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Economics of Tunnel Ventilation for Freestall Barns

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Summary: A cash flow analysis of the application of tunnel ventilation to four standard freestall barn configurations was conducted with the objective of determining the amount of milk production required to be sustained based on a break-even investment. Other variables that are negatively affected by heat stress were not accounted for in the analysis due to the high degree of intangibility associated with them. Analysis showed that relatively little sustained production is required to pay for a tunnel ventilation system based on a 5-year payback period including areas of the country where tunnel fans would be used as little as 50 fan days per year (1,200 hrs.). This is a cash only basis analysis and does not look at actual economic rates of return, which is necessary for individual businesses to determine if this investment should be made based on their unique circumstances.

Keywords: *Dairy housing, Tunnel ventilation, Heat stress, Dairy profitability*

Economics of Tunnel Ventilation for Freestall Barns

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INTRODUCTION

The application of tunnel ventilation to dairy freestall barns was first employed during the mid-1990's. Many producers are attracted to tunnel ventilation because it can easily be retrofitted into existing barns that have shown otherwise to be poorly ventilated. Still others are incorporating tunnel ventilation into new freestall barn designs with the two-fold goal of ensuring predictable summer-time ventilation and air movement over cows' bodies – both of which are essential components to relieve heat stress.

The objective of this paper is to provide economic information regarding tunnel ventilation of various freestall barn configurations. A multitude of fan sizes and capacities are presented for each barn configuration along with a calculated amount of milk production that needs to be sustained in order to pay for the investment and recover operating costs.

In performing the analysis a cash flow budget approach was followed. This type of analysis is most commonly utilized when determining the financial feasibility of an investment. That is, will the investment pay for itself in a reasonable period of time? For this paper it was assumed that if an investment cash flows positively in a relatively short period of time that investment has a positive rate of return.

Tunnel ventilation system variables analyzed to perform this analysis include costs for purchasing, installing, operating, and maintaining the system. Cow-related variables analyzed were limited to milk production as it is the most tangible.

Determining if an investment cash flows in a reasonable period of time and has a positive rate of return on a dairy farm is becoming more and more crucial. Although the late 90's had higher than average profits, long-term profit margins continue to tighten making poor investment decisions one of the primary reasons why many dairy producers are struggling.

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BACKGROUND

During summer conditions, dairy cow housing facilities need adequate **ventilation** and **air velocity** to help keep cows' comfortable and healthy. Tunnel ventilation is a special and simple summer-time ventilation technique that provides predictable ventilation and various degrees of air velocity concurrently in a barn. Equipping a barn with tunnel ventilation requires that the tunnel fans be placed in one gable endwall of a barn. These fans are operated to create a negative pressure within the barn causing air to be drawn through large inlets located at the opposite gable endwall as shown in Figure 1. Once in the barn, fresh air travels longitudinally through the structure and is exhausted by the tunnel fans. For tunnel ventilation to function at its maximum potential, all sidewall, ceiling, and floor openings must be sealed to form the "tunnel".

