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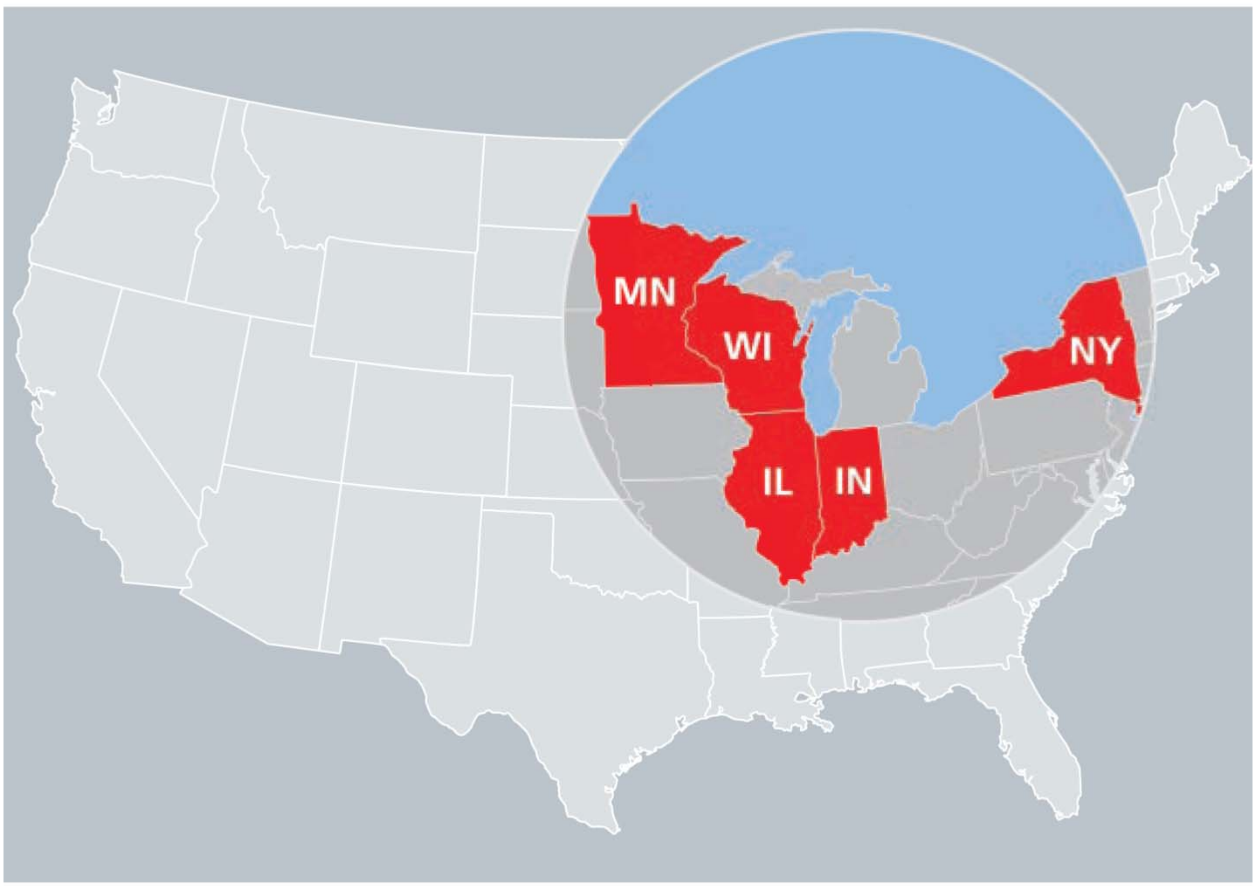
Great Lakes Region Food Industry Biogas Casebook

March 2011



ECW Report 261-1

Great Lakes Region Food Industry Biogas Casebook

March 2011

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ACKNOWLEDGEMENTS

This project was made possible with funding from the following organizations:

- Agricultural Utilization Research Institute
- Center for Innovative Food Technology
- Focus on Energy
- General Mills
- New York State Energy Research and Development Authority
- U.S. DOE Midwest Clean Energy Application Center (managed by the Energy Resources Center of the University of Illinois at Chicago)
- Wisconsin Milk Marketing Board.

The following organizations also provided in-kind assistance contributing toward this effort:

- Agricultural Utilization Research Institute
- Center for Innovative Food Technology
- General Mills
- Midwest Food Processors Association
- New York State Energy Research and Development Authority
- US Department of Energy Midwest Clean Energy Application Center
- Wisconsin Cheesemakers Association.

The author would like to thank the numerous food and wastewater treatment industry professionals who shared their knowledge, insights and advice to make this casebook possible. Special thanks go to:

- Nick George, Midwest Food Processors Association
- Dennis Totzke, Applied Technologies, Inc.
- John Umhoeffer, Wisconsin Cheesemakers Association

TABLE OF CONTENTS

COMMON ABBREVIATIONS AND TERMS

ACP	anaerobic contact process
AD	anaerobic digestion
CHP	combined heat and power
CO_2	carbon dioxide
HDPE	high density polyethylene
H_2S	hydrogen sulfide
HRT	hydraulic retention time
MTP	municipal treatment plant
SRT	solids retention time
UASB	upflow anaerobic sludge blanket
WWTP	wastewater treatment plant
Units	
Btu	British thermal units
cfd (ft^3 /day)	cubic feet per day
gpd	gallons per day
kW	kilowatt
kWh	kilowatt hours
therms	a unit of heat equal to 100,000 Btus

Term	**Definition**
Acidogenic	acid producing
Anaerobic Contact Process (ACP)	type of complete-mix anaerobic digester including recycling of biota back into the digester tank
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>

Term	Definition
Anaerobic Digestion (AD)	the biological, physical and or chemical breakdown of animal manure in the absence of oxygen
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 (also referred to as cogeneration)
Complete-Mix Digester (AKA Continuous-Mix)	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
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 anaerobic 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
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
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

Term	**Definition**
Psychrophilic	of, relating to, or being at a relatively low temperature
Scrubber (Biogas)	biogas cleaning device or process to remove hydrogen 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).
Thermophilic	of, relating to, or being at a relatively high temperature

INTRODUCTION AND METHODOLOGY

Food and beverage producers have been using anaerobic treatment of their production wastewaters for decades. These systems have become increasingly popular in recent years for both economic and environmental reasons. As energy costs have risen, the reduced energy intensity of anaerobic digester treatments over aerobic treatment options has presented a clear cost advantage for facilities producing high strength wastes. Anaerobic treatments also result in much smaller amounts of biosolids than alternative aerobic treatments, meaning the costs associated with disposing of these are lower. In addition, rising concerns over anthropogenic global climate change have made an increasing number of companies look at options for reducing the carbon footprint of their operations. Anaerobic digestion can create opportunities for producers to reduce both energy intensity and carbon emissions by providing biogas, a renewable fuel they can use to help reduce fossil fuel purchases.

This casebook focuses on a subset of facilities in the Great Lakes Region of the United States. States with systems profiled in the casebook are shown in Figure 1.

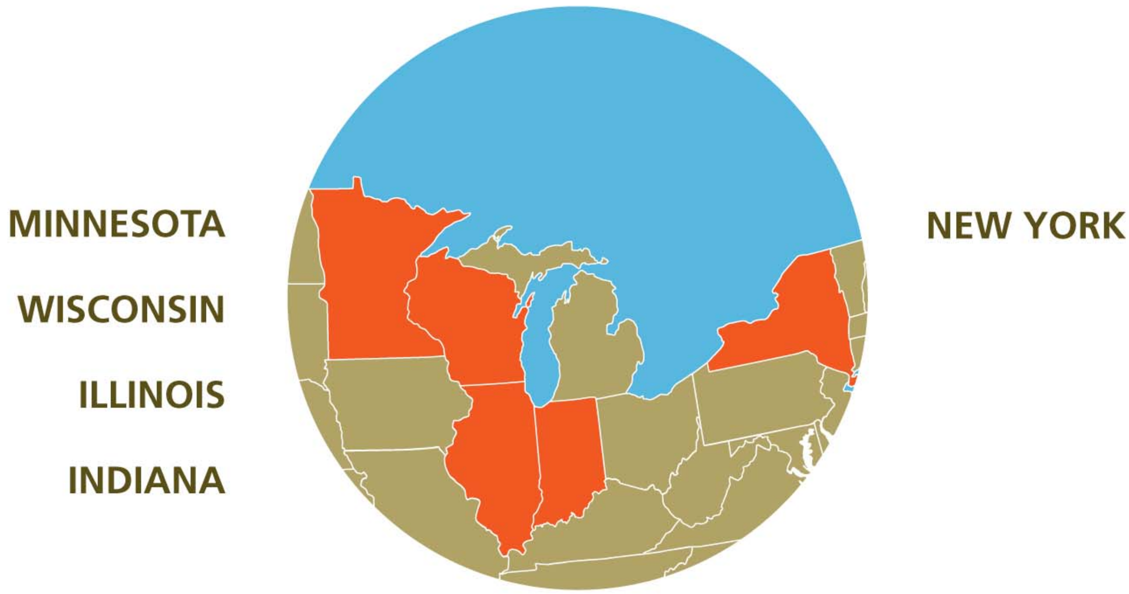

Figure 1 - States with profiled facilities.

We reviewed 12 facilities to provide a snapshot of how their systems were functioning and to give some background on how anaerobic digestion is working for them. Companies profiled in this casebook have taken the extraordinary step of agreeing to share their experiences so others can build on them, improving their likelihood of success.

Information was gathered through telephone interviews with plant managers and other company representatives. Participants were given final review of all write-ups prior to publication.

Our criteria for selecting the facilities profiled in this casebook were based on the geographic focuses of project funders, the degree to which facilities are using, or have the potential to use biogas, and the willingness of companies to be included in the study.

ANAEROBIC DIGESTER TYPES

The companies profiled use several different types of digesters. The following section provides some brief descriptions of these systems. A more in-depth description of these systems and their applications can be found in Dennis Totzke's 2010 report on digester systems.[1]

Covered lagoon systems, shown in Figure 2, are among the least complex. They consist of a lagoon that is often lined with an impermeable or semi-impermeable layer, such as high density polyethylene (HDPE) or clay. These are covered with a flexible air-tight material that can temporarily store biogas and channel it to gas collection systems. Covered lagoons sometimes include an additional open cell for storage of the treated effluent.

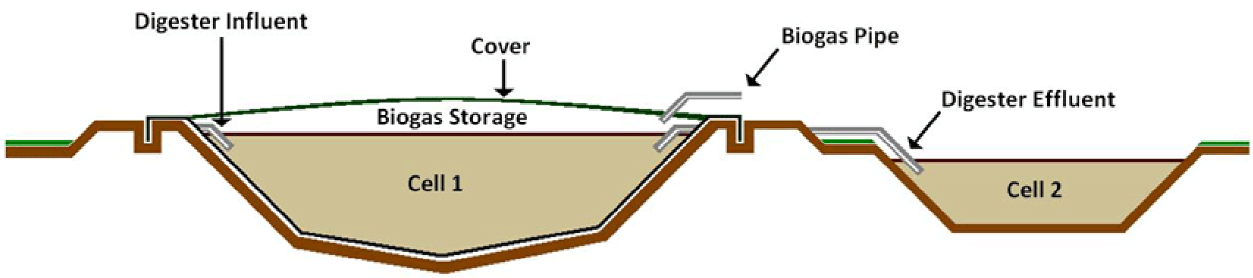

Figure 2 - Covered lagoon schematic. Graphic courtesy of US EPA AgSTAR Program.

