CLEAR HORIZONS LLC

Crave Brothers Farm

Digester Project Feasibility Study

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Executive Summary

Crave Brother Farm is interested in installing an anaerobic digestion system on the farm to take the manure from the farm and the whey from their cheese factory located across the road. This feasibility study, funded in part by Wisconsin Focus on Energy, Crave Brothers Farm, and Clear Horizons LLC, will provide the Crave Brothers with the data to make an informed decision on whether installing a digester plant on their farm is in their best interest.

Clear Horizons LLC was retained by Crave Brothers Farm to perform the feasibility study. Clear Horizons joined the Crave brothers to tour numerous digester plants of various designs including some municipal facilities to get an understanding of digester systems currently available and to discuss the positives and negatives of each system. Following these site visits, an above ground complete mix system was selected that would have the instrumentation and controls similar to municipal facilities. Additional design features were also discussed to ensure ease of maintenance and minimal downtime.

Clear Horizons contracted Applied Technologies located in Brookfield, WI to perform the preliminary engineering on the system. Applied Technologies was provide a rough site survey, an aerial a scaled aerial photo of the farmstead, analysis of the manure from the barn, and analysis of the cheese whey. With this information, the mass balance and energy balance were completed. Numerous options were calculated to determine the impact of the proposed expansions of the farm and cheese factory. Following the mass and energy balance, the digester tank was designed to provide at least 30 days retention time with 800 milking cows and 200 heifers. Preliminary drawings were completed for all the major components of the system and the P&ID drawings were created to estimate the control system.

Following the preliminary design, the quotes were gathered for all components, the mechanical and electrical construction, and the site civil work that would be required. The total turn-key cost for the system was estimated at $1,540,000.

With the digester cost established, the mass balance and energy balance were used to determine the revenue and expenses associated with operating this system. Based on the gross profit of the system, the simple payback of the system is approximately 9 years. The effects of depreciation and interest were also considered to provide a cumulative project cash flow of ($12,428) in 10 years utilizing debt financing or $295,610 in 10 years utilizing equity financing.

Crave Brothers Farm plans to evaluate the information presented in this feasibility study and make a determination on whether or not they will invest in this digester system. Additional work will need to be performed to determine alternate financing schemes and options to improve the profitability of this project.

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Introduction

Crave Brothers Farm located near Waterloo, WI has interest in installing an anaerobic digester system. The farm currently milks 600 cows, has 100 heifers and dry cows, and their own cheese factory located across the road. The farm plans to expand to 800 milking cows and 200 heifers by the end of 2007. The cheese factory also anticipates doubling in size over the next few years.

The purpose of the feasibility study is to collect the data and summarize the financials to assist in determining if undertaking a digester system is in the best interest of the farm. Some of the goals include finding a location for the system that will not interfere with the future growth plans of the dairy farm, determining how the expansion influences the economics of the system, size the system, provide preliminary engineering of the system, and put together a budget cost of the system that is based on quotes from suppliers for the complete turn-key installation of the system.

Some of the design criteria of the system for Crave Brothers Farm include an above ground complete mix system, utilizes instrumentation and a control system to allow all pertinent data to be monitored and collected, and is easy to operate and maintain.

Crave Brothers Farm selected Clear Horizons LLC to perform the feasibility study. Site visits were taken to numerous installations and the positives and negatives of each system were discussed with Clear Horizons. Some of the reasons for selecting Clear Horizons to perform the study include the fact that it will be completed by engineers who understand agriculture, understand how other technologies can be adapted to fit this technology to improve its operation and maintenance, and Clear Horizons is a partnership of The Boldt Company, Pieper Electric, and Wolter Power Systems which will provide solid estimations of the cost to complete all aspects of the design, construction, operation, and maintenance of this system.

This feasibility study is funded in part by Wisconsin Focus on Energy, Crave Brothers Farm, and Clear Horizons. The goal of this feasibility study is to facilitate a decision on whether or not to install an anaerobic digester system. If the decision is to move forward on the project, the project would be built in 2006 or early 2007.

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System Mass Balance

The basis for the system design starts with the mass balance for the system. A spreadsheet was created to calculate the amount of manure, whey, and water that would enter the system. For the current case, as shown in Table 2, the following assumptions were made:

- Farm operates with 600 milking cows
- Farm has 100 heifers/dry cows (Produce 70% as much manure as lactating cow)[1]
- Adds approximately 2,100 gallons of parlor wash water per day
- Will send 3,750 gallons of whey to the digester each day with 2000 gallons of cheese factory wash water.

With these assumptions, the digester feed rate is 12.3 gallons per minute. The total amount of solids available for digestion was calculated along with the amount of volatile solids. The volatile solids represent the portion of the solids that will decompose in the digestion process, creating biogas. The amount of volatile solids in the manure was assumed from the AgStar data, and the amount of volatile solids in the whey was calculated from the analysis provided by Crave Brothers Farm. The rate of volatile solids destruction varies from 50-80% depending on the type of digester and hydraulic retention time. For these calculations, 65% destruction of volatile solids was assumed for the manure and 80% destruction was assumed for the whey.

Based on these rates of volatile solids destruction, 43 MMBTU of biogas will be produced each day with a 60% concentration of methane. The amount of separated solids produced is approximately 23,000 lbs./day. The digestion process is anticipated to reduce the average manure volume generation by 8.4% with the volatile solids destruction and solids separation.

These calculations were repeated for four additional options:

1.) 600 cows, 100 heifers – no whey added to the digester (Table 3)
2.) 600 cows, 100 heifers – cheese whey production doubled (Table 4)
3.) 800 cows, 200 heifers – cheese whey production constant (Table 5)
4.) 800 cows, 200 heifers – cheese whey production doubled (Table 6)

[1] Michigan State University Research via webpage

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The key portions of the mass balance are summarized in Table 1.

Table 1: Solids and Biogas Production in Various Cases

Case	Daily Solids Production	Daily Biogas Production
Current	12 tons	43 MMBTU
Option 1	10 tons	39 MMBTU
Option 2	14 tons	47.5 MMBTU
Option 3		
Option 4		

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Table 2: Current Case – Mass Balance Summary

Clear Horizons Mass Balance					
	Unit				
		Per cow			
Total Number of Cows		**600**	**Per day**	**Per Year**	
Total manure	Tons		36	13,140	
Manure per animal, published data	Lbs	120.00			
Total manure produced	Lbs		72,000	26,280,000	
Total manure as liquid	Gallons		8,643	3,154,862	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	2.5	**1,500**	547,500	
Total water volume	Gallons		1,500	547,500	
Total diluted manure volume	Gallons		10,143	3,702,362	
Total diluted manure volume	Lbs		84,191	30,729,604	
Solids as Bedding	Lbs	5.000	3,000	1,095,000	
Solids in the manure-dry basis	Lbs	16.800	10,080	3,679,200	
Volatile Solids available	Lbs	14.000	8,400	3,066,000	
Total Solids	Lbs	21.800	13,080	4,774,200	15.54%
Total Number of Heifers		**100**			
Total manure	Tons		4	1,533	
Manure per animal, published data (70% of cow)	Lbs	84.00			
Total manure produced	Lbs		8,400	3,066,000	
Total manure as liquid	Gallons		1,008	368,067	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	-	**-**	-	
Total water volume	Gallons		-	-	
Total diluted manure volume	Gallons		1,008	368,067	
Total diluted manure volume	Lbs		8,370	3,054,958	
Solids in the manure-dry basis	Lbs	11.750	1,175	428,875	
Volatile Solids available	Lbs	9.800	980	357,700	
Total Solids	Lbs	11.750	1,175	428,875	14.04%
Total Whey Produced	Gallons		**5,000**	1,825,000	
Percent Whey to Digester	Percent		75%		
Whey volume added to Digester	Gallons		**3,750**	1,368,750	
Whey volume added to Digester	Lbs		31,125	11,360,625	
Percent Moisture in Whey			93.8%		
Total Solids in Whey	Lbs		1,930	704,359	
Total Volatile Solids in Whey	Lbs		714	260,613	
Mg-Whey, dry basis	Lbs		50		
P-Whey, dry basis	Lbs		252		
K -Whey, dry basis	Lbs		806		
Ca Whey, dry basis	Lbs		302		
Cl - Whey, Dry basis	Lbs		504		
Cheese Factory Wash Down Water	Gallons		**2,000**	730,000	
Cheese Factory Wash Down Water	Lbs		16,600	6,059,000	
Total Volume to Digester	Gallons		17,263	6,301,107	
Total Volume to Digester	Lbs		143,285	52,299,187	
Total Volume to Digester	Gal/Minute	**12.0**			
Total Solids to Digester	Lbs		16,185		12.3%
Total Volatile Solids available to Digester	Lbs	-	10,094		8.8%
Energy Generation					
Total manure VS converted into methane (60%)	Lbs		5,628	2,054,220	
Total whey VS converted into methane (70%)	Lbs		500	182,429	
Methane generated (7.0 CFT/VS-Lb Converted)	CFT		42,895	15,656,542	
Total Biogas Produced	CFT	60%	71,491	26,094,237	
Energy Potential - Biogas	BTU	600	42,894,637	9,393,925,448	
Organic solids (60% moisture)	Lbs		25,142	9,176,962	
Organic solids (dry basis)	Lbs		10,057	3,670,785	
Orgainc Solids Recovered	Lbs	**95%**	23,885	8,718,114	

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Table 3: Option 1 – Mass Balance Summary – 600 cows, No Whey

Clear Horizons Mass Balance					
	Unit				
		Per cow			
Total Number of Cows		**600**	**Per day**	**Per Year**	
Total manure	Tons		36	13,140	
Manure per animal, published data	Lbs	120.00			
Total manure produced	Lbs		72,000	26,280,000	
Total manure as liquid	Gallons		8,643	3,154,862	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	2.5	**1,500**	547,500	
Total water volume	Gallons		1,500	547,500	
Total diluted manure volume	Gallons		10,143	3,702,362	
Total diluted manure volume	Lbs		84,191	30,729,604	
Solids as Bedding	Lbs	5.000	3,000	1,095,000	
Solids in the manure-dry basis	Lbs	16.800	10,080	3,679,200	
Volatile Solids available	Lbs	14.000	8,400	3,066,000	
Total Solids	Lbs	21.800	13,080	4,774,200	15.54%
Total Number of Heifers		**100**			
Total manure	Tons		4	1,533	
Manure per animal, published data (70% of cow)	Lbs	84.00			
Total manure produced	Lbs		8,400	3,066,000	
Total manure as liquid	Gallons		1,008	368,067	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	-	-	-	
Total water volume	Gallons		-	-	
Total diluted manure volume	Gallons		1,008	368,067	
Total diluted manure volume	Lbs		8,370	3,054,958	
Solids in the manure-dry basis	Lbs	11.750	1,175	428,875	
Volatile Solids available	Lbs	9.800	980	357,700	
Total Solids	Lbs	11.750	1,175	428,875	14.04%
Total Whey Produced	Gallons		**-**	-	
Percent Whey to Digester	Percent		75%		
Whey volume added to Digester	Gallons		**-**	-	
Whey volume added to Digester	Lbs		-	-	
Percent Moisture in Whey			93.8%		
Total Solids in Whey	Lbs		-	-	
Total Volatile Solids in Whey	Lbs		-	-	
Mg-Whey, dry basis	Lbs		-		
P-Whey, dry basis	Lbs		-		
K -Whey, dry basis	Lbs		-		
Ca Whey, dry basis	Lbs		-		
Cl - Whey, Dry basis	Lbs		-		
Cheese Factory Wash Down Water	Gallons		**-**	-	
Cheese Factory Wash Down Water	Lbs		-	-	
Total Volume to Digester	Gallons		11,513	4,202,357	
Total Volume to Digester	Lbs		95,560	34,879,562	
Total Volume to Digester	Gal/Minute	**8.0**			
Total Solids to Digester	Lbs		14,255		16.9%
Total Volatile Solids available to Digester	Lbs	-	9,380		11.1%
Energy Generation					
Total manure VS converted into methane (60%)	Lbs		5,628	2,054,220	
Total whey VS converted into methane (70%)	Lbs		-	-	
Methane generated (7.0 CFT/VS-Lb Converted)	CFT		39,396	14,379,540	
Total Biogas Produced	CFT	60%	65,660	23,965,900	
Energy Potential - Biogas	BTU	600	39,396,000	8,627,724,000	
Organic solids (60% moisture)	Lbs		21,568	7,872,138	
Organic solids (dry basis)	Lbs		8,627	3,148,855	
Orgainc Solids Recovered	Lbs	**95%**	20,489	7,478,531	

