the gas and the relative density of the gas. $W \cong HV / \sqrt{G}$, where HV is the gross heating value of the gas (btu/scf) and G is the relative density defined according to ISO6976 as the ratio of the density of a gas to the density of air under the same temperature and pressure.

APPENDIX II - Outline of Model Interconnection Guidelines for Biomethane Production Facilities

The following guidelines are based on the *Wisconsin Distributed Generation Interconnection Guidelines*, relating to the development of rules for the interconnection of distributed generation (DG) to Wisconsin electric providers. The DG guidelines have been adapted to be used as biomethane production facility interconnection guidelines. Source: *Wisconsin Distributed Generation Interconnection Guidelines*, April 2004, Wisconsin Distributed Resources Collaborative (www.WisconsinDR.org).

NOTE: An actual guidelines document should be developed in a consensus-based process.

GENERAL

Scope

Definitions: See Appendix 1 - Definitions

Interconnection of Biomethane Production Facilities to a Natural Gas Pipeline:

Point of Delivery:

Biomethane Production Facility Categories:

Biomethane production facility categories can be used to set specific requirements according to the feedstock, gas producing technology used and smallest pipeline system into which the biomethane is injected.

Capacity Restrictions for Individual Production Facilities:

Gas Purchase Agreement:

A gas purchase agreement must be completed before any biomethane injection can take place.

Applicant Responsibilities

- Applicants must sign a gas purchase agreement/tariff with their gas provider for sale of gas into the gas provider's pipeline system.
- A biomethane production facility applicant must have all necessary agreements executed before gas injection (transfer) commences.
- An applicant shall be responsible for and will coordinate the design, installation, operation, and maintenance of its biomethane production facilities to conformance with the requirements of Wisconsin Administrative Code – PSC 134, relevant laws, applicable codes and regulations (local, state, and federal). The requirements specified in the guidelines are designed to protect the gas provider's pipeline system facilities, avoid customer equipment/appliance problems, ensure the safety of customers, gas provider employees, and the general public, and maintain overall system reliability. The responsibility of protecting biomethane production facilities is the applicant's and should be accomplished through the proper installation, operation, and maintenance of the specified protective devices. The applicant shall obtain, at its expense, any and all authorizations, permits and licenses required for the construction and operation of its biomethane production facilities.
- [adapted from PSC 119]

Gas Provider Responsibilities

Designated Point Contact of Gas Provider:

Each gas provider shall designate one point of contact for all customer inquiries related to biomethane production facilities and from which interested parties can obtain interconnection guidelines and the appropriate standard commission application and interconnection agreement forms. [adapted from PSC 119]

Application Process for Interconnecting Gas Production Facilities

→To be developed in a consensus-based guidelines document.

Interconnection Application Form

A standard application form must supply sufficient information to allow a gas provider to accurately evaluate the interconnection requirements for a biomethane production facility, but not so burdensome as to become a barrier. The standard application form has been designed to make clear what information is required for the application to be processed efficiently. [adapted from PSC 119]

→To be developed in a consensus-based guidelines document.

Interconnection Agreements

→To be developed in a consensus-based guidelines document.

Warranty, Indemnification and Insurance:

An applicant seeking to interconnect a biomethane production facility to the distribution system of a pas provider shall maintain liability insurance equal to or greater than the amounts stipulated ($___________), per occurrence, or prove financial responsibility by another means mutually agreeable to the applicant and the gas provider. [adapted from PSC 119] Each party to the standard interconnection agreement shall indemnify, hold harmless and defend the other party, its officers, directors, employees and agents from and against any and all claims, suits, liabilities, damages, costs and expenses resulting from the installation, operation, modification, maintenance or removal of the biomethane production facility. The liability of each party shall be limited to direct actual damages, and all other damages at law or in equity shall be waived. [adapted from PSC 119]

Modifications to Gas Production Facilities:

The applicant shall notify the gas provider of plans for any material modification to the biomethane production facility by providing at least (_____) working days of advance notice. The applicant shall provide this notification by submitting a revised standard application form and such supporting materials as may be reasonably requested by the gas provider. The applicant may not commence any material modification to the biomethane production facility until the gas provider has approved the revised application, including any necessary engineering review. The gas provider shall indicate its written approval or rejection of a revised application within (____) number of working days. Upon completion of the application process, a new standard interconnection agreement shall be signed by both parties prior to gas injection/transfer operation. If the gas provider fails to respond in the time specified, the completed application is deemed approved. [adapted from PSC 119]

