Biogas Upgrading for Dairy Digesters

Introduction

Biogas generated from the anaerobic digestion (AD) of livestock manure is a reliable source of renewable energy and is most commonly used to generate electricity (US EPA AgSTAR Database 2021). In more recent years, biogas has increasingly been refined and used as a "drop in" fuel to replace natural gas in transportation applications (see Figure 1). Financial incentives from multiple credit programs operated by the US federal government (e.g., Renewable Fuel Standard [RFS]) and by states like California, Oregon, and Washington that have clean fuels standards (also called low carbon fuels standards) are driving this trend.

Figure 1. Increase in RNG usage for transportation fuel. Source: Coalition for Renewable Natural Gas (RNG Coalition).

When biogas is upgraded to biomethane and then used directly to replace fossil fuel natural gas (FFNG), it is commonly referred to as renewable natural gas (RNG) (US EPA 2021).

Digester gas that is used in a cogeneration engine must be cleaned or "scrubbed" of some of its impurities to avoid damage to downstream mechanical equipment. However, upgrading biogas to RNG for transportation fuel via pipeline injection or direct vehicle fueling requires a more significant purification process. This publication will explore the differences between biogas and RNG, the impurities that must be removed, and the technological approaches currently available to refine and upgrade raw digester gas to fuel quality.

Biogas vs. RNG

Biogas is a mix of gases that are generated when organic material decomposes anaerobically (in the absence of oxygen). Anaerobic decomposition and production of biogas is generated naturally within areas such as wetland swamps, reservoirs, wastewater lagoons, and even in human digestive tracts. The process, however, can be controlled via engineering, with anaerobic digesters designed to take advantage of this biological process. Various types of organic wastes (e.g., manures, food residuals, crop leavings, wastewater solids) can be processed in digesters to generate biogas. The primary constituent of biogas is methane, the same molecule that

This publication is part of the Anaerobic Digestion System Series, which provides research-based information to improve decision-making for incorporating, augmenting, and maintaining anaerobic digestion systems for dairy manure and food byproducts. An introduction and overview for the series is provided in the publication *The Dairy Manure Biorefinery*. Readers who are not familiar with anaerobic digestion can find a helpful introduction in *Anaerobic Digestion Effluents and Processes: The Basics*.

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is in FFNG. Depending on the feedstock, the methane content of biogas can vary between 45% and 75% with the bulk of the remaining composition (25%–55%) comprised of carbon dioxide. Small but critical concentrations of water vapor, hydrogen sulfide, siloxanes, nitrogen, and oxygen are present as well (Tchobanoglous 2014).

Because of the high concentration of carbon dioxide in biogas, the heating value, expressed as BTU/ft^3, is significantly lower than FFNG: typical biogas BTUs are 550–650/ft^3 compared to FFNG BTUs of ~1,000/ft^3 (Tchobanoglous 2014).

RNG is biogas that has been largely cleaned of carbon dioxide. During this process, referred to as upgrading, the carbon dioxide is stripped out of the raw biogas, leaving high-purity methane with comparable heating values to FFNG. The other impurities (e.g., hydrogen sulfide) that cause corrosion in equipment and engines are also removed, leaving a fuel that can be used directly in natural gas engines. Pipeline-quality RNG may require even further upgrading depending on state and utility standards, which vary nationwide. Table 1 provides a comparison of the composition of typical raw biogas with proposed standards for RNG use in various utilities.

Table 1. Comparison of raw biogas to proposed pipeline standards.*

	Heating Value		**Water Content**		**CO_2**		**O_2**		**H_2S**		**Ammonia**		**Siloxanes**		**Total Inerts**	
	BTU/scf		lb/Mscf		(% vol)		(% vol)		(grain/100 scf)		(% vol)		(ppmv)		(% vol)	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
Raw Biogas	500	750	~1,800		25	60	0.2	2	50	625						
Pipeline Proposals	950	1,150	4	7	1	3	0.1	0.4	0.25	1	0.005	-	0.01	1	2.7	5

*Adapted from data from the Washington State Department of Commerce.

