Financial Analysis of Implementing an Anaerobic Digester and Free Stall Barn System on a Mississippi Dairy Farm

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Abstract

This paper studies the viability of placing an anaerobic digestion (AD) system, or an AD system and a free stall barn onto a Mississippi dairy farm. Both situations were financially examined because some farmers' current systems cannot accommodate the new digester technology. An AD system extracts the methane gas from; in this case, cattle manure in order to create electricity for farm use or for buyback by the power company. The economic implications of this system could provide a more environment friendly dairy farm and a more efficient operation.

The purpose of this study is to determine if AD technology can be economically beneficial for a dairy farm. The AD system for this study has an estimated cost of $290,000. The free stall barn system has an estimated cost of $475,000. The analysis tools used in this study were net present value (NPV), internal rate if return (IRR), modified internal rate of return (MIRR). These figures were calculated on a constant net income covering the next 5, 10, 15, and 20 years into the future. Cost-share plans were also integrated into the financial summaries at different rates. The different rates were calculated from using no cost-share, 20%, 40%, 60%, and 80% of total cost. The assumed interest rate for the initial investment was set at a rate of 5.0%.

Of course, the combination of the AD and the free stall barn exhibited the slowest returns because of the amount of the initial investment. Even with a cost share of 80%, the combination system could not realize a positive NPV at year five. With a 60% cost-share plan, it reached a 2% MIRR by year ten, but it still had a negative NPV. On the other hand, the AD system only reached a positive NPV by year five with a 20% cost share plan. It also showed a positive value for IRR and MIRR by year ten with a 60% cost share plan. Of course, the AD system reached positive and more financially stable values faster then the combination of the two.

Keywords: Anaerobic digester, Dairy farm, Cost-share plan

Dairy farms in the U.S. have been targeted along with many other confinement livestock operations for the unique odors that tend to linger from their locations along with pollution issues from concentrated waste disposal. Many of these operations have had to face lawsuits and fines and have simply upset their neighboring communities because of these reasons. An anaerobic digestion system is designed to help resolve these problems. The dairy farm discussed in this paper is Mill's Dairy located in Scott County, Mississippi. Mill's Dairy currently milks 431 cows. Mr. Quinton Mills is the owner of Mill's Dairy and he is currently in the process of installing an anaerobic digestion system on his farm. He is installing the combination of both the anaerobic digestion system and a free stall barn for the methane recovery process (Davis, 2003).

Normally, most dairy farms with a decent size herd of dairy cows have some type of manure storage system. The manure usually travels from the dairy barn to some type of storage container where it sits until the farmer finds a use for it. It can be taken out of the storage system and placed directly in a pasture or field as a fertilizer, it can be placed in a compost pile for later use, or it can used for whatever the farmer's preference might be. The problem with this is that these techniques tend to create undesirable odors. The farmers and those who've grown up on a farm usually overlook these odors, but they don't pass over so well with most people. It has been proven that an anaerobic digester (AD) can help reduce these odors by harnessing the energy in the manure before it has a chance to bother others.

Manure contains methane gas. This methane gas is what anaerobic digestion focuses on. An AD focuses on harnessing the energy possibilities of this methane gas for energy conservation. Dairy farms are prime targets for this kind of energy conservation because the waste produced by them is more suitable than others for the extraction of methane gas as an energy source. The waste produced by dairy cows is more liquid in form than other types and energy production through anaerobic digestion works better with a slurry mix. The actual process anaerobic digestion that the waste must go through in order to be used is a three-step process. The first step is the hydrolysis of the manure. Hydrolysis breaks down the organic material. The second step is that the broken down material must be converted into organic acids. These organic acids are what will be converted over to methane gas. Last is the actual production of the methane gas. After the removal of the methane gas, it can be used to produce electricity. It does so by fueling a generator that will produce electricity to power the dairy operation and possibly have enough excess electricity to sell back to the power company. These applications of an AD system will provide cost savings and a new source of revenue for the dairy farm.

