

PART B: ECONOMIC VIABILITY OF ALTERNATIVE DAIRY SYSTEMS

Part 1: Capital budgeting analysis of the digester and related manure handling and electricity generation equipment

Introduction

The need to more fully understand questions posed by anaerobic digesters was spurred in Minnesota by the installation of an anaerobic digester system at Haubenschild Farms, an 800-cow, 1000-acre dairy farm an hour north of Minneapolis/St. Paul. In 1999, the farm installed a heated plug flow digester with a 130-kilowatt engine/generator to utilize the biogas. The successful operation of this facility (the generator has been running over 98% of the time since start-up) has resulted in much interest from policy-makers as to the applicability of digesters to other animal feedlot operations in the state. Also, there were claims by the digester industry of the superiority of digested manure, with only anecdotal evidence to support them, and there was a desire to more fully investigate these claims.

In 2000, The Minnesota Project, a non-profit environmental and rural development group, was the recipient of a 4-year U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) grant to look into several questions related to the environmental performance and financial feasibility of anaerobic digesters at dairy farms, as compared to alternative dairy systems. Specifically, the project had three objectives:

1. Compare effects of soil quality, crop growth and nutrient uptake for three nutrient sources – commercial fertilizer, undigested manure and digested manure;
2. Determine weed seed survival as affected by manure handling; and
3. Conduct an economic evaluation of alternative manure management systems on dairy profitability.

The Minnesota Project contracted with several partners from the University of Minnesota to conduct much of this work. More information on the Haubenschild Farm and this grant is available at www.mnproject.org

Economic Analysis of the Digester System

This section presents one component of a two-part economic analysis being conducted under the EQIP project. The component is a partial, capital budgeting analysis of the digester and related manure handling and electricity generation equipment. The analysis is "partial" in that it assumes that the rest of the modern, confinement dairy operation (currently at 800 milking cows and 1,000 acres of cropland) would remain the same if the digester were absent. The analysis considers the investment requirements for the digester, financing, electricity sales and avoided purchases, LP gas avoided purchases, labor requirements, and repairs and maintenance for the equipment involved. This analysis is based on performance data from the farm through October, 2003.

The other component of the economic analysis will be a whole-farm comparison of the Haubenschild confinement dairy operation to a different dairy farm that is using rotational grazing. The whole-farm comparison will look at profitability issues such as the impact on rates

of return on assets, and liquidity and solvency measures, and will be carried out using the FINPACK farm financial analysis software.

The present capital budgeting analysis of the digester is implemented in an Excel spreadsheet template and has two general objectives. The first objective is to document the economics of the case farm's digester system, which is unique in certain respects. Its economics are affected by the fact that, as a demonstration facility, it was financed partially through grants that would not be available to later farms, and the electricity both no longer purchased by the farm and that sold back to the utility receives an advantageous price. Also, Mr. Haubenschild has taken a great deal of interest in managing the digester, and has recorded gas and electricity production levels that seem relatively high compared to similar digesters elsewhere.

The other objective is to compare the demonstration farm against scenarios representing the economics of a digester system that another farm might install in the future. Future installations may be able to match or surpass the demonstration farm's performance, or may be less successful. So, one of the future scenarios is based on the demonstration farm's production while the other two consider biogas performance at 80 and 60 percent of that level. The 60 percent level was based on averages calculated from the profiles of the 12 older dairy farm digesters profiled in Roos and Moser. LP gas savings and operating costs for the lower biogas production level scenarios are based on suggested planning numbers from Roos and Moser's Farmware software.

Case Farm Digester System Investment and Financing

The additional investment required for a digester system above and beyond a conventional manure 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 amounted to \$355,000 or \$444/cow (Table 1, from Nelson and Lamb, 2000, p. 17). In the five years since this digester was installed (August 1999 to August 2004), the cost of building materials has increased by around 10% while farm machinery has increased by 17%, according to USDA's index of prices paid by farmers. By those measures, the cost of a similar digester system would have risen around 14% to \$506/cow or \$405,000 in 2004.

The case farm faced a certain amount of financial risk when they invested in the digester technology, and have had to devote a considerable amount of time to the planning, communications, and bureaucracy associated with serving as a demonstration site. These costs and risks have been offset at least to some degree by the financial and technical assistance they

received from AgSTAR and state programs. The grants and in-kind assistance amounted to \$127,500, or 36 percent of the investment. In addition, the Minnesota Department of Agriculture provided a \$150,000 six-year, zero-interest loan.

Without the demonstration status of the case farm, other operations considering digester systems in the future will probably not receive as much financial assistance as the case farm has received. There are four financial incentives that apparently will be available to operations who install digesters in the future, however:

- 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 (Boerboom).
- An operating subsidy of 1.5 cents/kilowatt-hour (kwh) is available from the Minnesota Department of Commerce to be paid over a period of ten years, to producers who generate electricity from anaerobic digesters that have commenced operations after July 1, 2001 (de Fiebre).
- 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 is 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. Grants are also reported to be available from electric utilities to help defray the cost of the electrical generation equipment.
- A federal renewable energy tax credit of 0.9 cents/kilowatt-hour is available for digesters placed in service in 2005.

Table 1 shows three scenarios that might represent farms installing digesters in the future in addition to the case farm situation. In one scenario, the future farm receives \$200,000 in grant funding from sources such as the farm bill and a utility as well as the zero-interest loan, the state operating subsidy and the tax credit. The second scenario includes the zero-interest loan, the state operating subsidy and the tax credit but omits the grants. The final scenario omits all of these financial incentives. As operating subsidies, the operating subsidy and the federal credit are not shown in Table 1 but are shown in later tables of operating performance.

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 case 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.

Energy Production Performance and Operating Costs

The financial performance of case 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, so it has saved quite a bit of money by avoiding those purchases, and
- it has also been able to sell its extra electricity back to the local electricity utility at the same high price as it had been paying.

The case farm manager has kept a weekly log of generator operation and gas and electricity production, which was used to calculate the summary numbers shown in Table The case farm's generator has been operating nearly all the time, averaging 98 percent over five years. A benchmark of 95% is used in the financial analysis for projecting the case farm's performance into future years.

Generator running time on other farms profiled by Roos and Moser appeared to average only 62 percent, based on rough calculations based on numbers provided on generator size and estimates of electricity production. On at least one farm, the generator was apparently operated only as needed to meet the farm's electricity needs, because the price offered by the utility was not high enough to make generation for sale worthwhile. Hence, a low runtime performance may be due to the economic situation rather than any unreliability or lack of maintenance. To reflect this history on other farms and the possibility that digester management on future farms may be less intensive than here at the case farm, other scenarios were also analyzed assuming only 80 or 60 percent of this farm's electricity generation performance

Table 1. Investment Requirements and Financing Arrangements on the Case Farm and Assumptions about Future Operations

Item	800-Cow Case Farm	Future Pilot Projects with Grants	Future Pilot Projects, No Grants	Post-Pilot Farms
<i>Capital Investment Items</i> (beyond what would have been required for a conventional manure handling system):				
Mix tank/manure collection	\$32,400	\$36,963	\$36,963	\$36,963
Digester	125,100	142,720	142,720	142,720
Energy conversion (engine and generator)	157,500	179,683	179,683	179,683
<u>Miscellaneous</u>	<u>40,000</u>	<u>45,634</u>	<u>45,634</u>	<u>45,634</u>
Total investment	\$355,000	\$405,000	\$405,000	\$405,000
<i>Financing:</i>				
<u>Grants</u>				
AgSTAR technical assistance	\$40,000	\$-	\$-	\$-
Minnesota Office of Environmental Assistance	\$37,500	\$-	\$-	\$-
Minnesota Department of Commerce	<u>\$50,000</u>	\$-	\$-	\$-
Possible utility subsidy on generator, \$400/kw		<u>\$200,000</u>	<u>\$-</u>	<u>\$-</u>
Total grants	\$127,500	\$200,000	\$-	\$-
Percent of investment covered by grants	36%	49%	0%	0%
Net investment required from farm equity or debt capital	\$227,500	\$205,000	\$405,000	\$405,000
<u>Equity Capital</u>				
Amount	\$77,500	\$77,500	\$77,500	\$77,500
Percent of investment paid out of equity capital	22%	22%	22%	22%
Opportunity cost interest rate on equity capital	11%	11%	11%	11%
<u>Loans</u>				
Percent of investment from debt	42%	29%	78%	78%
Subsidized MDA zero-interest loan	\$150,000	\$ 127,500	\$250,000	-
Unsubsidized from commercial lender		\$-	\$ 77,500	\$ 327,500
Interest rate on commercial loan		7%	7%	7%

SOURCES: The case farm data is from Nelson and Lamb, 2000. The data on MDA zero-interest loans for future pilot farms is from Boerboom.