Table 4: Option 2 – Mass Balance Summary – 600 cows, Whey doubled

Clear Horizons Mass Balance					
	Unit				
		Per cow			
Total Number of Cows		**600**	**Per day**	**Per Year**	
Total manure	Tons		36	13,140	
Manure per animal, published data	Lbs	120.00			
Total manure produced	Lbs		72,000	26,280,000	
Total manure as liquid	Gallons		8,643	3,154,862	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	2.5	**1,500**	547,500	
Total water volume	Gallons		1,500	547,500	
Total diluted manure volume	Gallons		10,143	3,702,362	
Total diluted manure volume	Lbs		84,191	30,729,604	
Solids as Bedding	Lbs	5.000	3,000	1,095,000	
Solids in the manure-dry basis	Lbs	16.800	10,080	3,679,200	
Volatile Solids available	Lbs	14.000	8,400	3,066,000	
Total Solids	Lbs	21.800	13,080	4,774,200	15.54%
Total Number of Heifers		**100**			
Total manure	Tons		4	1,533	
Manure per animal, published data (70% of cow)	Lbs	84.00			
Total manure produced	Lbs		8,400	3,066,000	
Total manure as liquid	Gallons		1,008	368,067	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	-	**-**	-	
Total water volume	Gallons		-	-	
Total diluted manure volume	Gallons		1,008	368,067	
Total diluted manure volume	Lbs		8,370	3,054,958	
Solids in the manure-dry basis	Lbs	11.750	1,175	428,875	
Volatile Solids available	Lbs	9.800	980	357,700	
Total Solids	Lbs	11.750	1,175	428,875	14.04%
Total Whey Produced	Gallons		**10,000**	3,650,000	
Percent Whey to Digester	Percent		88%		
Whey volume added to Digester	Gallons		**8,750**	3,193,750	
Whey volume added to Digester	Lbs		72,625	26,508,125	
Percent Moisture in Whey			93.8%		
Total Solids in Whey	Lbs		4,503	1,643,504	
Total Volatile Solids in Whey	Lbs		1,666	608,096	
Mg-Whey, dry basis	Lbs		116		
P-Whey, dry basis	Lbs		588		
K -Whey, dry basis	Lbs		1,881		
Ca Whey, dry basis	Lbs		704		
Cl - Whey, Dry basis	Lbs		1,177		
Cheese Factory Wash Down Water	Gallons		**2,000**	730,000	
Cheese Factory Wash Down Water	Lbs		16,600	6,059,000	
Total Volume to Digester	Gallons		22,263	8,126,107	
Total Volume to Digester	Lbs		184,785	67,446,687	
Total Volume to Digester	Gal/Minute	**15.5**			
Total Solids to Digester	Lbs		18,758		10.8%
Total Volatile Solids available to Digester	Lbs	-	11,046		7.0%
Energy Generation					
Total manure VS converted into methane (60%)	Lbs		5,628	2,054,220	
Total whey VS converted into methane (70%)	Lbs		1,166	425,667	
Methane generated (7.0 CFT/VS-Lb Converted)	CFT		47,559	17,359,212	
Total Biogas Produced	CFT	60%	79,266	28,932,020	
Energy Potential - Biogas	BTU	600	47,559,486	10,415,527,379	
Organic solids (60% moisture)	Lbs		29,909	10,916,728	
Organic solids (dry basis)	Lbs		11,964	4,366,691	
Orgainc Solids Recovered	Lbs	**95%**	28,413	10,370,892	

Table 5: Option 3 – Mass Balance Summary – 800 cows

Clear Horizons Mass Balance					
	Unit				
		Per cow			
Total Number of Cows		**800**	**Per day**	**Per Year**	
Total manure	Tons		48	17,520	
Manure per animal, published data	Lbs	120.00			
Total manure produced	Lbs		96,000	35,040,000	
Total manure as liquid	Gallons		11,525	4,206,483	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	3.5	**2,800**	1,022,000	
Total water volume	Gallons		2,800	1,022,000	
Total diluted manure volume	Gallons		14,325	5,228,483	
Total diluted manure volume	Lbs		118,894	43,396,406	
Solids as Bedding	Lbs	2.500	2,000	730,000	
Solids in the manure-dry basis	Lbs	14.000	11,200	4,088,000	
Volatile Solids available	Lbs	11.900	9,520	3,474,800	
Total Solids	Lbs	16.500	13,200	4,818,000	11.10%
Total Number of Heifers		**200**			
Total manure	Tons		9	3,103	
Manure per animal, published data (70% of cow)	Lbs	85.00			
Total manure produced	Lbs		17,000	6,205,000	
Total manure as liquid	Gallons		2,041	744,898	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	-	-	-	
Total water volume	Gallons		-	-	
Total diluted manure volume	Gallons		2,041	744,898	
Total diluted manure volume	Lbs		16,939	6,182,653	
Solids in the manure-dry basis	Lbs	9.100	1,820	664,300	
Volatile Solids available	Lbs	7.800	1,560	569,400	
Total Solids	Lbs	9.100	1,820	664,300	10.74%
Total Whey Produced	Gallons		**5,000**	1,825,000	
Percent Whey to Digester	Percent		55%		
Whey volume added to Digester	Gallons		**2,750**	1,003,750	
Whey volume added to Digester	Lbs		22,825	8,331,125	
Percent Moisture in Whey			93.8%		
Total Solids in Whey	Lbs		1,415	516,530	
Total Volatile Solids in Whey	Lbs		524	191,116	
Mg-Whey, dry basis	Lbs		37		
P-Whey, dry basis	Lbs		185		
K -Whey, dry basis	Lbs		591		
Ca Whey, dry basis	Lbs		221		
Cl - Whey, Dry basis	Lbs		370		
Cheese Factory Wash Down Water	Gallons		**-**	-	
Cheese Factory Wash Down Water	Lbs		-	-	
Total Volume to Digester	Gallons		19,356	7,065,082	
Total Volume to Digester	Lbs		160,658	58,640,184	
Total Volume to Digester	Gal/Minute	**13.4**			
Total Solids to Digester	Lbs		16,435		11.6%
Total Volatile Solids available to Digester	Lbs	-	11,604		8.2%
Energy Generation					
Total manure VS converted into methane (65%)	Lbs		7,202	2,628,730	
Total whey VS converted into methane (80%)	Lbs		419	152,893	
Methane generated (7.0 CFT/VS-Lb Converted)	CFT		53,346	19,471,360	
Total Biogas Produced	CFT	60%	88,910	32,452,266	
Energy Potential - Biogas	BTU	600	53,346,191	11,682,815,785	
Organic solids (dry basis)	Lbs		8,814	3,217,207	
Orgainc Solids Recovered	Lbs	**95%**	8,374	3,056,347	
Organic solids (65% moisture)	Lbs		23,924	8,732,419	
Manure volume reduction	Lbs		15,994	5,837,969	
Manure volume reduction	Gallons		1,927	703,370	
Manure volume reduction	Percent		9.96%		

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Table 6: Option 4 – Mass Balance Summary – 800 cows, Whey doubled

Clear Horizons Mass Balance					
	Unit				
		Per cow			
Total Number of Cows		**800**	**Per day**	**Per Year**	
Total manure	Tons		48	17,520	
Manure per animal, published data	Lbs	120.00			
Total manure produced	Lbs		96,000	35,040,000	
Total manure as liquid	Gallons		11,525	4,206,483	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	3.5	**2,800**	1,022,000	
Total water volume	Gallons		2,800	1,022,000	
Total diluted manure volume	Gallons		14,325	5,228,483	
Total diluted manure volume	Lbs		118,894	43,396,406	
Solids as Bedding	Lbs	2.500	2,000	730,000	
Solids in the manure-dry basis	Lbs	14.000	11,200	4,088,000	
Volatile Solids available	Lbs	11.900	9,520	3,474,800	
Total Solids	Lbs	16.500	13,200	4,818,000	11.10%
Total Number of Heifers		**200**			
Total manure	Tons		9	3,103	
Manure per animal, published data (70% of cow)	Lbs	85.00			
Total manure produced	Lbs		17,000	6,205,000	
Total manure as liquid	Gallons		2,041	744,898	
Flush water added, 32 gal/cow/day	Gallons	-	-	-	
Parlor water added	Gallons	-	**-**	-	
Total water volume	Gallons		-	-	
Total diluted manure volume	Gallons		2,041	744,898	
Total diluted manure volume	Lbs		16,939	6,182,653	
Solids in the manure-dry basis	Lbs	9.100	1,820	664,300	
Volatile Solids available	Lbs	7.800	1,560	569,400	
Total Solids	Lbs	9.100	1,820	664,300	10.74%
Total Whey Produced	Gallons		**10,000**	3,650,000	
Percent Whey to Digester	Percent		78%		
Whey volume added to Digester	Gallons		**7,750**	2,828,750	
Whey volume added to Digester	Lbs		64,325	23,478,625	
Percent Moisture in Whey			93.8%		
Total Solids in Whey	Lbs		3,988	1,455,675	
Total Volatile Solids in Whey	Lbs		1,476	538,600	
Mg-Whey, dry basis	Lbs		103		
P-Whey, dry basis	Lbs		521		
K -Whey, dry basis	Lbs		1,666		
Ca Whey, dry basis	Lbs		624		
Cl - Whey, Dry basis	Lbs		1,042		
Cheese Factory Wash Down Water	Gallons		**-**	-	
Cheese Factory Wash Down Water	Lbs		-	-	
Total Volume to Digester	Gallons		24,356	8,890,082	
Total Volume to Digester	Lbs		202,158	73,787,684	
Total Volume to Digester	Gal/Minute	**16.9**			
Total Solids to Digester	Lbs		19,008		10.4%
Total Volatile Solids available to Digester	Lbs	-	12,556		6.9%
Energy Generation					
Total manure VS converted into methane (65%)	Lbs		7,202	2,628,730	
Total whey VS converted into methane (80%)	Lbs		1,180	430,880	
Methane generated (7.0 CFT/VS-Lb Converted)	CFT		58,677	21,417,268	
Total Biogas Produced	CFT	60%	97,796	35,695,447	
Energy Potential - Biogas	BTU	600	58,677,447	12,850,360,849	
Organic solids (dry basis)	Lbs		10,626	3,878,365	
Orgainc Solids Recovered	Lbs	**95%**	10,094	3,684,447	
Organic solids (65% moisture)	Lbs		28,841	10,526,991	
Manure volume reduction	Lbs		18,477	6,744,056	
Manure volume reduction	Gallons		2,226	812,537	
Manure volume reduction	Percent		9.14%		

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System Energy Balance

In the current case, the biogas production was calculated at 42.9 MMBTU per day. Given the efficiencies of conversion to electrical and thermal energy, this translates into a minimum generator sizing of 170 kW which will be able to offset approximately 150 kW of electrical demand on the farm (Table 2). Based on the information provided by WE Energies and readings gathered at the farm, the total consumption of the farm and cheese factory is approximately 200 kW.

