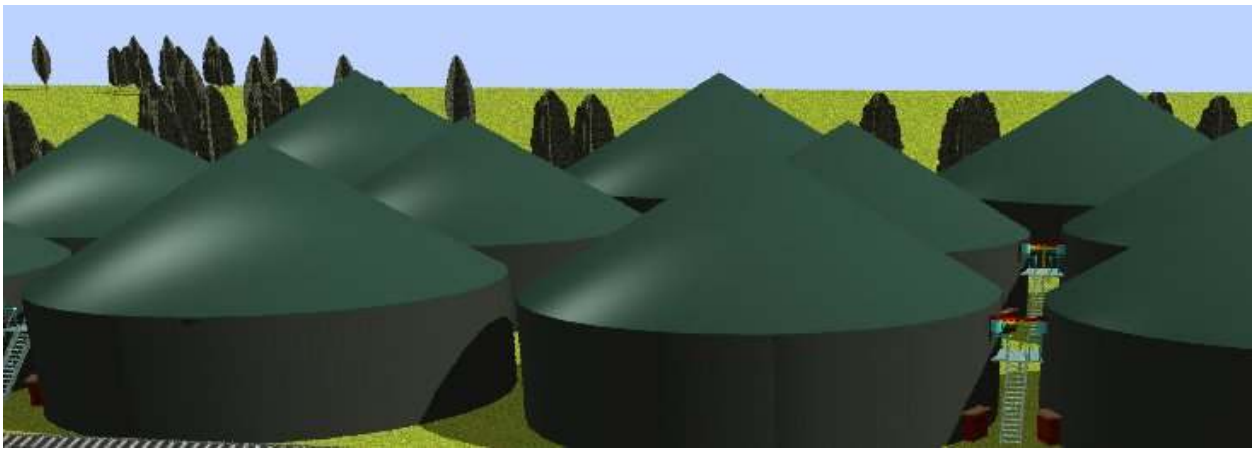
Key Elements of Biogas Energy Anaerobic Digesters

This document describes how Biogas Energy anaerobic digesters create system-wide operational efficiencies in energy production and operational costs. While the amount of methane that can be produced from a given feedstock is relatively fixed, system-wide facility design can optimize methane production and power generation. Redundancy, gas storage, flexibility, disaster prevention, multiple feed stocks: these features and more give Biogas Energy the ability to produce more energy from a given substrate.

An "apples to apples" comparison of digester technologies is problematic since each project has variables that may also change over time. Ultimately, the decision of which technology to use can be informed by examining the effectiveness of existing systems.
In Europe, where more than two thousand anaerobic digesters operate, biogas production has undergone decades of continual quality improvement. Since European farmers purchase digesters for energy production, they demand the highest efficiencies. Since they operate their digesters themselves, low-cost maintenance and operation is crucial.

Biogas Energy Inc. is dedicated to bringing mature anaerobic digestion technology to North America and to achieving the highest levels of biogas production.



Experience and Performance with Anaerobic Digestion

The complete mix mesophilic anaerobic digestion technology installed by Biogas Energy has been installed in hundreds of facilities around the world treating everything from cow and pig manure to energy crops to food and yard waste. Eleven digesters have been built in the US using this technology with more being built today.

Our customers benefit directly from this experience through fast development time, expert advice, and high energy production efficiencies.

Biogas Energy technology has been improved continuously for over a decade, spurred by the drive to be as efficient and cost efficient as possible.

Energy Production Efficiency

Many in the anaerobic digester industry use a cow/kW ratio to portray power generation efficiency, but this measure has several shortcomings. First, methane production varies dramatically depending on system downtime, so technologies that prevent or quickly recover from disaster have a clear advantage. Second, by adding other substrates to manure, far superior methane production is achieved. Various substrates have different methane production potential (see chart below).

