The AgSTAR Program, AD Opportunity & Marketplace

Purdue Extension AD Workshop - Thursday November 4, 2021

A discussion of the AD marketplace in the U.S., the types and applications of AD systems to manage manure, and AgSTAR resources to assist those interested in maintaining or pursuing an AD/biogas system to manage their manure resource.

WHAT WE'LL SEE TODAY

- The AgSTAR Program – Who we are, what we do
- Anaerobic Digestion – Types and Applications
  - System Specifications, Products of Anaerobic Digestion (AD), Business Model Options
- Overview of U.S. Livestock Biogas Market
- AD Methane Reduction Potential
- AgSTAR Resources

How AgSTAR Works

PARTNERSHIP PROGRAM

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4 **Promote Anaerobic Digestion**

Advancing economically and environmentally sound livestock manure management.

5 **Strong Ties**

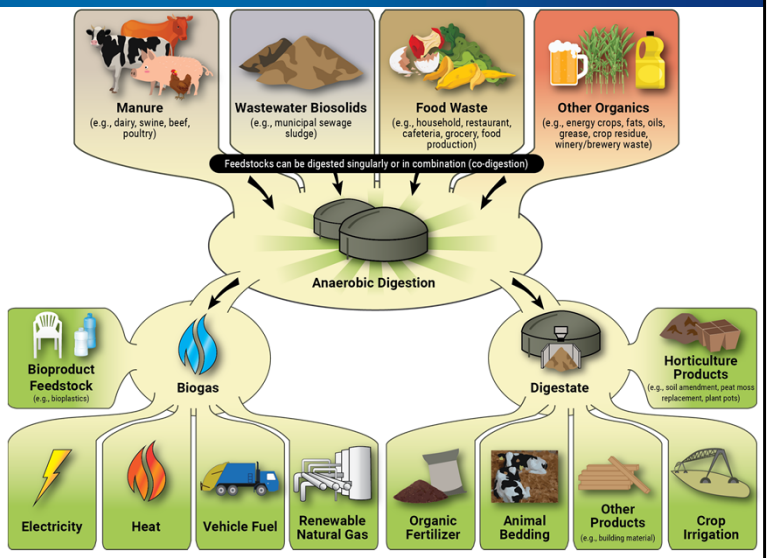
Working with industry, government, NGOs and university stakeholders.

6 **Helping Hand**

Assisting those who enable, purchase, or implement farm anaerobic digestion projects.

Digester Overview

- AgSTAR's focus is to provide guidance and best practices for managing manure resources.
  - Best Candidates – Dairy Cattle and Swine, Poultry, energy crops, some agricultural residues
  - "Output" can be estimated based on gender and lifecycle development of livestock
  - % Dissolved solids based on animal and collection
  - Not the best candidates - Beef Cattle – (infrastructure); Horses, sheep (lignin)
- AgSTAR also offers guidance on Other Organics in AD
  - Food Waste
  - Fats, Oils and Greases



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Organic Waste Handling System

The waste handling system prepares the feedstock for use in the anaerobic digester. Depending on the type of feedstock and the type of digester, pretreatment may be required. Pretreatment steps may include:

Size reduction: Depending on the type of AD/biogas system, the incoming feedstock may need to undergo size reduction. This is usually the case with continuously mixed low solid systems requiring a homogenized feedstock that is easily pumpable and mixed into the reactor.

Contamination removal: Depending on the feedstock's source, contaminants such as sand or packaging can show up at the facility. Prior to digestion, they need to be removed because they can disrupt the AD system over time. There are many available preprocessing options that can remove sand (sand separators, hydro-cyclones, or sand settling lanes), plastic bags, and other non-digestible materials (trommel screens or hydro-pulpers). Materials separated as contaminants are usually sent for disposal at a landfill.

Equilibration and Storage: The final blended feedstock is temporarily stored before being introduced into the reactor. Storage prior to digestion equilibrates and homogenizes the material and evens out fluctuations in the amount and other characteristics of the feedstock. Depending on the size and temperature of the

equalization and storage vessel, hydrolysis and acidogenesis can begin leading to significant odors.

Biogas

Biogas is composed of methane (CH_4), which is the primary component of natural gas, at a relatively high percentage (50 to 75 percent), carbon dioxide (CO_2), hydrogen sulfide (H_2S), water vapor, and trace amounts of other gases. The energy in biogas can be used like natural gas to provide heat, generate electricity, and power cooling systems, among other uses. Biogas can also be purified by removing the inert or low-value constituents (CO_2, water, H_2S, etc.) to generate renewable natural gas (RNG). This can be sold and injected into the natural gas distribution system, compressed and used as vehicle fuel, or processed further to generate alternative transportation fuel, energy products, or other advanced biochemicals and bioproducts.

Digestate

Digestate is the residual material left after the digestion process. It is composed of liquid and solid portions. These are often separated and handled independently, as each have value that can be realized with varying degrees of post processing.

With appropriate treatment, both the solid and liquid portions of digestate can be used in many beneficial applications, such as animal bedding (solids), nutrient-rich fertilizer (liquids and solids), a foundation material for bio-based products (e.g., bioplastics), organic-rich compost (solids), and/or simply as soil amendment (solids), the latter of which may include the farm spreading the digestate on the field as fertilizer. Digestate products can be a source of revenue or cost savings, and are often pursued to increase the financial and net-environmental benefit of an AD/biogas project.

Digested solids (known as fiber for farm-based systems) can be removed from the digester effluent with a solids separator. All manures produce recoverable solid fiber that may be used as animal bedding, as a soil amendment, a primary constituent in potting soils, or bio-based products (e.g., bioplastics). Emerging applications for effluent solids include use in structural building materials, such as deck boards and particle board.

The **liquid effluent** from a digester can be used as a fertilizer, reducing the purchase of commercial fertilizers.

Digester Types

Complete Mix

Plug Flow

Covered Lagoon

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- **Complete mix digesters** are designed with an enclosed, heated tank with a mechanical, hydraulic or gas mixing system. Complete mix digesters work best when there is some dilution of the excreted manure with water (e.g., milking center wastewater).
- **Plug flow digesters** are primarily used at dairy operations that collect manure by scraping. Mixed plug flow systems have been used at a wider variety of operations because they can tolerate a broader range of solids concentrations.
- In a **covered anaerobic lagoon** design, methane is recovered and piped to the combustion device from a lagoon with a flexible cover. Some systems use a single cell for combined digestion and storage.

Covered anaerobic lagoons use woven geotextile fabrics to line or cover, and therefore capture, the biogas produced from manures having less than 5 percent TS. Generally, large lagoon volumes are required, preferably with depths greater than 12 feet. The volume required

by a covered anaerobic lagoon can be roughly estimated by multiplying the daily manure volume by a desired HRT, which should be at least 60 days.

The areas where lagoon digesters can operate can generally be located south of the 40th parallel (cuts Indiana in half, divides the states of Nebraska and Kansas). They're called "ambient temperature digesters" and generally operate without added heat and can generate biogas in these warmer climates as lagoon temperature swings are relatively moderate. Covered lagoons with biogas recovery for energy purposes are typically only feasible in these moderate to warm climates.

During the colder months of the year (and for those lagoon digesters located in colder climates), less anaerobic degradation occurs as the digester temperature drops below ideal conditions. In these cases, less biogas is generated and the biogas that is recovered is usually flared to control odor.