Digestion efficiency in covered lagoons can often be improved by adding mixing, and, especially in cooler climates, providing some heat to maintain or approach temperatures in the mesophilic range (i.e., roughly 90-105 degrees F). Covered lagoon digesters are also used in processing of animal manures.

Complete mix (sometimes called continuous mix) systems include a heated, air-tight container with some form of mechanical or water jet mixing. The mixing action gives more opportunities for bacteria to have contact with the food, improving digestion. Figure 3 shows a simplified schematic for a complete mix digester.

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[1] A copy of the 2010 report can be requested on the following site: http://www.ati-ae.com/contact.html.

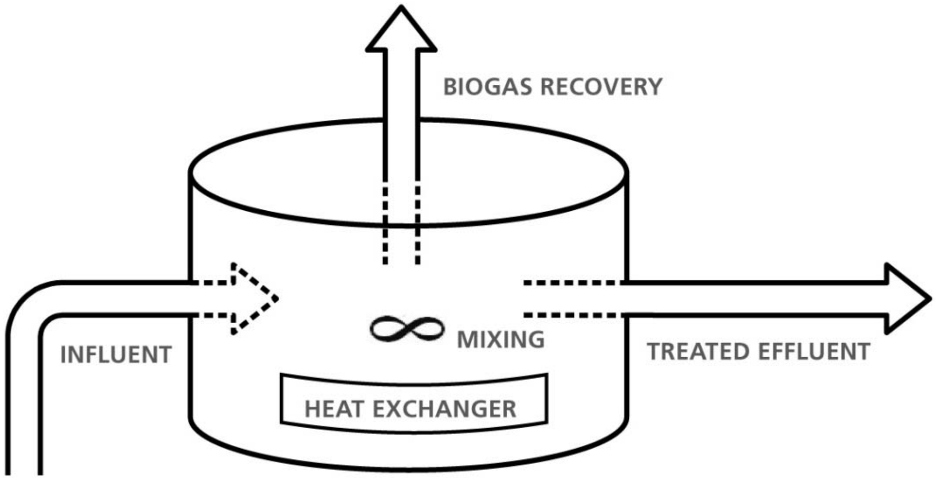

Figure 3 – Simplified complete mix digester schematic

The **anaerobic contact process** (ACP) digester is similar to a complete mix system but includes a separate tank for separating solids which are then reintroduced to the digester. This return of active biota to the digester allows the population of bacteria to focus more of their energy on digestion and less on reproduction. Figure 4 shows a simplified schematic of an anaerobic contact process system.

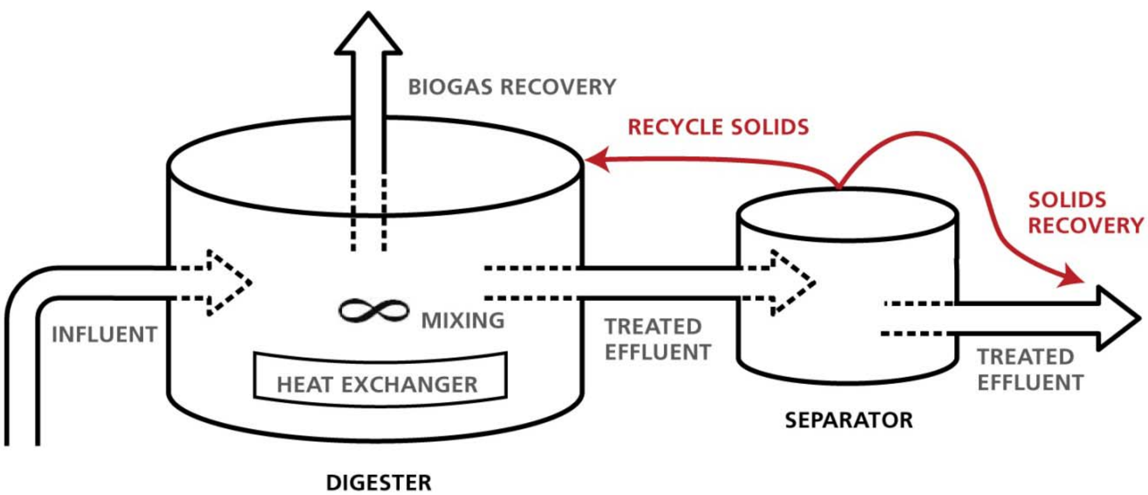

Figure 4 - Simplified anaerobic contact process schematic

ACP systems are notably effective at degrading wastewater with high total suspended solids (TSS) and fats, oils and grease (FOG) without excessive buildup of solids in the reactor.

The **upflow anaerobic sludge blanket** (UASB) digester is more complex. As the name implies, the direction of wastewater flow goes from entry at the bottom of the tank to exit at the top. The proper functioning of the digester depends on the production of a "blanket" of granular sludge particles through which the wastewater must flow. Figure 5 shows a schematic of a UASB system.

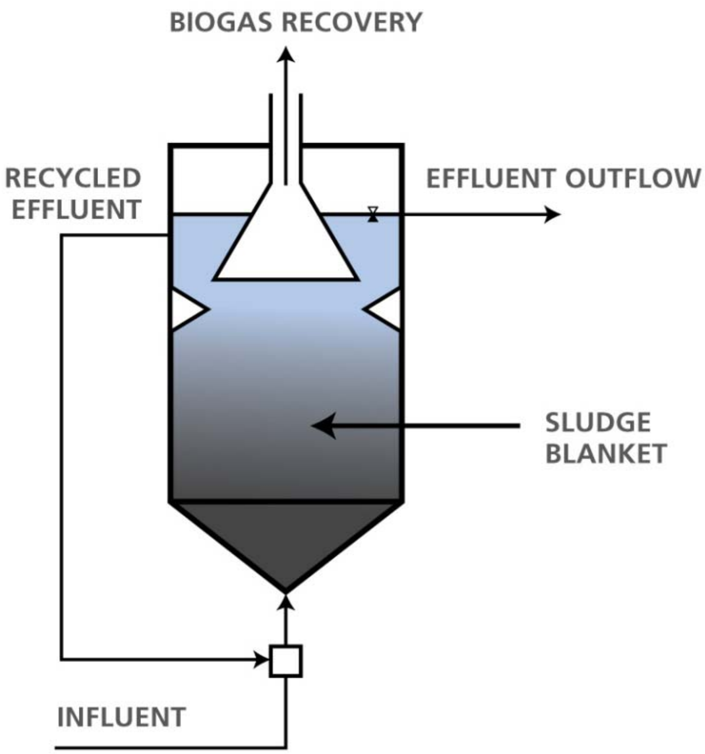

Figure 5 - Upflow anaerobic sludge blanket digester. Graphic courtesy of Doug Hamilton Oklahoma State University

Passing through the sludge blanket provides the wastewater with extensive contact opportunities with the bacteria for digestion. Therefore, these systems can allow higher rate treatment, processing wastewater more quickly than some other types and enabling the system to work with a smaller vessel. UASB systems, however, do not tolerate high total suspended solids (TSS) levels which can interfere with biota and wastewater interaction.

We do not include a description and schematic of the mobilized film technology digester because we were unable to get information and permission from the design company.

SUMMARY INFORMATION ON FACILITIES

Systems used in the facilities profiled in this casebook, and the number of facilities using each include:

- UASB (4)
- Anaerobic contact process (3)
- Complete mix (2)
- Mobilized film technology (1)
- Covered lagoon (1)
- Mixed heated covered lagoon (1)

Although facility managers interviewed tended not to dwell on the amount of time and effort they needed to optimize their systems for their wastewater, new systems sometimes required a significant amount of trial and error, and acclimation of the biota to their particular waste stream, to reach smooth and optimal operation. However, company representatives interviewed were uniformly positive about their use of anaerobic digestion as part of their waste treatment regimes.

Several different types of food industries use anaerobic digestion to treat their wastewaters. The facilities profiled in this casebook are listed in Table 1.

Company		**City**	**State**
American Crystal Sugar Company	Sugar production	East Grand Forks	MN
Anheuser Busch	Brewery	Baldwinsville	NY
Beaver Dam Wisconsin (City of), Kraft Foods	Cheese production	Beaver Dam	WI
City Brewing Company, Gunderson Lutheran	Brewery and beverages production	La Crosse	WI
General Mills	Refrigerated dough products	New Albany	IN
JBS, Green Bay Inc.	Beef production	Green Bay	WI
Kraft Foods, Inc.	Cream cheese products	Lowville	NY
McCleary, Inc. (parent co.), Axium Foods	Snack foods	South Beloit	IL
Monmouth (City of), Farmland Foods	Pork production	Monmouth	IL
Saputo Cheese USA, Inc.	Cheese and whey production	Waupun	WI
Seneca Foods Corporation	Peas and corn processing	Montgomery	MN
SunOpta Ingredients, Inc.	Oat fiber processing	Cambridge	MN

Table 1 - Participating companies and food production types

The types of facilities profiled include:

- Cheese production (3)
- Beer and other beverage production (2)

- Meat processing (2)
- Corn based snacks production (1)
- Frozen dough products production (1)
- Grain processing (1)
- Sugar refining (1)
- Vegetable processing (1)

Table 2 shows the types of systems installed at these facilities and the years they were installed.

Company	**Digester Type**	**Year Installed**
American Crystal Sugar Company	Anaerobic contact process	1979
Anheuser Busch	Upflow anaerobic sludge blanket (x4)	1991
Beaver Dam Wisconsin (City of), Kraft Foods	Upflow anaerobic sludge blanket	2011
City Brewing Company, Gundersen Lutheran	Upflow anaerobic sludge blanket	1982
General Mills	Complete mix	1997
JBS, Green Bay Inc.	Anaerobic contact process	1987
Kraft Foods, Inc.	Mobilized film technology	2007
McCleary, Inc. (parent co.), Axium Foods	Anaerobic contact process	1991
Monmouth (City of), Farmland Foods	Covered lagoon	Lagoon late 1970s, Cover 2000
Saputo Cheese USA, Inc.	Mixed heated covered lagoon	1991, upgraded 2009
Seneca Foods Corporation	Complete mix	2007
SunOpta Ingredients, Inc.	Upflow anaerobic sludge blanket	1990

Table 2 – Food industry facilities with digester types and install years

For this group, some of these systems were installed as long ago as the late 1970s, and some are only expected to become operational in 2011.

The digester types in the casebook are listed in Table 3 matched with the food industry types that are using them.

Digester Type	**Food Industry Types**
ACP	Beef processing, sugar refinery, snack foods
Complete mix	Refrigerated dough products, peas and corn
Covered lagoon	Pork processing
Mixed heated covered lagoon	Cheese products and acid whey
Mobilized film technology	Cheese production
UASB	Brewery, oat fiber processing, cheese production

Table 3 – Digester types by food industries using them

Waste streams across these industries are quite diverse, and biogas production potential varies as well. Therefore, companies have looked at a number of different options for using the biogas. Table 4 summarizes biogas production at these facilities and how it is used.