The farm and cheese factory will be connected to the utility with the generator providing the maximum available power supplying the milking parlor and cheese factory and the utility acting as a back-up, supplementing the production of the biogas generator.

The four additional options used in the mass balance were also used for the energy balance. These options are:

1.) 600 cows, 100 heifers – no whey added to the digester (Table 3)
2.) 600 cows, 100 heifers – cheese whey production doubled (Table 4)
3.) 800 cows, 200 heifers – cheese whey production constant (Table 5)
4.) 800 cows, 200 heifers – cheese whey production doubled (Table 6)

The electrical and thermal energy production for each case is summarized in Table 1.

Table 1: Electrical and Thermal Energy Production for the Various Cases

Case	Electrical Energy	Thermal Energy
Current	150 kW	5.0 MMBTU
Option 1	140 kW	4.3 MMBTU
Option 2	180 kW	7.3 MMBTU
Option 3	210 kW	9.9 MMBTU
Option 4	230 kW	11.6 MMBTU

These energy production values are used in the financial projections to estimate the cost offset possible by the anaerobic digestion system.

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Table 3: Current Case – Energy Balance – 600 cows

Clear Horizons Energy Balance					
Energy Generation			**Per Day**		
Energy Potential - Biogas	BTU	600	38,168,502		
Electrical Energy Efficiency			32.3%		
Thermal Energy Efficiency			40.0%		
System Energy Efficiency (Electrical & Thermal)			72.3%		
Energy Lost			27.7%		
BioGas Available for Electrical Generation					
Total Biogas Energy Converted to Electrical Energy			12.3	MMBTU/day	
Total Biogas Energy Converted to Hot Water			15.3	MMBTU/day	
Total Biogas Energy Lost			10.6	MMBTU/day	
Total Biogas Available			**38.17**	MMBTU/day	
Thermal Energy Equivalent to 1 kWh			3,412.0	BTU/kWh	
Total Electrical Energy Generated per day **(GROSS)**			3,613	KWh/day	**Gross** Electrical Energy Generated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Calculated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Blue Point Heat Rate @ 32.3 %
Hours per day			24	h/day	
Electrical Power Generation with zero % downtime			150.6	kW	
Uptime Percentage for Engine/Generator Set			90%		Typical Nominal Uptime
Power Generation Maximum Capacity Needed (kW)			167.3	kW	
Electrical Load Usage by Digester System			6.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Consumed by Digester System			217	kWh/day	
Electrical Load Usage by Manure Supplier			0.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Sold to Manure Supplier			0	kWh/day	
Net Available Electrical Energy for Sale			3,396	kWhday	
BioGas Available for Thermal Generation					
Total Biogas Energy Converted to Hot Water			15.3	MMBTU/day	
Assumed Influent Temperature			45	degree F	
Required Digester Temperature			95	degree F	
Available Hot Water that is used to Heat Anaerobic Digester			59.0%		Ranges from 40% (Summer) to 60% (Winter)
Thermal Energy Needed to Heat the Anaerobic Digester @ 80% Efficiency			9.00	MMBTU/day	
Thermal Energy for Sale to Manure Supplier @ 80% efficiency			5.01	MMBTU/day	

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Table 3: Option 1 – Energy Balance – 600 cows, No Whey

Clear Horizons Energy Balance					
Energy Generation			**Per Day**		
Energy Potential - Biogas	BTU	600	36,036,000		
Electrical Energy Efficiency			32.3%		
Thermal Energy Efficiency			40.0%		
System Energy Efficiency (Electrical & Thermal)			72.3%		
Energy Lost			27.7%		
BioGas Available for Electrical Generation					
Total Biogas Energy Converted to Electrical Energy			11.6	MMBTU/day	
Total Biogas Energy Converted to Hot Water			14.4	MMBTU/day	
Total Biogas Energy Lost			10.0	MMBTU/day	
Total Biogas Available			**36.04**	MMBTU/day	
Thermal Energy Equivalent to 1 kWh			3,412.0	BTU/kWh	
Total Electrical Energy Generated per day **(GROSS)**			3,411	KWh/day	**Gross** Electrical Energy Generated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Calculated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Blue Point Heat Rate @ 32.3 %
Hours per day			24	h/day	
Electrical Power Generation with zero % downtime			142.1	kW	
Uptime Percentage for Engine/Generator Set			90%		Typical Nominal Uptime
Power Generation Maximum Capacity Needed (kW)			157.9	kW	
Electrical Load Usage by Digester System			6.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Consumed by Digester System			205	kWh/day	
Electrical Load Usage by Manure Supplier			0.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Sold to Manure Supplier			0	kWh/day	
Net Available Electrical Energy for Sale			3,207	kWhday	
BioGas Available for Thermal Generation					
Total Biogas Energy Converted to Hot Water			14.4	MMBTU/day	
Assumed Influent Temperature			45	degree F	
Required Digester Temperature			95	degree F	
Available Hot Water that is used to Heat Anaerobic Digester			62.5%		Ranges from 40% (Summer) to 60% (Winter)
Thermal Energy Needed to Heat the Anaerobic Digester @ 80% Efficiency			9.00	MMBTU/day	
Thermal Energy for Sale to Manure Supplier @ 80% efficiency			4.33	MMBTU/day	

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Table 4: Option 2 – Energy Balance – 600 cows, Whey doubled

Clear Horizons Energy Balance						
Energy Generation			**Per Day**			
Energy Potential - Biogas	BTU	600	45,365,698		
Electrical Energy Efficiency			32.3%		
Thermal Energy Efficiency			40.0%		
System Energy Efficiency (Electrical & Thermal)			72.3%		
Energy Lost			27.7%		
BioGas Available for Electrical Generation					
Total Biogas Energy Converted to Electrical Energy			14.7	MMBTU/day	
Total Biogas Energy Converted to Hot Water			18.1	MMBTU/day	
Total Biogas Energy Lost			12.6	MMBTU/day	
Total Biogas Available			**45.37**	MMBTU/day	
Thermal Energy Equivalent to 1 kWh			3,412.0	BTU/kWh	
Total Electrical Energy Generated per day **(GROSS)**			4,295	KWh/day	**Gross** Electrical Energy Generated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Calculated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Blue Point Heat Rate @ 32.3 %
Hours per day			24	h/day	
Electrical Power Generation with zero % downtime			178.9	kW	
Uptime Percentage for Engine/Generator Set			90%		Typical Nominal Uptime
Power Generation Maximum Capacity Needed (kW)			198.8	kW	
Electrical Load Usage by Digester System			6.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Consumed by Digester System			258	kWh/day	
Electrical Load Usage by Manure Supplier			0.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Sold to Manure Supplier			0	kWh/day	
Net Available Electrical Energy for Sale			4,037	kWhday	
BioGas Available for Thermal Generation					
Total Biogas Energy Converted to Hot Water			18.1	MMBTU/day	
Assumed Influent Temperature			45	degree F	
Required Digester Temperature			95	degree F	
Available Hot Water that is used to Heat Anaerobic Digester			49.6%		Ranges from 40% (Summer) to 60% (Winter)
Thermal Energy Needed to Heat the Anaerobic Digester @ 80% Efficiency			9.00	MMBTU/day	
Thermal Energy for Sale to Manure Supplier @ 80% efficiency			7.31	MMBTU/day	

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Table 4: Option 3 – Energy Balance – 800 cows

Clear Horizons Energy Balance					
Energy Generation			**Per Day**		
Energy Potential - Biogas	BTU	600	53,346,191		
Electrical Energy Efficiency			32.3%		
Thermal Energy Efficiency			40.0%		
System Energy Efficiency (Electrical & Thermal)			72.3%		
Energy Lost			27.7%		
BioGas Available for Electrical Generation					
Total Biogas Energy Converted to Electrical Energy			17.2	MMBTU/day	
Total Biogas Energy Converted to Hot Water			21.3	MMBTU/day	
Total Biogas Energy Lost			14.8	MMBTU/day	
Total Biogas Available			**53.35**	MMBTU/day	
Thermal Energy Equivalent to 1 kWh			3,412.0	BTU/kWh	
Total Electrical Energy Generated per day **(GROSS)**			5,050	KWh/day	**Gross** Electrical Energy Generated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Calculated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Blue Point Heat Rate @ 32.3 %
Hours per day			24	h/day	
Electrical Power Generation with zero % downtime			210.4	kW	
Uptime Percentage for Engine/Generator Set			90%		Typical Nominal Uptime
Power Generation Maximum Capacity Needed (kW)			233.8	kW	
Electrical Load Usage by Digester System			6.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Consumed by Digester System			303	kWh/day	
Electrical Load Usage by Manure Supplier			0.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Sold to Manure Supplier			0	kWh/day	
Net Available Electrical Energy for Sale			4,747	kWhday	
BioGas Available for Thermal Generation					
Total Biogas Energy Converted to Hot Water			21.3	MMBTU/day	
Assumed Influent Temperature			45	degree F	
Required Digester Temperature			95	degree F	
Available Hot Water that is used to Heat Anaerobic Digester			42.2%		Ranges from 40% (Summer) to 60% (Winter)
Thermal Energy Needed to Heat the Anaerobic Digester @ 80% Efficiency			9.00	MMBTU/day	
Thermal Energy for Sale to Manure Supplier @ 80% efficiency			9.87	MMBTU/day	

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Table 5: Option 4 – Energy Balance – 800 cows, Whey Doubled

Clear Horizons Energy Balance					
Energy Generation			**Per Day**		
Energy Potential - Biogas	BTU	600	58,677,447		
Electrical Energy Efficiency			32.3%		
Thermal Energy Efficiency			40.0%		
System Energy Efficiency (Electrical & Thermal)			72.3%		
Energy Lost			27.7%		
BioGas Available for Electrical Generation					
Total Biogas Energy Converted to Electrical Energy			19.0	MMBTU/day	
Total Biogas Energy Converted to Hot Water			23.5	MMBTU/day	
Total Biogas Energy Lost			16.3	MMBTU/day	
Total Biogas Available			**58.68**	MMBTU/day	
Thermal Energy Equivalent to 1 kWh			3,412.0	BTU/kWh	
Total Electrical Energy Generated per day **(GROSS)**			5,555	KWh/day	**Gross** Electrical Energy Generated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Calculated
Heat Rate to Generate 1 kWh of electrical energy			10,563	BTU/kWh	Blue Point Heat Rate @ 32.3 %
Hours per day			24	h/day	
Electrical Power Generation with zero % downtime			231.4	kW	
Uptime Percentage for Engine/Generator Set			90%		Typical Nominal Uptime
Power Generation Maximum Capacity Needed (kW)			257.2	kW	
Electrical Load Usage by Digester System			6.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Consumed by Digester System			333	kWh/day	
Electrical Load Usage by Manure Supplier			0.0%	of Gross Elect Gen	Percent of Gross Electrical Energy Generated
Electrical Energy Sold to Manure Supplier			0	kWh/day	
Net Available Electrical Energy for Sale			5,221	kWhday	
BioGas Available for Thermal Generation					
Total Biogas Energy Converted to Hot Water			23.5	MMBTU/day	
Assumed Influent Temperature			45	degree F	
Required Digester Temperature			95	degree F	
Available Hot Water that is used to Heat Anaerobic Digester			38.4%		Ranges from 40% (Summer) to 60% (Winter)
Thermal Energy Needed to Heat the Anaerobic Digester @ 80% Efficiency			9.00	MMBTU/day	
Thermal Energy for Sale to Manure Supplier @ 80% efficiency			11.57	MMBTU/day	

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System Design

With the mass and energy balance completed, the system was designed. National Survey and Engineering performed a rough survey of the site to approximate the changes in elevations.