Electricity generation is shown in Table 2 as kilowatt-hours (kwh) generated and either used on the farm or sold, per cow based on the 800 cow herd size reached in the third year of operation. The first electricity was generated in September, 1999, so the 1999-2000 number of 1,670 kwh/cow/year represents somewhat less than a full year. The first full year of operation was 2000-2001, when 2,063 kwh/cow was produced. Electricity generation per cow during 2000 calendar year was somewhat higher than the July-June averages shown, but the per cow average declined in 2001 probably as a result of reaching the maximum generator capacity as the herd grew, averaging 1,295 kwh/cow/year for 2001-2002. The output was down slightly in 2004 to 1,155 kwh/cow due to a repair, which works out to a five-year average of 1,253 kwh/cow. That average is projected to continue for the remaining 5 years of the 10-year planning horizon.

The generator runtime efficiency and particularly the electricity generation are above the benchmarks. Electricity generation is almost twice as great. The higher generator runtime efficiency accounts for most of the increase. The other main factor thought to explain the increased gas and electricity production is the additional volatile solids entering the case farm's manure system in the form of recycled newspaper that is being used to bed the farm's freestall barns. Maintaining an adequate volatile solids level of 10 percent can be challenging on many dairy farms.

The amount of LP gas purchases avoided through use of the methane gas and waste heat from the digester system is the most difficult performance number to estimate for the case farm. The farm manager is recording the amount of LP gas used as a backup heat source. Also needed is an estimate of the LP gas that would have been used if the digester were not in place, however, and that information is not available. The Farmware default benchmark is 10.8 gallons of LP gas/cow/year. The case farm manager was forced to use LP gas to heat the milking parlor and cow holding area for the month of January, 2002, because of a breakdown in the digester system's heat exchanger. On the basis of that one month's data, we estimate that the LP gas savings for the most recent year are 10.5 gallons/cow. The farm recorded more LP gas during the first two years than it did for 2001-02, so less savings are credited for those years for a ten-year average of 9.1 gallons. The avoided LP gas purchases are priced in the financial analysis at 75 cents/gallon for the case farm for the first five years. Global oil prices rose sharply in 2004, however, so the "future farms" scenarios are based on a price of \$1.15/gallon in year one. The case farm LP price is also increased to that level in the sixth year. Prices for years later than 2004 are increased at three percent per year.

The farm manager estimates that the digester requires around one hour/day for monitoring and maintenance. The system has been so popular, however, that he also spends around two hours/week handling inquiries and giving tours. Those two time commitments then come to an average of 1.3 hours/day or 469 hours/year, which are factored into the analysis at an opportunity cost of \$20/hour placed on the manager's time. The case farm's 469 hours/year of operator labor was valued at an opportunity cost of \$20/hour for year 1 and inflated at the same 3 percent rate for the other years.

The case farm did not record any significant repair costs for the first two years, although engine oil and filters cost an estimated \$1,258/year. The third year saw repairs totaling \$13,150. Repair costs were less in the fourth or fifth years, so that operation and maintenance costs (or O&M, including both repairs and labor) averaged around \$15,000/year over the first five years of operation.

A coupling broke between the engine and generator early in the sixth year (2004-05). A new engine was installed at that time to avoid downtime later, although the original engine was still operating. That repair along with a pump replacement has cost around \$110,000 in addition to roughly 200 hours of operator labor. With the labor and normal maintenance, O&M costs will total around \$125,000 this year. 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 2004 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.

Electricity Pricing

Electricity pricing and interconnection requirements for connecting small electricity production sites to utility grids are complicated issues which can "make or break" a project financially. Two sources of information about these issues are Helgeson and the Ratevision section of the handbook by Roos and Moser.

The case farm is producing roughly twice as much electricity as the farm consumes, with the excess (46% to date) sold to the local utility cooperative. The case farm was able to negotiate a favorable five-year contract with the utility whereby they were able to sell this extra electricity at the same 7.25 cents/kwh that they would have paid to purchase electricity in the absence of the digester system. The rate increased to 7.3 cents as of January 1, 2001 (Nelson and Lamb, 2002). That contract will expire in 2004.

Electricity pricing for future farms appears far from certain. The two utilities that provide electricity to most of rural Minnesota are Alliant Energy and Great River Energy. Speakers from both utilities spoke at an August, 2002 workshop in St. Cloud, Minnesota and described the purchase prices they were offering for biogas-generated electricity at that time. Alliant Energy serves parts of southern Minnesota, with Great River serving much of the rest of the non-metro parts of the state. The speaker for Alliant Energy mentioned a price of 6 cents/kwh (Johnson). In a later conversation, however, the speaker indicated that the 6-cent price is available to only a few Wisconsin demonstration digesters, due to state-mandated programs in Wisconsin. In the absence of a special regulatory arrangement, Alliant would arrive at a price for digester electricity based on what they are paying for conventional sources, which would currently be in the range of 1 to 1.5 cents/kwh.

The Great River presentation mentioned a choice of contracts of 5, 10, or 20 years in length. For each contract length, there are further choices of either a constant price or one which increases over time (Selander). For the sake of simplicity, the projections below are based on the 10-year, levelized constant price of 3.56 cents for both avoided purchases and sales offered by Great River Energy as of June 3, 2004.

In the projections below, scenario 1 assumes that the case farm will receive the 3.56-cent price for both avoided purchases and sales for years 6 – 10. Scenarios 2 and 3 are also based on the 3.56-cent price. Scenario 2 also assumes a \$400/kw generator subsidy (\$56,000 total for a generator similar to the case farm's 140-kw unit), while scenario 3 omits that subsidy.

Table 2. Actual and Projected Performance and Operating Costs for the Case Farm's Anaerobic Digester, Compared to Benchmarks Based on Earlier Digesters ^a.

	1999-2000	2000-01	2001-02	2002-03	2003-04	Projected		Older Installations ^c
						2004-05	2005-09	
Cows in milking herd, number	400	550	800	800	800	844	800	980
Biogas produced, ft ³ /cow/day	122	130	85	88	84	84	88	57
Electricity generated, kwh/ft ³ of gas	0.0393	0.0436	0.0418	0.0410	0.0410	0.0393	0.0410	0.0373
Generator running time, % of total	98.6%	99.0%	98.4%	99.1%	97.2%	93.4%	95%	62%
Electricity generated, kwh/cow/year	1,670	2,063	1,295	1,314	1,248	1,099	1,239	745
Reduced LP gas use, gal./cow/year	7.25	8.11	10.53	10.53	10.53	10.53	10.53	10.8
Extra Labor Required, hrs/day	1.3	1.3	1.3	1.3	1.3	1.8	1.3	1.6
Repairs and Maintenance Not Including Operator Labor, \$/year	\$1,258	\$1,258	\$13,150	\$5,563	\$5,247	\$110,000 ^b	b	-
Operations and Maintenance Including Operator Labor, \$/year	\$10,638	\$10,919	\$23,101	\$15,929	\$16,114	\$125,514 ^b	b	\$10,677
Operations and Maintenance Including Operator Labor, \$/kwh	\$0.0159	\$0.0093	\$0.0210	\$0.0139	\$0.0143	\$0.1232 ^b	b	\$0.0146

^aThe performance numbers are calculated based on a year running from July 1 to June 30, in order to provide a roughly 12-month yearly period for the cash flow calculations that includes the construction period of summer and fall, 1999.

