RENEWABLE ENERGY

Wisconsin Agricultural Biogas Casebook

DECEMBER 2009 EDITION

Prepared for Focus on Energy by Joe Kramer, Energy Center of Wisconsin

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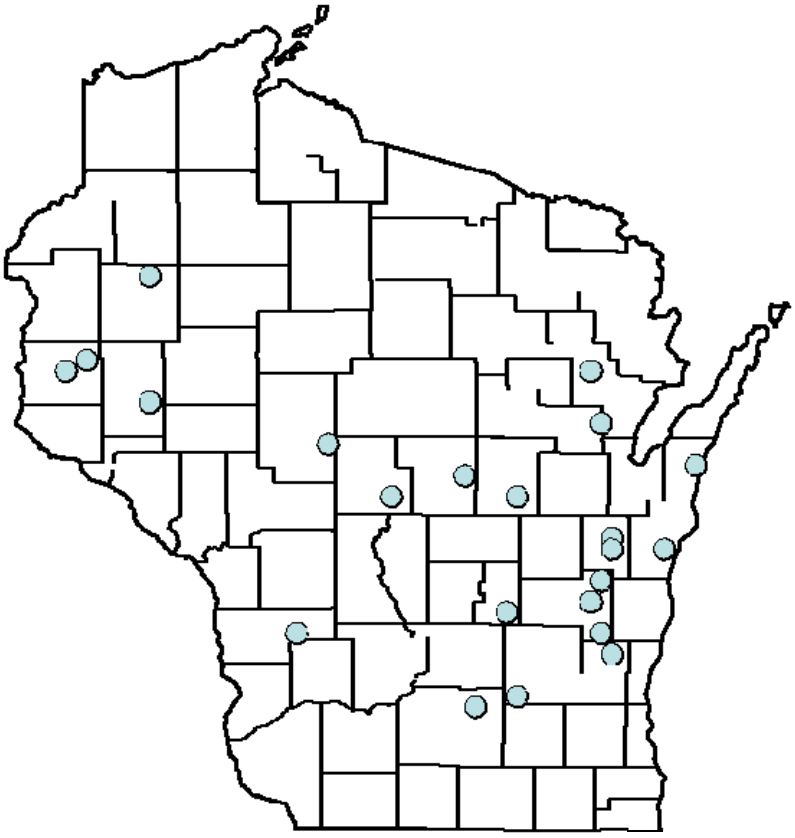
Wisconsin Agricultural Biogas Casebook – 2009



December 2009 Edition

Prepared for Wisconsin Focus on Energy – Renewables Program

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Common Abbreviations and Terms

AD	anaerobic digestion
CHP	combined heat and power
HRT	hydraulic retention time
RAS	return activated sludge
SRT	solids retention time
Units	
AU	animal units
Btu	British thermal units
cfd (ft^3/day)	cubic feet per day
gpd	gallons per day
kW	kilowatt
kWh	kilowatt hours

Term	**Definition**
Acidogenic	acid producing
AgSTAR	a voluntary program jointly sponsored by the USEPA, US Department of Agriculture and the US Department of Energy, that encourages the use of biogas technologies at confined animal feeding operations that manage manures as liquids or slurries <http://www.epa.gov/agstar/index.htm>
Anaerobic Digestion (AD)	the biological, physical and or chemical breakdown of animal manure in the absence of oxygen
Aquaponics	a bio-integrated system that links recirculating aquaculture with hydroponic vegetable, flower, and/or herb production. [1]
Biogas	the gas produced as a by-product of the anaerobic decomposition of livestock manure consisting of about 60-80 percent methane, 30-40 percent carbon dioxide, and trace amounts of other gases
Combined Heat and Power (CHP)	a system for producing electricity while capturing and using process heat
Combined Phase	digestion phases are in the same vessel
Complete-Mix Digester	a controlled temperature, constant volume, mechanically mixed vessel designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery
Composting	a process of aerobic biological decomposition characterized by elevated temperatures

[1] This definition was taken from the National Sustainable Agriculture Information Service: http://attra.ncat.org/attra-pub/aquaponic.html.

Term	Definition
Construction Phase	the period during which the anaerobic digester is under construction
Covered Lagoon Digester	an anaerobic lagoon fixed with an impermeable, gas- and airtight cover designed to promote decomposition of manure and produce methane
Digestate	the liquid discharge of a manure treatment system
Digested Solids	the solids portion of digested materials
Digester	a vessel or system used for the biological, physical or chemical breakdown of animal manure
Free on Board or Freight on Board (FOB)	used in this document to indicate that the buyer pays shipping cost, and takes responsibility for the goods when the goods leave the seller's premises – as in "FOB shipping point"
Hydraulic Retention Time (HRT)	average length of time any particle (liquid or solid) of manure remains in a manure treatment or storage structure. The HRT is an important design parameter for treatment lagoons, covered lagoon digesters, complete-mix digesters, and plug-flow digesters
H_2S	hydrogen sulfide
Hydronics	a system for the circulation of heated liquid for various on-farm purposes
Induction Generator	a generator that will operate in parallel with the utility and cannot stand alone (induction generation derives its phase, frequency and voltage from the utility)
Influent	the materials entering the manure treatment system
Mesophilic	of, relating to, or being at a moderate temperature
Methanogenic	methane producing
Microturbine	small-scale energy generation system that involves the direct combustion of gas and electricity generation in a single unit
Net Metering	an agreement with a utility that states the utility will purchase the net energy generated by a distributed generation system
Operational Phase	biogas production is stabilized in the digester
Plug-Flow Digester	a constant volume, flow-through, controlled temperature biological treatment unit designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery
Psychrophilic	of, relating to, or being at a relatively low temperature
Return Activated Sludge (RAS)	a process by which some of the digester bacteria are returned to the digester reducing the amount of energy the biological system expends on growth of new bacteria as well as the reaction time required for digestion
Scrubber (Biogas)	biogas cleaning device or process to remove hydrogen

Term	Definition
	sulfide and other impurities
Sell-All Contract	a power sales agreement in which all of the electricity produced is sold to the utility or other entity
Solids Retention Time (SRT)	average length of time any solid particle of manure remains in a manure treatment or storage structure. This is calculated by the quantity of solids maintained in the digester divided by the quantity of solids wasted each day (in digesters without RAS, HRT = SRT; in retained biomass reactors, the SRT exceeds the HRT).
Startup Phase	the digester is being fed manure, but biogas production is not yet stabilized
Struvite	a white crystalline substance consisting of magnesium, ammonium, and phosphorus in equal molar concentrations
Synchronous Generator	a generator that can operate either isolated (stand-alone) or in parallel with the utility (i.e., it can run even if utility power is shut down). It requires a more expensive and sophisticated utility intertie to match generator output to utility phase, frequency and voltage.
Thermophilic	of, relating to, or being at a relatively high temperature
Two Phase	the digestion phases occur in separate vessels

Introduction and Methodology

Use of anaerobic digestion (AD) to treat livestock manures and other feedstocks continues to grow. AD systems treat raw manure using a heated, oxygen free container that allows digestion that began in the cow's stomach to continue. This results in an output with improved environmental characteristics and value as fertilizer. It can also provide on farm benefits, income and cost reduction opportunities. AD systems with solids separation convert livestock manure into a combustible gas (i.e. biogas), liquid effluent, and digested solids. The gas is typically used for energy generation (electricity and or heat). The liquid effluent is generally land applied as a low-odor fertilizer with characteristics closer to commercial alternatives and can often be substituted directly for the increasingly expensive fertilizers. The phosphorus-rich (P) digested solids are commonly used as bedding for cows, but also have value as soil supplements either on agricultural lands or by landscapers, gardeners or greenhouses.

Wisconsin remains at the forefront of U.S. farm-based digester use. This second edition of the Wisconsin Agricultural Biogas Casebook includes brief case studies of farm-based anaerobic digesters installed in Wisconsin. This report gives a look at the experiences of 21 farms with operating anaerobic digester systems in Wisconsin as of fall 2009. The author extends a special thanks to the digester owners, operators, designers and utility representatives who have graciously shared their experiences, time and information to make this casebook possible. This information is presented to give those interested in digesters some insight into how these systems are working in Wisconsin. The task is made easier by the fact that these systems appear to be generally successful. When relevant, insights, problems, mistakes or other issues encountered by the parties involved are shared in the hope that future efforts can benefit from that history.

The sources chosen for information in compiling these case studies are:

1. digester owners – information on farm characteristics, operation, and experiences
2. technology providers – digester designs and characteristics, assumptions about the farm that went into designing the digesters, biogas utilization systems
3. utility representative – energy generation, power purchase agreements, interconnection issues
4. Focus on Energy – basic farm and contact information for installed digester systems

Sources were interviewed over the period of August through November 2009. Digester owners were given the opportunity to review draft versions of their case study write-ups to improve accuracy. Electricity generation information was requested from utilities (with the owners' prior written consent) for the 30-months period from January 2007 through June 2009, for all systems that have utility power purchase agreements. Generation information is based on billing cycles and roughly corresponds to monthly output (but is tied to months out of convenience for illustration). This information was ultimately obtained for 16 of the 20 farms generating electricity from biogas (one farm did not yet have the equipment installed). Two farms had very new systems without

histories in the data period, and two did not go through the necessary process to allow their data to be shared.

This casebook represents a step in a larger and ongoing effort to provide coordinated and consistent digester performance information to the general public using uniform methods. The Association of State Energy Research and Technology Transfer Institutions (ASERTTI), USDA Rural Development and EPA AgSTAR program have worked together to produce a standardized performance protocol.[2] This performance protocol has not been applied to the information gathered in this casebook. These case studies are broader in scope and generally lack independent third party verification (application of the protocol to these systems was well beyond the scope of this project). The ideal would be full protocol use at these installations. Focus on Energy (Focus) has instituted contracting measures in their grant language that are expected to enable monitoring and collection of more detailed information for current grant recipients.

The author originally intended to include expanded system economics information in this edition. However, issues with consistency, availability, and resources have resulted in the decision to exclude coverage of economics at this time. In addition to the great variation in data quality available, the degree of processing and interpretation of the data for each farm rendered this effort beyond the scope of the current casebook. The option of including greater coverage of system economics will be evaluated for future casebooks, and covered if conditions allow.

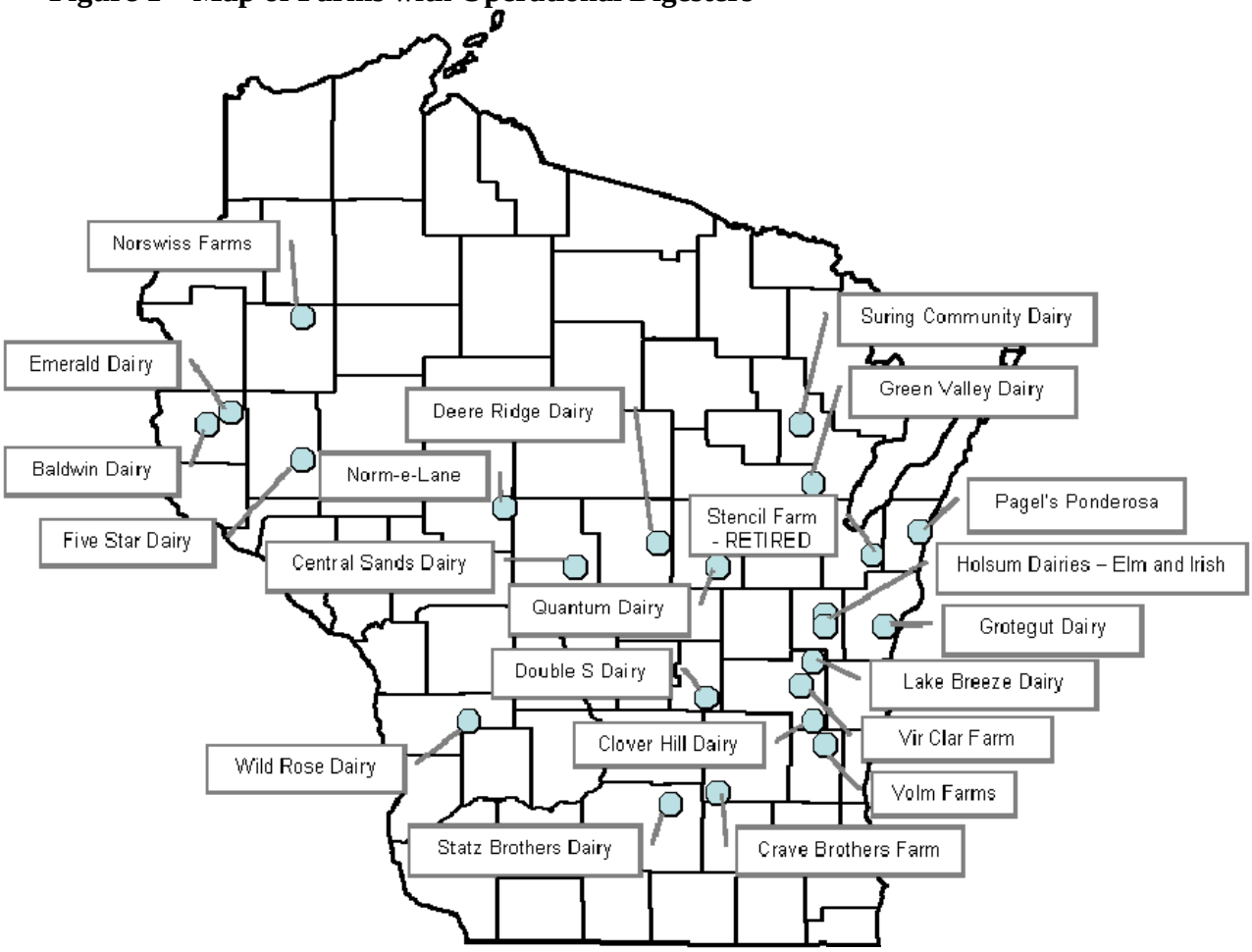
This casebook does include expanded information on digested solids generation and markets that are developing for their use. Each digester owner was asked for information on the quantity of solids being produced, whether they were used on the farm or sold to others, and the prices charged. This information is presented for all the systems in the front summary section and individually in each case study.

[2] A copy of the current protocol and additional information can be obtained from the ASERTTI Web site at: http://www.asertti.org/programs/digester/index.html.

Summary Information

The farms with digesters are spread throughout the state with some notable concentration in the east central region. Figure 1 below shows a map of the general locations for these farms.

Figure 1 – Map of Farms with Operational Digesters



As of fall 2009, there were 22 farms with 31 operating anaerobic digester systems in Wisconsin. This total excludes Stencil Farm which has retired their digester (described on page 4), and includes the reportedly operational digester at Grotegut Dairy whose owners declined to participate in this study. Digester statistics and descriptions in the remainder of this document all refer to installed systems on the 21 farms with 30 digesters that are profiled in this casebook. The 2008 casebook had a total of 17 farms with 22 digesters. All of the operational farm-based systems in Wisconsin are on dairy farms.[3]

[3] Maple Leaf Farms, a duck farm in Franksville, Wisconsin, was the only non-dairy livestock operation with an anaerobic digester. They closed their Wisconsin operations in May of 2008.

Farms Characteristics

Additional information on the farms including number of animals feeding the digester, how manure is collected and type of bedding used is listed in Table 1.

Table 1 – Farm Details

Farm name	Locality	Herd Feeding Digester	Collection Type	Collection Frequency	Bedding Type
Baldwin Dairy	Baldwin	1,050	scrape	3x a day	digested solids
Central Sands Dairy	Nekoosa	3,800	vacuum & scrape	3x a day	sand
Clover Hill Dairy	Campbellsport	1,400	scrape	continuous	digested solids
Crave Brothers Farm	Waterloo	1,900	gravity flow to pit & scrape	continuous	digested solids
Deere Ridge Dairy	Nelsonville	850	scrape	3x a day	digested solids
Double S Dairy	Markesan	1,100	scrape	3x a day	digested solids
Emerald Dairy	Emerald	1,600	scrape	3x a day	digested solids
Five Star Dairy	Elk Mound	975	scrape	3x a day	digested solids
Green Valley Dairy	Green Valley	3,400	scrape	continuous	digested solids
Holsum Dairy (Elm Road)	Hilbert	4,200	scrape	continuous	digested solids
Holsum Dairy (Irish Road)	Hilbert	3,850	scrape	3x a day	digested solids
Lake Breeze Dairy	Malone	3,000	flush	hourly	sand
Norm-E-Lane	Chili	2,500	scrape & gravity flow	3x a day	digested solids
Norswiss Farms	Rice Lake	1,240	scrape & gravity flow	3x a day	digested solids, sand
Pagel's Ponderosa Dairy LLC	Kewaunee	4,600	scrape & gravity flow	20 hours a day	digested solids
Quantum Dairy	Weyauwega	2,100	scrape	3x a day	digested solids
Statz Brothers, Inc.	Sun Prairie	2,560	scrape	3x per day	digested solids
Sunrise Dairy (formerly Suring Community Dairy)	Suring	1,075	scrape	15x per day	digested solids
Vir-Clar Farm	Fond du Lac	1,400	scrape	continuous	digested solids
Volm Farms	Kewaskum	825	automatic scrape collection	continuous	digested solids
Wild Rose Dairy	La Farge	880	scrape	3x a day	digested solids

Farms with installed digesters are predominantly using digested solids for bedding, although there are two in Wisconsin that use sand. One farm in this group was using sawdust, but has recently switched to digested solids because sawdust has been increasingly costly and hard to find.

As mentioned above, Stencil Farm recently retired their digester. Their system was an RCM Digesters Inc. designed standard plug-glow system with a flexible cover. They were having difficulty keeping it in their target operational temperature range in the colder months, and were considering a possible refurbishment or retrofit to add some mixing capability (Kramer 2008). Instead, they opted to retire the system and bought a "Bedding Recovery Unit" (BRU) from Fan Separator of Germany. The BRU is used to compost (i.e., aerobically treat) raw separated manure solids to produce a bedding product. Figure 2 below is picture of the BRU at Stencil Farm.

Figure 2 – Bedding Recovery Unit at Stencil

Photo courtesy of Bauer and Fan Separator North America.

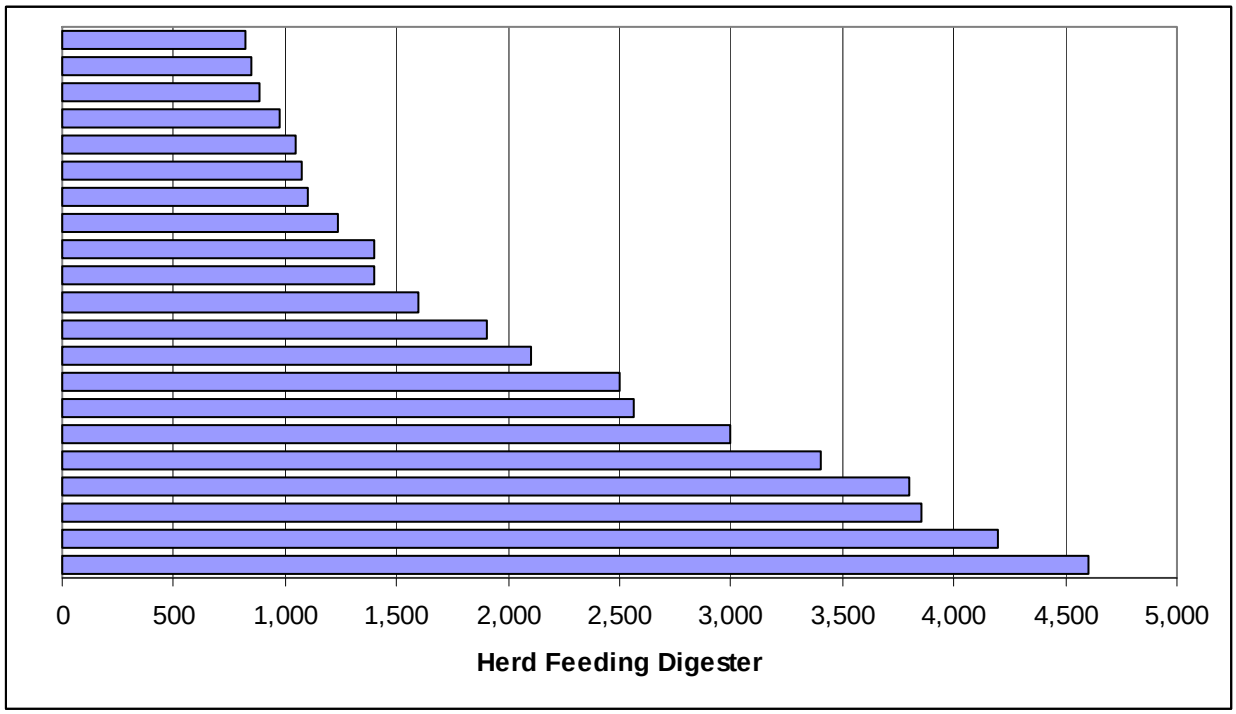
The system on Stencil Farm is reported to be composting manure at 140-150 degrees F. The owner says he is happy with the performance of the system, and it is being studied by a University of Minnesota postdoctoral student.[4] Since using this composted bedding, he has reported reductions in somatic cell counts. He is now running all their separated solids through it and using all the composted solids on the farm.

In Wisconsin, AD systems have only made a commercial presence on larger farms. The farms with operational systems in Wisconsin illustrate this condition.

Figure 3 shows the herd sizes on Wisconsin farms with operating digesters. Herd sizes for operational digester systems in Wisconsin range from about 825 to 4,600 head. The AgSTAR Handbook gives a minimum number of dairy cows and steers of about 500 for successful use of an anaerobic digester.[5]

[4] Dave Stencil, personal communication, October 2009.
[5] The AgSTAR Handbook can be downloaded at: http://www.epa.gov/agstar/resources/handbook.html.

Figure 3 – Herd Sizes for Farms with Digesters



Digester Characteristics

There are several system types being installed, fitting the classifications of mixed plug-flow and complete mix, and a total of seven different digester designers with active systems in Wisconsin. Table 2 on the following page lists some details on individual systems and design companies, and Table 3 shows the number of systems for each company installed in Wisconsin.