Raw Biogas Composition and Constituent Removal for Upgrading to RNG

This section will discuss each of the non-methane components of biogas and why they should be removed; the Cleaning and Upgrading Technologies section of this publication will discuss methods for removing each of these elements. Since the previous publishing of this fact sheet in 2015, the core technologies for upgrading biogas to RNG have not changed dramatically, but the efficiency of the technologies has improved.

Carbon Dioxide (CO_2)

The most prevalent, non-methane component of biogas is carbon dioxide. Carbon dioxide is primarily a concern because it substantially reduces the heating value of biogas. It can also react with water vapor to generate corrosive acids. When used in combined heat and power (CHP) systems, CO_2 removal is not critical; it simply passes through the engine. However, for pipeline injection or other RNG applications that rely on the higher BTU content, CO_2 removal is essential. Some biogas-to-RNG applications have found uses for the separated CO_2 (greenhouses, feeding algae, sale to beverage companies, etc.) but the gas is typically released to the atmosphere (Shin et al. 2019).

Water Vapor

Anaerobic digesters are operated with a working volume of liquid and a headspace, or empty volume, that is maintained above the surface of the mixed digester contents as a gas collection space and to allow for fluctuations in operational levels that may occur. Moisture from digester content evaporates and is trapped in the headspace as water vapor, which is drawn off with the biogas. The amount of water vapor is a function of temperature and pressure, which under typical digester operating conditions, means anywhere from 5% to 10% by volume of the gas will be water.

Water vapor in biogas causes operational issues in downstream equipment by lowering engine efficiencies and contaminating engine oil (Tchobanoglous 2014). More importantly, it reacts with hydrogen sulfide and carbon dioxide in the biogas to produce sulfuric and carbonic acid, respectively (Tchobanoglous 2014). These acids will corrode pipes and equipment and cause significant operations and maintenance issues.

Hydrogen Sulfide

Hydrogen sulfide gas (H_2S) is formed when sulfates in manure are converted by bacteria in the digester to hydrogen sulfide (H_2S), bisulfide (HS^-), and sulfide (S_2^-). The concentrations of each of these compounds depends on the pH of the system; as the pH shifts higher, H_2S concentrations diminish as bisulfide concentrations increase (Firer et al. 2008).

Within a digester, hydrogen sulfide is in an aqueous and gaseous equilibrium. This process also occurs in other wastewater contexts, such as in sewer pipes (Figure 2). Within the headspace of a digester, the gaseous hydrogen sulfide can react with water vapor and a different bacterial consortium to create sulfuric acid and corrosive conditions for the concrete or steel of the digester and the metal used in gas collection systems (US EPA 1991). Hydrogen sulfide can also precipitate as elemental sulfur when exposed to oxygen or under certain temperature and pressure conditions. This yellowish powder can accumulate in gas collection and conveyance systems and plug metering and monitoring equipment, leading to errors in measurement of critical parameters (dos Santos et al. 2016). Aside from causing issues with equipment, hydrogen sulfide is a health hazard: a toxic gas that can cause eye and lung irritation at extremely low concentrations (five parts per million [ppm]) and respiratory distress and even death at very high levels (200–700 ppm) (Tchobanoglous 2014). Finally, the combustion of sulfur molecules generates sulfur oxides (SO_x) that react with other compounds in the atmosphere to create fine particulate matter which has been correlated with respiratory and cardiovascular distress in humans

