



Penn England Farm Case Study

Type of farm: Dairy

Name of farm: Penn England Farm

County: Blair

Digester designer: RCM Digesters

Digester Installer: Penn England Farm acted as General Contractor

Construction start date: October 8, 2005

Date digester became operational: August 17, 2006

Number of animals contributing manure to the digester: 720 milking + 80 dry

Housing system: freestalls

Type of bedding: dried digested separated solids

Manure handling system: alley scrapers to auger

Type of digester: mixed loop

Digester cover: insulated flat flexible

Digester temperature: mesophilic 100°F

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

Biogas utilization equipment: engine generator set and flare

Heat recovery utilization: heat digester, hot water for milking parlor, genset radiator air
used to dry manure solids

Power Purchase Agreement: Yes

2007 status of digester: operational

Introduction:

Penn England Farm is located in Blair County, Pennsylvania. The family operated dairy farm was started in 1979 with 75 cows. It was gradually expanded to its current size of 1,620 Holsteins in 1998. Presently, manure from 720 milking and 80 dry cows and milking center waste water goes to the digester. The remaining animals consist of 60 dry cows, 390 heifers and 370 replacement cows. The manure is continuously scraped from the freestall barn and augered into the 9,000 gallon digester influent holding tank. The milk parlor and holding pen are flushed 3 times per day and this flush water is mixed in the digester influent holding tank.

Penn England decided to put in the digester system for power production to reduce electricity costs on the farm. Odor control, nutrient management and farm expansion also were contributing factors into the decision of installing a digester. Members of the farm researched and also visited digester systems in New York, California, Wisconsin and Pennsylvania over a four year period. In 2004 a feasibility study and the grant application process started. RCM Digesters helped Penn England with the grant applications. After two large grants were awarded to the farm, excavation started on October 8, 2005. Work continued through the winter and spring of 2006. The proud moment came when the engine started running on biogas on August 17, 2006.



Digester with flat cover

Digester information:

The digester designed by RCM Digesters is a mixed loop, heated, circular, partially above ground concrete tank, 80 feet in diameter and 16 feet in depth (manure level at 14 feet), with an internal dividing wall and has an insulated, flat flexible cover. The digester has a capacity of 525,000 gallons and is designed for 1,300 cows. It is designed to operate with 8 to 9 % solids and a hydraulic retention time (HRT) of 20 days at a temperature range of 98 to 104°F. Presently the digester is running with an HRT of 23 days with the percent solids unknown at this time and a temperature of 100°F. A hot water piping heat exchanger inside the concrete tank keeps the digester at the desired temperature. The tank exterior is insulated with 2 inches of re-manufactured rubber from recycled sneakers.



Floating insulation blanket

The digester cover consists of 4 layers: two - 60 mil HDPE (layers 1 and 4) and two - 2 inch rubber insulation blankets from recycled sneakers (layers 2 and 3). Environmental Fabrics manufactured the HDPE flexible 60 mil cover.

The internal dividing wall splits the digester into two chambers. Each chamber is mixed with a Baur, 12.6 kW mixer (18 inch diameter propeller) for approximately two hours a day. Every twelve hours one of the mixers runs for 50 minutes. A float controlled submerged manure pump in the influent holding tank, pumps 18,200 gallons of raw manure per day in batches of approximately 3,500 gallons per cycle four to five times a day through the 10 inch diameter PVC digester influent feed pipe into the digester. Parlor wash water of 6,000 gallons per day is also added to the influent tank and mixed into the manure.

Penn England monitored the digester system for two hours a day during the start-up phase. After steady state operation was achieved, monitoring takes approximately one hour a day; 45 minutes in the morning to take readings and grease the pumps and separator; at night, a 15 minute walk through to check all digester equipment. A log book is used to document monitoring, planned and corrective maintenance. During start-up, the oil was changed every 250 hours, then, based on engine oil analysis, upgraded to every 300 hours of engine operation with plans to extend to 350 hours. Digester internal and effluent temperatures, CO₂ content of the biogas, and influent and effluent pH are also monitored.

Biogas system:

The biogas leaves the digester through 6 inch diameter PVC pipe. There is a foam baffle separator used to condition the biogas. The biogas piping has gravity operated water removal drip pots that also provide over pressure relief protection. The piping travels underground downhill to the engine-generator set building.

