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Engineering Renewable Natural Gas Solutions

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Environmental regulations across the globe are mandating the reduction of greenhouse gas emissions, and methane is a particularly high-profile target due to its high global-warming potential (GWP).

An increasingly attractive solution captures methane generated from landfills and anaerobic digestion of various waste streams, upgrades it to pipeline-quality biomethane and injects it into natural gas pipelines to be used as a low-carbon fuel.

This can be a profitable enterprise, but only if the process is designed properly, the equipment is installed correctly, and the system operates reliably.

Governments around the world have passed a host of regulations to drive the reduction of greenhouse gases, with particular focus on gases with high GWP.

The 100-year GWP of methane is 28 to 36, meaning methane has 28 to 36 times the environmental warming effect as compared to carbon dioxide (CO_2). However, the 20-year GWP for methane jumps to 80 or more because the gas breaks down over time, producing a more significant effect when it first enters the atmosphere.

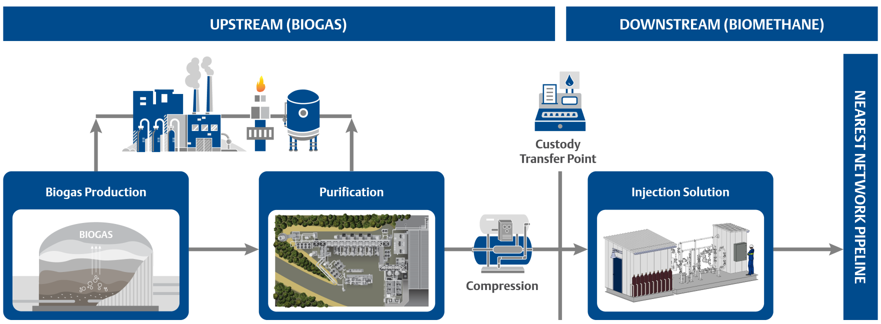

Figure 1: Biogas is generated from a variety of sources and then purified to remove undesired components and increase the methane concentration. The resulting renewable natural gas (or biomethane) is pressurized and then sold to a natural gas pipeline operator for injection into their existing pipeline infrastructure.

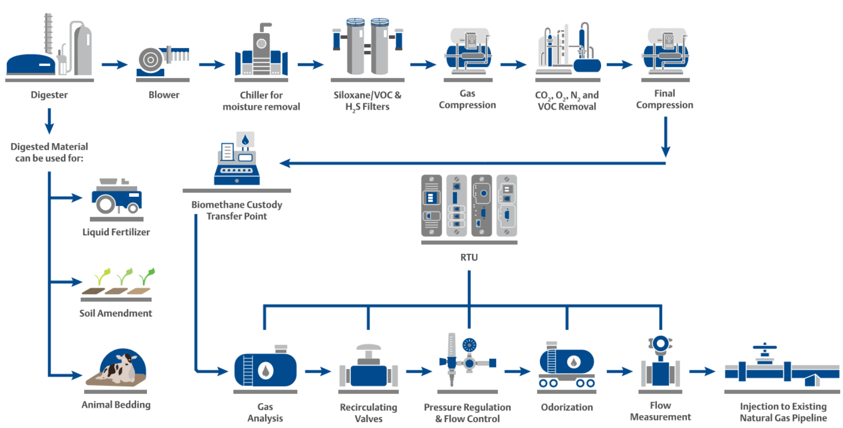

Figure 2: A generalized diagram of a biogas processing and biomethane injection system. The order of the steps varies depending on the application.

This GWP is the reason government regulations have targeted the reduction of methane emissions so aggressively. At the same time, government programs are hoping to replace high-carbon fossil fuels with low-carbon renewable fuels by awarding environmental credits for their production.

This combination of global awareness and legislative efforts has driven the solution of capturing fugitive methane emissions (biogas) from waste streams and upgrading it to biomethane, also known as renewable natural gas (RNG).

This biomethane, or RNG, can then be injected into natural gas pipelines **(Figure 1)**. This approach reduces methane emissions, generates profits by selling the reclaimed gas as a fuel and creates renewable credits at state and federal levels, which can be sold independently on the open market.