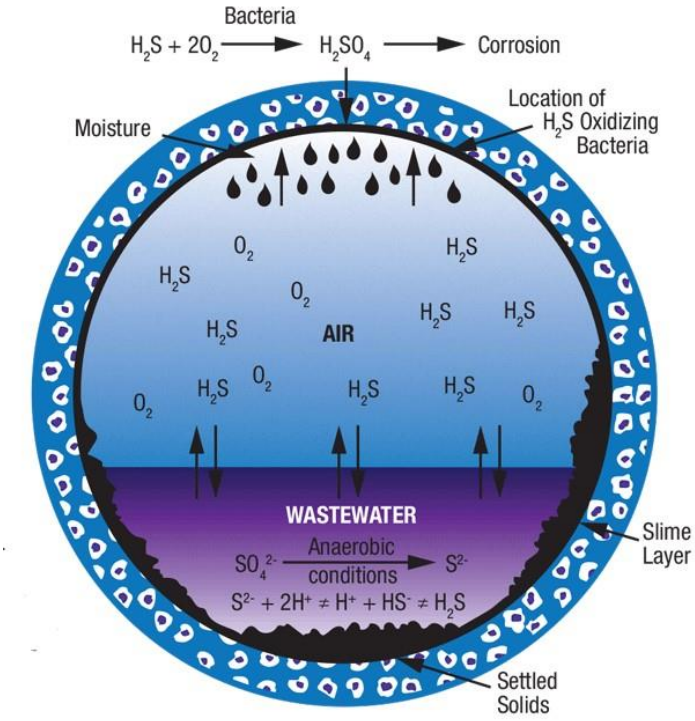

Figure 2. Crown corrosion in sewer pipes, analogous to the headspace in anaerobic digesters. Image courtesy of Ixom.

(US EPA 2008). Hydrogen sulfide removal is therefore both an operations and maintenance and human health requirement.

Siloxanes

Siloxanes are chemicals commonly used in personal care and industrial products. They are very rarely an issue for digesters that are only accepting dairy manure but can be introduced through the acceptance of co-digestion substrates from municipal or industrial sources or possibly from dairy washing solutions or detergents. Siloxanes are primarily made up of silicon and oxygen and are converted into silicon dioxide, or silica, during combustion. Although safe for human exposure, silicon dioxide when combusted forms hard deposits that accumulate on pipes, valves, and other equipment appurtenances, causing serious operational and maintenance issues (Tansel and Surita 2019).

Ammonia

Ammonia (NH_3) is generated when the nitrogen in organic feedstocks is converted by bacteria into inorganic ammonia. The ammonia in digesters is present largely in two forms: the ammonia ion dissolved in the liquid phase and free unionized gaseous form. When the pH and temperature in the digester increases, the equilibrium between the two types shifts to ammonia gas, which can

redissolve into the head space water vapor and be corrosive to downstream equipment and appurtenances (Tchobanoglous 2014).

As with siloxanes, the amount of nitrogen in biogas generated strictly from dairy manure is typically not in concentrations high enough to warrant removal. However, as can also happen with siloxanes, the introduction of pre-consumer food wastes or other sources of organic material for co-digestion can significantly increase the concentrations of nitrogen and therefore increase the potential for the development of ammonia gas. While removal of water vapor might seem the best way to avoid aqueous ammonia corrosion in downstream equipment, any nitrogen that remains in the gas stream is also a potential source of nitrous oxide (NO_x) emissions if combusted. NO_x, as with SO_x, is a known air pollutant. Thus, removal of nitrogenous species can be an issue for dairy digesters co-digesting non-manure feedstocks.

Less of a concern but still relevant to biogas is the potential for high levels of dissolved ammonia to inhibit gas production, as the bacteria responsible for methane generation are hampered under high-ammonia conditions. However, this is rarely a concern for dairy digesters, even those taking food residuals as co-digestion feedstock.

Oxygen and Nitrogen

Although biogas is produced in an anaerobic environment, contamination of the biogas with air and therefore both oxygen and nitrogen can occur through leaks in the piping and collection system or other exposure to atmosphere. Oxygen can react with other constituents in the gas to create acids and cause corrosion, making it a particular concern for pipeline injection projects. Nitrogen contributes to “total inerts” which reduce the total heating value of the biogas.

Cleaning and Upgrading Technologies

Every biogas utilization system—whether for electricity generation or RNG production—requires the removal of water vapor and hydrogen sulfide to some degree. Generators (gensets) and engines that can use biogas as fuel have less strict parameters than gas pipelines; some engines can withstand hydrogen sulfide concentrations in the hundreds of ppms whereas gas utilities operate at concentrations much lower (~ 4 ppm). Although cleaner gas does provide benefits in the operation and maintenance of engines, it is usually the gas utility standards that drive the need for upgrading technologies to strip out CO_2, siloxanes, and other constituents at digester-to-pipeline projects.