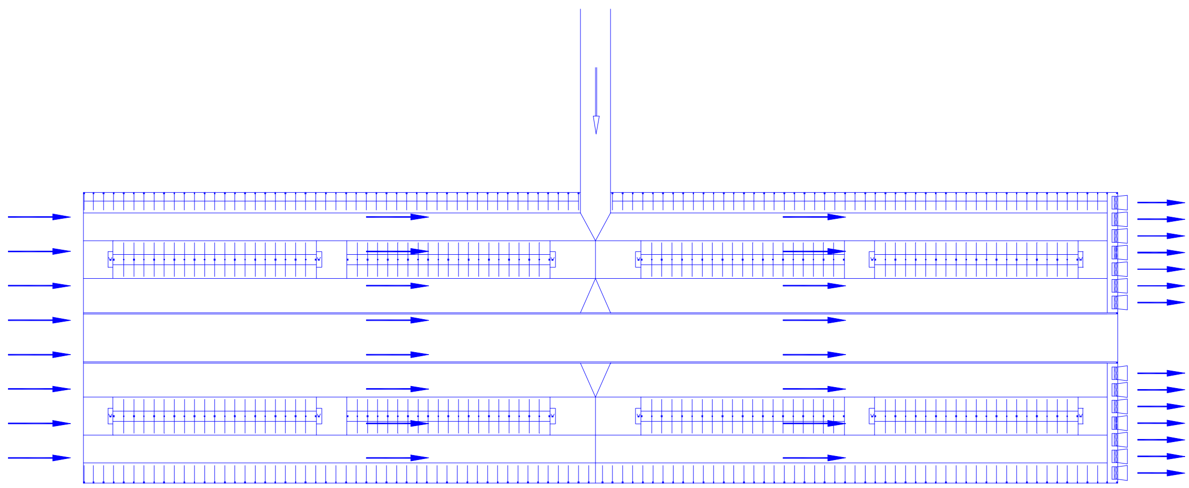

Figure 1. Plan view of a typical tunnel ventilated freestall barn.

Design Procedure

The procedure to design a tunnel ventilation system consists of two steps. First, the required total fan capacity is determined. Then this value is used as an input variable to determine the size of the air inlet.

Sizing Fans

Successful tunnel ventilation system design must achieve two goals: air velocity and air exchange. Each of these goals should be considered individually during the design stage to determine which one will ultimately govern. Experience has shown the need to satisfy air velocity criteria will almost always control design.

The total fan capacity is determined based on achieving a desired air velocity of 500 to 600 ft./min. A velocity in this range has shown to be beneficial in reducing heat stress (Shearer et al., 1991). Total fan capacity is determined by multiplying the cross sectional area in the barn, in square feet, by the desired air speed to produce a product with units of cubic feet per minute (cfm).

To ensure that there is adequate fan capacity to meet summer-time air exchange rates, multiply the number of cows in the barn by 1,000 cfm/cow. Use the larger of the two values calculated above to determine the overall theoretical fan capacity required. Generally many large fans are needed in freestall barns to create the tunnel effect as shown in Figure 2.

A complete description of tunnel ventilating freestall barns, including sizing of inlets, is available by reviewing Gooch and Timmons (2000).

Figure 2. Large tunnel fans on a six-row freestall barn.

CASH FLOW ANALYSIS

The net return on investment for a tunnel ventilation system is a direct function of how well cows maintain milk production in a tunnel-ventilated barn each summer beyond what would be produced in a naturally ventilated shelter. We will refer to this as sustained production. The additional cost of designing, purchasing, installing, operating, and maintaining the tunnel system must be offset by sustained milk production in order for the investment to deliver a positive return.

A complete cash flow analysis of a tunnel ventilation system is complex and difficult to fully quantify. While an analysis of the fixed and operating costs associated with the tunnel system can be quantified, an accurate analysis of the cow is much more challenging. The complexity of measuring a cow's complete biological response to heat stress combined with the lack of performance data to develop economic loss predictions make this difficult.

Consider the following items that are caused by heat stress:

- Depressed feed intake
- Reduced milk production
- Slug feeding leading to acidosis and laminitis
- Reduced conception rates
- Compromised growth rates of unborn calves
- Sub-optimal cow health

Reduced milk production is the most tangible item listed. The resulting economic loss can be determined if accurate milk production records are kept. However the other items listed above are less tangible and more difficult or even impossible to assign values. An analysis that shows a positive cash flow projection based on sustained milk production alone would be a conservative analysis of the investment. If the other less tangible benefits were realized, an increased positive impact of the decision would be seen.

The objective of the analysis presented was to determine how many pounds of milk per cow per day are required to pay all cash costs associated with the investment for several freestall barn configurations. No attempt was made to include additional benefits of heat stress relief that are less tangible.