Biogas is typically generated from landfills and the anaerobic digestion of various waste streams, such as agriculture waste, manure, wastewater, food waste and others.

While this gas is rich in methane, it also contains significant quantities of moisture, CO_2, oxygen and nitrogen, along with troublesome components such as hydrogen sulfide (H_2S), siloxanes and other volatile organic compounds (VOCs).

The latter three substances are particularly problematic because they can create equipment issues due to corrosion and plugging. The other major shortcoming of biogas is its low pressure.

Typically, anaerobic digesters operate at extremely low pressures and biogas is pulled off the site at a slight vacuum. These pressures are well below that of natural gas pipelines, which operate at hundreds and even thousands of pounds of pressure.

Injection Process

A biogas processing facility must eliminate undesired components, raise the biogas pressure to pipeline specifications and measure the quality of the gas. A biomethane injection skid can then verify the quality of the gas and

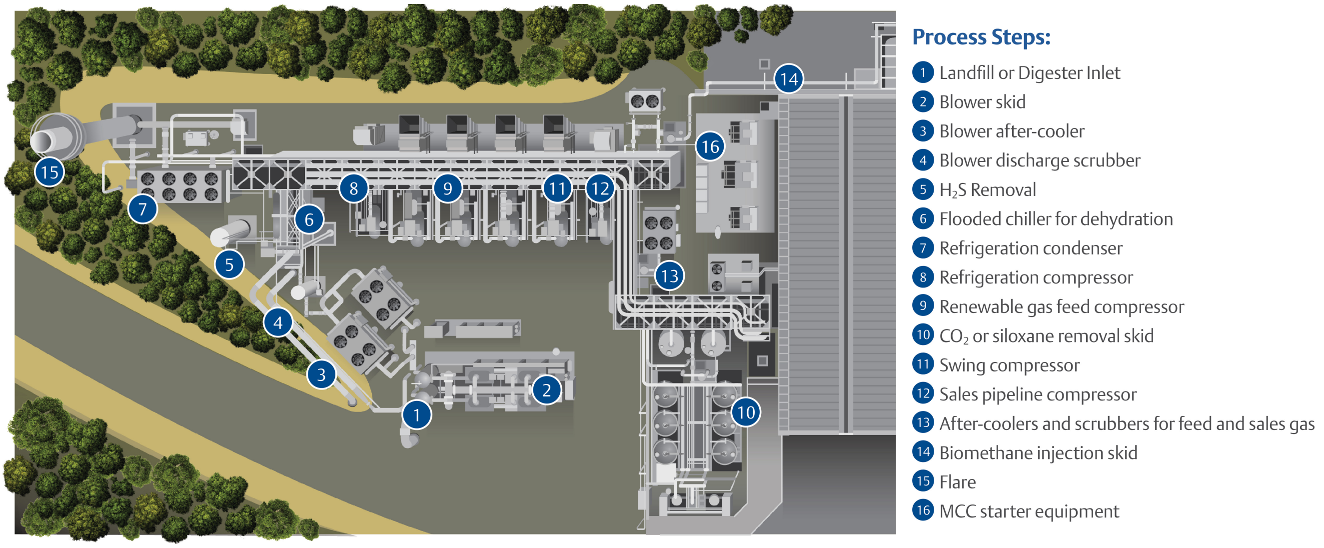

Figure 3: There are many components involved in a typical biogas processing facility. Each must be carefully chosen to handle the specific process application, and the entire system must be seamlessly integrated from digester supply to biomethane injection.

inject the measured volume into a natural gas pipeline **(Figure 2)** at a safe pressure.

The equipment on each side of the custody-transfer point is typically owned by different companies, but all systems must work together to provide a reliable supply of RNG.

Biogas Processing

Biogas processing requires a number of steps to purify and improve biogas quality. On most systems, a blower is used to pull raw biogas from the digester or landfill and then push it into the processing plant. The gas then passes through a chiller to condense and remove moisture followed by active carbon or regenerative filtering to remove H_2S, siloxanes and VOCs.

