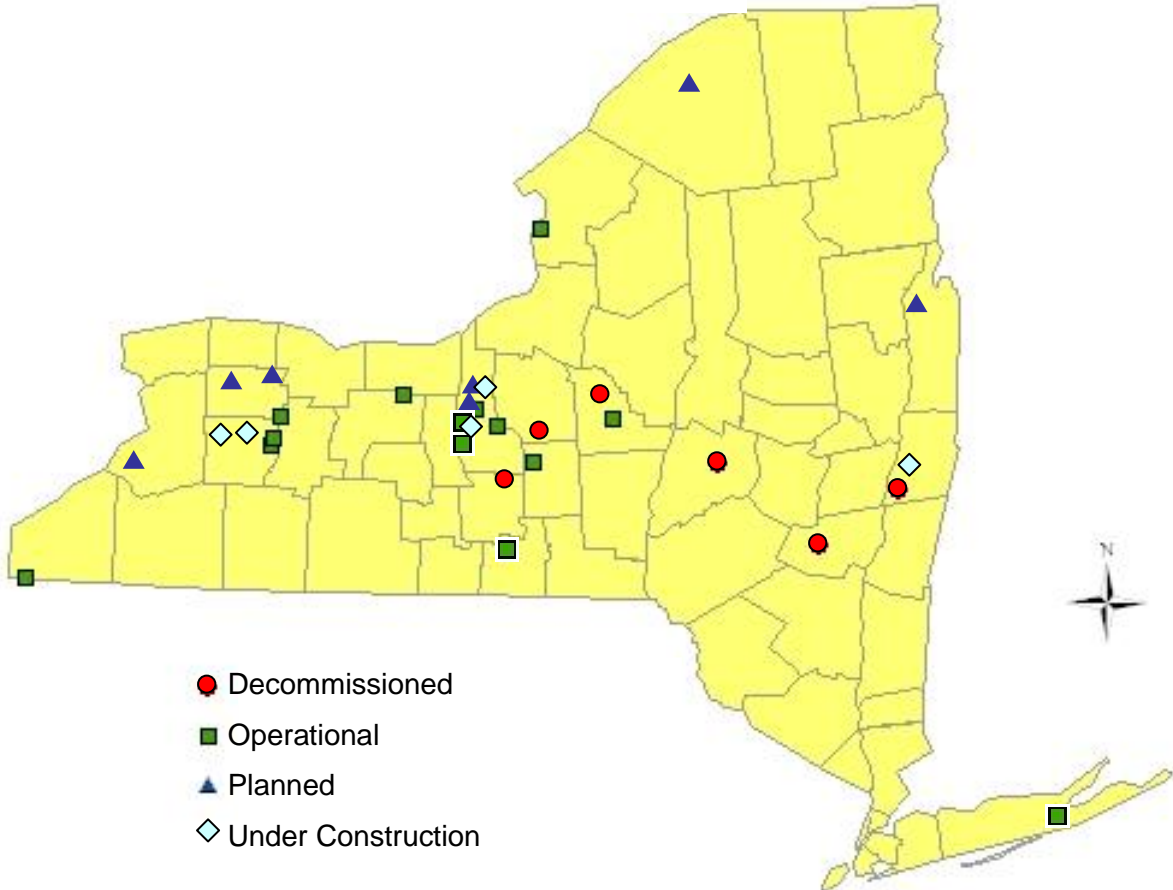


Biogas Casebook: NYS On-farm Anaerobic Digesters



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Table of Contents

Glossary & Abbreviations.....

Chapter 1. Background.....

Chapter 2. Summary charts.....

Chapter 3. Case Studies: New York.....

 3.1. Operating AD's

AA Dairy

Aurora Ridge Dairy

Corwin Duck Farm

El-Vi Farms

Emerling Farm

New Hope View Farm

Noblehurst Farms

Patterson Farms

Ridgeline Farm

Roach Dairy

Sheland Farms

SUNY Morrisville

Sunny Knoll Farm

Sunnyside Farms

Twin Birch Farms

 3.2 Design/Planning Stage AD's

 3.3 Decommissioned AD's.....

Farber Farm

Spring Valley Dairy

Cooperstown Holsteins

Agway

Millbrook Farm

Curtain Brothers

Chapter 4. Lessons learned & Common problems.....

Appendices.....

Abbreviations

AD	Anaerobic digester
HRT	Hydraulic retention time
kW	Kilowatt
kWh	Kilowatt hour
TS	Total solids
TVS	Total volatile solids
NYSERDA	New York State Energy Research and Development Authority
ASERTTI	Association of State Energy Research and Technology Transfer Institutions
Btu	British thermal unit
SLS	Solid-liquid separator
CH ₄	Methane
CO ₂	Carbon dioxide
H ₂ S	Hydrogen sulfide
ppm	parts per million
Eng-gen set	Engine-generator set
NYS	New York State
GHG	Greenhouse gases
MC	Milking center

Glossary¹

Anaerobic bacteria

Microorganisms that live and reproduce in an environment containing no “free” or dissolved oxygen.

Anaerobic digester

A vessel and associated heating and gas collection systems designed specifically to contain biomass undergoing digestion and its associated microbially produced biogas. Conditions provided by the digester include: an oxygen-free environment, a constant temperature, and sufficient biomass retention time.

Anaerobic digestion

A biological process in which microbes break down organic material while producing biogas as a by-product.

Anaerobic lagoon

A holding pond for livestock manure that is designed to anaerobically stabilize manure, and may be designed to capture biogas with the use of an impermeable, floating cover.

¹ Adapted from reference: (Public, 2006)

Annual capital cost

The equivalent annual capital cost converts the total capital costs into an annual charge. The equivalent annual capital cost is calculated according to the formula $EAC = pv / (1/r - 1/(r*(1+r)^n))$ where “pv” is the present value or total capital investment in today's dollars, r is the discount rate, and n is the life of the capital investment.

Barn effluent

Material exiting a barn structure, generally consisting of animal excrement (urine and feces) and used bedding material, and may contain milking center washwater.

Biogas

For the purposes of this document, the raw and un-cleaned gas produced by an AD, consisting of mainly methane CH₄ (~60%), carbon dioxide CO₂ (~40%), water vapor, and hydrogen sulfide.

British Thermal Unit (Btu)

The English System standard measure of heat energy. It takes one Btu to raise the temperature of one pound of water by one degree Fahrenheit at sea level.

Capital cost

A one-time fixed cost incurred on the purchase of buildings and equipment. A digester's capital cost includes the purchase of land the system is on, permitting and legal costs, the equipment needed to run the digester, cost of digester construction, the cost of financing, and the cost of commissioning the digester prior to steady-state operation of the digester.

Centralized digester

An anaerobic vessel which uses feedstocks from several farms and/or other biomass sources, within a relatively proximate distance to the digester location.

Co-generation

The sequential use of energy for the production of electrical and useful thermal energy. The sequence can be thermal use followed by power production or the reverse, subject to the following standards: (a) At least 5% of the co-generation project's total annual energy output shall be in the form of useful thermal energy. (b) Where useful thermal energy follows power production, the useful annual power output plus one-half the useful annual thermal energy output equals not less than 42.5% of any natural gas and oil energy input.

Combined Heat and Power (CHP)

The sequential or simultaneous generation of two different forms of useful energy – mechanical/electrical and thermal – from a single primary energy source in a single, integrated system. CHP systems usually consist of a prime mover, a generator, a heat recovery system, and electrical interconnections configured into an integrated whole.

Complete mix digester

An anaerobic vessel that is mixed with one or more mixing techniques.

Dewater

To drain or remove water from an enclosure. Dewater also means draining or removing water from sludge to increase the solids concentration.

Digestate

Effluent; Material remaining after the anaerobic digestion of a biodegradable feedstock. Digestate is produced both by acidogenesis and methanogenesis, and each has different characteristics.

Discount rate

The interest rate used in discounting future cash flows.

Distributed generation

A distributed generation system involves small amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads.

Distribution system (electric utility)

The substations, transformers and lines that convey electricity from power plant via transmission lines to consumers.

Effluent

Digestate; Material exiting the AD vessel.

Emission

The release or discharge of a substance into the environment; generally refers to the release of gases or particulates into the air.

End-use sectors

The residential, commercial, transportation and industrial sectors of the economy.

Engine-Generator set

The combination of an internal combustion engine and a generator to produce electricity; may be single or dual fueled depending on the location and set up.

Flare

A device used to safely combust surplus or unused biogas.

Greenhouse Gas (GHG)

A gas, such as carbon dioxide or methane, which contributes to a warming action in the atmosphere.

Grid

The electric utility companies' transmission and distribution system that links power plants to customers through high power transmission line service; high voltage primary service for industrial applications; medium voltage primary service for commercial and industrial applications; and secondary service for commercial and residential customers. Grid can also refer to the layout of gas distribution system of a city or town.

Hydraulic retention time (HRT)

The length of time material remains in the AD.

Hydrogen sulfide (H₂S)

A toxic, colorless gas that has an offensive odor of rotten eggs. Hydrogen sulfide has serious negative implications for the wear of gas handling equipment for an anaerobic digester system.

Hydrolysis

A biological decomposition process involved in the anaerobic digestion of organic material.

Influent

Biomass on the in-flow side of a treatment, storage, or transfer device.

Installed capacity

The total capacity of electrical generation devices in a power station or system.

Kilowatt-hour (kWh)

The most commonly used unit of measure of the amount of electric power consumed over time. The stand-alone unit indicates one kilowatt of electricity supplied for one hour.

Lagoon

In wastewater treatment or livestock facilities, a shallow pond used to store wastewater where biological activity decomposes the waste.

Lost capital

The portion of a capital investment that cannot be recovered after the investment is made, usually used to express the immediate loss in value of a purchased or constructed item.

Main tier

Distributed renewable energy systems where the electrical power produced is not used on-site but rather transported to the grid for use elsewhere. Wind generation generally falls into this category.

Manure

The combination of urine and feces.

Methane (CH₄)

A flammable, explosive, colorless, odorless, gas. Methane is the major constituent of natural gas, and also usually makes up the largest concentration of biogas produced in an anaerobic digester.

Methanogens

Active in phase 3 of the digestion process (methanogenesis), acids (mainly acetic and propionic acids) produced in phase 2 are converted into biogas by methane-forming bacteria.

Microturbine

A small combustion turbine with a power output ranging from 25- to 500-kW. Microturbines are composed of a compressor, combustor, turbine, alternator, recuperator, and generator.

Net generation

Gross generation minus the energy consumed at the generation site for use in maintaining energy needs (heat or electric).

Net metering

A billing practice used by utilities for certain customers who generate electricity. “Net” refers to the difference between the electricity sold to the customer-generator by the utility and the electricity purchased by the utility from that customer-generator.

Net Present Value (NPV)

The present value of an investment’s future net cash flow minus the initial investment. Generally, if the NPV of an investment is positive, the investment should be made.

Operation and Maintenance (O&M) costs

Operating expenses are associated with running a facility. Maintenance expenses are the portion of expenses consisting of labor, materials, and other direct and indirect expenses incurred for preserving the operating efficiency or physical condition of a facility.

Plug-flow digester

A design for an anaerobic digester in which the material enters at one end and is theoretically pushed in plugs towards the other end, where the material exits the digester after being digested over the design HRT.

Present value

The current value of one or more future cash payments, discounted at some appropriate interest rate.

Rate of return

The annual return on an investment, expressed as a percentage of the total amount invested.

Siloxane

Any of a class of organic or inorganic chemical compounds of silicon, oxygen, and usually carbon and hydrogen, based on the structural unit R_2SiO where R is an alkyl group, usually methyl.

Tipping fees

Monies that are paid to a site that is accepting outside sources of organic material (non-farm biomass).

Ton

US short ton equals 2,000 lbs

Tonne

Metric ton equals 1,000 kg

Treatment volume

Inside volume of an anaerobic digester that, under normal operating conditions would be occupied with material undergoing anaerobic decomposition.

Turbine

A device for converting the flow of a fluid (air, steam, water, or hot gases) into mechanical motion.

Volatile solids

Those solids in water or other liquids that are lost on ignition of the dry solids at 550 degrees Centigrade.

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Chapter 1. Background

This casebook provides case study synopsis reports of all on-farm animal waste anaerobic digesters (ADs) in New York State (NYS) as of July 2010. Over the past decade in NYS, anaerobic digestion technology has been increasingly implemented as an on-farm manure treatment strategy to reduce odors and environmental pollution, and to produce renewable electricity. More recently, the issue of greenhouse gas (GHG) emissions from agriculture has received increased attention and anaerobic digestion is seen as a viable solution to managing methane gas – one of the more potent GHGs.

This case study book was modeled after the *Agricultural Biogas Casebook* containing similar case studies of digesters in the Great Lakes region of the U.S. (Kramer, 2002) and the *Agricultural Biogas Casebook* which was updated in 2008. The information contained in these case studies is intended to provide a basic understanding of on-farm ADs in NYS. The lessons learned reported by each farm are provided herein to help others avoid similar mistakes in future projects. Existing and future AD owners/operators and their advisors, as well as government agencies, academia, policy makers, and the general public will find this casebook helpful for a current overview of the status of anaerobic digesters in NYS.

Details for each case study were collected through site visits to each AD system and extensive conversations with each system owner/operator. On-going updates are made to this document as new information becomes available; the most recent version, as indicated on the front cover, can be found on the website listed at the bottom of the page. Complete versions of each case study are also available, and can be found at the website listed at the bottom of the page.

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Chapter 2. Summary Tables

An overview of the basic aspects of each anaerobic digester system is provided in Tables 1 and 2 for the purpose of a quick comparison. It is recommended however, that each individual case study be examined for details regarding changes in animal population, management practices, or system design. Only operational ADs with a case study synopsis provided herein, are described in Tables 1 and 2.