The procedure followed was to first determine the required total fan capacity for each barn configuration, which was then used to determine the number of fans required based on specifics for an array of possible fans. Next, based on the total number of fans operating, the daily electrical cost was calculated using various energy costs. It was assumed that fans once activated they would operate at full capacity for the entire day. The final step was to determine the amount of milk production required for a break-even return based on information determined in the preceding steps combined with some conservative cow response estimates. The results can be interpreted by the number of fan days (1 fan day = 24 hrs. of continuous fan operation) of operation per year. Each step of this procedure is described in detail below.

<u>Determination of Required Overall Fan Capacity</u>

The first step of the analysis was to determine the overall fan capacity for a tunnel ventilation system. Total fan capacity was determined by multiplying the cross sectional area of the barn by the desired air velocity. All barns in the analysis have a ceiling, which is common in most tunnel ventilated barns. Presence of a ceiling reduces the cross sectional area, which in turn reduces the required total fan capacity. The cost of installing the ceiling was not included in the analysis. This is justified by the fact that many barns already have a ceiling prior to the adoption of a tunnel ventilation system.

The cross sectional area shown in Table 1 is based on width and height parameters for the two and three-row barn configurations. Typically two and three-row barns utilize a drive-along feed concept resulting in nominal widths of 39 and 47 ft respectively. A cantilevered truss system is often employed to provide the feed delivery area with sun and rain protection, resulting in truss lengths of about 10 ft more than building width. For these barns to be effectively tunnel-ventilated it was assumed that the drive-along feed area would be enclosed in order to form the tunnel. This method of forming the tunnel does not preclude ad libitum feed access and only adds slightly to typical barn truss spans.

The standard recommended widths of 98 and 114 ft were used for the four and six-row barns in the calculations. To determine the overall cross sectional area for the four and six-row barns one-third of the area above the horizontal plane formed by the top of the sidewall headers was added to the area determined by multiplying the sidewall height by the barn width. This is done to account for the sloping ceiling that is normally present extending from the sidewall to a point approximately four feet inwards from the intermediate structural support posts that are commonly located at the head to head stalls.

Air velocity through the barn was used as the governing design factor. A design air velocity of 500 feet per minute was used based our field observations and measurements of air movement in large tunnel-ventilated freestall barns.

Table 1. Theoretical fan capacities (cfm) for various barn configurations with a theoretical tunnel air velocity of 500 ft./min.

		Barn Configuration			
Parameter	Unit	2-Row	3-Row	4-Row	6-Row
Barn Width	ft.	52	60	98	114
Barn Height	ft.	10	12	12	12
Cross Sectional Area	sq. ft.	520	720	1,443	1,729
Desired Theoretical Velocity	ft./min.	500	500	500	500
Required Fan Capacity	cu. ft./min.	260,000	360,000	721,389	864,500

Calculation of the Number of Fans Required for Various Barn Configurations

The number of fans required to develop the overall fan capacity for each barn configuration was determined by dividing the required total fan capacity by the rated capacity of a given fan under consideration. Barn endwall spatial requirements can preclude the use of some fan sizes indicating the need to provide a range of fan options for consideration. Each fan has specific size and performance values that are shown in Table 2 under the column heading “Fan Characteristics”. Each row in the body of the table, identified by fan I.D. No., represents a specific fan that is suitable for tunnel ventilation application. All fan data was obtained from the fan manufacturer’s literature based on test results determined at the BESS Lab located at the University of Illinois at a static pressure of 0.15 in of water gauge (wg). This static pressure differential has been measured by the authors in large tunnel-ventilated freestall barns when all fans were operating.

Table 2. Number of fans required for various barn configurations with a theoretical tunnel velocity of 500 ft./min. Static pressure = 0.15 in. wg.