^bRepair and maintenance cost for 2004-05 includes a new engine. Repairs and maintenance costs for the remainder of the planning horizon, 2005-09, are inflated using a projected inflation rate of 3%/year.

^c"Older installations" are averages for 12 dairy farms profiled in Roos and Moser, except for reduced LP gas use which is based on Farmware default data. Not all farms reported information on all parameters. Generator running time on the profiled farms of 62% is based on numbers provided on generator size and estimates of electricity production. Electricity generated on the profiled farms averaged 745 kwh/cow/year. On at least one farm, the generator was operated at less than full capacity because the price offered by the utility was not high enough to make generation for sale worthwhile.

The 3.56-cent price implies that if a future farm were to generate twice as much electricity as it uses, and if it paid 7.3 cents for the usage while receiving 3.56 cents for all of the generated electricity, the sales revenue would be less than the payment and it would end up still owing the utility a net payment despite the fact that it is generating twice its usage in physical terms. This may seem unfair from the producer's viewpoint, but the logic from the utility's point of view relates to the expected pattern of usage between peak and non-peak time periods. Much of the generated electricity is expected to occur during non-peak times, while usage is more likely during peak times. Actual pricing arrangements that future farms negotiate would likely consider load patterns explicitly and might result in an average price higher than the 3.56 cents assumed here.

Again, while the scenarios discussed below are based on the data from these two presentations by utility representatives, our understanding is that these prices and terms are subject to change and may be different by the time you read this. Check with your utility representative for the latest information before basing any decisions on this analysis.

Benefits of the Digester Other Than Energy Production

Economists who evaluate new technologies frequently must decide how reliable the purported benefits are and when they are sufficiently well-documented to include in the analysis. Proponents of the technology are often enthusiastic about performance, while others are more skeptical.

While the electricity production is the best-documented aspect of the digester system, the Haubenschilds feel that their operation is also benefiting in several other ways. The main benefits that they have observed are:

- some digested manure is being sold to a neighbor,
- less agitation is required for the manure storage pit before starting to empty it,
- more flexible timing of manure application because part of the digestate is applied to alfalfa stubble with minimal risk of burning the plants,
- some manure is being sold to a neighbor,
- fewer broadleaf weed problems are occurring on the corn, making it possible to avoid a post-emergence herbicide application,
- Fewer complaints from neighbors about odor after spreading, and
- Possible future carbon credits

An explanation of each benefit is provided below:

Sales or Utilization of Digestate

Mr. Haubenschild has been selling digestate to a neighbor for several years. In 2002, he replaced a smaller tank applicator with a 4,000-gallon one. He charged \$100/load in 2000 which

includes the digestate and applicator, with the purchaser supplying the tractor and operator. He sold 17 loads in 2000 for a total of \$1,700.

Mr. Haubenschild feels that he would not have been able to sell that as raw (undigested) manure, so he credits the entire \$1,700 to the digester. If one were to assume that a buyer could have been found to purchase the raw manure at its fertilizer replacement value, it would have been worth \$47/load at an analysis of 38-13-34, 75 percent availability, and N, P and K prices of \$0.20, \$0.28, and \$0.13. The value added by the digestion process would then have been \$53/load, or a total of \$901. But that is somewhat hypothetical if, as Mr. Haubenschild believes, the neighbor is not willing to buy raw manure, perhaps because of odor concerns. These calculations, then, suggest valuing annual digestate sales at between \$900 and \$1,700. Sales in 2004 were only \$200, however. So, a ballpark estimate of \$1,000/year is used in this analysis. The number used in the model is $(\$1,000/800 \text{ cows}) = \$1.25/\text{cow}$ for year 1, with later years inflated at 3%/year.

The other possible benefit cited in some digester studies is utilization of solids separated after digestion, composted and then used as bedding in the dairy barn free stalls (see, for example, Kramer). The case farm has access to paper for bedding so is not interested in this, but it was considered as a possible benefit in the future farm scenarios. Mr. Haubenschild has heard other farm operators estimate annual bedding costs of \$19/cow, which would amount to a savings of \$15,200/year for an 800-cow dairy operation. One concern about using composted solids for bedding is that enough pathogens might remain to cause increased mastitis problems. Aside from that, however, an additional investment would be required for the manure separator and composting site, which he estimates would be around \$80,000 for a fan-type separator. Additional operating expenses would also be involved. A University of Minnesota analysis found that a screen-type separator for a 500-cow dairy farm would cost around \$30/cow in annual capital ownership (\$17.41), operating (\$7.35), and labor (\$5.33) costs. Newer separator designs may operate more reliably and efficiently than the one considered in that study, but still it appears that the benefits would need to be greater than \$19/cow for separation to be economical. So, the bedding option has not been included in the future farm scenarios.

Reduced Pit Agitation Before Emptying

Mr. Haubenschild feels that as a result of solids breaking down in the digester, the digestate develops less of a crust in the outside earthen manure storage pit than raw manure would. The lack of a crust allows him to begin loading the liquid digestate into his applicators without agitating first. If the pit had a normal crust, he would have to agitate with two 130-horsepower tractors and pumps (one at each end of the pit) over two 12-hour days before

emptying. At an estimated cost of \$26/hour (from Lazarus and Selley), this amounts to an annual savings of \$1,248.

Digestate Application to Alfalfa

The crop mix on the case farm includes corn and alfalfa. In 2002, the acreage was 678 acres of corn and 277 acres of alfalfa, for a total of 955. Both the corn and the alfalfa have been receiving around 6,000 gallons of digestate per acre, with the alfalfa application being split into three separate applications each made within a few days of each cutting. Mr. Haubenschild feels that the digestate has less potential to burn the regrowing alfalfa than raw manure would. If he did not have the digester, he might still apply some manure to the alfalfa but would have to do it more quickly after each cutting to avoid problems.

Valuing this consideration is difficult. U of M agronomists feel that additional research is needed to determine how much difference in burning potential there really is. In the absence of that definitive research, we have done a rough calculation under the assumption that the 30 percent of the digestate now going on the alfalfa were instead sold to a neighbor for half of the application cost. He has estimated that his alfalfa fields are an average of 1.2 miles from the facility, slightly closer than his corn fields which average 1.8 miles away. One disadvantage of applying to the alfalfa is that the N in the digestate is basically wasted. Still, the P and K are needed on the alfalfa (assumed to require 50 pounds of P and 180 pounds of K per acre).

Valuing the digestate at what it would save in commercial fertilizer minus its application cost at a 1.2-mile hauling distance comes to \$10,249/year, using the model from Lazarus and Koehler. If he were to haul it 1.8 miles instead and apply at the 6,000-gallon rate, the application cost is estimated at \$6.79/1,000 gallons. If he were able to sell it for enough to recover half of that amount, it would come to \$3.40/1,000 gallons or \$5,349/year. So, the additional value resulting from the alfalfa application instead selling it, is the difference (\$10,249 - \$5,349) or \$4,900/year.

Agronomists are unsure about how much difference digestion makes when applying manure to alfalfa, and whether alfalfa should receive manure at all given that the N is not needed by that crop. Further research is needed to determine how likely these non-energy benefits are to occur in a typical installation. So, the magnitude of these non-energy benefits should be viewed cautiously for now.

Reduced Broadleaf Weed Problems

Mr. Haubenschild has observed that he has less severe weed problems on his digestate-receiving land than is the case on other cropland he farms or observes elsewhere in the area. Proso millet, in particular, seems to be less of a problem. Lambsquarters and velvetleaf are other weed species that may be affected, although he does not see much of the latter. His herbicide

program includes a pre-emergence herbicide, and then if broadleaf weeds emerge later he comes back with a post-emergence herbicide that costs around \$30/acre. That second application was not necessary last year and may not be needed this year. Other land he rents at another location which does not receive digestate, has weed problems this year and will need the second herbicide application. He believes that the difference may be that the weeds may germinate more quickly in the spring on the digestate-treated land as a result of going through digestion, and be killed by the pre-emergence herbicide.