Other Designs

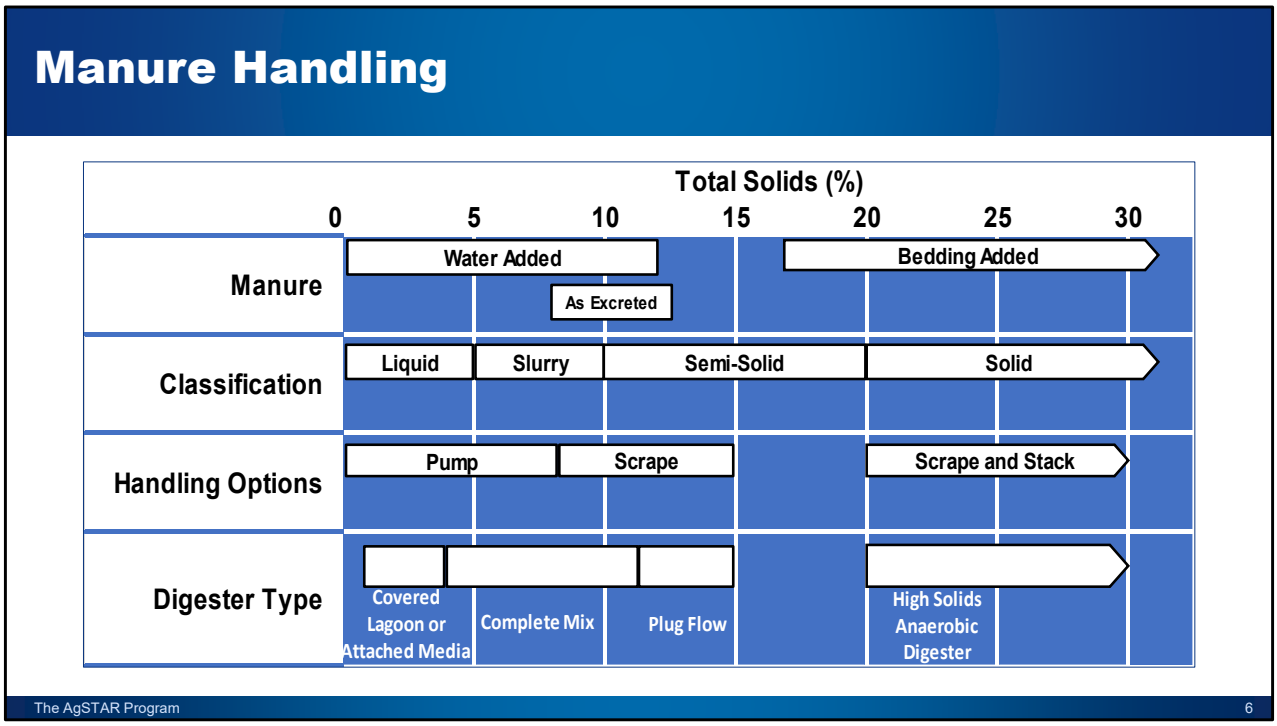
•A **batch digester** is the simplest form of digestion, where manure is added to the reactor at the beginning of the process in a batch and the reactor remains closed for the duration of the process.

•**Induced Blanket Reactors** are digesters in which a blanket of sludge develops and retains anaerobic bacteria, providing a bacteria-rich environment through which the

feedstock must pass.

•**Fixed film digesters** contain plastic media (e.g., pellets) on which bacteria attach and grow, instead of relying solely on suspended bacteria to break down the digester feedstock.

Many more resources at: https://www.epa.gov/agstar/anaerobic-system-design-and-technology



Manures from dairy and swine operations tend to be more suitable for farm-based energy conversion because dairy and swine manure management systems are often liquid- or slurry-based, which simplifies the necessary manure movement. Dairy manure also contains anaerobic bacteria, which increases the methanogen bacterial content in the digester, making it less susceptible to upsets.

There are also some things to watch out for with a manure feedstock. It must be free of large amounts of

bedding or other materials, such as rocks, stones, and sand. Animal manures containing even small amounts of fine solids can have them quickly fall out of suspension, unless they are continuously agitated. If not kept in suspension, these dropped solids can reduce reactor volume, reactor ability to produce biogas, and damage internal reactor parts.

Suspended solids can also drop out of suspension in the piping used for moving manure, which will require an expensive pump-out using a vacuum truck.

Dairy Cattle. Dairy cattle manure is quite conducive for the AD process. However, its biogas yield is comparatively low because the cows themselves already act as digesters, and the manure contains lignin that resists digestion. The benefit of using dairy manure is that it already contains anaerobic bacteria. Dairy manure adds to the methanogenic bacteria population, which helps stabilize the digester's operation. The most common methods for collecting dairy manure is either by flushing or by scraping. Dairy barns using flushing rely on large water volumes to clean the lanes between free stalls and the feed lanes. Due to the water volume, the collected manure is dilute (< 3 percent TS).

Swine. Swine manure is suitable for AD due to its high degree of readily biodegradable constituents. Most swine in animal feeding operations (AFO) are housed in barns with slotted floors. The pits under the floors are flushed, scraped or pull-plug designed. Flushed pits result in dilute manure with an approximate 2 percent TS, scraped pits yield manure that is approximately 6 percent TS, and pull-plug manure can vary between 3 and 6 percent TS.

Manure from farrowing barns presents issues for digesters due to the presence of hair from the mature hogs that can easily clog the digester. Because of the hairless nature of smaller pigs, manure used from nursery and finishing operations does not create this problem.

Poultry. Poultry manure has a high TS concentration (~25 percent TS), which makes it impractical to use on an as-excreted basis in lower-solids content digesters typically used on dairy and swine farms. Poultry manures also have high ammonia concentrations that inhibits biogas production and adversely affects the material handling equipment (i.e., it is a highly corrosive environment). Poultry feed contains considerable amounts of grit, which can also settle and accumulate in digesters. For

broiler chickens and turkeys, manure is routinely collected on an annual basis, and often contains wood shavings (liginin) and other bedding material collected from growout houses, presenting issues for digester without sophisticated handling systems.

Business Model: 3rd Party Operator

BAR-WAY FARM

Deerfield, MA

7,700 MWh
Annual energy output.

5,500 lbs
Daily offset of CO2 emissions.

Farm Facts
- 600-acres
- 250 cows milked daily

Digester Facts
- Built in 2016
- 660,000-gallon capacity
- Owned, operated and maintained by Vanguard Renewables

Annual Digester Input
- 9,200 tons of manure
- 30,000 tons of food waste

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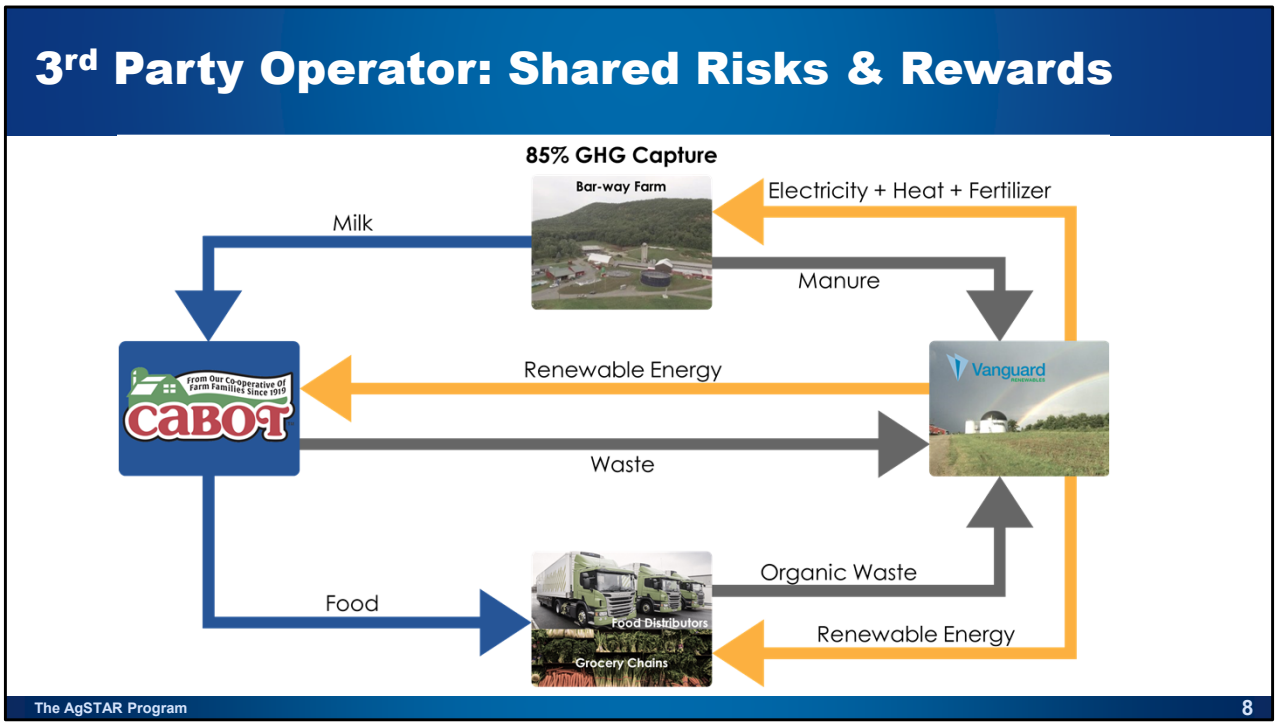
https://www.epa.gov/agstar/project-profile-bar-way-farm

