Haubenschild Manure Digester Study

Environmental Impacts and Economic Comparison of Alternative Dairy Systems

Profits from Manure Power? Economic Analysis of the Haubenschild Farms Anaerobic Digester

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Anaerobic digestion converts volatile organic substances in livestock wastes into methane, carbon dioxide, and water. The remaining material is stabilized, reducing odor during storage and land application. The need to more fully understand questions posed by digesters was spurred in Minnesota by the installation of a demonstration digester and electrical generator at the 800-cow Haubenschild Farms dairy farm north of Minneapolis/St. Paul in 1999.

This fact sheet represents the economic evaluation of the digester and related manure handling and electricity generation equipment if operated for ten years with no salvage value. The analysis considers the investment requirements for the digester, financing, labor requirements, and repairs and maintenance for the equipment involved, electricity sales and avoided purchases, LP gas avoided purchases, and other benefits perceived by the farm operator.

Investment Required and Financing Alternatives

The extra investment required for a digester system includes a mix tank and piping to control the flow of manure into the digester, the digester itself, the engine and electrical generator set, and miscellaneous costs such as engineering costs.

- The costs of these items for the demonstration digester in 1999 amounted to $355,000, or $444/cow for the 800-cow operation.
- In the five years since that time, the cost of building materials and farm machinery has increased by 19 percent according to USDA's index of prices paid by farmers. By those measures, the cost of a similar digester system would be $424,000 or $530/cow in 2005.
- Also, the Haubenschilds did some of the construction themselves, and the above costs do not include the cost of that labor. Other farms that hire all labor may experience higher costs. Costs of up to $1,000 per cow have been reported for digesters elsewhere. A sensitivity analysis shows how initial investment/cow would affect profitability (see Table 2 on page 6).

The costs and risks involved in the demonstration digester have been offset at least to some degree by the financial and technical assistance received from AgSTAR and from the state of Minnesota. Grants and in-kind assistance amounted to $127,500. The Minnesota Department of Agriculture also provided a $150,000 six-year, zero-interest loan.

Now that the demonstration digester has shown that an anaerobic digester can operate successfully, other operations considering digester systems in the future will probably not receive as much financial assistance as this farm has received. There are, however, four financial incentives that likely will be available to operations who install digesters in the future:

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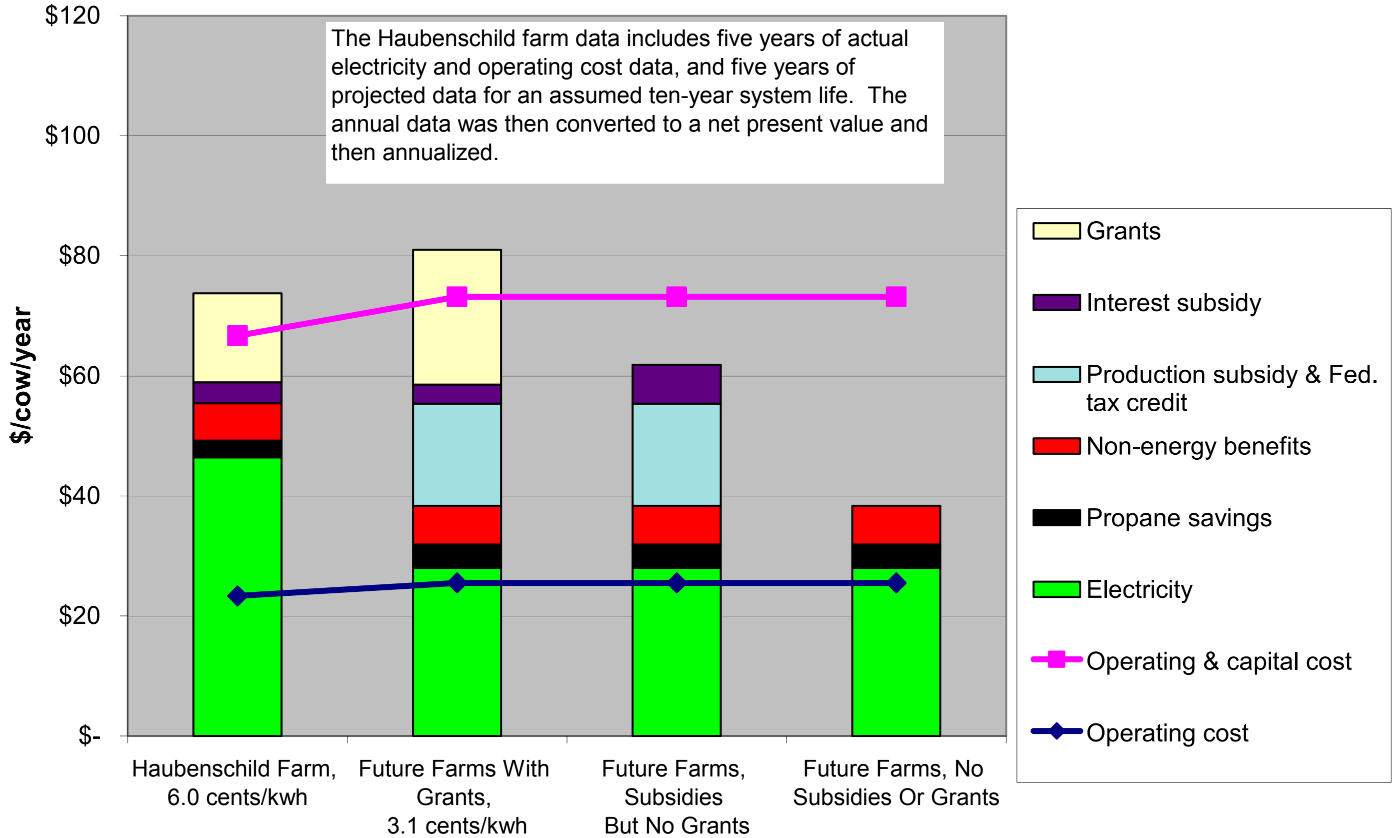
Methane Digester Costs and Benefits at The Haubenschild Farm and Possible Future Scenarios With and Without Government Subsidies



- The Minnesota Department of Agriculture has funds available to make additional zero-interest loans to three more pilot farms, with the maximum amount increased to $250,000 per farm.
- The Minnesota Department of Commerce has a 1.5 cents/kilowatt-hour (kwh) operating subsidy available. It is paid over a period of ten years to producers who generate electricity from anaerobic digesters that have started operations after July 1, 2001.
- The renewable energy section 9006 of the 2002 farm bill is another USDA source of grant funding for farm digesters. A total of 47 grants were made in FY03 for biomass projects, totaling $11.5 million. Grant availability under this program are for a maximum of 25 percent of the project cost, which would appear put a maximum of $88,750 or $120/cow for a project similar to the one discussed here. Funds are to be available through FY07 at $23 million/year. Additional grant funding may also be available from electrical utilities to help defray the cost of the electrical generation equipment.
- A five-year federal renewable energy credit of 0.9 cents/kilowatt-hour is available for digesters placed in service in 2005.

Energy Production Performance and Operating Costs

The successful financial performance of demonstration farm's digester system has been attributed to several main factors:

- higher-than-expected methane gas production rates,
- little maintenance downtime on the engine-generator set,
- the farm had been paying a fairly high price on electricity it had been purchasing from the local utility, the farm saved money by avoided purchases, and
- the farm has been able to sell its extra electricity back to the local electricity utility at a retail rate.

The demonstration farm's generator has been operating nearly all the time, averaging 98 percent over five years. Generator running time on other farms has often been less, so other producers considering digester investments might wish to consider a range of scenarios including some with lower generator runtime and/or lower gas output that might result due to management differences or other factors. Electricity sales have been 46% of the amount generated to date.

Operation and maintenance costs (O&M, mainly repairs and labor) averaged around $15,000/year over the first five years of operation. An engine replacement and generator repair in late 2004 will result in O&M costs of around $125,000 this year, however. The repairs also reduced the electricity output this year.

O&M costs for the remaining four budgeted years are projected at $25,000, under the assumption that repairs will be more costly than in the early years but that nothing as costly as the engine will be required. Operation and maintenance costs averaged over the ten years and adjusted for inflation to 2005 dollars are 3.1 cents/kwh on the case farm. That average O&M cost could be as much as 3.5 cents/kwh if additional major repairs are required or as little as 2.7 cents if repairs over the remaining years are minimal.