If the \$30/acre savings estimate is accurate, the benefit will be substantial. His 2003 corn acreage is 770 acres, so a herbicide savings of \$30/acre amounts to \$23,100/year in additional benefit. That is still less than the value of the electricity that the case farm is producing, but is almost as much as the electricity might be worth to future farms selling at a 3 cent/kwh rate or at a lower output rate. However, 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 (see Nelson, Allen and Katovich). So, the possible herbicide savings are not factored into the economic comparison below, pending additional documentation.

Fewer Odor Complaints and Possible Carbon Credits

The desire to be a good neighbor and avoid odor complaints from residences near the facility was one of the main reasons for installing the digester. The scope of this project did not extend to valuing that benefit, however.

Credits for carbon sequestration or emissions reductions are another possible future benefit which has not been valued in this analysis. The Chicago Climate Exchange (CCA) has recently begun trading carbon dioxide futures contracts (see http://www.chicagoclimatex.com/trading/stats/monthly/st_0409.html for details). The contract prices are for reductions that the exchange members make in their CO₂ emissions relative to a 1998-2003 base. The exchange members agree to reduction targets. Then, if a member misses a target, that member could purchase the right to emit the extra amount from another member that has reduced an emission by more than their target. There are only a few members of that exchange at this time and they tend to be large corporations rather than farms. So, the idea of a dairy farm generating cash income by selling CO₂ reductions to exchange members who have missed targets is obviously speculative at this point. However, given the public interest in this topic, we have estimated the potential carbon credit value a future farm might generate based on the 2002 methane digester gas output recorded at the case farm, using the September 2004 average Chicago Climate Exchange CO₂ futures price for delivery in 2005 or 2006. The estimated value is \$825/year, assuming the farm were show a reduction in emissions compared

to the 1998-2003 base or some other arrangement. Because the case farm's digester went into operation in late 1999, the present operation would not result in CO₂ reductions compared to a 1998-2003 base even if a marketing arrangement were to be set up. Future digester installations, however, might be able to document reductions required to potentially capitalize on this revenue source.

Biogas generated/day, 2002 average, cu. ft.	68,605
Biogas generated/year, 2002 average, 1,000 cu. ft.	25,041
Methane % in biogas	60%
Methane generated/year, 2002 average, 1,000 cu. ft.	15,024
Methane volume to wgt conversion, cu ft./metric ton	48,700 ^a
Methane generated/year, 2002 average, metric tons	309
CO ₂ greenhouse equivalent of methane	18.25
CO ₂ equivalent burned in 2002, metric tons	5,630
Futures price for delivery in 2005 or 2006 on the CCA, average for Sept. 2004, per metric ton CO ₂	\$ 0.96 ^b
Potential value of methane burned if sold on CCA	\$ 5,405

^a <http://www.eia.doe.gov/emeu/iea/tablec1.html>, assuming natural gas

^b http://www.chicagoclimatex.com/trading/stats/monthly/st_0409.html

Total Non-Energy Benefits

The total of the digestate sales (based on \$2.13/cow), the \$1,248 in avoided pit agitation, and \$4,900 in avoided alfalfa fertilizer is \$7,848/year for year 1. Later year values increase at the 3% inflation rate, plus the digestate sales amount is increased as the herd increases to 800 cows in year 3.

Tax Considerations and Capital Pricing

The economic analysis is carried out on an after-tax basis. A marginal tax rate of 35 percent is used for all scenarios, representing both U.S. and Minnesota income taxes. The digester system is assumed to be classified as a "single-purpose livestock structure" for depreciation purposes, except for the engine-generator set which is classified as "farm machinery". The tax deductions for depreciation are based on a year 2001 declining-balance GDS schedule with a half-year convention, over seven years for the engine-generator and 10 years for the rest of the system.

A 10-year annual cash flow was calculated in the Excel template and compared against one calculated by the Farmware program. The cash flows compared very closely, with the exception of the depreciation expenses. Farmware allocated more of the depreciation to the first few years. Farmware was published in 1997, so we suspect that the discrepancy may be due to a change in the tax rules depreciation between 1997 and 2001. The Farmware documentation does not discuss their assumptions about depreciation, so we are not sure.

Taxability of government incentives for renewable energy such as the 1.5-cent state production subsidy is unclear at this time. The Internal Revenue Service has form 6497 for government agencies to use to designate energy grants or subsidized financing as nontaxable, apparently at the agency's discretion. The form instructions state: "Grants are always taxable to recipients unless specifically exempted by the Federal statute authorizing the grants." On that basis, the production subsidy is assumed to be taxable for the purposes of this report.

Comparative Economic Analysis

Three likely future scenarios are compared with the case farm's economic performance in and Figure 1 and Table 3. They consider the values of the energy (electricity and heat) produced from the digester and the non-energy benefits discussed above (digestate sales, avoided pit agitation, and alfalfa application), if the possible herbicide savings are not considered.

Scenario 1 represents the case farm, with five years of actual performance and projections for another five years of a ten-year planning horizon, with both avoided electricity purchases and sales priced at 7.29 cents/kwh for the first two years, 7.3 cents for years three through six, and 3.56 cents for the last four years. When these prices are adjusted to 2004 levels based on recent inflation rates, they average 5.7 cents/kwh in 2004 dollar terms. The "Future Farms" scenarios 2 and 3 are based on Great River Energy's projected 10-year constant price of 3.56 cents/kwh, but the real purchasing power of those prices in the later years will be less if there is inflation. Discounting those prices back to a 2004 present value at 3 percent/year results in an average of 3.1 cents/kwh in 2004 dollars. Electricity production for all four scenarios is as shown in Table 2, and averages 1,253 kwh/cow/year.

"Future Farms With Grants, Loans and Subsidies" scenario 2 includes the \$200,000 USDA and utility grant amounting to 49 percent of the total system's investment. The remaining investment is assumed to be provided as 29 percent debt and 22 percent equity, which is the same ratio as for the case farm. The debt capital is in the form of a \$127,500 zero-interest loan from the Minnesota Department of Agriculture. The 11 percent opportunity cost is charged on the equity capital. This scenario also includes the 1.5-cent state production subsidy and the 0.9-cent federal renewable fuel tax credit.

The "Future Farms with Loans and Production Subsidies" Scenario 3 omits the grants but includes the other incentives. The MDA loan increases to the maximum \$250,000, with the remaining \$77,500 from a 7 percent commercial loan. Scenario 4 omits all of the financial incentives to reflect a situation that might prevail once the biogas concept moves beyond the

pilot phase. It leaves out the utility generator grant and assume that all of the debt comes from a commercial lender at a 7 percent rate.

Several different decision criteria were examined in the analysis:

1. Simple payback period,
2. Internal rate of return (IRR) on assets and on equity capital, ignoring any value on the investment beyond ten years,
3. Net present value (NPV) on equity capital
4. NPV converted to a constant annual cash flow equivalent
5. Debt servicing cost, \$/cwt of milk
6. Additional capital debt repayment capacity resulting from the benefits, as a percentage of the amortized capital service cost of the investment, and
7. Change in the milk production cost, \$/cwt.

