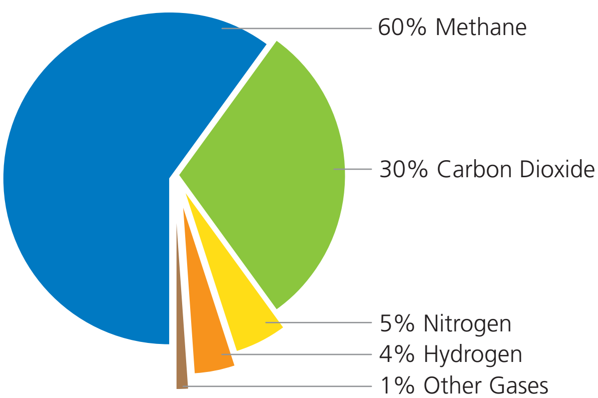
RNG FOR MUNICIPALITIES

Technology for Generating Biogas & Upgrading to RNG

Introduction

Biogas generated from organic wastes can displace non-renewable sources of fossil fuel-derived natural gas, reducing the greenhouse gas (GHG) emissions associated with the production of natural gas as well as the avoided emissions associated with other disposal methods for the organic wastes. Biogas is generated through anaerobic digestion (AD), a biological and chemical process in which microorganisms break down organic matter in an oxygen-free environment. Methane, which is 50-70 percent of the overall composition, is the key component of biogas, and can thus pose as a renewable alternative to natural gas.[1] In North America, natural gas contains 95 percent methane. Thus, biogas needs to be "upgraded" by removing the other constituents of the biogas, which are primarily carbon dioxide and nitrogen as illustrated in the graph.

Typical Composition of Biogas



Sources of Biogas

Major sources of biogas production include: anaerobic digestion of municipal and commercial organic waste, landfill gas, wastewater treatment AD plants, and agricultural AD systems. Production of biogas varies based on the feedstock composition and AD technology selected. Examples of feedstock used to generate biogas include: food waste, livestock manure, municipal wastewater sludge, high strength industrial wastewater and residuals, fats, oils and grease (FOG), and various other organic waste streams.
https://www.americanbiogascouncil.org/biogas_what.asp

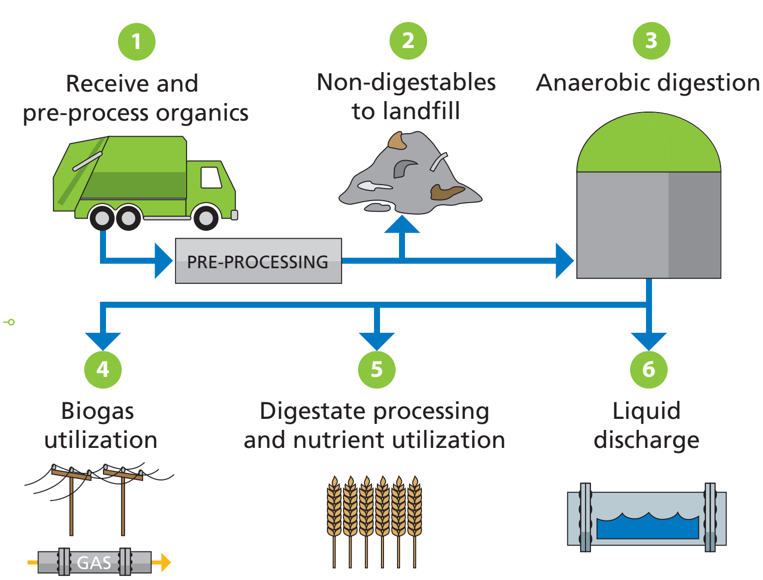
Introduction to AD Systems

AD systems can be utilized as a tool to treat organic wastes and divert food waste from landfills. The biogas generation is a byproduct of the treatment process and a potential additional revenue source for the facility on top of the tipping fees typically charged by these facilities.

An AD system is centered around the sealed anaerobic digester as illustrated in the figure below. The process steps ahead of digestion are focused on receiving the organic feedstock materials and removing any contaminants or non-digestible materials from the feedstock.

http://www.biogasassociation.ca/bioExp/images/uploads/documents/2015/municipal_guide_to_biogas/Municipal-Guide-to-Biogas-2015March.pdf

Simplified AD & Biogas Process Flow Chart



1 *http://www.biogasassociation.ca/bioExp/index.php/infopage/about_biogas.*

Biogas is collected off the top of the anaerobic digester. There are multiple potential utilization options for biogas, including:

- burning directly in a boiler to produce heat
- combusting to produce both heat and electricity, also known as co-generation
- upgrading to RNG, also referred as biomethane, to displace natural gas
- upgrading to biomethane and compressing to displace compressed natural gas vehicle fuel
- simple flaring to destroy the methane and retire the environmental attributes of the biogas

A key question in planning an AD system is whether to use the biogas to power and heat the AD process itself. Energy requirements of AD systems can vary significantly depending on the season, the operating temperature of the digester and any pasteurization requirements of the feedstock or final digestate to access fertilizer or other markets for the digestate. If biogas is used to heat the digesters, there may be no biogas available for export at times during colder months when more energy is required to maintain the digesters at the required temperature. This also coincides with the period when natural gas demand for residential heating is the highest, thus supply does not match demand. At certain branch locations on the natural gas pipeline with lower pressures, injection may not be possible during periods of the warmer months when natural gas demand is down, which will have an impact on where the AD facility can be located.