Using an aerial photograph of the project site, an initial location for the digester plant was selected near the bunker silos. Applied Technologies was contracted to provide preliminary engineering for this project. The cheese whey was sampled and analyzed as well as the manure to determine its properties for digestion. These results can be found in Appendix A. The digester tank was sized to provide a minimum of 30 days of retention time for 1000 cows. The remaining system components were sized based on the loading rates of 1000 cows and the changes in elevations.

Using the information provided by National Survey and Engineering, the digester system was plotted on the aerial photograph. Following review of this layout, the proposed position of the digester plant would potentially interfere with future barn construction. The digester plant was relocated to the east side of the existing free-stall barn in an area that is approximately 15 feet lower than the barn. This will allow gravity flow to the digester from the barn.

Individual component drawings were completed for the main elements of the system to allow for budget quoting of the digester plant. The automation control drawings were also completed to allow for the estimation of the control and monitoring system. These drawings can be found in Appendix C.

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System Technical Description

The proposed digester system is a single-stage, above ground, complete mix digester system. This system was selected to provide maximum flexibility with combined whey and manure waste streams. This system is designed to allow for expansion and growth as the farm and cheese factory grow. Mechanically, this system offers a simple design utilizing proven system components. One of the main features of this system is an advanced automation and control system that will continually monitor and control the process. This system will also allow for remote operation by Clear Horizons.

The system is designed to allow for an additional tank prior to the digester for research on single versus two stage digestion. The system is also designed to grow with the farm. Most mechanical systems provided redundancy to allow for continued system operation in the event of a part failure.

The following section breaks down the system into its major components. Each component is physically described with a brief discussion on its role in the system and its operation.

Manure Collection Pit

The manure collection pit will be a pre-cast concrete tank, approximately 5 ft. in diameter and 12 ft. in height. The tank will be placed in the ground on a concrete foundation with the top of the tank just over the current surface elevation.

The manure from the barn will gravity flow into the tank. Inside the tank will be two positive displacement manure feed pumps, one primary pump and one standby pump. Each pump will have a variable frequency drive (VFD) in order to control the manure feed rate to the digester. The tank will also have a level indicator to monitor the level of the manure in the tank.

The manure collection pit is adequately sized to allow for future expansion as well as the pumping of manure from the 5th Group. As future barns are constructed on site, the manure from these barns can be directed to the manure collection pit and incorporated into the digester system with few modifications.

Whey Holding Tank

The existing Slurrystore^{TM} tank located south of the Cheese Factory will be used as the whey holding tank. The tank will be equipped with two positive displacement whey feed pumps, one primary pump and one standby pump. Each pump will have a variable frequency drive (VFD) in order to control the whey feed rate to the digester. The whey

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tank will be equipped with a level indicator to monitor and control the level in the whey tank.

It is assumed that the whey disposal process currently used will be continued. A portion of the fresh whey is pumped to the milking parlor and loaded into a tank to feed the cows. The remaining whey is pumped into the whey holding tank. All the wash down water and cleaning agents are also pumped into the whey holding tank. Due to the relatively low concentrations of these chemicals, it is assumed they will have very little adverse effect on the digestion process.

Digester

The digester will be an above ground fabricated steel tank. The tank is approximately 56 ft. in diameter and 24 ft. in height. The manure and whey will enter the tank at a common point. The tank will be constructed on a concrete foundation. The foundation will incorporate an inverse cone with a pipe from the bottom of the cone to an above ground location near the digester. This will allow the tank to be cleaned of sediment build-up without removing the digester cover or interrupting the digestion process.

The tank is designed to offer a retention time of approximately 20-25 days with a storage capacity of 411,000 gallons. The system is designed to operate at either mesophilic temperature (95 degree F) or at thermophilic temperature (125 degree F).

The only components located inside the tank are two mixing units. These mixers will keep the slurry agitated to minimize the settling out of denser particles. These mixing units and the digester cover will form a seal with the effluent. This will allow the mixing units to be serviced or removed without the removal of the cover. The will be a stairs and platform located by each mixer. Located on the platform will be a jib crane to assist with the removal of the pumps.

The tank will be insulated thoroughly to minimize heat loss to the atmosphere, even on a cold winter day. The insulation value will only allow for a loss of one degree per day from the tank if no heat is added to maintain the tank temperature. This will allow the digester to continue operating properly while maintenance is performed on the engine-generator or on the heat exchanger.

The digester cover will be a flexible membrane secured to the top of the digester tank. Biogas will be captured and stored between the digester cover and the effluent in the tank.

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Settling Tank

Following the digestion process, the effluent will be pumped to a settling tank. The settling tank is approximately 30 ft. in diameter and 20 ft. in height. It has an inverse cone shape to allow the solid particles to fall to the bottom, leaving the liquid effluent on the top. The settling tank will be located on a concrete foundation.

The solid effluent gathered from the bottom of the settling tank will have two possible paths. A portion of the solids will be recycled back to the digester in order to maintain the digester temperature and an adequate bacteria level to ensure optimal digester performance. The remaining solids will go to the solids separation system.

The liquid effluent removed from the top of the settling chamber will be combined with the liquid from the solids separation system and pumped into the existing manure lagoon.

Solids Separation

The solids separation system will consist of a feed hopper, screw press, liquid sump, conveyor system for the solids, and a storage area for the separated solids.

The solids coming from the settling chamber will enter the feed hopper located above the screw press. The hopper will feed the material into the screw press. The screw press will remove a majority of the remaining moisture from the digested solids. The solids coming out the end of the screw press will be conveyed to a solids storage area. This solids product will be used as a bedding replacement for the farm with the remainder processed into additional materials by Clear Horizons.

The liquid removed from this process will drain into a sump, combine with the liquid effluent from the settling tank, and be pumped into the existing manure lagoon.

External Heat Exchanger

The portion of the solids recycled back to the digester from the settling tank will pass through a heat exchanged located near the digester tank. The solids will be heated by the hot water captured from the engine-generator.

The solids will be fed through the heat exchanger at a constant rate and the hot water rate will be varied in order to control the temperature of the digester. This system minimizes the components located inside the digester to maximize both safety and system availability. These components can easily be serviced without interrupting the digestion process.

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Servicing these units will require opening the end and cleaning out with high pressure water. This unit is also designed to allow for easy removal and replacement should something fail inside the heat exchanger.

Biogas Fuel Train

The biogas fuel train will consist of piping from the digester to the engine-generator system. Located in the piping will be a series of particulate filters and water traps. The gas will also pass through a hydrogen sulfide scrubber to remove this harmful contaminant prior to entering the combustion chamber of the engine. The gas will also pass through a coalescing unit to remove the remaining water vapor prior to entering the engine.

The gas will be collected with a blower. The gas pressure, quantity, quality, and contaminants will be continually monitored. The final component in the fuel train will be a flow regulator to meter the proper amount of biogas into the engine at the correct pressure.

Hot Water System

The hot water system will consist of a storage tank and circulation pumps. The water will pass through heat exchangers for cooling the engine jacket water and recovering a portion of the heat in the engine exhaust. The hot water will be circulated to the digester heat exchanger. The hot water may also be used for preheating water used in the milking parlor. At a future time, the hot water may also be used in an evaporative cooling system to aid in cooling the milk. The hot water will also be used to preheat the water prior to the steam boiler in the cheese factory. The heat exchangers are assumed to be food grade to allow for potable water to be preheated.

The water used in this system will be distilled water to minimize deterioration or scale build-up in any other the heat exchangers. The heat exchangers are assumed to be food grade to allow for potable water to be preheated.

Generator System

The biogas generated from the digestion process will fuel a 200 kW engine and generator. The exhaust from the engine will pass through a heat exchanger providing heat to the hot water system. The engine jack water will also pass through a heat exchanger providing heat to the hot water system. There will be an external radiator to allow further cooling of the engine jacket water if necessary.

The generator system will be equipped with a control system to monitor the performance of the engine and the generator. This control system will allow for maximum generator

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efficiency while protecting the unit from operating outside its recommended parameters. This control system will be integrated into the plant control system.

Generator and Control Building

The generator system, motor control center, and operator room will be housed in a building located near the milking parlor. The building will be approximately 25 ft. wide and 75 ft. long. The building will be divided into three rooms. The generator room will have a large door to allow for easy access, installation, and removal of the generator system. The motor control center (MCC) room will house all the motor starters, VFDs, and the automation system. The operator room will have a computer on a desk to allow for viewing and operation of the digester plant. The MCC room and the operator room will be insulated and have a HVAC unit.

Electrical Distribution System

The electrical distribution of the farm and the cheese factory will be modified to allow electricity generated by the digester plant to power as many of the electrical loads on the farm and cheese factory as possible with the utility supplying the remainder of the required power. In the event of a generator failure or if the generator is down for maintenance, the utility will automatically supply all the required power to the farm.

The power from the utility will come through a transformer located near the control building. Following the transformer will be an automatic transfer switch and power paralleling equipment. The power will be redistributed to the cheese factory and the farm from this location. The generator will be setup as the main source of power with the utility supplementing any additional power that may be required and acting as a back-up when the generator is not in operation. If utility power would fail, the generator would continue to supply as much power as it could generate until utility power is restored. If during a utility failure the demand exceeded the production of the generator, non-critical loads can be shed with power directed to the critical loads such as the milking parlor and cheese factory.

Following the generator, transformers will be installed to supply the correct voltage to the existing electrical services on the farm and cheese factory. All the motors and signals required for operation of the digester plant will receive power from the MCC room located in the control building.

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Automation and Control System

The digester plant will be monitored and controlled by an automation system designed to maximize the performance of the digester plant while ensuring the plant operates within its design parameters. The system will be located in the operator room of the control building and will also be viewed and operated from a remote location. The system will consist of all the required instrumentation to generate plant data such as temperatures, pressures, flow rates, pH, gas quality, etc. All these sensors will be wired to a central point located in the MCC room. From there, these signals will be processed by a computer programmed to display the information and control the plant based in these inputs. Following is a basic description of the control philosophy of the plant.

As both the manure and whey are fed into their collection tanks, the automation system will monitor the level in these tanks and adjust the speed of the variable speed motors to prevent the tanks from overflowing or getting too low and starving the pumps. The system will also monitor the biogas production and adjust the mixture and quantity of manure and whey to maintain maximum and constant gas production. Each of the feed streams will be monitored for pH level and high concentrations of chemicals that may harm the digestion process. If high concentrations are detected, the feed pumps will stop, and the collection tanks will have to be emptied.

The temperature of the tank influent and effluent will be monitored, and the performance of the digester heat exchanger will be modified to maintain the optimal temperature of the digester. The control system will continually vary the temperature of the digester slightly ensuring the digester is operating at peak biogas production.

The automation system will monitor the level of material in the solids separation feed hopper and the liquid sump. It will activate the pumps and ancillary equipment as necessary. It will also monitor the generator performance and make necessary adjustments to the engine-generator operating system and cooling system.

All information monitored will be collected and stored by the operating computer. The computer will be equipped with an interface that will allow the operator to view all components in the plant as a general overview or by each individual component. The system will also have a troubleshooting and diagnostics screens to allow the operator to quickly find the problem with the plant and take corrective action. The operation screens will show which components in the plant are in operation and the operating data associated with the component.