Fan Characteristics					Barn Configuration							
					2-Row		3-Row		4-Row		6-Row	
I.D. No.	Diameter (in)	Capacity @ 0.15 sp (cfm)	Motor (Hp)	Efficiency (cfm/Watt)	No. Fans	Demand (kw)	No. Fans	Demand (kw)	No. Fans	Demand (kw)	No. Fans	Demand (kw)
1	48	19,200	1	16.0	14	16.80	19	22.80	38	45.60	45	54.00
2	60	27,250	1.5	17.0	10	16.03	13	20.84	26	41.68	32	51.29
3	60	31,450	2	15.8	8	15.92	11	21.90	23	45.78	27	53.74
4	51	22,300	1	18.2	12	14.70	16	19.60	32	39.21	39	47.79
5	51	26,400	1.5	17.2	10	15.35	14	21.49	27	41.44	33	50.65

The most efficient fan shown in Table 2 is fan No. 4. It produces 22,300 cfm of air with a 1-hp motor. Fan No. 3 has a capacity of 31,450 cfm, the largest of the five analyzed. It is interesting to note that while the total number of required fans is higher for the more efficient fan compared to the number required of the highest capacity fan, the electrical demand is always the lowest for the option using the most efficient fan.

Determination of Energy Cost

The energy cost to operate a tunnel system is an important value to determine when performing a cash flow analysis. The electrical demand (kW) was calculated in Table 2 by multiplying the capacity of a fan by the number fans operating and then dividing this product by the fan efficiency. Daily electrical costs are shown in Table 3 for various tunnel systems utilizing fan options 1 through 5 based on a range of electrical costs. Values in the table were calculated by multiplying the corresponding demand value by the electrical cost.

Table 3. Daily electrical costs to operate tunnel fans for various barn configurations.

Fan I.D. No	Barn Configuration															
	2-Row				3-Row				4-Row				6-Row			
	Energy Costs ($/kW-hr.)				Energy Costs ($/kW-hr.)				Energy Costs ($/kW-hr.)				Energy Costs ($/kW-hr.)			
	0.06	0.08	0.1	0.12	0.06	0.08	0.1	0.12	0.06	0.08	0.1	0.12	0.06	0.08	0.1	0.12
1	24.2	32.3	40.3	48.4	32.8	43.8	54.7	65.7	65.7	87.6	109.4	131.3	77.8	103.7	129.6	155.5
2	23.1	30.8	38.5	46.2	30.0	40.0	50.0	60.0	60.0	80.0	100.0	120.0	73.9	98.5	123.1	147.7
3	22.9	30.6	38.2	45.9	31.5	42.0	52.5	63.1	65.9	87.9	109.9	131.9	77.4	103.2	129.0	154.8
4	21.2	28.2	35.3	42.3	28.2	37.6	47.1	56.5	56.5	75.3	94.1	112.9	68.8	91.7	114.7	137.6
5	22.1	29.5	36.8	44.2	30.9	41.3	51.6	61.9	59.7	79.6	99.5	119.4	72.9	97.3	121.6	145.9

As expected the most energy efficient fan, fan No. 4, has the lowest daily operating cost for each barn configuration.

Determination of Required Milk Production to Break-Even

The bottom line of this analysis is to determine the threshold value of milk production, measured in pounds per cow per day, required to pay for the investment and cover operating and maintenance expenses over a reasonable period of time. Five years was used in this analysis. Production levels above a calculated threshold value would lead to greater cash generation from the investment while a value below would lead to supplemental cash required from other aspects of the business to for pay a portion of the investment and operating and maintenance costs.

The spreadsheet titled “Cash Flow Projection for Tunnel Ventilated Freestall Barns” was used to develop the values shown in Tables 4a and 4b. This spreadsheet provides a cash flow budget projection for known capital, operating, and maintenance costs for a 5-year period. From this information it calculates the pounds per cow per day required to break-even based on the number of lactating cows in the barn and number of days milk production is sustained over and above the number of days the tunnel system is in operation. The spreadsheet does not take into consideration the potential of increased production loss for a higher producing herd over lower producing herd due to heat stress. For this purpose the investment was considered to be 100 percent financed and repaid over five years. A hard copy of the spreadsheet is provided in the Appendix; it shows the values used to develop the break-even production value of 4.1 lbs. per cow per day for the case of a six-row barn stocked with 600 cows, operating the tunnel system 100 fan days per year using fan No. 3, and 40 additional days of sustained production realized.