Easements and Rights-of-Way:

If a gas provider’s pipeline system extension or upgrade is required to accommodate a biomethane production facility interconnection, the applicant shall provide, or obtain from others, suitable easements or rights-of-way. The applicant is responsible for the cost of providing or obtaining these easements or rights of way. [adapted from PSC 119]

Disconnection:

A gas provider may refuse to connect or may disconnect a biomethane production facility from the gas provider's pipeline system only under any of the following conditions:

(1) Lack of approved standard application form or standard interconnection agreement.
(2) Termination of interconnection by mutual agreement.
(3) Non-compliance with the technical or contractual requirements.
(4) Pipeline system emergency.
(5) Routine maintenance, repairs, and modifications, but only for a reasonable length of time necessary to perform the required work and upon reasonable notice.

NOTE: The disconnection and reconnection conditions specified in PSC 134 also apply.
[adapted from PSC 119]

Procedure for Appeal:

→To be developed in a consensus-based guidelines document.

Fees and Gas Distribution System Upgrade Costs

Upon receiving a standard application form, the gas provider shall specify the cost of any engineering review or gas pipeline system upgrade cost. Application fees shall be credited toward the cost of any engineering review or gas pipeline system upgrade. The gas provider may choose to waive the fees in whole or in part at its discretion.

The gas provider may recover from the applicant an amount up to the actual cost, for labor and parts, of any gas pipeline system upgrades required. No gas provider may charge a commissioning test fee for initial start-up of the biomethane production facility. The gas provider may charge for retesting an installation that does not conform to the interconnection agreement requirements. [adapted from PSC 119]

Facility Documentation

Gas Production Facility Operations Manual
Gas Production Facility Maintenance Records (Operational Logs)
System Schematic Diagram
Site Plan
Control Schematics

DESIGN REQUIREMENTS

General Design Requirements

Regulatory Requirements and Standards: →To be delineated in a consensus-based guidelines document.

Biomethane Interconnection Specifications

Permitted Quantities and Blending:

→To be developed in a consensus-based guidelines document.

Interconnection Equipment and Minimum Pipeline Protection Functions:

- Leak Detection
- Gas Pressure Regulation, Overpressure Protection and Pressure Relief
- Interconnection Automatic Shutoff
- Operating Limits: delivery pressure, breather vents
- Corrosion Control and Grounding

Automatic Shutoff Valve:

System Purging:

Gas piping must be purged whenever is installed, repaired or extended, according to 49 CFR 192.623(b) and PSC 135.629.

Metering Requirements:

→To be developed in a consensus-based guidelines document.

Labeling Requirements:

→To be developed in a consensus-based guidelines document.

Test Valves and Test Bypasses:

→To be developed in a consensus-based guidelines document.

Monitoring Instrumentation for Gas Quality & Calibration:

→To be developed in a consensus-based guidelines document.

Telemetry / SCADA and Communication Links:

For a Category (___) biomethane production facility, the gas provider may require that the facility owner provide telemetry equipment whose monitoring functions include transfer-trip functionality for gas quality, injection pressure, and leak detection.

<u>Gas Delivery Specifications</u>

Gas Quality:

a. Heating Value:
b. Moisture Content or Water Content:
c. Hydrogen Sulfide:
d. Mercaptan Sulfur:
e. Total Sulfur:
f. Carbon Dioxide:
g. Oxygen:
h. Inerts:
i. Hydrocarbons:
j. Merchantability:
k. Hazardous Substances:
l. Delivery Temperature:
m. Liquids: The gas shall contain no liquids at the point of interconnection.
n. Biologicals: Biogas must be free from bacteria, pathogens and any other substances injurious to utility facilities or that would cause the gas to be unmarketable.

Note: PSC 134.22 Purity of gas
Any deviation of gas quality will be required to be approved prior to gas actually flowing in the pipeline system.

Gas Interchangeability:

Interchangeability: minimum Wobbe Number and maximum Wobbe Number The gas shall meet American Gas Association's Lifting Index, Flashback Index and Yellow Tip Index interchangeability indices for high methane gas relative to a typical composition of gas in the Utility system serving the area.

Odorization:

Conformance with requirements of gas provider and section 192.625 of Title 49 Code of the Federal Regulations

→To be developed in a consensus-based guidelines document.

COMMISSIONING TESTS

<u>Commissioning Tests</u>

Gas Quality Specification Test
Interconnection Automatic Shutoff Test
Gas Overpressure Protection Test
Monitoring Instrumentation Calibration
Additional Tests

→To be developed in a consensus-based guidelines document.

