Anaerobic Digester at Freund Dairy: Case Study

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Who Should Consider a System Like This?

- Farms in need of odor control.
- Farms where manure can be collected easily.
- Farms with capital available for initial start up costs.
- Farms with technical interest and skills for the system operation and maintenance.
- Farms with adequate cropland for the nutrients.
- Farms that need to separate manure year round.
- Farms that need to handle manure as a liquid year round.
- Farms with a use for heat.

Farm Information

Freund Dairy, located in East Canaan, Connecticut, is operated by Matthew Freund. The farm owns a total of 600 acres of land, with a milking cow population of 250. Heifers are raised off the farm, and the milking herd is grazed during the summer months. An anaerobic plug-flow digester was installed and operated since 1997, which is one of two on-farm digester applications currently existing in the state of Connecticut.

Why the Digester?

Unlike most other digester applications on dairy farms for energy generation and odor control, the digester on Freund Dairy was initially installed to increase manure management efficiency. The system allows manure handling throughout the year, especially during the cold winter months. A specific goal is to be able to separate fiber from manure in winter months and store the liquid filtrate for irrigation. Odor control was not a major issue even though the residential neighbor's property line is only 15 ft. from the edge of the manure storage pond. Biogas recovery for heat generation using a boiler has become another major goal of the system.

Digester System

System and Process Description

Designed by the Resource Conservation Management, Inc. and later modified by the farmer himself, the anaerobic digester on Freund Dairy is a plug-flow digester. For the past three years, gas captured by the digester has fueled a hot water boiler that, in turn, heats the Freund's milking center, farmhouse and offices as well as the digester.

The whole system is composed of several components (see Figure 1):

- Digester for biogas production
- Manure pond for liquid storage
- Boiler and boiler room
- Separator to separate liquids and solids after the manure is digested

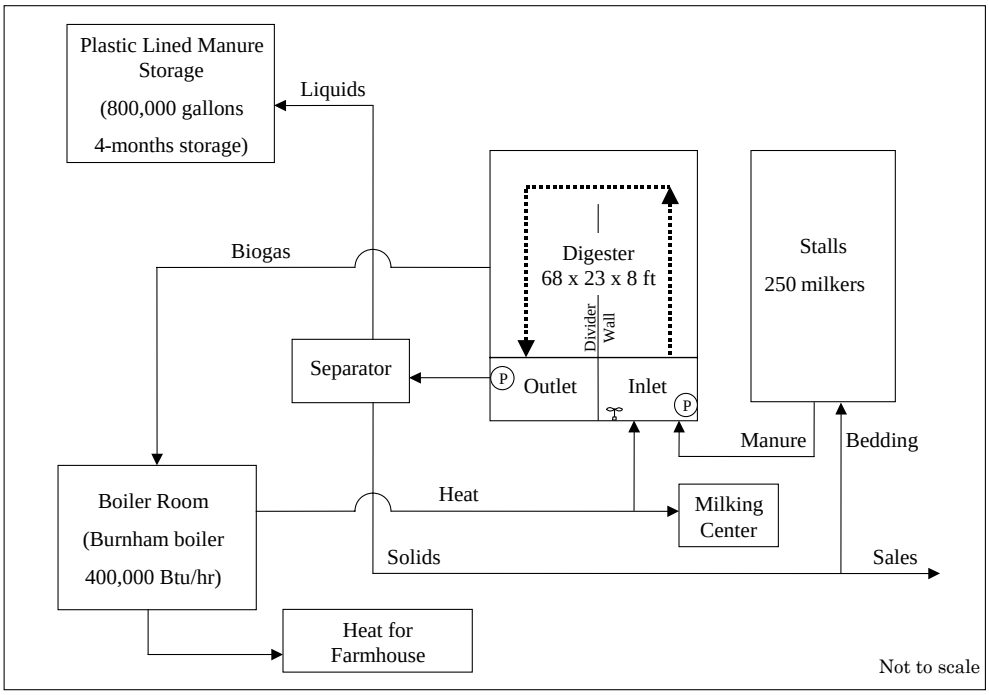

Figure 1. Schematic of Anaerobic Digester System on Freund Dairy.