Table 1. New York State operational AD specifications

Farm	Type	Designer	Capital Cost (\$)	Start-up	# of milking cows	Est. HRT (days)	Est. loading rate (gal/day)
AA Dairy	Plug-flow	RCM Digesters, Inc.	363,000	1998	600	37	11,000
Aurora Ridge Dairy	Plug-flow with biogas recirculation	GHD	2,300,000	2009	1,600	22	84,000
Corwin duck farm	Complete mixed	Applied Technologies, Inc. (Wisconsin)	2,200,000	2005	130,000 ducks	10	100,000
El-Vi Farms	Plug-flow/mixed	N/A	294,000	2004	800	10	30,000
Emerling Farm	Plug-flow	RCM Digesters, Inc.	N/A	2006	1,100	20	48,000
New Hope View Farm (formerly DDI)	Plug-flow	RCM Digesters, Inc.	984,000	2001	850	20	25,000
Noblehurst Farms	Plug-flow; twin cells	Cow Power, Inc.	747,700	2003	1,600	23	30,000
Patterson Farms	Complete Mixed	RCM Digesters, Inc.	1,500,000	2005	1,000	22	45,000
Ridgeline Farm (formerly Matlink)	Complete mixed; twin cells	RCM Digesters, Inc.	622,000	2001	600	20	25,000
Sheland Farms	Vertical complete mixed	Siemens Building Technologies, Inc.	1,200,000	2007	560	17	14,000
SUNY Morrisville	Plug-flow; twin cells	Cow Power, Inc.	936,000	2007	400	25	10,000
Sunny Knoll Farm	Plug-flow	RCM Digesters, Inc.	1,000,000	2006	1,400	18	43,000
Sunnyside Farms	Plug-flow with mixing	GHD	4,500,000	2009	3,750	N/A	N/A
Twin Birch Farms	Plug-flow	AnAerobics/Twin Birch Farm	N/A	2003	1,200	20	29,000

N/A: information not available

Table 2. Operational AD Specifications (continued)

Farm	Influent	Stall Bedding	Rumensin [®] usage	SLS	Biogas use(s)	Carbon Credits
AA Dairy	Manure, SLS ² liquid	Sawdust	Yes	Yes; compost produced and sold	130-kW eng-gen set	No
Aurora Ridge Dairy	Manure	Sawdust	Yes	N/A	500-kW eng-gen set	No
Corwin duck farm	Manure	None	No	Yes; settling tank and double drum screen	Compressed air generation	No
El-Vi Farms	SLS liquid	Post-digested separated solids	N/A	Yes; solids used for bedding and sold	Biogas fired boiler	N/A
Emerling Farm	Manure, hog processing waste	Post-digested separated solids	N/A	Yes; solids used for bedding	230-kW eng-gen set	No
New Hope View Farm (formerly DDI)	Manure	Sawdust	No	No (not currently in use)	70-kW microturbine	No
Noblehurst Farms	Manure, hog processing waste	Post-digested separated solids	Yes	Yes; solids used for bedding	130-kW eng-gen set	Yes
Patterson Farms	Manure, cheese whey, onion waste	Post-digested separated solids	Yes	Yes; solids used for bedding	250-kW eng-gen set	Yes
Ridgeline Farm	Manure, various food wastes (hog processing waste, ice cream waste, salad dressing, etc.)	Sawdust	Yes	No (not currently in use)	130-kW eng-gen set; biogas fired boiler	Yes
Sheland Farms	Manure	Post-digested separated solids	Yes	Yes; solids used for bedding	125-kW eng-gen set	No
SUNY Morrisville	Manure	Sawdust	N/A	No	50-kW eng-gen set	No
Sunny Knoll Farm	Manure	Sawdust	Yes	No	230-kW eng-gen set	No

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² SLS: solid-liquid separator

Farm	Influent	Stall Bedding	Rumensin[®] usage	SLS	Biogas use(s)	Carbon Credits
Sunnyside Farms	Manure	Post-digested separated solids	N/A	Yes; solids used for bedding	500-kW eng-gen set	N/A
Twin Birch Farms	Manure	Post-digested separated solids	Yes	Yes; solids used for bedding and sold	(6) 30-kW microturbines; biogas fired boiler	Yes
					Total: 2,525 kW	

Chapter 3. Case Studies: New York State

3.1 In operation

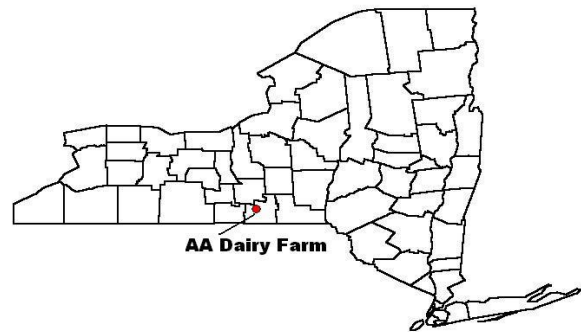
AA Dairy

169 Spencer Road
Candor, NY 13743

Farm overview

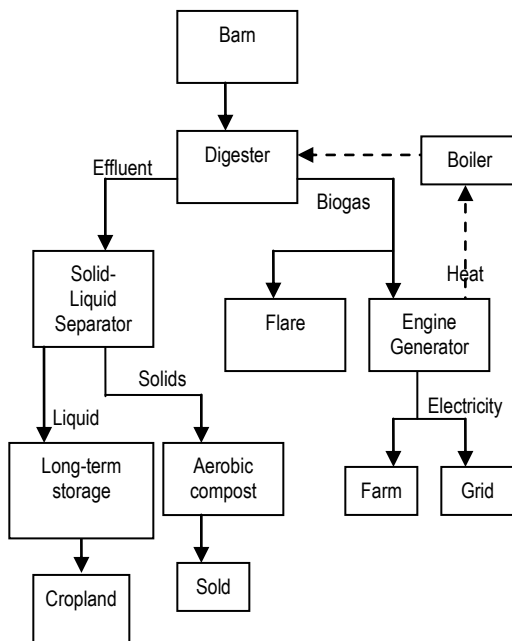
AA Dairy is a 600-cow dairy operation located on 2,200 acres in the town of Candor in Tioga County, New York. The current dairy facilities were populated in the summer of 1993. Shortly thereafter, farmstead odors began to cause local concern, and thus, the decision was made to construct an anaerobic digester; it began operating in June 1998. Benefits (other than odor control) derived from this digester include:

- Electricity and heat generated from the biogas
- Compost produced from the post-digested separated solids
- Irrigation liquid from the post-digested separated liquid



Digester system

An RCM Digesters, Inc. plug-flow digester sized for 1,000 cows was constructed. The below-grade cast-in-place concrete digester structure is 130' long, 30' wide and 14' deep. Influent is warmed to approximately 100°F by an in-vessel



Digester type	plug-flow
Digester designer	RCM Digesters, Inc.
Number of cows	600
Influent material	raw manure
Dimensions (WxLxD)	30' x 130' x 14'
Design temperature	100°F
Estimated total loading rate	11,000 gal/day
Treatment volume	408,436 gallons
Estimated hydraulic retention time	37 days
Solid-liquid separator ...	yes; composted solids
Carbon credits	no
Capital cost	\$363,000
Start-up	1998
Biogas clean-up	present; not in use
Biogas utilization	130-kW eng-gen set

heating system. A 7.5-Hp piston pump transfers influent (raw manure mixed with freestall bedding, milking center wastewater if necessary to dilute manure, and/or solid-liquid separator (SLS) liquid effluent) to the digester continuously for 4-6 hours per day. Approximately 11,000 gallons of influent are fed to the digester each day (Gooch et al., 2007). With this daily flow volume, the estimated hydraulic retention time is about 37 days.

Liquids and solids process description

Shredded newspaper, sawdust, and approximately 10 yd³/week of kiln-dried shavings are used for bedding. Manure mixed with used stall bedding (barn effluent) is continuously scraped by alley scrapers from the freestall barn to a central, cross-barn, below-grade manure channel. Barn effluent in this channel flows by gravity to the digester influent holding pit and is mixed with milking center wastewater to dilute the digester influent as needed. The farm adds about 10 gallons per week of used restaurant fryer oil, claiming it keeps foaming to a minimum, and prevents crust buildup within the digester.

After digestion, effluent is pumped to a FAN screw-press SLS with a 7.5-Hp piston pump. The separated solids are aerobically composted in windrows, and the separated liquid flows by gravity to a 2.4 million-gallon HDPE-lined long-term storage. Finished compost is sold in large and small bulk quantities and in 20-pound bags available at local farm and garden suppliers. The compost has been approved for use in organic food production. The long-term storage contents (separated liquid + rainwater) are pumped by buried pipeline to the farm's fields and applied to crops using irrigation equipment following a comprehensive nutrient management plan (CNMP).

Combined heat and power generation

The digester is equipped with a gas tight flexible membrane cover to collect biogas. Biogas produced is used to fuel a 130-kW (3306 Caterpillar) engine-generator set. The engine is a diesel block with a natural gas head that has been converted to run on biogas. The electric power produced is used for on-farm needs, and excess is sold to the local utility, New York State Electric & Gas, under the New York State Net Metering Law. Heat exchangers transfer heat from the engine to water, to keep the digester at a constant 100°F.

Initial capital costs

Costs associated with the digester vessel construction were approximately \$189,000, energy conversion equipment and associated costs were totaled at \$61,000, solid-liquid separation costs were totaled at \$53,000, long-term storage construction and liner were totaled at \$60,000, making the final digester system capital cost \$363,000.

Digester clean-out

In the summer of 2008, the farm made the decision to clean the solids out of the digester because 1) it was known the digester had significantly built up solids over the 10 years of operation, and 2) there was some suspicion of damage to the internal heating pipes. Upon removal of all solids, several places on the internal heating rack were found to be severely corroded. The damage was repaired and the digester was re-covered and put back into operation. The farm decided against implementing any means of cathodic protection.

Please find a comprehensive case study for AA Dairy at:

http://www.manuremanagement.cornell.edu/Docs/AA_Case%20Study_revision%201.htm

Aurora Ridge Dairy

2542 Angling Rd.
Aurora, NY 13026

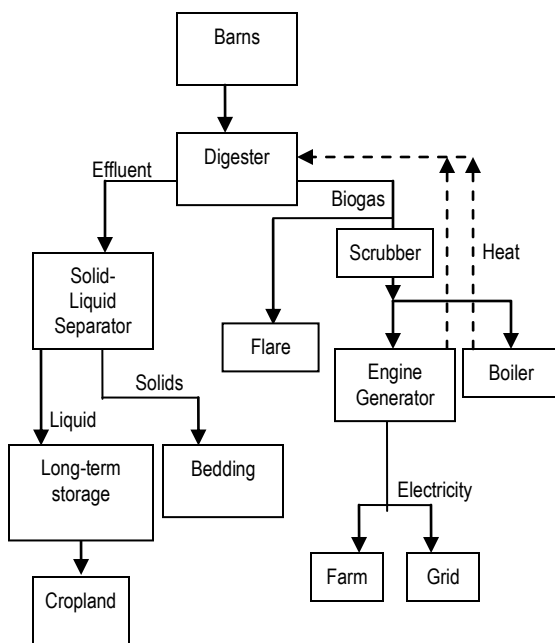
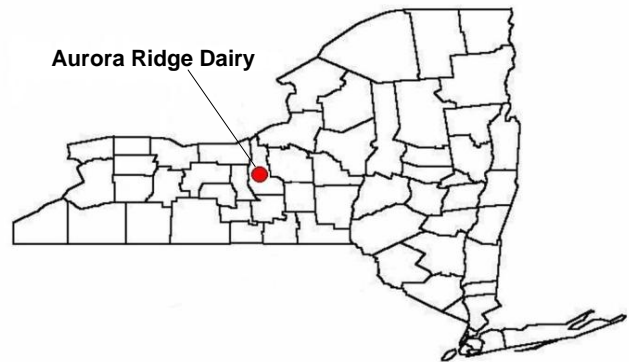
Farm overview

Aurora Ridge Dairy is a 2,000-cow dairy operation located near the Village of Aurora in Cayuga County, New York. The farm is owned and managed by William Cook. Digester construction began in late summer 2008 and began operating in August 2009. Digester construction was funded in part by a USDA Rural Development grant and by NYSERDA. Digester effluent is separated using FAN screw-press separators and post-digested separated solids are used for freestall bedding.



Digester system

The digester vessel, a below-grade rectangular insulated cast-in-place concrete tank has a concrete top. The digester has a longitudinally oriented divider wall resulting in a hair-pin configuration; digester influent and effluent enter and exit the digester on the same end-wall. A portion of the biogas produced and collected is reintroduced back into the digester vessel with the goal of providing agitation of digester contents.



Digester type	plug-flow with biogas recirculation.
Digester designer	GHD
Number of cows	2,000
Influent material	raw manure
Dimensions (LxWxD)	248' x 72' x 16'
Design temperature	100°F
Estimated total loading rate	61,000 gal/day
Treatment volume	1,912,837 gallons
Estimated hydraulic retention time	20 days
Solid-liquid separator	yes; bedding
Carbon credits	no
Start-up	2009
Biogas clean-up	Yes; microbial reduction
Biogas utilization	500-kW eno-oen set

A 40-Hp blower is used to force recycled biogas thru aerators located near the bottom of the vessel. Water jacket and exhaust heat from the engine-generator set are harvested and used to heat digester influent to operating temperature and also to provide maintenance heat. Additional heat is provided by a 4 mmBtu dual-fuel boiler as required. Heating pipes are located within the digester vessel and controlled on a zone basis.

Liquids and solids process description

Digester influent is comprised of manure from 2,000 dairy cows and from 1,300 other dairy animals, milking center wastewater, bunk silo low-flow effluent, and used bedding. Digester influent is pumped from two manure collection pits, one located in the adolescent heifer barn and the other centrally located adjacent to the cow barns. Manure is pumped to the digester 3-4 times per day.

Digested effluent is aggregated and subsequently processed by multiple FAN screw-press solid-liquid separators (SLS) with SLS liquid effluent pumped by a centrifugal pump to a remote earthen long-term storage. Storage contents are recycled to the farm's land base in accordance with their CAFO permit. Some of the separated manure solids are further processed by FAN Bedding Recovery Units (BRU). (A BRU is essentially a rotary-drum composting unit that has sufficient retention time for the manure solids to be heated to about 145°F before being discharged.) BRU solids are used for freestall bedding, sold or recycled to the land base.

Combined heat and power generation

Biogas that has undergone hydrogen sulfide (H₂S) reduction by a GHD biological H₂S removal system is used to fuel:

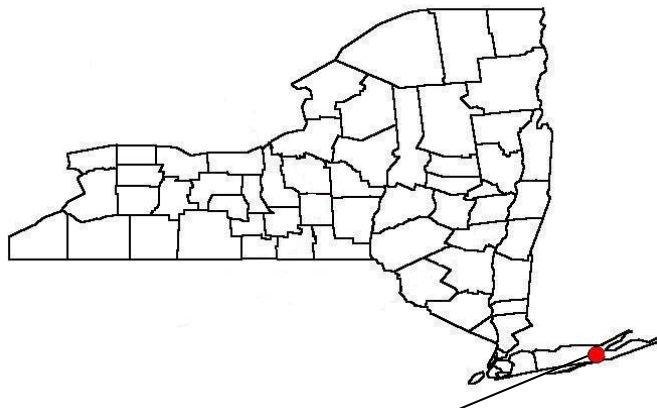
- 1) 500-kW Guascore engine-generator set
- 2) 4 mmBtu dual-fuel boiler (also runs on No.2 fuel oil)

Excess biogas is currently combusted by a flare.

The dual-fuel boiler is used as the secondary means to heat the hot water circulation loop that provides the heat source to the shell and tube heat exchanger. In the future, the farm plans to use excess heat in a greenhouse application.