The computer will also have a trending and graphing package that will allow the operator to quickly trend the data to determine operational relationships. The trends will also provide the operator with preventative maintenance information in order to dispatch service as required.

An alarm system will also be a part of the automation system. If a parameter goes outside a preset limit, the system will attempt to take corrective action. If the system is

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unable to correct this situation, an alarm will notify the operator of the fault and provide information on the cause of the fault. There will be various alarm levels with yellow alarms indicating the plant is operating outside the set points, but the control system is attempting to correct this situation. Orange alarms indicate faults that must be addressed by the operator since the control system is unable to correct them, but do not require the plant to shut down. Red alarms will indicate a fault that will require immediate attention by the operator, and the plant will begin to shut down until the fault is corrected.

The automation system is adaptable to changes in the performance of the plant and the layout of the screens viewed by the operator. The system will allow for manual override and operation of the plant if needed, but this feature will be password protected to provide security of the system. The computer located on the site will be password protected to allow only viewing capabilities of the plant, but prevent local control unless authorized.

High-speed internet access will be required to allow for remote viewing and operation. The information collected on-site will be sent back to the remote control center on a pre-defined interval. If a fault occurs, the system will save all the data collected over the past few hours and start collecting data at a more frequent interval. The system will continue to collect the data until the fault is corrected.

The automation system will also generate a one page report documenting the performance of the plant each day, each week, and each month. This data will provide the owner with a quick reference to the amount of waste processed, the quantity and quality of the biogas collected, the amount of electricity generated, and the availability of the plant.

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Project Schedule

A project schedule was developed using Microsoft Project to illustrate the anticipated delivery lead times and construction times for this project. The project will take approximately 12 months from the time of contract signing to the full operation of the system. The detailed project schedule is on the following page.

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System Financial Projections

Capital Expense

Following the preliminary system design, pricing was gathered on the majority of the system components. Multiple suppliers were contacted for pricing on the fabricated and purchase components. Pieper Electric completed the electrical design and estimated the cost of installing all electrical components, the inter-connection with the utility, and the distribution around the farm and cheese factory. Pieper also estimated the required system instrumentation, sized the Programmable Logic Controller (PLC), and estimated the programming time to develop the digester control system. Boldt Construction estimated the installation of all the mechanical components of the system including the tanks, pumps, and piping. They also designed and estimated the foundations for all the large components. Dunneisen Excavating estimated all the required trenching, fill and grading for the digester tank area, creating a road to the digester tank area, and grading and ditching around the current lagoon to keep drainage away from the digester area.

The complete turn-key installed price for the digester system is $1,546,627. The price does not include any expenses for permits or fees. For the financial calculations, it was assumed this cost would be spread evenly over the four months projected for construction or $385,000 for the months of March, April, May, and June of 2006. This system is designed to accommodate the growth from 600 cows to 800 cows by the end of 2007. All the financial projections use the 600 cow mass and energy balance numbers for 2006 and 2007 and the 800 cow mass and energy balance numbers for 2008-2016.

With the total installed cost of the system established, the system operating revenues and expenses were determined from the information developed in the mass and energy balance calculations.

Electrical Revenue

Analyzing the electric bills for the farm and cheese factory, the farm is paying a continuous rate of $0.09-$0.095/kWh. The cheese factory is paying a rate of $0.064/kWh with a Demand Charge of $5.43/kW. This equates to an average rate of $0.099/kWh. Based on this information, the greatest revenue generation will be offsetting as much of the $0.09/kWh if the cost of installing the distribution system makes this possible. The maximum kW load assuming converting the loads to 480 Volts at the various locations around the farm are listed in Table 1. The price of electricity over the ten year projections was increased by 3% per year to account for the rise in cost of electricity and the increase in demand of the farm over this time period. This is based on the information collected from WE Energies which shows the price of electricity has increased approximately 2.5% per year based on the utility bills from 2002-2005.

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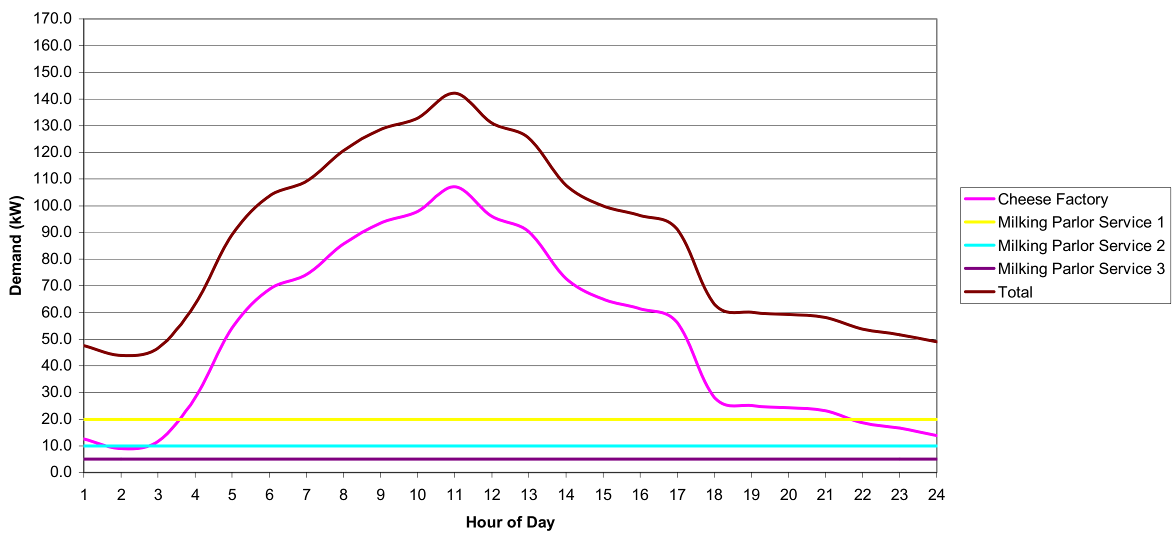
Table 1: Maximum kW Usage

Location	Maximum kW
Milking Parlor	50-60
Cheese Factory	120
Feed Barn	40
Hospital Barn	40
House	10-15
Total	**260-275**

The electrical demand profile for the cheese factory was obtained from WE Energies. Reviewing multiple days and weeks, the trends appear to be consistent. A seven day period in July was plotted and used as the average cheese factory demand (Chart 1).

Chart 1: Crave Farm Electricity Consupmtion



Based on the usage history from WE Energies, the milking parlor services were plotted as straight lines for the average usage. As shown, the peak demand does not exceed the capacity of the generator. Therefore, the bio-gas generator should be able to completely offset the demand from the cheese factory and milking parlor.

Since there is excess electricity during the 24 hour period, another plot was developed showing the amount of electricity consumed by the farm versus the amount of electricity available for sale to the Utility (Chart 2).

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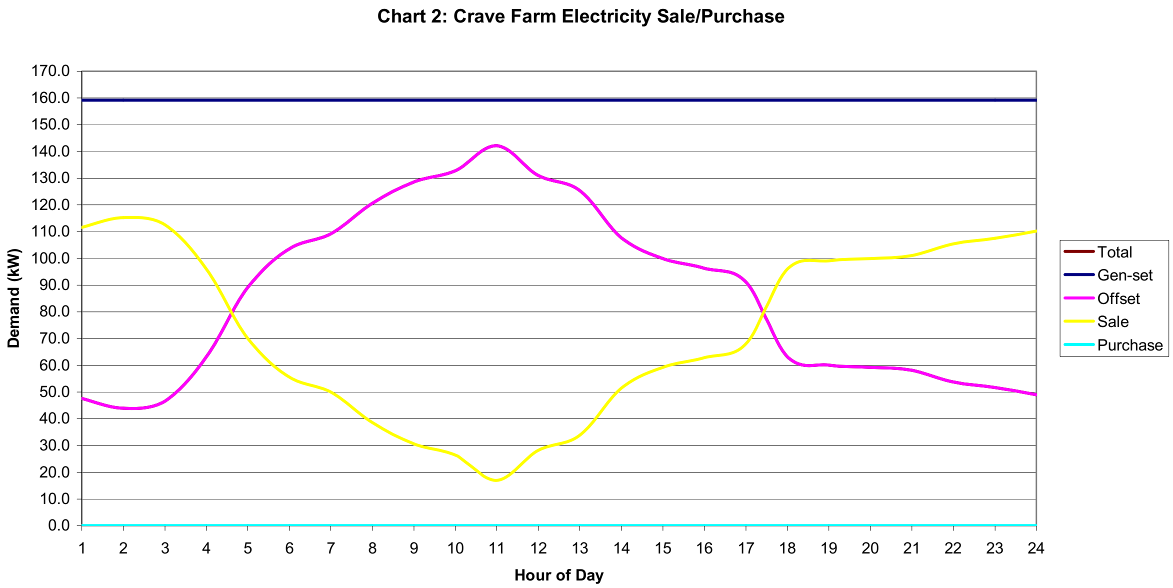

At this point, it is assumed the available electricity for sale to the Utility is as much as 115 kW with no purchase required by the farm. This data was used to determine the revenue generation from the electricity produced by the digester system. The offset amount is calculated at $0.10 which is the projected average blended rate of the cheese factory and the milking parlor for the fall of 2006. The sale price to the Utility is assumed at $0.06 which is currently proposed to the Public Service Commission for approval for their renewable energy programs.

For 2006 and 2007, it is estimated the sale of electricity to the Utility will account for revenue of approximately $2,700 per month or about $$32,400 per year. Once the farm expands to 800 cows, the revenue from the Utility is expected at approximately $5,170 per month or $62,000 per year. The anticipated savings by offsetting the electrical demand at the cheese factory and the milking parlor is also considered a revenue in the financial calculations. It is estimated the farm will save approximately $5,200 per month or $62,400 per year. The savings will increase by 3% per year based on the correction factor mentioned previously.

Thermal Revenue

The LP gas consumption over the last year was provided and analyzed. The rate for gas ranged from $1.29/gallon to $1.49/gallon. Based on gas projections through next year, it is anticipated the rate will average above $1.49/gallon, but this value is used in the calculations.

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Table 2: LP Consumption

Month	Cheese Factory	Milking Parlor	All Else	Total
January	2200	300	770	3270
February	1845	265	858	2968
March	1625	250	330	2205
April	1125	0	100	1225
May	1700	275	100	2075
June	1850	300	70	2220
July	1475	0	150	1625
August	1700	300	80	2120
September	1875	325	335	2535
October	1750	300	120	2170
November	2100	0	100	2200
Average	**1750**	**210**	**274**	**2234**

Using 91,600 BTU/Gallon of LP gas[1], the farm consumes approximately 204 MMBTU/month. The milking parlor consumes 19.2 MMBTU/month, and the cheese factory consumes 160.3 MMBTU/month. The engine/generator is capable of producing an excess of 195 MMBTU/month in the winter months after providing heat to the digester and 300 MMBTU/month in the summer months in the form of hot water. For the financial calculations, it was assumed that none of the hot water produced by the digester plant can be utilized by either the cheese factory or the milking parlor. This is due to the current configuration of the hot water systems at each location. The most economical way to offset the thermal load at the cheese factory and the milking parlor would be to supply bio-gas to fuel the boiler in either or both locations. This option can be explored at a later date.

Bedding Revenue

The bedding cost for the farm in 2004 was $67,000. It was estimated that the digested solids could replace 90% of this expense or about $60,000. The digester solids represent a savings of approximately $86/cow assuming 600 milking cows and 100 heifers. When the farm expands, the savings in bedding is anticipated at $86,000 based on 800 milking cows and 200 heifers.