Table 2 – Digesters and Designers Profiled

Dairy Name	Type of digester	System Designer	Temperature	Operational
Baldwin Dairy	modified mixed plug-flow	Bob Komro	mesophilic	2006
Central Sands Dairy	mixed plug-flow (x2)	GHD, Inc.	mesophilic	2008
Clover Hill Dairy	mixed plug-flow	GHD, Inc.	mesophilic	2007
Crave Brothers Farm	complete mix (x2)	Clear Horizons, LLC	mesophilic	2007, new 2009
Deere Ridge Dairy	mixed plug-flow	GHD, Inc.	mesophilic	2002
Double S Dairy	mixed plug-flow	GHD, Inc.	mesophilic	2002
Emerald Dairy	mixed plug-flow	GHD, Inc.	mesophilic	2005
Five Star Dairy	complete mix	Microgy, Inc.	thermophilic	2005
Green Valley Dairy	complete mix (x3)	Biogas Direct,** new Northern Biogas*	mesophilic	2007, new 2009
Holsum Dairy (Elm Road)	mixed plug-flow (x2)	GHD, Inc.	mesophilic	2007
Holsum Dairy (Irish Road)	mixed plug-flow (x2)	GHD, Inc.	mesophilic	2003
Lake Breeze Dairy	mixed plug-flow (x2)	GHD, Inc.	mesophilic	2006
Norm-E-Lane	mixed plug-flow	GHD, Inc.	mesophilic	2008
Norswiss Farms	complete mix	Microgy, Inc.	thermophilic	2006
Pagel's Ponderosa Dairy LLC	mixed plug-flow (x2)	GHD, Inc.	mesophilic	2008
Quantum Dairy	mixed plug-flow	GHD, Inc.	mesophilic	2005
Statz Brothers, Inc.	mixed plug-flow	GHD, Inc.	mesophilic	2009
Sunrise Dairy	complete mix	American Biogas Co., Inc.	mesophilic	2006
Vir-Clar Farm	complete mix (x2)	Biogas Direct**	mesophilic	2004
Volm Farms	mixed plug-flow	GHD, Inc.	mesophilic	2009
Wild Rose Dairy	complete mix	Microgy, Inc.	thermophilic	2005

* The new system installed was designed and built by Northern Biogas a new company formed by the farm owners.
** Biogas Direct has changed its name to Energies Direct, LLC.

Table 3 – Total Systems for Designers

Digester Type	Designer	Farms	Digesters
Mixed plug-flow, mesophilic	GHD, Inc.	13	18
Modified mixed plug-flow, mesophilic	Komro International	1	1
Complete mix, thermophilic	Microgy, Inc.	3	3
Complete mix, mesophilic	Biogas Direct	2	4
Complete mix mesophilic	Northern Biogas	1*	1
Complete mix, mesophilic	Ambico	1	1
Complete mix, mesophilic	Clear Horizons	1	2
Total		21	30

* The Northern Biogas digester is on a farm that has two Biogas Direct systems also, therefore it doesn't count as an additional farm for the totals.

Biogas Use

The most common choice for digester owners to use their biogas is to run it through an engine generator set to generate electricity for sale and heat for on farm use. Table 4 lists the biogas uses and information on the equipment.

Table 4 – Biogas Uses

Farm name	Biogas utilization	Type of prime mover	Generator Manufacturer and Capacity
Baldwin Dairy	heat and flared	biogas boiler, expect to add engine generator set	na
Central Sands Dairy	electricity and heat	engine generator set	Guascor 720 kW
Clover Hill Dairy	electricity and heat	engine generator set, synchronous	Guascor MGG-355, 300 kW
Crave Brothers Farm	electricity and heat	engine generator set, synchronous	Jenbacher, JMC 312 engine gen set, 633 kW
Deere Ridge Dairy	electricity and heat	engine generator set, induction	Caterpillar 3408 140 kW
Double S Dairy	electricity and heat	engine generator set, induction	Caterpillar 200 kW
Emerald Dairy	electricity and heat	engine generator set, synchronous	Waukesha 110 kW
Five Star Dairy	electricity and heat	engine generator set, synchronous, but not operated to stand alone*	Waukesha 775 kW, 750 kW net
Green Valley Dairy	electricity and heat	two engine generator sets, synchronous	two Caterpillar 3512, 600 kW, 1200 kW total
Holsum Dairy (Elm Road)	electricity and heat	two engine generator sets, synchronous, set to shut down during outage	two Guascor sets at 600 kW each, 1200 kW total net
Holsum Dairy (Irish Road)	electricity and heat	two engine generator sets, synchronous, set to shut down during outage	Guascor 500 kW and 400 kW
Lake Breeze Dairy	electricity and heat	two engine generator sets, synchronous	two Caterpillar 300 kW, 600 kW total
Norm-E-Lane	electricity and heat	engine generator set, induction	Guascor 480, 600 kW
Norswiss Farms	electricity and heat	engine generator set, synchronous, but not operated to stand alone*	Jenbacher JGS316 GS-B.L. 848 kW
Pagel's Ponderosa Dairy LLC	electricity and heat	engine generator set, induction, boiler	Caterpillar 3516, 800 kW
Quantum Dairy	electricity and heat	engine generator set, induction	Guascor 450 kW
Statz Brothers, Inc.	electricity and heat	engine generator set, synchronous	Guascor 600 kW
Sunrise Dairy	electricity and heat	engine generator set, synchronous	Deutz 250 kW (230 net), engine is dual fuel using 20% diesel
Vir-Clar Farm	electricity and heat	engine generator set, synchronous	Caterpillar/SEVA 3412, 350 kW
Volm Farms	electricity and heat	engine generator set, induction	Guascor 225 kW
Wild Rose Dairy	electricity and heat	engine generator set, synchronous, but not operated to stand alone*	Waukesha 775kW, 750 kW net

*The engine generator sets owned by Dairyland Power at Five Star, Norswiss, and Wild Rose dairies are synchronous systems that are used to provide voltage support in the distribution networks, but are configured to shut down in the event of a system outage.

Since the 2008 casebook, installed capacity on farm scale biogas systems in Wisconsin has grown by almost 60 percent from 7.3 to 11.6 megawatts.

Co-Digestion

Nine digester owners are adding other substrates to their influent in addition to the usual manure, bedding and wastewater. Three of these owners report adding other on-farm wastes such as chopped straw, waste corn silage and moldy or unused feed. Five farms regularly process off-farm wastes with their manure to boost biogas production. Table 5 below lists farms with information on co-digestion.

Table 5 – Manure Volumes and Other Wastes Being Digested

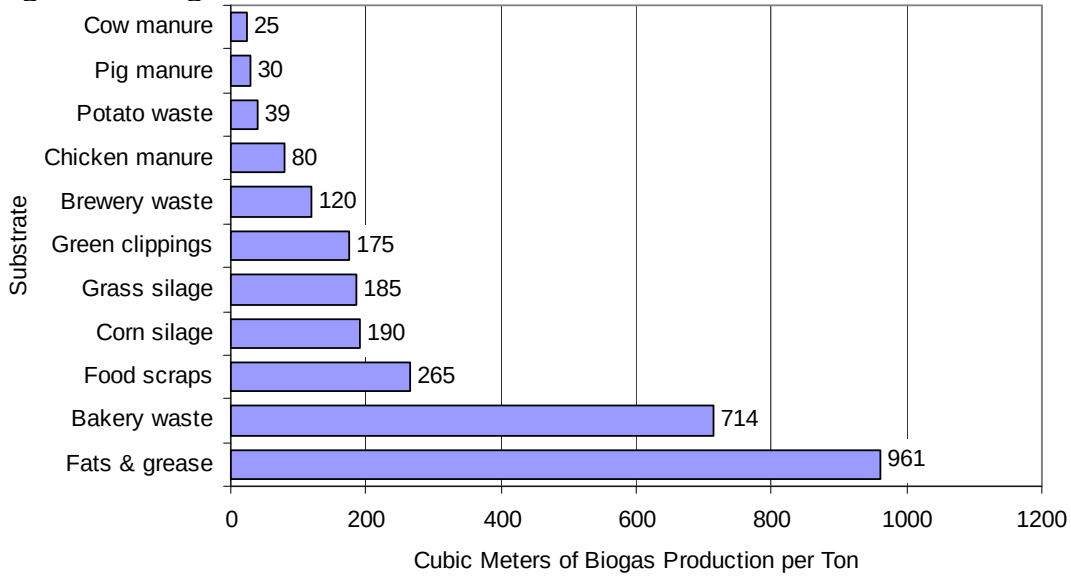
Farm name	Daily Manure Volume	Other Waste Added
Baldwin Dairy	35,000 gallons	none
Central Sands Dairy	120,000 gallons	none from off farm, waste corn silage
Clover Hill Dairy	40,000 gallons	none
Crave Brothers Farm	55,000 gallons	5,000-8,000 gallons per day whey and other wastes added (some seasonal)
Deere Ridge Dairy	28,000 gallons	none
Double S Dairy	na	none
Emerald Dairy	50,000 gallons	none
Five Star Dairy	41,000 gallons	+10% industrial food-waste grease
Green Valley Dairy	135,000 gallons	none
Holsum Dairy (Elm Road)	84,000 gallons	+10% waste substrates from 3 food processing industries
Holsum Dairy (Irish Road)	77,000 gallons	+10% waste substrates from 3 food processing industries
Lake Breeze Dairy	100,000 gallons	none
Norm-E-lane	55,000 gallons	none
Norswiss Farms	47,000	+10% industrial food-waste grease
Pagel's Ponderosa Dairy	160,000 gallons	none
Quantum Dairy	60,000 gallons	none
Statz Brothers	75,000 gallons	none
Sunrise Dairy	28,000 gallons	none
Vir-Clar Farm	40,000 gallons	bunker waste, moldy feed, whatever not eaten by the cows (on-farm wastes)
Volm Farms	20,000 gallons	add some chopped straw to produce more bedding
Wild Rose Dairy	25,000 gallons	+10% industrial food-waste grease

Increases in biogas generated through addition of high energy feedstocks can only benefit the farm if it has the capacity to use the biogas. Otherwise, the biogas is flared. Some farms are using some limited on-farm biogas storage to maximize electricity production during energy demand peak hours when they can get the highest price for their generation.

Increasing interest in keeping compostable organics out of landfills[6] will mean owners of digesters may have increased options for accepting off farm substrates. Figure 4 gives an estimate of the biogas production potential from various substrates. Manure is one of the lowest potential biogas producers.

[6] For example, see the COOL 2012 Web site: www.cool2012.com.

Figure 4 – Biogas Generation Potential of Substrates



Source: Data derived from www.biogas-energy.com, © 2007 Biogas Energy, Inc., translated from: Basisdaten Biogas Deutschland, Marz 2005,: Fachagentur Nachwachsende Rohstoffe e.V.

Waste management service providers are increasingly seeking, on behalf of clients such as retail or grocery chains, options for converting organic wastes to energy and other products. These food wastes tend to have higher energy value than manure, and could be good supplements to farm wastes for co-digestion, or could be added to industrial food processing digester facilities.

Energy Generation

Biogas generation information was not available for many of the systems in this report due to the lack of gas metering on older systems. Newer systems include biogas metering and this statistic is expected to be included in future editions of this casebook once a suitable history has been established.

Nearly all the farms generating electricity have purchase agreements with utilities. With the energy generation owners' consent we obtained purchase histories from the utilities for 16 of these systems. Table 6 on the following page shows the installed capacity, total electrical production over the data periods, theoretical production capacities for each if they were operating at maximum output for the entire period, and the "capacity factor" determined by the percent actual production represents of that theoretical maximum. Monthly generation profiles for individual systems are included in the case studies.

Table 6 – Installed Capacity and Generation

Facility	Installed Capacity (kW)	Production Sold to Utility (kWh)	Theoretical Production Capacity (kWh)	Capacity Factor	Months in Estimate
Central Sands (net) *	720	1,120,100	5,702,400	20%	11
Clover Hill	300	3,904,570	6,264,000	62%	29
Crave Brothers	633	4,203,536	5,362,200	78%	28
Deere Ridge	140	1,901,634	3,024,000	63%	30
Five Star	750	11,659,607	16,200,000	72%	30
Green Valley	1200	9,860,216	15,120,000	65%	30
Holsum Elm	1200	15,912,086	25,920,000	61%	30
Holsum Irish	700	5,321,262	15,120,000	35%	30
Lake Breeze	600	6,406,022	12,960,000	49%	30
Norm E Lane	600	3,087,800	4,320,000	71%	10
Norswiss	848	10,801,484	18,316,800	59%	30
Pagel's Ponderosa	800	2,488,441	3,456,000	72%	6
Quantum	450	4,518,330	7,020,000	64%	30
Statz Brothers	600	1,247,060	2,160,000	58%	5
Vir Clar	350	5,413,400	7,560,000	72%	30
Wild Rose	750	5,452,858	15,660,000	35%	29

* Central Sands production is net of that used on farm. Therefore, calculated capacity factor will be artificially low.

Notes: Installed capacity is the rated capacity of the engine generator set. Theoretical production capacity is calculated based on the number of hours in the monitoring period (assuming 30-day months) multiplied by the installed capacity. Facilities that underwent changes in installed capacity during the data period (i.e., Crave Brothers, Green Valley, and Quantum) were adjusted accordingly based on estimates of when the upgrades were installed. Holsum Irish is listed in this table at 700 kW capacity because they had not yet upgraded to their current 900 kW capacity during the data period. These numbers are rough estimates based on energy purchase data received from the utilities, and some may include startup or partial months during which facilities had lower than typical generation.

It should be recognized that theoretical capacity as presented here cannot be practically achieved, given necessary downtime for oil changes and other maintenance. Numerous other conditions influence observed capacity factors. To find out more detail on the generation histories of these systems see the annotated generation histories and discussion in the individual case studies.

Business Models

The profiled farms are working under several different business models and contracts. Table 7 on the following page describes the business models for the digester installations and utility contracts.

Table 7 – Business Models and Utility Contract Types

Farm name	Business Model	Utility	Utility Contract Type
Baldwin Dairy	farm owns digester, looking at biogas use options, may supply heat to other farm operations	St Croix Electric Coop	na
Central Sands Dairy	farm owns all	Dairyland Power	na
Clover Hill Dairy	farm owns all, sells electricity to utility	We Energies	sell-all
Crave Brothers Farm	Clear Horizons owns digester and energy generation, farmer buys solids and fertilizer back from CH, We Energies buys elecricity.	We Energies	buy excess
Deere Ridge Dairy	farm owns digester and sells biogas to utility, utility owns and operates generator on site	Alliant Energy	sell-all biogas
Double S Dairy	farm owns all, sells electricity to utility	Alliant Energy	sell-all
Emerald Dairy	farm owns digester, energy generation, energy used on farm	St Croix Electric Coop	na
Five Star Dairy	Microgy built, operates and maintains digester, Dairyland buys biogas and owns/operates genset and scrubber, sells elec to member coops, gas sales and carbon credits buy down debt for farmer on digester	Dairyland Power	biogas sales to Dairyland Power, output goes into Dairyland system and is made available to member coops
Green Valley Dairy	farm owns all, sells electricity to utility	We Energies	sell-all
Holsum Dairy (Elm Road)	farm owns all, sells electricity to utility	Wisconsin Public Service	sell-all
Holsum Dairy (Irish Road)	farm owns all, sells electricity to utility	Wisconsin Public Service	sell-all
Lake Breeze Dairy	farm owns all, sells electricity to utility	We Energies	sell-all
Norm-E-Lane	farm owns all	Dairyland Power	sell-all
Norswiss Farms	Microgy built, operates and maintains digester, Dairyland buys biogas and owns/operates genset and scrubber, sells elec to member coops, gas sales and carbon credits buy down debt for farmer on digester	Dairyland Power, Barron Electric	biogas sales to Dairyland Power, output goes into Dairyland system and is made available to member coops
Pagel's Ponderosa Dairy	farm owns all	Wisconsin Public Service	sell-all
Quantum Dairy	farm owns all, sells electricity to utility	We Energies	sell-all
Sunrise Dairy	farm has new owners, digester and genset owned and operated by third party	Wisconsin Public Service	sell-all
Vir-Clar Farm	farm owns all, sells electricity to utility	Alliant Energy	sell-all
Volm Farms	farm owns all	We Energies	sell-all
Wild Rose Dairy	Microgy built, operates and maintains digester, Dairyland buys biogas and owns/operates genset and scrubber, sells elec to member coops, gas sales and carbon credits buy down debt for farmer on digester	Dairyland Power	biogas sales to Dairyland Power, output goes into Dairyland system and is made available to member coops

Digested Solids

Markets for separated digested solids have been developing in Wisconsin. Digester owners are increasingly reporting that some solids are currently sold off farm either to other farms for bedding, or to gardeners or landscapers. These markets are still developing, and will likely be quite local. One digester owner (Clear Horizons on Crave

Brothers Farm) has bagged retail products sold as soil amendments. This section looks at markets for loose solids sold by the ton or yard.

Eight of the 21 farms are using all the solids they produce on their own farm, either as bedding, land applied as soil supplements, or both. Of the 12 farms selling some off-site, the average price is about $20 per ton. The summary statistics on these prices are:

Average price = $20/ton ($7/yard)
Median price = $20/ton ($7/yard)
Maximum price = $35 ($12/yard)
Minimum price = $10 ($3/yard)

These solids are typically sold by the ton or yard. We converted all to tons using conversion rules of 3 yards = 1 ton (used by some owners) and a "semi-load" = 52 yards or about 17 tons. Needless to say, tonnage estimates are ballpark estimates at best and variations in moisture content could change weights significantly. Based on responses and these conversion factors the summary statistics for weight of usable solids extracted from digester effluent per head were:

Average = 0.009 tons/head/day
Median = 0.008 tons/head/day
Maximum = 0.027 tons/head/day
Minimum = 0.003 tons/head/day

Biogas Treatment

Biogas pretreatment information was also gathered. Virtually every system is using a device of some kind to reduce the moisture of the biogas. A number of farms are now employing scrubbing systems or practices to reduce hydrogen sulfide (H_2S) levels in biogas prior to using it in their engines. Farms with reported biogas treatments are described in Table 8 below.

Table 8 – Biogas Treatment

Farm name	Pretreatment of biogas
Clover Hill Dairy	GHD H_2S reduction system
Crave Brothers Farm	H_2S reduction through air injection into digester
Emerald Dairy	iron sponge
Five Star Dairy	Biothane scrubber
Green Valley Dairy	aerobic bacteria treatment (O_2 injection system they designed)
Holsum Dairy (Elm Road)	H_2S reduction through air injection into digester
Holsum Dairy (Irish Road)	H_2S reduction through air injection into digester
Norswiss Farms	Biothane scrubber
Pagel's Ponderosa Dairy	GHD H_2S reduction system
Quantum Dairy	added scrubber from Martin Machinery in 2009
Sunrise Dairy	H_2S reduction through air injection into digester
Vir-Clar Farm	H_2S reduction through air injection into digester
Wild Rose Dairy	Biothane scrubber

Having H_2S in the biogas can cause excessive engine wear. The primary benefit reported of reducing biogas H_2S levels is the reduced frequency of oil changes needed, which translates directly into increased uptime for the engine and lower oil costs.

Case Studies

This section includes brief case studies of operational systems in Wisconsin. As of this writing, all farm-based anaerobic digester systems in Wisconsin were on dairy operations.

Baldwin Dairy – Baldwin, Wisconsin

Farm Name:	Baldwin Dairy	**Location:**	Baldwin
Farm Type:	dairy	**Herd Size:**	1,050 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	modified mixed plug flow	**Design Temperature:**	100 deg F
Digester Notes:	not available		
Design Capacity:	1,200 head	**Date Operational:**	2006
Design HRT:	22 days	**Current HRT:**	21 days
Design Solids %:	not available	**Current Solids %:**	8%
Biogas Use:	currently fuels a boiler and flared, building greenhouse	**Utility Contract:**	none
Solids Separation:	yes, screw press	**Solids Use:**	bedding, sell about 10-20%
Farm Owns:	digester	**Utility Owns:**	none
Digester Designer:	Komro International, LLC	**Utility:**	St. Croix Electric Coop.

Baldwin Dairy is located in Baldwin, Wisconsin, in central St. Croix County. It has a current milking herd size of about 1,050 Holsteins. This farm operation produces about 35,000 gallons of manure and water per day to feed the digester. The influent averages about eight percent solids, and is scrape collected three times per day, and put into the digester six times per day. They use a Fan screw press solids separator post digestion to generate bedding for their cows. Figure 5 below shows some of the barns at Baldwin Dairy. The former manure storage system for the farm was a covered anaerobic lagoon.

Figure 5 – Baldwin Dairy

Photo courtesy of Agri-Waste Energy, Inc.

Digester. As in the 2008 casebook[7], a description of the digester from the designer was not available. The owner provided the following information. This is the first system of this type designed by Komro International and the only digester of this design in Wisconsin. The digester is a modified mixed plug flow digester that is designed to operate in the mesophilic temperature range (100 degrees F). Liquid is sucked out on the bottom and re-injected on the sides to provide mixing. It uses return of activated sludge (RAS) from the last stage to improve digestion efficiency by keeping more active bacteria in the system. The system is designed to use heat from the effluent to help pre-heat the manure going in. Influent is pumped into the digester six times per day. They also used Wieser Concrete pre-cast panels for the walls and roof of the digester rather than casting all concrete in place. They report that this made it easier for permitting, and it took only about 30 days to build. The hydraulic residence time (HRT) is currently about 21 days, and the average operating digester temperature is 100 degrees F.