Brief explanations of these criteria are as follows:

The *simple payback period* is the expected years required to recover the original investment. The simplicity of this measure is appealing, but it is criticized by academic economists because it does not consider preferences that most people have for receiving money in the near future rather than later on (referred to as the “time value of money”). The IRR and NPV are preferable from that standpoint, but are more complex. The NPV is the sum of the cash inflows and outflows (CF) over expected n years of project life, discounted at the project’s cost of capital k,

$$NPV = CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \dots + \frac{CF_n}{(1+k)^n} = \sum_{t=0}^n \frac{CF_t}{(1+k)^t}$$

The IRR is that discount rate which equates the present value of a project’s expected cash inflows to the present value of the project’s costs. The IRR assumes that the cash flows are reinvested at the IRR. Some users like the internal rate of return (IRR) as a criterion because it is a percentage that can be compared to interest rates charged by lenders. The NPV of the return on equity shown in Table 3 is calculated based on the 11 percent opportunity cost of equity mentioned previously

The *Internal Rate of Return (IRR) on assets* ignores financing issues. That is, it assumes that all of the initial investment for the digester construction (net of grants) is paid for out of the farm’s equity capital, without borrowing. The reason for making this simplifying assumption is to separate the question of profitability of the digester investment, on one hand, from the question of how to finance it. This separation of the questions of profitability and financing should make it easier for readers to generalize the results to other situations where the

financing possibilities may be different. It should be noted that since financing is not considered, the IRR on assets is not affected by the availability of low- or zero- interest subsidized financing such as the case farm received from the Minnesota Department of Agriculture.

The *internal rate of return on equity capital* and the *net present value* and *annual cash flow equivalent (AECF)* measures shown below, on the other hand, do consider financing. That is, the annual cash flows used to calculate these measures include the \$77,500 in initial equity capital and the payments on the debt financing shown in Table 1 above. The IRR on equity capital tends to fluctuate more across the scenarios than does the IRR on assets, because the fixed debt payments are netted out of cash flows before calculating the IRR on equity capital. That is, we start with a varying net operating cash flow, and subtract a fixed debt payment. The difference, then, fluctuates more percentagewise than did the original cash flow. In this case, the debt payments are not quite fixed across the seven scenarios because the debt interest rate is zero for scenarios 1 – 4 and seven percent for scenarios 5-7. But, this difference is still much less than the difference in the operating cash flows, so in Table 4 the IRR on equity capital varies from 39% to less than -10%, while the IRR on assets only varies from 20% to -6%.

The NPV can be converted to a constant AECF, so this measure was added for the convenience of such readers who prefer annual dollar measures. An earlier version of this paper included only the IRR and NPV, but a reader then asked how the economics of the digester would compare to other odor control methods such as pit additives that don't require a major investment but do involve significant annual operating expenditures. The AECF is a constant annual amortization payment which, over the n years of project life, has a present value equal to the NPV of the project. is simply a constant amortization payment similar to what a borrower would typically pay on a mortgage loan, and is easily calculated using Excel's PMT function. The AECF measure is particularly useful for analyzing investment alternatives with unequal lives – ten years in the case of the digester and perhaps one year or less for the pit additive alternative.

Change in milk production cost per hundredweight is calculated from the AECF divided by milk production, with the milk production valued at an estimated long-run value of \$12.50 per hundredweight.

The annualized present values of the various benefits and the operating and total annual cost of the digester system are shown in Figure 1. The per-cow numbers are based on the current herd size of 800 cows, with the recognition that the herd size was smaller in the first two years of operation.

The general arrangement of the figures are that the operating and maintenance costs and total annual costs of owning the digester system are shown as lines, while the benefits are shown as bars. The total cost numbers are calculated as if the system were financed at market rates on capital – 7 percent on debt and 11 percent on equity. The grants and the interest subsidy on the zero-interest loan are then shown as offsetting benefits.

The components of the bars represent the benefits that were discussed above. The electricity and LP gas savings are shown at the bottom of the bars. The government and utility incentives (grants and the production and interest subsidies) are shown next. The non-energy benefits are shown at the top because they are thought to be more speculative at this point. Locating them at the top makes it easier to determine how important these non-energy benefits are to making the investment break even.

Figure 1 shows that the LP gas savings, electricity, and non-energy benefits would not have covered the total cost of the digester system on the case farm without the grants and subsidies. The second bar shows a similar future scenario but with the electricity priced at only 3.56 cents. At that lower price, even the subsidies are not quite enough to provide profitability. The third and fourth bars show reduced electricity generation performance of only 80 and 60 percent of what the Haubenschields have achieved. The last three bars show that the unit would not be profitable without the subsidies.

Figure 1.

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

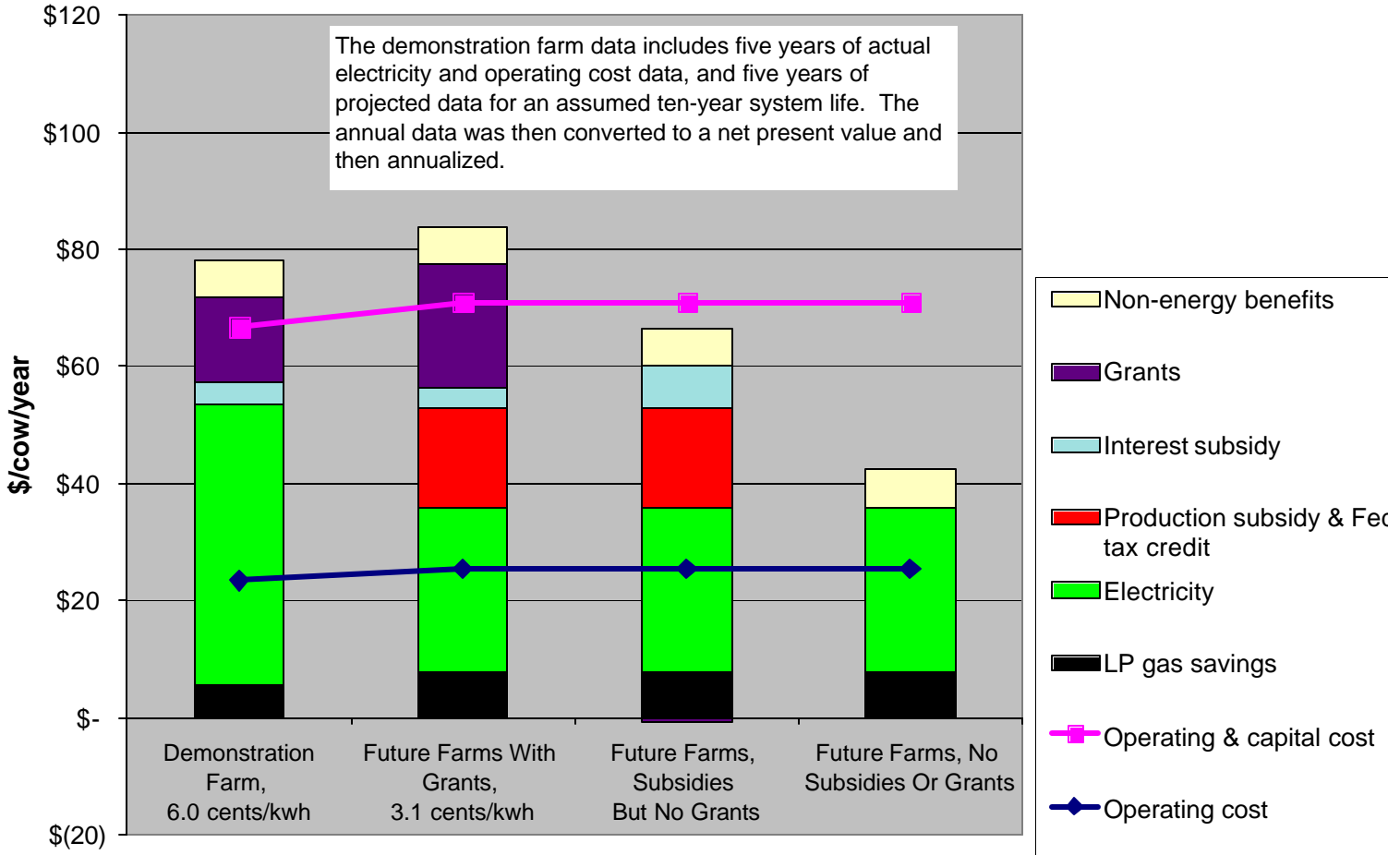


Table 3 provides additional details for the four scenarios. Scenario 1 shows that the case farm's system's payback period is 4 years, with a 11 percent return on the \$355,000 investment, or a 26 percent internal rate of return on the \$77,500 of equity capital after subtracting principal payments on the 6-year zero-interest loan. The payback period for Scenario 2 is only 3 years because nearly half of the investment has been covered by the \$200,000 in grants. The return on investment is 13 percent with a 30 percent return to the equity capital invested.