Company	**Biogas volume composition**	**Utilization**
American Crystal Sugar Company	Volume not available, 65-80% methane, 185,220 mmBtu of biogas produced over process season, variable based on season, frozen beets lose more sugar, start using frozen beets toward middle to extend production cycle	use 53,100 mmBtu direct-fired drum dryers for pulp replacing NG, and flared, no gas trmt needed, newer steam dryer for pulp uses process steam
Anheuser Busch	Volume unavailable, 75-80% methane, compressed and dried prior to use	used in brewing process in boilers for hot water
City of Beaver Dam Wisconsin	(predicted) 250 scfm, 73% methane, 22% CO_2, 5% water/other	CHP, 2 engine generator sets
City Brewing Company, Gundersen Lutheran	100-700 CFM average 170 CFM, (~89mmcf/yr), 60-65% methane. volume and H_2S both highly variable daily-seasonally, scrubbed at Gunderson facility	CHP, some biogas is flared and some is piped to a Gunderson-owned engine gen-set on brewery property, electricity is sold and recovered heat is used for the digester
General Mills	6-10 CFM, ~82% methane, 18% CO_2, very little H_2S	flared and have heat exchanger on side of flare, heat ~20 gal per minute of water

Company	Biogas volume composition	Utilization
JBS, Green Bay Inc.	315 CFM, 70-76% methane, avg 3176.3mcf per week, avg. 697Btu, usually no H_2S, 24-30% CO_2	have project piping it to dedicated boiler for hot water for process heat, use only biogas, it is lead boiler out of 5, on weekends do some flaring because less demand for steam
Kraft Foods, Inc.	Volume unavailable, content unavailable, offsets about 22% of their total annual energy demand	used in boiler (they have a backup boiler for plant stream that uses NG)
McCleary, Inc. Axium Foods	13-16 CFM, methane content highly variable, after changes this summer hope to double or triple biogas production	have been flaring for some years, not enough volume or consistency to use otherwise, but expect design changes this summer to make use of biogas for heating the digester in winter, or CHP
City of Monmouth, Illinois	~238 SCFM/ fairly steady, 70% methane 142mscf per year	flared, exploring energy use options, U.S. DOE Midwest RAC study shows enough production for 1MW engine gen/set, now discussing with vendors to start CHP by 2011
Saputo Cheese USA, Inc.	76 CFM, ~60% methane, volume 100-120,000 CFD, scrubbing with iron sponge scrubber and moisture removal	flared and in boiler/heat exchanger for digester heat
Seneca Foods Corporation	198 CFM, 55-60% methane, 35-40% CO_2, 200-250ppm sulfur, remove moisture before use, 1500-1800 therms/day	use all biogas in boiler and burner, for space heat and process heat, blended with NG
SunOpta Ingredients, Inc.	100-300 SCFM, 53-58% methane, ~35-40% CO_2, 200-500 ppm H_2S, O_2 0-0.5%, excludes N	Scrubbing and dehumidifying, compressing and use for facility process heat, to heat water, flare excess and downtime per MN DPR

Table 4 - Biogas characteristics and use

Anaerobic digester systems allow companies to pre-treat their high strength wastewaters providing benefits under two scenarios:

- enable cost-effective on-site treatment with their other systems, or
- reduce costs and/or risk of non-compliance with their discharge permits or municipal treatment plant (MTP) agreements.

The roles anaerobic digesters serve for the profiled companies are listed in Table 5.

Company, Facility Name	**Digester Role**
American Crystal Sugar Company, East Grand Forks Facility	Stage of on-site treatment
Anheuser Busch, Baldwinsville Facility	Stage of on-site treatment
City of Beaver Dam, Beaver Dam MTP	Pre-treatment ahead of MTP
City Brewing Company, LLC, Gundersen Lutheran	Pre-treatment ahead of MTP
General Mills, New Albany Production Facility	Pre-treatment ahead of MTP
JBS, Green Bay Inc.	Pre-treatment ahead of MTP
Kraft Foods, Inc., Lowville Facility	Pre-treatment ahead of MTP
McCleary, Inc., Axium Foods	Stage of on-site treatment
City of Monmouth, North Pretreatment Plant	Pre-treatment ahead of MTP
Saputo Cheese USA, Inc., Waupun Facility	Stage of on-site treatment
Seneca Foods Corporation, Montgomery Facility	Stage of on-site treatment
SunOpta Ingredients, Inc., Cambridge Facility	Pre-treatment ahead of MTP

Table 5 - Digester roles at profiled facilities

AMERICAN CRYSTAL SUGAR COMPANY EAST GRAND FORKS FACILITY, EAST GRAND FORKS, MINNESOTA

SUMMARY TABLE

Facility Name:	East Grand Forks Facility	**Location:**	East Grand Forks, Minnesota
Food Products:	Sugar	**Site Employees:**	303 in season, 228 all year
Digester Type:	Anaerobic contact process	**Year Installed:**	1979
Digester Role:	Primary COD removal prior to aerobic activated sludge treatment and discharge		
Digester Design:	AB Sorigona, Sweden		
Biogas Use:	Direct fired drum dryers for beet pulp and flared		
Make and capacity	Old NG fired dryers converted from coal, Stearns Roger dryers		
PM Provider:	Stearns Roger		
Ownership Model:	Company owns the digester as part of overall wastewater treatment system		

Figure 6 - American Crystal Sugar Company East Grand Forks Facility. Photo courtesy of American Crystal Sugar Company.

FACILITY BACKGROUND

The American Crystal Sugar Company's East Grand Forks facility, shown in Figure 6, processes sugar beets into refined sugar. They process fresh beets for roughly the first half of their 250 day production cycle. They begin processing frozen beets about midway through as a means of extending their sugar production period. The characteristics of fresh versus frozen beets provide some seasonal variability to their wastewater composition. The high strength and volume wastewater during production season led them to anaerobic digestion as logical choice. They also recognized that they had ample waste heat from their current processes to heat a digester system while using minimal additional fuel.

Their sugar production operation creates 750,000 gallons of wastewater for treatment per day, consisting of the water that transports and washes the beets, and settles mud out. The facility's wastewater is stronger when they are processing frozen beets (i.e., second half of their production season), which lose more sugar than fresh beets do during processing.

DIGESTER

The East Grand Forks facility had an anaerobic contact process (ACP) digester system installed in 1979. Anaerobic digestion was needed because of the high strength of their wastewater during production season. Their wastewater treatment process was installed as a multi-stage system dubbed ANAMET for anaerobic-aerobic-methane, by AB Sorigona, of Staffanstorp, Sweden. It includes both the ACP and an activated sludge aerobic system for polishing. The ACP digester takes out about 95 percent of the COD, and the activated sludge takes care of the rest. They store their effluent, prior to treatment in the ACP, in a covered lagoon which also generates some biogas. This biogas is captured and joined with the main digester biogas production. Since installation of the ANAMET system, they have added a different clarifier and a pre-acidification tank. Nearly all the heat for the digester is provided as waste heat from production processes. The HRT for this system is five to seven days. Treated effluent is stored in open ponds prior to discharge.

OUTPUTS AND USES

The digester produces an estimated 185,200 mmBtu of biogas containing between 65 and 80 percent methane. The biogas does not require treatment prior to use and is co-fired with natural gas in direct-fired drum dryers for pulp. They estimate about 53,100 mmBtu of biogas is used per year replacing an equivalent amount of natural gas. The dryers are several decades old and were originally fueled with coal.

HISTORY AND COMMENTS

Beyond the digester, the company has taken more steps to control odors. They put in additional clarification and recovery of anaerobic sludge which more than doubled their treatment capacity. The return of anaerobic sludge to the digester allows for faster processing of the wastewater. They installed as pretreatment a 10.5 million gallon covered pond to limit odors neighbors might detect. This pond also generates biogas which they collect and combine with biogas from the digester. They now heat the covered pond using waste heat and steam injection. They also put in a pre-acidification tank to manage acidification step of anaerobic treatment.

Wastewater engineer Sheldon Seaborn says the company feels anaerobic digestion is the most economical way to treat large volumes of high strength wastes. They like the contact process because it has higher retention times. Another benefit of this process is its resistance to scaling which could be a problem because they use lime in their flume process.

SOURCES

Sheldon Seaborn, American Crystal Sugar Company
Scott Knowles, Minnesota Pollution Control Agency

ANHEUSER BUSCH BALDWINSVILLE BREWERY, BALDWINSVILLE, NEW YORK

SUMMARY TABLE

Facility Name:	Anheuser Busch Brewery	**Location:**	Baldwinsville, NY
Food Products:	Beer	**Site Employees:**	~600
Digester Type:	UASB x4	**Year Installed:**	1991
Digester Role:	Pretreatment prior to further on-site treatment		
Digester Design:	Biothane		
Biogas Use:	Brewery process heat		
Prime Mover:	Package boilers, ~100,000 pounds per hour		
Make and capacity	Babcock and Wilcox		
Ownership Model:	Company owns all		

Figure 7 - Anheuser Busch Baldwinsville Facility. Photo courtesy of Anheuser Busch.

FACILITY BACKGROUND

Anheuser Busch (AB) is the world's largest beer brewer. The company has facilities in 23 countries worldwide. Production at the Baldwinsville, New York facility, shown in Figure 7 above, averages more than 7 million barrels per year. They produce about 1.5 million gallons per day of high strength (BOD) and low nutrient wastewater from the brewing process and other washing operations. This wastewater has average concentrations of 1,000 mg/l of total solids, 5,500 mg/l of COD, and 600 mg/l of total volatile solids, and fluctuates in volume with higher production during summer. In the early 1990s, they were looking for more efficient and effective options than their current aerobic treatment system for treating this waste stream. The company also has pursued a number of environmental initiatives aimed at reducing their production carbon footprint, conserving energy and water while improving the efficiency of their operations. These changes have allowed AB to reduce the electricity needed for treatment by 60 percent over the last 20 years.

DIGESTER

In 1991 they had four Biothane upflow anaerobic sludge blanket (UASB) digesters installed as pretreatment prior to their other onsite treatments. A conceptual schematic of how Biothane UASB systems work is shown in Figure 8 below. UASB systems force wastewater upward through a zone of suspended sludge granules composed of anaerobic microorganisms. The flow of wastewater allows the bacteria to have contact with the wastewater and convert COD/BOD into biogas. UASB digesters are designed to provide high rate treatment, and the hydraulic residence time of wastewater in the Baldwinsville digesters is about six hours.

