Final Report Summary:
Haubenschild Farms Anaerobic Digester

Updated!

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About this report

The original Haubenschild Report was published in December of 1999, and updated with new operating information in August 2002. This is a summary of the full updated report, which has over 30 pages of more detailed information on the Haubenschild digester as well as general information on digesters. It can be downloaded at www.mnproject.org. The update for this report was made possible by a grant from the U.S. Department of Energy and the Minnesota Department of Commerce.

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Summary

This report is an update of the December 2000 report and documents the installation and 34-month performance of a heated plug-flow anaerobic digester for managing dairy manure at Haubenschild Farms. This type of digester is appropriate for treating manure with a high solids content, such as cow manure that is collected by scraping.

Haubenschild Farms is a 1000-acre, family owned and operated dairy farm near Princeton, Minnesota. In 1998 the owners were planning to increase the size of their operations, and considered the possibility of installing an anaerobic manure digester. They knew that this type of system could result in environmental benefits while offering a return on their investment.

Some of the key expected benefits of an anaerobic digester are:

- Odor control
- Renewable energy production
- Pathogen reduction
- Greenhouse gas reduction
- Reduction in total oxygen demand of the treated manure (total oxygen demand is a measure of potential impact on aquatic systems)

Haubenschild Farms applied for and was selected as an AgSTAR "Charter Farm," one of 13 such farms selected nationwide to demonstrate farm-scale anaerobic digestion technologies. AgSTAR is a joint program of the Environmental Protection Agency, Department of Energy and Department of Agriculture, designed to promote the use of anaerobic digestion systems. In addition to the AgSTAR program, the Haubenschild Farms project received assistance from the Minnesota Department of Agriculture, Department of Commerce and Office of Environmental Assistance. With financing complete, construction of the digester was started in the summer of 1999 and completed in October of the same year. Total construction cost of the digester and generator system was about $355,000.

The Haubenschild Farms digester is a covered 350,000-gallon concrete tank installed in the ground, with suspended heating pipes to heat the manure inside the digester where bacteria breaks down the manure, creating methane. A 135-kilowatt engine-generator set is fueled with methane captured from the digester. The hot water to heat the digester is recovered from the engine-generator's cooling jacket. Barn floor space is also heated with the recovered heat. The digested effluent, odor reduced, flows to a lined storage pond where it is kept until it can be injected or broadcast spread on fields for crop production.

When the digester was started, it was processing manure from about 425 dairy cows, which was about half of its total design capacity of 1000 cows. In 2000, Haubenschild Farms built a second free stall barn and has expanded to a current size of about 750 cows.

Since startup in the fall of 1999, the biogas output of the digester steadily increased to about 65,000 cubic feet by May 2000. Currently, more biogas is being produced than can be used by the engine-generator, so it is hard to estimate exactly how much biogas is being produced. The Haubenschilds are considering adding generation capacity to utilize the excess biogas. Approximately 70,000 cubic feet/day of biogas is used by the engine-generator; the rest is currently flared. With 425 cows, the biogas output per cow was almost twice projections – with 750 cows, the output per cow has come down somewhat to about 40 percent above projections. Haubenschild's cows are producing about 50 percent more manure per cow than the digester was engineered for, which somewhat explains the high biogas production per cow.

The sale of the electricity generated is an important benefit of the project. Before the digester was built, Haubenschild Farms entered into a power purchase contract proposed by the local electric cooperative, East Central Energy, who greeted the project with enthusiasm and offered Haubenschild Farms a very favorable contract. Since the expansion of the milking herd size from 425 to about 750 cows in the summer of 2000, the digester has been producing enough electricity to provide all the electric needs on-farm, plus enough surplus electricity to power about 75 additional homes.

The building and operation of the Haubenschild Farms project has offered several key lessons for future digesters:

- Payback of 5 years on investment is possible
- A good time to install a digester is when changing or expanding operations
- Electric utility cooperation is important
- Active management is crucial for stable digester and engine operation
- Digester design and engineering expertise is key
- There are barriers to financing digester systems
- Cooperative agency participation reduces the barriers to a project's success
- Manure collection method and collection frequency are important

Table 1: Projected and Actual Costs of Haubenschild Farm Digester System

Component	Projected $	Actual $
Mix Tank/ Manure Collection		
Excavation/grading	3,400	0*
Cement work	12,500	18,800
Manure pump	10,000	11,300
Other (piping, installing)		2,300
Subtotal	***25,900***	***32,400***
Digester		
Excavation/grading	10,600	8,500
Digester tank	68,500	88,700
Heating	8,500	19,800
Cover	4,600	8,100
Start-up	5,000	0*
Miscellaneous	7,800	0*
Subtotal	***105,000***	***125,100***
Energy Conversion		
Building	17,400	16,400
Gas pipes	2,000	2,100
Gas pump/meter	6,000	2,000
Engine-generator/hot water recovery	87,000	106,000
Components and installation	13,700	31,000
Subtotal	***126,100***	***157,500***
Miscellaneous		
Engineering	25,000	40,000
Contingencies	25,700	0*
Subtotal	***50,700***	***40,000***
TOTAL	**307,700**	**355,000**
COST/COW (assuming 1000 cows)	**$307**	**$355**

*Costs for these items are embedded in other items for which costs are shown

Table 2: Digester Design and Actual Performance

	Design	Actual, 425 cows	Actual, 750 cows
Time frame	1998	Jan - May 2000	Sep 2000 - Jul 2002
Cows (average)	1,000	425	750
Manure production			
gallons (per cow per day)	14	n/a	n/a
Manure slurry (including wash water and bedding)			
gallons (per cow per day)	17.5	27	27
total gallons slurry (per day)	17,500	11,500	20,000
Digester size			
volume (cubic feet)	47,000	47,000	47,000
volume (gallons)	352,000	352,000	352,000
retention time (days)	20	31	15
Gas production			
per gallon of manure slurry (cubic feet/day)	3.7	5.1	3.5*
per cow (cubic feet per day)	65	139	93*
total (per day)	65,000	58,900	70,000*
Electrical output			
per cow (kWh per day[1])	2.3	5.5	4.0
total (kWh per day)	2340	2350	2970
generator capacity (kW)	120	135	135
generator availability	90%	98%	98.8%
yearly output (kWh)	766,500	860,000	1,080,000
Thermal output			
total thermal output (mmBtu/day)	18	n/a	n/a
Revenue Generation			
offset heating costs (per year)	$4000	$4000	$4000
offset electricity use on-farm ($/kWh)	$0.07	$0.0725	$0.073**
excess electricity sales ($/kWh)	$0.02	$0.0725	$0.073**
projected annual electric revenue[2]	$40,300	$62,200	$80,957 *(actual, 2001)*
total projected annual revenue	$44,300	$66,200	$84,957

n/a means not available

* Actual biogas production is higher than reported here, because more biogas is being produced than the engine can accommodate, and thus cannot be metered with the current metering configuration

** A rate increase from 7.25 cents/kWh to 7.3 cents/kWh occurred effective Jan 1, 2001.

[1] For the design calculations of kWh per cow, this assumes an energy value of 600 Btu per cubic foot biogas and a heat rate of 15,000 Btu per kWh.

[2] Projected annual electric revenue for the 425 cow column is calculated based on the average electric production from January 14 to June 2. See later discussion on revenue generated.