BIOGAS COMPOSITION AND CLEANUP OPTIONS

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INTRODUCTION

The decision by farms to install an anaerobic digestion system is based on many factors, the largest of which is normally the potential value to be derived from the biogas – the net value of the energy produced. While combusting biogas “as is” for electrical production has been the most common use, farms do have the option to clean up or upgrade the biogas and change the net energy value equation.

It is helpful to first establish some common definitions or nomenclature. *Biogas* is the raw, untreated product coming from the digester and is typically comprised of:

Constituent	Concentration
• Methane (CH_4)	55 to 65 %
• Carbon Dioxide (CO_2)	35 to 45 %
• Nitrogen (N_2)	0.4 to 1.2 %
• Oxygen (O_2)	0.0 to 0.4%
• Hydrogen Sulfide (H_2S)	250 to 3000 ppm
• Water	Saturated

For electrical production, simple scrubbing or conditioning of biogas (aka *scrubbed biogas*) is all that is required: removal of free water droplets and hydrogen sulfide in excess of the engine manufacturer’s specifications, normally <500 ppm.

Because biogas has lower BTU content than conventional natural gas, it is normally valued at a discount to pipeline gas since equipment requires some amount of modification in order to accommodate the lower BTU content. *Upgraded biogas* means that the gas has been enriched for methane by removal of some or all of the non-methane components. The final composition of the resulting upgraded biogas is normally referred to as *biomethane.* The final purity composition of the biomethane will depend upon the specifications set by the user, the conversion equipment manufacturer, or the utility pipeline. In the chart below, the range of biomethane compositions produced is shown:

Constituent	Concentration
• Methane (CH_4)	99.8 % to 85%
• Carbon Dioxide (CO_2)	0.01 to 14 %
• Nitrogen (N_2)	0.01 to 1.0 %
• Oxygen (O_2)	0.0 to 0.4%
• Hydrogen Sulfide (H_2S)	0 to 3000 ppm
• Water	2-7 lbs./million scf

There are a variety of technologies for upgrading biogas, including chemical absorption, high pressure water scrubbing, pressure swing adsorption, cryogenic separation, and membrane separation. Within each of these technologies, different vendors offer somewhat unique and proprietary approaches. The capital and economic cost of each method varies by vendor and by scale (the standard cubic feet per minute – scfm - being processed) and by extent of upgrading (the final purity level required). The final effective upgrading cost including capital amortization ranges from $1.75 to $4.00 per 1000 scf (which is approximately 1 MMBTU if upgraded to 99% methane). The technologies also have different levels of methane capture efficiency, meaning that some technologies can separate and capture nearly all (98%) of the methane while others capture just 85%. This means that the total amount of biomethane which can be used to generate value will also vary by technology and must be part of the economic evaluation.

Biomethane with at least 820 BTU/scf can be used in many natural gas boilers and engines without any modification to generate heat, electricity or mechanical pressure. Biomethane with at least 900 BTU/scf is the minimum specifications for most OEM compressed natural gas vehicle engine manufacturers. Gas utility specifications will normally require at least 970 BTU/scf for pipeline insertion. This flexibility means that a farm can evaluate the economics for each of these energy values and determine which avenue provides the best rate of return.

ENERGY	UNIT	$/UNIT	$/MM BTU
Electricity	kWh	$ 0.10	$ 29.31
Natural gas	MM BTU	$ 6.00	$ 6.00
Propane	Gallon	$ 2.50	$ 27.47
Gasoline	Gallon	$ 3.50	$ 28.93
Diesel	Gallon	$ 3.75	$ 28.85