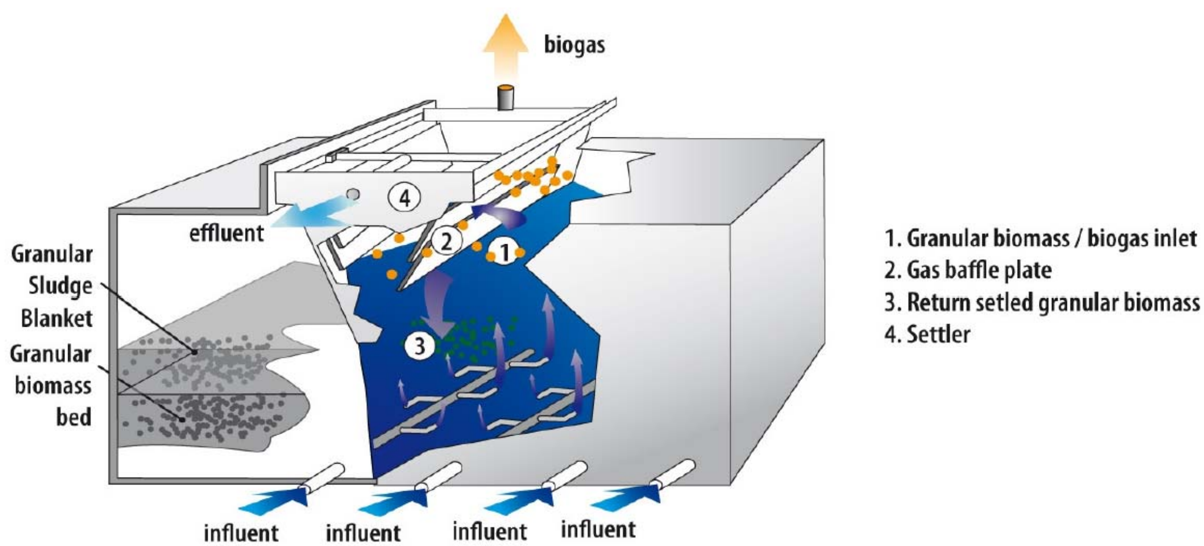

Figure 8 - UASB Concept Schematic. Graphic courtesy of Richard Mattocks, Biothane, Veolia Water, Inc.

The digesters are used or idled based on production levels. The digesters take the process and cleaning wastewater and provide a dramatic reduction in BOD. Since startup, the operators have managed the system so that it has become acclimated at lower temperature (down to 70 degrees F), allowing them to completely eliminate use of natural gas for heating, even in the coldest months, while still removing 97 percent of the influent SCOD. To compensate for a well known lack of nutrients in brewery wastewater, they add nitrogen in the form of urea to improve digestion efficiency.

AB reports no major problems with their digester system – all results from replacing the activated sludge system with digesters were positive. The UASB system was chosen because it is a very stable process. Addition of the UASB digesters resulted in decreased biosolids production and lower disposal costs for the facility. The digesters have very low space requirement and high volumetric loading rates with low energy requirements. They sometimes shut down a digester because of production variation, and have found that when dormant the bacteria are very stable over time. They can re-start one of their digesters in 48 hours to respond to increased production. Production at the brewery has a large need for heat providing a ready use for the methane gas produced.

OUTPUTS AND USES

The effluent from the digester has greatly reduced COD levels and can be sent to their next stage of on-site treatment. The digestion process produces about 5.9 cubic feet of methane per pound of COD destroyed. The biogas contains 75-80 percent methane. It is compressed with positive displacement rotary vane compressors, and dried prior to use. It fuels Babcock and Wilcox package boilers to provide hot water for brewing. AB estimates that biogas recovered from their digestion process replaces more than 15 percent of the brewery's fuel needs for production. They also sell some of the biomass from the digester as inoculant for new digester starts.

Further down the treatment system line, the solids from their primary and secondary clarifiers are treated aerobically, stabilized and used for soil amendments, to help reclaim salt marshes, and for growing willow trees.

HISTORY AND COMMENTS

The brewery found other benefits from adding the digesters. From 1990-1993 electric power used for wastewater treatment went from 27million kWh to 18 million kWh annually due directly to addition of UASB. The BOD removal rate they achieved enabled them to remove one aeration basin from service, shutting down 12 submersible jet mixing pumps and reduced the aerobic oxygen demand load on the other basin. Addition of UASB also increased the wastewater treatment capacity at the facility by over 300 percent. These benefits, along with the significant reduction in their fuel purchases, are why 10 of their 12 production facilities use some form of "bio-energy recovery system" replacing 300 million Btus per day of fossil fuel energy with renewable energy. Energy recovery is part of an overall corporate strategy to reduce the carbon footprint and water use in their production.

The facilities manager Bob Cleeton noted that odor control is a priority with the AD system. They have experimented over the years with systems to control odors associated with processing their wastewater. They are currently using a wood-chip biofilter and a scrubber to clean headspace gases from the digester.

SOURCES

Bob Cleeton, Anheuser Busch

CITY OF BEAVER DAM MTP AND KRAFT FOODS, BEAVER DAM, WISCONSIN

SUMMARY TABLE

Facility Name:	Beaver Dam Municipal Treatment Plant	**Location:**	Beaver Dam, Wisconsin
Food Products:	Cream cheese products	**Site Employees:**	Not available
Digester Type:	UASB	**Year Installed:**	Under construction, expected to be operational in 2011
Digester Role:	Pre-treatment of Kraft Philadelphia Cream Cheese production facility wastewater prior to treatment at MTP		
Digester Design:	Siemens/Paques design, Applied Technologies, Inc. installation		
Biogas Use:	Combined heat and power		
Prime Mover:	Two engine generator sets		
Make and capacity	Caterpillar G3508, 394kW each (total 788kW)		
Ownership Model:	Publicly owned pretreatment facility funded partly through industry fees		

FACILITY BACKGROUND

The City of Beaver Dam is located in south-central Wisconsin. A significant employer in the city is the Kraft Foods plant, which is the longest continuously operating cream cheese plant in the United States. The Phenix Cheese Company began making Philadelphia Cream Cheese in Beaver Dam in 1922, with Kraft Foods merging with the Phenix Cheese Company and purchasing the Beaver Dam Plant in 1928. A byproduct of cream cheese making, acid whey, has also been produced for that long. The acid whey was being condensed and sold for animal feed until 1984, when energy prices made that option uneconomical. Since then, the acid whey has been land spread. Other alternatives for acid whey were explored and about 10 years ago, Kraft put together a “World-Wide Whey” team to look into the feasibility of those alternatives. The most promising was anaerobic digestion, which produces a methane/carbon dioxide gas (biogas) that can be burned in a boiler or an engine. Trials were run at several New York facilities (see the other case study in this report on Kraft Foods Lowville facility) which resulted in several projects to permanently install anaerobic digesters.

A few years ago, the City of Beaver Dam began looking at upgrading their waste water treatment system and started talking with Kraft about the impact of pretreatment options that Kraft was exploring. The city was eligible for some financial assistance that would help make a digester option more cost-effective if it was a part of the city’s waste treatment facility. That led to an innovative public/private partnership agreement between the city and the Kraft plant. Bolstered by Kraft’s experiences with the anaerobic digester systems at their NY plants, the city decided to build a pretreatment facility for the acid whey and wastewater from the Kraft plant. Kraft Foods agreed to help pay for the pretreatment facility through higher wastewater processing fees including treatment of the new acid whey stream. The Kraft plant produces more than 100,000 gallons per day of acid whey which will be pumped to the city’s waste treatment plant along with the 150,000 gallons per day of wastewater.

Figure 9 - Beaver Dam UASB Digester during construction. Photo courtesy of Dennis Totzke, Applied Technologies, Inc.

DIGESTER

The city decided to build an upflow anaerobic sludge blanket (UASB) digester to treat acid whey and wastewater from the Kraft plant prior to sending it to the primary public wastewater treatment plant. The anaerobic digester, a Siemens Pacques design installed by Applied Technologies Inc., shown in Figure 9, is under construction and is expected to be operational in 2011. The digester is expected to have an average HRT of 2.9 days, and operate in the mesophilic temperature range. Since the Kraft Foods plant only operates five days out of the week, a surge tank is being installed upstream of the digester to help even out the flow of the system.

OUTPUTS AND USES

Once operational, the digester is expected to produce an average of 250 standard cubic feet per minute (SCFM) of biogas. The biogas is expected to have a composition of 73 percent methane, 22 percent CO_2, and 5 percent water/other. The biogas will be used as fuel for two Caterpillar G3508 engine generator sets with an electrical output capacity of 788 kW (total). Figure 10 shows the engine generator sets being installed at the Beaver Dam facility. All electricity generated will be sold back to Alliant Energy under a sell-all contract. The city expects to get as much as $200,000 per year in revenue from energy sales. The heat from the engines' after-coolers will be used to heat the influent wastewater. The heat recovered from the engine water jackets and exhaust will be used to heat the digester.

Another revenue stream for the city is expected to be the sludge from the digester tank. The city intends to sell sludge for inoculant for other digesters at 20-80 cents per gallon.

Figure 10 - Engine generator sets at Beaver Dam. Photo courtesy of Wayne Karlovich, Applied Technologies, Inc.

HISTORY AND COMMENTS

This facility was under construction at the time this report was written. The convergence of Kraft's efforts to find more sustainable ways of managing acid whey, the City of Beaver Dam's need for a wastewater treatment facility upgrade, and the availability of financial assistance for bioenergy projects through a Wisconsin Department of Natural Resources American Recovery and Reinvestment Act grant and low interest loan, helped make this project happen. The city notes that they could add other companies' waste streams into the pretreatment system in the future. The city and Kraft predict multiple benefits from the partnership they have developed.

Having the ability to accept and treat Kraft's acid whey means Kraft can move out of land-spreading on agricultural lands and the associated costs and transportation energy used. The price Kraft is paying for pretreatment is equivalent to the cost they incurred land-spreading their acid whey. The agreement with the city and available financial aid meant the project resulted in savings for everyone involved. The city predicts annual savings of $300,000, and the project is nearly cost neutral for Beaver Dam residents.

SOURCES

Don Quarford – City of Beaver Dam
Bob Koneck – Kraft Foods, Inc.
Dennis Totzke and Wayne Karlovich – Applied Technologies, Inc.

CITY BREWING COMPANY LLC AND GUNDERSEN LUTHERAN, LA CROSSE, WISCONSIN

SUMMARY TABLE

Facility Name:	City Brewing Company LLC	**Location:**	La Crosse, Wisconsin
Food Products:	Beer and other beverages	**Site Employees:**	500
Digester Type:	Upflow anaerobic sludge blanket	**Year Installed:**	1982
Digester Role:	Pretreatment before city WWTP		
Digester Design:	Biothane		
Biogas Use:	Combined heat and power		
Prime Mover:	Engine generator set		
Make and capacity	GE Jenbacher 633 kW		
Ownership Model:	Gundersen Lutheran owns generation and sells electricity to utility, City Brewing uses heat		

FACILITY BACKGROUND

In the early 1980s, G. Heileman Brewing Company in La Crosse, Wisconsin needed to reduce the strength of their wastewater before sending it to the La Crosse public treatment system. The company installed two digesters that became operational in 1982. The brewery used biogas as boiler fuel, but switched to flaring when they noticed some corrosion in their boiler. City Brewing Company LLC (CBC) bought the brewery facilities and started brewing again in 2001, and has since expanded production to include multiple beer labels and other beverages. Gundersen Lutheran (GL), a La Crosse area health care provider, has launched a plan to have their facilities be “energy independent” by 2014. An employee’s observation of the brewery’s flaring biogas seeded the idea of a partnership for renewable energy generation. The result is an innovative partnership between the companies with mutual benefits.

The brewery produces a daily average of 967,000 gallons of high strength wastewater from product residuals and tank cleanouts. As a contract brewer, the production levels and wastewater volume and composition vary considerably.