Corwin Duck Farm

Riverhead, NY 11901



Corwin Duck Farm

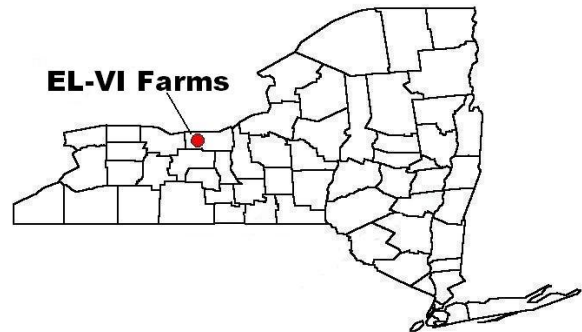
Digester type	aerobic/anaerobic
Digester designer ..	Applied Technologies, Inc.
Number of cows	130,000 ducks
Influent material	liquid manure
Estimated total loading rate ...	100,000 gal/day
Estimated hydraulic retention time	10 days
Solid-liquid separator	yes; settling tank
.....and double drum screen	
Carbon credits	no
Start-up	2005
Biogas clean-up	no
Biogas utilization ..	compressed air generation

EL-VI Farms

11 Pelis Road
Newark, NY 14513

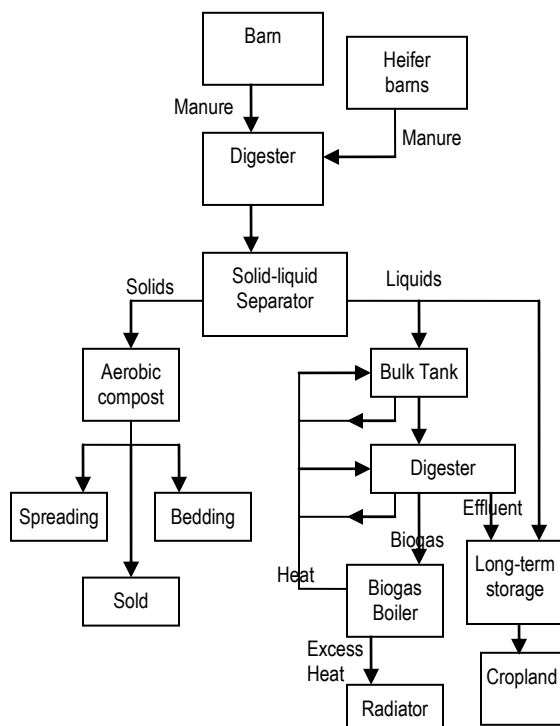
Farm overview

EL-VI Farms partnership is an 800-cow dairy located close to the Village of Newark in Wayne County, New York. It is managed by Ted Peck, Allan Ruffalo, George Andrew, and Josh Peck. The farm also has a stock of 700 heifers and 2,200 acres of cropland. Mr. Peck was motivated to install a low-cost anaerobic digester in order to control the odors from the long-term storage and crop application of manure. In order to keep costs down, a digester was designed with limited hydraulic retention time (about 10 days) and with the ability to expand when: (1) the digester did not provide enough odor control, (2) the herd size increased, or (3) more methane was desired to run an engine-generator set.



Digester system

The digester at EL-VI is a rectangular concrete tank with a capacity of 20,000 cubic feet and has a hybrid design with mixed and plug-flow portions. The digester influent is heated in a converted bulk milk tank with additional heat coils, then flows to the digester. Influent first enters the mixed digester portion, where a Houle 7.5-Hp



Digester Type	mixed/plug-flow
Number of cows	800
Influent material	raw manure,
	MC* wastewater, separated liquid
Design temperature	100°F
Estimated total loading rate	.30,000 gal/day
Treatment volume	20,000 ft³
Estimated hydraulic retention time	. 10 days
Solid-liquid separator	yes; composted solids
Capital cost	\$294,000
Start-up	2004
Biogas clean-up	No
Biogas utilization	biogas-fired boiler

*MC: milking center

agitator mixes the influent in a pre-digestion tank for about 5 days. The manure leaving this pit flows through a non-agitated, plug-flow digester to the outlet. Heating pipes cover the 1,800 square feet of walls inside the digester to provide internal heating.

Liquids and solids process description

Manure is scraped from the main barn and mixed with milking center wastewater, then pumped to a 75,000-gallon concrete tank where it is mixed with the manure scraped from the heifer barns. The influent is then pumped to a Vincent KP 10 screw-press solid-liquid separator. Separated solids are either composted and used as a soil amendment in the cropping program, used as bedding, or sold. The separated liquid flows by gravity to a 35,000-gallon concrete storage, or is re-mixed with the digester influent. After digestion, the effluent is combined with the rest of the separated liquid (about 44% of the separated liquid that is not digested) and pumped to a long-term storage.

Combined heat and power generation

Biogas is collected from the digester and transferred by a regenerative blower to pressurize the boiler. The 600,000 Btu/hour boiler is co-fired with natural gas and is specifically designed to handle low pressure, low energy “dirty” gas. The cast iron boiler produces hot water that is used to: (1) heat the influent to the digester, (2) maintain the digester temperature, and (3) provide hot water needs in the milking center. Excess heat is dissipated through a radiator.

Initial capital costs

Costs associated with the digester vessel construction totaled \$59,000, the solid-liquid separation equipment and associated costs totaled \$48,000, and the total capital cost of the digester system was \$294,000. The farm received a NYSERDA grant of \$56,750. The annual operating cost of the digester system was estimated to be \$24,000 while the annual benefits attributed to the system were valued at \$13,000.

Please find a comprehensive case study for El-Vi Farms at:

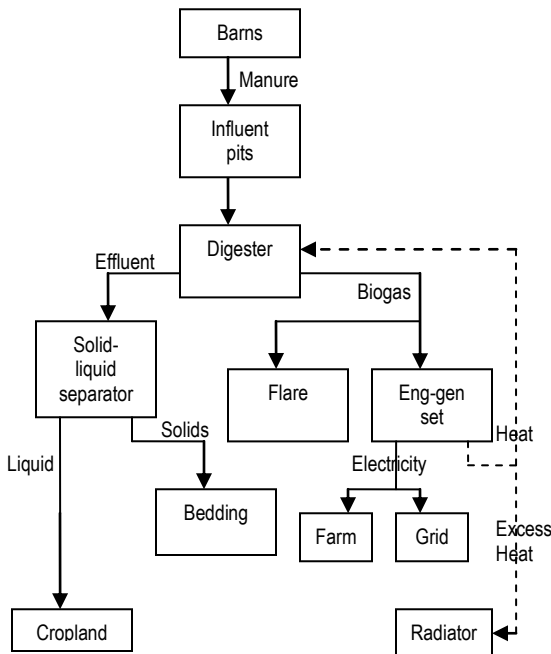
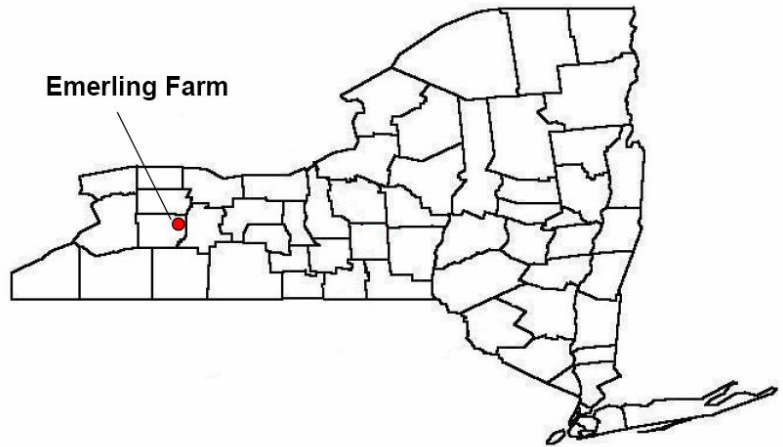
<http://www.manuremanagement.cornell.edu/Docs/EL-VI%20Case%20Study%20draft%20%286-11-04%29%28NEW%29.html>

Emerling Farm

2616 Route 246
Perry, NY 14530

Farm overview

Emerling Farm, Inc. in Perry, NY is a second and third generation family farm operated by John and Betty Emerling and Mike and Elizabeth Emerling. The farm was started in 1960 with 25 cows. Presently the farm houses 1,100 total dairy cows in two east/west oriented 6-row freestall barns, with plans to grow the business to 1,500 cows via internal growth. Cows are milked three times a day in a double 20 parallel parlor. The farm raises forage crops on 2,400 acres of land. A plug-flow digester was chosen in lieu of a mixed digester due to the reduced capital and maintenance costs. The farm received funding from the New York State Energy Research and Development Authority (NYSERDA) as well as from the United States Department of Agriculture (USDA).



Digester type	plug-flow
Digester designer	RCM Digesters, Inc.
Number of cows	1,100
Influent material	raw manure
Design temperature	100°F
Estimated total loading rate	48,000 gal/day
Treatment volume	1.2 x10⁶ gallons
Estimated hydraulic retention time	20 days
Solid-liquid separator	yes; bedding
Carbon credits	no
Start-up	2006
Biogas clean-up	no
Biogas utilization	230-kW eng-gen set

Digester system

A 1.2 million-gallon plug-flow anaerobic digester with a design retention time of approximately 20 days, based on manure from 1,100 dairy animals, was designed by RCM Digesters, Inc. The digester is equipped with a gas tight flexible membrane cover to collect biogas.

Liquids and solids process description

Currently, the digester processes 48,000 gallons per day of barn effluent (composed of manure from 1,100 cows [lactating and dry], manure from 100 heifers [15 months of age and older]), and milking center wastewater. Freestalls are bedded with separated solids. Manure flows by gravity to the AD influent pit, located on the south side of the southern freestall barn. Contents of the influent pit are transferred to the digester every 20 minutes for a five minute period with a J. Houle&Fils vertical piston pump. An impeller agitator is used to blend the influent tank contents on a timed schedule.

The digester system was originally designed to utilize gravity flow for transport of digester effluent to the farm's 8.5 million-gallon earthen storage. Digester effluent is now transferred to a screw-press solid-liquid separator (SLS), installed in January 2008. Separated liquid flows by gravity to the existing long-term storage and separated solids are currently being used for freestall bedding. Material from the long-term storage (digester effluent + rainwater) is recycled to the farm's cropland following their CNMP. During the summer of 2008, hayfields were top dressed with stored effluent; the farm reported that this has not been possible with raw manure for the last ten years due to significant odor emissions.

Combined heat and power generation

An electric blower is used to transfer biogas through a pipe from the digester to the biogas utilization building where it is used to fire a 230-kW Caterpillar GT379 engine-generator set. The engine-generator set was procured from Martin Machinery and consists of a remanufactured engine with a spark ignition system. Surplus biogas is burned by a flare.

Generated power is used on-farm and excess is sold to the New York State Electric and Gas (NYSEG) grid under the provisions of the New York State Net Metering law.

From November 2005 to August 2006 the engine-generator set utilized on average 110,400 ft³/day of biogas to generate 4,451 kWh/day of energy or 24.8 ft³ biogas / kWh generated. Heat recovered from the engine averaged 11,707 kBtu/day for the same time period. Heat recovered from the engine is primarily used to maintain the design operating temperature of 100°F and excess is used to heat milking center wash water. Excess heat is dispersed to the atmosphere by a heat dump radiator.

Please find a comprehensive case study for Emerling Farm at:
http://www.manuremanagement.cornell.edu/Docs/EM_case%20study_original.htm

New Hope View Farm

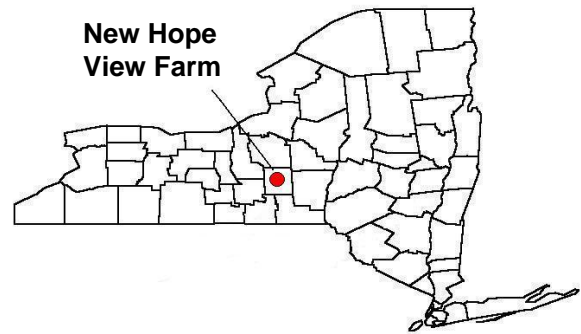
5937 Rte. 11
Homer, NY 13077

Farm overview

New Hope View Farm is an 850-cow dairy operation located in the town of Homer in Cortland County, New York. The farm changed ownership in February of 2007; it was formerly owned by DeLaval under the name Dairy Development International (DDI). The construction of DDI broke ground on December 4, 2000 and the first cow was milked on August 7, 2001. Farmstead odor reduction, due to

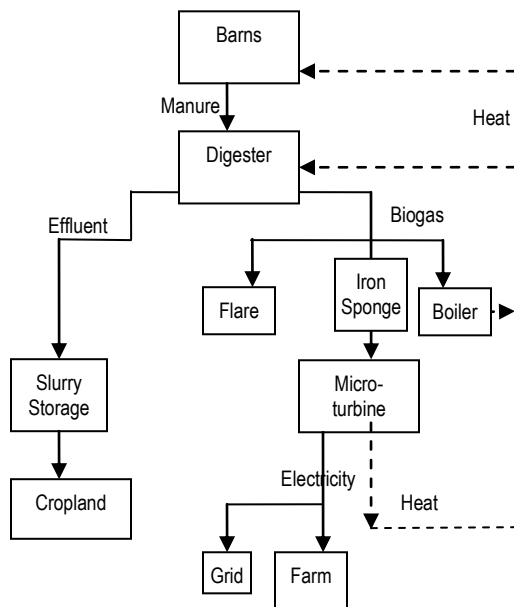


community concern, was the primary reason the farm incorporated an anaerobic digester into the original design plans.



Digester system

A plug-flow digester designed by RCM Digesters, Inc. was constructed. The containment vessel is a below-grade cast-in-place concrete pit with a design hydraulic retention time of 20 days. The digester is equipped with a gas tight flexible membrane cover to collect biogas. Manure is initially heated and maintained at approximately 100°F in the digester. A 7.5-Hp Houle influent pump transfers barn effluent (raw manure and soiled bedding) and some milking center wastewater to the digester. Approximately 20,000 gallons of influent are fed into the digester each day. Digester effluent is normally pumped directly to an above-ground steel storage tank, but can be pumped to a solid-liquid separator first, if desired.



Digester type	plug-flow
Digester designer	RCM Digesters, Inc.
Number of cows	850
Influent material	raw manure
.....	& MC wastewater
Dimensions (WxLxD)	30' x 118' x 19'
Design temperature	100°F
Estimated total loading rate	25,000 gal/day
Treatment volume	503,000 gallons
Estimated hydraulic retention time	20 days
Solid-liquid separator	present; not in use
Carbon credits	no
Capital cost	\$984,000
Start-up	2001
Biogas clean-up	yes
Biogas utilization	70-kW microturbine &
.....	Biogas boiler

Liquids and solids process description

Manure is scrapped to the center of each barn using mechanical alley scrapers; it then drops through a slot to the flow gutter. Using a series of one-foot step-dams, the manure flows to the final collection pit, which is a 30,000-gallon below-grade cast-in-place concrete storage pit (digester influent pit). An impeller agitator is used to mix influent (manure + bedding + milking center wastewater) before being pumped to the digester. Digester effluent is stored in a 2.9 million-gallon above-grade steel slurry tank; a screw-press separator is available but no currently in use.

Combined heat and power generation

Biogas is combusted in three different ways: a microturbine, a boiler, or a flare (for excess gas). During the farmstead layout processes, the biogas utilization equipment was located closer to the utility's electrical service connection instead of closer to the digester. It was determined the cost was lower to lay a pipe for biogas and a hot water heating pipe both allowing biogas to be pumped across the farmstead, than it was to pay for additional electrical lines. (This, however, does not mean it is less expensive overall, due to operating costs.)

In 2006 the decision was made to install one 70-kW Ingersoll-Rand (IR) microturbine designed for low energy fuels. An arrangement is in place between the farm and IR, in which the farm sells conditioned biogas to IR who in turn owns and operates the microturbine and sells electricity to the farm and to New York State Electric and Gas (NYSEG). The system includes a biogas clean-up unit that consists of an iron sponge, intended to reduce the hydrogen sulfide to approximately less than 50 ppm; only the biogas used by the IR microturbine is cleaned. Farm experience to date shows that the iron sponge media lasts about six months.