•Innovative business model featuring a third-party firm to develop and operate the digester
•Manure from the farm and food waste from nearby food manufacturers and businesses are fed into the anaerobic digester to produce electricity, heat, and hot water
•First digester in the United States to utilize a hydrolyzer (The hydrolyzer is a tank that aggregates and homogenizes the feedstock before it is pumped into the anaerobic digester.)
•End products from the digester are used as bedding for the farm's cows and as a fertilizer on the farm's hay fields



In 2014, Massachusetts banned the disposal of food waste by operations that generate more than one ton of food waste per week. The food waste is required to be diverted to compost, conversion, recycle, or reuse facilities. Anaerobic digesters are one option for food waste generators to divert and recycle their food waste. The Bar-Way Farm digester helps with implementation of Massachusetts' commercial food waste ban by accepting organic material from supermarkets, restaurants, institutions, and food manufacturers.

About 100 tons of organic waste per day arrives on trucks. Food waste for the anaerobic digester is sourced from manufacturers and local businesses.

The digester generates methane gas to fuel a 1-megawatt electricity generator and generates approximately 1.62 million BTU per hour of heat that is used both by the facility and by the farm. Vanguard Renewables uploads the energy to the Eversource grid. Additionally, approximately 26,000 gallons of liquid effluent is generated daily providing a high value, odor-free fertilizer that is used on the farm's crops.

Webinar: AgSTAR's Anaerobic Digestion Resource for Farms

Hosted by: NERC (Northeast Recycling Council)/NEWMOA (Northeast Waste Management Officials' Association)

Markets for Value added Coproducts

FREUND FARM

East Canaan, Connecticut

- Small Family-owned farm
- Horizontal plug flow digester
- 300 dairy cows feeding digester

Displace unsustainable peat moss and plastic planters.

Biodegradable planter pots made from digested manure solids.

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https://www.epa.gov/agstar/project-profile-freunds-farm-inc

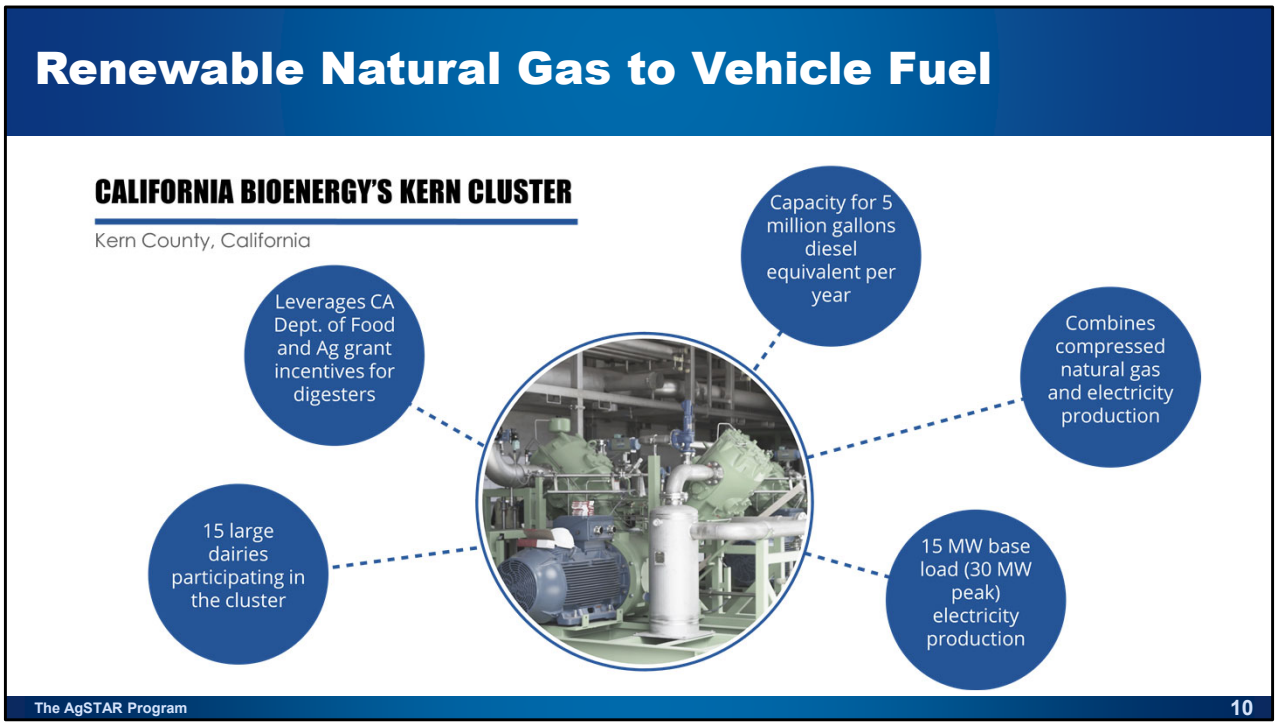
Freund's Farm, Inc., established in 1949, is a 300-head dairy farm managed and owned by the Freund family. The family's long-standing interest in pursuing sustainable farming practices, initiated by Eugene Freund, led them to build one of the first, and now longest-running, anaerobic digesters in the New England area, which then sparked the concept for CowPots™. The focus on sustainability is not limited to the digester; more than 1,200 solar panels installed on the roof of the dairy barn and CowPots™ facility ensure that the farm is completely energy independent.

In 1997, Freund's Farm installed a plug flow digester during a complete rebuild of the existing waste management system. The purpose of installing the digester was to improve manure handling during the winter months, when the cows are kept in the barn, while also recovering energy. The farm needed the ability to separate fiber from manure during the winter and to store the liquid filtrate for irrigation.

After much research and trial-and-error over several years, the Freund brothers finalized a patented process for forming the digestate into biodegradable pots made out of solid manure. The CowPots™, which are 100 percent biodegradable, are

naturally weed- and seed-free and dissolve into the ground after they are planted, leaving nutrients for young plants. CowPots™ are sold in 12 different shapes and sizes and can be purchased throughout the U.S. and internationally. Millions of CowPots™ have been produced at Freund's Farm for customers in the United States and around the world.

Matthew Freund also serves on EPA's **Farm, Ranch, and Rural Communities Federal Advisory Committee (FRRCC)** (LINK: https://www.epa.gov/faca/frrcc)



To learn more about RNG projects on Farm, EPA hosted a webinar in 2019 explaining more: https://www.epa.gov/agstar/agstar-webinar-rng-projects-agricultural-sector.