Water Vapor Removal

Water vapor can be removed by passing the gas over desiccants, like silica gels, or via condensation by chilling the gas stream and collecting the condensate with water traps. Water vapor can also be removed more passively through gas piping design that takes advantage of the temperature differential between the digester and ambient air to encourage condensation. Designing adequate piping that incorporates condensate traps and appropriate slopes in pipe runs can be an inexpensive method for removing a significant portion of water vapor. However, RNG upgrading will require a more consistent and more significant reduction in water vapor than piping adjustments can achieve, and additional equipment, such as chillers or driers, will be needed. The placement of water vapor removal systems is also a function of the other constituent removal technologies; some systems rely on saturated gas while others require dry gas to efficiently remove contaminants.

Hydrogen Sulfide Removal

There are many ways to remove hydrogen sulfide from the gas stream. Some treatments occur in the digester itself (in-situ), though most upgrading technologies treat biogas after it has exited the digester.

Oxygen Dosing

Perhaps the most cost-effective way of removing sulfur is through the injection of small amounts of air into the digester, a process known as micro-aeration. This process allows a particular consortium of bacteria to aerobically convert H_2S to primarily elemental sulfur, which precipitates as an insoluble powder and does not make it into the gas stream.

Although this process reduces sulfur considerably and is very cost effective, this approach has several drawbacks. First, sulfur reduction levels are not low enough to meet RNG/pipeline specifications. Also, as often happens in the headspace of sewer pipelines (see Figure 2), any remaining dissolved sulfur constituents can react with the oxygen in the airstream, via aerobic biological activity, to form sulfuric acid, which will corrode the digester and digester mixing equipment. Finally, if the dosing is not controlled properly, too much oxygen and nitrogen can be introduced, requiring their downstream removal prior to pipeline insertion (Allegue and Hinge 2014).

Ferric Salts

Liquid iron salts, ferric chlorides, and even porous suspended solids of iron salts have been widely used at wastewater treatment plants and in sewer collection

systems, primarily for odor abatement. The iron binds with odor-causing sulfuric compounds and precipitates the sulfur out as an insoluble iron salt. The same principle can be applied to anaerobic digesters to remove or reduce the amount of dissolved sulfur before it is converted to gas. In this case, iron salts can be added into the digester influent pipe or mixed in a small pretreatment tank upstream of the digester. This process, however, increases the risk of accidentally introducing air, and therefore oxygen and nitrogen, into the digester.

While the addition of iron salts can dramatically reduce sulfur levels, this method will only enable an installation to meet criteria for natural gas pipeline quality when used in combination with another technology. Iron salts have achieved reductions of hydrogen sulfide to 100 ppm, but typical natural gas pipeline standards require 4 ppm or less (see Table 1) (Allegue and Hinge 2014). Consequently, iron salts are often used as a first step that helps economize on the more expensive downstream polishing equipment used to reduce sulfur to pipeline levels.

Activated Carbon and Iron Sponge

Outside of the reactor, several media can be used to adsorb hydrogen sulfide from the gas stream. Activated carbon can be used and has the added benefit of removing siloxanes as well as hydrogen sulfide (Bak et al. 2019), but its capacity for H_2S adsorption is low without additional impregnated additives (Ciahotný and Kyselová 2019). Regenerating and reusing the carbon is possible but requires heat inputs, forcing a trade-off between the capital expense of replacement on the one hand, and the operational expense and complexity of regeneration on the other. Consequently, activated carbon can be an expensive stand-alone option but can be used in pressure swing adsorption (PSA) upgrading technologies (see section Pressure Swing Adsorption below) or as a first step upstream of polishing equipment.

The iron sponge process is one of the oldest methods for removing sulfur from natural gas. Ferric oxides are applied to a support material such as wood chips. When biogas is passed through the treated media, the ferric oxides react with hydrogen sulfide to form insoluble iron sulfur complexes (Cherosky and Li 2013) that drop out of the gas stream. Other biodegradable substrates like dried dairy manure in fact can also serve as a substrate on which the ferric oxide is applied, thereby providing a cheap, readily available material for on-farm biogas treatment (Cherosky and Li 2013). The iron sponge process will benefit from the addition of moisture and oxygen, but that raises concerns about introducing these contaminants into the biogas. It also raises the issue about placing water vapor removal technologies in the most efficient place in the treatment train.

