Economic Considerations of Low Profile Cross Ventilated Barns

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TAKE HOME MESSAGES

- Low-profile-cross-ventilated (LPCV) barns provide an opportunity to significantly reduce the temperature variability in the barn.
- Increasing the percentage of time cows are in the thermal neutral zone allows both milk production and feed efficiency to be increased.
- Increased milk production along with improved feed efficiency result in over $100/cow higher returns for LPCV barns compared to naturally ventilated freestall barns.
- Economic benefits associated with improved reproduction and herd health would likely be realized that were not explicitly accounted for in this analysis.
- Operating costs for LPCV barns are slightly higher due to higher electricity requirements and increased feed associated with higher milk.
- When investment costs are spread over their useful life, the higher profitability of LPCV barns can support higher investment per cow.

INTRODUCTION

When thinking about their cow housing options, producers incorporate a number of factors into their ultimate decision. Obviously if the dairy wants to be competitive and remain in business in the long run, one of those factors needs to be the expected economic returns associated with the different housing types. While examining projected economic returns associated with various housing types (or any other production decision) does not guarantee things will play out exactly as projected, it can help producers avoid making costly mistakes and also realize some of the potential financial risks associated with their decisions.

Depending on location, producers will typically have a number of housing options they can consider. Furthermore, within a particular housing type there are many variants to consider (e.g., natural ventilated freestalls with heat abatement configurations). The housing type and the specific configurations have trade-offs such as: labor requirements, ability to manage cow comfort, investment required, and operating costs. This paper does not attempt to cover the gamut of housing types and configurations. Rather, it looks to compare the expected costs and returns associated with two specific facility types – (1) naturally ventilated (NatVent) freestall buildings with fans and soakers in place for heat abatement and (2) a low-profile-cross-ventilated (LPCV) freestall building with evaporative pads. It was assumed that both facility types had the ability to provide long day lighting for lactating cows and short day lighting for dry cows. Investment for the naturally ventilated freestall facility is based on 4-row configuration. The investment for the cross-ventilated facility is based on a 16-row LPCV building with an additional bay on each end to reduce the number of doors and to facilitate vehicle traffic.

The projected budgets used for this analysis are patterned off the Kansas State University projected dairy budget for a 2400-lactating cow freestall dairy (Dhuyvetter et al., 2007) and are presented on both a "per cow" and "per cwt" basis. As with any projected budgets, results are conditional upon numerous assumptions that may or may not hold over time. Therefore, in addition to estimating the expected costs and returns of the two facility types, referred to as the baseline scenario, this analysis includes sensitivity analyses around some of the key assumptions (e.g., investment, production). Because the primary objective of this analysis is to examine how LPCV barns compare with naturally ventilated freestall barns from an economic standpoint, discussion will focus on *differences* in costs and returns between the two housing types. In other words, absolute levels are not as critical for this analysis as differences that might exist.

ASSUMPTIONS

Assumptions were required for many factors related to income and costs, however, key drivers in differences are primarily related to differences in investment, milk production, feed efficiency, and utilities. This analysis did not attempt to explicitly account for differences in reproduction or health.

The cost of building a dairy can vary significantly temporally and spatially and thus this is somewhat of a "moving target" from an analysis standpoint. Initially, it was assumed that both systems would require an investment of $4,650 per cow in the herd (i.e., lactating and dry cows) for buildings and equipment, including rolling equipment.[1] Land was included at a cost of $5,500 per acre and it was assumed the NatVent facility would require 50 acres compared to 40 acres for the LPCV facility.

Milk production in the baseline scenario for NatVent is assumed to be 23,000 pounds per cow per year compared to 24,000 pounds for the LPCV system. This increase in milk production is driven principally be three factors: (1) increased milk related to improved feed efficiency (increased DM digestibility) because cow is kept in the thermal-neutral zone a higher percentage of the time (see Smith et al., 2008); (2) improved reproduction, due to less heat stress, which reduces the days in milk for the herd and also results in a more consistent calving pattern; and (3) improved overall health and reduced lameness.

Figures 1 and 2 show summarize the weather data that was used and the relationship between ambient and barn temperatures used in this analysis. Figure 1 demonstrates that the advantage the LPCV barn has in avoiding very cold days as well as hot days. While the NatVent facility was assumed to have fans and sprinklers, it was assumed that it could not cool the barn down near as much as could be done with the LPCV barn. On real cold days it is assumed that barn temperature will be slightly warmer than the ambient temperature due to body heat from the cows, but as with high temperatures, the NatVent barn will be considerably colder than the LPCV barn. Figure 2 incorporates the data from Figure 1 with a distribution of annual temperatures for Sioux Falls, SD (Anon. 1978) to show the distribution of temperatures in the different barns throughout the year. The NatVent facility reduces the areas in the tails of the

[1] This value was based on an informal survey of several contractors as to what it would cost to build both naturally ventilated and cross ventilated freestall barns.

ambient distribution, but not near as well as the LPCV facility. This much more stable environment is what leads to more milk production and the improved feed efficiency.

