PENNSTATE
Department of Agricultural
and Biological Engineering

Hillcrest Saylors Dairy Farms LLC

Type of farm: Dairy

Name of farm: Hillcrest Saylors Dairy Farms LLC

County: Somerset

Anaerobic digester operator: Shawn Saylor

Digester Installer: Shawn Saylor, Farm acted as the General Contractor

Construction start date: May 2006

Date Digester became operational: November 2006

Number of animals contributing to the digester: 608 (milking & dry)

Type of Barn: 2 freestalls

Manure handling system: continuous alley scraped to tank

Type of Bedding: digested, separated manure solids

Type of digester: Slurry Loop (Modified Plug Flow)

Digester cover: Hard Top - Concrete

Digester temperature: mesophilic 103^{o}F

Biogas uses: operate the CHP unit to produce electricity and heat

Biogas utilization equipment: engine generator set, auto flare

Recovered heat utilization: engine generator water and exhaust jackets to heat digester, hot water for milking parlor, space heat to milking parlor and office, domestic hot water; uses for engine radiator heat being explored.

Power Purchase Agreement: Yes

2009 July Status of Digester: operational

Four inches of soil covering the below ground anaerobic digester

Introduction:

Hillcrest Saylors Dairy Farms LLC is located in Somerset County, Pennsylvania. Saylor's farm has been in the family for 100 years and four generations. The farm started out with two horses, three dairy cows and 100 acres. Currently the farm consists of 1165 Holstein cows of which 598 are milking cows; average herd production is 73 pounds of milk per day, 90 dry cows and 477 heifers. The family farm has expanded to 1500 acres. Hillcrest Saylor Dairy Farms LLC has received the Dairy of Distinction Award.

In 2000, Shawn Saylor started learning about anaerobic digesters by talking with some digester owners, looking at several designs, attending conferences and touring many farms with digesters; some outside Pennsylvania. Saylor's decided to put in a digester for odor control, nutrient management, power production and heat. Many innovations are incorporated into the digester system including eight hours of biogas storage capacity.

The digester currently receives manure from 608 cows of which 598 are milking and 10 dry cows. Shawn Saylor is the digester operator.

Digester Information:

Shawn Saylor designed the digester for the family farm. Team Ag Inc. from Ephrata, Pennsylvania provided the Professional Engineering services for the project. Hillcrest Saylors Dairy Farms LLC acted as the General Contractor and Shawn took on the job of Project Manager to oversee all construction. Construction for the Slurry Loop Modified Plug Flow digester started May 2006 with a November 2006 start-up. The digester was producing good methane for two months before the electrical generator arrived. Power production using the biogas started in February 2007. The digester is designed for 1000 cows and an operating mesophilic temperature of 103^{o}F. Currently the digester is operating at the designed 103^{o}F, with the manure from 608 cows. Continuous alley scrapers are used to move the manure from the two freestall barns to a manure collection pit with the dimensions of 12' L x 12' W x 15' D and capacity of 16,156 gallons. The manure from the two freestalls and 1000 gallons of flush water from the milking parlor and common areas enters the digester each day. During the summer, the sprinkler water used to keep the cows cool also goes into the digester. Gravity flow moves the manure through a 30 inch pipe to the influent tank. The farm also receives potato chip waste which is off-loaded onto a stainless steel conveyor. An electric motor controls the speed of the conveyor as the food waste falls into the influent pit with each delivery. A 5hp piston pump and an agitator are used to mix the manure influent pit. Influent enters the digester by gravity, overflowing from the influent pit through a concrete weir. The digester is mixed using thermal heating. The circular, heated, slurry loop digester is completely underground with 4 inches of soil covering the digester. It has a reinforced concrete top and a flexible cover under the hard top. The digester is 70 feet in diameter and 16 feet in depth. A one foot freeboard is maintained allowing the digester to hold 432,000 gallons (57,750ft^{3}) of influent. The digester has a dividing wall down the center, external heating pipes run on both sides of this wall. There are ten rows of 3 inch steel heating pipes. The digester is insulated on the bottom with 18 inches of #2b stone, the sides have 36 inches of clay and the top is insulated with two inches of foam protected by poly to help maintain the 103^{o}F temperature. The heated slurry loop modified plug flow digester is designed for a hydraulic retention time (HRT) of 16 days. The digester is currently operating at 10 – 12% solids, and approximately 25 days HRT. Biogas is produced and collected in an auxiliary biogas storage.

The farm was using rumensin in the spring of 2009.

Influent and effluent are measured for total solids (TS), total nitrogen (N), ammonium N (NH_4-N), total phosphate (P_2O_5) and total potash (K_2O).