Combined Heat and Power unit (CHP):

Once inside the engine-generator set building, the biogas is directed to a blower, then to the gas flow meter before entering the Caterpillar G342, 6-cylinder, 130kW, 440V, 3 phase engine purchased through Martin Machinery Inc. of Ephrata, PA. The engine generator runs 24/7, 365 days a year. Biogas is not treated in the engine-generator building before entering the engine. During the initial start up phase the engine generator set was producing 65kW. After 10 months of operation production has improved to 110 – 140kW, averaging 120kW. Heat recovery from the water and exhaust jackets of the engine are used to heat the digester and milking parlor, make hot water and dry manure solids from the FAN separator for bedding.



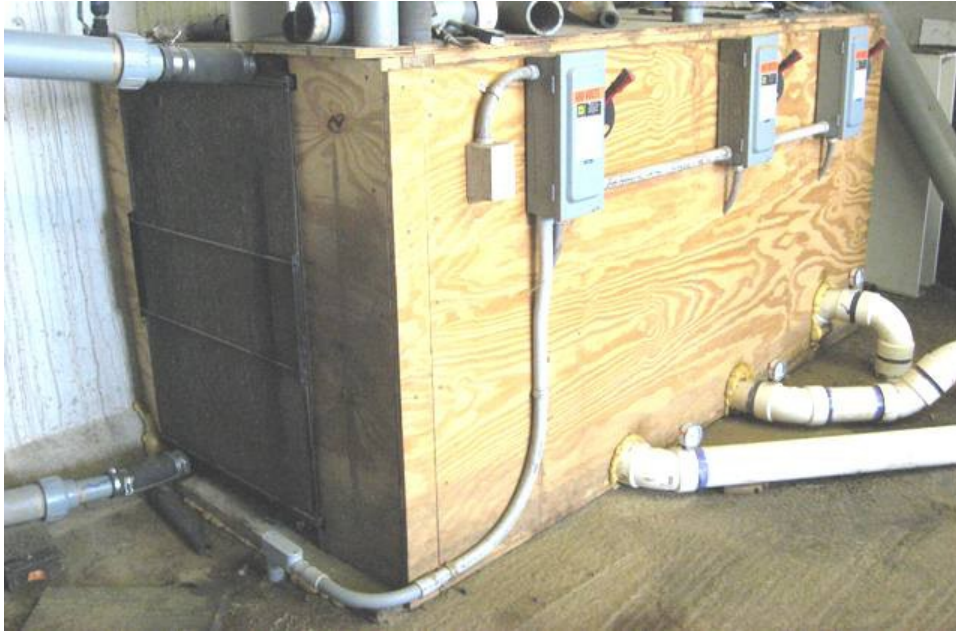
Combined Heat and Power Unit (CHP)

Power purchase agreement:

The engine generator set runs 24/7. Penn England has a power purchase agreement with Valley Rural Electric Co-operative (CO-OP) for 3.9 cents per kWh of any excess electrical power. At start-up, the CO-OP was not required to follow PA net metering guidelines. Since then, the CO-OP has followed the PA net metering guidelines and in December of 2006 the farm electrically connected (paralleled) with the utility making it possible to sell excess electricity generated or purchase electricity from the CO-OP when needed. The farm has been able to aggregate all their electric meters within a 2 mile radius of the digester. These meters are located at the dairy, tiestall barns, shop, trailer, employee building and the owner's residence.

Digester effluent:

A 10 inch PVC digester effluent pipe removes the digested manure and directs it to a 10,000 gallon effluent holding tank. A float controlled submerged manure pump in the effluent holding tank feeds the FAN separator in the upper level of the separated solids storage building. The solids travel from the separator across a conveyor belt and drop to the floor of the storage building. The solids are dried by hot air from the CHP unit auxiliary radiator installed in a wooden box with three blowers to direct the hot air through slots in the concrete floor. All of the dried digested solids are used for bedding for the cows. The liquid from the separator gravity flows to the approximately 4 million gallon manure storage pond.



Wooden box heat exchanger for drying manure solids



Separated solids drying on the slotted floor in the bedding storage area

Project costs:

The capital cost of the Penn England digester system was \$1.14 million. The farm owner acted as the general contractor and farm labor was used to build the system. A partial breakdown of costs is as follows:

digester \$141,370.00
power prime mover (CHP) \$135,000.00
biogas conditioning equipment \$50,000.00
switching gear, inter-connection fee \$155,000.00
designer, engineering, consulting fees \$85,000.00.

The farm received a Pennsylvania Energy Harvest Grant of \$280,500.00, a USDA Grant of \$203,725.00 and a MELF (grant or loan) of \$206,000.00. Penn England farm paid for or financed the rest of the \$480,275.00 needed for the digester project. Cost per head works out to be \$1,325.00.