Outputs and Uses.
The owner reports that the system is exceeding the predicted biogas production. Biogas is currently being used to fire a biogas boiler they designed to help heat the digester, and the rest is currently flared. They plan to add other energy generation, probably an engine generator set, to provide electricity and heat to some planned greenhouses. They plan to grow fish and fresh vegetables in the greenhouses using farm resources. They are still looking at options for biogas cleanup and sale, but recent low natural gas prices have made that currently uneconomical. They are producing digested solids running effluent through a Fan screw press, but do not have a current estimate of the volume. They sell about 10-20 percent of their solids for use off farm.

History and Comments.
The owner, John Vrieze, was an early adopter of anaerobic digestion technology when he installed covered lagoons at this and the Emerald Dairy in 1998 and 1999 respectively. When he did not get the digestion quality or biogas production he wanted, due to the cooling of the lagoons in cold months, he opted to replace them with heated systems. He feels the new Komro International system has been "pretty flawless." They had to do an EPA AgSTAR engineering study prior to construction and have found that their biogas production exceeds that predicted by the study. He has plans to add an engine generator set to provide power for some planned greenhouses. The greenhouses will be used to produce tilapia (fresh water fish) and vegetables. Biogas upgrading and sale is still a possibility but not in the immediate future.

Information Sources.
John Vrieze – Baldwin Dairy

[7] Kramer J, *Wisconsin Agricultural Biogas Casebook – July 2008 Edition*, produced for Wisconsin Focus on Energy Renewables Program, July 2008, www.focusonenergy.com/biogascasebook.

Central Sands Dairy – Nekoosa, Wisconsin

Farm Name:	Central Sands Dairy	**Location:**	Nekoosa
Farm Type:	dairy	**Herd Feeding Digester:**	3,800 head
Collection Method:	vacuum liquid, scrape frozen	**Bedding Type:**	sand
Digester Type:	mixed plug-flow (x2)	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	3,500 head	**Date Operational:**	2008
Design HRT:	22 days	**Current HRT:**	14 days
Design Solids %:	8-9%	**Current Solids %:**	4.2%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, type not available
Solids Separation:	yes, screw press	**Solids Use:**	land applied
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Dairyland Power

Central Sands Dairy is located in Nekoosa, Wisconsin, in eastern Juneau County. They have a herd size of 3,800 head that produce roughly 120,000 gallons per day of manure and wastewater for treatment. The herd consists of one third Jerseys, and two thirds Holstein-Jersey cross breeds. The dairy herd is bedded with sand and they note they need to add significant water to facilitate sand separation. Manure is vacuum-collected three times per day, and scrape collected when it is frozen. They employ a three step system for sand removal and recovery consisting of a McClanahan sand separator, a Hydrocyclone sand separator, and a sand settling lane prior to the influent entry into the digester. The digester complements a 22 million gallon liquid storage system and concrete pad for solids storage.

Digester.
The farm owners had two mixed plug-flow digesters designed by GHD, Inc. of Chilton, Wisconsin, installed in 2008. The digesters are U-shaped, below grade cast concrete structures, with gas induced mixing and return of activated sludge (RAS). Figure 6 below shows a schematic for a typical GHD system.

Figure 6 – GHD Digester Schematic

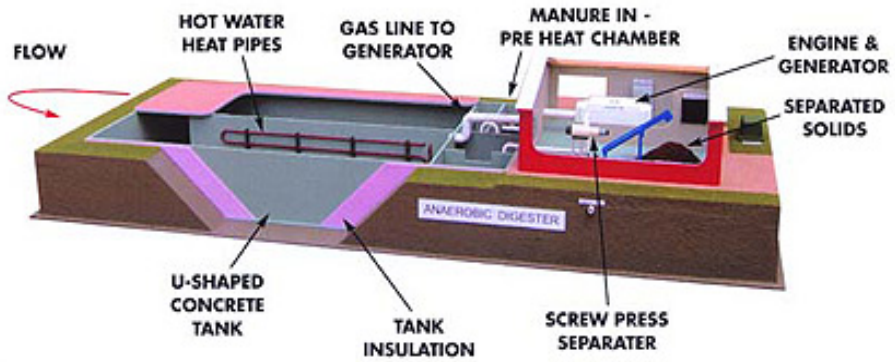


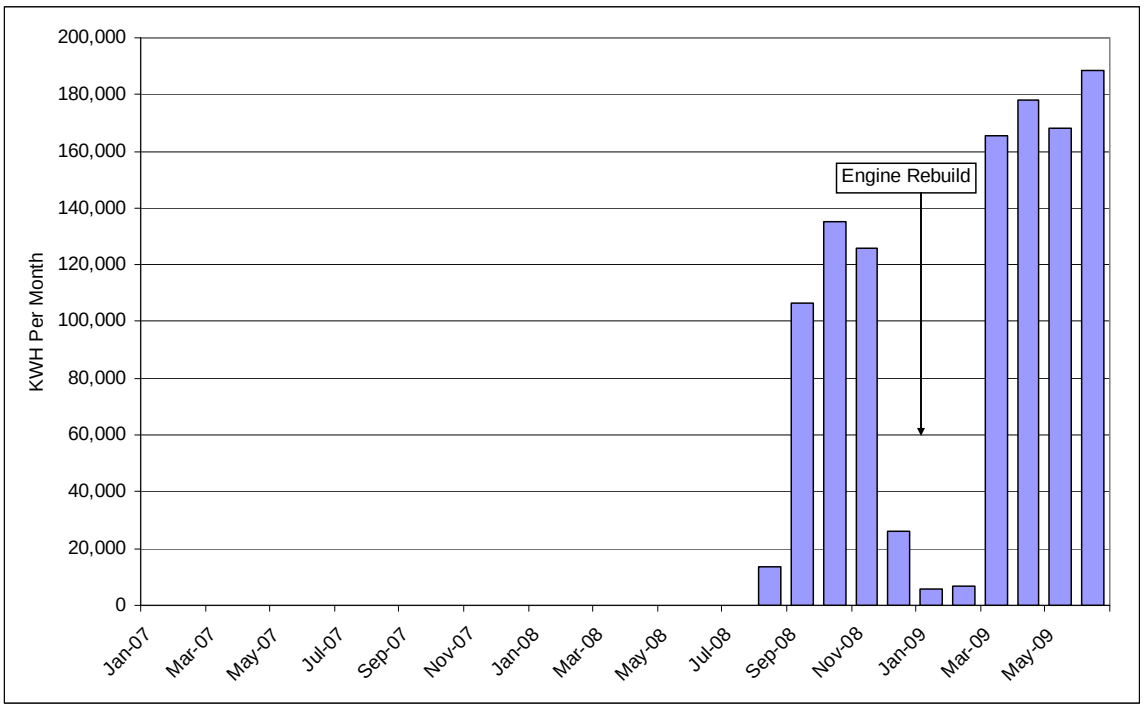
Image courtesy of GHD, Inc.

The following description applies to most GHD systems in general. Manure and wastewater enter and exit on the same end of the digester (i.e., on the right end of the diagram), making a 180 degree turn at the enclosed end (i.e., left end). The design theoretically will allow expansion of the digester by extending the structure on the enclosed end. The central shared wall holds hot water piping that heats the manure and helps conserve heat in the system by reducing outside surface area of the structure. The structure includes two distinct phases or digestion zones and is described as a two-phase system in which manure from the first phase flows directly into the second. The digester operates in the mesophilic range (design temperature of about 100 degrees F) and RAS. The design HRT is 22 days. The biogas is reintroduced into the digester along the bottom and the gas percolation through the manure provides passive mixing of the contents.

Manure is fed continuously into the digester during vacuuming. They sometimes add waste corn silage to the influent stream. Their current HRT is about 14 days and they are maintaining an average temperature of 100 degrees F. They use a Fan solids separator on the digester effluent to try to get solids content down to two percent for best efficiency of liquid transfer to the irrigation system.

Outputs and Uses.
The digester is metered for biogas production and is reported to be producing biogas currently at about 407,000 scf/day. The biogas is used to fuel a 720 kW Guascor engine generator set. The net electricity generation history (i.e., amount of power sold to the utility less what was used on the farm) of this system, which came online in the last quarter of 2008, is summarized in Figure 7.

Figure 7 – Electricity Generation for Central Sands Dairy



They recover heat from the engine jacket and exhaust which is used for heating the digester, and for pre-heating the manure in the winter. Separated solids taken from the digester effluent are land applied as a soil supplement on the farm.

History and Comments.
Installation reportedly went smoothly. The digesters became operational in 2008. They decided to install digesters to help with public acceptance of the facility by reducing odor. They saw the digester option as one that would also allow them to generate power and provide a reasonable payback. They were doing some sludge return, but did not see a significant increase in biogas production so have stopped recycling it. They have noticed a huge reduction in odor since the digester has been operational and odor complaints have stopped. They elected to wire their system to sell only excess generation. So electricity sales are net of the dairy load.

They did have a major engine failure that required a rebuild in December 2008.

Sources.
Dr. Gordon Jones, Central Sands Dairy
Melissa VanOrnum, GHD, Inc.
John McWilliams, Dairyland Power

Clover Hill Dairy – Campbellsport, Wisconsin

Farm Name:	Clover Hill Dairy	**Location:**	Campbellsport
Farm Type:	dairy	**Herd Feeding Digester:**	1,400 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	1,050 head	**Date Operational:**	2007
Design HRT:	20 days	**Current HRT:**	22-24 days
Design Solids %:	8-9%	**Current Solids %:**	6%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	bedding, sold, land applied
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	We Energies

Clover Hill Dairy is a 1,400 head Holstein dairy located in Campbellsport, Wisconsin, in southeastern Fond du Lac County. They use digested solids for bedding and scrape collect manure continuously throughout the day. The farm produces about 40,000 gallons of manure and liquids for treatment each day. The average solids content is six percent and includes some pack manure from the freshening lots. The digester replaced a manure pit storage system.

Digester.

The owner decided to install a mixed plug-flow digester designed by GHD, Inc. The system is a U-shaped, below grade, concrete structure with a fixed concrete cover. Figure 8 below shows the digester.

Figure 8 – Clover Hill Dairy Digester

The digester uses RAS and passive biogas induced mixing. The digester has two phases of digestion and operates in the mesophilic range with a target temperature of 100 degrees F. The target solids content for this design is between eight and nine percent. The system is reportedly operating at an average temperature of 101 degrees F, and at an influent solids content of six percent.

Outputs and Uses.

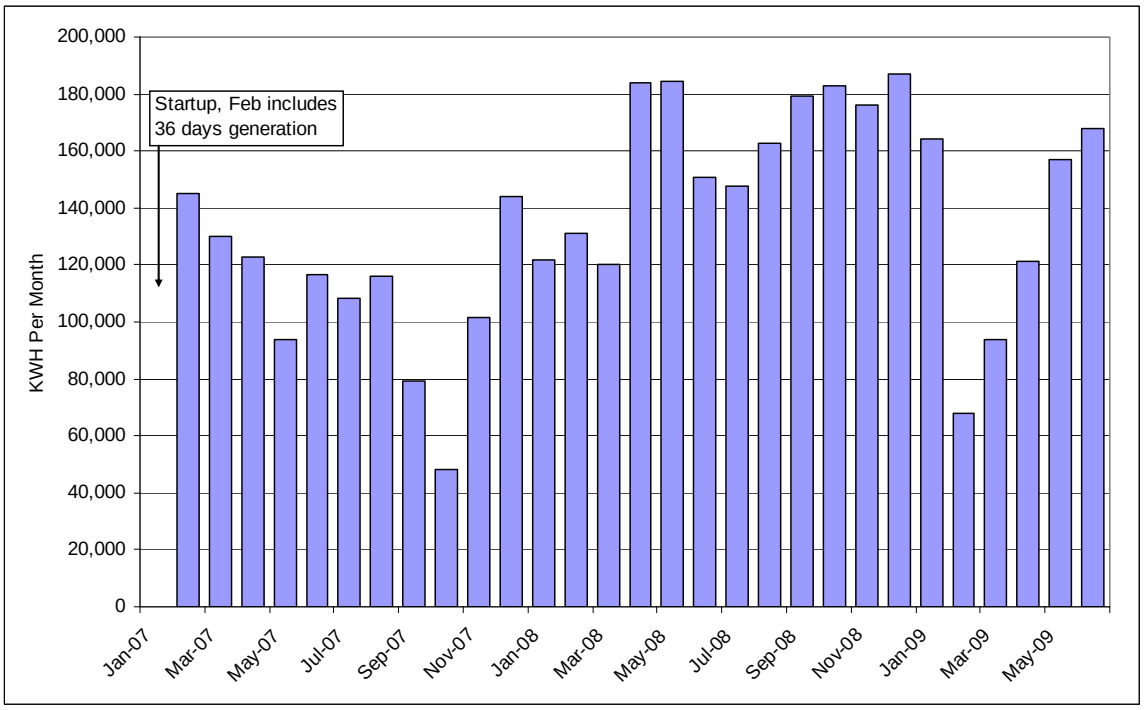
Biogas is treated with a GHD-designed passive hydrogen sulfide removal system[8] and a chilling unit for condensate removal. It is then run through a 300 kW Guascor engine generator set (pictured in Figure 9 below) to produce electricity.

Figure 9 – Guascor 300kW Engine Generator Set

The generator is synchronous or capable of running independent of the grid, so could be used as backup power in the event of a power outage. This function requires a more expensive and complex utility intertie to match the generator output to utility phase, frequency and voltage. Figure 10 below shows the recent generation history for this system.

[8] GHD describes their scrubbing system as being "low-maintenance" and requiring no chemicals or media replacements. VanOrnum M, GHD, Inc., personal communication, October 2009.

Figure 10 – Clover Hill Electricity Generation History



Waste heat from the water jacket and exhaust is used for heating the digester, milk house, parlor, lanes, offices, lunch room, separator building and wash water. They do not have a boiler backup system to heat the digester when the engine is not operating.

Figure 11 – Digested Solids from Clover Hill Digester

They use an Anderson screw press and produce about 100 tons of digested solids per week. The farm uses about 50 tons for both bedding and field application. They sell some to a landscaping company at $20 per ton "free on board" (FOB – the buyer is responsible for shipping costs and takes control of the goods when they leave the seller's premises) and are evaluating options to provide a bagged product. Their solids storage area is shown in Figure 11.

The farm retains ownership of the carbon credits and has signed on with the Pure Farm Energy® Producer Network of farm energy project owners.[9]

History.
The digester was installed in 2006 and was operational in early 2007. The owner reported that construction and contracting went "smoothly." But it took a while to get the purchase and interconnect details worked out. They originally had a smaller engine generator set but after two to three months realized they were producing enough biogas to use a 300kW system. Now they are considering adding another engine generator set to use the excess biogas they are producing. They purchased a maintenance agreement with Martin Machinery and are very happy with it. They are also getting more usable heat from the energy generation than they expected and are still exploring ways to use it effectively.

They did have a crusting problem in the digester but believe they have fixed it. They are pleased with the large reduction in odor from the lagoon and land application of digested manure. The owner noted that they can also apply the effluent on to growing crops without burning or other adverse effects, which is not possible with raw manure. They also installed a system designed by GHD, Inc. to reduce H2S and believe it is greatly improving engine performance and reducing wear on components.

Information Sources.
Joseph Bonlender – Clover Hill Dairy
Chris Bonlender – Clover Hill Dairy
Melissa Dvorak – GHD, Inc.
Randy Jerome – We Energies, Inc.

[9] The Pure Farm Energy® Producer Network is an aggregator and certifier of carbon credits for farm energy project owners. http://www.agrefresh.org/401.html

Crave Brothers Farm – Waterloo, Wisconsin

Farm Name:	Crave Brothers Farm	**Location:**	Waterloo
Farm Type:	dairy	**Herd Size:**	1,900 head
Collection Method:	gravity flow, slotted floors, scrape	**Bedding Type:**	digested solids
Digester Type:	complete mix (x2)	**Design Temperature:**	99 deg F
Digester Notes:	above ground steel tanks, proprietary mixing tech, remotely managed via Web		
Design Capacity:	1,900 head	**Date Operational:**	2007, 2009
Design HRT:	25 days	**Current HRT:**	25-26 days
Design Solids %:	12%	**Current Solids %:**	11%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, buy excess
Solids Separation:	yes, screw press	**Solids Use:**	bedding, composted and sold as soil supplement
Farm Owns:	none (Clear Horizons owns digester and generation)	**Utility Owns:**	none
Digester Designer:	Clear Horizons, LLC	**Utility:**	We Energies, Inc.

Crave Brothers operate a dairy farm and specialty cheese production facility in Waterloo, Wisconsin, in northwestern Dodge County. They have expanded their herd size over the last year and routed more manure from their animals to their digester. They have 950 head of milking cows, 200 dry cows, and 750 head of replacements. These 1,900 head produce about 55,000 gallons of manure for treatment per day. They also add substrates from their cheese production facility averaging about five to eight thousand gallons per day with some seasonal variability. To make the drier heifer manure pumpable, they mix the whey in with it. Their manure moisture content averages between 10 and 12 percent. They use digested solids for bedding. Manure gravity-flows with water added and drops through a slotted floor to a collection pit. Their former manure storage system was a pit.

Digester.

The Crave Brothers Farm partnered with Clear Horizons, LLC to have a digester installed. This was the first system of its kind built by Clear Horizons for a livestock operation. In 2009, Clear Horizons installed a second digester, expanding the treatment capacity on the farm to manure from 1,900 head. These systems can be monitored and operated remotely by PC using a Web interface. The digesters are above ground mesophilic complete mix stainless steel tanks. The target operating temperature is 99 degrees F, and it has an HRT of 25 days. Operating their own system, Clear Horizons has been able to reasonably maintain these target parameters. Figure 12 below shows the two systems.

Figure 12 – Crave Brothers Digesters

Figure 13 – Clear Horizons Mixer

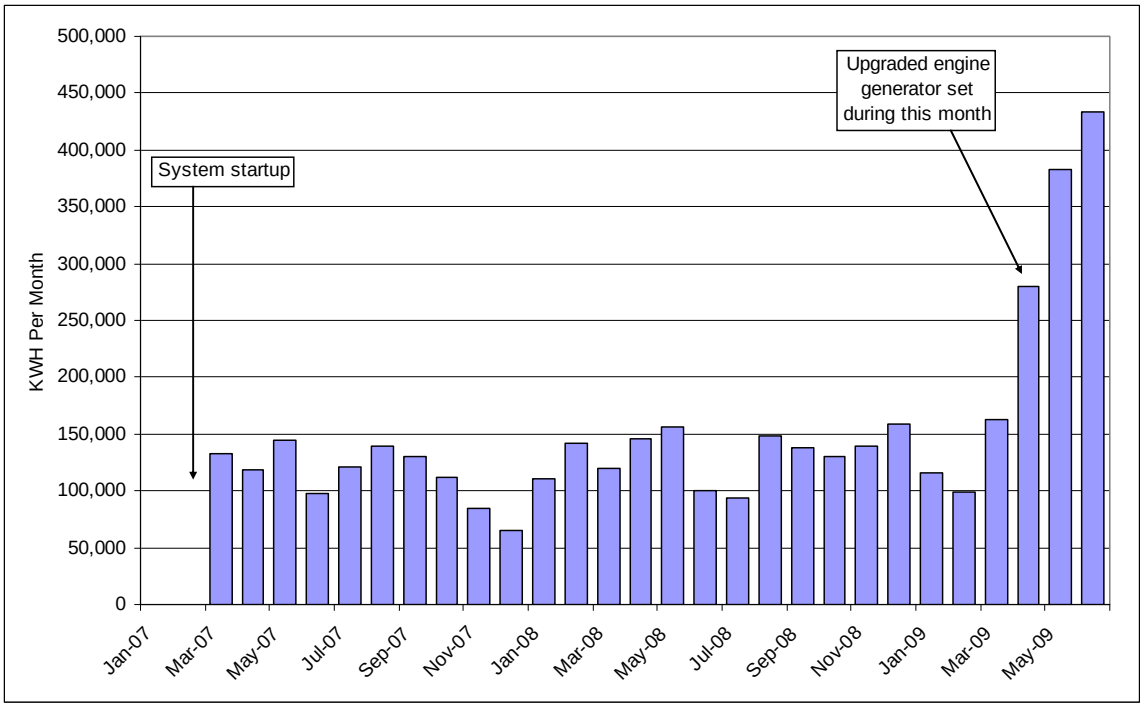
Under their business model, Clear Horizons develops, owns, operates and maintains the digesters, and generation equipment. It has rights to the products and credits associated with the digestion and energy generation. The farm buys solids back from Clear Horizons.

The Clear Horizons digesters use a patented mixing technology. The external mixer mounting apparatus is pictured in Figure 13.

Outputs and Uses.
The digesters produce biogas which is treated with passive hydrogen sulfide removal and a chilling unit for condensate removal. The digesters were reportedly producing 150-160 cubic feet per minute (i.e., about 223,000 cubic feet per day) of biogas containing about 55 percent methane. They upgraded their engine generator set from a Deutz 230 kW to a GE Jenbacher, model JMC 312 633 kW set in 2009. Electricity is used to operate the digestion plant with excess sold to We Energies. Heat captured from the engine generator set is used for digester heating, substrate tank heating, and heating of pumping and separation rooms, farm office, shop, hospital pen and waste storage tank. Clear Horizons has a portable LP gas boiler in a trailer designed mainly for startup of systems,

but is also available for digester heating when engines are undergoing maintenance or repair. Figure 14 below shows the monthly gross energy generation for the Crave Brothers system.

Figure 14 – Electricity Generation for Crave Brothers System



Solids are separated using a Vincent brand screw press solids separator. Clear Horizons is the only operation in Wisconsin currently selling a bagged solids product through retail outlets. They produce trademarked Energro potting mixes using digested solids, perlite and vermiculite. The sales of bedding to the farm and of the Energro products are reportedly significant portions of the total income from the digester. Figure 15 shows the bagged commercial potting mix product.

Figure 15 – Digested Solids Potting Mix

<u>History and Comments</u>.
This is the first system Clear Horizons has produced after researching other plants in Wisconsin and Germany. The addition of a second tank, doubling the capacity of their system, went well. Dan Nemke of Clear Horizons noted that because they were able to keep the existing plant running during construction, this made startup of the new system much easier. He notes their system has been running at 90-95 percent capacity factor since startup.