The AD system includes a heat exchanger to recover combustion heat from the microturbine exhaust; it is used to assist in meeting the digester heating demand. A portion of the biogas is used to fire a 1.5 million Btu boiler which provides heat for the hot water heating system used to heat the digester. There is an automatic control located on the boiler that keeps hot water flowing to the digester at 124°F in order to keep the digester operating at the target temperature of 100°F. Biogas not used by the microturbine or the boiler is flared by a power flare.

Initial capital costs

Costs associated with the digester totaled \$350,000, Electrical and heating components totaled \$186,000, solid-liquid separation equipment cost \$89,000, resulting in a final capital cost of \$984,000. The annual operating costs were estimated to be \$93,989.

Digester clean-out

In the spring of 2006, the farm made the decision to remove all solids from the digester, as there was a validated suspicion that there was a water leak in the black iron steel internal heating pipe system. Upon removal of all solids, the suspected leak was located. Corrosion of the pipes was isolated to one area within the digester vessel. Damaged sections of pipe were removed from the heating loop and new sections were welded in their place. After welding the heating system was pressure tested before re-filling the digester.

Please find a comprehensive case study for New Hope View Farm at:
http://www.manuremanagement.cornell.edu/Docs/NHV_case%20study_revision%201.htm

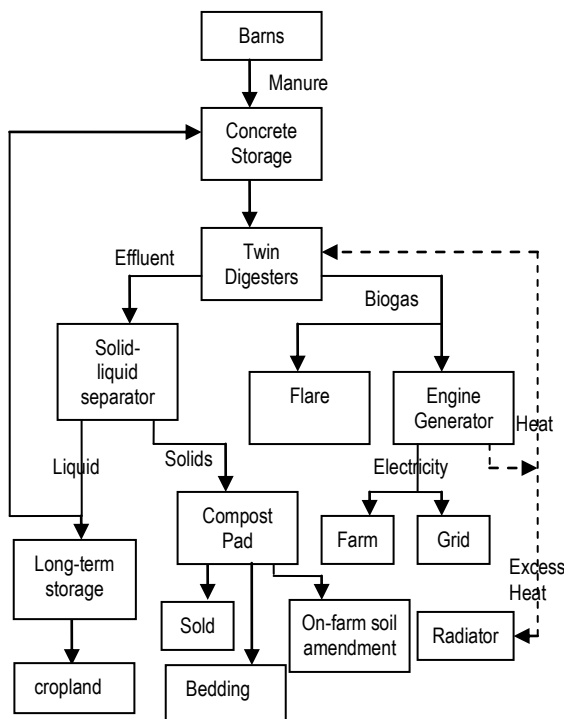
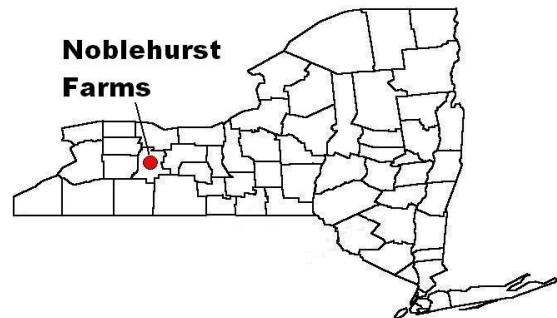
Noblehurst Farms

1818 Linwood Rd
Linwood, NY 14486

Farm overview

Noblehurst Farms, Inc. is a 1,100 milking cow commercial dairy located in Livingston County and managed by Robert Noble. There are also 200 heifers and 250 calves on the 2,000-acre farm. In January 2003, Noblehurst Farms, Inc. began operating an anaerobic digester to address a variety of issues and improve the business viability of the farm.

The management at Noblehurst Farms had several reasons for choosing to build an anaerobic digester. Environmental concerns were a high priority as the farm is sited in two watersheds that provide primary drinking water for surrounding communities. Traditionally manure was spread daily on crop fields and as a result, pollution from pathogens and nutrient loading was a concern in these watersheds. Long-term storage could create greater odor issues in a community that already had expressed their objection to existing odors from the intensive dairy farming in the area.



Digester type	.....plug-flow (twin cells)
Digester designer	.....Cow Power
Number of cows	..... 1,100
Influent material	..... raw manure, hog processing waste
Dimensions (LxWxD)	..... 120' x 50' x 16'
Design temperature	..... 100°F
Estimated total loading rate	.... 18,000 gal/day
Treatment volume	..... 673,246 gallons
Estimated hydraulic retention time	.....23 days
Solid-Liquid separator	..... yes; bedding
Carbon credits	..... yes
Capital cost	..... \$747,700
Start-up	..... 2003
Biogas clean-up	..... no
Biogas utilization	..... 130-kW eng-gen set

Digester System

The Noblehurst plug-flow digester is a rectangular, in-ground concrete tank (120' x 50' x 16') consisting of two digesters separated by a concrete wall. Manure is scraped from each barn to a central flow channel, where it flows to a collection pit. Manure from this collection pit is mixed with post-digested separated liquid, and then pumped to the influent manifold of the digester. The flow is distributed essentially equally between the two parallel digesters twice a day. As manure is displaced in the digesters, it flows to the effluent chamber.

Liquids and solids process description

The retention time of the digester is about 23 days. The Noblehurst digester has a flat concrete cover made of pre-stressed concrete panels covered with Styrofoam insulation and earth. Manure is pumped from the effluent chamber to an elevated separator. The separated solids are composted and either used as bedding, a soil amendment in the cropping program or sold. Some of the separated liquid is recycled back to the influent pit, to make the influent easier to pump into the digester. The remainder of the separated liquid is land applied in accordance with the farm's CNMP.

Combined heat and power generation

Biogas is collected from the digesters and fed to a 285Hp Caterpillar 3406NA engine attached to a generator (Marathon 447) with a capacity of 130-kW. Hot water reclaimed from the engine is used to maintain the digester temperature and for other on-farm hot water needs. A radiator serves as a heat exchanger to dissipate excess heat.

Initial capital costs

The total capital cost for the digester vessel, engine-generator set, solid-liquid separator and auxiliary equipment was totaled at \$747,000. The annual operating cost was estimated to be \$88,675 while the annual savings and benefits are valued at about \$77,680.

Please find a comprehensive case study for Noblehurst Farms at:

<http://www.manuremanagement.cornell.edu/Docs/Noblehurst%20Case%20Study%20draft%20%286-11-04%29%28NEW%29.html>

Patterson Farms

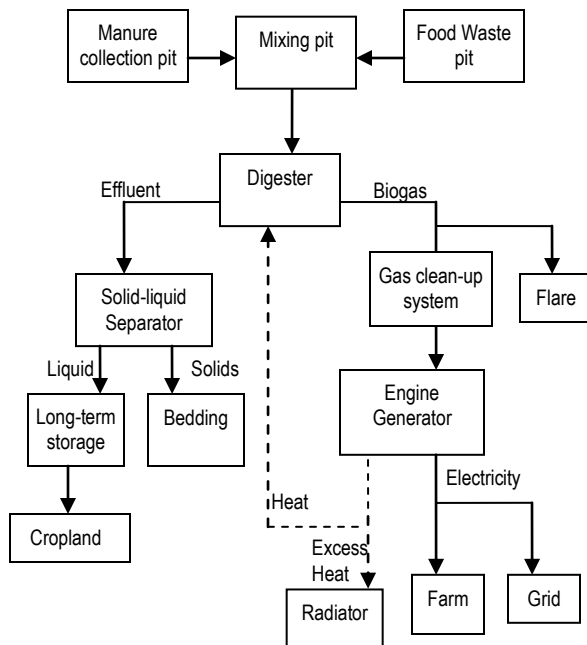
Farm overview

Patterson Farms, Inc. in Auburn, NY, is a seventh generation family farm owned and operated by Mrs. Connie Patterson with her son, Jon and his wife, Julie and Dairy Manager Bob Church. The farm has 1,000 dairy cattle and raises forage crops on 2,400 acres of land. Patterson Farms experienced their first major odor emission issues in 2000 after constructing a 4.5 million-gallon earthen manure storage, completed in 1999. After receiving grant funds from several sources (see *Initial Capital Costs*), digester construction started in August 2004 with commissioning in October of 2005.



Digester system

A 1.2 million-gallon mixed digester with a design hydraulic retention time of approximately 20 days, based on manure from 1,000 dairy animals, was designed by RCM Digesters, Inc.



Digester type	.....complete mixed
Digester designer	.....RCM Digesters, Inc.
Number of cows	.....1,000
Influent material..	manure, onion waste, whey
Dimensions (WxLxD)	.....30' x 104' x 19'
Design temperature	..... 100°F
Estimated total loading rate	.... 65,000 gal/day
Treatment volume	..... 1.2 x10 ⁶ gallons
Estimated hydraulic retention time	.....22 days
Solid-liquid separator	..... yes; bedding
Carbon credits	..... yes
Capital cost	.....\$1.5 million
Start-up	.....2005
Biogas clean-up	..... yes
Biogas utilization	..... 250-kW eng-gen set

Currently the digester processes 45,000 gallons per day of raw manure pre-mixed with 15,000 – 22,000 gallons per day of whey, in addition to onion waste. Cow and heifer barn manure alleys are cleaned with alley scrapers, and manure is supplied by approximately 1,000 dairy animals (73 dry cows and 692 heifers). Whey, milk slop and formerly post-digested sludge (no longer input to the digester) is delivered to the farm from the Kraft Foods cream cheese plant located in Lowville, NY and is received and stored in an 18,000-gallon rectangular concrete pit. Onion waste is commingled in the mixing pit and transferred to the digester by a chopper pump to chop the onions, resulting in more surface area.

Liquids and solids process description

Raw manure is pumped from the cow and heifer barns to a below grade storage tank, which is then mixed with the food waste in a pre-mix tank. The pre-mix tank feeds the digester, and the digested effluent is processed by the screw-press separator. Separated solids are used for freestall bedding and the excess is sold.

Combined heat and power generation

Biogas is contained by a flexible, multi-laminate flat top and transferred from the digester to the biogas utilization building where it is used to fire a CAT G379 engine to drive a 250-kW generator, and as of 2009 to fire a second 250-kW engine-generator set. Generated power is used on-farm and excess is sold to the grid under the provisions of the New York State net metering law. Excess biogas, which represents a significant portion of the overall amount, is automatically routed to and burned by a gravity flare. Reclaimed engine heat is primarily utilized to maintain digester temperature of 100°F and excess heat is dispersed to the atmosphere with a heat dump radiator.

Initial capital costs

The digester vessel and associated costs totaled \$759,000, the energy conversion equipment totaled \$569,000, and the solid-liquid separator and building totaled \$181,000, making the final capital cost total for the digester and manure management system approximately \$1,508,000. The farm received funding from the New York State Energy Research and Development Authority (NYSERDA), the Cayuga County Soil and Water District (CCSWD), and the United States Department of Agriculture (USDA) totaling \$1,268,122. This amount represents 88 percent of the initial capital costs.

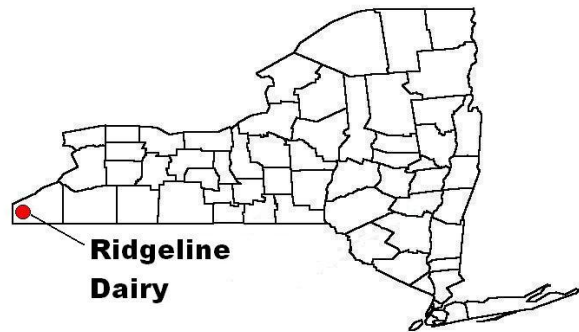
Please find a comprehensive case study for Patterson Farms at:
http://www.manuremanagement.cornell.edu/Docs/Patterson_case%20study_revision%201.htm

Ridgeline Farm

439 Legters Rd.
Clymer, NY 14724

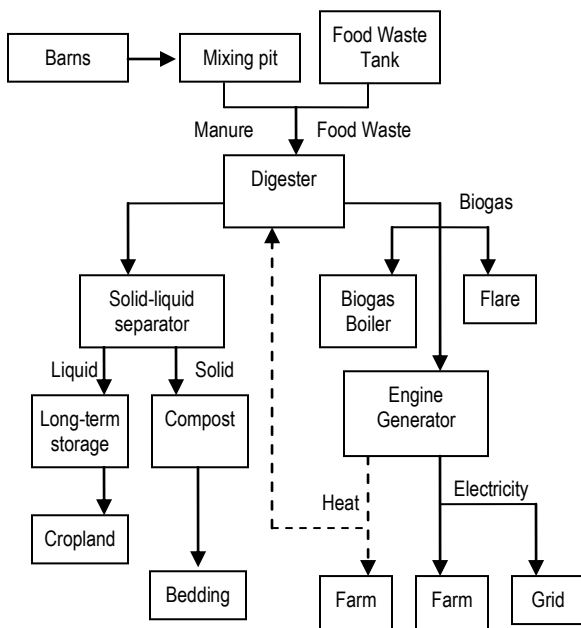
Farm overview

Ridgeline Farm (formerly Matlink Dairy Farm), operated by Carl Neckers (dairy facility) and Vinny Howden (anaerobic digestion facility), is located in the town of Clymer in Chautauqua County, New York. The farm, with 525 milking cows, employs 16 people, and has a considerable impact on the local economy. To address a variety of issues, including odor emissions, nutrient planning, and revenue, the farm installed an anaerobic digester with support from New York State Energy Research and Development Authority (NYSERDA) in late December 2001. Matlink Dairy Farm began construction of their anaerobic digester system in the summer of 2000; the system was in operation by the end of 2001. As of 2005, Matlink Dairy changed management and was renamed Ridgeline Farms.



Digester system

Ridgeline’s complete mix anaerobic digester is a rectangular below-grade cast-in-place concrete tank covered by two flexible membrane covers to collect biogas. The digester was built at the middle of a slope, using gravity to transfer manure from the barn collection system to the digester, and from the digester to the long term storage.



Digester type	complete mixed
Digester designer	RCM Digesters, Inc.
Number of cows	525
Influent material	raw manure, ice cream ..waste, hog processing waste, grape juice, etc.
Dimensions (LxWxD)	78' × 68' × 16'
Digester temperature	100°F
Estimated total loading rate	25,000 gal/day
Treatment volume	634,826 gal
Est. hydraulic retention time	20 days
Solid-liquid separator	present; not in use
Carbon credits sold	yes
Capital cost	\$622,520
Start-up	2001
Biogas clean-up	no
Biogas utilization	130-kW eng-gen set

Liquids and solids process description

Barn effluent flows by gravity to the digester influent pump pit. In addition to manure from some 500 cows, influent to the digester historically included food wastes such as: ice cream waste, salad dressing, dog food, hog processing waste and fryer grease. Food waste comes in loads of approximately 5,000 gallons. Two 20-Hp agitators fixed at opposite corners of the digester run two hours per day to blend the digester contents. The design hydraulic retention time (HRT) is about 20 days. The farm is not currently operating their solid-liquid separator, but is planning on purchasing a new unit and incorporating it into the system.

Digester effluent flows to a 4.2 million-gallon earthen long-term storage pond. Material from the long-term storage is land-applied to 1,800 acres of corn and hay cropland.

Combined heat and power generation

Biogas is collected and sent to a Waukesha engine attached to a Marathon generator (130-kW). This engine-generator set produces about 884,000 kWh/year, which meets the electricity needs for the dairy farm and also provides excess electrical power for sale to the local utility (National Grid). The farm is currently applying for a grant to cover costs associated with installing an additional engine-generator set with a 225-kW capacity. Heat is generated using a biogas boiler, which provides hot water to maintain a constant 100°F temperature in the digester; heat is also produced and used to heat the barn floors.