There has been related research conducted on this topic. Cornell Cooperative Extension, a department of Cornell University, conducted a case study on Matlink Dairy Farm in Chautauqua County, New York. Matlink Dairy milks 675 dairy cows and decided to install an AD system to help reduce odor and increase revenue. Matlink Dairy decided to build the digester when communities and schools upwind of their farm complained about odor when they sprayed their fields with the raw manure produced by their operation. Also, another incentive to start the project was that the Environmental Protection Agency's (EPA) Agstar program conducted a feasibility study in which the resulted in Matlink reducing electricity and natural gas purchases by approximately $41,000 per year. An engine-generator combination used by Matlink produced about 884,000kWh/year. This met the farm's electricity needs plus they had electricity left over to sell. Also, the heat generated from the process was used to heat the digester and was used for other on-farm purposes. The use of this heat created a savings of $500 per month. Matlink's total annual benefits from the AD system were $292,785. These benefits are broken down to about $171 per cow, per year. Other benefits included odor reduction, energy savings, pathogen reduction, and fuel savings (Wright and Ma, 2003).

Another project on AD technology was conducted on an 800-cow dairy operation in Minnesota. The economic data provided by the research was gathered over a five-year period and the remainder was projected for an additional five years. The owners of the farm decided to use a simple plug flow digester for their operations. This type of digester works well with manure scrape management systems with little bedding and no sand. The total cost for the digester system was $355,000 or about $444 per cow. With this digester and this size farm it was calculated that 1,253kWh per cow, per year could be produced from the processed methane. Also, the farm sold about 40% and used about 60% of that electricity produced. Finally, the project proved that with the current selling price of electricity, building an AD system is not justified without any form of subsidy or cost-share plan (Lazarus and Rudstrom, 2007).

Problem Statement

The purpose of this study is to determine the feasibility of installing an AD system on a Mississippi dairy farm with or without a cost-share plan. Installing an AD system is very capital intensive. An AD system is very expensive alone, but many farms have to install a new free stall barn facility in order to accommodate the AD system. Since a large number of farms find themselves having to install a free stall barn, the costs of installing one were included along with AD system cost. Including a free stall barn can dramatically increase the initial cost for startup. The specifics of the economic or cash flow analysis conducted were focused on determining how much, if any, cost-share must a dairy farm receive in order to be profitable. The cost-share plans were forecasted over a period of five to twenty years.

Data

The startup costs for the installation of this system were limited to building and equipment costs only. The cost and benefit analysis conducted was based on two scenarios, purchasing an AD system only or purchasing an AD system along with a free stall barn as well. The funding for this operation comes from a direct, joint financing loan. The interest rate used to calculate total interest on the given amount of the loan taken out was 5.00% (USDA, 2007). The AD system startup cost for the dairy discussed in this paper is $290,000. The initial investment required for the free stall barn required to complement this AD system is $475,000. The generator to be used to provide the electricity for the farm and for sale is assumed to operate at an efficiency rate of 75%. The cost savings from using this generator are based on a rate of $0.075/kWh. Also, the buyback rate for the excess electricity produced is assumed to be $0.05/kWh. Considering the generator operational efficiency of 75% mentioned earlier, the farm's generator is estimated to produce 602,250 total kWh per year. Of this total amount, 369,015 of these kWh will be used to meet the farm's electricity needs. The excess 233,235kWh will be sold back to the power company. The dairy farm should receive an $11,661.75 profit from its electricity production. Also, an obvious contribution to farm income is milk production. The milk produced will be sold for $12.17 per cwt.