Total feed efficiency (pounds of milk produced per pound of feed on a dry matter basis) was estimated to be 1.30 for the NatVent facility compared to 1.34 for the LPCV facility. This difference was due to higher milk production for cows in the LPCV facility with similar feed intake levels due to improved digestibility during periods of low temperatures, and also because of decreased maintenance energy requirements during periods of high temperatures.

While utilities do not have near as large of impact on profitability as milk production or feed costs, this cost will vary between the two systems. It was assumed that the LPCV facility would require 50% more electricity (3.0 kW/cow/day compared to 2.0 kW/cow/day for the NatVent facility). The cost of utilities was based on electricity at 6¢ per kilowatt.

The following are other assumptions that impact profitability, and were the same for both housing types unless specified otherwise.

- **Cow numbers**: 2,400 lactating cows, 2,832 total cows (lactating + dry).
- **Milk price**: gross price of $18.50/cwt.
- **Milk hauling:** $0.75wt.
- **Coop fees and promotion:** $0.25/cwt.
- **Calves sold:** based on a 95% calf crop and selling all calves at birth (heifers = $450/head and steers = $50/head).
- **Cull cows sold:** assumes cull income is realized on 28% of the herd even though 34% of the herd is replaced annually. The 6% with no income represents cow death loss and cows with zero salvage value (cull cow value = $933/head).
- **Feed:** lactating cow feed = $13.56/cwt (DM) and dry cow feed = $7.57/cwt.
- **Labor:** based on 25 full-time persons (113 cows per employee) at an average of $38,000 (salary + benefits).
- **Veterinary, drugs and supplies:** costs for prevention and treatment and general dairy supplies (total =$140/cow).
- **Water:** water costs based on 140 gallons/cow/day in NatVent and 145 gallons/cow/day in LPCV (difference is due to higher milk production) at a cost of $1.55/thousand gallons.
- **Fuel, oil and auto expense:** share of the farm car and trucks plus gasoline, diesel and oil for scraping and hauling manure and for hauling feed to the dairy herd (total = $60/cow)
- **Building and equipment repairs:** annual building and equipment repairs were calculated as 2.5% of the total investment.
- **Replacements and breeding:**
  - **Capital replacement:** price of a heifer replacement ($2,000/head) times the replacement rate (34%).
  - **Semen, A.I. services, and supplies:** includes semen, artificial insemination services and supplies.
  - **Interest:** 8% interest is charged on the value of the breeding herd, which is based on the cost of replacement heifers entering the herd.
- **Professional fees (legal accounting, etc.):** business costs allocated to the dairy enterprise ($3000/month for dairy).

- **Miscellaneous:** miscellaneous costs (subscriptions, education, etc.) allocated to the dairy enterprise ($50,000/year for the dairy + $5/cow).
- **Depreciation on buildings and equipment:** depreciation is based on the total original cost less the salvage value of buildings and equipment on a per cow basis divided by the estimated life. The useful life is assumed to be 20 years for buildings and improvements and 7 years for equipment. A salvage value of 10% percent is assumed on buildings and improvements and 20 percent on equipment.
- **Interest on land, buildings and equipment:** interest is charged on the land investment at a rate of 5% and one-half the average investment [(initial cost + salvage value) ÷ 2] for buildings and improvements and equipment at a rate of 8%.
- **Insurance and taxes on land, buildings and equipment:** insurance on buildings and equipment is based on the original cost times 0.25%, taxes are based on 1.5% of the original cost for buildings and improvements and 0.50% for land.
- **Interest on operating costs:** calculated on one-half of operating costs at a rate of 8%.

CALCULATED VALUES

Given the different assumptions, costs and returns, hence profitability, could be estimated. There are several "results" that are useful to examine when considering the relative profitability of the two housing types.

- **Returns over total costs:** represents the profit earned by the dairy. It is important to note that the budgets used here include depreciation and interest on all assets and thus returns over total cost will not match up with cash flow (i.e., net cash flow is not a good measure of profitability)
- **Breakeven milk price to cover total costs:** represents the price needed for milk per cwt. to cover total costs of production. Assumes government payment, calf and cull income and all costs remain constant.
- **Asset turnover:** (returns per cow divided by total assets) asset turnover is the percentage of total investment recovered by total returns. Inverting this measure allows different enterprises to be compared on the basis of capital required to generate a dollar of gross income.
- **Net return on assets:** [(returns over total costs + interest on breeding herd + interest on operating costs + interest on land, buildings and equipment) + assets] net return on assets is the percentage return on investment capital (both borrowed and equity). This measure enables comparisons to be made between enterprises as well as other investment alternatives.