Initial capital costs

The digester vessel and auxiliary equipment totaled \$337,000, the engine-generator set and building totaled \$129,000, and the solid-liquid separator and building totaled \$61,000, making the final digester system capital cost about \$622,500.

Please find a comprehensive case study for Ridgeline Farm at:

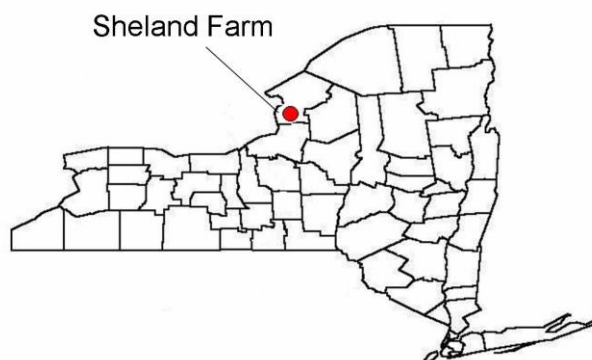
http://www.manuremanagement.cornell.edu/Docs/RL_case%20study_revision%201.htm

Sheland Farms

12043 County Rt 79
Adams, NY 13605

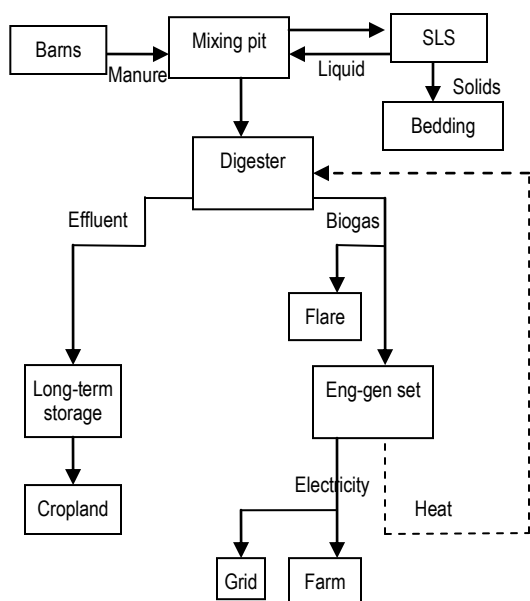
Farm overview

Sheland Farms is located in the town of Ellisburg in Jefferson County, NY. The farm is a fourth generation family farm operated by Donald, Douglas, and Todd Shelmidine. The farm houses 560 dairy cows and raises forage crops on 1,100 acres. Lactating cows and heifers are fed Rumensin[®]. Copper Sulfate is used in two footbaths, one located in the dry cow pen and the other in the springing heifer pen. After receiving grant funds from several sources (see *Initial capital costs*), digester construction began in the fall of 2005 with commissioning in the summer of 2007.



Digester system

This completely mixed anaerobic digester consists of an upright above-ground cylindrical tank with a 238,000-gallon capacity and a design hydraulic retention time of approximately 17 days, and a design capacity of manure from 660 dairy animals, engineered by Siemens Building Technologies, Inc. An annual maintenance fee is paid to Siemens to keep the engine-generator set running. Siemens guarantees the farm 16 yards³/day of usable bedding from the system, and 381,000-kWh of electricity produced annually from the engine-generator set.



Digester type	vertical complete mixed
Digester designer	Siemens
Number of cows	560
Influent material	raw manure
Dimensions (D x H)	30' x 35'
Digester temperature	100°F
Estimated total loading rate	14,000 gal/day
Treatment volume	238,000 gal
Est. hydraulic retention time	17 days
Solid-liquid separator	yes; bedding
Carbon credits sold	no
Capital cost	\$1,200,000
Start-up	2007
Biogas clean-up	no
Biogas utilization	125-kW eng-gen set

Liquids and solids process description

Currently, the digester processes 14,000 gallons per day of barn effluent (composed of manure from 560 cows [lactating and dry] and manure from 70 bred heifers) as well as pre-digested solid-liquid separator (SLS) liquid effluent. The ratio is about 60% barn effluent and 40% SLS liquid effluent. Freestalls consist of mattresses bedded with processed separated manure solids and some sawdust. Manure and soiled bedding are conveyed by alley scrapers to centrally located manure drops in each barn. A pump transfers manure from the barns, to a reception pit where it mixes with liquid from the SLS.

The digester is fed unheated influent every 30 minutes with a 10-Hp Vaughan pump, which runs about 5% of that time period. A Roto-Mix[®] pump/agitator system is used to mix the digester contents, in order to prevent material from settling in the conical bottom of the digester tank. This system consists of a 30-Hp Vaughan 3-phase electrical pump, located on the exterior of the digester tank. Operating experience has shown that the Roto-Mix[®] design works well with this particular system when operated continuously for two hours on a four hour cycle. Digester effluent is transferred to the farm's 3.5 million-gallon earthen storage by gravity.

Combined heat and power generation

Biogas flows under positive pressure to a gas conditioner, where it is cooled and condensed to lower the dew point, removing moisture. An electric blower increases the biogas pressure to meet the engine inlet requirements. Biogas is then sent to the gas utilization room where it is used to fire a 125-kW Caterpillar engine-generator set. For a biogas flow of 30 ft³/minute, the engine-generator set produces 85-kW of power.

Generated power is used on-farm and excess is sold to National Grid under the provisions of the New York State Net Metering Law. Any excess biogas is automatically routed to and burned by a flare.

Engine-generator set reclaimed heat is used to supply heat to the water-to-manure heat exchanger. The target operating temperature for the digester is 101°F. Excess heat is dispersed to the atmosphere with a heat dump radiator.

Initial capital costs

The digester vessel and associated equipment totaled \$760,000, and the energy conversion system and building cost \$440,000, making the final digester and manure management system capital cost approximately \$1,199,000. The farm received funding from the New York State Energy Research and Development Authority (NYSERDA), the United States Department of Agriculture (USDA) Rural Development program, and New York State Environmental Protection Fund totaling \$1,160,000.

*Please find a comprehensive case study for Sheland Farms at:
http://www.manuremanagement.cornell.edu/Docs/Sheland_case%20study_original.pdf*

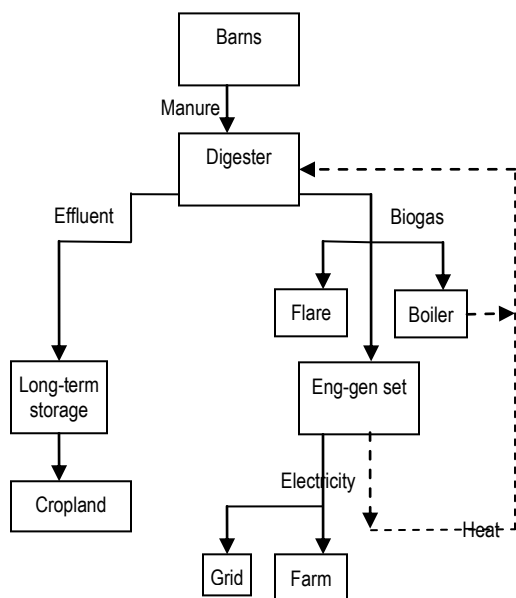
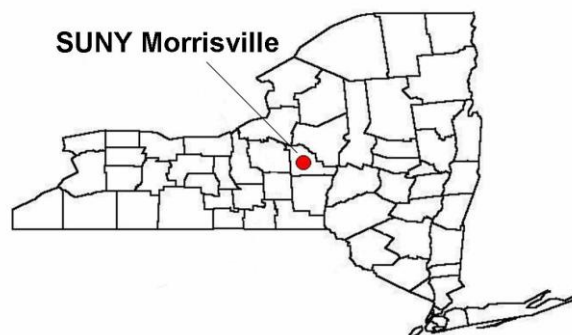
Farm overview

The State University of New York (SUNY) at Morrisville, designed a 400-cow complex to simulate an actual NYS dairy farm. In conjunction with this project, a hard-top plug-flow anaerobic digester was constructed. Construction on the digester was completed in 2006 and the Combined Heat and Power system (CHP) became operational in February 2007. The digester was designed specifically with education and research initiatives in mind.



Digester system

The plug-flow digester at Morrisville is an in-ground concrete tank with a pre-cast concrete top. All walls inside and out are covered with polyurea and other sealants to provide a gas-tight environment with up to 15" water column pressure. The outside of the digester is lined with a layer of polyurethane insulation to maintain temperature. The digester is fed manure only, and operates at a mesophilic temperature of around 98°F (Shayya, 2008).



Digester type	plug-flow
Digester designer	Cow Power
Number of cows	400
Influent material	raw manure
Dimensions (WxLxD)	37' x 90' x 12'
Design temperature	98°F
Estimated total loading rate	10,000 gal/day
Treatment volume	249,000 gallons
Estimated hydraulic retention time	25 days
Solid-liquid separator	no
Carbon credits	no
Capital cost	\$936,000
Start-up	2007
Biogas clean-up	no
Biogas utilization	50-kW eng-gen set and 300,000 Btu/hour boiler

Liquids and solids process description

Manure is collected in the barns by alley scrappers, and then transferred to a pre-digestion storage pit. Manure from one of the barns is hauled to the storage pit. Manure is mixed and then pumped from the storage pit to an influent manifold, where the material is distributed equally to both parallel cells of the digester. Material within the digester is displaced with the addition of new material, and flows to the effluent storage pit, next to the influent storage pit. From there, effluent is either sent to long-term storage or land applied.

Combined heat and power generation

Biogas is collected from both parallel cells of the digester, and piped to a 50-kW engine-generator set. Heat from the engine is used to keep the digester at operating temperature, and also used to provide heat to another research project on-site. When the engine is down, a dual fuel boiler (propane or biogas) is used to maintain digester operating temperature, and a flare burns the excess biogas. Electricity is produced by the engine and used to meet on-site electricity needs while excess is fed into the grid, following the NYS Net Metering law.

Initial capital costs

The total capital cost of the digester and related system components totaled \$936,000, while the SlurryStore tank cost \$246,000, for a final capital cost of \$1,182,000 (Shayya, 2008).

*Please find a comprehensive case study for SUNY Morrisville at:
<http://people.morrisville.edu/~shayyaw/anaerobicdigestionatmorrisvillestatecollege.pdf>*

Sunny Knoll Farm

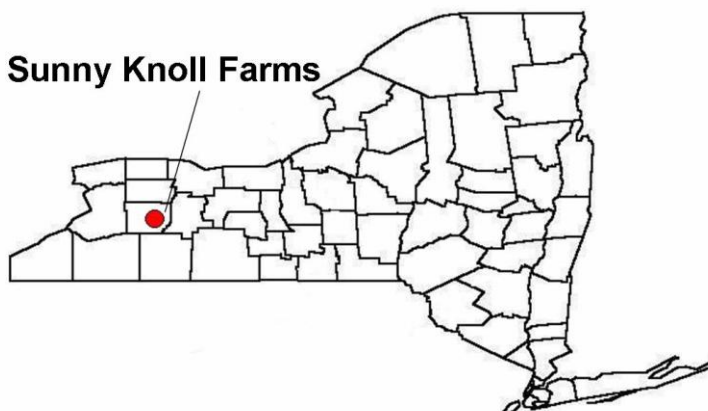
746 Meyers Road
Perry, NY 14530

Farm overview

Sunny Knoll Farm, Inc. in Wyoming County, (Perry, NY) is a third generation family farm owned by Don Butler and his three sons, Eric, Scott and Jason. The farm houses 1,400 dairy cows in three 6-row freestall barns. All lactating cows are fed Rumensin[®]. Manure is spread on a land base of 2,000 acres, used to raise forage crops. Freestalls consist of mattresses bedded with green sawdust/shavings. After successfully receiving a cost-share from NYSERDA (through the Town of Perry) and USDA, construction of a plug-flow digester started in August 2005 and was completed in July 2006.

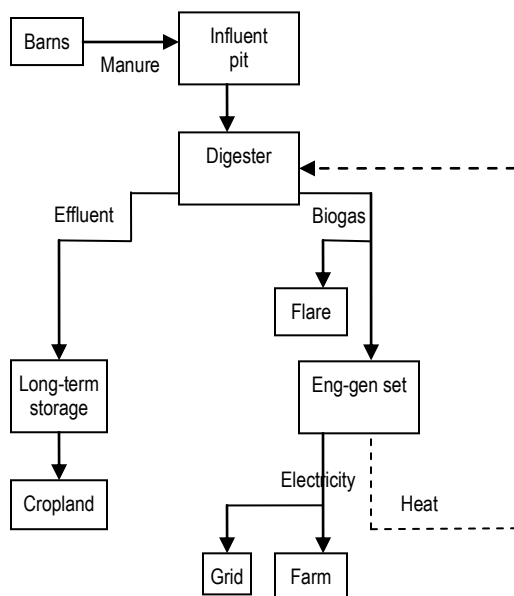


Sunny Knoll Farms



Digester system

The plug-flow digester, designed by RCM Digesters, Inc. consists of a below-grade insulated concrete tank with inside dimensions of



Digester type	plug-flow
Digester designer	RCM Digesters, Inc.
Number of cows	1,400
Influent material	raw manure
Dimensions (LxWxD)	190' x 34' x 16'
Digester temperature	100°F
Estimated total loading rate	43,000 gal/day
Treatment volume	780,000 gal
Est. hydraulic retention time	18 days
Solid-liquid separator	no
Carbon credits sold	no
Capital cost	\$1,000,000
Start-up	2006
Biogas clean-up	no
Biogas utilization	230-kW eng-gen set

190 x 34 x 16 feet, covered with a flexible, non-insulated membrane cover. With a working volume of 784,500 gallons and an estimated influent volume of 43,200 gallons, based on manure from 1,400 dairy animals, the estimated hydraulic retention time is 18 days.

Liquids and solids process description

Currently the digester processes barn effluent (composed of manure from 1,400 cows [lactating and dry], manure from 400 heifers [15 months of age and older]), milking center wastewater and approximately 10 gallons per week of used restaurant fryer oil. Manure flows by gravity from the barns to the digester influent pit. A pump transports digester effluent to the farm's 9 million-gallon earthen storage. Stored material (digester effluent + rainwater) is spread on the farm's land base following their CNMP.

Combined heat and power generation

An electric blower, located in the biogas utilization building, is used to pressurize biogas prior to use in a 230-kW Caterpillar G379 engine-generator set. The farm indicated that Martin Machinery guarantees a 180-kW output with this engine set when biogas is the fuel source. Generated power is used on-farm and excess is sold to NYSEG under the provisions of the New York State net metering law. Excess biogas is automatically routed to and burned by a gravity flare.

On average 185-kW to 195-kW is generated by the engine when run on biogas. Engine combustion heat is captured and primarily used to heat digester influent to 100°F and maintain operating temperature. Captured heat is also used for heating milking center wastewater. Excess heat is dispersed to the atmosphere with a heat dump radiator.

Initial capital costs

The digester vessel and associated equipment totaled \$522,000, and the energy conversion equipment and building cost \$555,000, making the digester system capital cost approximately \$1,084,500.