The annual income for the dairy farm is $1,043,911.86. It is comprised of a total of $891,455.61 for milk sold, $52,962.50 for bull calves sold, $80,080 for cull cows sold, $7,752 for cull bred heifers, and $11,661.75 for yearly electricity sales. The total annual cost for the dairy is estimated to be $1,012,265.70. This is comprised of all normal operational costs for a dairy farm and it also accounts for $27,676.13 in electricity cost savings. The farm will realize a net income of $31,646.16 per year throughout the five to twenty year periods. As mentioned earlier, there will be a cost-share plan associated with the initial cost of the AD system. The cost-share plan used will range from 20% of total cost to 100% of total cost absorbed by outside funding. Interest will only be added to the amount of funding provided by the farmer. Interest was not added on the amount of outside funding because of unknown interest rates assumed by different agencies. All estimated figures are listed in Table 1 for more convenience.

Table 1. Rates and Annual Estimations for Mill's Dairy

Name	Rate or Estimation
Generator Efficiency	75%
Total Electricity Production	602,250kWh
Total Electricity Use	369,015kWh
Total Excess Electricity Produced	233,235kWh
Cost Savings Rate for Electricity Produced	$0.075/kWh
Premium Paid for Excess Electricity	$0.05/kWh
Average Price for Milk Sold	$12.17/cwt
Interest Rate for Direct, Joint Financing Loan	5.00%
AD System Cost	$290,000.00
Free Stall Barn Cost	$475,000.00
Income From Electricity Sales	$11,661.75
Total Income from Milk Sold	$891,455.61
Bull Calves Sold	$52,962.50
Cull Cows Sold	$80,080.00
Cull Bred Heifers	$7,752.00
Total Annual Farm Income	$1,043,911.86
Annual Electricity Cost Savings	$27,676.13
Total Annual Farm Cost	$1,012,265.70
Net Income	$31,646.16

Methods and Procedures

The methods used in this paper were simple accounting analysis measures. As you can see in Table 1, there were many costs and revenues used to determine annual net income for Mill’s Dairy. All of these estimated figures revolve around the efficiency of the generator used in the experiment. A generator that operates at an efficiency rating other than 75% will yield different results in the amount of electricity produced by the AD system. A generator with a higher efficiency rating will produce more electricity and therefore more excess electricity that can be sold back to the power company. On the other hand, a generator with a lower efficiency rating than 75% will produce less electricity and therefore the farmer will have less excess to sell back to the power company, or possibly not enough electricity to power the farm's needs. Also, a lower generator efficiency rating will conclude that the farmer is an inefficient producer of electricity and could have effects on other factors of production such as time management.

The accounting measures used were NPV, IRR, and MIRR. The NPV calculates the value of an investment by adding the present value of the expected future cash flows of the business to the initial cost of the investment. NPV is an indicator used to measure how much value an investment or project adds to the value of a firm. With any particular project being analyzed, if the net cash flow for a certain time frame is a positive value, the project has a status of a discounted cash inflow in that certain time frame. On the other hand, if the net cash flow is a negative value the project has the status of a discounted cash outflow in the particular time frame. In this case, the time frame ranges from five to twenty years. A positive NPV will merit an investment. The formula used to calculate NPV is as follows:

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - C_0$$

Where;
t = time of the cash flow
n = the total time of the project
r = the discount rate
C_t *= the net cash flow at time t*
C_0 *=the capital outlay at the beginning of the investment (t=0)*

The next measurement used was IRR. The IRR is the annualized rate of return that is possible to earn on the newly invested capital. It is basically the yield created from the investment. A project is considered to be a good investment if its IRR is greater than the rate of return that could be earned by alternative investments. Mathematically, the IRR is defined as any discount rate that results in a NPV of zero of a series of cash flows. The formula used to calculate IRR is as follows:

$$NPV = 0 = InitialInv. + \sum_{t=1}^{N} \frac{C_t}{(1+IRR)^t}$$

Where;
t = time of the cash flow
n = the total time of the project
C_t = the net cash flow at time t
IRR = i, (i = interest rate in percent)