DIGESTER

The brewery’s digesters are upflow anaerobic sludge blanket (UASB) systems installed by Biothane in 1982. The primary role of the digesters is to reduce the wastewater strength (i.e., chemical oxygen demanding compounds or COD) prior to discharge to the public wastewater treatment plant. The digesters have a design HRT of 4.4 hours, but in practice the HRT varies due to production-related variations in effluent volume and characteristics. The system has a design flow capacity of 3 million gallons per day, but is operated at between 750,000 and 1.7 million gallons per day. The target operating temperature for the digester is 90 degrees F.

Figure 11 – Gundersen Lutheran energy generation equipment at City Brewing Company. Photo courtesy of Gundersen Lutheran.

Outputs and Uses

The digesters produce on average 170 cubic feet of biogas per minute. This biogas is 60-65 percent methane, with fairly large daily and seasonal variation in hydrogen sulfide (H_2S) content. GL purchased a gas cleanup system to remove H2S from the biogas. They installed a Jenbacher 633 kW engine generator set on CBC property to use about 40 percent of the biogas as fuel. Figure 11 shows the engine container with the engine generator set. The engine generator set generates electricity that is sold to Xcel Energy. Heat is captured from the engine and used to bolster digester heat and may be used to heat a cleaning facility, reducing fossil fuels used and improving operation. Figure 12 shows an overall process flow of the system.

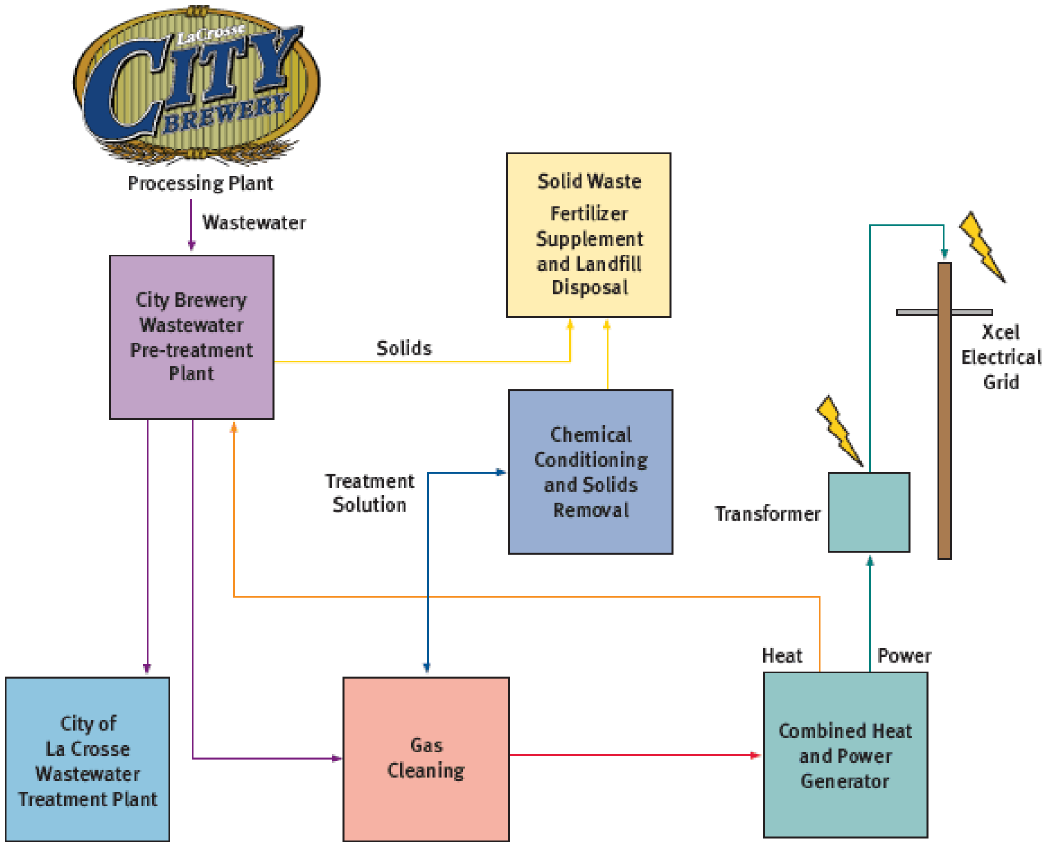

Figure 12 – Process flow chart for Gundersen Lutheran and City Brewing Company. Graphic courtesy of Gundersen Lutheran.

The purple box (upper left) represents the digesters which provide outputs of treated wastewater, biogas and solids. Biogas is sent to the gas cleaning stage then on to the energy generation. Treated wastewater (with strength greatly reduced) is sent on to the city wastewater treatment facility. Solids removed from the wastewater are used as soil amendments and/or landfilled.

HISTORY AND COMMENTS

The brewery's expansion to production of non-beer beverages resulted in some higher-strength wastewater than they have produced historically. The partnership with GL provided a free, renewable heat source enabling improved heating and effectiveness of the digester, especially in the winter. The GL proposal to share heat from their engine allowed CBC to avoid buying new boilers. The owners report that their system handles the variable loadings quite well and adapts quickly without apparent stress. They find the digester a definite cost saver over sending the higher strength stream to the city (i.e., charges from the city would be much higher than their operation and maintenance costs of the digester). CBC reports finding no negatives with their digester and partnership agreement.

GL includes this project as one step in their quest toward energy independence and in lowering energy related costs. They sized the housing at the generation site (i.e., on CBC land) to fit one large engine, but decided on two smaller engines, with one currently installed. They are hoping for about 3 million kW hours of electricity generation from their currently installed equipment. Because of daily and seasonal variation in beverage production, they are currently using about 40 percent of the biogas produced. They are still examining options for using the rest of the biogas (which is currently flared), but options are limited due to the variability in volume. Gas cleaning is necessary due to high H_2S creation when certain beverages are produced.

SOURCES

Corey Zarecki, Gundersen Lutheran
Gerald Clements, City Brewing Company LLC
Biocycle Magazine, December 2009, Vol. 50, No. 12

GENERAL MILLS NEW ALBANY FACILITY, NEW ALBANY, INDIANA

SUMMARY TABLE

Facility Name:	General Mills New Albany Production Facility	**Location:**	New Albany, Indiana
Food Products:	Refrigerated dough products	**Site Employees:**	NA
Digester Type:	Complete mix	**Year Installed:**	1997
Digester Role:	Pretreatment of wastewater prior to sending it to the WWTP		
Digester Design:	Applied Technologies, Inc.		
Biogas Use:	Flared with some heat captured through heat exchanger to make hot water		
Prime Mover:	Flare, heat exchanger		
Make and capacity	NA, heat exchanger on flare creates ~20 gallons of hot water per minute		
Ownership Model:	Company owns all, use some energy on site		

FACILITY BACKGROUND

General Mills facility produces numerous refrigerated dough products. This production also creates 30,000 to 40,000 gallons of wastewater per day from washing various pieces of equipment. The facility produces fairly steadily. When they faced a permit requirement for production wastewater pre-treatment before the public wastewater utility in 1996, they had their environmental group research the options. Anaerobic digestion was identified as the most cost-effective and easy to run.

DIGESTER

General Mills chose to have an Applied Technologies, Inc. digester installed to treat their production wastewater. The digester, operational in 1997, is an above-ground complete mix concrete tank that is part of an overall treatment system at the facility. It operates in the mesophilic temperature range with a target operating temperature of about 96.7 degrees F. The digester is somewhat oversized, with a capacity of closer to 100,000 gallons per day, which leads to the relatively long HRT of about 27 days. Influent entering the digester has approximately 0.1 percent solids, and the contents of the digester have about 1.1 percent solids. The digester retains some sludge to keep the microbe population in the digester high which results in higher solids content in the digester than in the influent. Adjacent to the digester is an odorous air biofilter through which odorous gas is filtered. Figure 13 on the following page shows the digester with the biofilter in the foreground.

An employee monitors and manages the system six days a week for about six hours per day. The digester does not require a full time operator, and it generally runs well unattended. They estimate the digester costs about $70,000 in labor annually, and about that much in chemicals for buffering.

Figure 13 - General Mills Complete Mix Tank Digester. Photo courtesy of Dennis Totzke of ATI.

OUTPUTS AND USES

The New Albany digester produces 6-10 cubic feet of biogas per minute. The biogas has an average methane content of about 82 percent and has very little H_2S. Biogas is sent to a Varec brand flare and heat is captured from the flare with a wrap-around heat exchanger. Heat captured with the flare heat exchanger, installed in 2004, allows the facility to offset some natural gas purchases.

They explored options for using a biogas boiler or electricity generation, but found they did not produce enough biogas for most options. Also, currently available systems do not offer the typical return on investment for capital projects. In similar situations, public partnerships often help overcome this gap.

Effluent from the digester, along with the sanitary waste from the facility, are sent on to the public wastewater treatment plant for treatment.

HISTORY AND COMMENTS

General Mills first considered an anaerobic digester for the facility when their discharge permit to the public treatment plant required some pre-treatment. Their environmental group researched options and found AD to be the most cost effective and easy to run.

The low pH level of their influent has caused some problems. They had a tank lining failure at one point, and also had some galvanized bolts on their surge tank (which feeds into the digester) that corroded and needed to be replaced. The system also has normal wear and tear including periodic pump replacement.

They choose to continue to use steel mixing propellers because it is cheaper to replace them every few years than to get corrosion resistant propellers.

The first year was a learning exercise according to Facility Engineer, Ted Iverson. They had to make some flow rate modifications to get the right amount of flow to keep the bacteria colony happy. He points out that it took three to five years of trial and error to get the system working optimally. The system has been fairly dependable once they figured out what to do. He says he feels it's a good system, and would recommend it again.

SOURCES

Ted Iverson and Jon Russett, General Mills, Inc.

JBS GREEN BAY, GREEN BAY, WISCONSIN

SUMMARY TABLE

Facility Name:	JBS Green Bay	**Location:**	Green Bay, Wisconsin
Food Products:	Beef and related products	**Site Employees:**	1,300
Digester Type:	Anaerobic contact reactor	**Year Installed:**	Operational in early 1987
Digester Role:	Pretreatment before WWTP		
Digester Design:	AC Biotechnics		
Biogas Use:	Piped to dedicated boiler for hot water, process heat and steam production		
Prime Mover:	Boiler		
Make and capacity	Cleaver Brooks, 24.56 mmBtu/hour		
Ownership Model:	Company owns all, uses biogas heat for on-site processes		

Figure 14 - JBS Green Bay product distribution facility. Photo courtesy of JBS Green Bay.

FACILITY BACKGROUND

JBS Green Bay, Inc. (JBS-GB), formerly known as Packerland Packing, is a beef production facility in Green Bay, Wisconsin. Figure 14 shows the JBS-GB product distribution facility. The facility discharges production wastewater to the Green Bay Metropolitan Sewerage District (GBMSD) for treatment. The company explored pretreatment options in 1985 to help reduce wastewater surcharges. Anaerobic digestion stood out as an effective pretreatment technology that could also generate biogas for beneficial use.

Wastewater operators closely monitor digester functions and are certified under the State of Wisconsin Wastewater Operators Certification Program. The facility generates about 1.1 million gallons of high strength wastewater per day that is high in biochemical oxygen demanding compounds (BOD) and fats, oils and grease (FOG). This is primarily from the harvesting of approximately 2,200 head of cattle per day. The facility typically uses more water in the summer and has an onsite rendering operation.