Please find a comprehensive case study for Sunny Knoll Farm at:
http://www.manuremanagement.cornell.edu/Docs/SK_case%20study_original.htm

Sunnyside Farms

2231 Indian Field Rd
Venice Center, NY 13147

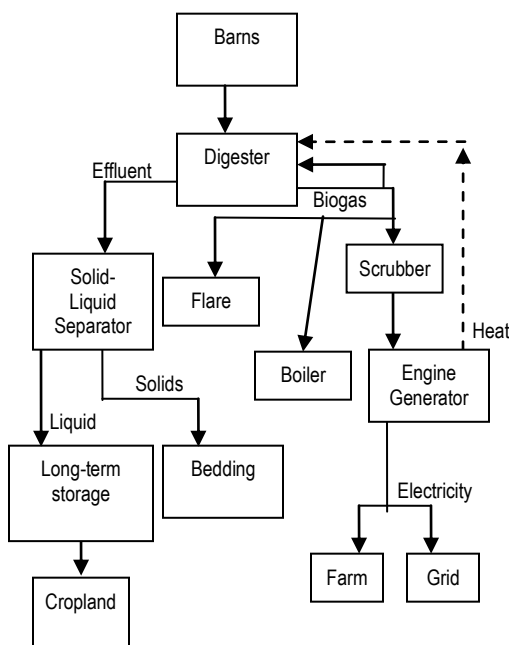
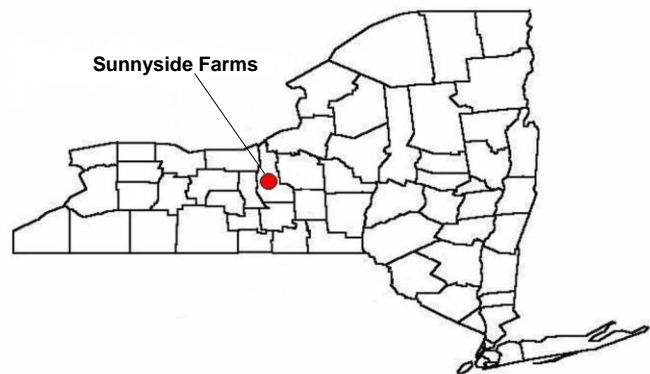
Farm overview

Sunny Side Dairy, Inc. in Venice Center, NY has been a family farm for three generations, and is currently operated by the managing partners Greg and Neil Rejman. The farm has 3,300 total milking age cows and 1,400 heifers. The farm raises forage crops on 5,000 acres of land. Digester construction started in April 2008 with commissioning in May 2009.



System and process description

The digester system was designed by GHD. There are two parallel anaerobic digestion vessels, each 72' wide by 240' long by 16' deep with a 1.5' biogas head space above the manure surface. Total processing capacity of the two units is 3.76 million gallons. Overall the digester vessels are designed to process manure from 4,400 cow equivalents with a design retention time of 20 days. Based on the current loading rate of 2,900 lactating cows and most of the farm's heifers, the daily influent volume is 65,000 gallons with resulting hydraulic retention time of 57 days. The digester is designed to co-digest liquid substrates and this may be pursued in the future.



Digester type	plug-flow with biogas recirculation.
Digester designer	GHD
Number of cows	2,900
Influent material	raw manure
Dimensions (WxLxD)	(Two) 72' x 240' x 16'
Design temperature	100°F
Estimated total loading rate	80,000 gal/day
Treatment volume	3.76 million gallons
Estimated hydraulic retention time	57 days
Solid-liquid separator	yes; bedding
Carbon credits	no
Start-up	2009
Biogas clean-up	yes
Biogas utilization	500-kW eng gen-set and 1.8 mmBtu boiler

The concrete digester vessel and pre-digestion holding tanks and support buildings were constructed by contractors.

Liquids and solids process description

Cow and heifer barn manure alleys are cleaned with alley scrapers. Alley scrapers deposit collected manure in barn pump pits where it is subsequently pumped to a 75,000-gallon influent pit located adjacent to the digester. Digester feeding and mixing is performed automatically 24 times per day by a Pro-Logic controller. A Vaughn 10-Hp pump is used to transfer material from the influent pit to the digester.

The digester's solid top, constructed with pre-cast concrete insulated with spray foam, followed by a sealer, is used to contain the produced biogas. A portion of the collected biogas is recirculated with a 40-Hp blower back into the digester vessel with the goal of providing in-vessel agitation.

Digester effluent is processed with one of three FAN screw-press solid-liquid separators. Separated solids are used for freestall bedding and excess is either sold or land-applied. The screen size used is 0.75 mm. Separated liquid flows by gravity to an intermediate long-term storage where it is stored or subsequently pumped to one of the farm's satellite storages. Stored effluent is recycled to the farm's cropland, following their comprehensive nutrient management plan (CNMP), using either liquid tankers or drag hose equipment, depending on the field location and time of year.

Combined heat and power generation

Electric blowers are used to pressurize the biogas before it is used primarily to fire the Guascor engine driving a 500-kW generator unit procured from Martin Machinery. Generated power is used on-farm and excess is sold to the grid under the provisions of the New York State net metering law. A 1.8-MW engine-generator set was initially ordered but the order had to be cancelled after the farm learned that the local utility lines were not sized sufficiently to carry the extra power.

A dual-fuel Columbia boiler (Pottstown, PA), with a 1.8 mmBtu/hr output rating, can be fired with biogas when the system calls for more heat than is reclaimed from the engine water jacket and exhaust. Excess biogas, which represents a significant portion of the overall amount, is flared thru one of two 12" power flares.

A biogas hydrogen sulfide (H₂S) scrubber was added in September, 2009 by Energy Cube, LLC to remove the majority of the H₂S prior to utilization by the engine-generator set. A lower biogas H₂S concentration reduces maintenance needs and resulting maintenance costs, therefore likely increasing the capacity factor. Based on a few measurements, biogas H₂S concentrations before scrubbing were on average 4,000 ppm and post scrubbing were dropped to 40 ppm.

Initial capital costs

The initial overall anaerobic digester system had a capital cost of \$4.5 million or \$1,023 per lactating cow equivalent (LCE). No grant funding was obtained in order to cover the capital costs of the system.

Twin Birch Farms

Benson Rd
Skaneateles, NY 13152

Farm overview

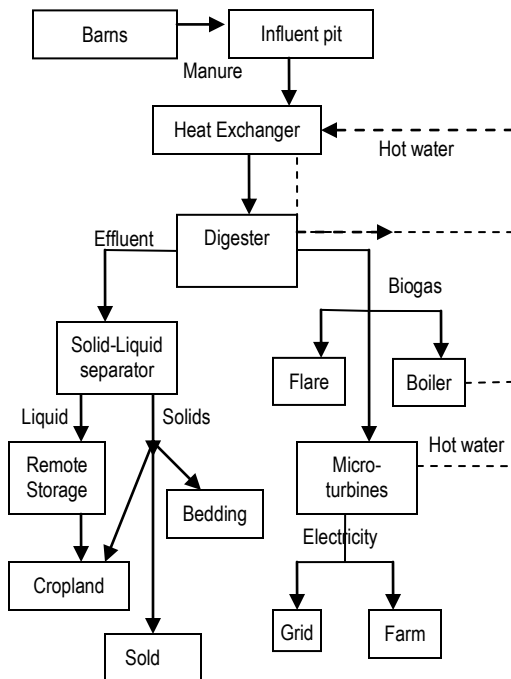
Twin Birch Farm is a 1,200-cow dairy operation located close to the Village of Owasco in Cayuga County, New York. The farm is owned and managed by Dirk Young. Construction of the digester began in 2001; after overcoming equipment difficulties, the digester successfully began operating in September 2006 and the microturbines started producing power in January 2007. The digester was funded in part by the NYS Clean Water, Clean Air Act and in part by NYSERDA. The farm acted as its own designer and general contractor after the original system designer failed to perform.



System and process description

The digester, a below-grade rectangular insulated concrete tank, was designed with a hard top to develop a relatively high biogas pressure. Initially, the concrete top formed the base for the equipment room, which was in turn covered with a fabric-cladded metal arch structure. The equipment room formerly housed the gas dewatering and compression equipment along

with the microturbines, boiler and heat exchanger. Unstoppable biogas leaks in the concrete top led to the corrosion of several equipment components,



Digester type	plug-flow
Digester designer	AnAerobics*/Twin Birch Farms
Number of cows	1,200
Influent material	raw manure
Dimensions (LxWxD)	140' x 40' x 14'
Design temperature	100°F
Estimated total loading rate	29,000 gal/day
Treatment volume	586,500 gallons
Estimated hydraulic retention time	20 days
Solid-liquid separator	yes; bedding, sale
Carbon credits	yes
Start-up	2003
Biogas clean-up	no
Biogas utilization	7 x 30-kW microturbines, 850 Btu dual-fuel boiler

*Company no longer in business

and the decision was made to move the equipment to a separate structure, which was later constructed about 100 feet away from, instead of above, the digester.

Liquids and solids process description

Manure from 1,200 dairy cows, milking center wastewater, and used bedding is collected and pumped from a centralized collection pit to the digester on a 12 minute cycle, every 3 minutes. Influent is warmed to digester operating temperature with a shell and tube heat exchanger. No maintenance heat is added to the digester. Field measurements performed by the farm show the effluent is about 3°F less than the influent. The digester has a longitudinally oriented divider wall resulting in a hair-pin configuration; digester influent and effluent enter and exit the digester on the same end-wall of the digester.

Digested effluent is pumped to a FAN screw-press solid-liquid separator (SLS) with SLS liquid effluent pumped by a 160-Hp centrifugal pump to a remote earthen storage 7,500 feet away with a 220 foot increase in elevation. The separated solids are stacked in a roof covered area and either used for freestall bedding, sold or recycled to the land base.

Combined heat and power generation

Biogas is used to fuel a 900,000-Btu dual-fuel boiler and seven 30-kW Capstone microturbines. Excess biogas is currently combusted by a flare. The dual-fuel boiler is used as the secondary means to heat the hot water circulation loop that provides the heat source to the shell and tube heat exchanger. (The primary means is the combustion heat recovered from the microturbine exhaust gas.) Biogas destined for use by the bank of microturbines first goes thru a multi-step dewatering process and is subsequently compressed to about 90 psi.

Please find a comprehensive case study for Twin Birch Farms at:

http://www.manuremanagement.cornell.edu/Docs/Twin%20Birch_case%20study_revision%201.htm

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Chapter 3. Case Studies: New York

3.2 Design/Planning/Recently commissioned

The following tables outline the currently known specifications for each of the farms currently operating a digester without a comprehensive case study developed as of yet, farms currently in the construction stages of installing a digester, and farms planning to install a digester. The last eight unnamed farms in the planning stage have applied for funding to build a digester on their farm, but the contracts have not yet been finalized.

Operational; no case study synopsis available yet				
<i>Farm name</i>	<i>Location</i>	<i>Approx. cow #</i>	<i>AD type</i>	<i>Est. kW capacity</i>
Boxler Farms	Varysburg, NY	2,000	Plug-flow with mixing	500
Lamb Farms	Oakfield, NY	1,120	Plug-flow with mixing	450
Roach Dairy Farm	Scipio Center, NY	1,200	Plug-flow	450
Wagner Farms	Poestenkill, NY	340		100
Zuber Farms	Byron, NY	1,380	Plug-flow	300
TOTAL		6,040		1,800

Under Construction				
<i>Farm name</i>	<i>Location</i>	<i>Approx. cow #</i>	<i>AD type</i>	<i>Est. kW capacity</i>
Cayuga County SWCD	Auburn, NY	1,000	Complete mixed	625
TOTAL		1,000		625

Planning/Design				
<i>Farm name</i>	<i>Location</i>	<i>Approx. cow #</i>	<i>AD type</i>	<i>Est. kW capacity</i>
Greenwood Dairy Farm	Potsdam, NY	1,200	Complete mixed	300
Oakwood Dairy	Auburn, NY	1,600	Complete mixed	500
Phillips Family Farm	North Collins, NY	1,200	Complete mixed	300
Sprucehaven Dairy	Fleming, NY	1,850	Complete mixed	500
Swiss Valley Farms	Warsaw, NY	1,200	Plug-flow with mixing	300
Walker Farms	Fort Ann, NY	1,100	Complete mixed	225
Farm 1	-	2,000	Plug-flow with mixing	400
Farm 2	-	900	Complete mixed	225
Farm 3	-	1,250	Plug-flow with mixing	315
Farm 4	-	720	Complete mixed	135
Farm 5	-	637	Complete mixed	120
Farm 6	-	500	Plug-flow	150
Farm 7	-	2,100	Complete mixed	2,248
Farm 8	-	1,440	Complete mixed	300
TOTAL		15,807		6,018

Chapter 3. Case Studies: New York

3.3 Decommissioned

Farber Dairy Farm

Decommissioned

Farm overview

JJ Farber Dairy was a 100-cow dairy that had been a closed herd for several years. It was located in the town of East Jewett in Greene County – in the New York City watershed. It used a liquid manure storage system for 10 years, but the odor began to cause complaints from neighbors, which was the primary reason for the installation of the fixed-film digester.

Digester system

The fixed-film digester owned by the JJ Farber farm stood 10.5' in diameter x 16' overall height, as an insulated concrete tank. Inside, the fixed-film media was made of corrugated plastic drainage tile that was set upright in bundles, which gave 12,000 square feet of surface area for microbial attachment. Maintaining a large population of microbes in a digester allowed for the relatively short 4-day retention time.

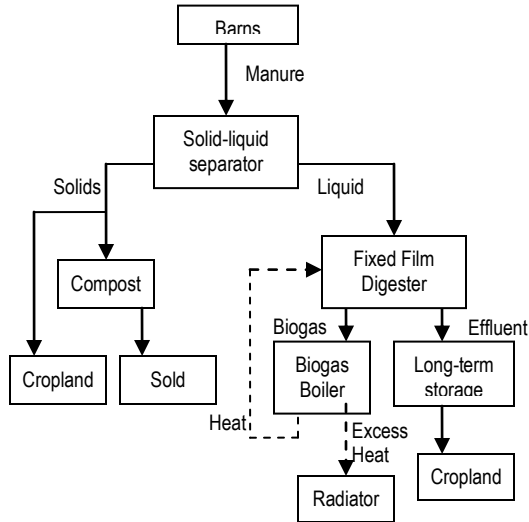
Liquids and solids process description

About 2,400 ft³/day of biogas was produced by the gas tight digester. A gutter collected 1,872 gallons of manure daily from the tie-stall barn. The manure was delivered into a reception pit where pipeline wash water could be added, in order to create a pumpable slurry. Each day, 2,000 gallons of this slurry was pumped to a screw-press solid-liquid separator, and the separated liquids were transferred to the digester, while separated solids were used as bedding or composted and sold.

Combined heat and power generation

Heat for the digester was provided by two natural gas boilers, set up in series. The methane boiler would first heat the water; then, if needed, the secondary propane boiler was used to raise the water to the desired temperature. The digester generally produced enough methane to maintain the design operating temperature. The heated water from the two boilers flowed through a stainless steel heat exchanger. Manure from the digester tank was also continuously circulated through a shell-in-tube heat exchanger with a 1-Hp pump. This heating system kept the digester at 98°F.