Their goal was to have a system that can be remotely operated (via an Internet-linked workstation) and to maximize the long term rate of return. They are doing extensive real-time monitoring of the systems to optimize operation.

Karl Crave (also representing Crave Brothers Farm) had a “great group” of local contractors and construction and start-up went smoothly. The farm is now able to focus more effort on their prime businesses: livestock and cheese operations. The option to pass on manure management duties to Clear Horizons was very welcome. As owners of the digester and the energy generation, Clear Horizons also handled utility power purchase and interconnect negotiations, as well as politics and permitting associated with the project.

Sources.
Dan Nemke – Clear Horizons, Inc.
Karl Crave – Clear Horizons, Inc.

Deere Ridge Dairy – Nelsonville, Wisconsin

Farm Name:	Deere Ridge Dairy / Gordondale Farms	**Location:**	Nelsonville
Farm Type:	dairy	**Herd Size:**	850 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	750 head	**Date Operational:**	2002
Design HRT:	22 days	**Current HRT:**	23 days
Design Solids %:	8-9%	**Current Solids %:**	8.8%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all biogas
Solids Separation:	yes, screw press	**Solids Use:**	bedding and land applied
Farm Owns:	digester	**Utility Owns:**	energy generation
Digester Designer:	GHD, Inc.	**Utility:**	Alliant Energy, Inc.

Deere Ridge Dairy or Gordondale Farms is an 850 head Holstein dairy operation in Nelsonville, Wisconsin in eastern Portage County. Some 28,000 gallons of manure, bedding and milking parlor wastes are generated per day with an average moisture content of 8.8 percent. Their manure is scrape collected using a skid steer at two hour intervals and they do not add any off-farm wastes. They use digested solids for bedding and their former manure storage system was a pit.

Digester.

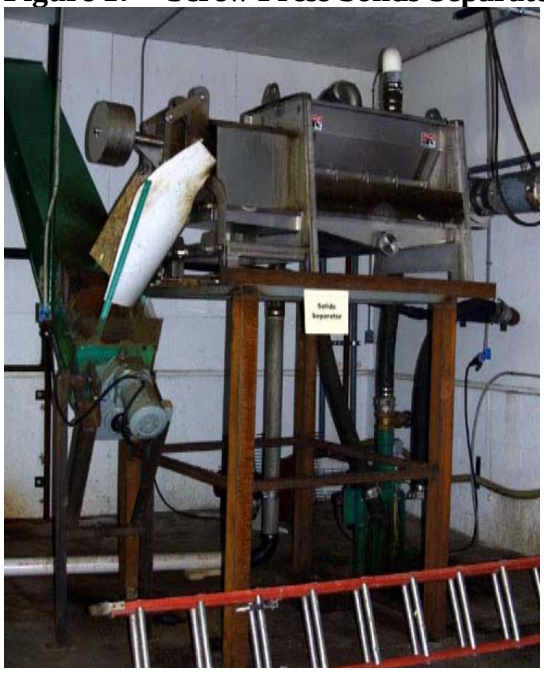
The digester owned by Deere Ridge is the first farm-scale digester designed by GHD, Inc. Installed in 2001, it is a below-grade, U-shaped mixed plug-flow digester, with a fixed concrete cover. It uses biogas-induced mixing and RAS. The digester operates in the mesophilic temperature range with a target of 100 degrees F, and has two distinct digestion phases within the main chamber. Figure 16 below shows the digester and the adjacent equipment building.

Figure 16 – Deere Ridge Dairy Digester

Photo: Courtesy of GHD, Inc.

The digester has a target influent solids content of eight to nine percent. The design HRT is 22 days. Deere Ridge does solids separation after digestion using a Fan screw press solids separator pictured in Figure 17.

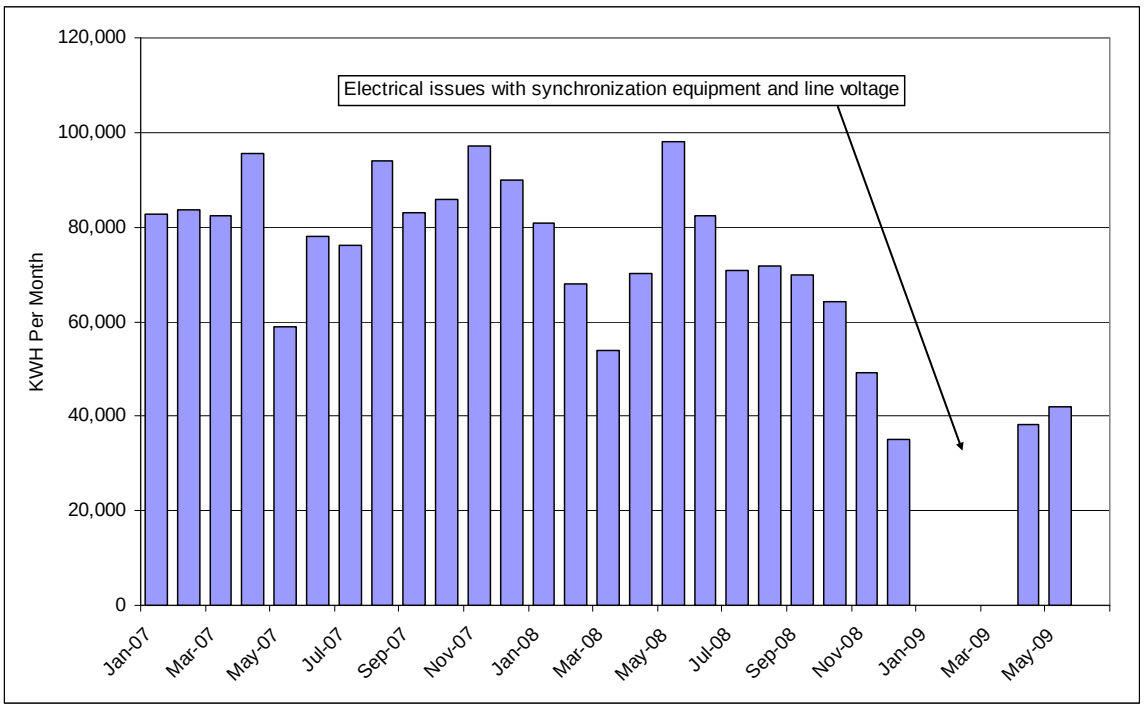
Figure 17 – Screw Press Solids Separator



Outputs and Uses.
Alliant Energy owns the on-site energy generation equipment – a Caterpillar 140 kW engine generator set. Biogas from the digester is treated with a water trap and sold to Alliant Energy for energy generation. Alliant is responsible for the operation and maintenance of the energy generation equipment. Figure 18 shows the monthly kW hours of electricity generated from January 2007 through June 2009.

Captured heat from the engine water jacket and exhaust is used to heat the digester and milking parlor, and for facility water heating. They do not have a backup boiler for digester heat on site but have the option of having GHD bring in a boiler if needed.

Figure 18 – Deere Ridge Dairy Electricity Generation



They separate solids from their effluent stream post digestion with a Fan screw press separator. All separated digested solids are used on the farm. The amount of solids generated weekly was not available.

History and Comments.
This installation originally came about because the farm owners were building a new dairy facility and were aware of the benefits of anaerobic digestion. Alliant Energy was also interested in a pilot project using biogas, so the two parties talked with GHD, Inc. and agreed to have the first GHD digester installed on the farm. To reduce the financial risk for the farm, Alliant Energy agreed to supply, operate and maintain the engine generator set. Therefore, the farm owns the digester and the utility owns the energy generation.

The digester has been operating well and they feel it is a good fit for the farm. Gale Gordon observed "It's the first of its kind in the state and it's still running." He is surprised more digesters have not been built given the obvious advantages. He notes, particularly the benefits to farm nutrient management. Phosphorus (P) is concentrated mostly in the solids which are lighter-weight giving the farm more flexibility in applying it to fields over greater distances so they can target fields that can use it. This added control helps farmers work within their nutrient management plans. He feels very strongly that digester designs should be as simple as possible.

Sources.
Gale Gordon – Deere Ridge Farm / Gordondale Farms
Melissa VanOrnum – GHD, Inc.
Duane Hanusa – Alliant Energy, Inc.

Double S Dairy – Markesan, Wisconsin

Farm Name:	Double S Dairy	**Location:**	Markesan
Farm Type:	dairy	**Herd Size:**	1,100 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	1,200 head	**Date Operational:**	2002
Design HRT:	20 days	**Current HRT:**	slightly below 20 days
Design Solids %:	8-9%	**Current Solids %:**	not available
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes , screw press	**Solids Use:**	bedding and land applied
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Alliant Energy, Inc.

The Double S Dairy was another early adopter of anaerobic digestion technology. The farm has 1,100 milking Holsteins and is located in Markesan, Wisconsin, in southern Green Lake County. Their operation produces about 33,000 gallons of manure, wastewater and bedding for treatment every day. They scrape-collect manure three times per day. They use digested solids for bedding which they pull out of their digester effluent stream using a Fan screw press. Figure 19 is a photo of some Double S Holsteins.

Figure 19 – Double S Dairy Holsteins

Digester.

Double S Dairy had a GHD, Inc. mixed plug-flow system installed on their farm in 2002. The digester is U-shaped, below grade concrete structure with a fixed concrete cover. It uses gas-induced mixing and RAS, and has a target operating temperature of 100 degrees F. Manure is added to the digester several times per day, and the solids concentration is unknown. The digester is operating very near its designed temperature and HRT.

Outputs and Uses.
Biogas is not pretreated other than to dehumidify it with a water trap prior to running it through a 200 kW Caterpillar engine generator set to produce electricity and heat. The system operates as an induction generator; it cannot operate in stand-alone mode.

Double S has a sell-all contract with Alliant Energy for the electricity which also includes utility ownership of the environmental attributes of the generation. Heat is recovered from the generation and used to heat the digester, milking parlor, shop, and in the summer and fall, the family swimming pool.

They produce about three to four semi-loads of digested solids per week and use about half for bedding. The rest are land spread on the farm. Figure 20 shows their solids separation area.

Figure 20 – Double S Dairy Solids Separator

History and Comments.
Their system became operational in 2004. Adding the digester prompted them to switch from sand bedding to digested solids, which was a significant change for the farm. They also switched from flush collection to scrape to make the influent stream more compatible with the digester. Owner Dan Smits notes that they have one of the earlier systems and it requires significant maintenance and that it "is not a money-making machine." However, he feels their digester has given them significant odor reduction, and that overall these systems are very "environmentally positive." He adds that systems are getting more refined over the years and are constantly being improved. If he had the opportunity to start over, one thing he would do differently would be to spread out the buildings and structures more.

Sources.
Dan Smits – Double S Dairy
Melissa VanOrnum – GHD, Inc.

Emerald Dairy – Emerald, Wisconsin

Farm Name:	Emerald Dairy	**Location:**	Emerald
Farm Type:	dairy	**Herd Size:**	1,600 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	1,600 head	**Date Operational:**	2005
Design HRT:	20 days	**Current HRT:**	20 days
Design Solids %:	8-9%	**Current Solids %:**	8%
Biogas Use:	electricity and heat, will power planned greenhouses	**Utility Contract:**	no
Solids Separation:	yes, screw press	**Solids Use:**	bedding
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	St. Croix Electric Coop.

Emerald Dairy is a 1,600 head Holstein dairy in Emerald, Wisconsin, in eastern St Croix County. The dairy produces about 50,000 gallons of manure, bedding and wastewater per day. Manure is scrape collected six times per day and averages about eight percent solids content. They use digested solids for bedding, and their former storage system was an unheated anaerobic covered lagoon.

Digester.
They replaced an unheated (psychrophilic) covered lagoon digester with a GHD, Inc. digester in 2005. The new digester, which became operational in 2006, is a U-shaped mixed plug-flow system, with gas induced mixing and RAS. It is a below-grade concrete structure with a fixed concrete cover. Figure 21 shows the digester and the currently idle gas processing facility.

Figure 21 – Emerald Dairy Digester and Gas Cleanup Building

The digester is running at the design HRT of about 20 days and the design operating temperature of 100 degrees F. Influent is pumped in to the digester four to six times per

day. They use a Fan brand solids separator to remove solids from the digester effluent stream.

Outputs and Uses.
The farm has successfully tested the feasibility of conducting on-farm gas upgrading to pipeline quality gas, and has examined options for injecting it into the gas pipeline for sale. Low natural gas prices have made biogas sale temporarily uneconomic. The farm is currently using biogas to run a Waukesha 110 kW engine generator set to produce electricity and heat for on farm use. Biogas produced by the digester is run through a moisture drop and iron sponge to remove hydrogen sulfide.

Effluent from the digester is stored in a lined lagoon before being land applied. The farm produces about 38 tons of digested solids per week at about 67 percent moisture. They use all these for bedding on farm.

History and Comments.
Both Emerald and Baldwin dairies had installed covered lagoon digesters in 1999 and 1998 respectively. When these systems did not provide an adequate level of digestion, they were replaced with heated systems. The heated digester at Emerald allowed the owner to arrange an innovative sales contract with the company 3M, Inc. which was interested in using renewable fuel. They installed gas cleanup and upgrading equipment on the farm and used tube tanker trucks to move the biogas to the injection point in the gas pipeline. Transportation of biogas with tube tanker trucks was a stopgap measure until a biogas pipeline was to be built. The price of natural gas has made this less economical.

After successfully demonstrating gas upgrading feasibility, the owner is now focusing on developing other on-farm processes that can use the energy they generate and produce food. He is currently considering installing greenhouses to grow fish and fresh vegetables year round similar to his Baldwin Dairy business model.

Sources.
John Vrieze – Baldwin Dairy
Melissa VanOrnum – GHD, Inc.

Five Star Dairy – Elk Mound, Wisconsin

Farm Name:	Five Star Dairy	**Location:**	Elk Mound
Farm Type:	dairy	**Herd Size:**	975 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	complete mix	**Design Temperature:**	125 deg F
Digester Notes:	above ground cylindrical tank, carbon steel, thermophilic, fixed steel cover		
Design Capacity:	800-1,200 head	**Date Operational:**	2005
Design HRT:	20 days	**Current HRT:**	20 days
Design Solids %:	6-8%	**Current Solids %:**	6.5%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all biogas
Solids Separation:	yes, screw press	**Solids Use:**	bedding, give away for gardeners, sell to farms
Farm Owns:	digester (designer operates and maintains)	**Utility Owns:**	energy generation
Digester Designer:	Microgy, Inc.	**Utility:**	Dairyland Power

Five Star Dairy in Elk Mound, Wisconsin in east-central Dunn County, has 975 milking cows and 75-100 heifers. The owner planned to eventually add anaerobic digestion when he was building this new dairy in 2000. The farm uses digestion for manure from 975 head (including some dry cows) and composts some manure as well. The daily volume of manure and other liquids requiring treatment is about 45,000 gallons per day, including about 10 percent off farm food waste grease. Manure is scrape collected three times per day and they use a Fan screw press for solids separation after digestion. Their former manure storage system was a lagoon.

Figure 22 – Five Star Dairy Digester

Digester.
Five Star Dairy entered into an agreement with Microgy, Inc. and Dairyland power to have an anaerobic digester installed on the farm. Figure 22 shows the digester installed at Five Star Dairy.

The digester is a complete-mix above ground, carbon steel tank. It operates in the thermophilic range with a target temperature of 125 degrees F. The design HRT is 20 days, and as a complete mix system it has an inherent retention of activated sludge. In practice the system is generally operated at 115 to 125 degrees F, and has an HRT of 20 days. The Microgy systems are designed to include

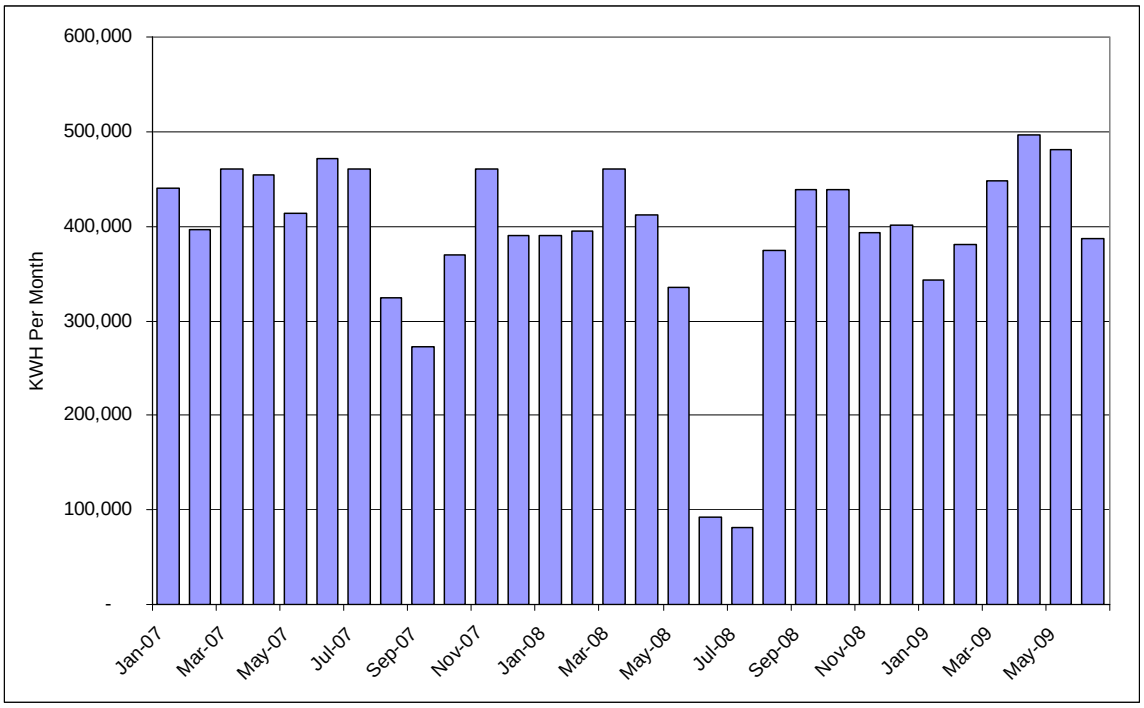
additional off-farm food wastes, preferably high fat wastes such as greases and oils. The systems and business model are designed around the co-digestion of such wastes and the resultant high level of biogas production. Five Star Dairy includes a storage tank for delivered food processing wastes (visible in Figure 22 as the smaller cylindrical shape in shadow on the left). A mixture of manure and about 10 percent food wastes is batched into the digester every half hour. Solids are separated out after digestion.

Outputs and Uses

Under this agreement, Microgy installed the digester with no cash outlay from the farm owner who immediately owns the system, and they sell biogas to Dairyland Power for electricity generation. Microgy operates and maintains the digester. The proceeds of biogas sales to Dairyland Power and from carbon credits from avoided methane emissions go toward buying down the farm's debt on the digester. Dairyland Power owns an engine generator set at the farm and generates green electricity for sale to their member cooperatives. Subsequent installations of Microgy systems at Norswiss and Wild Rose dairies in Wisconsin had similar business agreements.

Dairyland Power owns a Waukesha brand 750 kW net engine generator set on the farm that uses the biogas to generate renewable energy. Figure 23 below shows the last 30 months of electricity produced from biogas in monthly kWh totals.

Figure 23 – Electricity Generation at Five Star Dairy



Heat captured from the energy generation is used to heat the digester, barn floor, and a shop. After solids separation, the effluent from the digester flows to a lagoon for storage before being applied to fields. Most of the separated solids are used for bedding on the farm and some are sold to another dairy for bedding at $10/yard. The owner installed a

lagoon cover to capture any additional biogas from residual digestion occurring in the lagoon. That gas is now flared but they are evaluating options for using it.

History and Comments.
The digester at Five Star Dairy was the first establishment of the farm/Microgy/Dairyland Power business model in Wisconsin and the other two systems (Norswiss and Wild Rose) were able to copy the business model. The owner, Lee Jensen, is happy with the resulting arrangement and feels it is a good deal for all the parties involved. He feels having the digester has been a great thing for the farm, the image of his operation and for the community. They have a good product, low odor, and good fertilizer. They are getting growing interest from the community in the manure solids for gardening and from other farms for bedding.

As an additional control measure, they have recently installed a cover and gas capture equipment on their lagoon (where effluent from the digester is stored) and are monitoring the gas coming off for possible uses. He has already seen some benefits from the lagoon cover. Mr. Jensen reports the addition cost about $300,000. The covered lagoon is producing biogas with 60-70 percent methane, and odor from the lagoon has been eliminated. He estimates in the last year the cover has kept 1-1.5 million gallons of precipitation out of the lagoon, greatly reducing the volume they need to pump out to the fields and also saving on agitation. He says it's "like an insurance policy" because it's safer; there is less chance of anything falling in. Also, there is literally no odor and it is much less likely to ever overflow. When he gives tours, "people smile" at the lack of odor by the lagoon. He said the digester helped (with manure management issues) and the cover made it better. Now "you can't smell anything within 24 hours of spreading, even on hay."

When they added the cover, they also added a gas trap box for separated effluent to go into. Now they have the ability to take hot effluent back to the barn for other uses such as melting frozen manure or to pre-heat or thaw contents of the mix-tank in the winter. This helps them manage the liquid content of manure without actually adding new water.

Mr. Jensen notes that the system is very well metered which has helped him fine tune his operation and reduce costs. Gas production has been "predictable and consistent" and feels Microgy and their operator have learned how to fine-tune operations. He has also learned that you can move liquids farther and more efficiently with slow hydraulic pumps. He says having many spots where you can open up the flow lines for cleanout is important and they must be cleared regularly. To help keep the lines clear, they have put in filters and also have the local septic truck come out and clear them out with suction and a pig. He stresses the key to making gas is consistent flow.