The expected O&M cost for future farms would be about the same as for the case farm. Future farms may avoid the roughly two hours of extra time/week that Mr. Haubenschild estimates that he devotes to educational activities related to the digester, but inflation would likely make up the difference. So, the 3.1-cent rate is also used in the “Future Farms” scenarios.

Valuing The Energy Benefits of The Anaerobic Digester System

Electricity prices offered by utilities to future farms will be lower than the concessionary rate offered by the utility for at least the first five years of operation of this demonstration digester. Also, not all farm operators will be as successful at keeping the generator running. How will the subsidy situation, electricity prices, and generator output affect the financial results of future digester installations?

Table 1 compares breakeven electricity prices with average prices received by the demonstration farm and projected for future farms. The breakevens are after adjusting for recovered waste heat used for heating the milking parlor. The electricity generated is valued at 7.3 cents/kwh for the first five and one-half years of the demonstration digester’s operation, and 3.56 cents for the remaining four and a half years. Adjusted for inflation, this averages to six cents in 2005 dollar terms. The three "Future Farm" scenarios are based on a flat price of 3.56-cent/kwh for all ten years, which averages 3.1 cents when discounted to 2005 dollars. The recovered heat to heat the milking parlor is valued at 75 cents/gallon for 1999-2003, and then increased to $1.15/gallon in 2004 with a 3% inflationary increase for future years.

These prices are used to value both the sales and avoided purchases. Purchase prices are typically more than this at peak demand times. However, these prices are used as a conservative estimate of purchase prices in the absence of a more detailed analysis of the peak/non-peak timing of purchases versus generation, and other considerations such as demand load charges.

Benefits Other Than Energy Production and Odor Reduction

The electricity production is well-documented but the farm operators feel that their operation is also benefiting in several other ways that are more difficult to document and value. They have been able to sell some digested manure because it smells less than raw manure. Timing of manure application is more flexible because part of the digestate is applied to alfalfa stubble with minimal risk of burning the plants. The green bars in the graph below show their estimates of these non-energy benefits.

Other benefits not valued at this point are odor control and possible reductions in weed seeds. Corn herbicide costs might be lower as weed seeds are killed during digestion. Experiments have thus far shown that immersion of weed seeds in the digester does not have a statistically significant impact on germination rates of most weed species, however. Further research is needed on the effect of digestion on weed seeds.

Cost-Effectiveness of a Digester Investment

The first bar on the graph and the first column of Table 1 show the results for this farm so far, with projections to the end of the ten-year planning horizon, in 2008. The second "Future Farms With Grants" scenario assumes that these financial incentives are utilized, with the USDA and utility grants assumed to be $200,000. On a per-cow basis, this would be around $250/cow compared to the $175/cow received for the demonstration farm. The $200,000 in grant funding assumed here for future farms with subsidies may be an optimistic estimate of the grant funding available at this time.

The remainder of the investment would need to be provided by debt obtained from commercial lenders at market interest rates, or from the farm's equity capital. The financial analysis below assumes that 22 percent of the investment is paid from the farm's equity capital, as for the demonstration farm. The remainder is financed from debt. An opportunity cost of 11 percent/year is charged on equity capital and a 7 percent interest rate is charged on debt borrowed from commercial lenders. This scenario also includes Minnesota's 1.5-cent/kwh production subsidy for all ten years and the new 0.9-cent federal renewable energy tax credit for the first five years.

The grants are perhaps the least certain of the financial assistance available and may require an arduous application process that some producers may be unable or unwilling to go through. The third "Future Farms With Loans and Production Subsidies" scenario omits the $200,000 in grants and increases the MDA zero-interest loan to its maximum of $250,000. The state production subsidy and the federal tax credit are also included. The fourth "Future Farms, No Incentives" scenario shows the situation if none of these incentives were available.

The two lines on the graph show the operating cost and maintenance per cow and the total with capital costs for the digester system. The bars show the value of the electricity produced, LP gas savings from heat recovery, non-energy benefits, and government subsidies and grants received.