Biological Scrubbers

Biofilters incorporate biological treatment for hydrogen sulfide removal, relying on the same conversion of sulfides to elemental sulfur as was completed during in-vessel air dosing but using a design similar to that of an external iron sponge. Instead of relying on chemical transformation, gas is passed through a reactor filled with media that has been colonized by bacteria, which convert the hydrogen sulfide to elemental sulfur and sulfates/sulfuric acid, thereby dropping it out of the gas stream. These types of systems are commonly used in odor control installations for wastewater treatment plants, but the level to which sulfur is removed is still lower than that required by RNG applications, and the footprint of these systems can be large. Biological scrubbers are best used as a relatively inexpensive upstream technology in RNG applications to remove a portion of the sulfur prior to more expensive polishing options.

Commercial Technologies

More proprietary commercial technologies are also being used at dairies for desulfurization. Some use chemical scrubbing to remove sulfur, but then the system includes a bioreactor to convert the stripped hydrogen sulfide dissolved in the solution to elemental sulfur powder (Figure 3). Upgrading the gas beyond sulfur removal is still required, and the system relies on a caustic liquid (sodium hydroxide), which can pose safety and disposal issues (although the bacteria themselves generate alkalinity and reduce the volumes of sodium hydroxide needed). The

Figure 3. Elemental sulfur system installed on an Idaho dairy (dark gray components only). Courtesy Martin Tielbaard, Paques Environmental Technologies.

bacteria in the bioreactor must also be supplied with air, increasing operational costs associated with sulfur recovery. However, the sulfur powder obtained from the process can be used as fertilizer which may provide the farm with some additional revenue options. These types of desulfurization systems are relatively new compared to the other technologies.

Carbon Dioxide Removal

Water and Solvent Scrubbing

Scrubbing is a process by which the raw biogas is introduced in a counter current flow to various solvents. Carbon dioxide, sulfurous compounds, and some other contaminants are dissolved into the liquid while methane passes through relatively unaffected. These technologies have been widely used across a number of industries and are thus fully mature. There are several solvents (e.g., sodium hydroxide) that can be used in scrubbing towers, each with their own benefits and disadvantages, but the disadvantage of all scrubbers is the production of a liquid that must be treated or disposed.

Water scrubbing is the oldest technology in use for gas cleaning and can remove both H_2S and CO_2 from raw biogas and requires no toxic solvents that might create a disposal issue (Figure 4). The equipment is also relatively straightforward to procure and maintain. However, there are some disadvantages. High-pressure scrubbing requires compression of the biogas, which in turn requires energy, and water use is high: consumption averages 0.3–0.5 liters of water per cubic meter of biogas (Lombardi and Francini 2020). For a 1,000 standard cubic feet per minute (scfm) installation, this translates to water use of roughly 200,000 to 300,000 gallons per day. Low-pressure scrubbing is possible, but while the installation saves on energy, the liquid-to-gas ratio required to maintain the same CO_2 removal is higher, which means a larger installation footprint for the scrubbing system and larger volumes of water. Regenerative, as opposed to single-pass scrubbing, is a process through which the CO_2-saturated water is circulated through a stripper that releases the CO_2 to the atmosphere, thereby regenerating the water for reuse in the initial biogas scrubber. While this saves on water consumption, the stripping tank, and its ancillary equipment (e.g., air compressor) adds to capital and operating expenses. For dairies, single pass scrubbing has the advantage of requiring less equipment, and the CO_2 saturated water could be stored in stock ponds to allow for slow release of CO_2 to atmosphere (Krich et al. 2005).

Amine scrubbing is also a mature technology with many worldwide upgrading installations. Instead of water, amine solvents (methanolamine [MEA], diethanolamine [DEA], and methyldiethanolamine [MDEA]) can be used in scrubbers for biogas treatment. These chemicals are more efficient than water at removing both H_2S and CO_2 but are toxic, and once used, the solvent is pressurized and heated to release the CO_2 into atmosphere. The amine, now itself stripped of the CO_2, can be recycled back to the stripper, but the regenerative step requires additional thermal energy (Lombardi and Francini 2020).

Figure 4. Hydrogen sulfide and carbon dioxide scrubber. CC BY-NC 2.0 by Livestock & Poultry Environmental Learning Center.