We are currently sponsoring a **Four-Part Series on Renewable Natural Gas (RNG) for Farms**
Someday as much as 10% of RNG in the U.S. pipeline could come from farm digesters (September 2011 report from the Gas Foundation, called The Potential for Renewable Gas). The opportunities for farms to create RNG are growing, but it can be challenging to keep tabs on this growing renewable energy space. Join this webinar series hosted by Newtrient to hear from RNG specialists, economists and dairy farmers who will provide a step by step approach to ensuring a successful RNG project on your farm – from start to finish.
View past recordings: https://www.epa.gov/agstar/agstar-webinars

3) Permitting, Contracts & Financing for Renewable Natural Gas (RNG) Projects
What do you need to know?
November 10, 2021 12 PM CT
Register

HTTPS://US02WEB.ZOOM.US/WEBINAR/REGISTER/WN_1Z3KIGWJQXCWBSGCUSUIFG

4) Get Ready to Break Ground on Your Renewable Natural Gas (RNG) Project

What steps do you need to take to ensure success?

December 1, 2021 12 PM CT

Register LINK:

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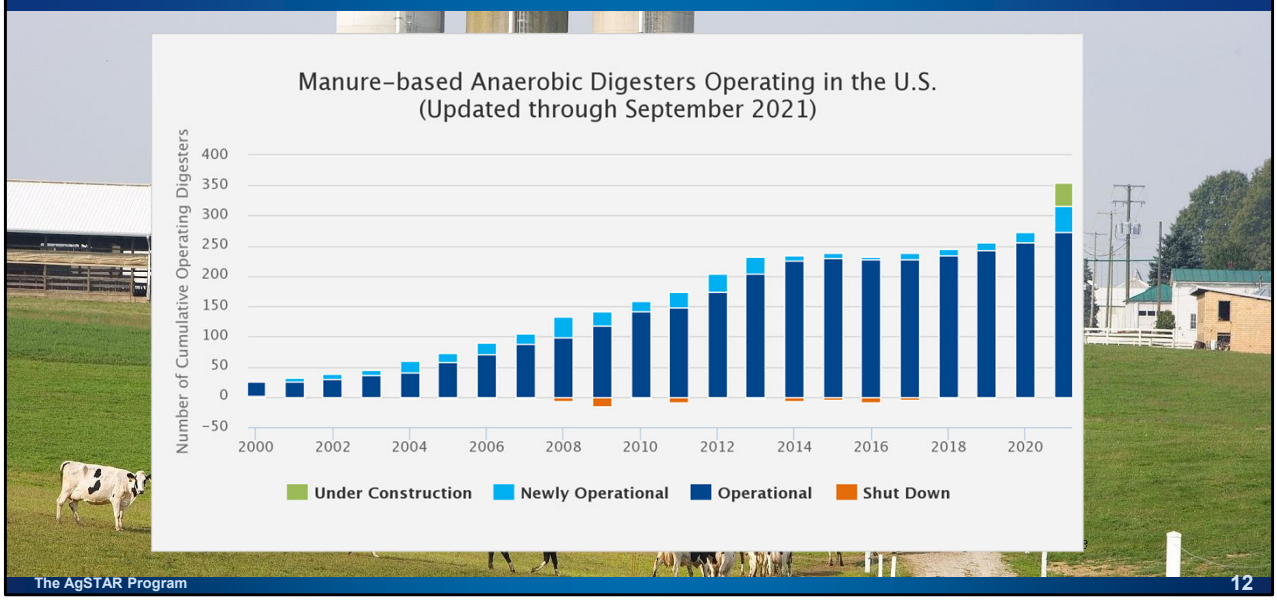
Digester Benefits in Summary

Farm Digester Market Growth



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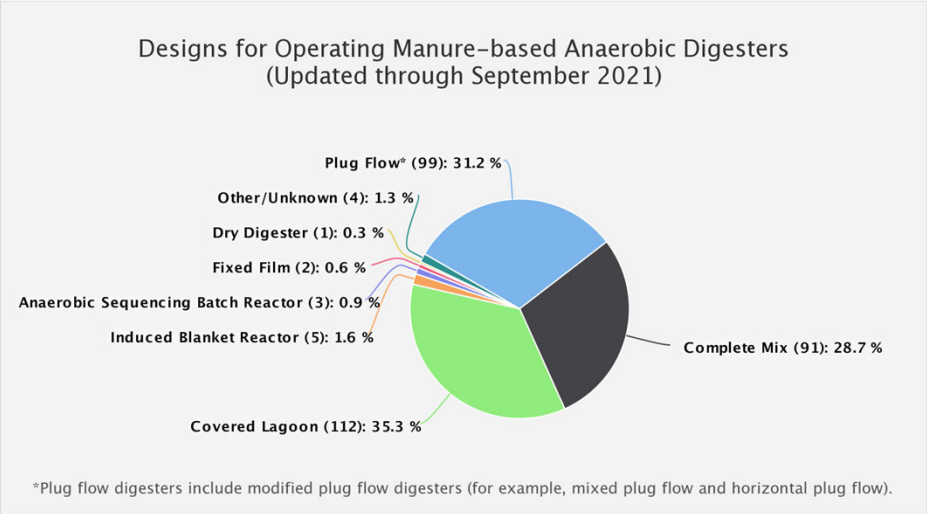
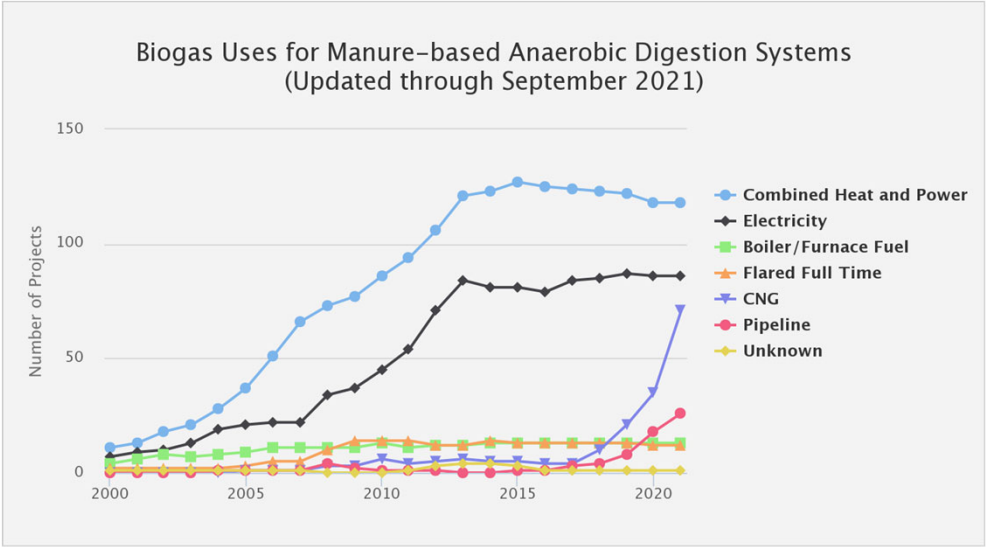
This chart shows the growth in the number of cumulative operating digester systems accepting livestock manure (Source: AgSTAR Livestock Anaerobic Digester Database). In addition to the 44 systems that have come online so far this year, another 38 are currently under construction or undergoing modification to upgrade biogas to renewable natural gas (RNG).

https://www.epa.gov/agstar/agstar-data-and-trends

Breakdown of Digester Types



End Uses of Biogas



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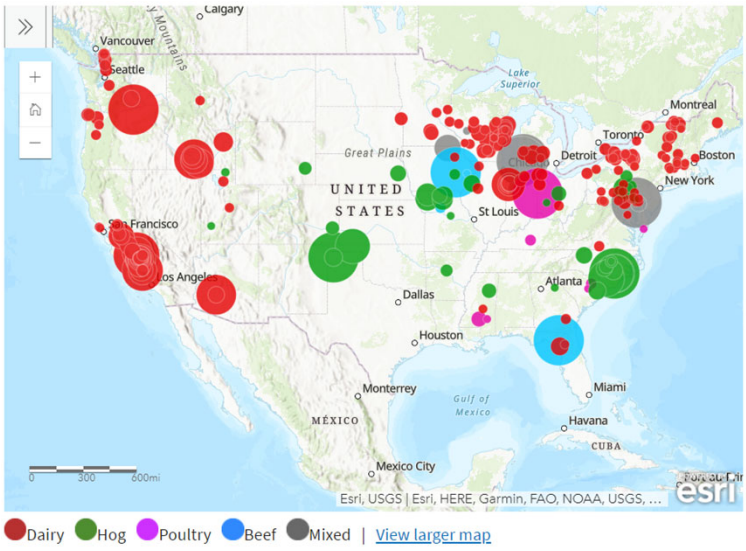
Captured and recovered biogas can be used to generate electricity, to fuel boilers or furnaces, or to create pipeline quality gas or compressed natural gas that can be sold as a vehicle fuel. While a variety of biogas use options are available, collected biogas is most often used to generate electricity and provide combined heat and power (CHP). CHP projects generate electricity and use the excess heat from electricity generation to heat digesters or adjacent buildings.