For both Tables 4a and 4b a cost of $15 per year was used for cleaning each fan. Fans need to be cleaned frequently (at least once a month) to maintain maximum efficiency. An additional $15 per fan was also used as the cost to maintain and repair the each fan. Fan belts need to be tightened and frequently replaced to ensure power from the electrical motor is efficiently transferred to the fan blades. Other consistent costs for each table include a milk marketing expense ($0.50/Cwt.) and an expense for variation of cost of feeding grain and concentrate to the cows based on production ($3.57/Cwt.).

The required production levels presented in Table 4a were calculated using the most efficient fan, fan No. 4, for each barn configuration. A fan purchase cost and installation cost of $1,170 and $400 per fan were used. The daily required sustained production in lbs./cow/day ranged from 12.1 to 2.7 for a two-row barn, from 16.1 to 1.8 for a three-row barn, from 16.1 to 2.4 for a four-row barn, and from 19.1 to 2.2 for a six-row barn.

The required sustained production levels presented in Table 4b were calculated using the least number of required fans (largest capacity), fan No. 3, listed in Table 2 for each barn configuration. A fan purchase price and installation cost of $1470 and $600 per fan were used. Both of these costs are greater than the cost used for fan No. 4 in Table 4a (the larger fan has greater electrical hardware requirements increasing the price). The daily required sustained production values in lbs./cow/day ranged from 11.1 to 2.7 for a two-row barn, from 15.3 to 1.8 for a three-row barn, from 16.0 to 2.6 for a four-row barn, and from 18.8 to 2.3 for a six-row barn.

Comparing required sustained production values between Tables 4a and 4b yield some interesting results. With a five-year payback period the utilization of the larger, less energy efficient fans requires less sustained production than using the more energy efficient fans in almost every case. However, as the number of fan days per year increases, there is a positive movement in favor of using the more energy efficient fans. Extending this trend over a payback period greater than five years would show a major shift towards less sustained production required for the more efficient fan applications.

Table 4a. Pounds of milk per cow per day required to break-even using the most energy efficient fan (fan No. 4) shown in Table 2. Analysis based on a five-year pay back period, interest rate of 8 percent, and no changes in operating costs due to inflation. Gross milk price = $12 per Cwt. and energy cost = $0.10/kW-hr.

		Barn Configuration															
No. of Cows[1]	Extra Benefit Days[2]	2-Row				3-Row				4-Row				6-Row			
		Average No. of Fan[3]/Year Operating Over 5 Years															
		50	100	150	200	50	100	150	200	50	100	150	200	50	100	150	200
100	20	12.1	8.9	7.6	6.9	16.1	11.9	10.1	9.2								
	40	9.4	7.6	6.8	6.3	12.5	10.2	9.1	8.4	—	—	—	—	—	—	—	—
	60	7.7	6.7	6.2	5.8	10.3	8.9	8.2	7.8								
	80	6.5	5.9	5.6	5.4	8.7	7.9	7.5	7.2								
200	20	6.0	4.5	3.8	3.4	8.1	5.9	5.1	4.6	16.1	11.9	10.1	9.2	19.1	14.5	12.4	11.2
	40	4.7	3.8	3.4	3.2	6.3	5.1	4.5	4.2	12.5	10.2	9.1	8.4	15.3	12.4	11.1	10.3
	60	3.8	3.3	3.1	2.9	5.1	4.5	4.1	3.9	10.3	8.9	8.2	7.8	12.5	10.9	10.0	9.5
	80	3.3	3.0	2.8	2.7	4.3	4.0	3.7	3.6	8.7	7.9	7.5	7.2	10.6	9.7	9.1	8.8
400	20					4.0	3.0	2.5	2.3	8.1	5.9	5.1	4.6	9.8	7.2	6.2	5.6
	40	—	—	—	—	3.1	2.5	2.3	2.1	6.3	5.1	4.5	4.2	7.6	6.2	5.5	5.1
	60					2.6	2.2	2.1	1.9	5.1	4.5	4.1	3.9	6.3	5.4	5.0	4.7
	80					2.2	2.0	1.9	1.8	4.3	4.0	3.7	3.6	5.3	4.8	4.6	4.4
600	20									5.4	4.0	3.4	3.1	6.6	4.8	4.1	3.7
	40	—	—	—	—	—	—	—	—	4.2	3.4	3.0	2.8	5.1	4.1	3.7	3.4
	60									3.4	3.0	2.7	2.6	4.2	3.6	3.3	3.2
	80									2.9	2.6	2.5	2.4	3.5	3.2	3.0	2.9
800	20													4.9	3.6	3.1	2.8
	40	—	—	—	—	—	—	—	—	—	—	—	—	3.8	3.1	2.8	2.6
	60													3.1	2.7	2.5	2.4
	80													2.6	2.4	2.3	2.2