With 250 cows on farm, the manure production is about 3,600 gallons daily. The dimensions of the digester are 62 ft. x 14 ft. x 8 ft., with a capacity of 13,800 ft.^{3} or 108,400 gallons. The digester has 4 in. of insulation on the floor and 6 in. foam board insulation on the sides. The base of the digester is concrete lined with rubber roofing to prevent leaks. The inlet chamber has 225 ft. of 2-inch tubing forming a picket dam. This is used in the winter to hold back frozen chunks of manure until they are thawed and heated before entering the digester. The mesaphillic (100ºF) digester is heated with 800 ft. of 2½ in. black iron pipe once in the digester. Manure flows into the digester down to the far end and back to the outlet around a 7 ft. high wooden divider wall. The retention time is 20 days. It is estimated that the biogas production is about 14,000 ft.^{3} per day, with a methane (CH_4) content of 60% and other byproducts such as carbon dioxide (CO_2), and trace gases like hydrogen sulfide (H_2S).

After failure of the original flexible cover, Freunds built an aluminum-framed greenhouse structure over the digester to collect and contain the biogas. This structure is not insulated. The walls are made from clear plastic attached with galvanized bolts. The inside gas temperature ranges from 100ºF – 120ºF in the summer, and does go down to 30ºF in the winter. Foam can be seen inside the structure, occasionally rising to 8 ft., but is typically 6-12 in. high.

The effluent from digester is separated into solids and liquids. The screw press separator is on the third motor, the second auger, and the fourth screen since installation in 1997. The solids are used as bedding material. The liquids are stored in a plastic-lined manure storage pond with a capacity of 800,000 gallons or 4 months storage. The plastic liner for the manure storage pond is used because the site is located on permeable soils near a creek. A Burnham boiler (400,000 Btu/hour) was installed to generate heat, using biogas. The generated heat is used to maintain the temperature of the digester to keep the methanogens at a high level of activity. The heat is also used for heating the milking center and farmhouse.

Economic Information

	Items	Cost/Benefit
Capital Costs	Digester - Digester Construction and Materials - Cover for digester - Pumps Subtotal	 $125,000 $20,000 $8,500 $153,500
	Boiler	$14,000
	Solids and Liquids Separation - Separator	$12,000
	Liquid Manure Storage	$55,000
	Engine Building	$3,000
	Pipeline	$4,000
	Meters	$6,000
	Others	$11,000
	Total Capital Cost	$249,500
	Total Annual Capital Cost	$28,367
Annual Operating Costs	Digester Maintenance	$5,000
	Separator Repair and Maintenance	$5,000
	Pumps Repair and Maintenance	$1,100
	Others (Maintenance, Repairs, Labor, Fuel, Insurance, etc.)	$5,784
	Total Annual Operating Costs *	$16,884
Benefits / Revenues	Saving on fuel for heating	-$1,000
	Selling compost	-$4,000
	Saving on bedding materials	-$7,000
	Total Annual Benefits	-$12,000
Total Annual Net Cost of the Digester System ($/year)		$33,250
Annual Net Cost Per Cow ($/cow/year)		$133

* Total Annual Capital Costs = Annual interest charge of 5% plus depreciation.
*** Spreading Costs are not included on this system. They are not materially different with the treatment system.

The economic analysis indicates that the total capital cost is $998/cow and the annual net cost is about $133/cow/year to stabilize, deodorize, and keep the manure from freezing to facilitate winter handling. The project received considerable amount of funding from governmental sources that is not considered in this analysis.

Environment Benefits

Since the installation of the anaerobic digester system on the Freund Dairy, the odor from manure handling and spreading has been greatly reduced. The nutrients in the manure are also controlled and the pathogens are also reduced.

Advantages and Disadvantages

Advantages	Disadvantages
- Odor Control - Energy Production - Fuel Saving - Energy Saving - Nutrient Management Ease - Pathogen Reduction - Manure handling ease	- High Capital Cost - Dedication to Digester System Management - Manure handling system must utilize the digester

Lessons Learned

The digester was designed with a center-dividing wall to move the manure down one side and up the other. During construction an opening was created in the dividing wall that allowed short-circuiting of the manure and little treatment and biogas production.

Utilizing the biogas to run a boiler to heat a grid of pipes allowed the farm to introduce frozen chunks of manure into a preheat chamber. As the manure is thawed the pipe grid keeps the frozen chunks from moving into the digester until they are melted.

Translucent ridged greenhouse material was used to cover the digester after the original fabric cover failed. The biogas is withdrawn from the digester under a slight vacuum to prevent leakage of biogas outside the digester. This allows observations of foam levels in the digester.

Who to Contact

- Matt Freund, Owner, 324 Norfolk Road, East Cannan, CT 06024. Phone: 860-824-0266
- Curt Gooch, Manure Treatment Specialist, PRO-DAIRY, Cornell Cooperative Extension. Phone: 607-255-2088 Email: cag26@cornell.edu
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