Pressure Swing Adsorption (PSA)

Pressure swing adsorption (PSA) is a common and technologically mature process through which gas constituents are adsorbed to various media (zeolites, activated carbon, etc.) based on their molecular weight. Pressurized gas is fed into a column of media where carbon dioxide, hydrogen sulfide, oxygen, and nitrogen are retained but methane passes through. Once the media is saturated with the undesired constituents, the column is depressurized and the components (e.g., CO_2) are released, thereby regenerating the media for further use. There will be some methane trapped in the media as well, so the exhaust from the depression cycle is reintroduced to the treatment system to extract the methane released from the media.

One drawback to this system that can be ameliorated is the release of stripped CO_2 to atmosphere. Some PSA installations capture the carbon dioxide and use it in various applications, taking advantage of both gas streams as a source of revenue. Although sulfurous compounds will be removed from the gas stream, they are not removed from the media during the depressurization/regeneration step, and so sulfur removal is important to have upstream of the PSA unit. Although pressurization of the gas is required, these systems require relatively low energy and do not require toxic solutions to operate nor do they require a source of water (Angelidaki et al. 2018). Additionally, the media is not able to be indefinitely regenerated and will require eventual replacement.

Membrane Separation

Compared to scrubbing and PSA technologies, membrane technologies are a more recent adoption for biogas upgrading (Figure 5). Membranes act as a molecular sieve, separating the molecules of carbon dioxide from those of methane. The efficiency of membrane treatment is particularly reliant on the materials of membrane construction (various synthetic polymers, mixed matrices, etc.), porosity, and selectivity (Miltner et al. 2017). Improvements and modifications of these membranes is an ongoing area of research. Consequently, as materials research has advanced, membrane use for biogas upgrading has increased, particularly in the last decade (Miltner et al. 2017). In Europe in particular, membranes are beginning to compete with scrubbing as the most common technology to remove CO_2 (Hidalgo et al. 2020).

Gas-phase membranes are popular not only for their high purity product but because they use no toxic solvents or water. They also have a relatively small footprint and provide the added benefit of a treatment that more easily concentrates and recovers the CO_2 for use rather than releasing it to the atmosphere (Shin et al. 2019). This can provide RNG installations with yet another revenue stream to offset the capital costs associated with upgrading systems. However, the membranes themselves are susceptible to damage and fouling if the raw biogas is not adequately pretreated. Membrane systems are also often proprietary, requiring a specific, singular source of parts or maintenance if the system experiences issues.

Figure 5. Membrane system treating approximately 125 scfm (200 Nm^3/hr) of gas from a cattle manure digester. Courtesy Bright Biomethane.

Summary

A number of recent studies (Angelidaki et al. 2018; Gustafsson et al. 2020; Lombardi and Francini 2020; Ardolino et al. 2021) have evaluated in detail each commonly used process across myriad parameters. For simplicity, Table 2 compares all these technologies across a few of the most important long-term operational variables using the aforementioned studies, in addition to presenting more general advantages and disadvantages relating to operations.

One thing to bear in mind with any of these technologies is the ancillary equipment and operations and maintenance required by each process step, within the whole system of drying, sulfur removal, compression, and any other needed processing. Pumps, blowers, complex valving, and specialty piping accompanies each of these installations to varying degrees and requires differing levels of expertise for operation. Each installation will require a detailed analysis of the site, including how much space is available, the power capabilities or feed to the site, and staff expertise, among other concerns, before the most appropriate technology can be chosen. An example diagram of full system upgrading and the accompanying equipment is provided in Figure 6.

Table 2. Advantages and disadvantages of upgrading technologies.