The payback period is over 10 years for the future farm scenarios without the grants, whether the loan and subsidies are included or not. The loan and subsidies bring Scenario 3 close to breakeven, with a negative 1% return on assets and an annualized net present value of \$-5,696. Without any incentives, Scenario 4 shows a substantial loss of an annualized \$-30,583.

Scenario 4 would result in a 2% percent increase in the milk production cost. The net present values and annualized net present values in Table 3 are calculated using an after-tax capital cost of 5.6 percent on assets or 7.15 percent on equity.

Table 4 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, based on the “Future Farms With Grants, Loans and Subsidies” Scenario 2. 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. Returns go negative at an investment of \$500/cow or more.

Little data is available on the O&M costs of older digesters such as cleanouts of accumulated solids and scum. Moser and Langerwerf report that cleanout and maintenance of a sixteen-year-old digester on a 400-cow California dairy cost around \$50,000 in 1998. Given the uncertainty about future O&M costs on the case farm’s and future farms’ digesters, another calculation that was made in this analysis was to calculate a time-discounted net present value of the cash flows expected on the case farm over the remaining four planning years. That net present value gives the additional O&M expenditures that would be justified, over and above the \$25,000 currently projected, in order to keep the digester system operating that much longer. Present indications are that the digester will probably operate more than another four years, in which case the breakeven additional O&M estimates below are on the conservative side.

The projected after-tax cash flows and breakeven O&M costs by year are shown below. For example, it would be worthwhile to spend up to an additional \$123,495 at the beginning of 2005-06 in order to keep the digester running and generating four years of cash flows. By the beginning of 2008-09, however, one would only be able to justify an expenditure of \$31,328 (on top of the currently budgeted \$25,000) in order to generate the final year’s after-tax cash flow of \$21,819:

<u>Year</u>	<u>2005-06</u>	<u>2006-07</u>	<u>2007-08</u>	<u>2008-09</u>
After-tax net cash flows	\$ 26,530	\$24,244	\$21,951	\$21,819
Breakeven additional before-tax O&M justified by after-tax cash flows through end of year 10	\$ 123,495	\$91,510	\$60,754	\$31,328

Summary

The performance of the case farm's anaerobic digester system to date looks profitable to date, which can be attributed partially to careful management by a motivated and detail-oriented manager who has achieved outstanding digester and generator performance, and partially to favorable electricity pricing by the local utility along with assistance from various government agencies due to the demonstration status of the system. Future installations will not be eligible for the grants and zero-interest loan the case farm received and will likely not receive as high an electricity price. At the electricity prices currently being discussed, a smaller new operating subsidy would not be quite enough to assure profitability if performance is comparable to the case farm's performance. However, even without the non-energy benefits a digester may still be cheap "insurance" against odor complaints and lawsuits even if operating at a loss.

Table 3. Comparative Analysis of Benefits of Digester System Scenarios With Varying Electricity Prices and State and Utility Incentives, Compared to the Case Farm^a

	Demonstration farm	Future Farms With Grants, Loans and Subsidies	Future Farms With Loans and Production Subsidies	Future Farms, No Incentives
INVESTMENT PER COW	\$ 444	\$ 506	\$ 506	\$ 506
Grants as % of Investment	36%	49%	0%	0%
Debt as % of Investment	42%	29%	78%	78%
MDA zero-interest loan	\$ 150,000	\$116,600	\$250,000	\$ -
MN production subsidy	\$ -	\$ 0.015	\$ 0.015	\$ -
Federal energy tax credit (first 5 yrs)	\$ -	\$0.009	\$0.009	\$ -
Electricity generated, kwh/cow/yr	1,253	1,253	1,253	1,253
LP gas savings, gal./cow/yr	9.1	9.1	9.1	9.1
Electricity O&M cost w/labor (in 2004 dollars), \$/kwh	\$0.031	\$0.031	\$0.031	\$0.031
Breakeven electricity generation price (in 2004 dollars), \$/kwh	\$0.050	\$0.019	\$0.045	\$0.084
Average electricity price received (in current dollars), \$/kwh	\$ 0.058	\$ 0.036	\$ 0.036	\$ 0.036
Average electricity sale price received (in 2004 dollars), \$/kwh	\$0.057	\$0.031	\$0.031	\$0.031
Simple Payback Period, Years	4	3	10+	10+
Internal Rate of Return on Assets	11%	13%	-1%	-10%
Internal Rate of Return on Equity	26%	30%	-6%	<-12%
Net Present Value of Return on Equity	\$64,382	\$73,637	\$(39,730)	\$(213,319)
Annualized Net Present Value	\$9,230	\$10,557	\$(5,696)	\$(30,583)
Change in milk production cost	-0.6%	-0.7%	0.4%	2.0%

^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.

Table 4. Sensitivity Analysis of Financial Performance As Investment Varies, for a Future Digester with Current State and Utility Incentives, Per Cow Basis^a.

Investment	Annualized Capital Costs^b	Operating Returns^c	Annualized Net Present Value^d	Rate of Return to Equity
\$400	\$(18)	\$37	\$19	46%
\$500	\$(22)	\$37	\$15	31%
\$600	\$(27)	\$37	\$10	20%
\$700	\$(32)	\$37	\$5	12%
\$800	\$(36)	\$37	\$1	7%
\$900	\$(41)	\$37	\$(4)	2%
\$1,000	\$(45)	\$37	\$(8)	-2%

^a The values in this table correspond to Scenario 2, "Future Farms With Incentives, Performance 100% of Case Farm" in Table 3.

^b "Annualized Capital Costs" corresponds to the total cost line of the Figure 1 minus the value of the grants and interest subsidy sections of the graph bars.

^c "Operating Returns" represents to the benefits shown in the Figure 1 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.

REFERENCES

Boerboom, Jim. "Financing Your Project," presentation at Digesters for Managing Animal Waste: A Practical Workshop, August 21, 2002, St. Cloud, Minnesota.

Brigham, E.F. and J.F. Houston. Fundamentals of Financial Management. Hinsdale, Illinois: Dryden Press, 1997.

Chicago Climate Exchange, "September 2004 Monthly Market Summary, CCX Carbon Financial Instruments (CFIs, web site)," http://www.chicagoclimatex.com/trading/stats/monthly/st_0409.html, accessed October 20, 2004.

de Fiebre, J., Minnesota Department of Commerce, St. Paul, Minnesota. Personal communication, July 25, 2002.

U.S. Environmental Protection Agency, "The AgSTAR Program," accessed 8/2/2002. <http://www.epa.gov/agstar/operation/index.htm>

Hagy, William F. Funding Assistance and Other Initiatives. Presentation at the AgStar National Conference. 3/24/2004.

Hawkins, R., R. Craven, K. Klair, R. Loppnow, D. Nordquist, and W. Richardson. FINPACK User's Manual, Center for Farm Financial Management, University of Minnesota, St. Paul.

Helgeson, P. "Utility Connect Issues," presented at the Wisconsin Manure Biogas Symposium, Plover, Wisconsin, April 4, 2002 (Proceedings available on CD from the University of Wisconsin Center for Dairy Profitability, Madison, Wisconsin).

Johnson, Bill. "Selling Your Electricity," presented at "Digesters for Managing Animal Waste: A Practical Workshop," St. Cloud, Minnesota, August 21, 2002

Lazarus, W.F. and R.G. Koehler. "Economics of Applying Nutrient-Rich Manure at Low Rates." Review of Agricultural Economics 24(2002):141-159.