Simple payback periods, net present value and internal rates of return on total assets and on equity after financing are shown at the bottom of Table 1. The net present value converted to an annual equivalent cash flow is a measure that can be compared to other odor control alternatives that may involve high annual maintenance costs but no investment. The breakeven electricity generation price for the Haubenschild digester situation, after crediting the non-energy benefits and subsidies, would have been 5 cents/kwh when it was installed in 1999. Adjusting for inflation since then would bring that amount to 5.6 cents/kwh in 2005 dollars.

The two lines on the graph show the total cost and operating cost per cow for the digester system. The "Future Farm" breakeven electricity generation prices range from 2.5 cents with the $200,000 in grants or 5.3 cents with only the loan, production subsidy and tax credit. Without the subsidies, 9.3 cents would be required for breakeven.

With the subsidies available to the next few pilot farms, a digester would be a breakeven proposition relative to total operating and capital costs. If digesters move beyond the subsidized pilot stage, however, a higher electricity price or substantial non-energy benefits would need to be sizable if the system is to be cost-effective.

Table 2 shows how the amount invested in a digester system would affect the cost-effectiveness of the investment, assuming the design and performance is similar to that of the demonstration farm but with the electrical prices and state and utility incentives that might be available to a farm installing a digester today. The first column, "Annualized Capital Costs", corresponds to the total cost line of the graph minus the value of the grants and interest subsidy sections of the graph bars. "Operating Returns" represents to the other benefits shown in the graph and corresponds to the height of the bar. "Annualized Net Present Value" is the difference between the returns and costs. The last column then puts this net on a rate-of-return basis.

Impact on Whole-Farm Financial Performance

The anaerobic digester is one of several enterprises of the dairy farm operation. It is a relatively small enterprise. The demonstration farm was modeled with and without investment in the methane digester. Net electricity sales and avoided purchases each accounted for only 1% of gross revenue on the demonstration farm (Table 3), making whole farm impacts of the digester small.

The addition of the $355,000 digester does not significantly impact whole farm performance, given the level of excess electricity sales. That is the farm is neither better nor worse off having invested in the methane digester, given the level of electricity production on the demonstration farm.

Conclusions

- The performance of the demonstration farm's anaerobic digester system to date looks profitable to date, attributed to two primary factors:
  - careful management by a motivated and detail-oriented manager who has achieved outstanding digester and generator performance, and
  - favorable electricity pricing by the local utility along with assistance from various government agencies due to the demonstration status of the system.
- While future installations will not be eligible for the grants and zero-interest loan the demonstration farm received and will likely not receive as high an electricity price, a new state production subsidy and

federal renewable energy credit appear to offer enough support to cover costs if performance is comparable to that of the demonstration farm.

- An electricity price of 8 to 10 cents /kilowatt-hour would probably be required to make a digester like this one a profitable investment, unless subsidized or unless the digester reduces odors or provides other benefits to the farm. Current subsidies such as a 1.5-cent state production subsidy and low-interest loans plus the other benefits would probably make this digester profitable at a price as low as 5 cents, or even as low as 2.5 cents if grants are obtained from both USDA and utility sources.
- From a whole farm perspective, investment in the methane digester does not impact whole farm financial performance. Additional electricity sales and lower fuel and utilities costs offset the increased cost of debt servicing of the investment in the digester.

Table 1. Comparative Analysis of *Energy and Other* Benefits of Digester System Scenarios with Varying Electricity Prices and State and Utility Incentives[a]