Biogas System:

Biogas is piped underground from the digester through 12 inch PVC pipe reduced to 6 inch diameter PVC pipe to the biogas storage using a Fuji 2.2 hp gas blower with variable frequency drive. The Auxiliary Biogas Building (Bladder Building) is 40' L x 45' W. A stitched, rubberized textile bag attached to the concrete floor makes up the storage bag. The biogas storage bag volume is 15,120 ft3; calculated to hold eight hours of biogas. The farm would like to have 12 hours of gas storage to better take advantage of premium bonus payments for peak hour power generation supplied to the grid. The biogas is pre-treated by condensate removal in the gas storage bag. Biogas is then piped underground through 8 inch diameter PVC pipe from the auxiliary biogas storage through two constant speed biogas blowers, each supplying an engine generator set. Biogas is measured by an Eldridge Products, Inc. gas flow meter. The digester biogas production averages 55,200 ft^3/d; without the addition of food waste. An auto flare burns any excess biogas not consumed by the engine generator sets. A Bacharach Fyrite® Gas Analyzer is used to measure the CO_2 concentration in the biogas, which is typically 35%, making the methane concentration calculation 65%.

Biogas Storage, bag volume 15,120 ft^3, Bladder Building 40'L x 45'W

Combined heat and power unit (CHP):

The biogas is piped to two reconditioned, 1200 rpm Caterpillar G342NA internal combustion engines, each coupled to a 440 volt, three phase 130kW generator. These units were purchased from Martin Machinery Inc. of Ephrata, PA. Daily average electrical production with one generator is 3220 kWh. Two generators operate as needed to supply peak power conditions or as biogas supply dictates. Heat recovered from both the engine water jacket and exhaust jacket heats hot water for the digester, milking parlor, barns, office space and domestic hot water. Currently, the radiators dump their waste heat inside a segregated portion of the generator building with the plans of capturing that heat for air heating of future additions (possible greenhouse). Thermal savings from capture and use of reject engine heat is equivalent to approximately 8,000 gallons of fuel oil per year. The CHP units are available 24/7/365 days a year, except when oil changes or repairs are required. Mobilgard 450 NC diesel engine oil is being used and changed every 500 hours of operation. Engine oil analysis is performed at each oil change.

2 - G342NA Caterpillar engines with 3 phase 130kW generators

Power purchase agreement:

Hillcrest Saylors Dairy Farms LLC has a power purchase agreement with Allegheny Electric Cooperative, Somerset Rural Electric Company. Power production averages 6440 kWh/day. All power needs for the farm are met. Net metering is used on all 12 of their meters with the surplus electricity sold to the power company. The farm is paid .06084 cent per kWh (net metering) and can also receive extra peak payments. The February 2009 electric bill shows 35,000 kWh of avoided electrical purchases for the month. The farm has been able to avoid purchasing over 1,000,000 kWh per year.

Digester effluent:

The nearly odorless digested manure gravity flows to an effluent storage pit measuring 12' L x 15' W x 12' D. A Houle Electromix piston pump directs the effluent to the solids separation section of the building. The solid/liquid separation room is above the separated solids storage bay. A Vincent screw press solid/liquid separator with a 10 hp motor is used. The solids fall directly into the digested solids storage bay. These separated solids are then used as bedding for cows, soil amendments and on the fields. The farm sells bedding and soil amendments to other farms. Approximately 111 cubic yards of digested separated solids are used each week as bedding on the Saylor farm. The somatic cell count is currently 270,000. The separated liquid effluent gravity flows to a 2.5 million gallon storage pond which has a 3 month holding capacity. The effluent is stored then field applied as needed.

Digested, separated manure solids: bedding, soil amendments and land application.

Project costs:

The total digester project investment cost $900,000. Hillcrest Saylor Dairy Farms LLC received grant funding of $600,000 for the initial phase of the project, consisting of the first gen-set and the anaerobic digester. Later when a second gen-set was needed the farm received another $130,000. The grants were received from the Pennsylvania Department of Environmental Protection (PADEP). Some carbon credits were sold to Native Energy. The farm used cash flow, farm labor and farm equipment to hold down the borrowing cost of the digester project.

Lessons learned:

Shawn Saylor states that major parts of the system worked as planned, spending some money on small updates and repairs.

The biogas storage bag should have been sized for 12 hours of hold time to take advantage of putting electricity on the grid using both gen-sets during peak power usage. Doing so would enable the farm to receive more peak power bonus payments.

Digester Project and Maintenance History:

The digester tank construction was delayed due to excavating rock instead of dirt. The digester was producing good methane two months before the generator arrived – heated digester with biogas from the digester. The use of a Houle 3" pump for effluent kept plugging. This was replaced with a Houle Electromix piston pump. Before the solid/liquid separator was installed the shavings used for bedding the cows almost plugged the digester. It took almost a year for the plug to break up and come out of the digester. Currently having some problems with heat transfer, this may be due to external scaling on the heat pipes.