Sources.
Lee Jensen – Five Star Dairy
Mike Casper – Microgy, Inc.
Dan Kegley – Microgy, Inc.
John McWilliams – Dairyland Power Cooperative

Green Valley Dairy – Green Valley, Wisconsin

Farm Name:	Green Valley Dairy	**Location:**	Green Valley
Farm Type:	dairy	**Herd Size:**	3,400 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	complete mix (x3)	**Design Temperature:**	102 deg F
Digester Notes:	three above ground cylindrical tanks, flexible membrane covers		
Design Capacity:	3,700 head	**Date Operational:**	2006, 2009
Design HRT:	22 days	**Current HRT:**	23 days
Design Solids %:	not available	**Current Solids %:**	8.5%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	bedding, sold to farms
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	Biogas Direct, Northern Biogas	**Utility:**	We Energies, Inc.

Green Valley Dairy is a 3,400 head (3,000 milking) dairy operation in Green Valley, in eastern Shawano County, Wisconsin. They scrape collect manure continuously throughout the day, and produce about 120,000 to 150,000 gallons of manure and other material for treatment. When milking parlor wash water is added the influent stream has about 8.5 percent solid matter. The farm uses digested solids for bedding. The dairy recently expanded (summer 2008) and increased their manure processing capacity. Their former manure storage system was a lagoon.

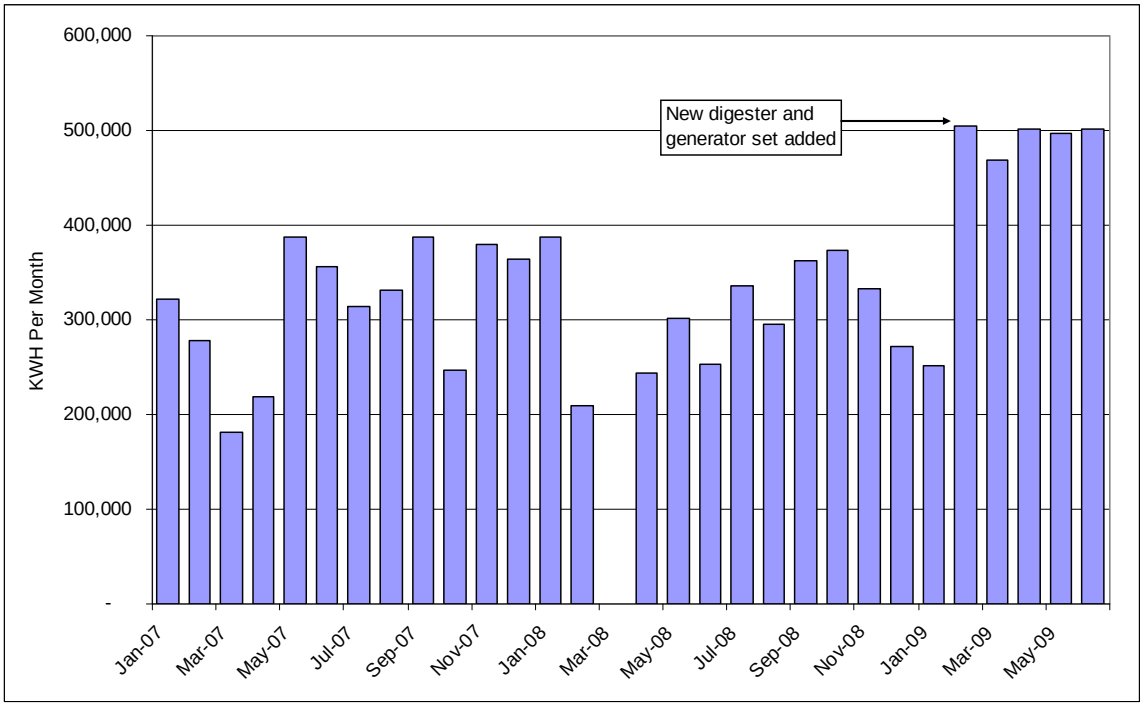
Digester.
The owners chose to install two Biogas Direct digesters for manure treatment. In the summer of 2008 they began construction of a third digester of modified design by a company the owners created called Northern Biogas, LLC. Figure 24 below shows the digesters.

Figure 24 – Digesters at Green Valley Dairy

Addition of the third tank in 2008 expanded the digesters' design capacity from 2,500 to 3,700 head. The digesters are complete mix above ground tanks with a flexible dual membrane cover which can expand to accommodate some limited biogas storage. Biogas is held in the inner membrane and there is a layer of air between the membranes. It is a mesophilic system with a design operating temperature of 102 degrees F and an HRT of 22 days. The system is currently operating adhering to those parameters and manure is batched into the systems regularly throughout the day. As a complete mix system the digesters retain activated sludge during normal operation. The manure undergoes some pre-heating before entering the digesters, and is fed into the digester continuously. They do not add any off farm wastes to the digesters.

Outputs and Uses.
Biogas from the digesters is dehumidified using a condensate trap and chiller with oxygen addition. It is also scrubbed aerobically with bacteria using an O_2 treatment system they redesigned. The biogas is then used to generate electricity and heat with their two Caterpillar 600 kW engine generator sets (total installed capacity of 1200 kW – although they report they can run it up to 1275 kW). Their generators are induction and cannot run in stand-alone mode. Electricity is sold to We Energies under a "sell-all" contract. Figure 25 shows the electricity production from January 2007 through June 2009.

Figure 25 – Green Valley Dairy Generation History



Heat is captured from the engines with a water jacket and from the exhaust. Recovered heat is used for heating the digester, calf barns, shop and other buildings, and pre-heating or thawing manure in winter. They added a remote heat exchanger and they also have a

cast iron Columbia boiler that can run on biogas for digester heat and pre-heating of manure. Sometimes they supplement the heat with the boiler as well.

They use three Fan brand solids separators to separate digested solids for bedding. The farm generates about 120 tons per week of digested solids. They use half that on the farm and sell the other half to neighboring dairies for $20 per ton FOB. They have changed from using mattresses (because the cows end up kicking a lot of bedding into the aisles) to deep beds which has reduced the per cow bedding lost.

In purchasing the renewable energy from Green Valley Dairy, We Energies also receives any environmental attributes associated with the energy generated (i.e., renewable energy credits or RECs). The farm gets carbon credits for methane emissions avoided through the use of an anaerobic digester. Green Valley works with AgCert, a carbon credit aggregator.

History and Comments.
The owners of Green Valley Dairy chose to install anaerobic digesters because they have a goal of becoming a "green, low-carbon-footprint dairy." The added potential for "odor and nutrient reduction," and to maximize gas and electric generation led them to select a "total-mix" anaerobic digestion system. Co-owner Guy Selsmeyer said they have experienced very good biogas production and have generally had more biogas than they could use – they have had to flare the excess.

They completed an expansion in 2008 with systems operational in the beginning of 2009. They added cows, a third digester and an additional 600 kW engine generator set. The additions were done by the owners under the company they created called Northern Biogas. Mr. Selsmeyer reports that installation and startup went smoothly. With their exhaust heat recovery he reports they have lots of Btus to work with. Their digesters' gas storage capabilities and the added generation have allowed them to store biogas during off-peak and run both engines on full during peak hours, when prices for energy are highest. One engine runs 24 hours per day, and the other 12 hours during peak demand.

Mr. Selsmeyer stressed that it is very important to have a backup boiler to provide heat to the digester, especially if the farm is using solids for bedding. During an engine breakdown they were able to keep the digester up to temperature and continue production of good quality bedding until the engine was up and running again. Also, during below zero days, when ice crystals form in the manure, it can take significant extra heat to bring it up to digester temperature. They found that they got better digestion if they pre-heated the manure. They added a remote heat exchanger to be used for pre-heating and found that about 75 percent of the Btus they use for digester heat goes into that phase.

Sources.
Guy Selsmeyer – Green Valley Dairy, Northern Biogas
Michael Zander – Energies Direct, LLC (formerly with Biogas Direct, LLC)
Tom Young – We Energies, Inc.

Holsum Dairy, Elm Road – Hilbert, Wisconsin

Farm Name:	Holsum Dairy, Elm Road	**Location:**	Hilbert
Farm Type:	dairy	**Herd Size:**	4,200 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow (x2)	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS, fixed concrete covers		
Design Capacity:	4,000 head	**Date Operational:**	2007
Design HRT:	22 days	**Current HRT:**	21-22 days
Design Solids %:	8-9%	**Current Solids %:**	11%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw presses	**Solids Use:**	bedding, sold to farms
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Wisconsin Public Service

Holsum Dairy has two separate farms both of which have digesters and are characterized in this casebook. The Elm Road dairy has about 4,200 head of Holsteins and is located in Hilbert, Wisconsin in Calumet County. Total volume of manure added to the digester is about 84,000 gallons per day plus about 10 percent off-farm waste from area food processing operations. Their influent solids content is currently about 11 percent. They use solids for bedding and scrape collect the manure three times per day. Their former manure storage method was in ponds.

Digester.

Having worked with GHD digesters at their other dairy, the dairy owner decided to install two GHD, Inc. designed digesters at this facility as well. The systems were installed in 2006-2007 and became operational in 2007. Figure 26 on the following page shows one end of a digester near the generator shed with the flare in the center.

Unlike the linear Irish Road digesters, these are GHD's usual U-shaped mixed plug-flow digesters with passive gas-induced mixing. The structures are concrete and below grade with fixed concrete covers. They operate in the mesophilic temperature range with a target operating temperature of 100 degrees F. The system has a design HRT of 22 days. In practice, they are seeing the temperature range between 95 and 100 degrees, and estimate a 21-22 day HRT. The GHD system has RAS to help maintain the bacteria colonies. Frequency of the manure addition to the digester was unavailable. They also add about one to one and a half semi loads per day of non-farm food processing industry wastes from three industries to their influent stream and receive an undisclosed tipping fee.

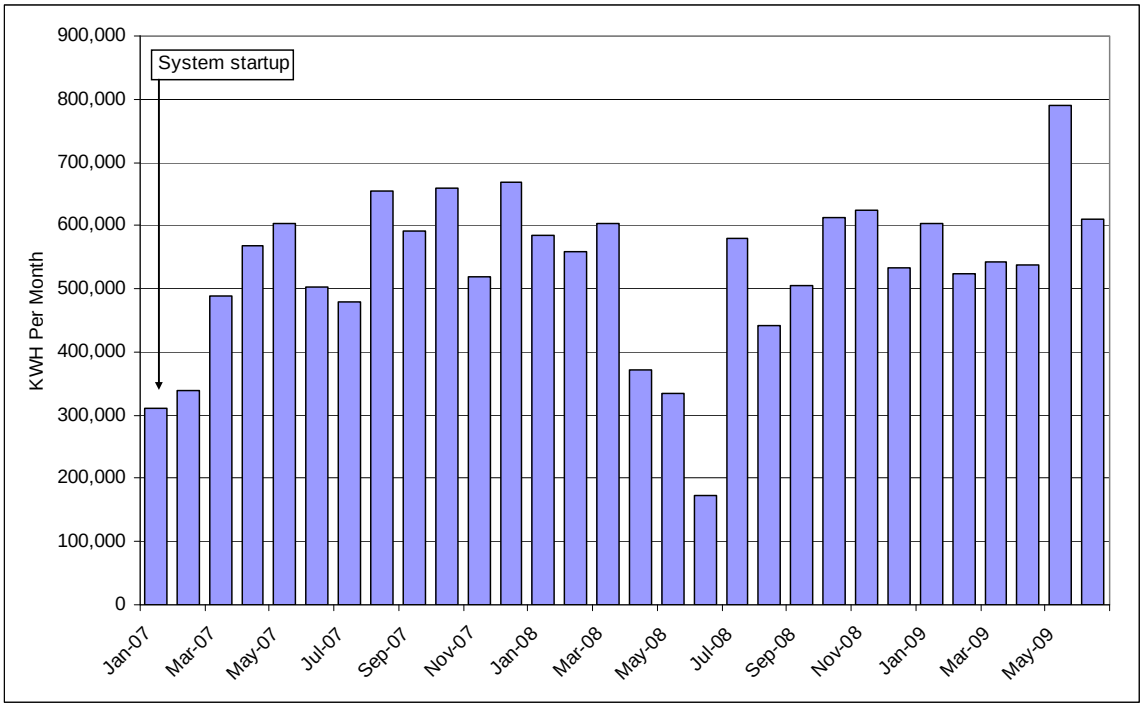
Figure 26 – Holsum Elm Road Digester and Equipment Shed

Outputs and Uses.
The biogas is dehydrated by running it through a condensate trap and chiller. They have also started doing H_2S reduction through atmospheric injection into the digester. Biogas is then run through two engine generator sets to generate electricity. They have two 600 kW Guascor engine generator sets for a total installed capacity of 1200 kW. Figure 27 below shows their engine generator sets.

Figure 27 – Holsum Engine Generator Sets at Elm Road

They have a contract to sell all the electricity they generate to Wisconsin Public Service Corporation. Figure 28 shows the last 30 months of electricity generation for the Elm Road dairy.

Figure 28 – Elm Road Electricity Generation History



Heat recovered from the engine generator sets is used for heating the digester, milking parlor, office, shop, and holding and transfer areas. They have a dual fuel boiler (brand unknown) for backup heat that can run on either diesel or biogas.

The farm uses three Fan screw presses to separate the solids from the digestate. The two farms combined produce about 82 tons of solids per day. They use about 40 percent of these on the farms and sell the rest to other farms at about $15 per ton.

History and Comments.
The layout for this system was somewhat different from their Irish Road dairy (see the following case study). They arranged the buildings differently, having engine generator building further away from the radiators and heat exhaust which has worked out well. They put up a separate concrete building for the electronics and engine and had no corrosion. The owner values anaerobic digestion because it helps with dairy management, nutrient management and loading, fly control and provides a bedding source. He also stressed that it is valuable if you can get a maintenance agreement for the switchgear and engine. He also suggests that flow meters are almost a must at this point with EPA requirements and accounting for carbon credits.

Sources.
Kenn Buelow – Holsum Dairy
Melissa VanOrnum – GHD, Inc.
Joe Sinkula – Wisconsin Public Service Corporation

Holsum Dairy, Irish Road – Hilbert Wisconsin

Farm Name:	Holsum Dairy, Irish Road	**Location:**	Hilbert
Farm Type:	dairy	**Herd Size:**	3,850 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow (x2)	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, straight, gas-induced mixing, RAS, fixed concrete covers		
Design Capacity:	4,000 head	**Date Operational:**	2003
Design HRT:	22 days	**Current HRT:**	18-20 days
Design Solids %:	8-9%	**Current Solids %:**	11%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw presses	**Solids Use:**	bedding, sold to farms
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Wisconsin Public Service

Holsum Dairy on Irish Road is one of two Holsum dairies with digesters in Hilbert, Wisconsin, in Calumet County. The Irish Road dairy, the site of the older digester of the two, has 3,850 head of Holsteins (about 3,200 milking). The herd and dairy operation produce about 77,000 gallons per day of influent for treatment. The farm also takes in about an additional 10 percent off farm food industry wastes for co-digestion for a total influent volume of about 84,000 gallons per day at about 11 percent solids content. They use scrape collection three times per day and use digested solids for bedding. Their former manure storage method was in ponds.

Figure 29 – Holsum Dairy Irish Road Digesters

Digester.

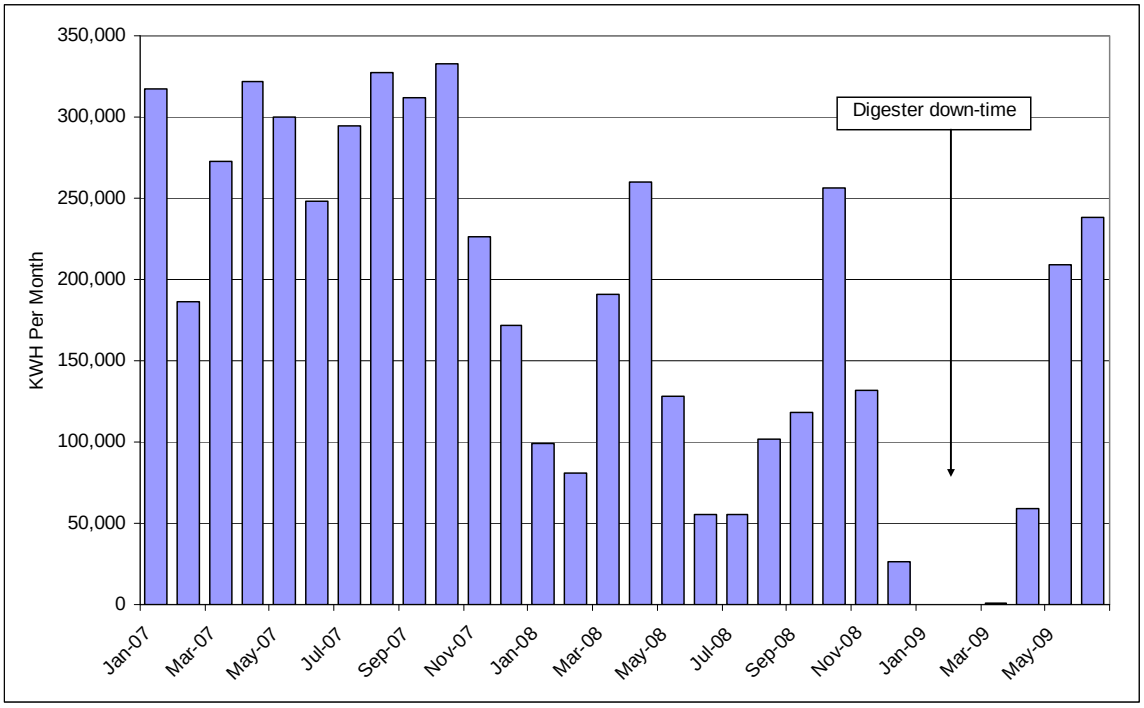
Holsum Dairy was one of the early dairies in Wisconsin choosing anaerobic digestion for manure treatment. They installed two GHD designed digesters in 2001-2002, and they were operational in 2003. Figure 29 shows a view along the length of the digesters with flare. These systems are unlike the typical GHD digesters in that they are straight (laid out end to end) rather than U-shaped. The digesters are mixed plug-flow systems using biogas for passive mixing and RAS. They operate in the mesophilic range with a target temperature of 100 degrees F and have a target HRT of 22 days. The system is currently operating in the temperature range of 95-100 degrees F, and has an

estimated HRT of 18-20 days. The structure is concrete below grade and has a fixed concrete cover. Manure mixed with food industry waste is added to the digesters three times a day. The one to one and a half semi-loads per day of off farm wastes are byproducts from three area food processing industries for which the farm receives tipping fees. The manure and other wastes are not pre-treated in any way.

Outputs and Uses.
Biogas produced from the digester is dehydrated with a condensate trap and chiller. They are also reducing H_2S by injecting air into the digester biogas chamber. The biogas is then used to fuel two engine generator sets. At the time of the interview, the owner was in the process of upgrading the systems to Guascor 500 and 400 kW engine generator sets for a total installed capacity of 900 kW. Electricity produced is sold to Wisconsin Public Service Corporation under a "sell-all" agreement. The new generators are being installed with switchgear that would allow operation independent of the grid, but will be set to shut off in the event of an outage. Waste heat from the engines and exhaust is captured and used for the digester, milking parlor, office, and holding and transfer areas. They also have a backup boiler (make unknown) that can use either diesel or biogas to provide supplemental heat to the system.

Figure 30 shows the electricity production from Irish Road for the 30 months from January 2007 through June 2009

Figure 30 – Holsum Dairy Irish Road Electricity Generation History



The two dairies combined (Holsum Elm and Irish Roads) produce about 82 tons of digested solids per day. They use about 40 percent of this on the farm and sell the rest to other dairies at about $15 per ton.

History and Comments.
They installed the digester to allow expansion of the farm, provide odor control, and with a goal of breaking even. The owner wanted to share a mistake they made so others can avoid it. They tried putting in waste straw which was a bulkier than the usual feedstock. This eventually caused crusting and lifted the digester cover causing some downtime for repair and resealing. He also stressed the importance of keeping the electronic equipment separate from the engine generator and solids separation areas. If owners are co-digesting substrates, he points out that if they are not premixed with the manure, the entry point for the substrates should be at the front, where the manure enters. He also suggests that it's probably best to over-insulate the digester to make more heat available for other uses.

Sources.
Kenn Buelow – Holsum Dairy
Melissa VanOrnum – GHD, Inc.
Joe Sinkula – Wisconsin Public Service Corporation

Lake Breeze Dairy – Malone, Wisconsin

Farm Name:	Lake Breeze Dairy	**Location:**	Malone
Farm Type:	dairy	**Herd Size:**	3,000 head
Collection Method:	flush	**Bedding Type:**	sand
Digester Type:	mixed plug-flow (x2)	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	2,900 head	**Date Operational:**	2006
Design HRT:	22 days	**Current HRT:**	18-20 days
Design Solids %:	8-9%	**Current Solids %:**	7.5%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	sold to farm
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	We Energies, Inc.

Lake Breeze Dairy is a 3,000 head (2,550 milking) Holstein dairy in Malone, Wisconsin, in northeastern Fond du Lac County. They use flush collection of their manure and use sand for bedding (sand removal procedures are described in the Digester section below). Their farm operations produce about 100,000 gallons of material for treatment per day. Their former manure storage system was in ponds. Figure 31 below shows Lake Breeze Dairy facilities.

Figure 31 – Lake Breeze Dairy

Photo: Courtesy of Lake Breeze Dairy

Digester.

The owners decided to install two GHD anaerobic digesters to treat their manure. The digesters are shown in Figure 32. Because the farm uses sand bedding and flush collection, some additional treatments are required before the manure reaches the digesters. To remove the sand bedding the manure stream flows through one of two alternating sand settling lanes which were added during the spring and summer of 2008. .

The lane used is switched daily so the idle one can be scooped out. The sand is stored so bacteria cultures die off and it can be re-used. After the sand settling lanes, the manure stream goes into a mechanical rotary screen solids separation system. The liquid from this stage goes into a settling tank and the fine solids that settle out of this are re-mixed with the separated solids from the mechanical screen. This combination, approximating a solids composition of seven to eight percent, is fed into the digester while the clarified liquid is sent to a lagoon. The clarified undigested liquid is re-used for the flush collection system.