JBS-GB maintains and continuously improves environmental performance by managing environmental affairs with an Environmental Management System (EMS) certified in conformance with International Standards Organization (ISO) 14001. JBS-GB will be recognized by The Wisconsin Sustainable Business Council for participating in the "Green Masters" program. JBS-GB has multiple American Meat Institute awards for maintaining an elevated level of environmental performance and compliance.

DIGESTER

Packerland Packing, the original owner, installed an anaerobic contact process (ACP) digester in 1986, based on a design by AC Biotechnics. The 2.4 million gallon digester, which became operational in early 1987, operates in the mesophilic temperature range, and has an HRT of 1.95 to 2.3 days. The system has a longer solids retention time (SRT) due in part to the return of biomass to the digester. The ACP digester is designed for an influent solids content of one percent, and maintains a solids level within the digester of four to 10 percent. Figure 15 shows the ACP digester and smaller equalization tank.

Figure 15 - JBS-Green Bay anaerobic contact process digester and equalization tank. Photo courtesy of JBS Green Bay.

OUTPUTS AND USES

The digester produces an average of 3,176,000 cubic feet of biogas per week, with an average heating value of 725 BTUs per cubic foot. The biogas has a methane content of 70 to 76 percent, and a CO_2 content of 24 to 30 percent.

Biogas is piped to a dedicated Cleaver Brooks 24.56 mmBtu boiler, installed in 2004. This boiler produces steam for facility operations. This boiler is dedicated to biogas use and is one of five boilers in the plant. JBS-GB uses 92-95 percent of the biogas they produce and only flares biogas on weekends when there is less demand for steam. Figure 16 shows the biogas boiler and operator.

Effluent from the digester is further treated in a secondary clarifier and discharged to the GBMSD for final treatment. Removed solids from the digester are land applied. These solids have high nutrient value and have been delivered to other digesters for inoculation.

Figure 16 - JBS Green Bay dedicated biogas boiler and operator Paul Wandrey. Photo courtesy of JBS Green Bay.

The company continues to explore beneficial reuse options for digester solids. JBS-GB is an active participant in the Brown County Waste Transformation Initiative (WTI), an organization that is actively seeking solutions for the transformation of animal waste and other organic residuals into beneficially reusable products. The WTI initiative also seeks to reduce non-point source pollution typically associated with agricultural runoff.

HISTORY AND COMMENTS

Anaerobic digestion has allowed JBS-GB to control treatment costs and generate biogas for beneficial use. According to Environmental Manager Larry Collins, the use of biogas to offset natural gas use saves the company \$10,000 to \$13,000 per week in operating costs. The system significantly reduces the JBS-GB environmental impact while simultaneously contributing to environmental sustainability efforts.

JBS-GB manages the digester six days per week - three shifts per-day. The wastewater treatment collection system is monitored for key performance indicators and concentrations of chemicals that could upset the system. Mr. Collins noted that certain food safety chemicals containing quaternary ammonium compounds and oxidizers can create upset conditions in the digester by disrupting anaerobic microbial activity. This can inhibit digestion until the microbes repopulate. Working in proximity to these cleaning chemicals is a necessity because of the JBS-GB emphasis on food safety.

Anaerobic digestion has proven to be an asset to JBS-GB operations. In 2005, the company won the Wisconsin Governor's Award for Excellence in Environmental Performance for beneficial reuse of biogas.

SOURCES

Larry Collins, JBS Green Bay[2]

[2] Larry Collins also cited the following sources he relied on to provide information for this study: American Meat Institute, NSF Strategic Registrations, Wisconsin Focus on Energy, Wisconsin Sustainable Business Council, Federation of Environmental Technologists, and facility records.

KRAFT FOODS LOWVILLE FACILITY, LOWVILLE, NEW YORK

SUMMARY TABLE

Facility Name:	Kraft Foods Lowville	**Location:**	Lowville, New York
Food Products:	Cream cheese and cream cheese spreads	**Site Employees:**	330
Digester Type:	Mobilized film technology, pulsed fluidized bed	**Year Installed:**	2007 startup
Digester Role:	Pretreatment prior to discharge to WWTP		
Digester Design:	Ecovation, a subsidiary of Ecolab		
Biogas Use:	Process heat, steam		
Prime Mover:	Older boiler		
Make and capacity	NA		
Ownership Model:	Treatment system is leased from design company, Ecovation, who owns and operates it for Kraft		

Figure 17 - Kraft Lowville facility. Photo courtesy of Kraft Foods

FACILITY BACKGROUND

The Kraft Foods production facility in Lowville, New York, shown in Figure 17, produces cream cheese and cream cheese spreads. This facility is the largest producer of Philadelphia Brand Cream Cheese® in the world. The primary byproduct of cream cheese production is acid whey. After years of working with alternative disposal methods including concentration and distribution as a component of livestock feed, and land application, the Lowville production facility was the first Kraft Plant in the US to adopt anaerobic digestion as recommended by their own whey team looking at best practices across the cheese and dairy category. Switching to a disposal option that does not involve transporting whey off site improved their carbon footprint. In 2005, Kraft Foods set company goals to reduce energy use by 25 percent and energy-related carbon emissions by 25 percent, by 2011. To this end, the facility has also undergone energy efficient lighting upgrades, water conservation, and an aggressive recycling program.

DIGESTER

In 2006, Kraft Foods agreed to lease a treatment system from Ecovation and signed an agreement to have them operate it on their property. Ecovation, since acquired by Ecolab, installed one of their patented mobilized film technology (MFT) pulsed fluidized bed digesters at the Kraft Foods facility, and it became operational in 2007. The digester processes all the acid whey produced by the facility (volume not disclosed), eliminating their need for land-spreading it. The digester has a one-to–six- day HRT, and operates in the mesophilic temperature range. Figure 18 shows a schematic of an MFT system.

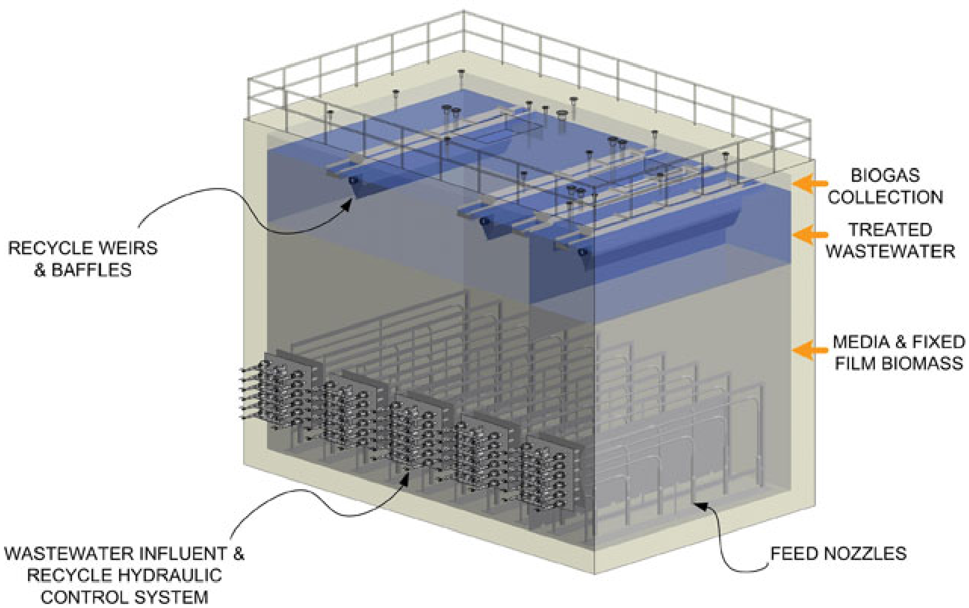

Figure 18 - MFT Digester Schematic. Graphic courtesy of Ecolab.

OUTPUTS AND USES

The biogas from the digester is used in an older boiler to produce steam for Kraft's production processes. This offsets about 22 percent of their total annual energy demand. Effluent from the digester is sent to the public wastewater treatment plant along with process wastewater from the facility. High nutrient sludge is also produced, and Ecolab is currently working with the New York State Department of Environmental Conservation to evaluate using it blended with manure as fertilizer for farms.

HISTORY AND COMMENTS

The digester lease and agreement with Ecovation was part of a larger investment in the facility. Kraft Foods Lowville plant manager Darin Zehr indicated the digester option was a cost-effective way to sustainably treat their wastewater. Other than the obvious benefit of being able to reduce natural gas purchases, they have the added benefit of making their own renewable energy. Zehr notes that this investment has been a springboard to other sustainability efforts by the company toward the goal of reducing their overall carbon footprint.

Zehr notes that startup of the digester in 2007 presented some challenges. The facility has variable wastewater production which required some adaptation since digesters tend to like steady consistent flows. The digester has been operating stably as of 2010.

SOURCES

Darin Zehr, Kraft Foods

MCCLEARY, INC., AXIUM FOODS SOUTH BELOIT FACILITY, SOUTH BELOIT, ILLINOIS

SUMMARY TABLE

Facility Name:	McCleary Inc., Axium Foods	**Location:**	South Beloit, Illinois
Food Products:	Snack foods	**Site Employees:**	150
Digester Type:	Anaerobic contact process	**Year Installed:**	1991
Digester Role:	Treatment of high strength food processing wastewater as part of overall treatment system prior to land application		
Digester Design:	Applied Technologies, Inc.		
Biogas Use:	Currently flared, but expect operational changes allowing consideration of CHP or heat only applications		
Prime Mover:	Flare		
Make and capacity	NA		
Ownership Model:	Company owns all		

FACILITY BACKGROUND

Axium Foods, owned by McCleary Inc., is a primarily corn-based snack food producer with a production facility in South Beloit, Illinois. The facility is in production all year, with some demand-driven seasonal variation. Daily production creates an average of more than 100,000 gallons per day of wastewater requiring treatment. The City of South Beloit was out of capacity and when alternatives were discussed, the company founder saw adding an anaerobic digester system as the preferred option.

Figure 19 - Axium Foods Digester. Photo courtesy of Axium Foods.

DIGESTER

Axium Foods has used anaerobic digestion at this facility as part of their production wastewater treatment regime for nearly twenty years. Their system, installed by Applied Technologies, Inc. (ATI) and operational in 1991, is an anaerobic contact process (ACP) digester. The digester is pictured in Figure 19. ACP systems have a reactor containing microbial biomass into which the liquid to be treated is injected. They also have a second vessel after the main digester in which solids are settled out for reintroduction to the digester (i.e., return of activated sludge). Contact with microbes is achieved by thorough mixing in the main digester tank. The digester operates in the mesophilic range with a target operating temperature of 96 degrees F. The digester has an average hydraulic residence time of about five days, but it varies with production levels.

The digester currently removes larger solids and reduces COD, prior to wastewater entering a clarifier and an aerobic sequencing batch reactor system. Activated sludge is returned to the digester to help maintain biological communities. The digester runs 24/7 and is largely automated. They employ one full-time operator and a mechanic for troubleshooting.

OUTPUTS AND USES

Biogas volume has been low and of variable quality historically, precluding energy generation options and leading to biogas disposal via use of an onsite flare. The flare is pictured in Figure 20.

Figure 20 - Biogas flare. Photo courtesy of Axium Foods.