[1] No. of cows = total no. of lactating cows in the barn.

[2] Extra Benefit Days = additional days of sustained production; the number of days subsequent to tunnel shut down that positively affect the cows' milk production.

[3] A fan day is defined as all fans operating in the barn continuously for a 24-hour period.

Table 4b. Pounds of milk per cow per day required to break-even using the least number (highest capacity) of fans (fan No. 3) shown in Table 2. Analysis based on a five-year pay back period, interest rate of 8 percent, and no changes in operating costs due to inflation. Gross milk price = $12 per Cwt. and energy cost = $0.10/kW-hr.

		Barn Configuration															
No. of Cows[1]	Extra Benefit Days[2]	2-Row				3-Row				4-Row				6-Row			
		Average No. of Fan[3]/Year Operating Over 5 Years															
		50	100	150	200	50	100	150	200	50	100	150	200	50	100	150	200
100	20	11.1	8.5	7.4	6.8	15.3	11.7	10.2	9.4								
	40	8.7	7.3	6.6	6.3	11.9	10.0	9.1	8.6	—	—	—	—	—	—	—	—
	60	7.1	6.4	6.0	5.8	9.7	8.8	8.3	7.9								
	80	6.0	5.7	5.5	5.4	8.2	7.8	7.5	7.4								
200	20	5.6	4.3	3.7	3.4	7.7	5.8	5.1	4.7	16.0	12.2	10.7	9.8	18.8	14.3	12.5	11.5
	40	4.3	3.6	3.3	3.1	6.0	5.0	4.6	4.3	12.4	10.5	9.5	9.0	14.61	12.3	11.2	10.6
	60	3.5	3.2	3.0	2.9	4.9	4.4	4.1	4.0	10.2	9.2	8.6	8.3	2.0	10.8	10.1	9.7
	80	3.0	2.8	2.7	2.7	7.7	5.8	5.1	3.7	8.6	8.1	7.9	7.7	10.1	9.6	9.3	9.1
400	20					3.8	2.9	2.6	2.3	8.0	6.1	5.3	4.9	9.4	7.2	6.3	5.8
	40	—	—	—	—	3.0	2.5	2.3	2.2	6.2	5.2	4.8	4.5	7.3	6.1	5.6	5.3
	60					2.4	2.2	2.1	2.0	5.1	4.6	4.3	4.2	6.0	5.4	5.1	4.9
	80					2.1	1.9	1.9	1.8	4.3	4.1	3.9	3.9	5.1	4.8	4.6	4.5
600	20									5.3	4.1	3.6	3.3	6.3	4.8	4.2	3.8
	40	—	—	—	—	—	—	—	—	4.1	3.5	3.2	3.0	4.9	4.1	3.7	3.5
	60									3.4	3.1	2.9	2.8	4.0	3.6	3.4	3.2
	80									2.9	2.7	2.6	2.6	3.4	3.2	3.1	3.0
800	20													4.7	3.6	3.1	2.9
	40	—	—	—	—	—	—	—	—	—	—	—	—	3.7	3.1	2.8	2.6
	60													3.0	2.7	2.5	2.4
	80													2.5	2.4	2.3	2.3

[1] No. of cows = total no. of lactating cows in the barn.