At this stage, the biogas is compressed and can be utilized as a low-quality fuel for on-site heat or electricity generation, or it can undergo further processing to remove CO_2, nitrogen and oxygen, converting the biogas to biomethane.

These additional processing steps typically require pressure-driven filtration through stages of membranes; however, pressure swing adsorption, amine scrubbing or water washing techniques might also be used. Once the gas achieves pipeline specifications for composition, energy density and pressure, it is ready for injection into the natural gas grid. This is typically when the biomethane goes through a custody transfer to the pipeline operator.

Biomethane Injection

Once the pipeline operator has taken ownership of the gas, more equipment is necessary to ensure safe injection into their natural gas system. The biomethane is analyzed first and measured to verify it meets pipeline specifications.

Should it fail this test, a series of automated isolation valves will divert the flow of gas to a flare or return it back to the processing plant for further cleaning.

If the biomethane meets specifications, it is odorized and routed through pressure regulators and flow control valves to ensure safe, reliable injection into the gas system.

Flow meters, pressure transmitters and gas analysis instruments take readings throughout this process and transmit data back to a remote telemetry unit (RTU). The RTU is used for automation of the skid, alarm historization and custody-transfer calculations.

Throughout the upgrading and injection process, a variety of analytical instruments measure the energy content and level of gas stream components, such as moisture, H_2S, sulfur, CO_2, oxygen and nitrogen.

A variety of different instruments, or by using a process gas chromatograph and a continuous gas analyzer, can accomplish this process. The gas chromatograph and gas analyzer can be installed to simultaneously measure these values and simplify the gas analysis process. Further analysis, to detect components like siloxanes, may require gas sampling for lab analysis.

All these analytical instruments and the control equipment must be carefully selected to handle the specific design requirements. The instruments and equipment used for biomethane injection must communicate seamlessly with the upstream processing equipment to reliably convert the biogas for sale of the resulting biomethane to the pipeline company.

In most cases, this equipment must operate autonomously, with little or no local operator interaction, and while being remotely monitored.

Operational Challenges

Designing high-performing biogas processing and biomethane injection systems can be a difficult engineering endeavor. Each application is unique, with differences in incoming gas components, delivery pressures and final gas specifications.

The task is made even more challenging due to the wide variability in feed biogas quality often encountered in normal operation. There is no "one size fits all" solution for these systems, with each system being custom designed to operate successfully in a particular application.

Due to the uniqueness of each application, each equipment component must be carefully selected, and the performance of every component must be coordinated with all the others to provide reliable operation **(Figure 3)**.

If any equipment is poorly selected or fails to function properly, some of the biomethane gas may not meet specification and must be flared or reprocessed, reducing and even eliminating profits.

Most biomethane processing systems involve a multitude of vendors, each provid-

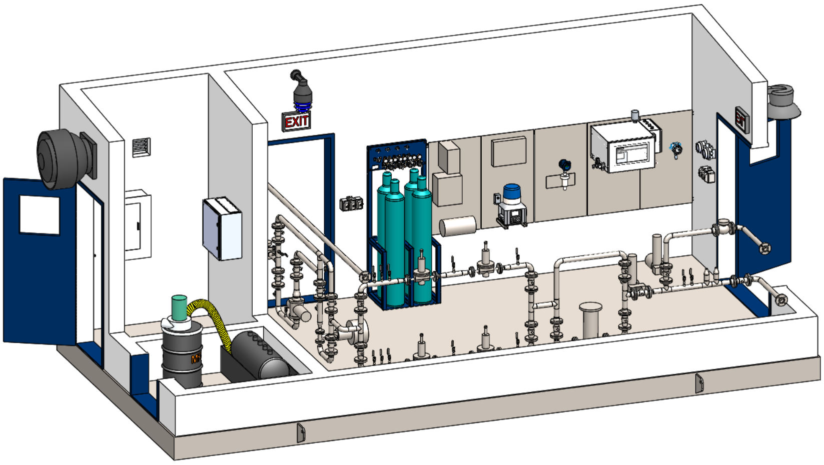

Figure 4: A single vendor for all biomethane injection equipment can custom-engineer a process solution and deliver the entire package as an integrated, skid-mounted solution. (Courtesy of Laurentide Controls)

Figure 5: A biomethane injection skid can receive renewable natural gas from a processing area, analyze it to confirm it meets specification, odorize it and meter the gas for custody transfer and injection.

ing different pieces of the overall system on each side of the custody-transfer point. This makes coordination difficult and invariably leads to finger pointing when issues arise.