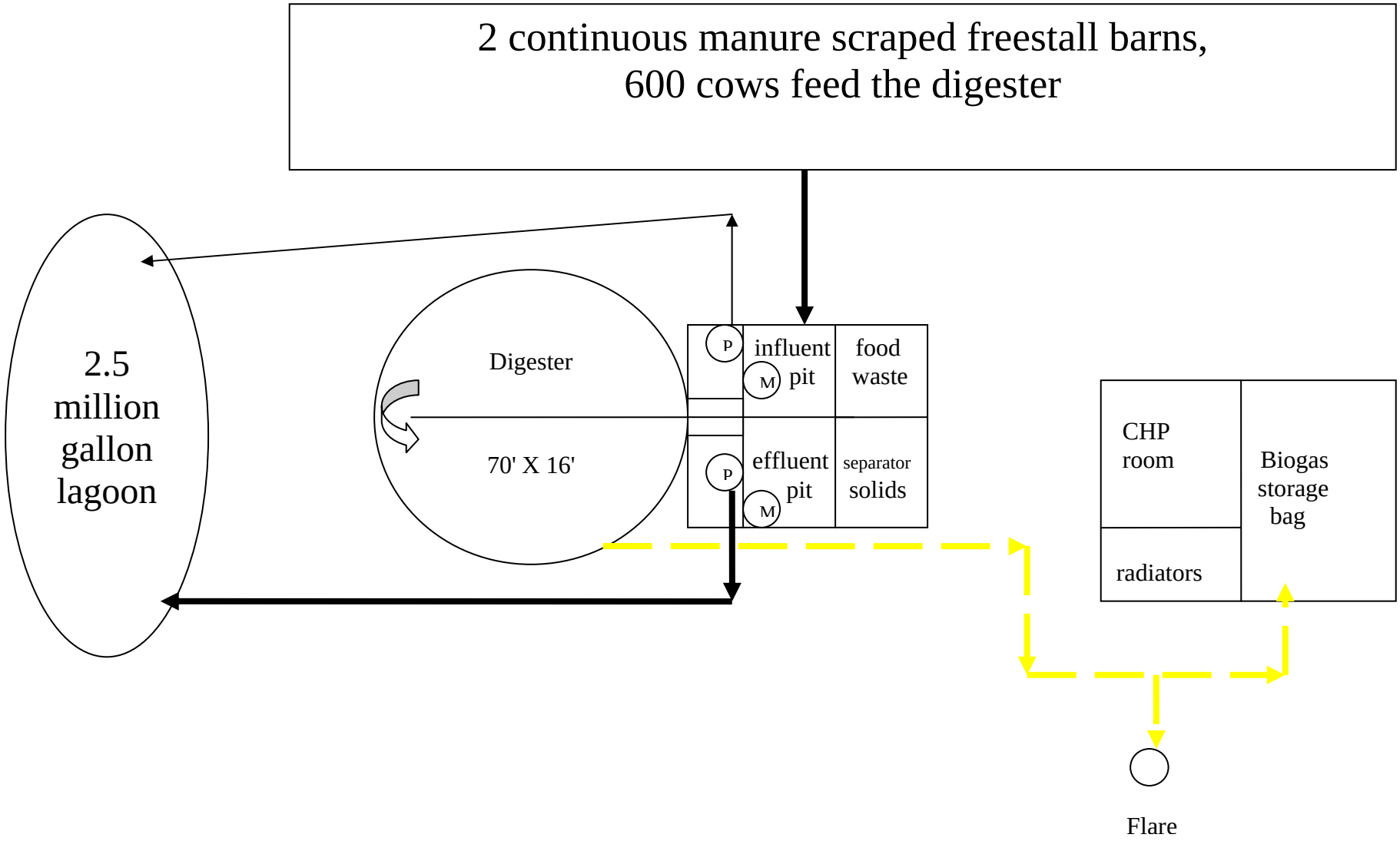
Would you install a digester again? Yes

***Please see the digester system schematic and log sheet on the following two pages.**

The information obtained in this case study was collected by Penn State researchers, Deborah Topper and Patrick Topper during a farm tour, observations, farmer completed questionnaire and interviews at the Hillcrest Saylor Farms LLC in 2009.

This material is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Agreement No. 2008-51130-19500 and No. 2006-34437-17166
Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture

The Pennsylvania State University, Department of Agricultural and Biological Engineering, College of Agricultural Sciences.



Hillcrest Saylors Dairy Farms LLC

Hillcrest Saylor Dairy Farms LLC Generator Building Bi Daily Checklist Month: Mar. Year: 2009 Total KWH 1- 2-

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Check process control for errors. Check gas detector	A																															
	P																															
Check generator control for errors Record KW	G 1																															
	G 2																															
Total generator hours. Button 8	G 1																															
	G 2																															
Gas output SCFH?																																
Gas total SCF?																																
Record digester pressure or vacuum level	A																															
	P																															
Generator oil reservoir level in sight glass?	A																															
	P																															
Gas bubble tight or loose? T or L	A																															
	P																															
Flaring? Y or N	A																															
	P																															
Loop temp ok? 130 – 200 F	A																															
	P																															
Loop Pressure ok? 25 lbs	A																															
	P																															
Digester supply temp ok? 115 – 130 F	A																															
	P																															
All circulators and fans operating?	A																															
	P																															
Temperature in room ok?	A																															
	P																															