Figure 32 – Digesters at Lake Breeze Dairy

The digesters are side-by-side mixed plug-flow systems that are U-shaped. They operate in the mesophilic temperature range with a target of 100 degrees F. They use biogas for passive mixing and have return of activated sludge. They are below grade concrete structures with fixed concrete covers.

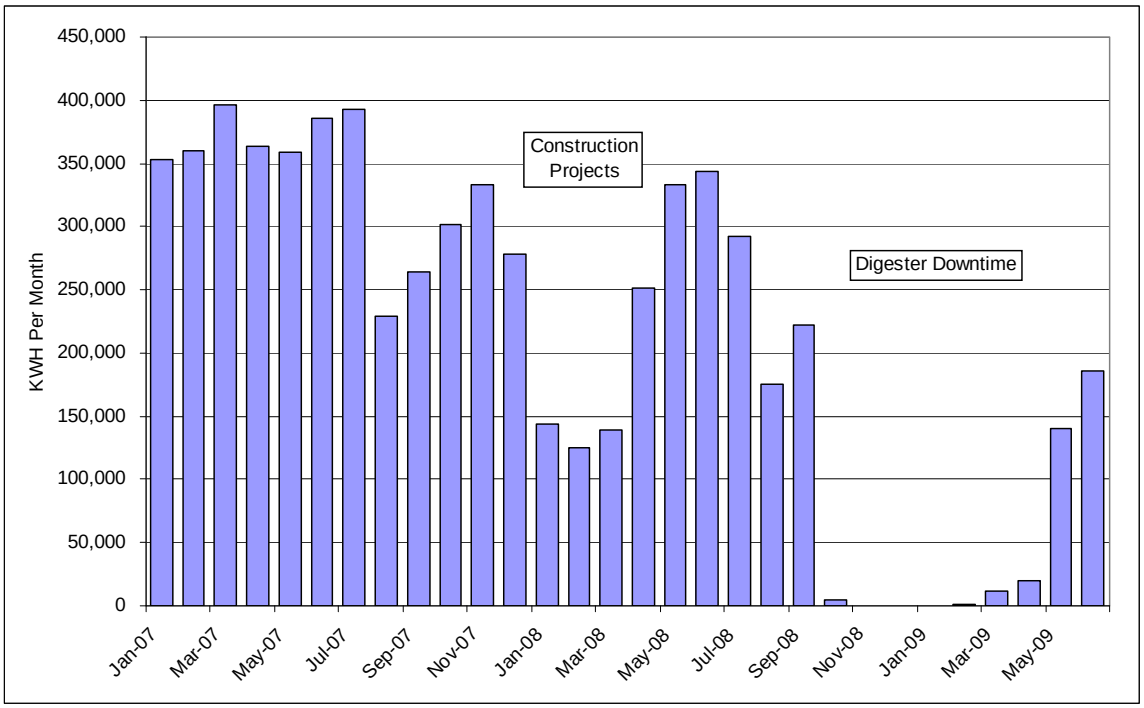
Outputs and Uses.
Biogas produced by the digesters is conditioned using a condensate trap and chiller. Then it is fed into two Caterpillar 300 kW capacity engine generator sets that are capable of operating in stand-alone mode (i.e., synchronous generation). The engine generator sets are pictured in Figure 33 on the following page. Electricity produced is sold to We Energies under a sell-all type of contract. Waste heat is captured from engine water jackets and exhaust and is used to heat the digester and the shop.

Figure 33 – Lake Breeze Engine Generator Sets

Photo courtesy of Lake Breeze Dairy.

Figure 34 shows the electricity production over the last 30 months.

Figure 34 – Lake Breeze Dairy Electricity Generation History



After digestion, solids are again separated using two Anderson brand screw presses. Figure 35 shows the solids separators used after digestion and the solids separation area. They tried using the solids for bedding but had some incidence of mastitis so switched to sand. They produce about 10 tons of solids per day which they sell to a dairy in Minnesota for $25 per ton FOB. The Minnesota farmer composts the solids then uses them for bedding. They are currently adding ferric chloride treatment for the effluent from the solids separators for odor control prior to sending it to the lagoon.

History and Comments.
The owners installed the anaerobic digesters to reduce odor from the farm. Brian Gerrits of Lake Breeze Dairy said that they researched options and saw anaerobic digestion as a fairly expensive one, but were encouraged by the benefits. Once the digesters were in they did not get the level of odor control they expected. Their water has a lot of sulfates in it which contribute to hydrogen sulfide (H_2S) formation. They also noticed openings in the final section of the digester where manure is pumped to the screw press. They closed these and experienced a reduction in odor. They are now adding ferric chloride to the effluent when it goes from the screw presses to the lagoon for H_2S control. They tried adding ferrous chloride to the influent but that did not work well.

Figure 35 – Digested Solids Separation Area

They had a digester failure possibly due to sand settling in the digester interfering with the agitation. They believe solids and sand accumulated in the digester caused a mat to form which lifted the digester lid and caused the collapse of some sections. They only replaced the panels that failed. After starting it up again, the other panels soon failed. They think the pressure release valves got stuck during the downtime then pressure during startup caused the other panels to collapse. They have since added stronger blowers for the gas mixing and think they have the problem solved.

Maintenance of their system was more expensive than they thought. The feasibility study also did not give the amount of parasitic load (i.e., energy needed to run the manure handling and treatment system) for pumps and agitation equipment which was especially high due to the flush collection and associated systems. Still, they feel that power generation from their overall system is “pretty good.”

Some anaerobic digester experts contend that the practices of flush collection and sand bedding are incompatible with most anaerobic digesters (or at a minimum, present a reduced chance for successful implementation).[10] The coordination of these systems clearly involved some fine-tuning and compromises, but both designer and farm owners feel the sand separation and digester system are working well. Mr. Gerrits suggests some conditions that could make installation of digesters more economical such as: better rates for biogas generated electricity; coordinated collection and distribution of substrates to boost biogas production; development of distribution system and markets for digested solids uses.

Contacts.
Brian Gerrits – Lake Breeze Dairy
Melissa VanOrnum – GHD, Inc.
Randy Jerome – We Energies, Inc.

[10] For example, see the Agricultural Utilization and Research Institute "Self-Screening Checklist" at: http://www.auri.org/research/digester/digchck.pdf. This identifies each as "key issues."

Norm-E-Lane – Chili, Wisconsin

Farm Name:	Norm-E-Lane	**Location:**	Chili
Farm Type:	dairy	**Herd Size:**	2,500 head
Collection Method:	scrape, gravity flow	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	2,000 head	**Date Operational:**	2008
Design HRT:	22 days	**Current HRT:**	21-24 days
Design Solids %:	8-9%	**Current Solids %:**	not available
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw presses	**Solids Use:**	bedding, sold to dairies
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Dairyland Power

Norm-E-Lane is a 2,500 head dairy farm in Chili, Wisconsin, in eastern Clark County. The farm uses scrape manure collection and gravity flow structures to move manure to the mixing pit before going into the digester. In the mixing pit the manure is mixed with chopper pumps which may cause some size reduction. Their operation generates between 50,000 and 60,000 gallons of manure and other liquids for treatment per day. They use digested solids for bedding and collect their manure three times per day. Figure 36 shows the Norm-E-Lane dairy.

Figure 36 – Norm-E-Lane

Photo courtesy of Norm-E-Lane

<u>Digester</u>.
The owners had a GHD mixed plug-flow digester system installed in late 2007 through early 2008. The digester is U-shaped and uses gas induced mixing and RAS. It is a below-grade concrete structure with a fixed concrete cover. It is designed to operate in the mesophilic range with a target temperature of 100 degrees F, and have a HRT of about 22 days. They are currently operating essentially on target for both of these parameters. Manure is added to their digester periodically throughout the day as needed.

They began heating the manure in June 2008, began separating solids at the end of June, and started generating electricity in August. Figure 37 on the following page shows the top of the digester.

Figure 37 – Digester at Norm-E-Lane

Photo courtesy of Norm-E-Lane

Outputs and Uses.

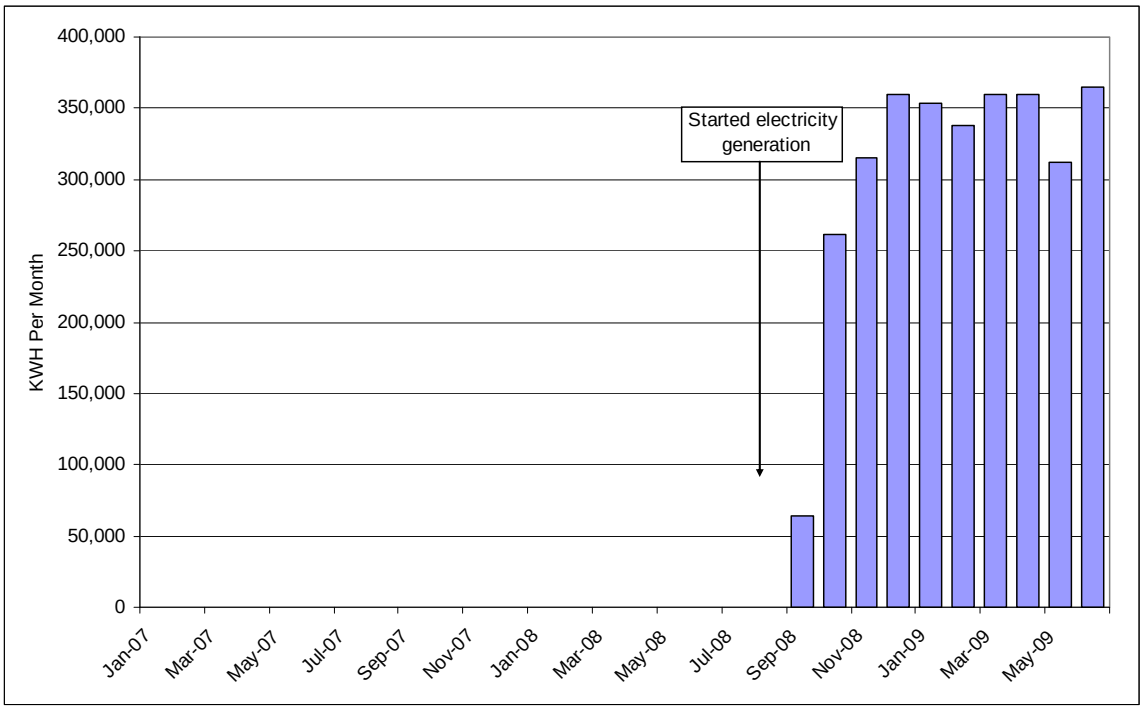
Biogas from their system is sent through a condensate trap and chiller, then run through a Guascor 600 kW engine generator set installed by Martin Machinery. They change the oil on their engine every 400 hours (it takes about an hour to change the oil) and have had over 10,000 hours of engine up time without a valve failure and 90 percent uptime in the first year. Figure 38 show the Norm-E-Lane engine and equipment room.

Figure 38 – Engine and Equipment Room

Photo courtesy of Norm-E-Lane

Figure 39 on the following page shows their energy generation history.

Figure 39 – Energy Generation History for Norm-E-Lane



Their two Bauer brand solids separators run 10 to 12 hours per day and produce about 100 tons of separated solids per week. They use about 80 tons on the farm and sell the excess to other dairies.

They recover heat from the engine through a water jacket and the exhaust. The heat is used to heat the digester, calving and dry cow pens, and for the pressure washer in the wash bay.

History and Comments.
The owners carefully researched digesters, looking for the system that provided what they believed to be the best return on investment while staying as simple as possible. These criteria led them to choose GHD, Inc. They wanted to turn their manure into something more than just fertilizer for their crops. They saw an opportunity to not only reduce air emissions and create green power, but to also cut bedding costs on the dairy by using the separated digested solids. They give many tours of their farm, with the digester being the highlight as of late. Norm-E-Lane owners feel it has been a great thing for them, not only for what they believe to be obvious economical reasons, but also for the environment. They find it fits well with their focus of being "continuous stewards of the land."

Sources.
Jerod Schmidt, Norm-E-Lane
Josh Meissner, Norm-E-Lane
Melissa VanOrnum, GHD, Inc.
John McWilliams, Dairyland Power

Norswiss Farms – Rice Lake

Farm Name:	Norswiss Farms	**Location:**	Rice Lake
Farm Type:	dairy	**Herd Size:**	1,240 head
Collection Method:	scrape, gravity flow	**Bedding Type:**	digested solids
Digester Type:	complete mix	**Design Temperature:**	125 deg F
Digester Notes:	above ground cylindrical tank, carbon steel		
Design Capacity:	800-1,200 head	**Date Operational:**	2006
Design HRT:	20 days	**Current HRT:**	14 days
Design Solids %:	6-8%	**Current Solids %:**	5.9%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all biogas
Solids Separation:	yes, screw press	**Solids Use:**	bedding
Farm Owns:	digester (designer operates and maintains)	**Utility Owns:**	energy generation
Digester Designer:	Microgy, Inc.	**Utility:**	Dairyland Power Cooperative, Barron Electric

Norswiss Farms is a 2,800 head dairy farm with mostly Holsteins and some Swiss cows. The dairy is located in Rice Lake, Wisconsin, in northern Barron County. They recently doubled their herd size adding another barn (new barn). The herd in the new barn (about 1,600 head) is bedded with sand and manure is vacuum collected. They have implemented sand recovery systems and use a Parkson brand mechanical separator. Manure from the old barn, in which they bed with digested solids, is scrape collected three times per day to a center gravity flow system from which it is pumped to the digester. After sand removal, some manure from both barns is sent to the digester and some goes directly to the lagoon. The influent stream also includes 10 percent off farm high fat food wastes. The daily manure production amount that is digested (from 1,240 head) is between 45-50,000 gallons. The rest of the manure is currently sent directly to the lagoon. The farm uses a solids separator on the digester effluent. Their former manure storage system was a lagoon.

Digester.
The farm owner chose to work with Microgy and Dairyland Power to have a digester installed. Figure 40 shows the Norswiss digester, the surrounding structures and the storage lagoon in the background.

The Microgy digester is an above-ground carbon steel cylindrical complete mix tank. It operates in the thermophilic temperature range with a target of 125 degrees F. The digester has design HRT of 20 days. The Norswiss digester is currently operating close to 125 degrees, and has an HRT of about 14 days. Next to the digester is a 50,000 gallon tank in which the off farm food wastes, primarily grease, are stored. These wastes are pumped into the digester every half hour and are limited to about 10 percent of the total volume in the digester. The farm puts all farm waste liquids into the digester including waste milk and footbath water.

Figure 40 – Norswiss Farms Digester

Photo courtesy of Microgy, Inc

This system uses the same business model as the Five Star Dairy and Wild Rose Dairy. Microgy installed the digester, which is owned by the farm, with no cost outlay from the farm. Dairyland Power installed an engine generator set on the farm as well. Microgy operates and maintains the digester and sells biogas to Dairyland Power. The proceeds from these sales pay down the farm's debt on the digester. Dairyland Power generates green electricity with the biogas and sells it to its member cooperatives. Co-digestion of off-farm food processing wastes, preferably high fat greases and oils, boosts biogas production and produces more income to pay down the debt.

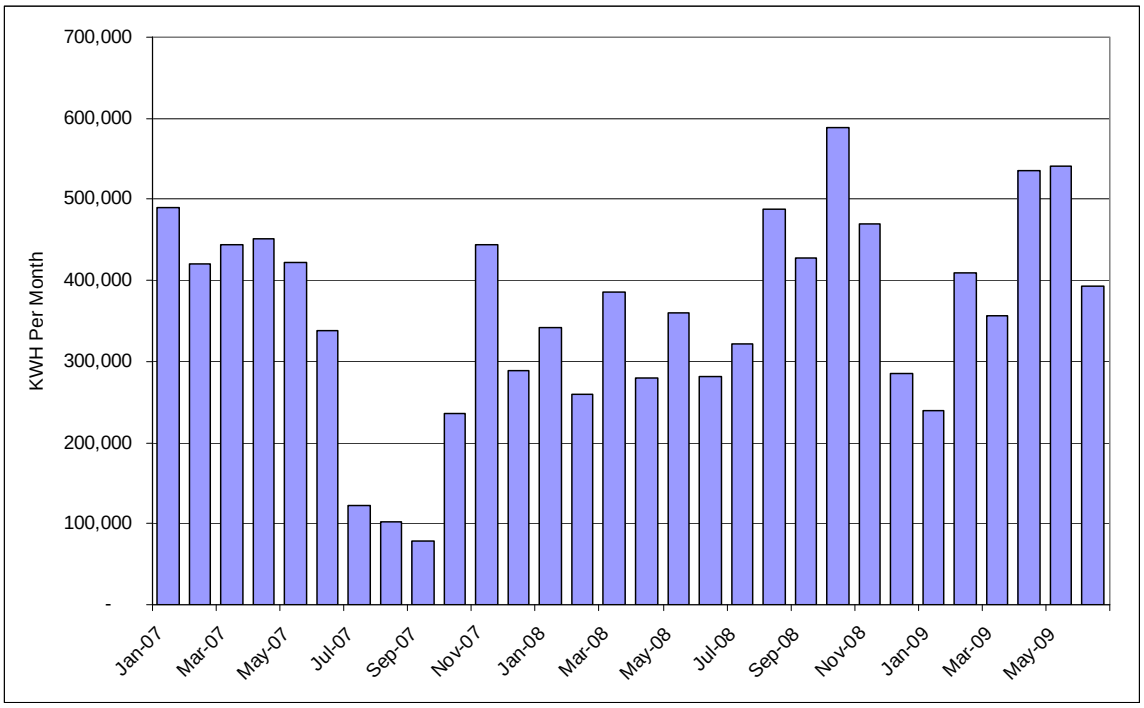
Outputs and Uses.

The biogas produced by the digester is scrubbed with a Biothane brand scrubber to remove H_2S. It is then used in Dairyland Power's on-site Jenbacher 848 kW engine generator to generate electricity to be sold to Dairyland Power member cooperatives. The system is synchronous, but is set to shut down in the event of power failure. As a synchronous generator the utility relies on it to provide voltage support for their distribution system. Figure 41 on the following page shows the electricity production history for Norswiss.

Renewable energy credits from the generation are owned by Dairyland Power, and carbon credits from methane emissions avoided are owned by the dairy. Sales of these carbon credits also go toward paying down the debt on the digester.

The farm also has a backup boiler that runs on biogas to provide heat to the digester in the event the engine is down. Recovered heat is used for digester heating only.

Figure 41 – Electricity Production History at Norswiss Farms



Effluent from the digester goes through a Fan brand screw press solids separator which according to the owner runs "almost constantly." The liquid fraction is pumped into the storage lagoon seen at the top of the photo. They are producing about 55 yards of solids per day and use all of it on the farm as bedding on mattresses. They apply heavy amounts of bedding on top of mattresses in the stalls which provides very good cow comfort.

History and Comments.
The owner, Andreas Heer, commented that the recently added barn with sand bedding has presented some challenges. The mechanical separation of sand is "not perfect" and some sand goes through to the solids separator which has caused some wear on the separator screens. They have been able to manage solids content of the influent by adding dryer manure from the dry barns to offset some of the higher liquid manure coming from the new barn.

Once digested, the manure is more liquid with relatively little biochemical oxygen demanding compounds (BOD). They can use it on their hayfields which they cannot do with raw manure. They have been able to eliminate fertilizer purchases for hay, bean and alfalfa fields which the owner sees as a very good benefit.

The digester took a bit longer than predicted to build due to some permitting delays and some problems with out of state contractors. But this did not negatively affect the farm operation. He says the digester and business arrangement is working well for them – they had no cash outflow and are now saving money on bedding and fertilizer. The availability of these solids has allowed them to do heavy bedding (6-12 inches) on

mattresses for much better cow comfort and performance, and they have had low somatic cell counts. They are avoiding the expense of using sawdust which would otherwise be costing them $1,800 every six days, and is sometimes hard to find.

The owner feels the overall system is working well and he is impressed and happy with it.

Sources.
Andreas Heer – Norswiss Farms
Mike Casper – Microgy, Inc.
Dan Kegley – Microgy, Inc.
John McWilliams – Dairyland Power Cooperative

Pagel's Ponderosa Dairy – Kewaunee, Wisconsin

Farm Name:	Pagel's Ponderosa Dairy	**Location:**	Kewaunee
Farm Type:	dairy	**Herd Size:**	4,600 head
Collection Method:	scrape, gravity flow	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow (x2)	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	3,600 head	**Date Operational:**	2008
Design HRT:	20 days	**Current HRT:**	21 days
Design Solids %:	8-9%	**Current Solids %:**	7-7.5%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	bedding, sold to farms or gardeners
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Wisconsin Public Service

Pagel's Ponderosa is a 4,600 head dairy operation in Kewaunee, Wisconsin, in east-central Kewaunee County. Their herd consists of Holsteins and Holstein-Jersey cross-breeds and they use digested solids for bedding. Their operation produces 160,000 gallons of material for treatment per day. Manure is scrape collected continuously 20 hours per day and pushed into a gravity flow system. Manure flows from the various barns to one adjacent to the digester. From that barn it is pumped to the digester.

Digester.
The Pagels chose to have two GHD, Inc. digesters installed on their farm. Construction began in 2008 and the systems were operational in December of that year. The farm owns the digesters and the energy generation. Figure 42 shows the Pagel's Ponderosa digesters.

Figure 42 – Pagel's Ponderosa Digester

The digesters are mixed plug-flow systems, below grade, with U-shape and fixed concrete covers. They use passive mixing with biogas, and have RAS. They are designed with a target operating temperature of 100 degrees F, 20 days HRT, and solids content of eight to nine percent. The system is currently operating very close to design targets at about 101 degrees F, a 21 day HRT, and solids content of about 7.5 percent.