The line chart below shows trends in the end uses of biogas from manure-based anaerobic digestion systems since 2000. CHP is the most common end use, followed by electricity.

The number of CHP and electricity projects steadily increased each year from 2000 to 2013. Since then, the number of CHP and electricity projects has remained relatively stable.
The number of boiler and furnace fuel projects increased much more slowly from 2000 to 2013 and has seen little change since.
RNG projects, including pipeline injection and compressed natural gas (CNG) for vehicle fuel or other uses, have risen steadily and significantly since 2017. The rise in the number of systems producing CNG has been particularly sharp in the last year.

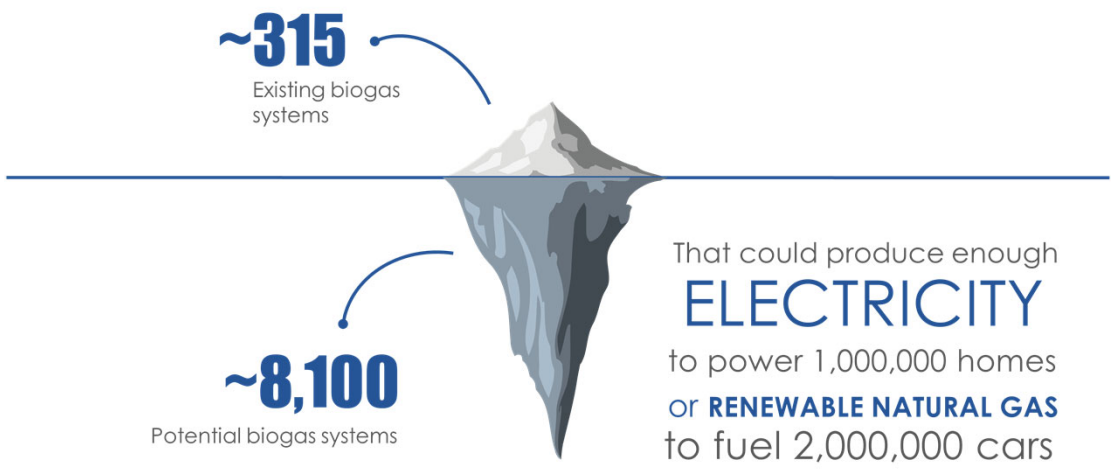
Projects that flare the biogas full time currently make up approximately 4 percent of all projects.

Where are digester's Found?



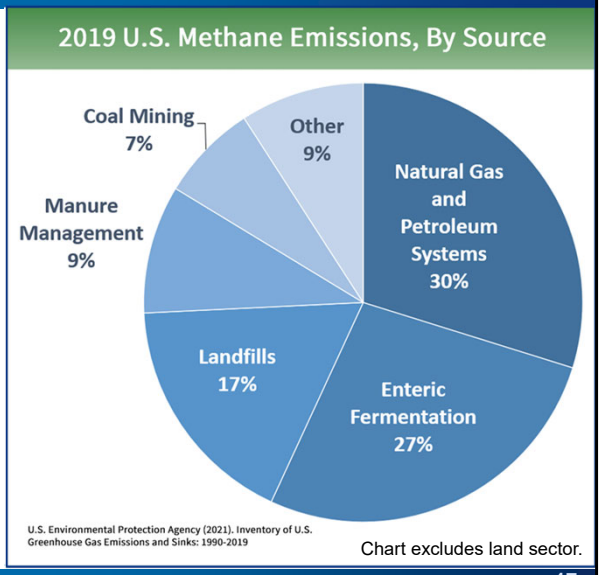
Map will be updated Tuesday Nov 2nd

Biogas system potential from manure-based anaerobic digestion



2019 U.S. Methane Emissions, By Source

- Methane = 28 - 36x greater GWP than CO_2
- Total U.S. methane emissions in 2019 = **6,558.3 MMTCO$_2$e**
- From agriculture sector = **628.6 MMTCO$_2$e** = **82.0 MMTCO$_2$e** (manure management)
- From waste sector = **110.6 MMTCO$_2$e** (landfills) = **44.8 MMTCO$_2$e** (wastewater)