	Advantages	Disadvantages	Does it remove…			Methane Purity/Losses ("slip") (%)	Electricity Use (kWh/Nm^3)[a]	Thermal Use (kWh/Nm^3)
			H_2S	O_2	N_2			
High Pressure Water Scrubbing	Simple, mature technology	Gas must be dried before use in pipeline	Yes	No	No	96/1	0.25	—
	Less likely to experience process upsets	Uses considerable amounts of water						
	No chemicals required	Possibility of biological contamination						
Amine Scrubbing	Simple, mature technology	Solvent disposal	Yes	No	No	99/0.1	0.13	0.55
	Less likely to experience process upsets	Gas must be dried before use in pipeline						
	High methane content in gas	O_2 in the gas reacts with amines to degrade the solvent						
Pressure Swing Adsorption	Mature technology with many installations	High capital expenditure for large systems	Upstream removal is recommended	Yes	Yes	98.5/1.5	0.2	—
	No chemicals required	Requires significant process control						
	Compact installation	Separate treatment may be required for the gas from which the CO_2 is stripped						
Membrane Separation	High methane recovery	High upset risk	Upstream removal is recommended	No	No	98/1	0.25	—
	No chemicals required	Pretreatment of constituents that may harm membranes is strongly recommended						
	Compact, modular installation	Technology advances quickly so new installations can become outdated						
	Can be configured to recover the CO_2 for industrial use	Multiple-pass systems, requiring more equipment, are usually needed to achieve pipeline standards						

[a] Nm^3 = Normal cubic meter of treated biogas; approximately 35 cubic feet.

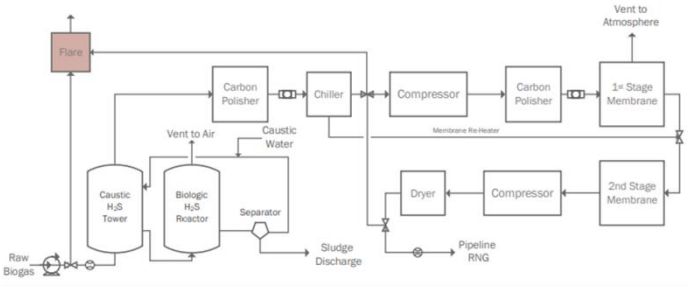

Figure 6. Schematic of a membrane upgrading system. Courtesy Craig Frear, Regenis.

Technology Comparison Across Dairy Upgrading Projects

In 2020, Argonne National Laboratory released its database of current and projected RNG projects by sector (food waste, landfills, agriculture, wastewater plants). According to their data, among the RNG projects using manure as the primary AD feedstock, CO_2 removal was accomplished using membrane systems for 64% of the installations, PSA for 12%, and water scrubbing systems for 6% (US EPA 2021). The remaining projects used other technologies, or the technology was not specified. It is possible that the more frequent use of membranes, which are generally more complex and require higher levels of operation and maintenance attention, is correlated with the increase in regional, multi-farm RNG projects where gas upgrading is centralized, can take advantage of economies of scale, and are being operated by a dedicated third-party entity rather than dairy staff. In Europe, however, the practice is still to use water and chemical scrubbers, with less reliance on the dry systems (PSA and membranes), though as mentioned previously, membrane use has increased in Europe as technology advances (Khan et al. 2021).

Conclusion

Although the initial capital outlay for RNG upgrading technologies can be a hurdle, available data indicate that the number of dairy AD projects that incorporate RNG is growing. Between March 2020, when Argonne National Laboratory documented existing RNG projects, and December 2020, the projected number of projects (those expected to begin operating or start construction by December 31, 2020) identified as livestock or agricultural doubled from 29 to 58 (Argonne National Laboratory 2020). The majority of added projects are on dairy farms.

Several entities (The Coalition for Renewable Natural Gas, American Biogas Council) are tracking these projects and RNG project data are changing rapidly in the face of technological advancements and economic incentives. As of the drafting of this publication, the Coalition for Renewable Natural Gas listed 72 operational livestock/agricultural waste RNG projects with 150 planned or under construction (RNG Production Facilities in North America, viewed August 2021). The American Biogas Council's resource page listed 287 agricultural digesters, and 61 covered lagoons; 269 digesters and 41 lagoons are designated operational, while 18 digesters and 14 lagoon are under construction (viewed August 2021). There is no indication of how many are dairies, however. While each of these sources may have some amount of error, the indication is clear that RNG projects are becoming more common on US livestock operations.

In the long-term, there are opportunities for dairies to generate RNG for sale or in some cases provide on-farm power or fuel. Costs and risks associated with these projects can be shared through collaborative efforts among dairies: numerous swine and dairy farms have centralized upgrading facilities that treat gas from farm clusters, thereby capitalizing on economies of scale and providing a more reliable project for funding sources.

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