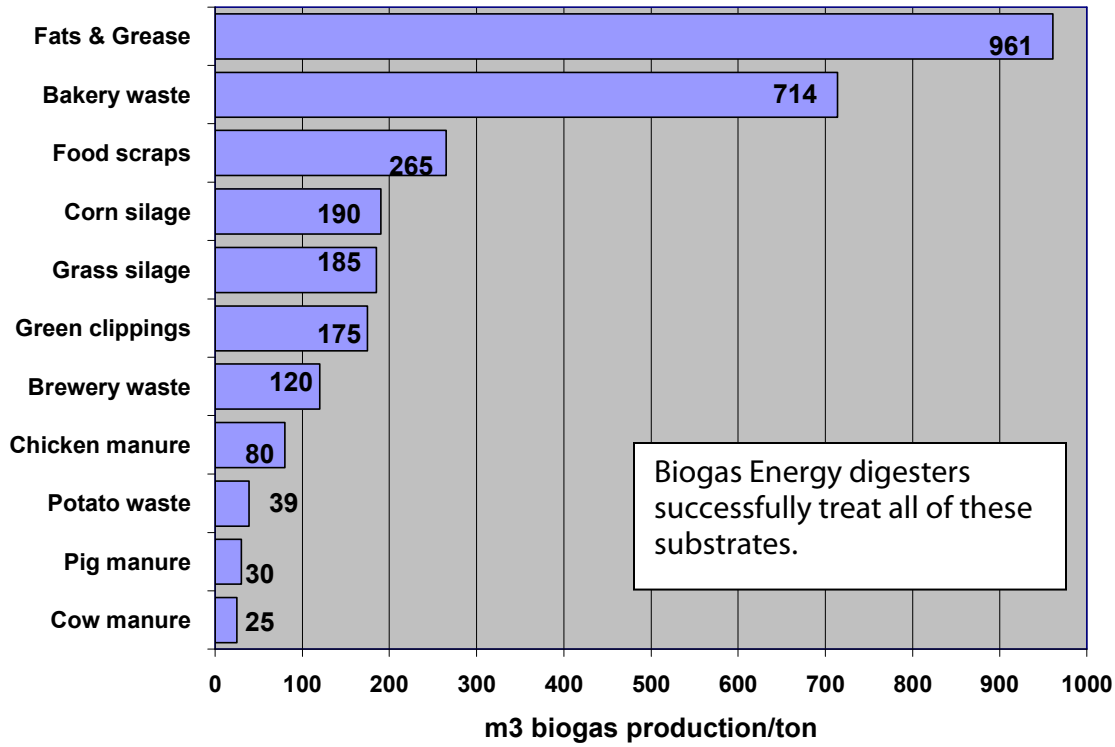
Key questions for energy production, with Biogas Energy answers in italics:

- Can the digesters accept multiple substrates to maximize biogas production? *Absolutely*
- Is gas storage built into they facility? *Yes; in the roofing structure*
- Is redundancy and flexibility built into the facility? *Yes; when more than one digester tank is installed*
- How are problems prevented? *See section below*
- When a system failure occurs, how long does it take to fix it and get back up and running? *Within hours or days (not weeks), depending on the issue*

Increased methane production from multiple substrates

A key element to maximizing methane production is to co-digest multiple substrates in the digesters. Manure has relatively low energy content since cows have already digested the feedstock. As complete mix anaerobic digestion technology, Biogas Energy digesters are extremely effective at treating various high-energy substrates. The reactors accept substrates other than manure, from grease to corn silage without any problems. Even mixed food waste can be digested on its own as a significant source of energy.

Biogas Energy has a proven track record and best practices to enable customers to successfully produce the maximum amount of methane from their investment.



Source: Basisdaten Biogas Deutchland, Marz 2005: Fachagentur Nachwachsende Rohstoffe e.V.

The digesters run perfectly on manure alone, but with such a dramatic effect on methane production, customers may consider adding other substrates. In fact, there are a number of digesters running without any manure at all, making significant energy from food waste and energy crops. Plug flow and covered lagoon digesters are unable to efficiently digest these materials, and consequently haven't seen the adoption rates the complete mix digesters enjoy in Europe.