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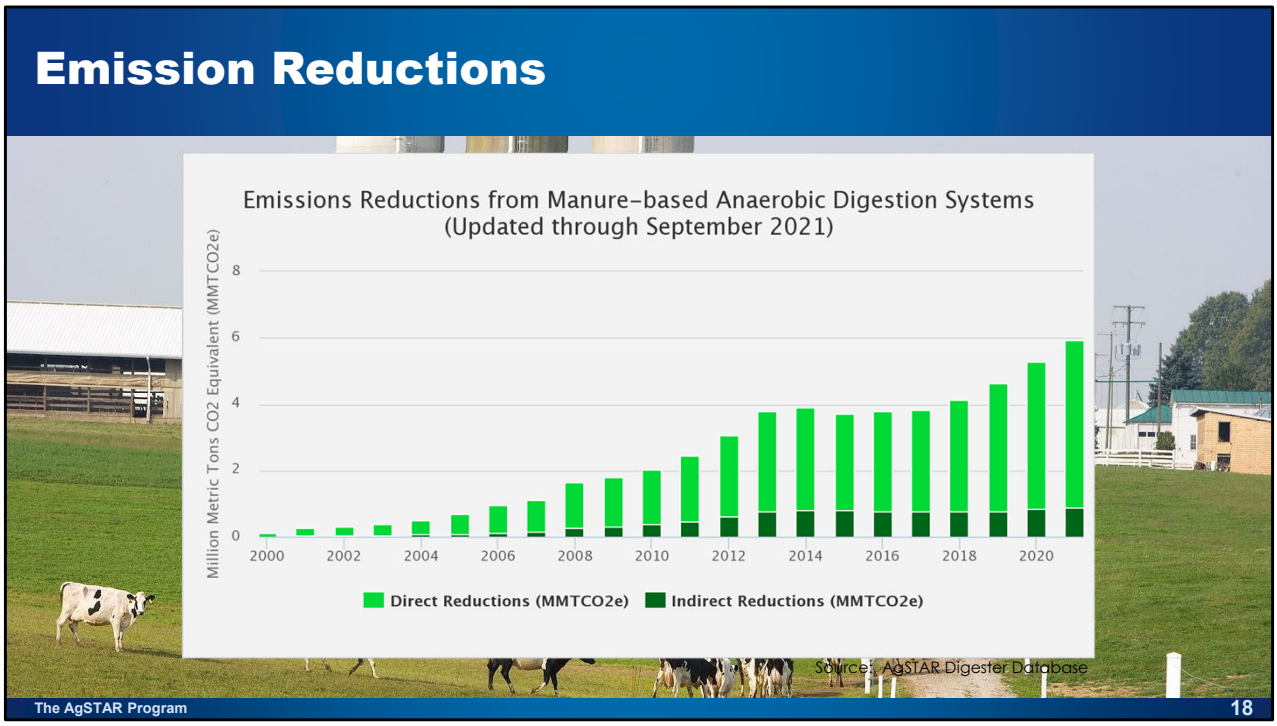
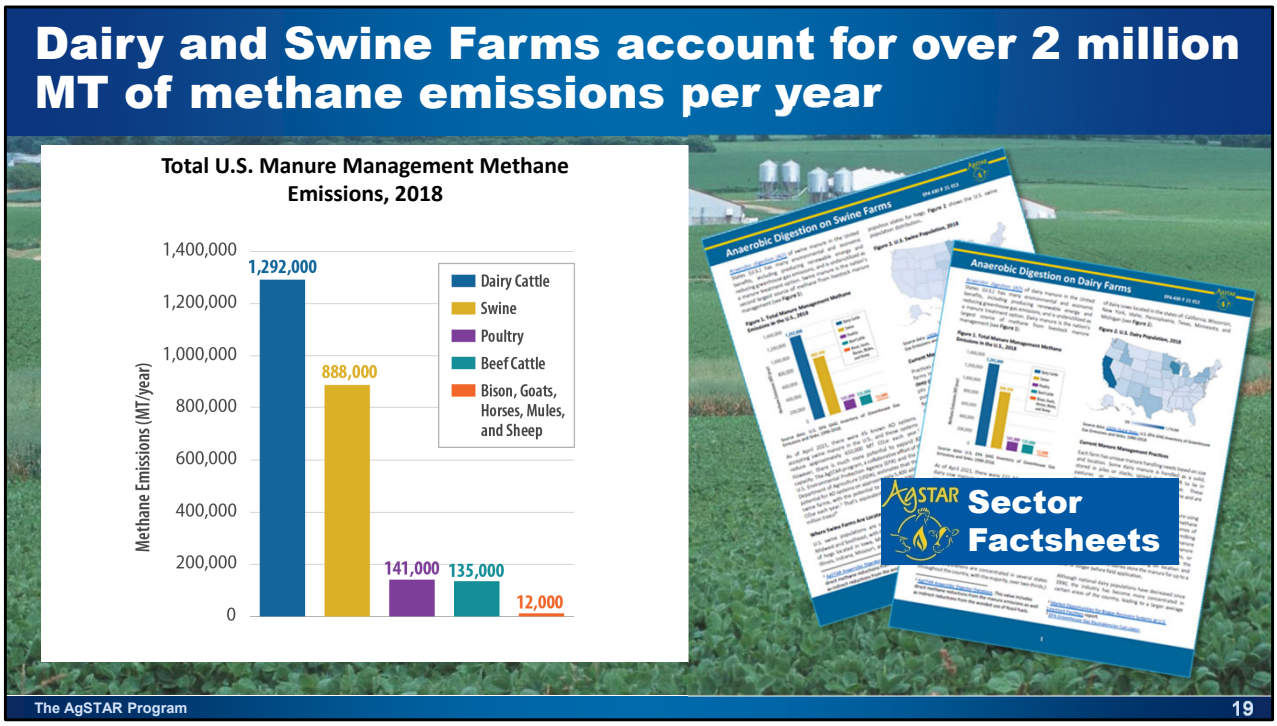
In 2019, methane (CH_4) accounted for about 10 percent of all U.S. greenhouse gas emissions from human activities.
CHART EXCLUDES LAND SECTOR: Agricultural Soil Management (344.6 MMTCO2e), Rice Cultivation (15.1 MMTCO2e), Urea Fertilization (5.3 MMTCO2e) and Liming (2.4 MMTCO2e)

Chart: https://www.epa.gov/ghgemissions/overview-greenhouse-gases
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019
Total Methane – GHGRP, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018 – Main Text" page 2-10
Manure Management – GHGRP, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018 – Main Text" page 2- 9
Landfills - GHGRP, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018 – Main Text" page 2-10
Wastewater - GHGRP, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018 – Main Text" page 2-10



The chart below shows the direct and indirect GHG emission reductions from manure-based anaerobic digesters since 2000. The chart shows a steady increase through 2013 with a projected total of 5.95 MMTCO2e in 2021. The increase in direct reductions in recent years is driven in large part by the uptick in RNG projects coming online since 2017.



Anaerobic digestion (AD) of dairy manure in the United States (U.S.) has many environmental and economic benefits, including producing renewable energy and reducing greenhouse gas emissions, and is underutilized as a manure treatment option. Dairy manure is the nation's largest source of methane from livestock manure management, with swine having the second highest potential.

AgSTAR Dairy Factsheet: https://www.epa.gov/agstar/anaerobic-digestion-dairy-farms,
AgSTAR Swine Factsheet: https://www.epa.gov/agstar/anaerobic-digestion-swine-farms

Current Dairy Farm Anaerobic Digestion Systems

221 AD systems reduce approximately 4.29 MMTCO2e each year

Potential for 2,700 more AD systems on dairy farms to reduce 29.9 MMTCO2e each year

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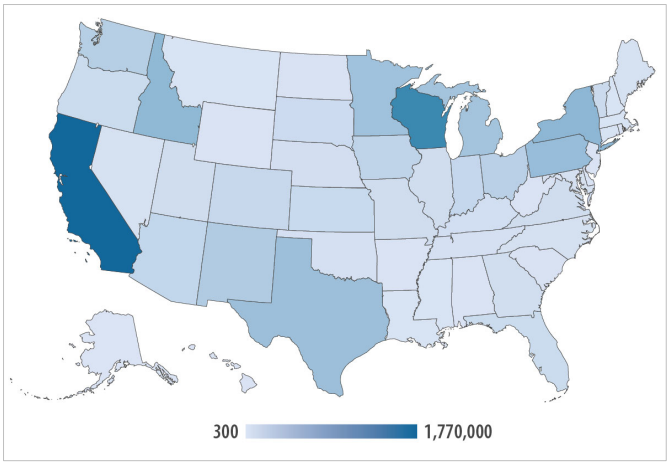
U.S. Dairy Population, 2018



As of April 2021, there were 221 AD systems processing dairy cow manure in the U.S., and these systems reduce approximately 4.29 $MMTCO_2e$ each year.[1] In addition, more than 50 dairy AD systems are currently under construction with significant opportunity to scale AD capacity over the coming years. The AgSTAR program, a collaborative effort of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA), estimates that there is potential for AD systems on approximately 2,700 additional dairy farms, with the potential to reduce 29.9 MMTCO2e each year.[2] That's equivalent to planting nearly 500 million trees![3]

U.S. dairy populations are concentrated in several states throughout the country, with the majority, over two-thirds,) of dairy cows located in the states of: California, Wisconsin, New York, Idaho, Pennsylvania, Texas, Minnesota, and Michigan

Current Dairy Farm Anaerobic Digestion Systems

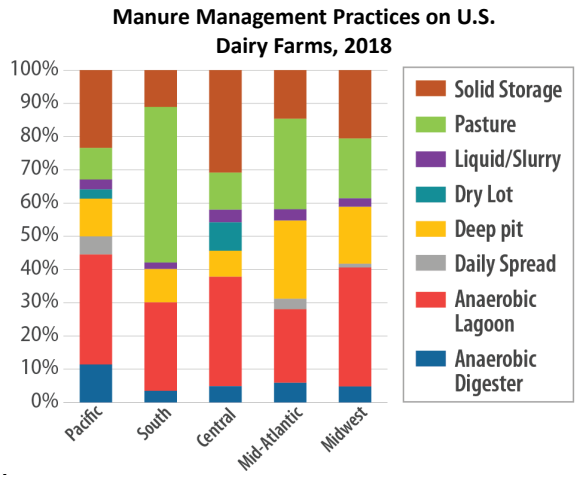
Popular AD systems for dairy manure:

- Plug flow digesters
- Complete mix digesters
- Covered lagoons

Project development trends

- Third party hub-and-spoke systems
- Centralized biogas processing

Visit the AgSTAR Dairy Factsheet to learn more.