Digester typefixed-film
Digester designer Stan Weeks
Number of cows 100
Influent material..... separated liquid (from
raw manure + MC wastewater)
Dimensions (D x H)10.5' x 16'
Digester temperature..... 98°F
Estimated hydraulic retention time4 days
Capital cost..... \$294,000
Biogas utilization biogas boiler

Reason for decommissioning

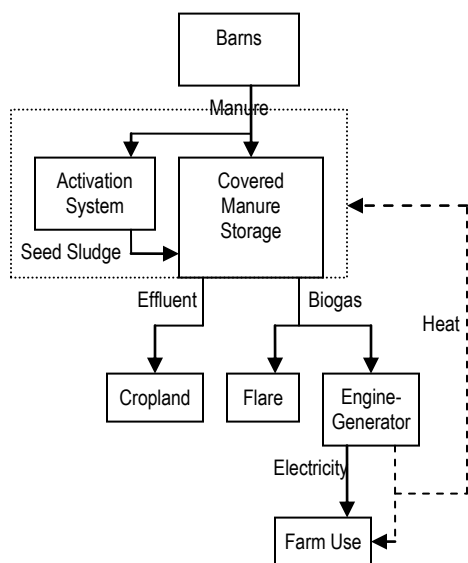
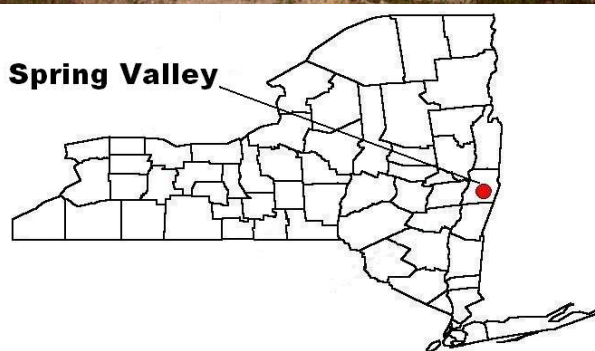
The farm decided to sell the cows, thus no manure was available to continue operating the digester.

Spring Valley Dairy

Decommissioned

Farm overview

Spring Valley Dairy was operated by Edward Swartz, Jr. and was located in the town of Schodack, in Rensselaer County. There were 236 animals on this 1800-acre farm, including 150 milkers, 50 heifers, and 36 calves. The farm turned to anaerobic digestion technology as a solution to a variety of issues of concern, including odor control, nutrient planning, stricter government regulations on animal waste, and a potential revenue stream. One hesitation was the high capital costs for the installation of an anaerobic digester – however, this was remedied by the introduction of a new type of anaerobic seeding process, known as the ‘Manure Activation System’. This system had the potential of dramatically reducing capital costs. Spring Valley Dairy received funding from the New York State Department of Agriculture and Markets and the New York State Energy Research and Development Authority to install the activation system as well as covered storage and gas collection and utilization equipment, designed by Stephen Hoyt, Dubara company Inc.



Digester typeactivation system w/ covered storage
Digester designer Stephen Hoyt, Dubara Company Inc.*
Number of cows 240
Influent material raw manure
Digester capacity
 Activation System 2 × 1,000 gallons
 Covered Manure Storage 300,000 gallons
Estimated total loading rate 3,400 gal/day
Estimated hydraulic retention time
 Activation System 20 days
 Covered Manure Storage 90 days
Capital cost \$143,650
Biogas utilization 25-kW eng-gen set

**Company no longer in business*

Digester system

The digester at Spring Valley Dairy, unlike other AD systems, previously had two tanks. One tank was the activation system that used small-scale reactors to provide a continuous supply of seed sludge, which was used to activate the storage pit for biogas production by maintaining high levels of methanogenic bacteria. The second, and much bigger tank, was the covered manure storage that held and processed manure for bioas production. The retention times were 20 days for the activation digesters and 90 days for the manure storage pit.

Liquids and solids process description

The manure production was about 3,400 gallons per day on average, with 236 animals on the farm. The manure was collected and transported by gravity flow to the manure influent pit, where it was pumped into the activation system, consisting of two seed digesters.

Combined heat and power generation

The biogas produced was collected and fed into an Isuzu diesel engine that was attached to a 25-kW generator. The electricity produced was used on-farm, and the recovered heat from the generator was used to help facilitate anaerobic digestion activity or for other farm needs.

Initial capital costs

The subtotal for digester vessel and associated equipment was \$40,000, the totals for energy conversion equipment and building were \$27,000, while miscellaneous other costs totaled \$15,000; resulting in a capital cost of \$144,000 for the digester system.

Cooperstown Holstein

Decommissioned

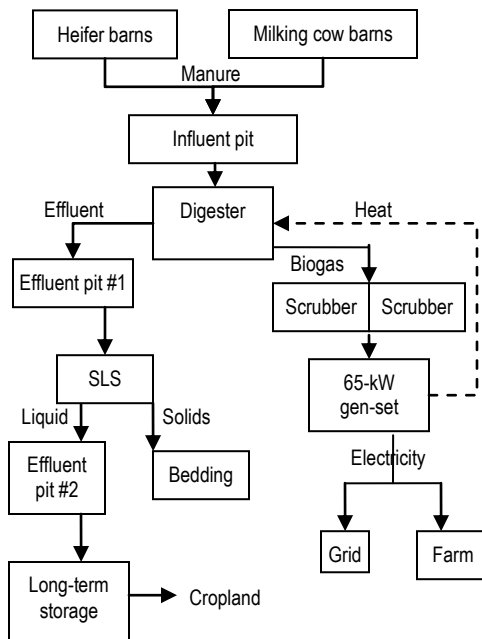
Farm overview

The Cooperstown Holstein Corporation Farm was formerly owned and operated by Mr. Peter Huntington, in Otsego County, NY. The farm formerly housed approximately 220 milking cows, 25 dry cows and 180 replacements. The farm made the decision to install the digester along with several other upgrades to the manure management system to allow for future growth and expansion.



Digester system

The complete-mix Harvestore™ Methastore™ digester was put into operation in December 1985. The digester had an inside diameter of 31 feet and the depth of manure was 28 feet, making the total treatment volume 155,000 gallons. The digester was constructed with glass-coated steel plates and a double-walled upright cylinder design with 4” of urethane foam insulation between the side walls and beneath the roof of the digester (Lusk, 1997).



Digester type	complete mix
Digester designer	Harvestore™ Methastore™
Number of cows	320
Influent material.....	raw manure
Dimensions (D x H)	31' x 28'
Design temperature	100°F
Treatment volume	158,000 gallons
Solid-liquid separator	yes; bedding
Carbon credits	no
Start-up	1985
Biogas clean-up.....	yes (iron sponge)
Biogas utilization	65-kW eng gen-set

Liquids and solids process description

Manure from the barns housing lactating cows was collected beneath the barns in a pit, where a pump transferred material to an influent pit by way of an underground 6-inch PVC pipe. The piping was set up to allow for a by-pass to the digester if necessary and the lactating cow manure could be pumped directly to the long-term storage. Manure from the heifer barns was mixed

with water, and gravity-flowed to the influent pit, where it was mixed with manure from the lactating cows. After manure from both cow groups was mixed, the influent was pumped to the digester 8 times per day. Manure was pumped into the bottom of the digester and post-digested effluent material was displaced from the top of the digester, and flowed to effluent pit #1. From effluent pit #1, material was sent to a solid-liquid separator and from there, separated solids were used as bedding material and liquids were sent to effluent pit #2. Post-digested separated liquids were then sent to long-term storage and subsequently land-applied.

Biogas usage

After scrubbing, compressing and storing, biogas produced by the digester was piped underground and sold to the Otsego County Infirmary for use in their boilers to supply hot water for heating and domestic uses from 1985 to 1994. During this time, biogas was sent through a series of two iron sponge scrubbers to remove H₂S. The gas was then sent to a compressor to increase gas pressure to 50 psig and collected in a storage tank with a capacity of 670 ft³ then piped to the infirmary. In 1994 the decision was made to pursue co-generation to provide a source of on-farm generated electricity. By 1997 the farm was off-setting the majority of electricity purchased from the utility. The compressors and gas storage were no longer used, and gas was sent directly to a 65-kW engine generator set. Formerly, the average daily biogas production averaged 21,000 – 25,000 ft³ (Lusk, 1997).

Agway Farm

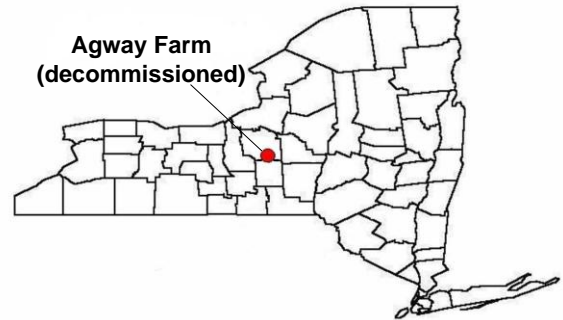
Decommissioned

Farm overview

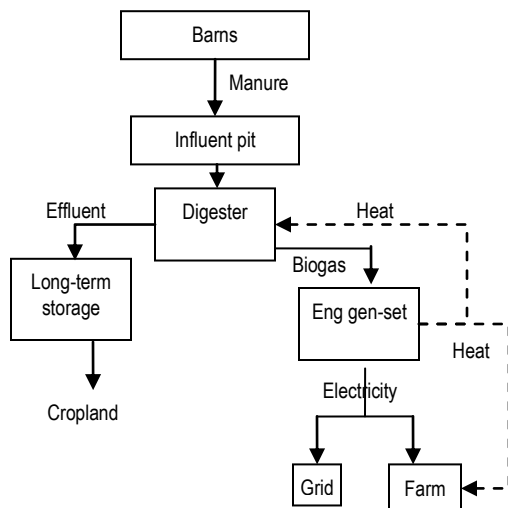
The Agway farm decided to install their digester in order to test and evaluate digester technology after the 1970's showed anaerobic digestion to be a prime manure management strategy.

Digester system

The Agway digester was a vertical concrete slurry tank with no mechanical mixing. There was a vertical wall dividing the manure influent and effluent. Mixing occurred through thermal convection centered around the interior heating pipe. The digester design was continually improved based on operating experiences.



Daily performance readings were collected to monitor the digester, including: checking condensate, reading digester and engine temperatures, checking engine oil levels, checking engine oil pressure, and recording biogas production (Lusk, 1997). Major repairs were scheduled annually including engine re-builds and solids removal from within the digester vessel.



Digester type	vertical tank (no mixing)
Digester designer	Agway/Stan Weeks
Number of cows	250
Influent material	raw manure
Dimensions (D x H)	20' x 28'
Design temperature	95-100°F
Treatment volume	54,000 gallons
Solid-liquid separator	yes; composted
Carbon credits	no
Start-up	1981
Out of commission	1998
Biogas clean-up	no
Biogas utilization	18-kW engine-gen set

Liquids and solids process description

Effluent was displaced from the top of the digester by new incoming manure. Effluent gravity-flowed to storage and was then recycled to the land base. Computer controlled fans were used for composting solids.

Biogas usage

The end use of biogas was electricity production and heat recovery used to supply digester maintenance heat and to heat two on-site buildings. Electricity was produced by combusting biogas in an 18-kW 4-cylinder Mercruiser engine rebuilt by Perennial Energy. Data collected showed approximately 12,000 ft³ per day of biogas production.

Reason for decommissioning

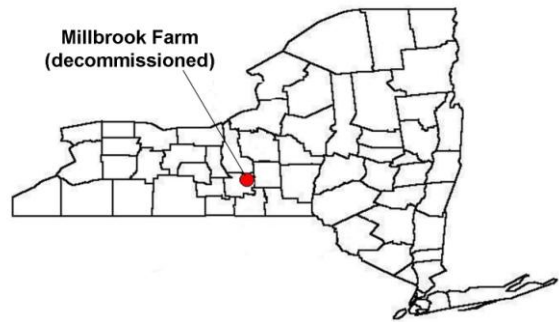
In 1998, the farm was sold and the new owners decided not to continue operating the digester.

Millbrook Farm

Decommissioned

Farm overview

The Millbrook Farm was located southeast of the town of Groton, NY.

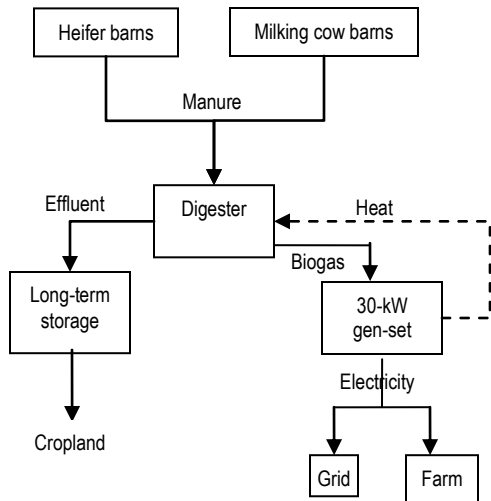


Digester system

The Millbrook Farm plug-flow anaerobic digester became operational in 1982. The digester was 75 feet long, 20 feet wide and 8 feet deep. The digester treated 90,000 gallons with a design capacity to digest manure from 250 lactating cows. The digester walls were constructed from reinforced concrete 10-inches thick and the floors were made of 4-inch thick reinforced concrete. 2-inch rigid polystyrene insulation was used to insulate the walls and floor, while the flexible cover was lined with 3 inches of insulation (Koelsch et al.).

Liquids and solids process description

Sawdust was used as bedding in the freestalls. Manure from 180 lactating cows and 120 replacements was incorporated to the digester. Manure was scraped from the barn floors and collected in a pit beneath the floor. From this pit the manure gravity-flowed to the digester. The effluent from the digester also flowed by gravity, to the long term earthen storage. 30-inch galvanized steel pipes carried the influent and effluent to and from the digester. Digester effluent was spread on 565 acres of cropland.



Digester type	plug-flow
Digester designer	Dr. Larry Walker (Cornell University)
Number of cows	300
Influent material	raw manure
Dimensions (LxWxH)	75' x 20' x 8'
Design temperature	100°F
Treatment volume	90,000 gallons
Solid-liquid separator	no
Carbon credits	no
Start-up	1982
Biogas clean-up	no

Biogas usage

Biogas was combusted in a Ford 4.9 liter 6-cylinder engine and a 30-kW PrimeLine generator to generate electricity; excess electricity not used by the farm was sold to the NYSEG utility grid. Heat was recovered from the engine to provide hot water for the parasitic heat load of the digester. When the digester was at full capacity, approximately 14,500 ft³ of biogas was produced daily (Koelsch et al.).

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Chapter 4. Common Problems & Lessons Learned

Most digester owners/operators in NYS have reported their positive and negative experiences from the project and important lessons they have learned in different venues. A compilation of common problems, successes and overall lessons learned as communicated by digester operators are shown below by category. ‘The farm’ mentioned in the statements below, refers to the digester operator(s) providing that specific comment, and represents several digester operators throughout the tables. All observations expressed here originated from NYS digester operators. These comments are provided for the benefit of future digester owners/operators to prevent similar problems and to encourage strategies that were found to be successful.