The last measurement used in the analysis was MIRR. The MIRR assumes that the cash flow from the business is reinvested into the farm's cost of capital instead of reinvesting at the IRR. MIRR is a modification of the previous financial measure IRR. The main difference between the two is that instead of ignoring the investment rate of the positive cash flow, MIRR makes an assumption about the rate of return of investment of those positive cash flows. It assumes that all positive cash flows are reinvested, usually at the weighted average cost of capital, to the last year of the project. Therefore, it can project the profitability of a project more accurately. The formula used for MIRR is as follows:

$$MIRR = \left(\frac{-NPV(reinv.\_rate, pos.\_values[1,2,...,i]) * (1+reinv.\_rate)^n}{NPV(fin.\_rate, neg.\_values[1,2,...,j]) * (1+fin.\_rate)} \right)^{\frac{1}{n-1}} - 1$$

Where;
n = i + j

The financial measures described above were all calculated along with the presence of a cost-share plan used by the dairy farmer. The cost-share plan used assumed that outside funding would be provided for the initial costs of the AD system. The cost-share plan ranges from zero to eighty percent of total cost absorbed by outside funding. Also, interest was added to the amount of the loan the farmer would have to take out to absorb his or her portion of the initial cost. The interest rate was taken from the United States Department of Agriculture's website. The interest rate offered to dairy farms is 5.00%. With the incorporation of the cost-share plan, startup costs, annual net income, and the financial analysis measures we can measure how much outside funding would be required, if any, for the installation of an AD system or the combination of the AD system and a free stall barn.

Results

As mentioned earlier, the interest rate used to calculate the cost to the farmer was 5.00%. First, the combination of the AD system and the free stall barn required the most interest and the greatest cost to the farmer. The farmer's cost ranged from the highest cost of $803,250 down to $160,650. The interest calculated from these costs ranged from $38,250 down to $7,650. These values were calculated in respect to their relative cost-share plan. The highest payment is associated with the lowest cost-share plan of 0% and the lowest payment with the highest cost-share plan of 80%. A cost-share plan of 100% was included in the calculations but is highly unlikely. The initial cost for the AD system only ranged from the highest cost of $304,500 down to $60,900. The interest calculated from these costs ranged from $14,500 down to $2,900. These values were also calculated in respect to their relative cost-share plans. Tables 2 and 3 below show the cost-share plans associated with the loan, grant, interest, and total amount paid for the project.

Table 2. AD and Free Stall Barn

Cost Share	Loan	Grant	Interest	Total
0%	$803,250	$0	$38,250	$803,250
20%	$642,600	$153,000	$30,600	$795,600
40%	$481,950	$306,000	$22,950	$787,950
60%	$321,300	$459,000	$15,300	$780,300
80%	$160,650	$612,000	$7,650	$772,650
100%	$0	$765,000	0$	$765,000

Table 3. AD only

Cost Share	Loan	Grant	Interest	Total
0%	$304,500	$0	$14,500	$304,500
20%	$243,600	$58,000	$11,600	$301,600
40%	$182,700	$116,000	$8,700	$298,700
60%	$121,800	$174,000	$5,800	$295,800
80%	$60,900	$232,000	$2,900	$292,900
100%	$0	$290,000	$0	$290,000

Tables 2 and 3 represent the disbursements of the total capital paid considering all relative cost-share plans that the farmer and whichever financial institution he chooses for his outside funding will absorb.

Next, due to limited information about the net income of Mill's Dairy, I assumed that net income remained at $31,646.16 throughout each examination from five years to twenty years. No matter what scenario, cost-share plan, or length of examination, the net income remains the same. Tables 4 and 5 below show all NPV, IRR, and MIRR values calculated with all different cost-share plans and all years one through twenty.