They expect to make operational changes to send higher energy density residues through the digester greatly increasing the biogas production and making other options for biogas use worth reconsidering. They plan to add several levels of filtration in the summer of 2010, including pre-filtration, ultra-filtration and nano-filtration to concentrate the solids. Filtered water will have a 99.7 percent reduction in total suspended solids, and 99.2 percent reduction in BOD, leaving it clean enough for direct discharge into the river. The filtration systems will be before the digester, making the influent to the digester more concentrated, giving it a higher energy value and allowing longer residence times in the digester. Company president Jerry Stokely says they estimate their biogas production could double or triple. With sufficient biogas production, they will look into options for combined heat and power or heat only to provide digester heat in the winter.

They have not yet identified alternative uses for sludge due to lack of a practical means of drying it down. Mr. Stokely suggests it may have value as a fertilizer or other byproduct and hopes to put more resources into exploring these options in the future.

HISTORY AND COMMENTS

The digester system at Axium Foods had some issues early on with operational practices. They had many differing opinions on how the side entry mixers should be run and there was little experience with an ACP system at that time. They debated whether it should operate in batch or continuous throughput mode. They tried shutting off mixers for a half day to let it “cook” which did not work because you need to move the microbes to the feedstock. They also tried running the mixers all day which caused them to fail. Eventually they replaced the side mixers with a jet system centrifugal pump that pulls water out of the sides of the reactor, increases pressure and jets out into the center of the reactor. ATI helped with this “very aggressive” mixing system and it proved the key to improved performance.

SOURCES

Jerry Stokely, McCleary, Inc., Axium Foods
Dennis Totzke, Applied Technologies, Inc.
Cliff Haefke, University of Illinois – Chicago, Energy Resources Center

CITY OF MONMOUTH NORTH PRETREATMENT PLANT, MONMOUTH, ILLINOIS

SUMMARY TABLE

Facility Name:	Monmouth North Pretreatment Plant	**Location:**	Monmouth, Illinois
Food Products:	Wastewater from hog slaughter plant	**Site Employees:**	5 at treatment plant, 1500 at hog facility
Digester Type:	Covered lagoon	**Year Installed:**	Cover installed in 2000, lagoon operated uncovered before that
Digester Role:	Pretreatment before municipal wastewater treatment plant		
Digester Design:	Plastic Fusion Fabricators installed the cover, Alley and Associates designed the cover		
Biogas Use:	Currently flared, considering CHP		
Prime Mover:	(expected) engine generator set		
Make and capacity	NA, up to 1059kW		
Ownership Model:	City owns facilities, has 10 year contract with source for pretreatment		

FACILITY BACKGROUND

The City of Monmouth, Illinois, has provided pretreatment services for livestock operations for more than 20 years. The pretreatment facility is a lagoon located adjacent to the municipal wastewater treatment plant which up until 2000 has been uncovered. The city was receiving complaints about odors coming from the lagoon leading them to look at other options. The food industry source feeding the lagoon is Farmland Foods, a local hog processing operation which produces about 1 million gallons of high strength wastewater per day. The Monmouth pretreatment facility processes only the food processing waste from Farmland Foods, and employs five people.

DIGESTER

After receiving odor complaints regarding their open clay-lined lagoon, the City of Monmouth had a high density polyethylene cover and gas handling equipment installed in 2000. The cover was designed by Alley and Associates, and was installed by Plastic Fusion Fabricators (PFF). The covered lagoon is shown in Figure 21. The lagoon is unmixed and unheated, but receives hog facility effluent that is already sufficiently heated to keep the lagoon between 80 and 90 degrees F even through winter months. The city has been flaring biogas since installation. However, Monmouth commissioned a study by the University of Illinois at Chicago, Energy Resources Center (ERC, a partial funder of this project) to explore energy use options for the biogas they create.[3]

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[3]Haefke, Cliff, "Biogas Utilization Feasibility Study for the City of Monmouth," U.S. DOE Clean Energy Application Center (U.S. DOE Midwest RAC – a partial funder of this project), May 2009.

Figure 21 - Monmouth North Pretreatment Plant Covered Lagoon. Photo courtesy of Cliff Haefke, US DOE Midwest RAC.

OUTPUTS AND USES

The DOE Midwest RAC study found that biogas produced is sufficient to fuel an engine generator set of slightly more than 1,000 kW. The digester produces on average about 238 standard cubic feet per minute (scfm) of biogas, with a composition of over 70 percent methane, and about 1.7 percent H_2S. Because of the relatively high levels of H_2S produced, the study recommended gas cleanup prior to combustion in an engine. The study also found the quickest simple payback (between 8 and 9 years) involved electricity generation with no heat recovery since the effluent entering the covered lagoon was already heated and the lagoon already maintained a temperature between 80 and 90 degrees F. Further CHP opportunities utilizing the recovered heat may still include increased heating of the lagoon or supplying heat to the nearby city wastewater treatment facility. The City of Monmouth is now pursuing options for energy generation. Solids containing the nutrients phosphorus, nitrogen, and sulfur are applied to nearby farmlands as fertilizer.

HISTORY AND COMMENTS

The lagoon was first installed in 1963, and was modified in the 1970's and again in 1992 by Crawford, Murphy & Tilly. These modifications included expanding the treatment volume and installing a clay lining. The lagoon cover, installed in 2000, was first considered as a means to reduce odors and improve the quality of life for the surrounding area. Although at the time of interview for this casebook (i.e., summer-fall 2010) the generation equipment was not yet installed and therefore there were no recordable benefits from energy generation, they have experienced other significant benefits. First, the covered lagoon is very effective in its function as a primary treatment unit. Despite the fact that it is unheated and unmixed, facilities manager Andy Jackson reports an average BOD removal efficiency of 85-90 percent.

Second, they have experienced a large reduction in the odors from the lagoon improving the quality of life on and in the neighborhood of the lagoon.

Figure 22 - Monmouth North Pretreatment Plant Gas Handling Equipment, courtesy of Cliff Haefke, US DOE Midwest RAC.

Mr. Jackson noted that the lagoon cover and electronics require the most attention. The 100 millimeter HDPE cover has had minor patching repairs done on it since 2000. The gas collection equipment has had some corrosion (evident in Figure 22 above) due to the high level of sulfur in the biogas. They were not scrubbing the biogas at the time of interview, but the U.S. DOE Midwest RAC report recommends scrubbing if energy generation is installed. Gas conditioning equipment could cost an estimated 50-70 percent of the total costs for the energy generation addition. Phosphorus and other nutrients removed from the waste are concentrated in the digested solids cleaned out of the lagoon. They expect to continue applying these to area farmland as a soil amendment.

SOURCES

Eric Hanson and Andy Jackson – City of Monmouth
Floyd Schanbacher – Ohio State University
Cliff Haefke – University of Illinois, Chicago, Energy Resources Center, U.S. DOE Midwest RAC

SAPUTO CHEESE USA, INC WAUPUN FACILITY, WAUPUN, WISCONSIN

SUMMARY TABLE

Facility Name:	Saputo Cheese USA, Inc. Waupun Facility	**Location:**	Waupun, Wisconsin
Food Products:	Cheese and whey products	**Site Employees:**	Approximately 375
Digester Type:	Mixed, heated covered lagoon	**Year Installed:**	1991, 2009
Digester Role:	Reduce COD and BOD before on-site aerobic treatment, cleaned to dischargeable levels		
Digester Design:	Procorp, Inc. (for both original and remodeled)		
Biogas Use:	Digester heat and flared		
Prime Mover:	boiler and heat exchanger		
Make and capacity	Walker boiler		
Ownership Model:	Company owns all, heat used on site		

FACILITY BACKGROUND

Saputo Cheese USA Inc. bought the former Alto Dairy Cooperative in Waupun, Wisconsin in 2008. The company produces several types of cheese and whey products and employs approximately 375 people. Production creates two waste streams. The stream with all high-strength wastewater from the whey plant and wash-water from the mixers amounts to 25,000 to 40,000 gallons per day. An additional 150-200,000 gallons of diverted wastewater also goes to the digester. The facility wastewater does not have significant seasonal variation. This high strength wastewater has TSS levels as high as 10,000ppm, and 37,000 mg/l COD. Lower strength production wastewater circumvents the digester going directly to the aerobic stage for treatment.

DIGESTER

The Alto Dairy Cooperative chose to have Procorp, Inc. install a heated mixed covered lagoon in 1991. In 2009, Saputo Cheese USA, Inc. had Procorp upgrade, expand and refurbish this digester. The improvements included a capacity expansion, improved mixing, reconfiguration of piping, and an insulated cover to help it maintain heat in the winter. A picture of a new mixer pump is shown in Figure 23. The target operating temperature is between 95 and 100 degrees F, and it has an operational HRT of about five to six days.

Figure 23 - Mixing pump for digester. Photo courtesy of Saputo Cheese USA, Inc.

This digester is seen as the most economical way to keep the plant in compliance with its discharge permit. The covered lagoon is shown in Figure 24. The anaerobic treatment stage is not only important for compliance, but with the 2009 upgrade was also a key factor enabling the facility to expand production. The digester is used to greatly reduce COD and BOD in the wastewater before it goes into the aerobic treatment stage. Following aerobic treatment, the wastewater is cleaned up to a dischargeable level.

Figure 24 - Mixed, heated covered lagoon digester. Photo courtesy of Saputo Cheese USA, Inc..

OUTPUTS AND USES

The digester produces 100,000-120,000 cfd of biogas that is used solely for digester heating. The biogas is cleaned with an iron sponge scrubber to remove hydrogen sulfide prior to entering a boiler. Biogas is burned in a Walker boiler with a rated capacity of 1.5 mmBtu/hour. During warmer months when additional heat is not needed the biogas is flared.

Liquid effluent after the anaerobic and aerobic treatments is cleaned up to dischargeable quality and is then discharged to a branch of the Rock River. Biosolids are also land applied on farmland which is DNR approved.

HISTORY AND COMMENTS

The facility (under Alto Dairy Cooperative at the time) first installed a covered anaerobic lagoon in 1991. They had issues with mixers not working effectively and found the COD removal to be about 70-80 percent at best. They needed to replace the cover in 2001, reflecting the estimated 10-year useful life for covers. The cover was replaced again in 2009 when the digester was cleaned and upgraded.

Plant manager Steve Nighbor points out that mixing is always an issue in covered lagoons. The 2009 upgrades included improved mixing equipment and an insulated cover as well as an expansion in treatment capacity. They also redid the plumbing for the system. With the upgrades they now get COD removal percentages in the 90s.

He notes that for a dairy plant, a digester is the answer. For them, the alternative of using only aerobic treatment would have been prohibitively expensive due to high energy inputs and they would have needed to dispose of a much higher volume of solids. Without the anaerobic digester system they would have had discharge limit violations and plant shutdowns. “Rules keep getting tighter for dairy high strength waste, so treating it on site is very helpful.”

They diligently manage and maintain the digester and supporting equipment. He estimates they spend about 20-30 hours per week on tasks such as lab work, monitoring the drip trap, and scrubber maintenance. Nighbor feels the system requires very little maintenance, and makes wastewater management a much easier job. Also, he notes, it is the most economical way to increase production and still meet permit requirements.

SOURCES

Steve Nighbor and Bernie Moen, Saputo Cheese USA, Inc.