Economics
“The price the farm receives for electricity sold back to the utility grid needs to be much higher in order to make the digester system financially viable.”
“The projected savings from hot water use never materialized, since changing from the existing radiant heating system to a hot water heating system in the milking center would have been cost prohibitive. Since electricity produced by on-farm generation can meet the electric needs of the farm, there was not a significant incentive to make an expensive change.”
“The cost estimate for the farm’s AD project was initially less than \$500,000. The actual cost to date has been over \$1,300,000. It is important to get realistic cost estimates and include plans for contingencies.”
“The farm has experienced that accepting food waste can substantially offset the cost to own and operate the digester. The tipping fee received is \$0.06 per gallon for whey delivered to the farm by the processor. A profit center approach to the manure treatment system justifies the management requirement for the digester operation. This additional income should also help to offset the estimated \$700,000 in equipment maintenance and replacement the farm expects.”
Digester Design
“The weir wall consists of wooden boards placed across the concrete opening at the outlet of the digester. These wooden boards eventually failed. Until repairs were made, it was necessary to keep the effluent pit full in order to prevent the loss of biogas.”
“Engineering companies must combine several disciplines in order to design an AD system. Drains to control the water table around the digester to prevent buoyancy of the empty digester and to control heat loss were not included in the initial designs. Uplifting and excessive cooling were prevented by adding well-positioned drainage pipes after construction. The farm learned that all in-ground structures should have drainage systems in the backfill to reduce heat loss and to prevent floatation.”
“The anaerobic digester - including manure handling, gas collection, gas utilization, and digester heating, should be designed as a system. This site experienced a structural beam failure due to lateral loads that were not anticipated. If the concrete design had been better integrated with the rest of the system, this problem may have been avoided.”
“Choosing an engineering company to design and construct the digester was confusing. Each company had different ideas of the type of digester, gas collection, gas cleaning, electrical generation system, electric hook-up, and heating system. Each company had to have the capacity, tenacity and range of expertise to put a complex system together on the farm. Comparing companies with different pricing schemes, sales pitches, and promises was difficult. Many seemingly insignificant issues became serious issues when they caused the whole system to fail. The farm believes it is important to review the

experiences and references of the engineers carefully, paying particular attention to their work on similar projects.”
“The anaerobic digester system should have been completely designed and laid out prior to starting construction. Engineering design was an ongoing process that resulted in construction delays that could have been avoided.”
“Difficulties were encountered when there was a disconnection among the design team. Different areas of the company were unaware of aspects of the project out of their scope of responsibility, and the farm received very different recommendations and opinions from people in the same area of expertise.”
“The digester is a complex system that required more time to design and build than many other components of the farm, including barns, parlors, and long-term storages. Design of the system required several months and construction lasted more than a year. The farm believes that producers need to understand and plan for the time required before they start the process of installing a digester on their farm.”
“The farm experienced that all digester system components need to be properly sized, constructed, installed, operated and maintained properly in order for the system to operate effectively and efficiently.”
“The farm believes that a complete mix digester should have been chosen in lieu of a plug-flow digester. Formation of a crust within the digester has caused problems. It is believed that the addition of restaurant grease-trap waste will help reduce crust build up; the farm adds about 10 gallons per day. On occasion, the farm also adds similar volumes of a by-product from a bio-diesel plant.”
“When foaming occurs, the biogas collection and transport pipes often fill with foam. The digester biogas pressure-control system consists of water buckets that maintain the proper water-level to sustain biogas pressure. Providing a drain for the pipe chases, a solid bottom and water supply, has made clean-up easier. Removing the top of the pipe chase allows easy access and good ventilation for those working in the area. The manure influent pipe should not have been located in the same pipe chase as the pipe carrying biogas from the digester.”
“The microturbine and control room were located closer to the existing electrical infrastructure as opposed to locating it closer to the AD. Heating pipe was installed a long distance instead of electric conductors. Because of this, hot water must be pumped across the farm to heat the digester, and significant heat and energy is wasted in the transport process. Better operation and energy efficiency could be achieved if the digester and its power generation equipment had been located closer to each other.”
“The farm has experienced that heavy snow load can collapse the flexible cover on the digester if it accumulates faster than it can melt. Shoveling the snow off will allow the cover to re-inflate.”
“Two parallel cell digesters were constructed to avoid one excessively long digester. Additionally, the twin digester design makes it possible to shut down and start up each digester independently and therefore increases management flexibility. Operating experience has shown that it is hard to divide digester influent equally between the two digesters; an appropriately designed flow meter along with an automated control device may help solve this problem.”
“Temperature sensors installed in vessel read 3°F higher than reality. Checking and calibrating the instrumentation should have been an important step in start-up procedures.”

Solid/Liquid Handling
“Post-digested separated manure solids were used as bedding for a short time. Incidence of mastitis increased in the milking herd and bedding was the first potential cause that was eliminated. The farm decided the use of manure solids for bedding was too much of a risk for the health of the milking herd.”

<p>“The flow gutter often becomes clogged with solids, and must be flushed with milking center wastewater. The problem is acquiring clean water to flush with, since the wastewater from the foot baths contains copper sulfate, which the farm believes decreases microbial activity in the digester.”</p>
<p>“Subsequent to digester commissioning, it was determined that the food waste (cheese whey) storage pits needed to be covered in order to minimize odor emissions.”</p>
<p>“Sale of post-digested separated solids cured and marketed as compost, has been increasingly successful over time due to repeat customers, word-of-mouth advertising and the use of a website. Compost prices vary depending on the size of the purchase. All post-digested solids turned into compost, are able to be sold.”</p>
<p>“Co-digestion with food waste contributes additional solids to the digestion system, and the farm observes that the effluent has a lower solids content than if manure were digested alone. The farm interprets this to mean the extra energy content of food waste apparently makes it possible for additional solids destruction.”</p>
<p>“The farm believes that solids are destroyed in the long-term storage when post-digested manure is introduced. The existing manure storage was approximately one-half full of manure solids when digested effluent was introduced. After two years of operation, the farm observed that the solids in the storage had decreased significantly with out excessive agitation.”</p>
<p>“Accepting food waste is highly profitable for the farm – tipping fees make the manure treatment system a profit center for the farm. This is a win-win situation for the farm and the food processor. The company supplying food waste has an environmentally responsible and relatively less expensive way to export their waste product(s). Nutrients from the food waste are recycled back to the land and power is produced from a renewable source.”</p>
<p>“The food waste received by the farm is high in energy, having almost three times more biogas production per unit of mass than manure. However, not all farms can take advantage of this. The farm believes that only farms that have a land base able to accept extra nutrients should consider this option.”</p>
<p>“Compost marketing needs to be done in order to sell post-digested separated manure solids. The separated, digested solids are homogeneous, dark in color, and have good tilth. When the digester was constructed, the demand for compost or manure solids was not evident, and transportation costs restricted the potential marketing area to relatively near the farm. Currently however, more interest is being generated in the use of separated manure solids, and if a stable and reliable market can be found, the revenue collected from this by-product would be a valuable asset in the economic performance of the digester.”</p>
<p>“Before the AD system was constructed, a feasibility study was performed to explore the possibility of partnering with other nearby farms to construct a community-based anaerobic digester. A major disadvantage discovered was the expense of manure transportation to the community site and the expense of transporting digester effluent back to each farm.”</p>
<p>“When digester effluent was added to the heifer barn’s manure storage pond, the farm observed that odor was reduced. The farm deduced that, to control on-farm odors, not all manure has to be digested, and that mixing digester effluent with raw manure may provide some odor control.”</p>
<p>“The farm experienced that changing the feedstock of the digester too quickly can disrupt the normal functioning of the bacteria and shock the system.”</p>
<p>“The plug-flow digester on our farm relies on the proper moisture content of the influent. It was observed that when extra liquid is added to the influent, the floatable and settleable solids separate inside the digester leaving a floating crust and a settled deposit. The farm believes that as these two portions of the digester get larger they will decrease the usable volume in the digester and decrease the hydraulic retention time. We foresee that lower retention times will decrease biogas production and fail</p>

to reduce the odors in the effluent.”

Biogas

“Conditioning biogas before sending to the compressors and microturbine is critical for the power generation system. Hydrogen sulfide and water vapor in biogas present the potential for corrosion - the compressor has sensitive components that will corrode. A biogas scrubber, with iron-coated bark as the operative cleaning device was installed to remove hydrogen sulfide.”

“The farm feels that the sizing of the gas handling system needs to account for the additional production of biogas that food waste creates. Pre-planning and analysis of possible food waste sources was helpful to the farm to estimate gas production potential.”

“The farm experienced that raw biogas was released by the top cover due to seal imperfections and the biogas pressure relief system. Biogas release events resulted in odor emissions that were more offensive than untreated manure stored long-term. This has presented an issue with on-farm odor that is now worse than prior to digester construction.”

“A blower and control system was installed in an attempt to keep the biogas pressure in the digester head space neutral to minimize biogas leakage; however, when the equipment fails, biogas still leaks causing odor emissions. The farm experienced that the greater the pressure the more difficult it was to seal the digester. The farm feels that digesters operated at high pressures should be pressure-tested as part of the start-up procedure. Use proven technologies to seal digesters.”

“The farm believes it is important to separate equipment from biogas sources.”

“The digester was designed with a hard top with the goal of developing 12 inches of water column biogas pressure to force biogas into the compressor. The compressor is needed to increase the biogas pressure to microturbine target inlet pressure of 90 psi. Difficulties were encountered in sealing the concrete top which led to biogas leaks and partially digested by-products. Biogas leaks caused odor problems, and since the equipment building was initially located on top of the digester, leaking biogas created both a safety problem and a corrosive environment for electronic equipment.”

“The initial design was to maintain pressure within the digester at 6” of water column. However, it was found that the flare would not function properly at this pressure, thus, the decision was made to increase the pressure to 10” of water column. Since this change has been made, excess biogas has been successfully flared, and emissions of raw biogas have been eliminated.”

“When biogas was not being combusted by the engine, a blow out in the pipe chase would occur, since the diameter of the pipe carrying excess gas to the flare was too small. Keeping the gravity flare lit during windy conditions for high and low biogas flows was difficult. Two automatic spark ignition systems are needed in this case to provide a spark where a flammable mixture of biogas and oxygen is present. The decision was made to change to a power flare, due to the windy conditions and highly variable biogas flows.”

Power Generation

“The noise from the engine in an un-insulated pole barn is loud. People that had been keeping their windows shut from the odor were beginning to complain about the sound. Providing a sound insulated engine room can reduce the sound on-farm as well as the sound heard from a distance.”

“A complete engine-generator set and biogas handling skid, appropriately sized and assembled in a factory, provided ease of design and mechanical equipment installation. The system was assembled with compatible equipment and controls so on-farm installation was easily accomplished.”

“Burying the engine-generator set exhaust pipe and out-letting it some distance from the engine room helped to reduce corrosion of the biogas utilization building and also helped to reduce noise near the building. The internal combustion engine is loud. Additional sound control may further reduce noise

emissions.”
“The microturbine is sensitive to biogas pressure and methane concentration, which can vary widely. The microturbine has complex, sensitive electronics controlling its operation, however, it had significant advantages over an internal combustion engine (including energy conversion efficiency, lower maintenance need, higher exhaust temperatures, and less noise) based on the goals of the farm.”
“The engine-generator set was selected by the farm based primarily on price and not the most efficient size. A used engine-generator set became available and was purchased for use in the digester power generation system. This oversized engine is less efficient in converting fuel to power at lower operating speeds.”
“Since the digester was designed for 1,000 cows and is operating it at half capacity, it has reduced process efficiency.”
“The farm believes that two smaller engine-generator sets should have been chosen instead of one larger unit. Some of the engine-generator set maintenance requires down time and consequently results in the need to procure power from the local utility which increases the farm’s stand-by demand charge.”
“The majority of the problems experienced in the past with microturbines on the farm were due to the corrosive environment created by the leaking concrete top. The electronics had to be replaced after being in a corrosive gas environment prior to start-up. Also, the initial biogas compressors failed despite specifications for biogas use.”

Heat
“Temperature control of the digester is critical for the AD system. Air locks in the heat pipes can prevent proper circulation of hot water inside the digester to heat the incoming manure to 100°F and to keep it at operating temperature throughout the 20-day retention time. It is imperative that temperature gauges are calibrated and working properly, to help diagnose a possible heat-loss problem.”
“The farm believes that groundwater impingement on the bottom of the digester can significantly reduce the temperature of hot water piped to the digester to maintain operating temperature. When a reduced volume of material is transferred to the digester, the amount of heat to the digester is adjusted, since heat will not be needed for incoming manure. Without adjustment, higher temperatures than desired may result.”
“Operational experience revealed that the digester heating system had several initial design flaws. The heat exchanger was sized too small to heat digester influent to 100°F. In addition, groundwater saturating the insulation outside the digester increased heat loss.”
“The heat balance of the digester system is vital. The design needs to address heat recovery from the engine, methods to heat the AD influent, and correct estimates for maintenance heat, which is needed to maintain a constant temperature in all weather conditions.”
“There is a significant amount of heat recovered from the engine-generator set, which is used to heat the digester influent, to maintain the digester operating temperature, and to heat the calf barn and milking parlor. Despite the many uses for waste heat in our system, a radiator to dissipate extra heat is still needed. The un-insulated gas utilization building is kept very warm, even in the winter months, due to the excess heat produced by the engine. This offers a prime opportunity for a shop facility.”
“Although heat recovered from the engine-generator set can be supplied continuously for on-farm demands, during sharp cold snaps, in-floor heating was not sufficient to prevent the pipes from freezing.”
“Maintaining control of digester operating temperature is important, especially during cold weather. Frozen manure and manure with excessive water regularly bypasses the digester. When the digester feed is reduced, biogas production decreases and less heat is available to warm influent. In this case,

either external energy is needed to maintain the digester operating temperature, or the digester needs several months of warmer weather to recover.”

Other

“Technical service support was found to be lacking for much of the equipment associated with the digester system, including the engine-generator set and electrical connections. A small problem that went unfixed for a long period of time led to a more serious problem. There is demand for maintenance service to assist farms in operating and maintaining digester system components.”

“The farm experienced that a project with comparatively high capital cost requires a dedicated person to research the funding opportunities, construction specifics, and permitting requirements prior to construction.”

“Utilizing farm labor to construct the digester was a cost-savings method, which required the farm to be intricately involved in bringing together several components of the AD system. This involvement was valuable in the long run for maintenance and troubleshooting of future problems with the AD system.”

“Shock-loading a digester with high-energy food waste has been known to create substantial amounts of foam. Loading the digester incrementally has reduced the incidence of foaming.”

“One difficulty noted by the farm during the construction process, was the repeated delay and mistakes in ordering of parts and materials. This issue lies more with the companies providing supplies, but the farm should be cognizant to choose reliable companies to furnish parts.”

“The farm invested in various pieces of equipment considered “extra” for the AD system, including a biogas conditioner, draghose, and SLS separator, in order to reduce future farm maintenance needs for the system and assist in the overall goal of recycling manure from the barn to the field, with as little effect possible on humans and the environment.”

“Anaerobic digestion systems have associated safety requirements that are new to a production farm that have taken time and investigation to fully understand.”

“Foaming has occurred when operational and management changes were made, such as, changing the diet of the cows, changing the temperature of the digester or adding other organic materials. Foam escaping from the digester creates a mess, but spraying the foam with water seems to control the foaming. A water source and spray device near the effluent tank has proven to be useful.”

“Manure associated odors have shown to be negligible when the volatile acid levels in the AD effluent are below 500 ppm. Changes in temperature control or retention time have shown to affect the volatile acid concentration in digester effluent, resulting in a potential increase in odor emissions.”

“Currently there are no entities that provide complete technical support or services for anaerobic digestion systems. There are several separate digester components designed by different companies that need to come together for successful digester operation and biogas utilization.”

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