EMISSIONS FROM BIOGAS-FUELED DISTRIBUTED GENERATION UNITS
Part 3: Greenhouse gas reduction and other benefits of biogas upgrading?

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Biogas obtained from anaerobic digestion of livestock manure is complex mixture containing ~60% methane (CH_4) and other less valuable gases. Upgrading the biogas to reduce contaminants and increase the CH_4 concentration is advantageous for several reasons[1]. These are summarized below:

GREENHOUSE GAS REDUCTION

Combustion of biogas for electrical generation significantly reduces greenhouse gas emissions compared to fossil fuels as biogas which is generated from renewable organic materials is considered CO_2 neutral. Biogas upgrading then further improves the greenhouse gas emissions reduction benefits of this renewable fuel. Combustion of upgraded (cleaner, higher CH_4 concentration) biogas improves the capacity factor (ratio of actual electrical output to potential electrical output over a period of time) of engine-generator sets. When operated at higher capacity factors (maximal energy per run time), emissions per energy generated are reduced. Some have also shown that combustion of gas with a higher CH_4 concentration generates slightly less CO_2[2], though this is not always the case[3]. Some biogas upgrading processes can also reduce greenhouse gas emissions. For example, biological biogas upgrading processes using bacterial or algal heterotrophs coverts CO_2 to oxygen[1]. This form of upgrading essentially sequesters the carbon from CO_2 in microbial biomass, preventing emission of the greenhouse gas.

INCREASING VALUE

Carbon dioxide (CO_2) is the biggest contaminant of biogas (~30-40%). Removing CO_2 can improve the specific caloric value of the biogas or the potential energy output. Where infrastructure permits, CO_2 can almost completely be removed to generate biomethane (> 95% CH_4) which can be sold into a natural gas grid or used as transportation fuel. Carbon dioxide is typically removed by physical/chemical scrubbing technologies at large industrial scales[1].

Some US dairy farms are upgrading biogas to biomethane. This fuel is then used by the farms' fleet vehicles and/ or sold to energy companies. There are also additional benefits as renewable energy credits for the upgrading of biogas to biomethane.

REDUCE GENERATION OF HAZARDOUS EMISSIONS

Hydrogen sulfide (H_2S) in biogas will lead to SO_x in exhaust gases if not removed prior to combustion. Hydrogen sulfide can be removed by chemical/physical means. These include an iron sponge where H_2S is adsorption onto iron coated filter media and scrubbers where H_2S is captured by a liquid absorbent. More typically H_2S is removed from biogas by biological processes. When properly designed, in-situ microaerobic removal is used where a limited amount of air injected into the anaerobic digester head space facilitates sulfur oxidizing bacteria to convert H_2S into elemental sulfur. Biotrickling filters (sometimes referred to as scrubbers) are more commonly used for H_2S removal. These systems harness sulfur oxidizing bacteria immobilized on inorganic packing media in a reactor column to convert H_2S to elemental sulfur then sulfate. A liquid phase is cycled to help absorb H_2S

from the passing effluent and deliver H_2S and nutrients to the bacteria [1].

Ammonia (NH_3) is a trace contaminant of biogas generated from the co-digestion of protein rich food wastes. During combustion of this biogas, the NH_3 can be converted to NO_x emissions. Ammonia can be removed from biogas by stripping or bubbling the gas through a liquid sorbent[4]. As NH_3 concentrations in biogas are typically very low, these systems may be more applicable to barn and manure storages, than to biogas.

REDUCE ENGINE CORROSION

Impurities such as H_2S, NH_3 in the presence of water can cause significant corrosion of biogas plumbing, engine-generations sets and other farm infrastructure. Removal of these impurities can significantly reduce system maintenance, increase life, and reduce operational costs.

In NYS, dairies typically use condensation sumps, demisting systems, chillers or combinations of these to remove moisture from biogas. Desulfurizing systems are increasingly used by NYS dairies to improve the quality of biogas and reduce corrosion. Typically, biotrickling filters are used, but there are farms using digesters designed for microaerobic treatment and at least one farm using iron sponge technology. As mentioned above NH_3 removal is not typical.

To learn more about biogas upgrading, and the specifics of biotrickling filters, see the Fact Sheet series on the topic.

FACT SHEET SERIES

Emissions from biogas-fueled distributed generation sources

Part 1: What are the potential emissions from engine-generation sets?
Part 2: What are the current emission regulations for New York State?
Part 3: Greenhouse gas reduction and other benefits of biogas upgrading.
Part 4: How do operators of engine-generation sets meet applicable emission regulations?

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