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Current Manure Management Practices

Each farm has unique manure handling needs based on size and location. Some dairy manure is handled as a solid, stored in piles or stacks, spread daily, or left to lie in pastures or ranges where animals graze. These management practices generate minimal methane and are common for smaller operations.

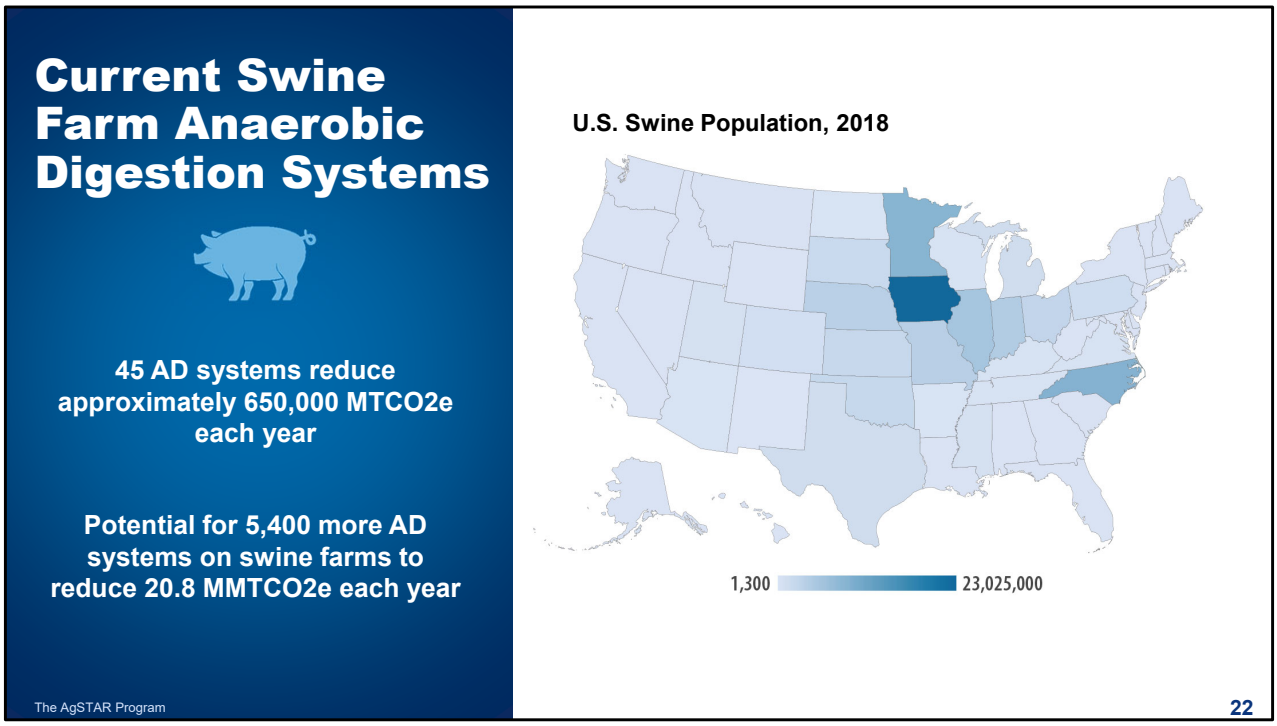
Large operations, however, tend to manage manure using systems that have a higher potential for methane emissions. **Flush collection** systems use large volumes of water to collect and remove manure from barns and milking parlors, while **scrape collection** systems remove manure from barns and alleyways. These systems move the manure into long-term storage in anaerobic lagoons, tanks, or earthen ponds under anaerobic conditions where the manure releases methane. Depending on location and cropping system, some dairies store the manure for up to a year or longer before field application.

Although national dairy populations have decreased since 1990, the industry has become more concentrated in certain areas of the country, leading to a larger average number of animals per dairy farm. As facility sizes increase, these operations are adopting more long-term manure storage systems, which have potential to emit methane.

Current Use of Anaerobic Digestion Systems

Plug flow digesters, are the most popular type of AD system for dairy operations, currently processing manure from more than 260,000 dairy cattle at about 91 AD sites.[4]

Complete mix digesters and covered lagoons, which are more suited for manure with low total solids content, are also popular for dairy manure. There are about 70 complete mix systems and 50 covered lagoon systems operating in the U.S., accepting manure from around 110,000 and 210,000 dairy cattle, respectively.[5]



As of April 2021, there were 45 known AD systems accepting swine manure in the U.S., and these systems reduce approximately 650,000 MT CO_2e each year.[1] However, there is much more potential to expand AD capacity. The AgSTAR program, a collaborative effort of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA), estimates that there is potential for AD systems on approximately 5,400 additional swine farms, with the potential to reduce 20,800,000 MT CO2e each year.[2] That's equivalent to planting nearly 350 million trees![3]

U.S. swine populations are concentrated mainly in the Midwest and Southeast, with the majority (over 55 percent) of hogs located in Iowa, Minnesota, and North Carolina. Illinois, Indiana, Missouri, and Nebraska are the next most populous states for hogs.

AgSTAR Swine Factsheet: https://www.epa.gov/agstar/anaerobic-digestion-swine-farms

Current Swine Farm Anaerobic Digestion Systems

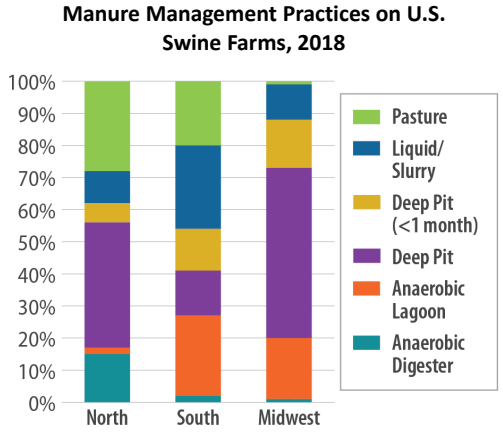
Common AD systems for swine manure:

- Covered lagoons
- Complete mix systems

Project development trends

- Integrator and project developer partnerships

Visit the AgSTAR Swine Factsheet to learn more



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Current Manure Management Practices

Practices for handling swine manure vary by region. Swine farms in some Midwest states, for example, typically use **deep pit storage**, which allows manure to drop into storage pits underneath slatted floors of the barn. Manure is pumped out once or twice a year and is land applied as fertilizer. Some digestion of manure does occur in the pits, resulting in odor issues and the release of methane into the atmosphere. Some operations send vented air from barns through a bio-filter (i.e., a bed of activated media such as wood chips) for odor control. However, due to the infrequent removal of manure, operations using deep pit storage must modify manure management processes and structures to incorporate AD systems.