	Demonstration farm	Future Farms With Grants, Loans and Subsidies	Future Farms With Loans and Production Subsidies	Future Farms, No Subsidies or Grants
Investment Per Cow	**$444**	**$530**	**$530**	**$530**
Grants as % of Investment	**36%**	**47%**	**0%**	**0%**
Debt as % of Investment	**42%**	**31%**	**78%**	**78%**
MDA zero-interest loan	**$150,000**	**$131,400**	**$250,000**	**$-**
MN production subsidy	**$-**	**$0.015**	**$0.015**	**$-**
Federal energy tax credit (first 5 yrs)	**$-**	**$0.009**	**$0.009**	**$-**
Breakeven electricity generation price (in 2005 dollars), $/kwh	**$0.056**	**$0.028**	**$0.051**	**$0.080**
Average electricity price received (in current dollars), $/kwh	**$0.056**	**$0.036**	**$0.036**	**$0.036**
Average electricity price received (in 2004 dollars), $/kwh	**$0.060**	**$0.031**	**$0.031**	**$0.031**
Simple Payback Period, Years	**4**	**6**	**10+**	**10+**
Internal Rate of Return on Assets	**8%**	**8%**	**-4%**	**-13%**
Internal Rate of Return on Equity	**21%**	**20%**	**<-12%**	**<-12%**
Net Present Value of Return on Equity, Annualized	**$5,919**	**$5,035**	**$(9,947)**	**$(27,856)**
Change in milk production cost	**-0.4%**	**-0.3%**	**0.7%**	**1.8%**

[a] A 10-year planning horizon is assumed, starting on July 1, 1999 for the demonstration farm and January 1, 2004 for the other scenarios. The per-cow numbers are based on the current herd size of 800 cows feeding the digester. The herd size was smaller during the first two years of operation, so the ten-year average herd size is 735 cows. ***Other*** benefits include digestate sales, avoided pit agitation, and more flexible timing of manure application, but ***not*** herbicide savings or any value on odor control or carbon credits. All four scenarios assume electricity generation of 1,253 kwh/cow/year and propane savings of 4.6 gallons/cow/year. Operations and maintenance costs with labor are estimated at $0.031/kwh for all four scenarios (discounted to year one, with the Haubenschild value adjusted for inflation to 2005 dollars).

Table 2. Sensitivity Analysis of Financial Performance As Investment Varies, for a Future Digester with Current Grants, Zero-Interest Loans and Production Subsidies, Per Cow Basis[a].

Investment	Annualized Capital Costs[b]	Operating Returns[c]	Annualized Net Present Value[d]	Rate of Return to Equity
$400	$(18)	$31	$13	43%
$500	$(23)	$31	$8	24%
$600	$(28)	$31	$3	13%
$700	$(33)	$31	$(2)	5%
$800	$(38)	$31	$(7)	0%
$900	$(43)	$31	$(12)	-4%
$1,000	$(48)	$31	$(17)	-7%

[a] The values in this table correspond to the second column of Table 1 and the second bar of the graph.

[b] "Annualized Capital Costs" corresponds to the total cost line of the graph minus the value of the grants and interest subsidy sections of the graph bars.

[c] "Operating Returns" represents to the benefits shown in the graph other than the grants and interest subsidy.

[d] "Annualized Net Present Value" is the difference between the returns and costs and corresponds to the second line from the bottom of Table 1, converted to a per-cow basis.

Table 3: Whole Farm Financial Performance of Digester System Scenarios with Varying Electricity Prices and State and Utility Incentives

	Demon-stration farm without digester	Demon-stration farm with digester	Future Farms With Grants, Loans and Production Subsidies	Future Farms With Loans and Production Subsidies	Future Farms, No Subsidies or Grants
Average electricity price (in current dollars), $/kwh		**$ 0.056**	**$ 0.036**	**$ 0.036**	**$ 0.036**
Average electricity sale price (in 2005 dollars)		**$0.056**	**$0.031**	**$0.031**	**$0.031**
Excess electricity sales		**$39,687**	**$26,548**	**$26,548**	**$26,548**
Gross revenue	**$3,295,492**	**$3,335,179**	**$3,321,950**	**$3,321,950**	**$3,321,950**
Net Farm Income	**$485,423**	**$509,970**	**$496,741**	**$492,315**	**$475,698**
Interest Expense	**$229,127**	**$229,127**	**$229,127**	**$233,554**	**$250,170**
Total cash expenses	**$2,589,261**	**$2,568,901**	**$2,568,901**	**$2,573,327**	**$2,589,943**
Rate of Return on Assets	**13.5%**	**13.3%**	**12.9%**	**12.9%**	**12.9%**
Rate of Return on Equity	**23.3%**	**23.2%**	**21.8%**	**23.7%**	**22.9%**
Asset Turnover Ratio	**37.1%**	**35.7%**	**35.5%**	**35.5%**	**35.5%**