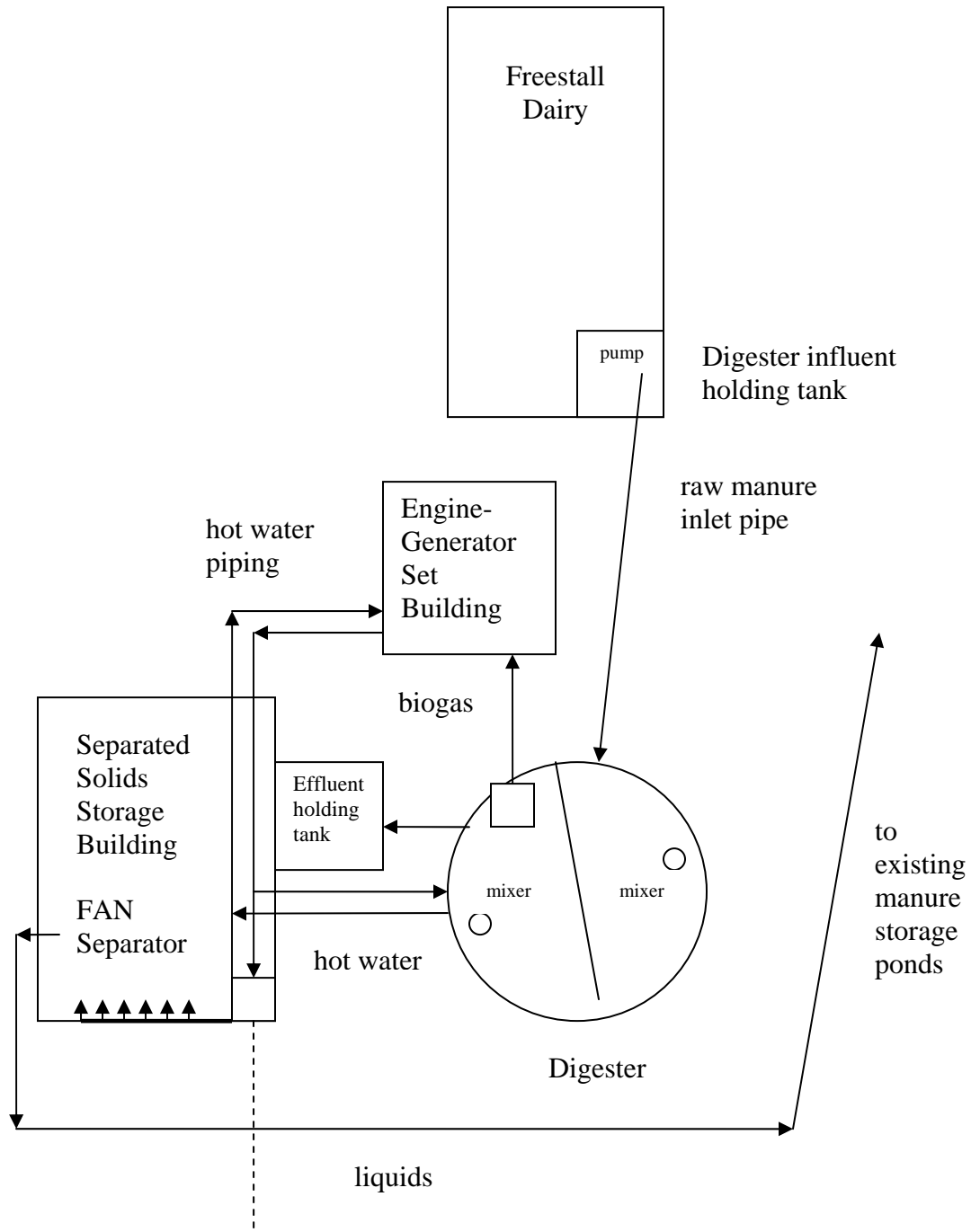
Operation and maintenance costs during the time period of August through December 2006 equals .0199 cent/kWh. Oil changes are performed on the engine every 300 hours of operation. A used engine oil sample is sent out to a laboratory for analysis.

Lessons Learned:

Lessons learned during the digester project include: build into the budget extra money to allow for unforeseen expenses and secondly, try to account for the electrical usage during the construction period.

The information obtained in this case study was collected by Penn State researchers, Deborah Topper and Patrick Topper during farm tours at the Penn England Farm and discussions with farm personnel during 2006 and 2007.

01/10/08



First Floor: The CHP unit auxiliary radiator wooden box heat exchanger is used to direct hot air under the floor to dry the separated manure solids for bedding.

Second Floor: The Fan separator receives digested manure from the effluent holding tank. The solids are conveyed then dropped to the building floor and the

Schematic of Penn England Farm Anaerobic Digester System