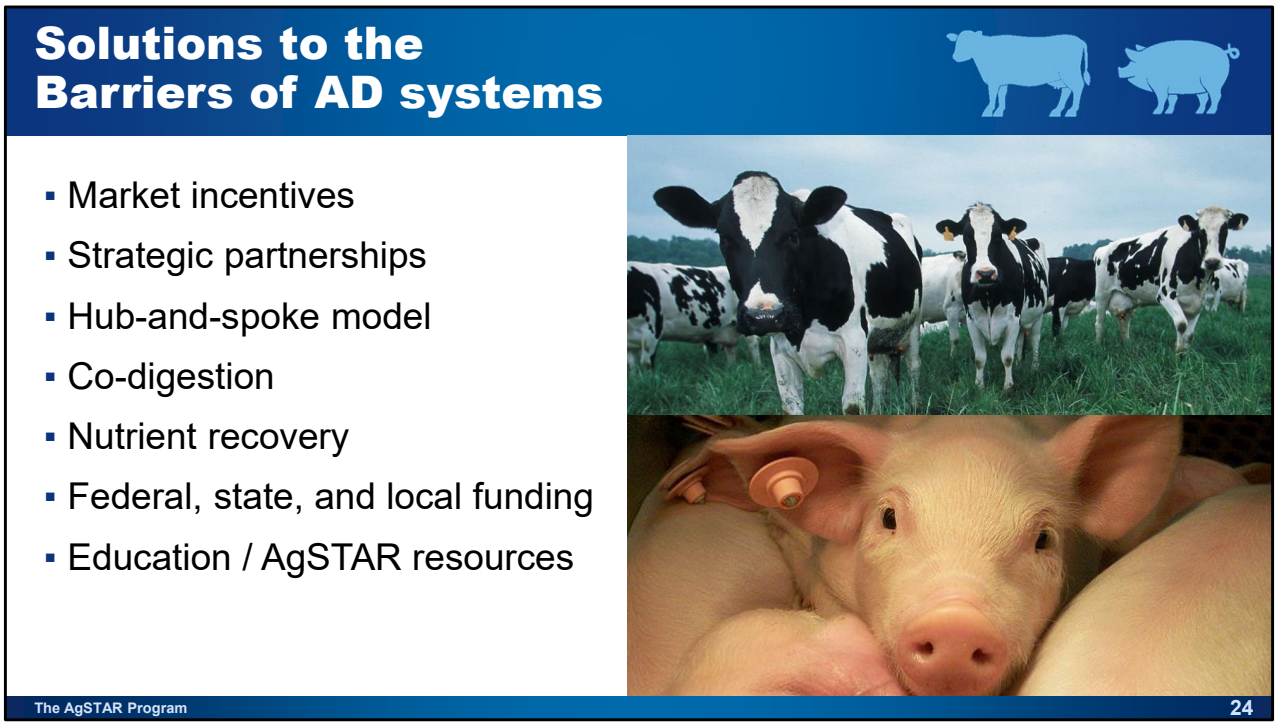
Flush collection, in which flowing water is used to remove manure, is another common manure management practice, particularly in North Carolina. The collected dilute flushed manure has traditionally been stored in outdoor uncovered lagoons. To make AD a more economical option, hog farmers may switch to **scrape collection**, thus reducing the size of the AD system needed and increasing the biogas production per gallon input potential.

Current Use of Anaerobic Digestion Systems

Covered lagoons are the most popular type of AD system for swine operations, currently processing manure from nearly 400,000 hogs at over 20 AD sites.[4] Some of these sites encompass multiple covered lagoons at adjacent farms, which send collected biogas to a centralized location for processing and use.

Complete mix systems are the second most common AD system currently in use for swine manure. There are about 18 of these systems operating in the U.S., accepting manure from around 160,000 head of swine.[5] Complete mix systems are primarily located at smaller, single-farm operations in the Midwest.

Covered lagoons and complete mix systems are typically the best AD technologies to treat swine manure because of the dilute nature of flushed swine manure.



AD remains an uncommon manure management practice in the dairy industry mainly due to economic challenges. In addition to the significant capital cost of the digester, hiring additional staff to operate and maintain the AD system and meeting regulatory or permitting requirements may also be costly. A farmer may be aware of the benefits of AD, but if the cost is perceived to outweigh those benefits, there is limited incentive to pursue AD. Benefits such as environmental stewardship, odor reduction, and emission reductions are difficult to monetize, and revenue from renewable electricity generation, although a potential source of direct income for a farm with an AD system, is often not high enough to make up the deficit. Furthermore, low electricity rates have made it increasingly difficult for power generation projects to remain profitable.

Solutions

The most effective way to address economic barriers is to develop dependable markets that increase project revenue and reduce project costs. Considerations for increasing revenue or cost savings include:

•***Market incentives for biogas.*** Tax credits, renewable energy credits, carbon offset credits, or other incentives offered through federal or state renewable or low carbon fuel standards are a potential source of revenue or cost savings. Several states have

created programs focused on the reduction of fossil fuel-based fuel, such as Low Carbon Fuel Standard (LCFS) incentive programs in California and Oregon. At the federal level, the Renewable Fuel Standard provides market-based monetary value for renewable fuels, including RNG.

Market trends for renewable/low carbon fuels have made RNG more valuable than electricity. If a project can demonstrate that RNG is used as transportation fuel and meets appropriate requirements, RNG can also generate Renewable Identification Numbers or LCFS credits. Because of this, a large portion of dairy projects currently in development have plans to produce RNG.

•***Strategic Partnerships.*** Many companies and utilities are willing to pay a premium for renewable energy or carbon offsets to reduce their carbon footprint. Biogas producers that partner with an organization to purchase the gas could potentially achieve greater revenues. Brightmark, for instance, an RNG developer with clusters of digester projects across the county, has partnered with Chevron in a joint ventureEXIT to produce and market dairy-based RNG. Brightmark owns the projects, and Chevron purchases and markets RNG produced from the AD systems for use in vehicles that run on CNG.

•***Third party build/own/operate models.*** These models can relieve the farmer of financial risk, as well as operational and maintenance responsibilities, while still providing the farmer benefits like odor reduction and improved public image. Hub-and-spoke business models like those noted above take advantage of economies of scale by using one large, centralized facility for multiple farms.

•***Codigestion.*** Depending on the AD system, food waste or other organics may be codigested with dairy manure to increase biogas production rates, which can increase revenue from energy sales. Charging a tipping fee for the disposal of other parties' wastes is another source of income. Barstow's Longview Farm (pdf), in Massachusetts, codigests approximately 22,000 tons of organic byproducts annually from a nearby creamery, in addition to the 9,000 tons of manure their dairy generates every year. Biogas from the digester is used to generate over 6,000 kilowatt hours per year, a portion of which powers the creamery.

•***Nutrient concentration.*** Where technically feasible, creating other products such as concentrated nutrient fertilizers can add to revenues or directly reduces costs of nutrient management. The Audet family, of Blue Spruce Farm in Vermont, installed a phosphorus recovery system (pdf) at their dairy to further dewater separated digestate solids from their plug flow digester. The system, which uses dissolved air flotation, can capture 75 to 85 percent of the fine solids and phosphorus in the manure stream, yielding low-solids irrigation water and a stackable nutrient-rich solid product that can be marketed and sold off site as a soil amendment or fertilizer.

•***Federal, state, or local funding and streamlined permitting.*** Federal, state, or local direct financial assistance for feasibility studies and/or up-front costs can reduce financial barriers to implementing sustainable practices. The Project Planning and

Financing page on the AgSTAR website includes a table of resources to help identify funding opportunities. Additionally, streamlining permitting processes can reduce project costs and expedite development of projects.

Additional New Resources for AD/ Biogas Systems

- **Biogas Toolkit**:
  - A web-based toolkit with 36 tools and resources to facilitate biogas project development.
- **Project Development Handbook (3rd Edition):**
  - A comprehensive compilation of the latest knowledge in the industry on best practices for anaerobic digestion AD/ biogas systems.
- **Operator Guidebook (1st Edition)**:
  - A guide for AD/ biogas systems operators to ensure safe and efficient operations the systems they manage.
- **AD Risk Analysis Checklist**:
  - A checklist of best practices to help users determine technical & financial feasibility of AD/ biogas projects.
- **AD Screening Tool**:
  - Free, Microsoft Excel-based screening tool to assess the potential feasibility of AD projects in the U.S. and globally.

Resources for the Agriculture Sector

www.epa.gov/agstar

Success Stories

- Project profiles
- Interviews with operators

Market Trends

- National data for anaerobic digester projects
- Market Opportunities Report

Technical Information

- Biogas Toolkit
- Updated 3rd Edition Project Development Handbook
- Operators Guidebook
- AD Risk Analysis Checklist

Collaboration

- Webinars
- Industry events & trainings - virtual

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