APPENDIX III – References on Regulations, Standards and Codes

[1] AGA Report No. 4A - *Natural Gas Contract Measurement and Quality Clauses*. 2009. American Gas Association. provides general definitions, language and criteria to consider when specifying measurement & gas quality parameters typically found in contracts & tariffs.
http://www.aga.org/Kc/OperationsEngineering/gasquality/Pages/default.aspx

[2] AGA Research Bulletin No. 36, *Interchangeability of Other Fuel Gases with Natural Gases.*
http://www.aga.org/Kc/OperationsEngineering/gasquality/Pages/default.aspx

[3] Department of Transportation Title 49 CFR Part 192 *(Title 49 of the Code of Federal Regulations)*. This document contains the actual safety regulations that must be complied with by the natural gas operator. Parts 190, 191, 192, and 199 of 49 CFR contain the federal pipeline safety regulations relevant to operators of natural gas pipeline systems.
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?sid=4d17069d068d47ce357be771e785c5f7&c=ecfr&tpl=/ecfrbrowse/Title49/49cfrv3_02.tpl

[4] Pipeline Quality Biomethane: *North American Guidance Document for Introduction of Dairy Waste Derived Biomethane into Existing Natural Gas Networks* - Final Reports—Tasks 1, 2, and 3, Gas Technology Institute (GTI), September 30, 2009, GTI Project Number 20614.
http://www.gastechnology.org/webroot/app/xn/xd.aspx?it=enweb&xd=1ResearchCap/1_4EnvironSci/DairyWasteBiomethane.xml

[5] White Paper on Natural Gas Interchangeability and Non-Combustion End Use, NGC+ Interchangeability Work Group, February 28, 2005
http://ferc.gov/industries/gas/indus-act/lng/gas-qual/natural-gas-inter.pdf

[6] Wisconsin Administrative Codes: PSC 133, PSC 134 & PSC 135
http://legis.wisconsin.gov/rsb/code/psc/psc.html

[7] Gas Rule No. 21 – Transportation of Natural Gas, Pacific Gas and Electric Company
www.pge.com/tariffs/tm2/pdf/GAS_RULES_21.pdf

[8] Rule 30 - Transportation of Customer-Owned Gas; San Diego Gas & Electric Company
http://www.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE30.pdf

[9] LNG Interchangeability/Gas Quality: Results of the National Energy Technology Laboratory's Research for the FERC on Natural Gas Quality and Interchangeability, U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-2007/1290, June 2007.
www.fe.doe.gov/programs/oilgas/publications/lng/lng-interchangeability-rpt.pdf

[10] Example Gas Plant; UOP LLC
http://www.uop.com/gasprocessing/6070.html

[11] Processing Natural Gas
http://www.naturalgas.org/naturalgas/processing_ng.asp

[12] Foss, Michelle M., Interstate Natural Gas—Quality Specifications & Interchangeability, December 2004, Center for Energy Economics, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin.

[13] Case Study: Massive U.S. Landfill Uses XEBEC M-3100 System to Purify Biogas to Pipeline-Grade Natural Gas for 25,000 Duke Energy Customers
http://www.xebecinc.com/pdf/e_bgx_casestudy_powers.pdf

[14] Rule 30 – Biomethane Guidance; Southern California Gas Company
http://socalgas.com/documents/business/Rule30_BiomethaneGuidance.pdf

[15] Policy Statement on Provisions Governing Natural Gas Quality and Interchangeability in Interstate Natural Gas Pipeline Company Tariffs; Federal Energy Regulatory Commission, 06/15/2006
http://elibrary.ferc.gov/idmws/File_list.asp?document_id=4414564

[16] Gas Producers Documents; Sothern California Gas Company
http://www.socalgas.com/business/suppliers/

[17] Methane – Sources and Emissions, U.S. Environmental Protection Agency
http://www.epa.gov/methane/sources.html

[18] Managing Animal Waste to Recover Methane, Methane to Markets, U.S. Environmental Protection Agency
http://www.globalmethane.org/documents/ag_fs_eng.pdf

[19] Rule 30 – Transportation of Customer-Owned Gas, Southern California Gas Company
http://www.socalgas.com/regulatory/tariffs/tm2/pdf/30.pdf

APPENDIX IV – Example Customer-Owned Gas Tariffs

The following pipeline gas specifications are typical of exiting tariff gas quality/interchangeability requirements.

