Select the right process technology for your dairy RNG project

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AT A GLANCE

There are several options for bedding material, type of digester and gas upgrading equipment to consider when planning an RNG project.

In recent years, dairy farmers have shown an increased ability to enhance farm revenue by installing anaerobic digesters. The latest business model of choice has been to convert the biogas from the farm's manure to renewable natural gas (RNG).

Producing RNG can help the farm earn lucrative carbon credits from such programs as the California Low Carbon Fuel Standard and Renewable Identification Number (RIN) credits from the Federal Renewable Fuel Standard. Additionally, it can also reduce farm methane emissions to enhance farm sustainability.

When looking to engage in an RNG project, however, farmers garner the greatest longevity and long-term value by selecting the right technology for key components of the design process, which include bedding material, digesters and gas upgrading.

Bedding material

Farms that use sand for bedding will require separation of the sand before the digesters. This is accomplished by adding water to dilute the manure enough to get the sand to come out of the manure emulsion. In contrast, farms that use manure solids, fiber or wood shavings for bedding are able to send their manure straight into the digester. Thus, sand-bedded farms typically consider looking at other bedding methods that are easier on material handling systems and don't require thinning out the manure ahead of digestion.

Digesters

The common features of all digesters are that they are sealed vessels, operate at about 100ºF, are agitated to keep all the contents in suspension and are sized for three to five weeks of residence time (based on project requirements and expectations). The two chief digester configurations are plug flow and complete mix.

Current plug flow digester systems use in-ground rectangular concrete tanks with pre-cast concrete roof panels. These systems send material to one end of the tank and down the length before exiting a month later. These units use compressed biogas to keep the contents agitated and to keep any suspended grit from settling. They are heated by the use of heating tubes mounted inside the basin.

In comparison, complete mix digesters are built with aboveground, round, engineered tanks made of steel or concrete. They are mixed by mechanical mixers mounted on the tank sidewalls or with a vertical mixer mounted on the tank roof. Other mixers include rotating paddles that are inside the tanks mounted on the tank floor. These systems will add heat to the tank contents either by heat exchangers in the tank itself or outside the tank to maintain required operating temperatures.

All digester configurations will include system insulation to keep the heat inside and a system boiler to provide heat from an energy source like natural gas or propane. Round tanks are available up to roughly 1.8 million gallons that use a soft double membrane roof cover with roughly a 4-to-1 diameter-to-height ratio. Tanks with a hard roof are available up to roughly 2.5 million gallons and have a 1-to-1 height-to-diameter ratio.

Additionally, all digester systems should consider the need for periodic grit cleanout. Some digesters can go decades without accumulating grit, while others require sand and grit removal every couple of years.

In order to prevent high levels of hydrogen sulfide in digester biogas, oxygen is sometimes added in small amounts to the digester head space. This oxygen supports growth of thiobacillus bacteria in the head space that reduces hydrogen sulfide to elemental sulfur and keeps the sulfur in the manure contents. Digesters with strict end RNG specifications, however, may not be suited for an oxygen injection approach. Iron salt chemicals like ferric chloride are effective binding agents that can prevent generation of hydrogen sulfide in the biogas. It is much less costly to keep sulfur and resulting hydrogen sulfide in the digester than handling it in the downstream biogas.

Systems should be designed to include several hours of biogas storage to provide reliable downstream gas upgrading performance. Plug flow reactors have limited gas storage volume, so separate storage domes are recommended.

Gas upgrading

Digester biogas is fully saturated with water and has elevated hydrogen sulfide and carbon dioxide levels when it leaves the digester. In order to get the gas to pipeline RNG specifications, all these contaminants must be addressed.

Hydrogen sulfide is generally removed first. Common means of controlling hydrogen sulfide are through dry media systems and wet scrubbing. Dry media systems include granular activated carbon (GAC), Sulfatreat and iron sponge. These each have very diverse material handling consistency, varying costs per unit weight and different operating conditions such as needing trace levels of oxygen or high levels of humidity to work properly.

Wet scrubbers can use water or high-pH chemicals like sodium hydroxide. These wet solutions solubilize the hydrogen sulfide and remove them from the gas and into a water stream where they are further managed. Once the hydrogen sulfide is trapped in liquid solution, it can be reduced to elemental sulfur in a biological reactor that uses thiobacillus bacteria for this bioreaction. One additional wet scrubbing approach for removing the hydrogen sulfide is through a chelated iron solution. The solution traps the hydrogen sulfide by using a closed loop regenerable iron salt chemistry.

Next, water vapor is most commonly removed by mechanical means using cold-water heat exchangers. These systems work just like any refrigerator through a mechanical compression step that uses a refrigerant to create cold temperatures. From there, the gas may need to be mechanically warmed depending on the downstream upgrading approach.

Once the gas has had the water and H2S removed, the remaining components are typically carbon dioxide and methane at roughly a 42% to 58% mixture. The next treatment goal is to strip out the carbon dioxide from the gas, which can be done in one of several ways. First, the gas can be chemically scrubbed. The most common chemical is an amine solution that chemically traps the carbon dioxide in solution. This is a regenerable two-step process where the gas is first scrubbed and then removed from the scrubbing solution by boiling the carbon dioxide out of solution.

Another common approach is to separate the gases by a membrane system with a feed pressure of roughly 200 psi. These membrane systems use a special polymer fiber where the carbon dioxide will pass through the fiber due to its higher permeability. The resulting cleaned biogas is purified methane that stays in the membrane fibers. These membrane systems are configured in a way to maximize the overall methane recovery.

Alternatively, the biogas can be cleaned by using a media adsorbent such as a carbon bed. The adsorbent traps the carbon dioxide and runs in batch cycles of adsorption and regeneration. These systems are known as pressure swing adsorption (PSA) units.

Lastly, a wet scrubber that uses water can be used effectively for removing the carbon dioxide from the biogas. The carbon dioxide is adsorbed under pressure much like carbon dioxide is adsorbed in water in a carbonated soft drink. Next, it is desorbed in a second depressurization step and vented.

Before injection into a natural gas pipeline or into an RNG trailer, the gas will need further compression. Reciprocating and screw-type compressors are the most common configuration.

By selecting tried-and-true components – either from domestic or proven global suppliers – to address these common parts of an RNG project design, dairy farms can look forward to years of reliable service from a manure RNG system.

Photos courtesy of Montrose Environmental Group.

Two complete mix, 1.5-million-gallon digesters, with soft double membrane covers being built in Arizona.

Chelated iron system for scrubbing biogas at a project site in Washington.

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