SENECA FOODS MONTGOMERY FACILITY, MONTGOMERY, MINNESOTA

Summary Table

Facility Name:	Montgomery Facility	**Location:**	Montgomery, Minnesota
Food Products:	Peas and corn	**Site Employees:**	125
Digester Type:	Continuous mix, mesophilic, partially above-ground tank	**Year Installed:**	Summer 2007
Digester Role:	Pre-treatment of silage and leachate from vegetable processing before spray irrigation		
Digester Design:	Custom built by Seneca		
Biogas Use:	Space heat and process heat, blended with NG		
Prime Mover:	Boiler and burner		
Make and capacity	Hurst 12mmBtu/hour (winter heating boiler), X-Plus Preferred Brand burner (process heat during production season), Burner Mate Management System		
Ownership Model:	Company owns all		

Figure 25 - Seneca Foods Digester. Photo courtesy of Seneca Foods.

FACILITY BACKGROUND

Seneca Foods (SF) Montgomery Facility is a pea and corn processing facility located in Montgomery, Minnesota that has been in operation since 1926 and employs 125 people. During processing season of June to October, they process between 15-25 tons per day of corn silage, and 30-40,000 gallons per day of leachate. Through a calendar year they process roughly 120,000 tons of vegetables. SF needed to reduce the strength of their wastewater prior to applying it to fields. They saw anaerobic digestion as a cost-effective way to enhance their business, treat their waste stream but not move out of their normal realm (i.e., vegetable processing) and provide a fuel they could use in plant processes. The facility runs its wastewater treatment system all year.

DIGESTER

SF engineers designed an anaerobic digester system for the Montgomery facility. The digester, pictured in Figure 25, came on line in 2007. It is a continuous mix, partially above-ground concrete tank reactor that operates in the mesophilic range (i.e., roughly 90-105 degrees F). The digester has an HRT of 25-30 days.

OUTPUTS AND USES

The digester produces about 1,500 to 1,800 therms per day of biogas composed of 55-60 percent methane, 35-40 percent CO_2 and 200-250 ppm H_2S. The biogas undergoes dehydration and compression prior to use. During processing season, biogas is blended with natural gas and fired in an X-Plus Preferred Brand burner at a rate of about 1800 therms per day (biogas only). Using the BurnerMateTS-FM Burner Management System and digital controllers, the burner receives a continuously adjusted blend of natural gas and biogas and the right amount of air to maximize burner efficiency. The fuel mix is variable but could be as high as 90 percent biogas.

During off-season, biogas fuels a Hurst 12mmBtu/hour boiler, shown in Figure 26, heating water that is sent to 31 radiant heaters warming the entire main process facility and warehouse.

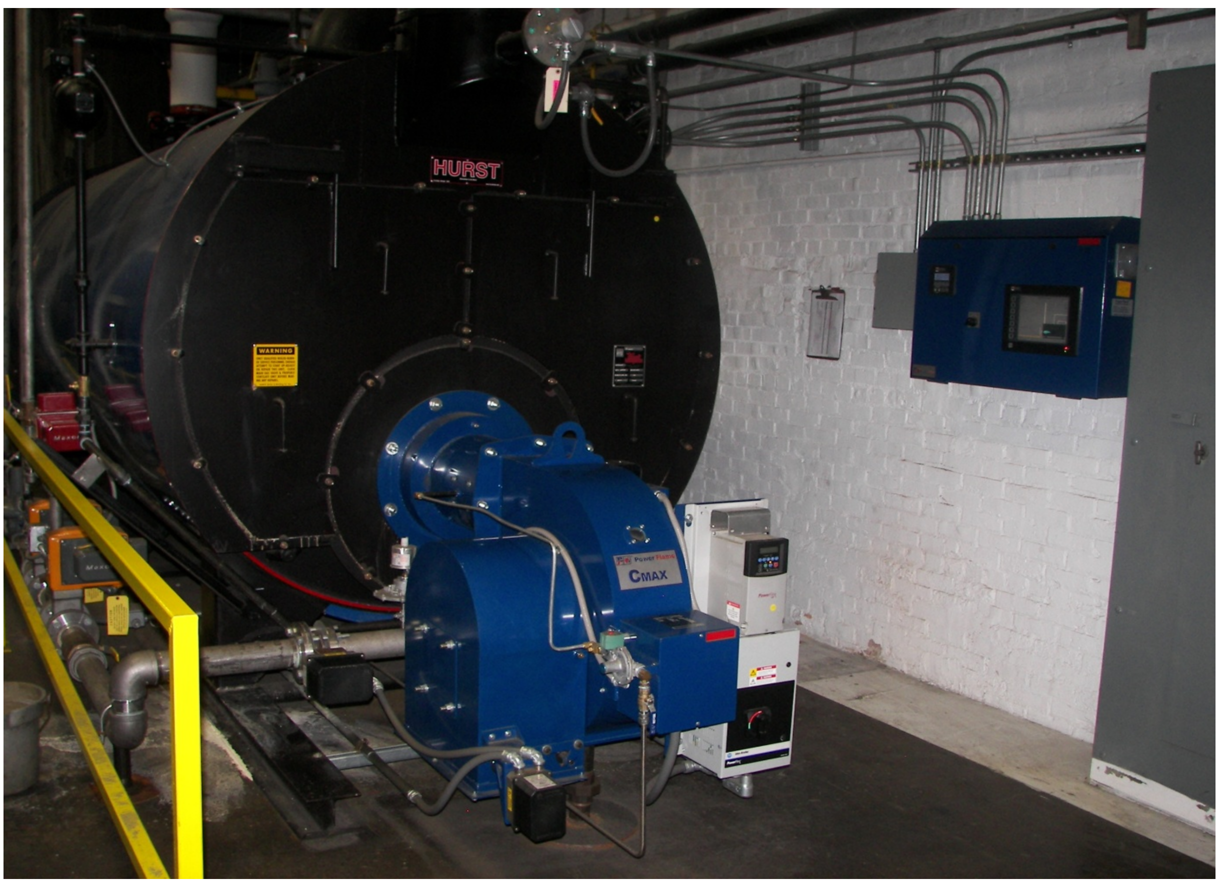

Figure 26 - Biogas hot water boiler. Photo courtesy of Seneca Foods.

HISTORY AND COMMENTS

SF indicated that they have had no issues with their system since it has come on line. Their digester has provided a cost-effective treatment of their waste-stream. The reduced-BOD wastewater provided by anaerobic digestion is spray irrigated on surrounding farmland for nutrient value. The byproduct methane gas has helped their operation financially by displacing some of their natural gas purchases.

Plant manager Paul Hendrickson points out that the most important thing when considering renewable energy systems "is to make sure what you are trying to accomplish fits with your operation." He pointed out Seneca is a vegetable operation, not a gas refinery. The goal was to enhance their business and treat their waste stream, but not move out of their normal realm. This system made sense for them since their major energy need is for natural gas.

SOURCES

Paul Hendrickson – Seneca Foods
Kenneth Brown – Minnesota Office of Energy Security
Minnesota Office of Environmental Assistance, "Renewable Methane from Vegetable Processing Industry – Fact Sheet."

SUNOPTA INGREDIENTS CAMBRIDGE FACILITY, CAMBRIDGE, MINNESOTA

SUMMARY TABLE

Facility Name:	SunOpta Cambridge Facility	**Location:**	Cambridge, Minnesota
Food Products:	Oat fiber processing	**Site Employees:**	55
Digester Type:	Upflow anaerobic sludge blanket	**Year Installed:**	1990
Digester Role:	Pretreatment prior to discharge to public owned treatment works		
Digester Design:	Paques ADI Incorporated		
Biogas Use:	Facility process heat, water heat, flared		
Prime Mover:	Steam generator for process heat		
Make and capacity	Not available		
Ownership Model:	Company owns all		

FACILITY BACKGROUND

SunOpta's Cambridge Minnesota facility is an oat fiber processing plant that generates between 100,000 and 300,000 gallons of wastewater per day. This is composed of oat processing wastewater and alkaline hydrogen peroxide bleaching wastewater. The plant has 55 full-time employees and operates all year, although production varies based on plant configuration. SunOpta has a number of environmental and sustainability initiatives. They were recognized in 2009 with both a Canadian Health Food Association Spotlight Award, and in 2010 with an Industrial Water Quality Achievement Award from the Water Environment Federation (www.wef.org, September 1, 2010). In addition, SunOpta monitors their carbon footprint at each of their 74 facilities throughout the world. The company saw the need to add a pretreatment option to avoid over-burdening the Cambridge municipal treatment plant with high strength wastewater. The company chose anaerobic digestion as their pretreatment option for cost, efficiency and environmental reasons.

Figure 27 - SunOpta UASB digester. Photo courtesy of SunOpta

DIGESTER

SunOpta installed a UASB digester designed by Paques ADI Incorporated. The digester became operational in 1990 and is pictured in Figure 27 (black covered low structure in the middle). The digester is an above ground tank with an operating HRT of about 35 days. This is longer than the design HRT because SunOpta's water saving measures have resulted in a lower than planned volume of wastewater needing treatment, allowing them to keep it in the tank longer.

OUTPUTS AND USES

The digester is creating between 100 and 300 standard cubic feet per minute of biogas, containing 53-58 percent methane, 35-40 percent CO_2 and 200-500ppm H_2S. Biogas is scrubbed (H_2S removed) dehumidified, and compressed prior to using it for process heat. Figure 28 shows the building that houses the gas conditioning equipment and compressor. From there it is piped into the plant where it fuels steam generators for process heat, and excess biogas is flared. The steam generator was installed recently (2010) and they were still in the startup phase of using biogas for energy on site as of summer 2010. They hope to use all the biogas they produce once operation is stabilized.

Figure 28 - Building with gas conditioning and compression equipment. Photo courtesy of SunOpta.

Their digestion process also produces biosolids which they land apply on farmland at no cost to farmers as soil amendment and fertilizer. Land application is monitored by a contract agronomist and reported to the Minnesota Pollution Control Agency. Effluent is cleaned up to the approximate quality of residential wastewater, and sent to the local publicly-owned treatment plant. They explored using raw (i.e., pre-digested) solids as animal food because they found it could be a good food for ruminants. After some successful test feeds, it became apparent that high transportation costs would make it uneconomical.

HISTORY AND COMMENTS

SunOpta chose the UASB digester for their wastewater treatment for a number of reasons: it produced lower sludge volume and had lower energy requirements than aerobic treatment options. Furthermore, it created biogas for production use at the plant. The Manager of Water Sustainability, Loren Larson, indicates they had a steep learning curve in getting the system to work with their waste stream. Over time they figured out their waste stream was missing some micronutrients needed for the bacteria populations. After consulting a micronutrient specialist they were able to supplement their input with small amounts of nutrients and smooth out production. They monitor their system closely with regular measurements of volatile solids and nutrients.

Because they have a lot of suspended solids (TSS) in their effluent, they needed to add a dissolved air flotation system after the digester. With the addition of coagulants and flocculants they gather these solids into "curds" where they can be raked off the top, enabling them to direct discharge the effluent.

Figuring out how to make their system work with their wastewater has required attention and adjustments over the years. They feel they now have it under control most of the time—upsets are infrequent. They have a good working relationship with the City of Cambridge treatment plant, which has been quite accommodating when a rare system upset occurs.

SOURCES

Loren Larson, SunOpta Ingredients, Inc.
Kenneth Brown, Minnesota Office of Environmental Safety