ANR Pipeline Company – Physical, Chemical Properties and Characteristics of Interest

Property or Characteristic	Symbol	Specified in Tariff
High Heating Value	HHV	Yes
Low Heating Value	LHV	Yes
Temperature	T	Yes
Water	H_2O	Yes
Hydrocarbon Dewpoint	D_{HC}	Under Review
Nitrogen	N_2	Yes
Carbon Dioxide	CO_2	Yes
Oxygen	O_2	Yes
Total Sulfide	S_{TOT}	Yes
Hydrogen Sulfide	H_2S	Yes
Particulates		Yes
Other Solids or Liquids		Yes

Northern Natural Gas Company Gas Quality Specification

Component / Property	Units of Measure	Pipeline Spec[1]	CNG Spec per DOT[2]
Water vapor	Lbs per mmscf (million std cu ft)	Less than 6	**Less than 0.5**
Hydrogen sulfide	Grains per Ccf	Less than or equal to 0.25	**Less than or equal to 0.10**
Total sulfur	Grains per Ccf	Less than or equal to 20	**Less than 0.1**
Heating value	Btu per Cubic Foot	**Greater than or equal to 950**	
Temperature	Degrees Fahrenheit	**Less than or equal to 120 F.**	
Oxygen	Per cent by volume	**Less than or equal to 0.2**	Less than 1.0
Carbon dioxide	Per cent by volume	**Less than or equal to 2.0**	Less than 3.0
Non-hydrocarbon gases	Per cent by volume		**Less than 4.0**

[1] Issued May 1, 2003 Northern Natural Gas Company FERC Tariff - fourth revised sheet 281

[2] DOT regulations DOT-E-8009 13th revision

Gas Rule No. 21 - Transportation of Natural Gas, Pacific Gas and Electric Company [ref: 7]

1. Carbon dioxide: The gas shall contain no more than one percent by volume of carbon dioxide.
2. Oxygen: The gas shall contain no more than 0.1 percent by volume of oxygen.
3. Hydrogen sulfide: The gas shall contain no more than 0.25 grains of hydrogen sulfide, measured as hydrogen sulfide, per one hundred standard cubic feet (4 parts per million (ppm)).
4. Mercaptan sulfur: The gas shall contain no more than 0.5 grains of mercaptan sulfur, measured as sulfur, per one hundred standard cubic feet (8 ppm).
5. Total sulfur: The gas shall contain no more than one grain of total sulfur, measured as sulfur, per one hundred standard cubic feet (17 ppm).
6. Water vapor: The gas shall contain no more than seven pounds of water vapor per million standard cubic feet at 800 pounds per square inch gauge (psig) or less; dew point of 20° Fahrenheit (F) if gas is supplied at over 800 psig.
7. Hydrocarbon dewpoint: The gas shall have a hydrocarbon dewpoint of 45°F or less for gas delivered at 800 psig or below, but measured at 400 psig; or 20°F for gas delivered at above 800 psig, also measured at 400 psig.
8. Liquids: The gas shall contain no liquids at, or immediately downstream of, the Receipt Point(s).
9. Merchantibility: The gas shall not contain dust, sand, dirt, gums, oils, or other substances in an amount sufficient to be injurious to PG&E facilities or which shall cause the gas to be unmarketable.
10. Temperature: The gas shall not be delivered at less than 60 degrees Fahrenheit or more than 100 degrees Fahrenheit.
11. Gas interchangeability: The gas shall be interchangeable with the gas in the receiving pipeline. Interchangeability shall be determined in accordance with the methods and limits presented in Bulletin 36 of the American Gas Association.
12. Heating value: The gas shall have a heating value that is consistent with the standards established by PG&E for each Receipt Point.
13. Biogas: Biogas refers to a gas made from anaerobic digestion of agricultural and/or animal waste. The gas is primarily a mixture of methane and carbon dioxide. Biogas must be free from bacteria, pathogens and any other substances injurious to utility facilities or that would cause the gas to be unmarketable and it shall conform to all gas quality specifications identified in this Rule.
14. Landfill Gas: Gas from landfills will not be accepted or transported under this Rule.