[2] Extra Benefit Days = additional days of sustained production; the number of days subsequent to tunnel shut down that positively affect the cows' milk production.

[3] A fan day is defined as all fans operating in the barn continuously for a 24-hour period.

The maximum and minimum results from Table 4a. based on a percent of daily milk production are shown in Table 5 for various daily herd averages. High producing cows, which have the potential to be more adversely effected due to heat stress than lower producers, require less sustained milk production to achieve a break-even investment.

Table 5. Percent of total production required to break-even for daily production levels ranging from 70 to 100 lbs./day per cow using the most energy efficient fan (fan No. 4) shown in Table 2.

Barn Configuration	Required Production From Table 4a.		Daily Average Production For The Herd							
			70 lbs./day cow		80 lbs./day cow		90 lbs./day cow		100 lbs./day cow	
	(max)	(min)	(max)	(min)	(max)	(min)	(max)	(min)	(max)	(min)
2 - Row	12.1	2.7	17.3	3.9	15.1	3.4	13.4	3.0	12.1	2.7
3 -Row	16.1	1.8	23.0	2.6	20.1	2.3	17.9	2.0	16.1	1.8
4 - Row	16.1	2.4	23.0	3.4	20.1	3.0	17.9	2.7	16.1	2.4
6 - Row	19.1	2.2	27.3	3.1	23.9	2.8	21.2	2.4	19.1	2.2

SUMMARY

A cash flow analysis of the application of tunnel ventilation to four standard barn configurations was conducted with the objective of determining the amount of milk production required to be sustained based on a break-even investment. Other variables that are negatively affected by heat stress were not accounted for in the analysis due to the high degree of intangibility associated with them. Analysis showed that relatively little sustained production is required to pay for a tunnel ventilation system based on a 5-year payback period including areas of the country where tunnel fans would be used as little as 50 fan days per year (1,200 hrs.). This is a cash only basis analysis and does not look at actual economic rates of return, which is necessary for individual businesses to determine if this investment should be made based on their particular circumstances.

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APPENDIX

Cash Flow Budget Projection for Tunnel Ventilated Freestall Barns

Date Collection Sheet

Number of Fans	27	Energy Demand, Kilowatts per Fan	1.99
Cost per Fan	$1,470	Energy Cost, Dollars per Kilowatt-Hr.	$0.10
Installation Costs, Total Dollars	$16,200	M & R Costs Due to Operating Fans, per Fan	$15
Term Length of Loan, Months	60	Gross Milk Price, $/Cwt.	$12.00
Interests Rate	8%	Milk Marketing Expenses, per Cwt. (Hauling plus + government promotion fee)	$0.50
Annual Cleaning Expenses, per Fan	$15	Variable Expenses that Change as Milk Production Changes, Per Cwt (purchased grain, milk marketing expense)	$3.57
Number of Days Fans Operate	100	Average Number of Milking Cows	600
Number of Hours per Day Fans Operate	24	Daily Milk Production per Cow	75
Number of Days Milk Production Is Sustained	140		

Cash Flow Budget Projection of Tunnel Ventilated Freestall Barns

Results

Initial Investment, Including Installation	$55,890
Loan Length 5 Years Interest Rate 8% Monthly Payment	$1,133.25
Total Annual Payment	$13,599
Annual Cleaning Expenses, Total	$405
Electrical Costs per Hour of Operation	$5.37
Total Hours of Operation, Annual	2400
Annual Electricity Costs	$12,895
Annual Repair Expenses, Total	$405
Total Annual Cash Costs	$27,304
Total Costs Over a Period of 5 Years Assuming No Inflation Adjustments	$136,521
Net Cash Margin per Cwt. of Milk Production	$7.93
Number of Cwt. Needed per Year for 5 Years to Breakeven	3,443 Cwt.
Pounds per Cow per Day of Impact over 5 Years to Breakeven	4.1 Lbs./cow/day
% of Average Daily Production	5.5%

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