In addition to increased methane production, multiple substrates provide waste disposal "tipping fees". The Biogas Energy digester in Ireland makes most of its revenue from tipping fees for treating food processing waste, restaurant kitchen waste, expired foods, grease, and more.

Biogas Energy digesters treat a wide variety of wastes due to several factors:

- Proprietary technology significantly reduces hydrogen sulphide in biogas
- Agitation of substrates promotes digestion and prevents surface foam or crust
- The ability to control timing and quantity when adding substrates prevents "shocking" the process
- Experience won from years of operation provides optimized methods of operation
- Monitoring systems and practical methods for digesting multiple substrates prevent issues and greatly facilitate disaster recovery

Retention time increases methane production

A critical factor in methane production is the amount of time the substrates spend in the digesters. Too short retention time means an inefficient extraction of methane, so full revenue is not realized. Too long retention time means too much was spent on surplus capacity or not enough substrate is being added to maximize revenue.

Biogas Energy plans digester retention time to get the maximum revenue with the most appropriate capital costs. Once the facility is built, however, the retention time can be changed as needed without affecting operations. The operator can change the amount of substrate added, or add or shut down digesters. The operator customizes and optimizes the system over time to achieve maximum efficiencies unique to that facility.

Cost of systems

Just as the cows/kW ratio isn't ideal for describing energy production, a cost per cow figure is inadequate due to the variables involved. If a 2,000 cow Biogas Energy digester also takes 10% grease waste, the enormous increase in methane production more than justifies the slight increase in capital costs (for reception tank & pump).

A more useful method to estimate cost is to determine all possible substrates for a particular project, which will determine capital costs as well as revenue from energy production and tipping fees. Then calculate power generation rates as well as downtime estimates. In this way a lifetime financial model can be created to give a better picture than a simple dollar-per-cow capital cost.

Based on available information, the capital costs of Biogas Energy digesters are comparable if not better than other vendors. If gas storage and gas cleaning equipment is added to our competitors' cost, then Biogas Energy is clearly superior. Looking at revenue from multiple substrates and avoided downtime, Biogas Energy digesters have a distinct advantage.

Operational costs

Since each site is unique and operators have their own priorities and methods of working with their facilities, operational costs vary.

If only manure is added to the digester and the operator does not maintain a CHP unit or gas processing equipment, the digesters require 15-30 minutes a day for monitoring. For example, a typical dairy's manure is pumped from the scrape pit or flush thickening system into the digester, and the substrate then flows via gravity through the digesters all the way to the solids separator. Liquids then flow to a lagoon for land spreading. Solids are automatically piled using a conveyor or auger, so there is no human interaction with the system (besides monitoring) until the solids are hauled away. By integrating the digesters into existing operations, minimal maintenance and operational work is required.
Many operators add other substrates to the digesters, which increases monitoring and may add extra work.

Over the lifetime of a digester, the only equipment that may need maintenance or replacement are the agitators or the roof. Since the agitators run only for 20 minutes an hour, they have an expected lifespan of 8-10 years. The roof is estimated to last for 10 to 20 years.

Separators, pumps, and other equipment used are required for standard manure management practices without digesters.

The main operation costs for Biogas Energy digester owners involve the combined heat and power unit or gas processing equipment. These must be maintained, and therefore have costs associated. The digesters themselves, however, require little maintenance other than daily monitoring.

It cannot be stated often enough that avoided downtime is a critical element in the operations of a facility. Simply put, avoiding downtime and eliminating flaring cuts costs and increases revenues. Biogas Energy digesters are built with that in mind.

Gas quality and H_2S treatment

Biogas produced by Biogas Energy digesters typically consists of ~ 60% CH_2 and ~40% CO_2. Moisture is reduced to levels required for gas use.

Biogas contains hydrogen sulfide that must be removed as much as possible before reaching the gas processing equipment. Some digester vendors produce biogas with 1000-3000 PPM H_2S which causes severe problems with the gas processing equipment.