Lazarus, W.F. and R. Selley. "Minnesota Farm Machinery Economic Cost Estimates for 2002." FO-6696, University of Minnesota Extension Service, September 2002, <http://www.apec.umn.edu/faculty/wlazarus/mf2002.pdf>.

Kosbab, Steve, Great River Energy. Personal communication, 7/30/02.

Kramer, Joseph M. "Agricultural Biogas Casebook." Resource Strategies, Inc., September 2002, available at <http://www.mnproject.org/>.

Moser, M. and L. Langerwerf. Langerwerf Dairy Digester Facelift: What We Found When We Took Apart a 16 Year-old Dairy Plug Flow Digester. http://www.epa.gov/agstar/resources/lag_cons.html.

Nelson, C. and J. Lamb. Final Report: Haubenschild Farms Anaerobic Digester, The Minnesota Project, 1885 University Avenue, Suite 315, St. Paul, Minnesota 55104, December 2000, <http://www.mnproject.org/pdf/haubyfinal3.pdf>.

Nelson, C. and J. Lamb. Final Report: Haubenschild Farms Anaerobic Digester, Updated, The Minnesota Project, 1885 University Avenue, Suite 315, St. Paul, Minnesota 55104, August 2002, <http://www.mnproject.org/index-main.html>.

Nelson, C.; D. Allen; and J. Katovich. "Fertilizer Value and Weed Seed Destruction Potential of Digested Manure." Presented at Anaerobic Digester Technology Applications in Animal Agriculture: A National Summit, Raleigh, NC, June 2-4, 2003, <http://www.mnproject.org/pdf/Raleigh%20paper-%20nutrients&weeds.pdf>.

Roos, K. "Status and Issues Facing the Anaerobic Digester Industry Relative to the U.S. Livestock Market," presented at the Wisconsin Manure Biogas Symposium, Plover, Wisconsin, April 4, 2002 (Proceedings available on CD from the University of Wisconsin Center for Dairy Profitability, Madison, Wisconsin).

Roos, K.F. and M.A. Moser. AgSTAR Handbook: A Manual for Developing Biogas Systems at Commercial Farms in the United States. U.S. Environmental Protection Agency, Atmospheric Pollution Prevention Division.

Selander, Stan. "Selling Your Electricity," presented at "Digesters for Managing Animal Waste: A Practical Workshop," St. Cloud, Minnesota, August 21, 2002.

USDA National Agricultural Statistics Service, Agricultural Prices, August 1999 and August 2004, <http://usda.mannlib.cornell.edu/reports/nassr/price/pap-bb/>.

U.S. Energy Information Administration, "Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emission Coefficients (web site)," <http://www.eia.doe.gov/oiaf/1605/coefficients.html>, accessed October 20, 2004.

Vincze, Zsolt. "Economic Evaluation of a Manure Separator System for Minnesota Dairy Farms," Plan B paper, Department of Applied Economics, University of Minnesota, July 1996.

Part 2: Whole-farm comparison of the Haubenschild confinement dairy operation to a different dairy farm that is using rotational grazing

Introduction

Methane gas production on dairy farms has garnered a great deal of interest. Investment in anaerobic digestion and electricity generation is substantial. The returns to the farm need to be assessed over the long-term. Returns are a function of the amount of electricity generated, the price received for excess electricity, as well of the financing arrangements. All of these factors are examined in the context of whole farm financial performance.

Haubenschild Dairy, located in Princeton MN, provides a case study of an anaerobic digester on a dairy farm. Methane gas is collected from the manure and piped to a generator, where it is converted to electricity. Great River Energy purchases the electricity. In addition to producing electricity, capturing methane reduces manure odor. This aspect of the anaerobic digester is important for Haubenschild Dairy as it is located in close proximity to urban populations.

The computer program FINPACK was used for the analyses. A subroutine call FINLRB allows for long-range planning. Budgets for cropping, dairy and electricity production are developed based on Haubenschild Dairy information. These budgets are used with an initial balance sheet (base plan) to develop a number of 'what if' scenarios. For example, what if investment is made in a methane digester and electricity pricing and production mirror Haubenschild's current levels? The analyses show expected farm financial performance under different electricity pricing, production and financing scenarios.

Crop acreage and yield

Cropping and milk production parameters are based on the production history of Haubenschild Dairy. Table 1 provides a description of typical individual crop acres and average crop yields. Again, these are based on historic crop yield. There are 975 crop acres. The analyses are based on 929 dairy cows with an average annual milk production of 21,000 pounds per cow.

Table 3: Crop acreage and yield

<i>Crop</i>	Acres	Yield per acre
Corn Silage	262.2	17 tons
Feed Corn	431.1	120 bu
Alfalfa Haylage	181.3	9 tons
Mixed alfalfa/grass hay	100	4.5 tons

The capital cost of the Haubenschild Dairy methane digester is presented in table 2. The total cost of the methane digester system was \$355,000. The digester was financed through a combination of grants, loans and equity provided by Haubenschild Dairy. There was a total of \$127,500 in grants, \$150,000 interest-free loan from the Minnesota Department of Agriculture and \$77,500 equity (cash) invested by Haubenschild Dairy. It is important to note, the capital costs are for a methane digester built in 1999. In addition, a significant amount of labor was

provided by Haubenschild Dairy in the construction of the digester. This in-kind contribution is not included in the construction cost. The cost of anaerobic digesters is dependent on the type of digester built. It is possible the cost of a methane digester could exceed \$600,000 today.

Table 4: Capital Cost for Haubenschild Dairy Methane Digester

Item	Amount
Mix Tank and Collection	\$32,400
Digester	\$125,100
Energy Conversion	\$157,500
Miscellaneous	\$40,000
Total	\$355,000

Haubenschild Dairy With and Without Methane Digester

The base plan is a farm that was identical to Haubenschild Dairy in terms of cropping and milk production but does not have an anaerobic digester. An initial balance sheet for the base farm was created using Haubenschild Dairy’s balance sheet with adjustments made to reflect a lower debt load and lower asset values by not investing in the methane digester.

Crop and livestock budgets were developed using production and cost information from Haubenschild dairy. Chemical costs for feed corn and corn silage with the methane digester are one-half of the crop chemical costs without the methane digester. The lower chemical cost with the methane digester is based on Haubenschild Dairy’s experience that one chemical pass provided sufficient weed control when digestate (manure that has passed through the methane digester) was applied to cropland.

Budgets were developed for electricity production. Electricity price for sales is 5.34 cents per Kwh and electricity production is 800 Kwh/cow annually. These are based on Haubenschild’s current electricity production and pricing contract.

Table 3 presents the income statement for the base plan (no methane digester) and Haubenschild’s current methane production situation. It is important to note from the outset that electricity sales represent a small portion of gross farm income. Under the current electricity price-production structure, electricity represents only 2% of gross farm income. As such, the whole farm impact of methane production is likely to be relatively small.

Table 5: Income statement with and without methane digester

	Base Plan	Haubenschild Dairy
Milk Sales	\$2,926,350	\$2,926,350
Electricity Sales		\$ 39,687
Gross Farm Income	\$3,295,492	\$3,335,179
Fuel and oil expense	\$ 34,032	\$ 30,032
Utilities	\$ 65,253	\$ 30,092
Other Cash Expenses	\$2,489,976	\$2,508,777
Total Cash Expenses	\$2,589,261	\$2,568,901
Depreciation	\$ 220,808	\$ 256,308
Net Farm Income	\$485,423	\$509,970

Net farm income is \$24,547 greater with the methane digester. Net farm income is just one measure of financial performance. Other profitability measures are available. **Rate of return on assets (ROA)** can be thought of as the average returned being earned by all farm assets, those owned by the farm and those owned by the bank. **Rate of return on farm equity (ROE)** is the returned earned on the investment or equity in the farm. **Asset-turnover ratio** is an efficiency measure showing the dollars being generated by the farm assets. Table 4 presents these financial measures for the base plan and Haubenschild dairy's methane production situation.