APPENDIX V – Wisconsin Administrative Code – Standards for Gas Service

PSC 134.21 Heating values and specific gravity.
(1) Each utility which is furnishing gas service shall have on file with this commission for each municipality served the heating value, specific gravity, and composition of each type of gas regularly supplied and also for the gas which may be used for standby purposes and the range of values for peak shaving. The heating value filed shall be the total heating value with the indication whether it is on a wet or dry basis. (See definitions in s. PSC 134.02.)
(2) All gases whether the regular gas supply, a mixture of gases or a substitute gas used for peak shaving purposes shall operate properly in normal gas utilization equipment. Where used for emergency or standby, the gas shall operate reasonably well in such equipment. (The customer requiring gas of a particular chemical composition shall make such arrangements as may be required to protect against damage by reason of change in composition.)
(3) The monthly average heating value of the gases as delivered to the customers in any service area shall not be less than the heating value standard on file with this commission and the heating value at any time at constant specific gravity shall not be more than 5% above or 4% below this standard. At constant heating value, the specific gravity of the gas shall not vary more than 10% from the standards filed with the commission. If the heating value is varied by a greater amount than specified, the specific gravity shall be varied in such a way that the gas will operate satisfactorily in the customer's utilization equipment. Customers using processes that may be affected by a change in the chemical composition of the gas shall be notified of changes. Agreements with such customers shall specify the allowable variation in composition.
(4) For required periodic heating value tests see s. PSC 134.25. The specific gravity of the gas shall be determined at least once each month when there is no change in the type or sources of gas and when there is a change in the type of gas. Whenever emergency or peak shaving plants are ran or when mixed gases are used, daily determinations of specific gravity shall be made.
History: Cr. Register, February, 1959. No. 38, eff. 3−1−59.

PSC 134.22 Purity of gas. (1) In no case shall gas contain more than 30 grains of sulphur per 100 standard cubic feet, 5 grains of ammonia per 100 standard cubic feet, nor more than 0.1 grain of hydrogen sulphide per 100 standard cubic feet. (Exception. If the gas is not to be placed in pipe or bottle type holders the hydrogen sulphide content may be 0.3 grains per 100 standard cubic feet.)
(2) Utilities supplying gas containing coal or water gas shall make quantitative determinations of total sulphur at least once every 6 months and qualitative hydrogen sulphide tests at intervals of 1 hour to 2 weeks depending upon the probability of this impurity being found.
(3) Utilities supplying liquefied petroleum gas, or liquefied petroleum air mixtures, or natural gas shall test the gas periodically for impurities or periodically obtain data concerning impurities from sources they believe the commission can accept as reliable.
History: Cr. Register, February, 1959, No. 38, eff. 3−1−59.

PSC 134.23 Pressure variation. (1) Every utility supplying gas shall file with the commission a standard service pressure by service areas. The service pressure shall be of such a value that the maximum pressure at any outlet as specified below shall not be greater than 12 inches of water column except for customers utilizing high−pressure service.
(2) For customers receiving standard service pressure, the gas pressure at the outlet of the utility's service meters shall meet the following requirements:
(a) At no outlet in the service area shall it ever be greater than one and one−fourth of the standard service pressure nor greater than 12 inches of water nor ever be less than one−half of the standard service pressure nor less than 4 inches of water.
(b) At any single outlet it shall never be greater than twice the actual minimum at the same outlet.
(c) At any one outlet the normal variation of pressure shall not be greater than the following:

Minimum Pressure	Normal Variation Permissible
4−5 in.	3 in.
5−6 in.	3½ in.
6−8 in.	4 in.

(3) For customers utilizing gas at high pressure, a service pressure shall be agreed upon by the utility and the customer, and the maximum pressure variation shall not exceed 15% of the agreed pressure unless the commission shall authorize a greater variation.
(4) No utility shall furnish gas to any customer at pressures higher than its filed standard service pressure until it has filed with the commission acceptable service rules governing high−pressure service to customers desiring to utilize gas at pressures higher than standard service pressure. Such service rules shall provide that the utility will make high−pressure service available to its customers upon request whenever high pressure gas is available at the customer's premises or may be made available in accordance with the utility's filed extension rules, and when such high pressure is required for proper operation of the customer's present or proposed utilization equipment.
History: Cr. Register, February, 1959, No. 38, eff. 3−1−59.

PSC 134.25 General use of calorimeter equipment.

(1) Unless specifically directed otherwise a calorimeter shall be maintained at each gas producing or mixing plant whether the plant is in continuous operation or used only for standby or peak shaving purposes. The calorimeter shall be used to check the operation of the plant and shall measure the heating value of the gas going to the gas lines.

(2) Unless specifically directed otherwise calorimeters shall be maintained in operation in locations where the heating value of the gas can be measured from each different supplier.

(3) Unless specifically directed otherwise a calorimeter shall be maintained and used to measure the heating value of the gas actually sold to customers in those cases where mixed gases are used.