Long-term support and maintenance can be equally problematic. With critical equipment on each side of the custody-transfer point, it can be difficult to troubleshoot and isolate the issue. For the natural gas operator injecting the RNG into their system, this can create a disruption in gas supply.

With most of the biogas processing equipment being owned and operated by a separate company, this can create significant downtime if the gas company's biomethane injection equipment detects issues with gas quality.

Even if the issue is identified as a piece of equipment in the biomethane injection system, the unfamiliar equipment required for RNG injection can create increased complexity for the field operations team. Likewise, getting a particular equipment vendor to accept their responsibility and address the problem can take valuable time and usually results in lost production.

The net result of these challenges is a lengthy engineering process, uncertain timeline for project conception to production and contentious lifecycle support. This increases project costs, lengthens the project schedule and reduces profitability.

A Better Way

To address these and other issues, many companies choose to engage a limited number of partners to design and furnish the major components of the biogas system. Choosing a partner that can not only engineer and deliver a complete biogas processing system, but one that also specializes in the automation equipment required for safe biomethane injection, reduces project inefficiencies and minimizes downtime for the biomethane supply.

For gas companies, this methodology ensures they can work with a single entity to choose the right combination of reliable, familiar equipment to supply low-carbon biomethane to their system. If a problem is encountered or routine maintenance is required on either side of the custody-transfer point, this partner can leverage their knowledge of the entire system to minimize downtime.

When evaluating potential project partners, their experience in several key areas should be considered. The partner must obviously be familiar with applicable local and national rules and regulations, and they must have the required engineering licenses and certifications.

Beyond these minimum requirements, a qualified solution provider must also have a deep knowledge of the biogas purification process and the natural gas system, know the equipment involved on both sides and have a proven track record of successful installations.

This combination of skills and experience allows the partner to make product and process recommendations, and to help the gas company choose the best combination of equipment to meet the needs and goals of the project.

The best solution providers either supply the vast array of necessary equipment and instrumentation directly, or have strong partnerships with technology providers, so that interoperability, high performance and expert support are guaranteed.

Such a solutions partner can often engineer, construct and bring the equipment into production in a much shorter time as compared to engaging many companies to build a system on-site. Often, the critical equipment can be furnished in a customized, integrated skid solution **(Figure 4)** that can be easily installed and commissioned on-site. This shortens the project construction timeline and simplifies system commissioning.

Case Study

A large wine maker in Italy needed to deal with significant agricultural and liquid wastes from their process. After studying the problem, the company decided to install anaerobic digesters to treat the waste streams and convert them to biomethane for sale to a local energy company for use in their natural gas network.

The winemaker had developed a system for processing the waste and upgrading the biogas to marketable biomethane, but it needed a fully integrated solution to analyze the critical gas product parameters, communicate with the upstream processing as required to meet specifications and safely inject the biomethane into the nearby natural gas pipeline system **(Figure 5)**.

The client lacked the engineering expertise to develop a biomethane injection unit on their own, so they engaged a leading global automation supplier to engineer the system, construct the skid-mounted solution, install it on-site, commission it and provide ongoing operating support assistance.

The skid was designed, delivered and placed into successful production in a very compressed time schedule, enabling the firm to quickly bring their biogas process online and into profitable production.

This integrated skid solution can be easily replicated at future locations, with Emerson providing local operational and maintenance support as necessary for all installations.

Conclusion

When faced with a fast-track biogas project, collaboration with a carefully selected and qualified solution provider is often the best approach.

The right partner will have a complete understanding of the biogas processing and natural gas pipeline systems, allowing them to create a fully integrated and customized system to provide robust and efficient operation.

The resulting skid-mounted solution typically cuts design and construction time significantly, paving the way for a successful project and profitable installation. ***P&GJ***

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