Using the biogas to supply the energy requirements of the AD facility is a plus from a sustainability perspective – which is sometimes a key objective of the AD facility owner. In jurisdictions where there is a policy incentive or mandate for utilities to green their grids by procuring RNG to displace an amount of fossil-fuel derived natural gas, the natural gas utility will prefer to purchase all of the biogas or RNG produced by the AD facility. Natural gas would then be sold back to the facility for energy requirements. This is a project specific decision that will need to be made during the planning stages of the AD facility in consultation with the RNG customer.

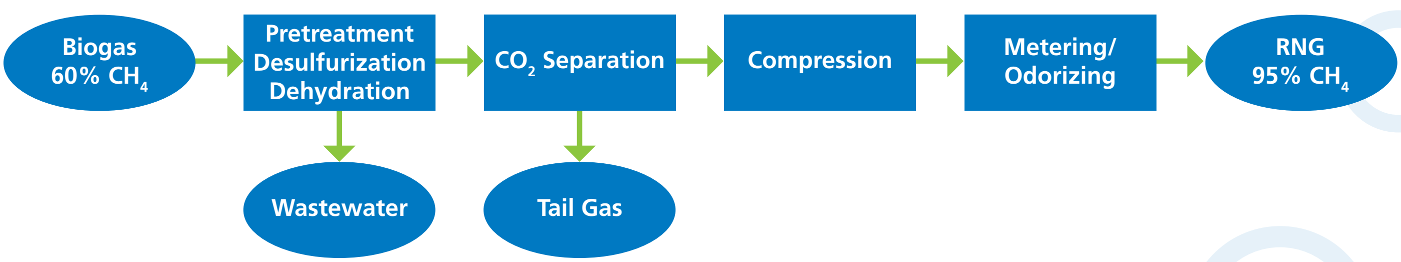
Additional information on AD systems can be found in our *Municipal Guide to Biogas (March 2015)*.

Upgrading to RNG

This section outlines some of the technical requirements for purifying or upgrading the biogas. Biogas can be comprised of approximately 60 percent methane, whereas biomethane or RNG can have 95 percent or more methane concentration. To increase the methane concentration in the gas, the other constituents of the biogas are removed, which are primarily the carbon dioxide, inerts such as nitrogen, hydrogen sulfide and moisture. The RNG quality and compression requirements can vary depending on the size of the natural gas pipeline being injected into and the end-use of the RNG. Small variations in RNG quality requirements can result in significant changes to the cost of the upgrading systems.

Biogas upgrading or refining systems are typically classified by the technology used to remove the carbon dioxide (CO_2). However, the systems are typically a series of processes to remove the different constituents in the biogas, such as hydrogen sulfide and water, and are typically customized based on the biogas quality (i.e., a landfill gas system might be different than an AD biogas system). These additional removal steps are grouped together as pretreatment in the diagram below.

Figure: Biogas Upgrading Process



The most widely used technologies for removing carbon dioxide are:

Pressure swing adsorption:
This technology purifies the gas by way of adsorption of impurities on active coal or zeolites. A tail gas is generated that requires an air pollution control system, typically a thermal oxidizing unit. A thermal oxidizing unit requires natural gas to operate.

http://www.biofermenergy.com/turnkey-gas-upgrading/gas-upgrading-systems/

Water scrubbing:
Water (or another liquid such as alcohol) is used to bind carbon dioxide. This is a form of physical absorption, and is also called pressurized water wash. This technology does not generate a tail gas requiring air pollution control but generates additional wastewater requiring treatment.

http://greenlanebiogas.com/americas/case-studies/

Membrane separation:
Methane can be separated from carbon dioxide using semipermeable membranes. The force can be a pressure difference, a concentration gradient, or an electrical potential difference. A tail gas (also called permeate) is generated that requires an air pollution control system, typically a thermal oxidizing unit. A thermal oxidizing unit requires natural gas to operate.

http://www.dmt-et.com/products/biogas-upgrading/

In addition and prior to the carbon dioxide separation, the biogas must also undergo desulfurization and dehydration pretreatment steps. Additional pretreatment steps may also be required depending on the composition of the biogas. Dehydration removes moisture from the biogas typically by cooling the biogas and condensing out the moisture. Desulfurization removes the hydrogen sulfide in the biogas which corrosive to RNG transmission infrastructure and combustion devices.

These pretreatment steps generate a wastewater that will require a sanitary connection or wastewater treatment. The volume and composition of the wastewater will depend on the type of pretreatment and CO_2 separation technology employed.

Regardless of the end use of the upgraded biomethane or RNG, some degree of compression will be required. The amount of compression required is dependent on the pressure in the natural gas pipeline where the injection will incur or the compression required for the vehicle fueling system, and is thus site specific. When connecting to a natural gas distribution system, it should be noted that low pressure systems may not have the ability to accept all of the RNG all year whereas high pressure systems require much more expensive compression and may require the full or part time supervision of an operating engineer. Consulting with the natural gas utility company during the planning and site selection stages of a biogas project development is critical.

Lastly, the RNG is odorized similar to natural gas and metered for billing purposes. The RNG quality is continually analyzed before delivery to the customer or utility to ensure the RNG meets the pipeline or customer gas quality specification. Any RNG that does not meet the gas quality specification must either be flared or may be able to circulated back into the upgrading system.

Biogas upgrading systems do not achieve 100 percent methane recovery. As a rule of thumb, upgrading systems are only able to convert about 90 percent of the methane in biogas to biomethane. There are small differences in the methane recovery efficiencies between technologies but typically the differences are not large.