Biogas Energy builds hydrogen sulphide cleaning technology into the digesters as standard equipment, and produces biogas with 100-500 PPM H_2S. For farms adding substrates with very high sulfur content, additional gas cleaning equipment is available.
The hydrogen sulphide issue is a critical factor for technologies that use the biogas. If the H_2S levels are too high, damage to gas treatment equipment is severe and costly. By using Biogas Energy technology, issue is addressed.

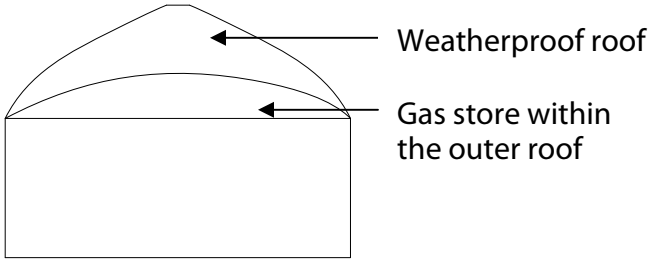
Biogas may be converted to energy in several ways. Burning it in a Combined Heat and Power unit generates electricity and heat. It may also be cleaned further and piped directly into gas lines, or compressed. The method used depends on capital costs and the price the energy can earn.

Gas storage increases overall efficiency

Gas storage is built into the roofing system, so no extra equipment or maintenance is required. Depending on the substrates and their corresponding biogas production rates, the gas storage can hold 10 hours of biogas or more.

By storing biogas while performing routine maintenance on gas processing equipment, no biogas is wasted. Since the roof and gas store can be opened and closed in minutes, repairs within the digester are quick and easy. Over the lifetime of a project, this ability to store gas and still have instant access to the tanks is a significant efficiency factor. Instead of shutting down operations for hours, days or even weeks, operators can avoid stoppage or limit it to a few minutes. Every minute of gas storage is revenue.

The roofing system acts as a shell and has withstood harsh Northern European climates for a decade. A small air pump keeps its form and maintains air pressure on the gas store.



Redundancy and flexibility of substrate management adds efficiency

Having one digester or one way to add substrate to a digester leaves little room for optimization or disaster prevention and recovery. Without redundancy or flexibility in substrate treatment, methane production must cease while repairs are made, losing money each minute the process is down. For farmers who rely on manure management plans, this can also mean costly fines.

Disaster prevention and recovery lowers costs, increases revenue

Digester downtime causes loss of revenue, additional work, and higher costs. Design elements developed over the last decade enable Biogas Energy to prevent issues from causing system degradation or failure. Farmers don't have time or expertise to devote to complex, error prone technology, so Biogas Energy builds digesters with simplicity in mind. Improvements or repairs can be done by the farmer/operator, and soon the owner knows the digester better than the builder. Over the lifetime of a project, reduced downtime translates into significant energy production efficiencies for Biogas Energy Systems. Any loss of methane production for any length of time is money lost, and the following elements prevent such problems.

- Windows into the digesters (at left of photo) give crucial visual status of the contents. Any unhealthy developments within the tank such as buildup of foam or crust can be quickly identified and dealt with before they become a real issue.[1] Changing the height and/or direction of agitators (center of photo) fixes these issues and prevents a disaster.
- Web-based computer monitoring and control of operations enables operators to see functions from anywhere in the world and make changes as needed. Alarms automatically phone the digester operator and provide a message of any issue that arises so the necessary steps can be taken.

[1] This is a critical problem for concrete-roofed digesters that have no visual access within. There have been cases of a buildup of foam within digesters that caused the roof to break its seal and stop operations for weeks. Without visual monitoring within the digester, it's impossible to know a problem exists.