Table 6: ROA, ROE and asset-turnover with and without methane digester

	Base Plan	Haubenschild Dairy
Rate of return on Assets	13.5%	13.3%
Rate of Return on Equity	23.4%	23.2%
Asset Turnover Ratio	37.1%	35.9%

As was mentioned previously, electricity sales are a small part of gross farm income (2%). It is not surprising the methane digester has a small impact on farm profitability. Both ROA and ROE are slightly lower with the methane digester as is the asset-turnover. This is the

result of a large investment in the methane digester (\$355,000) and the relatively low electricity sales. Given the level of annual electricity production and electricity sale price, the methane digester had little impact on the profitability of the farm.

Financing Considerations

Financing the methane digester was done via a combination of grants, loans and equity from the Haubenschild Dairy. The financing was presented in table 2. As methane digesters move beyond demonstration projects, the availability of grants might decline. If grants are not available, that portion of the construction cost would need to be financed by borrowing. Three different financing scenarios were examined.

1. No grants and 0% interest loan.
2. No grants and 7% interest loan.
3. Grants and 7% interest loan.

Each of the scenarios assumed the investment from Haubenschild Dairy was \$77,500. When no grants were available, the amount borrowed increased from \$150,000 to \$277,000.

Comparisons in this section are with the current electricity pricing (5.34 ¢/KwH) and production on the dairy.

Table 7: Income statement under alternative financing strategies

	Haubenschild Dairy	No grant 0% loan	No grant 7% loan	Grant 7% loan
Gross Farm Income	\$3,335,179	\$3,335,179	\$3,335,179	\$3,335,179
Interest Expense	\$229,127	\$229,127	\$247,571	\$243,849
Other Cash Expense	\$2,339,774	\$2,339,774	\$2,339,774	\$2,077,125
Total Cash Expenses	\$2,568,901	\$2,568,901	\$2,587,345	\$2,583,623
Depreciation	\$256,308	\$256,308	\$256,308	\$256,308
Net Farm Income	\$509,970	\$509,970	\$491,526	\$495,248

Differences in net farm income are the results of differences in interest paid. Under the scenario of no grants and a 7% interest loan, there is still a healthy net farm income, though it is \$18,444 less than the current financing arrangement. ROA and asset-turnover do not change under the different financing scenarios. ROE differs only slightly under each scenario (Table 6). In each case the ROE is higher under the alternative financing scenarios than the current financing scenario. The higher ROE with no grants and 0% interest loan is due primarily to lower equity or net worth position under this alternative financing strategy.

Table 8: ROE under alternative financing strategies

	Haubenschil d Dairy	No grant 0% loan	No grant 7% loan	Grant 7% loan
Rate of Return on Equity	23.2%	24.6%	23.7%	23.2%

Financial performance under low electricity prices

In order to sell electricity to the grid, power-purchasing agreements are required. The agreements set out the price electric companies pay for putting electricity on to the power grid. Generally, this price is determined by the least cost alternative method of electricity production. Haubenschild’s current power purchase agreement has electricity priced at 5.34¢ per Kwh. The impact on farm financial performance is examined using a lower electricity price of 3.56¢ per Kwh. Under the lower price scenario, electricity production, and financing arrangements are assumed to be at the current level on the dairy. Table 7 provides a summary of farm performance under the current electricity price and the lower price of 3.56¢ per Kwh.

It must be noted that electricity sales represent a small portion of total gross revenue on the dairy. Therefore, its impact on whole farm financial performance is small. With the lower electricity price the financial performance of the farm declines slightly. ROA is 13.0% at the lower price compared to 13.3% under the current situation. ROE declines from 23.2% to 22.6% under the lower pricing scenario. Even though the financial performance declines, it is still reasonably strong. On the income side, electricity sales revenue is \$13,229 less at \$26,458.

Table 9: ROA, ROE and asset-turnover under different pricing scenarios

	Haubenschil Dairy 5.34¢ per Kwh	Low electricity price 3.56¢ per Kwh
Rate of return on Assets	13.3%	13.0%
Rate of Return on Equity	23.2%	22.6%
Asset Turnover Ratio	35.9%	35.7%

Financial performance under lower electricity production

The electricity generation on Haubenschild's dairy is extremely efficient. It is important to assess the impact on whole farm profitability electricity generated was only sufficient electricity produced to meet the needs of the farm. The effect on farm profitability lies with lower gross farm income, because there are no electricity sales. Table 8 presents whole farm profitability for each of the 3 scenarios: 1) Current electricity production and 5.34¢ per Kwh; 2) current electricity production and 3.56¢ per Kwh; and 3) no electricity sales. Each of the scenarios assumes no change in how the methane digester was financed in terms of loans, grants and farm equity.

Table 10: ROA, ROE and asset-turnover under different pricing and electricity production scenarios

	Haubenschild Dairy 5.34¢ per Kwh	Low electricity price 3.56¢ per Kwh	No excess electricity sales
Rate of return on Assets	13.3%	13.0%	12.6%
Rate of Return on Equity	23.2%	22.6%	21.8%
Asset Turnover Ratio	35.9%	35.7%	35.2%

There are no differences in whole farm profitability between the low price and no excess sales scenarios. Again, this is due in large part to the small contribution electricity sales makes to total gross revenue. In the low electricity price scenario, electricity sales account for only 0.7% of gross revenue.

There is an additional measure of performance that looks at the rate of return on additional investment. Given the level of investment and the additional revenue generated, the rate of return on additional investment (methane digester) is calculated. For the three scenarios presented the return on additional investment are:

- Current price and electricity production: 8.8%
- Low price and current electricity production: 4.1%
- Low electricity production (no excess electricity sales): -5.5%

Alternative Dairy System

The anaerobic digester for large confinement dairy operations can have little negative impact on whole farm financial performance, as seen in the earlier analysis. An alternative dairy system is a grazing system and out-wintering of dairy cattle on bedding packs. Bedding packs are either partially or totally composted prior to spreading on cropland.

Grazing systems require less capital investment than confinement systems. This is especially true in terms of manure handling equipment and storage facilities. The model farm has 260 cows and is based on an actual low-input dairy farm in Stearns County.

Comparisons of major income statement items are done on a per cow basis rather than absolute dollar amount. Larger herds will have more dollars of milk sold than smaller herds based solely on the fact they have more cows. Table 9 presents comparisons of net farm income on a per cow basis between the two systems. The pattern seen is fairly typical of well-managed confinement and low-input dairy farms. Confinement dairies tend to have higher gross sales, higher cash expenses, higher depreciation and lower net income per than low-input grazing systems.

Table 11: Income statement Haubenschild's Dairy and a low-input grazing dairy

	Haubenschild Dairy	Low-Input Grazing Dairy
Milk Sales	\$3,150.00	\$2,498.65
Electricity Sales	\$ 42.78	
Gross Farm Income	\$3,590.07	\$2,989.16
Fuel and oil expense	\$ 32.33	\$ 53.01
Utilities	\$ 32.39	\$ 53.23
Other Cash Expenses	\$2,700.51	\$1,901.39
Total Cash Expenses	\$2,761.23	\$2,007.63
Depreciation	\$ 275.90	\$ 79.26
Net Farm Income	\$ 552.94	\$ 902.27

The ROA, ROE and asset-turnover ratio are on a percent basis and can be compared directly. Haubenschild's farm had a higher ROE than the low input farm. When looking at ROA, the low-input farm was higher. The low-input farm has less invested in assets on the farm because of the nature of the operation. Its lower revenues are more than offset by the lower asset values or investment, resulting in a higher ROA. Similarly the asset-turnover ratio is higher on the low-input dairy farm.

Table 12: ROA, ROE and asset-turnover Haubenschild's Dairy and a low-input grazing dairy

	HAUBENSCHILD DAIRY	Base Plan
Rate of Return on Assets	13.3%	15.8%
Rate of Return on Equity	23.2%	20.7%
Asset Turnover Ratio	35.9%	38.2%