Another source of revenue will be selling the solids not required for bedding the farm to other farms. The farm will be paid $20/ton for the solids that will be sold to other farms based on the pricing currently received by other farms with digesters. This provides the farm with $31,600 per year with 600 cows and $43,660 per year with 800 cows in additional revenue.

[1] Gas Heat Reference Guide, WE Energies Company.

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Manure Disposal Revenue

The cost for manure and whey removal in 2004 was $59,704 with the fuel charge. Based on this cost and the volume of manure processed through the digestion system each year as calculated in the mass balance, this equates to $0.01/gallon. Assuming the digestion process and solids separation system will reduce the manure and whey disposal volume by approximately 10%, this equate to a savings of $6,300 per year with 600 milking cows and $7,065 per year with 800 milking cows.

Tipping Fee Revenue

It was assumed no material would be brought into the system other than the manure and whey for co-digestion. Without bringing any additional materials to the farm, there is no revenue from tipping fees. A rendering plant is going to be built in Waterloo in 2006 which may provide a source for additional substrates. Other farms in the area may also want to haul their manure to the digester system which would provide additional loading. These options can be explored at a later date.

Plant Maintenance Expense

The maintenance expenses of the digester system are a function of the throughput of the system and the electrical production. It was assumed the digester system maintenance would cost $0.005 per pound of the total solids processed by the system. The maintenance for the engine/generator system is estimated at $0.025/kW based on previous history of Wisconsin Lift Truck. These combined expenses are approximately $55,000 per year with 600 cows and $76,000 for 800 cows.

Plant Operating and Monitoring Expense

In additional to the maintenance expenses, the system operational expense was estimated at 5% of the revenue generation of the system. This fee is structured to ensure Clear Horizons maximizes the performance and uptime of the system since it only collects this fee if the system is producing revenue for the farm. The operating and monitoring expense is projected at approximately $9,000 per year with 600 cows and $12,600 per year with 800 cows.

Miscellaneous Expense

An additional expense included in the financial projections is consumables. This should cover miscellaneous items that may not be covered under the maintenance contract. This was added since most projects that have been constructed have under estimated their

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maintenance costs. This is approximately $2,700 per year for 600 cows and $3,800 per year for 800 cows.

Financial Summary

The revenue and expense projections were calculated in a worksheet to provide the Project Gross Profit. The worksheet for the 600 cow option and the worksheet for the 800 cow option can be found in Appendix D. For this project, the Gross Profit is approximately 66% per year. The simple payback for this project based on the Gross Profit is 9 years.

In order to determine the Project Net Income, the Depreciation and Interest was calculated. The depreciation used in the financial projection is 10 year straight-line depreciation. This is based on our conversations with the Crave Brothers' accountant. He also suggested using 7% for the interest rate for debt calculations. Two financial summaries were developed for this project: Debt Financing and Equity Financing.

For each summary, the Net Income Before and After Tax was calculated as well as the Cash Flow. For the Debt Financing model, the cash flow after 10 years is a loss of ($12,428). For the equity financing model, the cash flow after 10 years is a gain of $295,610. I twill be up to the Farm to determine which financing model will make the most sense for their long term growth plan. The financing spreadsheet can be found in Appendix E.

Additional items were also explored relating to improving the payback to the system. One question concerned the value of the whey as a feed stock for the digester. Based on the revenue generation and expense to handle, the whey has an energy value of $0.04/gallon. If it is more valuable as a feed source, it should be used as feed rather than added to the digester.

Finally, no grant money was assumed in determining the payback of the project. As directed by Crave Brothers Farm, the USDA 9006 grant will not be pursued. Grant funding still available for this project include $50,000 from Focus on Energy for the electrical production.

There are also numerous "soft" benefits to the farming operation that are not quantified in these financial calculations such as odor reduction, fly reduction, pathogen kill in manure, weed seed destruction in manure, and the potential to couple additional technologies with a digester system such as a greenhouse and Living Machine™. Many of these factors simplify future permitting and compliance requirements with the Department of Natural Resources and the Environmental Protection Agency. The pathogen and weed seed kill improves the quality of the fertilizer value when the liquid effluent is applied to the fields.

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Appendix A:

Farm Data Collected for Study

Information contained in this document is Confidential and not intended for general distribution.

Manure Analysis Report

Date 9/23/05

Rock River Laboratory, Inc.
P.O. Box 169
Watertown, Wi 53094-0169
(920)261-0446

Dealer ROCK RIVER LAB, INC
PO 169
WATERTOWN, WI 53094-016

Feeder: CLEAR HORIZONS

Sample No: 10

Desc: DIGESTER SOLIDS - HOSPITAL

Moisture: 83.97% **Dry Matter:** 16.03%

1st Year Available

	Total		(incorp)		(Top Dress)*	
Nitrogen (N)	4.89	lbs/ton	1.96	lbs/ton	1.47	lbs/ton
Phosphorus (P2O5)	3.91	lbs/ton	2.35	lbs/ton	2.35	lbs/ton
Potassium (K2O)	4.94	lbs/ton	3.95	lbs/ton	3.95	lbs/ton
Sulfur (S)	0.71	lbs/ton	0.43	lbs/ton	0.43	lbs/ton

2nd Year Available (if applied 2 consecutive years)

	(incorp)		(Top Dress)*	
Nitrogen (N)	2.45	lbs/ton	1.96	lbs/ton
Phosphorus (P2O5)	2.74	lbs/ton	2.74	lbs/ton
Potassium (K2O)	4.44	lbs/ton	4.44	lbs/ton
Sulfur (S)	0.50	lbs/ton	0.50	lbs/ton

3rd Year Available (if applied 3 consecutive years)

	(incorp)		(Top Dress)*	
Nitrogen (N)	2.69	lbs/ton	2.20	lbs/ton
Phosphorus (P2O5)	2.93	lbs/ton	2.93	lbs/ton
Potassium (K2O)	4.69	lbs/ton	4.69	lbs/ton
Sulfur (S)	0.53	lbs/ton	0.53	lbs/ton

Lab Number M-1109

** Top Dress - Based on no incorporation withing first 72 hours.*

Manure Analysis Report

Date 9/23/05

Rock River Laboratory, Inc.
P.O. Box 169
Watertown, Wi 53094-0169
(920)261-0446

Dealer ROCK RIVER LAB, INC
PO 169
WATERTOWN, WI 53094-016

Feeder: CLEAR HORIZONS

Sample No: 3

Desc: RAW MANURE - DRY COW

Moisture: 83.61% **Dry Matter:** 16.39%

1st Year Available

	Total	(incorp)	(Top Dress)*
Nitrogen (N)	3.35 lbs/ton	1.34 lbs/ton	1.01 lbs/ton
Phosphorus (P2O5)	2.13 lbs/ton	1.28 lbs/ton	1.28 lbs/ton
Potassium (K2O)	6.32 lbs/ton	5.06 lbs/ton	5.06 lbs/ton
Sulfur (S)	1.06 lbs/ton	0.63 lbs/ton	0.63 lbs/ton

2nd Year Available (if applied 2 consecutive years)

	(incorp)	(Top Dress)*
Nitrogen (N)	1.68 lbs/ton	1.34 lbs/ton
Phosphorus (P2O5)	1.49 lbs/ton	1.49 lbs/ton
Potassium (K2O)	5.69 lbs/ton	5.69 lbs/ton
Sulfur (S)	0.74 lbs/ton	0.74 lbs/ton

3rd Year Available (if applied 3 consecutive years)

	(incorp)	(Top Dress)*
Nitrogen (N)	1.84 lbs/ton	1.51 lbs/ton
Phosphorus (P2O5)	1.60 lbs/ton	1.60 lbs/ton
Potassium (K2O)	6.00 lbs/ton	6.00 lbs/ton
Sulfur (S)	0.79 lbs/ton	0.79 lbs/ton

Lab Number M-1102

** Top Dress - Based on no incorporation withing first 72 hours.*

Manure Analysis Report

Date 9/23/05

Rock River Laboratory, Inc.
P.O. Box 169
Watertown, Wi 53094-0169
(920)261-0446

Dealer ROCK RIVER LAB, INC
PO 169
WATERTOWN, WI 53094-016

Feeder: CLEAR HORIZONS

Sample No: 1

Desc: RAW MANURE - DRY COW PEN

Moisture: 87.00% **Dry Matter:** 13.00%

1st Year Available

	Total	(incorp)	(Top Dress)*
Nitrogen (N)	5.62 lbs/ton	2.25 lbs/ton	1.69 lbs/ton
Phosphorus (P2O5)	3.00 lbs/ton	1.80 lbs/ton	1.80 lbs/ton
Potassium (K2O)	4.29 lbs/ton	3.43 lbs/ton	3.43 lbs/ton
Sulfur (S)	0.70 lbs/ton	0.42 lbs/ton	0.42 lbs/ton

2nd Year Available (if applied 2 consecutive years)

	(incorp)	(Top Dress)*
Nitrogen (N)	2.81 lbs/ton	2.25 lbs/ton
Phosphorus (P2O5)	2.10 lbs/ton	2.10 lbs/ton
Potassium (K2O)	3.86 lbs/ton	3.86 lbs/ton
Sulfur (S)	0.49 lbs/ton	0.49 lbs/ton

3rd Year Available (if applied 3 consecutive years)

	(incorp)	(Top Dress)*
Nitrogen (N)	3.09 lbs/ton	2.53 lbs/ton
Phosphorus (P2O5)	2.25 lbs/ton	2.25 lbs/ton
Potassium (K2O)	4.08 lbs/ton	4.08 lbs/ton
Sulfur (S)	0.53 lbs/ton	0.53 lbs/ton

Lab Number M-1100

** Top Dress - Based on no incorporation withing first 72 hours.*

Manure Analysis Report

Rock River Laboratory, Inc.
P.O. Box 169
Watertown, Wi 53094-0169
(920)261-0446

Date	9/23/05
Dealer	ROCK RIVER LAB, INC PO 169 WATERTOWN, WI 53094-016
Feeder:	CLEAR HORIZONS
Sample No:	2
Desc:	RAW MANURE - LACTATION COW

Moisture: 71.96% *Dry Matter:* 28.04%

1st Year Available

	Total	*(incorp)*	*(Top Dress)**
Nitrogen (N)	3.11 lbs/ton	1.24 lbs/ton	0.93 lbs/ton
Phosphorus (P2O5)	2.10 lbs/ton	1.26 lbs/ton	1.26 lbs/ton
Potassium (K2O)	4.46 lbs/ton	3.57 lbs/ton	3.57 lbs/ton
Sulfur (S)	0.95 lbs/ton	0.57 lbs/ton	0.57 lbs/ton

2nd Year Available (if applied 2 consecutive years)

	(incorp)	*(Top Dress)**
Nitrogen (N)	1.55 lbs/ton	1.24 lbs/ton
Phosphorus (P2O5)	1.47 lbs/ton	1.47 lbs/ton
Potassium (K2O)	4.02 lbs/ton	4.02 lbs/ton
Sulfur (S)	0.66 lbs/ton	0.66 lbs/ton

3rd Year Available (if applied 3 consecutive years)

	(incorp)	*(Top Dress)**
Nitrogen (N)	1.71 lbs/ton	1.40 lbs/ton
Phosphorus (P2O5)	1.58 lbs/ton	1.58 lbs/ton
Potassium (K2O)	4.24 lbs/ton	4.24 lbs/ton
Sulfur (S)	0.71 lbs/ton	0.71 lbs/ton