Table 4. AD and Free Stall Barn

Year	0%	20%	40%	60%	80%
0	($803,250.00)	($642,600.00)	($481,950.00)	($321,300.00)	($160,650.00)
Net Inc.	$31,646.16	$31,646.16	$31,646.16	$31,646.16	$31,646.16
			Years 1 thru 5		
NPV	($666,238.69)	($505,588.69)	($344,938.69)	($184,288.69)	($23,638.69)
IRR			-28%	-20%	-1%
MIRR	-26%	-23%	-18%	-11%	2%
			Years 1 thru 10		
NPV	($558,886.74)	($398,236.74)	($237,586.74)	($76,936.74)	$83,713.26
IRR	-14%	-11%	-7%	0%	15%
MIRR	-7%	-5%	-2%	2%	9%
			Years 1 thru 15		
NPV	($474,773.68)	($314,123.68)	($153,473.68)	$7,176.32	$167,826.32
IRR	-6%	-4%	0%	5%	18%
MIRR	-1%	0%	2%	5%	10%
			Years 1 thru 20		
NPV	($408,868.90)	($248,218.90)	($87,568.90)	$73,081.10	$233,731.10
IRR	-2%	0%	3%	8%	19%
MIRR	1%	2%	4%	6%	10%

Table 5. AD only

Year	0%	20%	40%	60%	80%
0	($304,500.00)	($243,600.00)	($182,700.00)	($121,800.00)	($60,900.00)
Net Inc.	$31,646.16	$31,646.16	$31,646.16	$31,646.16	$31,646.16
			Years 1 thru 5		
NPV	($167,488.69)	($106,588.69)	($45,688.69)	$15,211.31	$76,111.31
IRR	-18%	-13%	-5%	9%	43%
MIRR	-10%	-6%	-1%	8%	23%
			Years 1 thru 10		
NPV	($60,136.74)	$763.26	$61,663.26	$122,563.26	$183,463.26
IRR	1%	5%	11%	23%	51%
MIRR	3%	5%	8%	13%	21%
			Years 1 thru 15		
NPV	$23,976.32	$84,876.32	$145,776.32	$206,676.32	$267,576.32
IRR	6%	10%	15%	25%	52%
MIRR	6%	7%	9%	12%	17%
			Years 1 thru 20		
NPV	$89,881.10	$150,781.10	$211,681.10	$272,581.10	$333,481.10
IRR	8%	12%	17%	26%	52%
MIRR	6%	8%	9%	11%	15%

Summary and Conclusions

The analyses conducted show promise for the installation of an AD system on a Mississippi dairy farm. Even with the maximum cost-share plan of 80% the combination of the AD system and the free stall barn still cannot realize a positive NPV in years one through five. This situation also yields a negative IRR and MIRR as well. As more years are added to the examination period, the three calculations improve. They begin to require a less intensive cost-share plan. In the examination of years one through ten, the combination of the two reaches a positive NPV with an 80% cost-share plan. Also, it reaches both a positive IRR and MIRR with an 80% cost-share plan in the examination of years one through ten. For the examination of years one through fifteen, a positive NPV is realized with a 60% cost-share plan. The IRR and MIRR figures both show a 5% return. In the period of years one through twenty NPV does not show a positive value until a 40% cost-share plan again, but it is much higher than the value from the one to fifteen year period.

The AD system alone exhibited much better results than the combination of the two inputs, but that can only be expected because of the lower startup cost. It realized a positive NPV in the first period with only a 60% cost-share plan. The IRR and MIRR also showed to be acceptable during this time frame. As you can see in Table 5, as the time frame extended, the calculations only improved. By the time frame of one to ten years, the AD system only required a 20% cost-share plan to realize a positive NPV. Also, the IRR and the MIRR were both at 5% for this time frame.

The results for the AD system only are very promising, but as I mentioned before, most farmers require that a free stall barn be installed along with the AD system. This is somewhat disheartening for those farmers who do require the installation of a free stall barn but promising nonetheless. As for the more realistic situation of requiring both, it is necessary that a cost-share plan be used. A dairy farmer that is equivalent in size to Mill's Dairy must enter into a cost-share plan with another organization. An 80% cost-share plan would be great for the farmer, but a 60% plan would work. As you can see from the tables, a 60% cost-share plan is the minimum that a farmer must receive in order to install both the AD system and the free stall barn. If any particular grantor decides that a Mississippi farmer deserves a grant of at least this magnitude, that farmer will be able to step up to a new level of technology and efficiency and become a better influence on the environment.

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