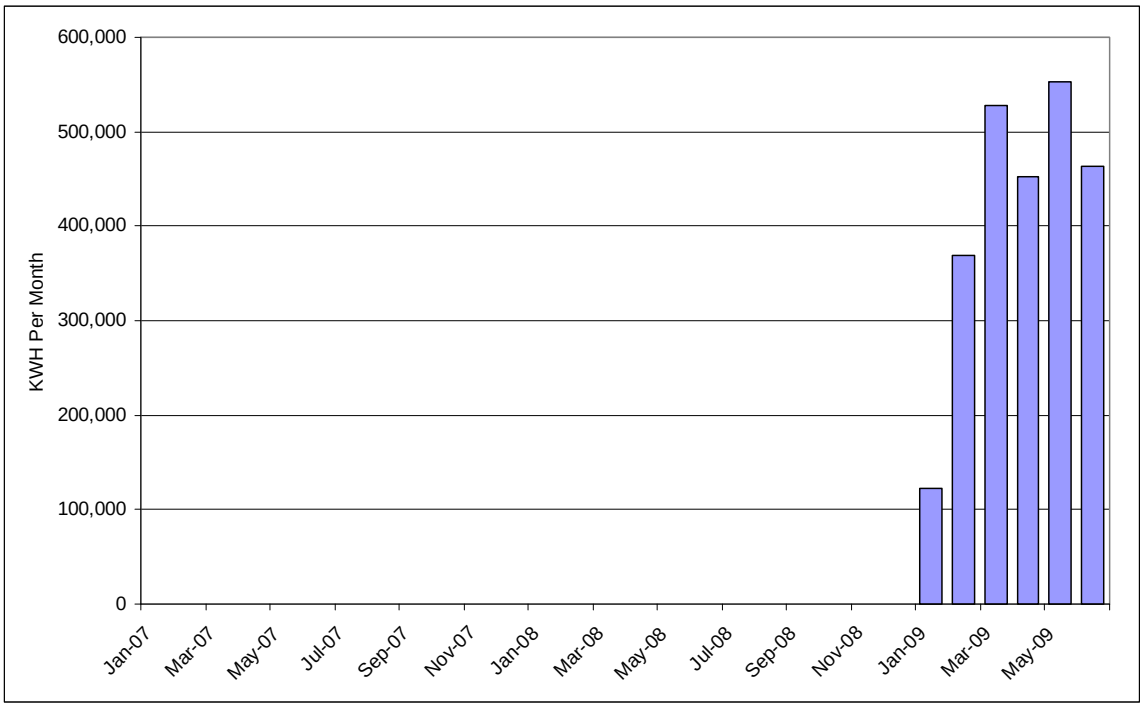
Outputs and Uses.
Biogas from the digester is treated with a condensate trap and chiller, then run through a GHD, Inc. design H_2S reduction system (reportedly reduces H_2S to about 500 ppm). Scrubbed biogas is used to fuel an 800 kW Caterpillar engine generator set to produce electricity and heat. The engine generator set is pictured in Figure 43.

Figure 43 – Pagel's Ponderosa Engine Generator Set

Photo courtesy of Pagel's Ponderosa.

Electricity produced is sold to Wisconsin Public Service under a sell-all contract. The farm began generating electricity in January 2009. Figure 44 on the following page shows the generation history for this operation.

Figure 44 – Pagel's Ponderosa Generation History



Recovered heat from the engine generator set is used to heat the digester and another building, and will be used to heat their new facility and offices. They also have a 4 mmBtu backup biogas boiler for digester heating. They also installed a line so the biogas boiler can be used for heating the floor of their new facility.

The farm produces about 15 tons of separated digested solids per day. They are currently selling about 27 tons per week to other farms at $10 per ton FOB, or $15 per ton delivered. Some people come to the farm with trailers to pick up loads. The rest of the solids are used on the farm.

History and Comments.
The owners report that the installation of the digester and energy generation systems went "really well." They had the engine down twice since June for 30 days each for overhauls but it has been working well since then.

They installed the digester system to control odors and because they wanted to do more with green energy. They found that the consistent and endless supply of bedding allowed them to eliminate sand bedding, and have a higher concentration of cows. They feel their system has been great for neighbor relations and has also helped the local economy.

Sources.
Brian Pagel, Pagel's Ponderosa
John Pagel, Pagel's Ponderosa
Melissa VanOrnum, GHD, Inc.
Joe Sinkula, Wisconsin Public Service

Quantum Dairy – Weyauwega, Wisconsin

Farm Name:	Quantum Dairy	**Location:**	Weyauwega
Farm Type:	dairy	**Herd Size:**	1,200 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	1,250 head	**Date Operational:**	2005
Design HRT:	22 days	**Current HRT:**	17 days
Design Solids %:	8-9%	**Current Solids %:**	12%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	bedding, sold to farms or gardeners
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	We Energies, Inc.

Quantum Dairy is a dairy in Weyauwega, in southern Waupaca County, Wisconsin. They have 1,800 head of milking Holsteins and a total of 2,100 head on site. The operation produces about 50,000 gallons per day of manure and liquids for treatment. Manure from 1,200 cows (about 29,000 gallons per day) is treated with the digester and used for bedding those cows. This influent has a solids content of about 12 percent. They use scrape collection of manure three times per day, and use separated digested solids for bedding. The other 900 cows are bedded with sand and their manure is removed by vacuum truck to a separate lagoon. Before installing their digester they had an open lagoon for manure storage.

Digester.
The owners researched digester designs and chose GHD, Inc. to design and install their digester and energy generation systems. The digester was built in 2004-2005 and became operational in 2005. Figure 45 shows the digester at Quantum Dairy and the effluent storage lagoon in the background.

Figure 45 – Quantum Dairy Digester

Photo courtesy of Quantum Dairy.

The digester is a U-shaped mixed plug-flow system with biogas induced passive mixing. It operates in the mesophilic temperature range with a target of 100 degrees F. It has a design HRT of about 22 days. The structure is below-grade concrete with a fixed concrete cover. The farm owns the digester and energy generation.

Manure from the reception pit is pumped to the digester 12 times per day. Cows undergoing footbath treatment are at a separate barn so that liquid currently does not go through the digester (this will soon be included in the influent). After the digester, solids are separated out of the effluent stream with a Fan brand screw press solids separator pictured in Figure 46. The conveyor used to move the solids was recently replaced with an auger to reduce maintenance.

Figure 46 – Screw Press Solids Separator

Outputs and Uses.
Biogas produced by the digester is sent through a condensate trap and chiller to remove moisture. They recently added a bubbler-type scrubber from Martin Machinery that is reportedly reducing their H_2S levels from 2,800 ppm to about 500 ppm. Sulfuric acid created in the scrubber is sent to the lagoon. They also recently upgraded their engine generator set to a 450 kW Guascor unit. Electricity is sold to We Energies under a sell-all contract. The generation history for the past 30 months at Quantum is shown in Figure 47 (on the following page).

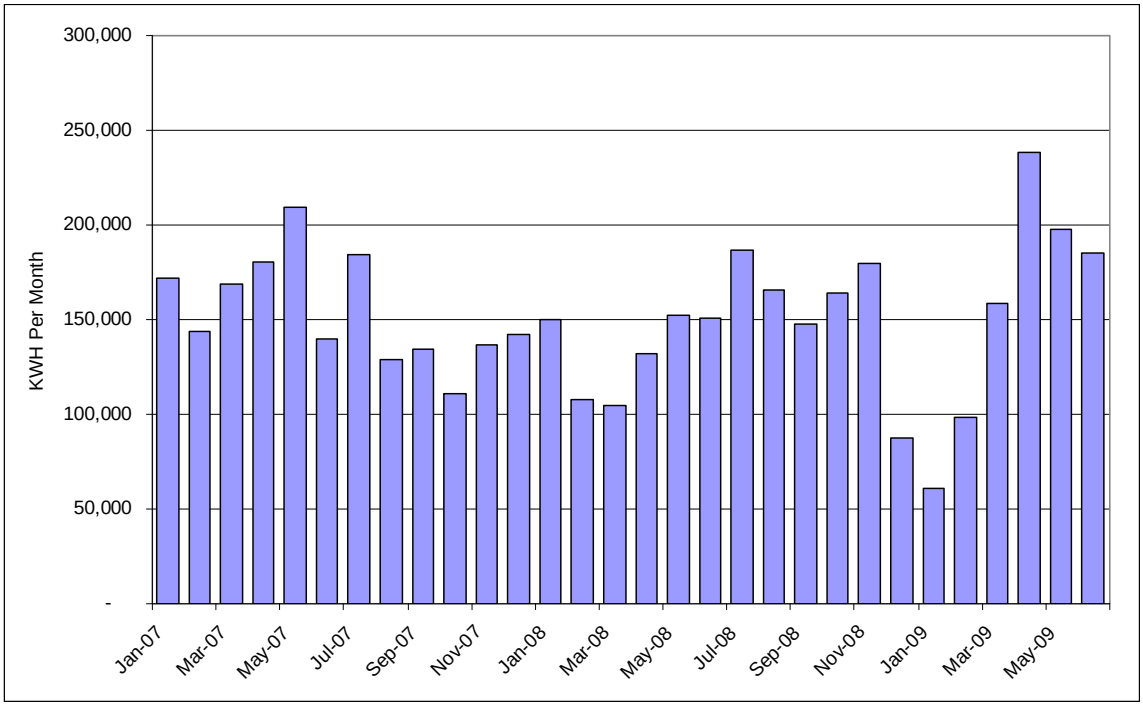
The recovered heat from the energy generation is used to heat the digester, parlor, genset building, shop, and the water for cleaning in the milk house. They also installed a 4 mmBtu biogas boiler they acquired through GHD, Inc.

The dairy creates about 85 tons of digested solids per week (at a moisture content of about 66 percent), most of which is used on the farm for bedding with about 25 tons left over for sale. They sell excess solids to other dairies and gardening companies for $15 per ton.

History and Comments.
GHD designed the digester, oversaw integration with the first engine generator set, and associated structures. The digester has a target design capacity of 1,250 head, but was seeing manure from about 2,100 head. This had resulted in an operational HRT of 14 days rather than the design HRT of 22 days. They had some herd health issues, presumably due to the overloading of the system resulting in incomplete digestion of

solids used for bedding. The farm more recently removed manure from 900 cows from the digester to increase the HRT to improve digestion and bedding quality.

Figure 47 – Electricity Generation History at Quantum Dairy



Since installation in 2005, they have upgraded their engine generator set and entered into a "bumper-to-bumper" maintenance agreement with Martin Machinery that has made "life much easier" according to owner Richard Wagner. The new H_2S treatment has allowed them to increase runtime between oil changes from 250 hours to 800-900 hours, improving their uptime. Also, the new system only uses about half the oil per day the previous system did.

They have experienced some pinhole leaks in the digester which they sandbagged. Mr. Wagner thinks GHD has fixed this problem by changing their foam applier and cover attachment. They have noticed that manure exiting the digester still has gas bubbles coming out and odor is still an issue (see overloading issue above). They are capturing gases from the exit pit, from a tank (used to send some liquid to the Martin Machinery sulfur scrubber) receiving liquids from the separator, and from a reception pit that receives liquid from that tank. This gas is bubbled through a tank with 12 inches of water. The water strips sulfur from the gases in the form of sulfuric acid. A small amount of water is continuously added to this tank, and its overflow goes to the lagoon. They recently installed a GHD designed flare that ignites better and stays lit. They are currently working with the fencer manufacturer, Dare Products, to improve the longevity of production of a strong enough spark for ignition in this flare. Fencers have weakened after about 6 to 12 months, and longer life is desired. The sulfur scrubber refresh liquid off the manure separator is more recently going through a larger 4,000 gallon balance tank. This hold up volume ages the liquid just enough to allow scrubber operation

without the addition of de-foam chemical. Other than the normal maintenance issues, the scrubber system performs “just great” according to Mr. Wagner.

Sources.
Richard Wagner – Quantum Dairy
Melissa VanOrnum – GHD, Inc.
Tom Young – We Energies, Inc.

Statz Brothers, Inc. – Sun Prairie, Wisconsin

Farm Name:	Statz Brothers, Inc.	**Location:**	Sun Prairie
Farm Type:	dairy	**Herd Size:**	2,560 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	2,100 head	**Date Operational:**	2009
Design HRT:	22 days	**Current HRT:**	20 days
Design Solids %:	8-9%	**Current Solids %:**	6%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw presses	**Solids Use:**	bedding, sold to farms
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	Alliant Energy

Statz Brothers dairy is a 2,560 head dairy in Sun Prairie, Wisconsin in Northeastern Dane County. The dairy operation produces about 75,000 gallons per day of materials for treatment. They use digested solids for bedding and scrape collect manure three times per day. Their influent stream currently has about six percent solids and is mixed with a chopper pump prior to entering the digester. Materials with mineral footbath treatments are diverted to the lagoon so they do not enter the digester.

Digester.
The farm owners decided to install a GHD, Inc. designed digester system. The digester was installed in 2008 and became operational in early 2009. The system is a below grade U-shaped mixed plug-flow with passive gas induced mixing and RAS. The structure is cast concrete with a fixed concrete cover. Figure 48 below shows the gas mixing system.

Figure 48 – Statz Brothers Gas Mixing System

Their system has the potential for pre-heating the manure in cold weather. Manure is fed into the digester periodically throughout the day, typically three times per day.

The digester design operating temperature is 100 degrees F, and the design HRT is 22 days. The Statz Brothers system is currently operating

close to these parameters at 100 degrees F, and an HRT of about 20 days. The six percent solids content of influent is somewhat below the design target of eight to nine percent solids.

Outputs and Uses.
Biogas from the digester is run through a condensate trap and chiller, then used to run a 600 kW Guascor engine generator set. Electricity is sold to Alliant Energy under a sell-all contract that includes utility ownership of environmental credits from generation. The generator is configured to be able to operate in stand-alone mode, independent of the grid. Figure 49 shows the Statz Brothers engine generator set.

Figure 49 – Statz Brothers Engine Generator Set

The system has been generating electricity since February 2009. The generation history for this farm is shown in Figure 50 on the following page.

Heat from the energy generation is recovered and used to heat the digester, separator building and digester maintenance building. They also have the built-in potential to use heat for the main dairy center, and to pre-heat the manure as needed in winter.

Figure 50 – Statz Brothers Generation History

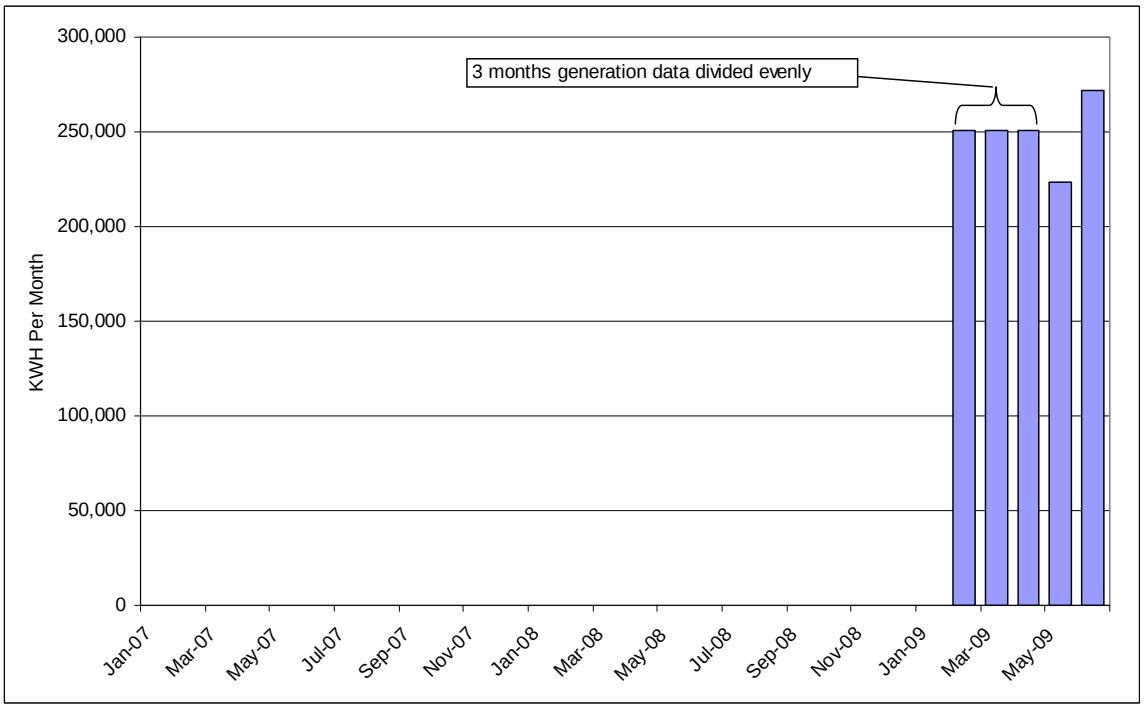


Figure 51 – Separated Solids Conveyor and Storage

Effluent from the digester is run through two Bauer brand screw press style solids separators. They have a conveyor system that drops separated solids from 20 feet up, providing some additional drying and leaving rows of solids on the floor for use. Figure 51 shows the conveyor system in the solids building. The farm produces 17 to 20 tons of solids per day and uses most of them on the farm. They recently switched from mattresses to deep beds. They also use some at another 500-cow facility they have nearby. Some solids are sold to other dairies for $20 per ton FOB.

<u>History and Comments</u>.
The farm owners opted to install an anaerobic digester so they could produce their own high-quality bedding. Their

experience with rice hulls was that they were dirty, and sawdust or shavings have become increasingly difficult to obtain and quality was quite variable. They chose a GHD, Inc. system because it looked simple and they had experience.

They had some delays during construction because of farm, utility, and construction coordination issues. Troy Statz reports that the digester is running as planned. They are currently (summer 2009) putting in a larger poly and clay-lined storage lagoon.

They are still in the first year of operation for the digester. Mr. Statz is happy with the bedding they produce and feels the outcomes are "ideal." He notes that during planning and installation, it is important to involve a dependable person who is responsible for manure handling on the farm especially regarding system flow. Installing a digester on an existing farm can be quite disruptive so people need to be prepared for that and able to adapt.

Sources.
Troy Statz, Statz Brothers, Inc.
Melissa VanOrnum, GHD, Inc.
Steve Argall, Alliant Energy, Inc.

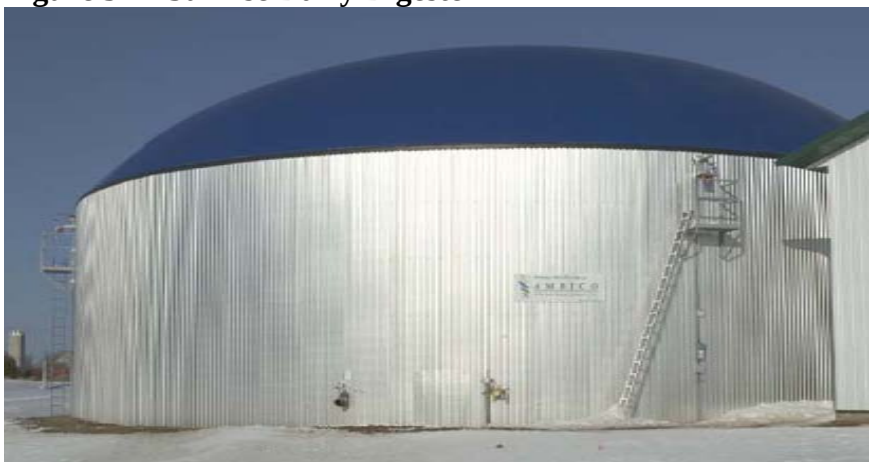
Sunrise Dairy (formerly Suring Community Dairy) – Suring, Wisconsin

Farm Name:	Sunrise Dairy	**Location:**	Suring
Farm Type:	dairy	**Herd Size:**	1,075 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	complete mix	**Design Temperature:**	100 deg F
Digester Notes:	above ground bolted stainless steel tank with dual membrane, flexible cover on floating concrete pad		
Design Capacity:	1,000 head	**Date Operational:**	2006
Design HRT:	28 days	**Current HRT:**	20-21 days
Design Solids %:	not available	**Current Solids %:**	10-11%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	bedding
Farm Owns:	none, (former farm owner owns digester and energy generation)	**Utility Owns:**	none
Digester Designer:	American Biogas Company, Inc.	**Utility:**	Wisconsin Public Service

Suring Community Dairy was sold to new owners in the summer of 2008. The former farm owner retained ownership of the digester and energy generation equipment and still operates those systems. The new dairy is Sunrise Dairy, with 1,075 head of Holstein in Suring, Wisconsin in Oconto County. They use scrape collection about 15 times throughout the day. The daily production volume of manure is about 28,000 gallons. The manure and wastewater influent stream requiring treatment has an estimated solids content of 10 to 11 percent. They use separated solids for bedding and their former manure storage method was a lagoon.

Digester.
The farm has an American Biogas Company (AMBICO) design complete-mix digester. Figure 52 shows the digester at Sunrise Dairy.

Figure 52 – Sunrise Dairy Digester



The digester is an above ground, stainless steel complete-mix tank with a dual membrane flexible cover, resting on a floating concrete pad. It operates in the mesophilic range with a target temperature of 100 degrees F, and an HRT of 22 days. The system is currently (Fall 2009) operating at about 96 degrees F and an HRT of 20-21 days.

The digester owner has adjusted their manure pumping schedule to do most of the pumping into the digester during off-peak energy hours or on weekends to take advantage of lower electricity rates. Several times per week they will pump in a couple thousand gallons even if it is during peak energy hours if levels in the holding tank get too high. They do not do any kind of pre-treating of the influent. Currently, only manure, wastewater and bedding are sent into the digester. Small amounts of footbath water are sent through the digester as well.