Lab Number M-1101

***** Top Dress - Based on no incorporation withing first 72 hours.***

Manure Analysis Report

Date 3/23/04

Rock River Laboratory, Inc.
P.O. Box 169
Watertown, Wi 53094-0169
(920)261-0446

Dealer CRAVE BROTHERS
W11550 TROPY RD.
WATERLOO, WI 53594

Feeder: CRAVE BROTHERS

Sample No: 1

Desc: LIQUID DAIRY MANURE

Moisture 95.11% **Dry Matter:** 4.89%

1st Year Available

	Total	(incorp)	(Top Dress)*
Nitrogen (N)	24.48 lbs/1000gl	9.79 lbs/1000gl	7.35 lbs/1000gl
Phosphorus	6.69 lbs/1000gl	4.01 lbs/1000gl	4.01 lbs/1000gl
Potassium (K2O)	14.23 lbs/1000gl	11.38 lbs/1000gl	11.38 lbs/1000gl
Sulfur (S)	3.04 lbs/1000gl	1.82 lbs/1000gl	1.82 lbs/1000gl

2nd Year Available (if applied 2 consecutive years)

	(incorp)	(Top Dress)*
Nitrogen (N)	12.24 lbs/1000gl	9.79 lbs/1000gl
Phosphorus	4.68 lbs/1000gl	4.68 lbs/1000gl
Potassium (K2O)	12.81 lbs/1000gl	12.81 lbs/1000gl
Sulfur (S)	2.13 lbs/1000gl	2.13 lbs/1000gl

3rd Year Available (if applied 3 consecutive years)

	(incorp)	(Top Dress)*
Nitrogen (N)	13.47 lbs/1000gl	11.02 lbs/1000gl
Phosphorus	5.01 lbs/1000gl	5.01 lbs/1000gl
Potassium (K2O)	13.52 lbs/1000gl	13.52 lbs/1000gl
Sulfur (S)	2.28 lbs/1000gl	2.28 lbs/1000gl

Lab Number M-454

*** Top Dress - Based on no incorporation**

Manure Analysis Report

Date 12/26/03

Dealer CRAVE BROTHER'S FARM, LLC
W11550 TORPY RD.
WATERLOO, WI 53594-9652

Rock River Laboratory, Inc.
P.O. Box 169
Watertown, Wi 53094-0169
(920)261-0446

Feeder: CRAVE BROTHER'S FARM, LLC.

Sample No: 1

Desc: LIQUID DAIRY MANURE

Moisture 98.74% ***Dry Matter:*** 1.26%

1st Year Available

	Total	*(incorp)*	*(Top Dress)**
Nitrogen (N)	3.15 lbs/1000gl	1.26 lbs/1000gl	0.95 lbs/1000gl
Phosphorus	1.89 lbs/1000gl	1.14 lbs/1000gl	1.14 lbs/1000gl
Potassium (K2O)	3.01 lbs/1000gl	2.41 lbs/1000gl	2.41 lbs/1000gl
Sulfur (S)	0.23 lbs/1000gl	0.14 lbs/1000gl	0.14 lbs/1000gl

2nd Year Available (if applied 2 consecutive years)

	(incorp)	*(Top Dress)**
Nitrogen (N)	1.58 lbs/1000gl	1.26 lbs/1000gl
Phosphorus	1.33 lbs/1000gl	1.33 lbs/1000gl
Potassium (K2O)	2.71 lbs/1000gl	2.71 lbs/1000gl
Sulfur (S)	0.16 lbs/1000gl	0.16 lbs/1000gl

3rd Year Available (if applied 3 consecutive years)

	(incorp)	*(Top Dress)**
Nitrogen (N)	1.73 lbs/1000gl	1.42 lbs/1000gl
Phosphorus	1.42 lbs/1000gl	1.42 lbs/1000gl
Potassium (K2O)	2.86 lbs/1000gl	2.86 lbs/1000gl
Sulfur (S)	0.17 lbs/1000gl	0.17 lbs/1000gl

CHLORIDE 6.64 lbs/1000 gl

Lab Number M-359

** Top Dress - Based on no incorporation*

DAIRYLAND LABORATORIES, INC.
Arcadia, WI 54612
Telephone 608-323-2123

Report date: 3/ 3/2005
Sample number: 004695

ACCOUNT # 864 (0)

TO: Crave Bros. Farm
W11550 Torpy Rd

Waterloo , WI 53594

SAMPLED BY: Crave Bros. Farm

SAMPLED FOR: CRAVE BROS. FARM

PRODUCT: Blend whey (6 - HWM3Z WY)

RESULTS:

Moisture			93.82%	
Dry Matter			- 6.18%	
pH			4.54	
	DRY BASIS:		AS IS:	
Crude Protein	25.89%		1.60%	
Fat (Acid Hydro.)	11.33%		0.70%	
Calcium	0.97%	4.40 g/lb	0.06%	0.27 g/lb
Phosphorus	0.81%	3.67 g/lb	0.05%	0.23 g/lb
Magnesium	0.16%	0.73 g/lb	0.01%	0.04 g/lb
Potassium	2.59%	11.75 g/lb	0.16%	0.73 g/lb
Sulfur	0.16%		0.01%	
Sodium	0.88%		0.05%	
Chloride	1.62%		0.10%	

CALCS: C.A.D. + 179.64 mEq/lb

--------------------------INVOICING INFORMATION--------------------------

SAMPLED BY: Crave Bros. Farm
SAMPLED FOR: CRAVE BROS. FARM
PRODUCT: Blend whey

Invoice: 0127929
Date: 3/ 3/2005
Sample: 004695

$ 16.00 PACKAGE H
$ 7.00 ACID HYDROLYSIS FAT
$ 39.35 TOTAL INVOICE

$ 12.35 CATION/ANION PACKAGE
$ 4.00 pH

PIEPERPOWER®

May 24, 2005

Meeting Notes with Charles Crave

Location: Crave Brothers Farm – Office in Maintenance Shed

1.) Manure Hauling Expense: $54,276 for 2004. This does not include the fuel charge. Add 10% for the fuel charge.
2.) Bedding Expense: $1,400/wk for 400 cows – pelleted oat hulls
    $80/wk for sand
    $67,000 for all bedding expenses for 2004
    For Project, assume 90% can be replaced with digester solids

Dan Nemke

Symbol, "Pieperpower" is service mark of Pieper Electric, Inc., Milwaukee, Wisconsin

10/13	750g	1.389	1041.75	CFC
[illegible]/27	1000	1.489	1489 -	CFC
10/27	300		446.70	New Parlor
10/27	120			Old Parlor

9/02	975	1.389	CFC	1354.27
9/16	325	"	New P	451.42
9/16	110	"	Old P	152.79
9/16	225	"	Shop	301.41
9/16	950	"	CFC	1319.55
9/29	900	"	"	1250.10

LP gas

Parlor

- 300 gal — 0/27/04 - $446.70
- 325 gal — 9/16 - $451.42
- 300 gal — 8/4 $356.70
- 300 gal — 6/23 - $356.70
- 275 gal — 5/10 - $326.97
- 250 gal — 3/25 ~~1~~ $322.25
- 265 g — 2/13 - $341.58
- 300 g — 1/2 $356.81

CFC

- ~~8/4~~
- 1050 gal — 11/10/04 $1563.59
- ~~100 gal~~ ~~11/24/04 — 148.90~~
- 1050 gal — 11/24/04 - $1563.45
- 1000 gal — 10/27/04 - $1484.00
- 750 gal — 10/13/04 - $1041.75
- 975 gal — 9/2/04 - $1354.27
- 950 gal — 9/16/04 - $1319.55
- 900 gal — 9/29 - $1250.10
- 700 gal — 8/4 - $842.30
- 1000 gal — 8/19 - $1389.00
- 700 gal — 7/07 - $832.41
- 775 gal — 7/21 - $921.47
- 950 gal — 6/09 - $1129.78
- 900 gal — 6/23 - $1070.10
- 575 gal — 5/10/04 - $683.67
- 1135 gal — 5/26 - $1337.62

All else

- 100 gal — 11/24/04 - $148.90
- 120 gal — 10/27/04 - $178.60
- 110 gal — 9/16 - $152.79
- 225 gal — 9/16/04 - $312.66
- 50 gal — 8/04 - $95.12
- 150 gal — 7/21 - $178.82
- 70 gal — 6/23 - $83.23
- 100 gal — 5/26 - $119.01
- 100 gal — 4/21 $118.90
- 175 gal — 3/25 - $225.57
- 155 gal — 3/25 $199.79
- 250 g — 2/13 - $322.25
- 115 g — 2/13 - $148.23
- 250 — 2/13 $322.25
- 82.9 — 2/20 $106.73
- 275 — 2/12 - $354.47

CFC cont.

4/7	625 gal	$ 805.62
4/21	500 gal	$ 594.50

3/25	900 gal	$ 1160.01
3/10	725 gal	$ 934.52

2/13	1000 gal	$ 1289.00
2/26	845 gal	$ 1089.21
1/29	800 gal	$ 991.81
1/14	600 g.	$ 743.52
1/2	800 g.	$ 951.31

All else cont.

1/29	110 g.	$ 136.29
1/14	250 g	$ 319.74
1/14	110 g.	$ 136.29
1/02	225 g	$ 267.52
1/02	75 g.	$ 89.29

over

Appendix C:

Preliminary Engineering Drawings

Information contained in this document is Confidential and not intended for general distribution.

Appendix D:

Feasibility Worksheets

Information contained in this document is Confidential and not intended for general distribution.

CAFO Model - Crave Brothers Farm - 600 Cows				
Electrical Energy Generation				
Net Available Electrical Energy per year for Sale		3,396	kWhday	
Power Cost and Demand Growth Factor		3.0%		Based on WE Enerrgies Data from past 5 years
Electrical Energy Rate paid by Manure Supplier		$ 0.100		Average current rate in WI paid by farmer to Utility
Electrical Energy Sales Rate		$ 0.060	$/kWh	Current rate in WI for green energy from Utility
Thermal Energy Generation				
Thermal Energy for Sale to Manure Supplier @ 80% efficiency		5.01	MMBTU/day	
Percent Hot Water used by Farm		0%		
Hot Water Energy Sales Rate		$ 16.000	$/MMBTU	Offset for LP @$16.00 MMBTU ($1.49/gallon)
LP Cost and Demand Growth Factor		5%		Based on LP Price Data from past 5 years
Gas Energy Sales Rate				
Digester Solids				
Total Solids Harvested with moisture per day		17,335	lb/day	
Total Solids Harvested with moisture per day		8.7	tons/day	
Solids Exported from Farm		50%		Based on observations at other farms
Digester Solids Sale Rate to Farm ($/cow/yr)		$86		
Digester Solids Sale Rate to Commercial ($/ton)		$ 20	$/ton	Ranges from $15 to $30 per Ton
Exogenous Substrate				
Tipping Fee		$ 0.05	$/gallon	
		-	Gallons per day	
Revenue for Tipping		$ -		
Revenues				
Electrical Energy Sales to Utility	17.6%	$ 89	$/day	Electrical Energy Sold to Utility
Electrical Energy Sales to Manure Supplier	32.9%	$ 167	$/day	Electrical Energy Sold to Farm
Digester Solids Sales to Commercial	17.1%	$ 87	$/day	Bedding Sold to Other Farms
Digester Solids Sales to Farm	32.4%	$ 164	$/day	
Tipping Fee	0.0%	$ 0	$/day	
Thermal Energy Sales to Manure Supplier	0.0%	$ 0	$/day	Hot Water Sold to Manure Supplier
LLC Total Revenues		$ 185,135	$/yr	
Cost of Waste Disposal		$ 0.010	$/gallon	
Avoided Waste Disposal Cost for Manure Supplier	0.0%	$ 0	$/day	
Manure Supplier Avoided Costs		$ 0	$/yr	
Total Financial Impact to Enterprise		$ 185,135	$/yr	
ANNUAL OPERATING COSTS				
Operating Cost for Digester per pound of Total Dry Solids		$ 0.0050	$/lb	
Digester: Labor, Consumables, Equip, O&M	33.8%	$ 59	$/day	Based on total dry solid through-put per year
Operating Cost for for Plant per kWh		$ 0.0250	$/kWh	Ranges from $0.015 to $0.020 per kWh
Engine-Generator Equipment O&M	51.7%	$ 90	$/day	
Remote Operation/Management Fee		5%		Percent of Revenue
Remote Operation/Management Fee	14.5%	$ 25	$/day	
LLC Total Annual Operating Costs		$ 175	$/day	
LLC Gross Earnings: Before Interest Taxes, Amort. (EBITDA)		$ 121,300	$/yr	