(4) Tests of heating value of the gas shall be made daily whenever gas is supplied at the calorimeter location unless specifically directed otherwise by the commission. The original records of the tests shall be dated, labeled and kept on file for 6 years. A copy of the daily average heating value of gas sold to customers shall be sent to the commission each calendar month.

(5) The calorimeter equipment shall be maintained so as to give results within + or − 1%. Recording calorimeters used to test or control the production or mixing of gas or measure the heating value of purchased gas when therm rates are not applicable shall be tested with a gas of known heating value at least 3 times a year or when the accuracy is in question. Recording calorimeters used only with standby or peak shaving production plants shall be tested with a gas of known heating value at least 2 times a year.

Non−recording calorimeter equipment such as the Junkers shall be tested with a gas of known heating value at least once a year or tested against another calorimeter of known accuracy at least once a year.

History: Cr. Register, February, 1959, No. 38, eff. 3−1−59; am. (5), Register, January, 1965, No. 109, eff. 2−1−65.

PSC 134.251 Use of recording calorimeter for therm billing. **(1)** In the application of gas rates based on the therm, a recording calorimeter shall be used to determine the heating value of the gas being distributed to utility customers. These calorimeters will be located as set forth in s. PSC 134.25 (2) and (3). They shall have such accuracy characteristics as to be able to measure the heating value of the gas to within + or −2 B.t.u., shall be able to reproduce these readings to within +or− 2 B.t.u., and shall be able to hold their accuracy over an extended period of time. The instruments shall be installed in accordance with the manufacturer's recommendations.

(2) Each utility selling gas shall file with the commission a complete installation report stating the following information: location of calorimeter, kind of gas tested, type of scale, uniform or split scale range, date installed, publication number of manufacturer's applicable book of instructions, outline of the building, the location of the calorimeter or calorimeters within the building, the size, length, gas pressure, and general route of the gas sample pipe from the supply main to each calorimeter and location of all secondary equipment necessary for the operation of the recording calorimeter.

(3) (a) Each utility selling gas shall keep a chronological record of dates and results of tests and operations performed on the calorimeter to test and maintain accuracy.

(b) Twice every month the following tests shall be made:

1. Two days of each month shall be selected for the performance of an "as found" accuracy test, mechanical tests, adjustments, and an "as left" accuracy test of each recording calorimeter, and thereafter the specified accuracy tests, adjustments, and maintenance work shall be performed on the same days of each month insofar as practicable.

2. In making the accuracy tests on the calorimeter, the utility shall use reference natural gas which has been certified by the Institute of Gas Technology before cleaning parts or making any adjustments to either the tank unit or the recorder mechanism. The change from line gas to the certified gas should be made so as to have a continuous chart recording. The inlet pressure used should be the same for both calibration and subsequent operation.

3. If the "as found" accuracy test is within + or−3 B.t.u., no adjustment will be required and the instrument may be returned to service. If the "as found" accuracy test is not within + or – 3 B.t.u., maintenance shall be performed to restore the accuracy of the instrument.

4. In order that adequate information concerning each cylinder of natural gas which is to be used for the semi−monthly check tests be available at all times, the following information shall be entered on a form or in a log book provided for the purpose and also on a label or tag securely attached to each cylinder in which the gas is stored:

a. Institute of Gas Technology Cylinder Number.
b. Institute of Gas Technology Certificate Number.
c. Date cylinder was certified.
d. Date cylinder was received by the utility.
e. Heating value certified by Institute of Gas Technology.
f. Basis of the heating value in subd. 4. e.
g. Heating value to be used in the semi−monthly accuracy tests. This heating value will not include any plus or minus values. For example, if the heating value is 1,000 + or− 0.9 B.t.u. per cubic foot, the heating value is 1,000 B.t.u. per cubic foot.
h. Basis of the heating value in subd. 4. g.

(5) The original chart records produced by the recording calorimeters shall be dated, labeled, and kept on file for 6 years. A copy of the daily average heating value of gas and the results of the semi−monthly"as found" and "as left" test shall be sent to the commission each calendar month.

(6) A gravitometer may be substituted for the calorimeter equipment required to control standby or peak shaving plants in subs. (1) and (5) provided the heat content of the standby or peak shaving gas produced does not directly affect the therm billing of the gas customer receiving it.

History: Cr. Register, January, 1965, No. 109, eff. 2−1−65; cr. (6), Register, July, 1983, No. 331, eff. 8−1−83.