Figure 53 – Sunrise Engine Generator Set

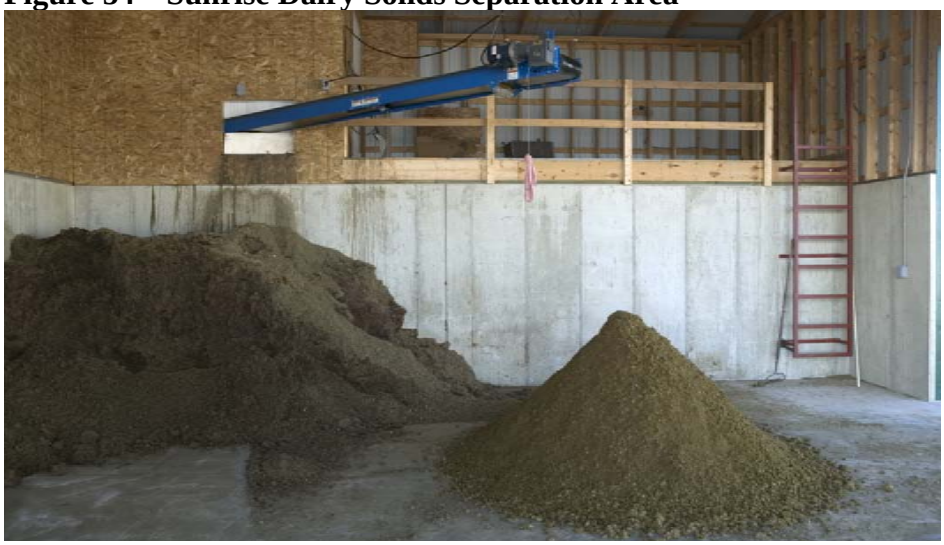
Outputs and Uses.
Biogas produced from the digester is sent through a passive hydrogen sulfide removal system and chilling unit for condensate removal. It is then fed into a 250 kW Deutz, dual fuel engine generator set which uses about six to nine liters (two gallons) of diesel per hour and is synchronous (i.e., can run in stand-alone mode). Figure 53 shows the engine generator set. Data on electricity produced on the farm was not available for this study period. Electricity is sold to Wisconsin Public Service Corporation under a sell-all agreement.

Heat captured from the engine and exhaust is used to heat the digester and the shop building.

They separate solids from the effluent stream. They own two separators: a Fan brand screw press solids separator (replacing a WHEDA model) that does almost all the separation, and a PTI (Press Technologies, Inc.) model. The switch to the Fan press has allowed them to increase throughput because it can handle the higher volume. They produce 100 yards (33 tons) of digested solids per week. The farm converted about 70 percent of the stalls to deep beds and now their solids are all used on the farm. They have previously supplied some solids for landscapers and gardeners. Figure 54 on the following page shows their solids separation area.

They now have a backup LP fueled 1.25 mmBtu boiler for digester heat if needed. The owner also has a permit to set up influent pre-heating using the hot effluent.

Figure 54 – Sunrise Dairy Solids Separation Area



History and Comments.
One of the digester owners, and former co-owner of Suring Community Dairy, Ray Leicht, oversees operation of the digester, engine generator set and solids separation. Mr. Leicht also has the power sales agreement with Wisconsin Public Service. When originally installed, he points out that the utility, digester designer, Focus on Energy, and the USDA Rural Development all worked well together to bring this project to life. They did encounter some problems working with component manufacturers in different countries (e.g., German engine, Japanese controllers). Sometimes things did not fit together properly.

They had planned to have substrates from off-farm brought in for co-digestion, but discovered that arranging this was not as easy as they thought it would be. One food producer was talking with them about some grease trap wastes and he found out from the Department of Natural Resources that using it may cause some permit issues related to their nutrient management.

The new farm owner is buying bedding back from the digester owners. Dave Hischke notes that they really do not notice the digester operation and the farm does not have a lot of interaction with it other than the exchange of materials. They are in the process of installing a return line to reroute effluent from the screw press back into the reception pit for pre-heating. This helps lower the energy needed to heat the manure up to digester target temperature by capturing heat from the effluent that would otherwise be wasted.

Sources.
Ray Leicht – digester owner and operator
Dave Hischke – Sunrise Dairy
Carsten Weber – American Biogas Company
Joe Sinkula – Wisconsin Public Service Corporation

Vir-Clar Farm – Fond du Lac, Wisconsin

Farm Name:	Vir-Clar Farm	**Location:**	Fond du Lac
Farm Type:	dairy	**Herd Size:**	1,400 head
Collection Method:	scrape	**Bedding Type:**	digested solids
Digester Type:	complete mix (x2)	**Design Temperature:**	100 deg F
Digester Notes:	above ground tanks, flexible membrane covers		
Design Capacity:	1,350 head	**Date Operational:**	2004
Design HRT:	33 days	**Current HRT:**	30 days
Design Solids %:	not available	**Current Solids %:**	12%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw presses	**Solids Use:**	bedding, farms and potting soil company
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	Biogas Nord/Biogas Direct	**Utility:**	Alliant Energy

Vir-Clar Farm is a 1,400 head Holstein dairy, in Fond du Lac, Wisconsin, in eastern Fond du Lac County. They produce about 40,000 gallons of manure and other material for treatment per day with an average solids content of 12 percent. They sometimes add other on-farm wastes such as moldy feed, bunker waste, and anything not eaten by the cows. They use digested solids for bedding and do continuous scrape collection. Their former system for manure storage was a storage tank. Figure 55 shows the farm entrance with digesters on the left.

Figure 55 – Vir-Clar Farm with Digester on Left

Photo courtesy of Vir-Clar Farm.

Digester.

In 2004, Vir-Clar Farm installed two Biogas Direct, LLC, digesters to treat their manure. These are above ground complete mix tank systems, with flexible dual membrane covers.

The inside membrane holds biogas, and there is a layer of air between the membranes. They operate in the mesophilic temperature range with a target operating temperature of 100 degrees F and a target HRT of 33 days. They are currently operating at between 101 and 102 degrees, and with an HRT of 30 days. Figure 56 shows the digesters at Vir-Clar.

Figure 56 – Vir-Clar Farm Digesters

Photo courtesy of Vir-Clar Farm.

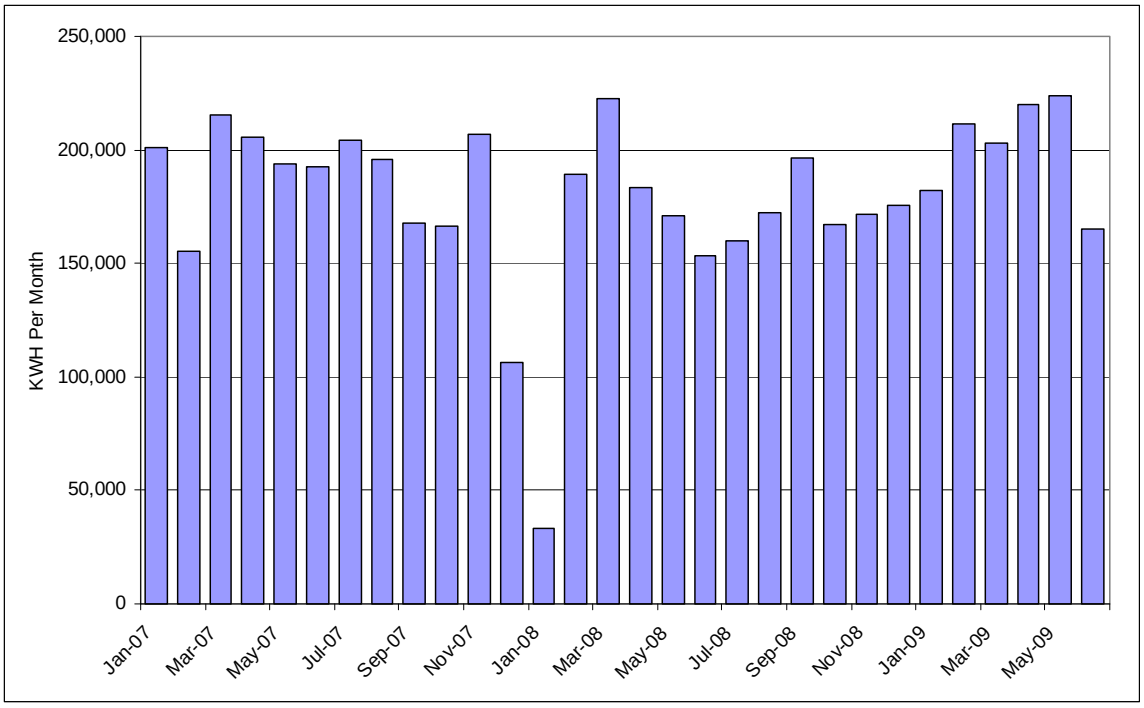
Manure is added to the digesters five times per day. They also digest other organics from the farm including bunker wastes, moldy feed, and whatever is not eaten by the cows. They mix the manure going into the digester with liquid coming from the solids separators. They avoid having footbath water go into the digester.

Figure 57 – Engine Generator Set in Container

<u>Outputs and Uses</u>.
Biogas from the digester is passed through a passive hydrogen sulfide removal system within the digester, and a chilling unit for condensate removal. It is then fed into a Caterpillar engine generator set that has been modified by the German company SEVA and has a 350 kW generating capacity. The owner pointed out that the engine has seen over 34,000 hours of operation. The engine generator set is containerized. Figure 57 shows a view of the inside of the

container. The generator is synchronous and can operate in stand-alone mode. The farm has a sell-all agreement for electricity sales to Alliant Energy. Figure 58 shows the electricity generation history for the Vir-Clar system for the past 30 months.

Figure 58 – Vir-Clar Electricity Generation History



They do not have a backup boiler. Heat from the engine and exhaust is captured and used for heating the digester, water for calves, the separator room, and to provide in-floor heating in the calf barn.

The farm has two screw presses (one is for backup): a Fan and a Bauer brand press. They produce about 150 tons of digested solids per week about half of which is used on the farm, and the rest is sold to other farms for bedding at $20 per ton FOB. Liquid digestate is stored in a storage tank under the cows before being land applied. Figure 59 on the following page shows one of their solids separators.

History and Comments.
Gary Boyke, owner of Vir-Clar Farm says they had a great experience with construction. They started building the digesters in the beginning of June 2004 and by mid-October they were filling them with manure. In November 2004 they were making electricity.

He thinks the system has paid for itself and is making them money. They are often making more gas than the engine can use and are looking for ways to improve production and get an even better return. He would be interested in finding consistent substrate streams he could add to their influent to boost biogas production and allow them to set up additional energy generation.

Figure 59 – Vir-Clar Solids Separator

Photo courtesy of Vir-Clar Farm

One thing he would do differently is to arrange the structures to better use their 1.5 million gallon storage lagoon, and to more easily allow for growth of the farm.

He points out that it has been five years since they installed their system and he thinks every large dairy in the country that can live without sand bedding should consider a digester. It "makes management simpler." They are looking for options to expand the digester concept on the farm.

Sources.
Gary Boyke – Vir-Clar Farm
Michael Zander – Energies Direct, LLC (formerly Biogas Direct, LLC)
Kimberly Schumway – Alliant Energy

Volm Farms – Kewaskum, Wisconsin

Farm Name:	Volm Farms	**Location:**	Kewaskum
Farm Type:	dairy	**Herd Size:**	825 head
Collection Method:	scrape (automatic)	**Bedding Type:**	digested solids
Digester Type:	mixed plug-flow	**Design Temperature:**	100 deg F
Digester Notes:	two-stage, below grade concrete tank, u-shaped, gas-induced mixing, RAS		
Design Capacity:	900 head	**Date Operational:**	2009
Design HRT:	22 days	**Current HRT:**	21 days
Design Solids %:	8-9%	**Current Solids %:**	not available
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all
Solids Separation:	yes, screw press	**Solids Use:**	bedding
Farm Owns:	digester, energy generation	**Utility Owns:**	none
Digester Designer:	GHD, Inc.	**Utility:**	We Energies

Volm Farms is an 825 head dairy operation in Kewaskum, Wisconsin, in northern Washington County. Manure is scrape collected with automatic scrapers throughout the day. The farm uses digested solids for bedding, and produces about 20,000 gallons of liquids for treatment per day. They also add about 300 bushels of chopped straw to their influent stream every day to increase bedding production. The farm's previous manure system had a storage tank under the free-stall barn and an earthen lagoon.

Digester.
The Volm Farms owners had a GHD, Inc. digester installed in 2009. Figure 60 shows a view of the Volm Farms digester.

Figure 60 – Digester at Volm Farms

The system became operational in June of 2009. The farm owns the digester and the energy generation. Manure is added to the digester every six hours. The digester is a below grade mixed plug-flow system with passive mixing and RAS. The structure is poured concrete, with a fixed cover. The digester has a design target temperature of 100 degrees F and design HRT of 22 days. The Volm system was currently operating essentially on these targets as of fall 2009.

Outputs and Uses.
Biogas produced by the digester is run through a condensate trap and chiller. They do have a gas meter installed that measures biogas content and were getting 54 percent methane at the time of the interview. The biogas is then used to run a Guascor 225 kW engine generator set to produce electricity and heat. They have a sell-all agreement for electricity with We Energies. Having just become operational in June 2009, the farm did not have energy generation during the data period covered by this study (i.e., January 2007 through June 2009).

Heat captured from the engine generator set through the water jacket and exhaust will be used to heat the digester, house, shop and possibly the parlor. The farm does not own a backup boiler. Figure 61 shows the heat exchanger.

Figure 61 – Volm Farms Heat Exchanger for the Engine Generator Set

The farm uses a Fan brand solids separator to remove solids from the effluent stream. The separator runs eight to ten hours per day and produces two and a half to three tons of

separated solids per hour. The farm produces about 25 tons of separated solids per day and uses it all on the farm (usually the day it comes out). Solids fall from the separator to a box from which they are blown with a fan into the next building and spread out on the floor. They are reportedly "dry as sawdust" after that.

History and Comments.
According to Shaun Volm, the farm owners had talked about using sand bedding but saw problems with it. They had a neighbor with a GHD system and liked it for the bedding. Construction was a "lot of work" and required substantial modifications on the farm. Their system is "getting better every month" and he hopes to have things running "very smooth" by the end of the year. He now gets automatic notification if the engine has a problem, and they are working on a system where it can be started and stopped by phone.

The motor oil for the engine is changed every two weeks and the valves are adjusted every three weeks. They have a mechanic who helps with this on the farm part-time.

Sources.
Shaun Volm, Volm Farms
Melissa VanOrnum, GHD, Inc.

Wild Rose Dairy – La Farge, Wisconsin

Farm Name:	Wild Rose Dairy	**Location:**	La Farge
Farm Type:	dairy	**Herd Size:**	880 head
Collection Method:	scrape	**Bedding Type:**	digested solids, sometimes add sawdust
Digester Type:	complete mix	**Design Temperature:**	125 deg F
Digester Notes:	above ground cylindrical tank, carbon steel		
Design Capacity:	800-1,200 head	**Date Operational:**	2005
Design HRT:	20 days	**Current HRT:**	20 days
Design Solids %:	6-8%	**Current Solids %:**	4.5%
Biogas Use:	electricity and heat	**Utility Contract:**	yes, sell-all biogas
Solids Separation:	yes, screw press	**Solids Use:**	sold to dairies and organic farmers (export P)
Farm Owns:	digester (designer operates and maintains)	**Utility Owns:**	energy generation
Digester Designer:	Microgy, Inc.	**Utility:**	Dairyland Power Cooperative

Wild Rose Dairy is a 1,045 head dairy consisting of half Holsteins, and half Jersey/Holstein crossbreeds. The dairy is located in La Farge, Wisconsin, in southeastern Vernon County. They currently have 850 head milking but expect that to increase to between 880 and 890 in the near future. Manure from the farm's 165 dry cows is not sent to the digester. They have a total of 880 head, including the milking herd and animals in the hospital barn, that produce about 25,000 gallons per day of materials for treatment with a solids content of between four and five percent. The farm also receives high fat off farm food waste for co-digestion totaling about ten percent of the influent volume. The farm is also re-processing 7,000 to 10,000 gallons of manure to return activated sludge to their system. They use scrape collection three times a day, and recently switched to digested solids for bedding. After treatment effluent is stored in an earthen basin. Their previous manure storage system was the earthen basin which now holds the liquid digestate.

<u>Digester</u>.
Wild Rose Dairy had a Microgy designed digester installed in 2004-2005 and it became operational in 2005. Under this business model, Microgy installs and operates the digester system at no cost outlay to the farm. The farmer immediately owns the digester and biogas is sold to the utility to pay down the farm's debt owed on the digester. Dairyland Power Cooperative installed energy generation (using biogas) equipment on the site and buys biogas from the farm.

Like the systems at Norswiss and Five Star, the digester is an above ground carbon steel tank complete-mix digester with a fixed cover. It is designed to operate in the thermophilic range with a target temperature of 125 degrees F and an HRT of 20 days. The Wild Rose digester is currently operating in the range of 115-125 degrees F, and at an HRT of 20 days. The system is designed to include co-digestion of off-farm high fat

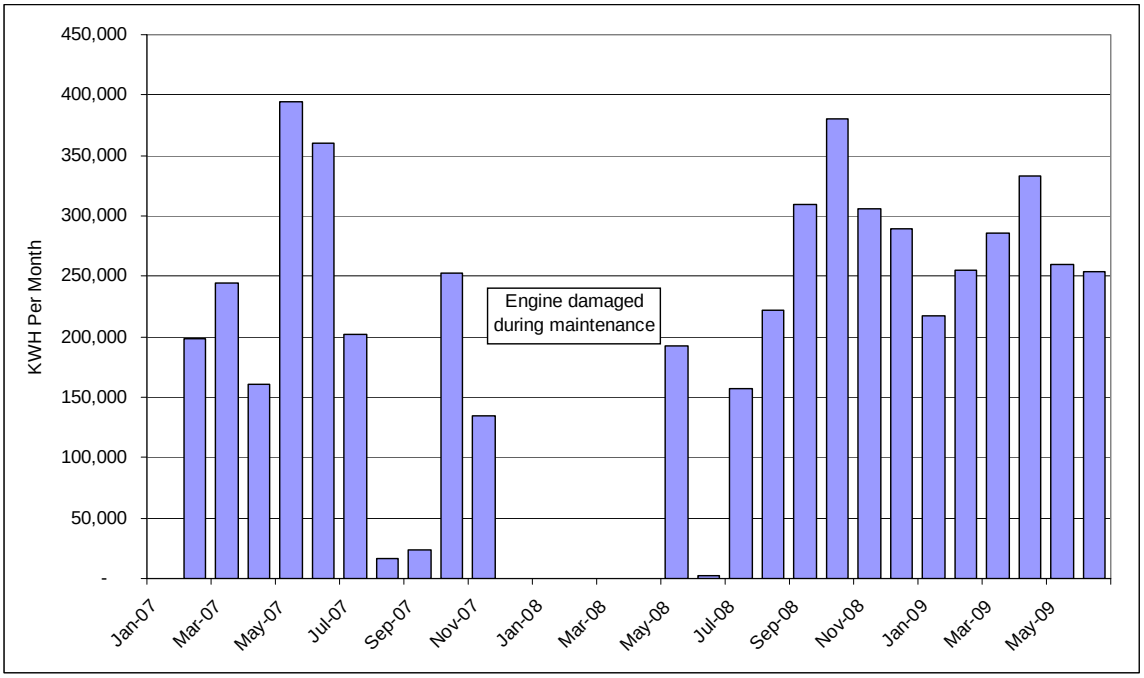
food wastes to boost biogas production. Manure is pre-mixed with food wastes and is fed into the digester continuously. Figure 62 shows the digester with the food waste storage tank on the left.

Figure 62 – Wild Rose Dairy Digester

Outputs and Uses.
Biogas produced by the digester goes through an H_2S removal process using a Biothane brand scrubber, water trap and dehumidifier. It fuels a Waukesha 750 kW (net) synchronous engine generator set owned, operated and maintained by Dairyland Power Cooperative. Although the system could run in stand-alone mode, Dairyland instead uses the generation for voltage support for their distribution system, and it is set up to shut down in the event of a power outage. Dairyland buys the biogas and owns renewable energy attributes from the electricity generation. Figure 63 on the following page shows 30 months of electricity generation history for this location.

Heat captured from the engine is used for the digester only. They have extra they could use but have not yet made the investment to do so and are looking at options such as putting in a greenhouse. All recovered heat is pulled off the water jacket. They have a backup furnace that runs on LP.

Figure 63 – Electricity Generation History for Wild Rose Dairy



They separate out solids using a Fan brand screw press solids separator and produce about five tons per day of these digested solids. They were selling separated solids to other dairies for bedding and to organic farmers for fertilizer at about $20 per ton. Since they switched to digested solids for bedding, they are now using all their solids on the farm for bedding. As much as 10,000 gallons of digestate per day is being fed back into the digester. Figure 64 shows some of the piping and structures at Wild Rose.

Figure 64 – Wild Rose Structures and Piping

<u>History and Comments</u>.
Dan Kegley of Microgy says they experienced greater variability in biogas output from this system than the other two systems in Wisconsin. To address this, they decided to re-process a portion of the manure to not only return activated sludge to the system, but to also increase the volume of material in the digester. This has worked well to stabilize bacteria populations and biogas production.

Wild Rose Dairy owner, Art Thelen, says he likes having the digester very much. Microgy did a great job during construction and the start-up went smoothly. They have many tours and people can see what they are doing. They can show how well the animals are being treated. He said it feels good to use the gas productively.

Mr. Thelen is also happy with the switch they made from kiln-dried sawdust to digested solids. He says the cows like it and he has seen no difference in somatic cell counts.

One thing he would do differently if starting over is he would try to group functions into a smaller number of buildings to avoid having so many small buildings. For instance, he would put all pumps and sensors in one place to use the excess heat and keep the computer area cool. He feels the government (WDNR and NRCS) forced them to pay high engineering fees for building heavy-duty sheds to hold solids because they were worried about runoff.

Sources.
Art Thelen – Wild Rose Dairy
Dan Kegley – Microgy, Inc.
Mike Casper – Microgy, Inc.
John McWilliams – Dairyland Power Cooperative