CAFO Model - Crave Brothers Farm - 800 Cows				
Electrical Energy Generation				
Net Available Electrical Energy per year for Sale		4,747	kWhday	
Power Cost and Demand Growth Factor		3.0%		Based on WE Enerrgies Data from past 5 years
Electrical Energy Rate paid by Manure Supplier		$ 0.100		Average current rate in WI paid by farmer to Utility
Electrical Energy Sales Rate		$ 0.060	$/kWh	Current rate in WI for green energy from Utility
Thermal Energy Generation				
Thermal Energy for Sale to Manure Supplier @ 80% efficiency		9.87	MMBTU/day	
Percent Hot Water used by Farm		0%		
Hot Water Energy Sales Rate		$ 16.000	$/MMBTU	Offset for LP @$16.00 MMBTU ($1.49/gallon)
LP Cost and Demand Growth Factor		5%		Based on LP Price Data from past 5 years
Gas Energy Sales Rate				
Digester Solids				
Total Solids Harvested with moisture per day		23,924	lb/day	
Total Solids Harvested with moisture per day		12.0	tons/day	
Solids Exported from Farm		50%		Based on observations at other farms
Digester Solids Sale Rate to Farm ($/cow/yr)		$86		
Digester Solids Sale Rate to Commercial ($/ton)		$ 20	$/ton	Ranges from $15 to $30 per Ton
Exogenous Substrate				
Tipping Fee		$ 0.05	$/gallon	
		-	Gallons per day	
Revenue for Tipping		$ -		
Revenues				
Electrical Energy Sales to Utility	24.6%	$ 170	$/day	Electrical Energy Sold to Utility
Electrical Energy Sales to Manure Supplier	24.1%	$ 167	$/day	Electrical Energy Sold to Farm
Digester Solids Sales to Commercial	17.3%	$ 120	$/day	Bedding Sold to Other Farms
Digester Solids Sales to Farm	34.0%	$ 235	$/day	
Tipping Fee	0.0%	$ 0	$/day	
Thermal Energy Sales to Manure Supplier	0.0%	$ 0	$/day	Hot Water Sold to Manure Supplier
LLC Total Revenues		$ 252,244	$/yr	
Cost of Waste Disposal		$ 0.010	$/gallon	
Avoided Waste Disposal Cost for Manure Supplier	0.0%	$ 0	$/day	
Manure Supplier Avoided Costs		$ 0	$/yr	
Total Financial Impact to Enterprise		$ 252,244	$/yr	
ANNUAL OPERATING COSTS				
Operating Cost for Digester per pound of Total Dry Solids		$ 0.0050	$/lb	
Digester: Labor, Consumables, Equip, O&M	33.8%	$ 82	$/day	Based on total dry solid through-put per year
Operating Cost for for Plant per kWh		$ 0.0250	$/kWh	Ranges from $0.015 to $0.020 per kWh
Engine-Generator Equipment O&M	52.0%	$ 126	$/day	
Remote Operation/Management Fee		5%		Percent of Revenue
Remote Operation/Management Fee	14.2%	$ 35	$/day	
LLC Total Annual Operating Costs		$ 243	$/day	
LLC Gross Earnings: Before Interest Taxes, Amort. (EBITDA)		$ 163,556	$/yr	

Appendix E:

Project Financial Summaries

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Income Statement

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Revenue											
Electricity - Utility	$8,221	$32,616	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990
Electricity - Farm	$15,346	$62,709	$64,536	$66,362	$68,189	$70,015	$71,842	$73,668	$75,495	$77,321	$79,148
Solids - Other Farms	$7,974	$31,636	$54,576	$54,576	$54,576	$54,576	$54,576	$54,576	$54,576	$54,576	$54,576
Solids - Farm	$15,123	$60,000	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714
Manure Disposal	$1,575	$6,300	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065
Total Revenue	**$48,239**	**$193,261**	**$273,881**	**$275,708**	**$277,534**	**$279,361**	**$281,187**	**$283,014**	**$284,840**	**$286,667**	**$288,493**
COGS											
Consumables	$827	$2,707	$3,925	$3,944	$3,962	$3,980	$3,998	$4,017	$4,035	$4,053	$4,071
Contract Maintenance Cost	$13,756	$54,576	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075
Management Fee Cost	$2,333	$9,256	$13,159	$13,159	$13,159	$13,159	$13,159	$13,159	$13,159	$13,159	$13,159
Total COGS	**$16,916**	**$66,539**	**$93,159**	**$93,178**	**$93,196**	**$93,214**	**$93,232**	**$93,251**	**$93,269**	**$93,287**	**$93,305**
Project Gross Profit	**$31,323**	**$126,722**	**$180,722**	**$182,530**	**$184,338**	**$186,147**	**$187,955**	**$189,763**	**$191,571**	**$193,379**	**$195,188**
Percentage	**65%**	**66%**	**66%**	**66%**	**66%**	**67%**	**67%**	**67%**	**67%**	**67%**	**68%**
Depreciation - 10 yr. Straight Lne	$64,167	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$89,833
Interest @ 7%	$87,461	$97,704	$89,255	$80,197	$70,483	$60,067	$48,898	$36,922	$24,079	$10,309	$310
Project Net Income Before Tax	**($120,305)**	**($124,981)**	**($62,534)**	**($51,666)**	**($40,144)**	**($27,920)**	**($14,943)**	**($1,159)**	**$13,492**	**$29,070**	**$105,044**
Percentage	**-249%**	**-65%**	**-23%**	**-19%**	**-14%**	**-10%**	**-5%**	**0%**	**5%**	**10%**	**36%**
Taxes @ 40%	($48,122)	($49,993)	($25,013)	($20,667)	($16,058)	($11,168)	($5,977)	($463)	$5,397	$11,628	$42,018
Production Tax Credit	$3,000	$11,900	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700
Project Net Income After Tax	**($69,183)**	**($63,089)**	**($20,820)**	**($14,300)**	**($7,387)**	**($52)**	**$7,734**	**$16,005**	**$24,795**	**$34,142**	**$79,727**
Percentage	**-143%**	**-33%**	**-8%**	**-5%**	**-3%**	**0%**	**3%**	**6%**	**9%**	**12%**	**28%**
Add Back Depreciation	$64,167	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$89,833
Less Payment	$91,346	$116,865	$125,313	$134,372	$144,086	$154,502	$165,671	$177,647	$190,489	$204,259	$35,451
Project Cash Flow	**($96,362)**	**($25,954)**	**$7,867**	**$5,328**	**$2,528**	**($554)**	**($3,936)**	**($7,642)**	**($11,694)**	**($16,117)**	**$134,109**
Cummulative Project Cash Flow	**($96,362)**	**($122,315)**	**($114,449)**	**($109,120)**	**($106,593)**	**($107,147)**	**($111,083)**	**($118,725)**	**($130,419)**	**($146,536)**	**($12,428)**
Capital Investment	**$1,540,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Project Rate of Return	**-6.3%**	**-1.7%**	**0.5%**	**0.3%**	**0.2%**	**0.0%**	**-0.3%**	**-0.5%**	**-0.8%**	**-1.0%**	**8.7%**

Income Statement

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Revenue											
Electricity - Utility	$8,221	$32,616	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990	$61,990
Electricity - Farm	$15,346	$62,709	$64,536	$66,362	$68,189	$70,015	$71,842	$73,668	$75,495	$77,321	$79,148
Solids - Other Farms	$7,974	$31,636	$43,661	$43,661	$43,661	$43,661	$43,661	$43,661	$43,661	$43,661	$43,661
Solids - Farm	$15,123	$60,000	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714	$85,714
Manure Disposal	$1,575	$6,300	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065	$7,065
Total Revenue	**$48,239**	**$193,261**	**$262,966**	**$264,793**	**$266,619**	**$268,446**	**$270,272**	**$272,099**	**$273,925**	**$275,752**	**$277,578**
COGS											
Consumables	$827	$2,707	$3,811	$3,829	$3,847	$3,866	$3,884	$3,902	$3,920	$3,939	$3,957
Contract Maintenance Cost	$13,756	$54,576	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075	$76,075
Management Fee Cost	$2,333	$9,256	$12,613	$12,613	$12,613	$12,613	$12,613	$12,613	$12,613	$12,613	$12,613
Total COGS	**$16,916**	**$66,539**	**$92,499**	**$92,517**	**$92,535**	**$92,554**	**$92,572**	**$92,590**	**$92,608**	**$92,627**	**$92,645**
Project Gross Profit	**$31,323**	**$126,722**	**$170,468**	**$172,276**	**$174,084**	**$175,892**	**$177,700**	**$179,509**	**$181,317**	**$183,125**	**$184,933**
Percentage	**65%**	**66%**	**65%**	**65%**	**65%**	**66%**	**66%**	**66%**	**66%**	**66%**	**67%**
Depreciation - 10 yr. Straight Lne	$64,167	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$89,833
Interest @ 7%											
Project Net Income Before Tax	**($32,844)**	**($27,278)**	**$16,468**	**$18,276**	**$20,084**	**$21,892**	**$23,700**	**$25,509**	**$27,317**	**$29,125**	**$95,100**
Percentage	**-68%**	**-14%**	**6%**	**7%**	**8%**	**8%**	**9%**	**9%**	**10%**	**11%**	**34%**
Taxes @ 40%	($13,137)	($10,911)	$6,587	$7,310	$8,034	$8,757	$9,480	$10,203	$10,927	$11,650	$38,040
Production Tax Credit	$3,000	$11,900	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700	$16,700
Project Net Income After Tax	**($16,706)**	**($4,467)**	**$26,581**	**$27,665**	**$28,750**	**$29,835**	**$30,920**	**$32,005**	**$33,090**	**$34,175**	**$73,760**
Percentage	**-35%**	**-2%**	**10%**	**10%**	**11%**	**11%**	**11%**	**12%**	**12%**	**12%**	**27%**
Add Back Depreciation	$64,167	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$154,000	$89,833
Less Payment											
Project Cash Flow	**$47,461**	**$149,533**	**$180,581**	**$181,665**	**$182,750**	**$183,835**	**$184,920**	**$186,005**	**$187,090**	**$188,175**	**$163,593**
Cummulative Project Cash Flow	**($1,492,539)**	**($1,343,006)**	**($1,162,425)**	**($980,760)**	**($798,010)**	**($614,174)**	**($429,254)**	**($243,249)**	**($56,159)**	**$132,016**	**$295,610**
Capital Investment	**$1,540,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Project Rate of Return	**3.1%**	**9.7%**	**11.7%**	**11.8%**	**11.9%**	**11.9%**	**12.0%**	**12.1%**	**12.1%**	**12.2%**	**10.6%**