- Since digester roofs can be opened easily to access any equipment within the digester, maintenance doesn't affect operations. If an agitator needs attention, fold back the roof, remove the agitator and close the roof within minutes.
- Gas production sensors automatically shut off gas processing or CHP equipment to prevent damage. The operator configures the controls so that the gas processing equipment can be automatically turned down if gas production drops. If gas production stops altogether, the gas processing equipment is turned off to prevent system damage.
- Using proprietary technology, H_2S is automatically removed from the biogas to 100-500PPM[2]; well within the accepted level for most gas processing equipment.
- By taking samples of pH at any time from the well-mixed digester contents, operators can tell when to add additional substrates and in what quantities. For example, if the pH starts to decline after adding a certain substrate, adding manure improves the process and prevents problems from escalating.
- Accidental over-input of substrate has no long-term ill effects; it just pops the roof. To fix it, simply drain substrate to the proper level and re-attach the roof to regain the seal. For concrete roofed digesters, an overflow like this means weeks of downtime to re-seal the roof.
- Typically, only one pump is used to operate the facility. Gravity forces substrate from the digesters and out of the system. Fewer mechanical parts mean lower costs, lower parasitic load and fewer repairs.
- Mesophilic digesters are less complicated and more easily maintained than thermophilic digesters, and have a wider range of acceptable temperature for substrate treatment.
  This translates into lower capital and operational costs, less downtime, and lower parasitic load.
- Equipment used to construct the facility is readily available and easily maintained by the operator. Biogas Energy Systems provides support.

Expandability reduces initial investment and can be done easily

Even with adequate planning, a digester's throughput capacity may be reached well within the lifetime of the facility, especially as the operator increases his success. As the farmer expands operations more digester capacity is required.
Rather than excavating around an underground digester and knocking down a wall to expand it, Biogas Energy's modular design enables the owner to simply add more digesters and expand capacity to any size in weeks.
Expansion is completed without interruption of existing digesters' operations.
This enables owners to install minimal capacity initially and expand as needed, rather than building for future capacity and having that capital costs go unused perhaps for years.

[2] Levels may vary depending on substrate.

Low parasitic load reduces costs

Digesters are heated to foster bacteriological action. Any biogas used for heating is not adding to the revenue stream, so the parasitic load is kept to a minimum. With insulation, a circular tank, and heating pipes embedded in the floor and walls promoting even, permeating heat, Biogas Energy digesters are extremely energy efficient.

Combined Heat and Power Unit

For those customers wanting to generate electricity and sell surplus power to the grid, Biogas Energy installs Combined Heat and Power (CHP) units.
Biogas Energy supplies several brands of CHP unit, including Jenbacher, Guascor, Caterpillar, or others, depending on customer requirements.
The CHP unit is typically shipped to the sight in a sound-insulated container, and simply hooked into the system.

Container housing the CHP unit

CHP unit within the container

Since the equipment is extremely sensitive to hydrogen sulphide in the biogas, H_2S is reduced to acceptable levels using proprietary Biogas Energy technology. This increases CHP efficiency by reducing maintenance, preventing downtime, and enhancing energy production.
Equipment built into the digester facility also extracts moisture from the biogas, thereby greatly reducing wear and tear on the CHP machinery.

Heat generated by the CHP unit is used by the digesters, and ample surplus heat is also available for heating of barns, buildings, parlor water, greenhouses, etc. or for additional, optional pasteurization of substrate.

Depending on the agreement made with local power utilities, electricity generated may be net metered, fed directly to the grid, or handled in another way.

Solids feeder for multiple feedstocks

By integrating a solids feeder into the digesters, Biogas Energy customers can increase biogas production with energy crops. The solids feeders are fed once a day and configured to dose the digesters automatically.

Fiber quality produces other sources of revenue

Farmers separate solids from the digester effluent and use it as bedding for cows, thereby eliminating bedding costs.

Solids can be composted and treated as soil amendment or peat moss replacement. There is reason to plan for solids getting $5-$25/yd3, which adds significantly to the facility's bottom line.

Anaerobic digestion for farms

In the future, anaerobic digestion will be a standard part of dairy operations.

- Eliminates odors
- Reduces or eliminates pathogens from waste stream
- Improves nutrient management
- Generates revenue from methane production & greenhouse gas emissions offsets
- Generates revenue from compost or bedding sales
- Offsets power costs
- Prevents regulatory penalties for waste treatment

Please contact us with any questions

We welcome questions about our technology.

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