RESULTS

Table 1 shows the projected budgets for the two housing types based on current price and cost estimates. The first obvious result is that neither system is profitable given the assumptions. This suggests that even though milk prices are considerably above historical averages, they are not high enough to offset the high costs of production dairy producers are currently facing. It is important to keep in mind that the returns over total costs in these budgets reflect full economic costs and thus somebody with 30-50% equity in their dairy could still experience positive cash flows even though profits are negative.

While the negative profits are relevant, they are not the focus of this particular study. Rather, the *relative* profitability of the two housing types is the focal point. The low-profile-cross-ventilated (LPCV) ban has $115/cow advantage over the naturally ventilated (NatVent) freestall barn. This advantage is driven by two factors – milk and feed. The 1,000 additional pounds of milk generated an extra $185 of income per cow and this only required about $37 of feed to accomplish. The reason feed did not increase as much as might be expected is because of the better temperature control in the LPCV barn where cows are kept in the thermal neutral zone a higher percentage of the time (see Figure 2). In addition to having higher feed costs, the LPCV barn also had about $22/cow higher utilities costs because of the high electricity usage and $10/cow more in hauling and promotion cows due to the added milk. The LPCV barn had about $1/cow lower costs associated with land because of a slightly smaller facility footprint, however, on costs of over $5,000/cow/year this is quite insignificant.

Tables 2 and 4 show how return on assets (ROA) (Line G of the budget) vary as milk production and total facility investment vary for NatVent and LPCV, respectively. These tables allow dairy managers to examine at what point the two systems might be comparable. For example, the baseline ROA for the LPCV barn is 3.10% compared to 1.36% for the NatVent barn. Looking at Table 2 it can be seen that even if the naturally ventilated barn were to cost $750/cow less, returns would still be lower unless they could get production within 500 pounds of what is in the LPCV barn (i.e., ROA = 3.19% at milk production of 23,500 pounds and facility investment of $4,737). Similarly, looking at Table 4 it can be seen that even if milk production is not higher with the LPCV barn (i.e., it was at 23,000), the returns are still better than the NatVent barn because of the improved feed efficiency. Figure 3 shows ROA at various production levels for three different investment levels (baseline +/- $500 per cow). When viewed this way it can readily be seen the milk production and investment combinations that result in a similar ROA.

Tables 3 and 5 show returns over total costs ($/cow/year) at various production and facility investment levels for NatVent and LPCV barns, respectively. Figure 4 shows the relationship between milk production and returns over total costs ($/cow/year) for the two different housing types.

Another potential benefit of better cow comfort associated with heat abatement is reduced culling rates. In the projected budgets, each 1% reduction in culling rate increases returns/cow/year about $12. Given the increases in energy costs recently, one concern about the LPCV barn is the increased requirements for electricity. Given the levels used in these budgets, an increase of 2.5¢ per kilowatt reduces the advantage for the LPCV barn by approximately $10/cow. Thus, while the increased electricity requirements cannot be overlooked, other factors impact profitability much more.

SUMMARY

Low-profile-cross-ventilated (LPCV) freestall barns appear to offer a viable alternative to the traditional naturally ventilated (NatVent) freestall barn. Based on the projections used in this analysis, the LPCV barn resulted in almost a 2% higher return on assets and about $115/cow advantage in returns over costs. Being able to better control temperature and manage cow

comfort should result in increased milk production and improved feed efficiency which lead to increased profitability. Other benefits associated with increased cow comfort (e.g., reduced culling, improved reproduction) were not explicitly accounted for and thus the advantages for LPCV barns reported here are likely conservative. Total costs per cow are slightly higher with LPCV barns due to increased electricity usage and slightly higher feed costs due to increased milk production. Given a 1,000 pound higher production level, even if LPCV barns require a larger initial investment per cow ($500 or more) they are still more profitable than the naturally ventilated barn when costs are spread over the useful life of the investment.

REFERENCES

Anon. 1978. Facility Design and Planning Engineering Weather Data. Departments of the Air Force, The Army and The Navy. U.S. Government Document No. AFM-88-29:TM 5-785:NAVFAC P-89. Washington D.C.

Dhuyvetter, K.C., J.F. Smith, M. Brouk, J.P. Harner, III. *Dairy Enterprise – 2,400 Lactating Cows (Freestall)*. Kansas State Univ. Coop. Ext. Serv. Bull. MF-2442, October, 2007.

Smith, J.F., J.P. Harner, B.J. Bradford, M.W. Overton, K.C. Dhuyvetter. 2008. *Opportunities with Low-profile Cross-ventilated (LPCV) Freestall Facilities* 2008 Proceedings of Dairy Housing of the Future Conference. Sioux Falls, SD. Sept. 2008.

Figure 1.

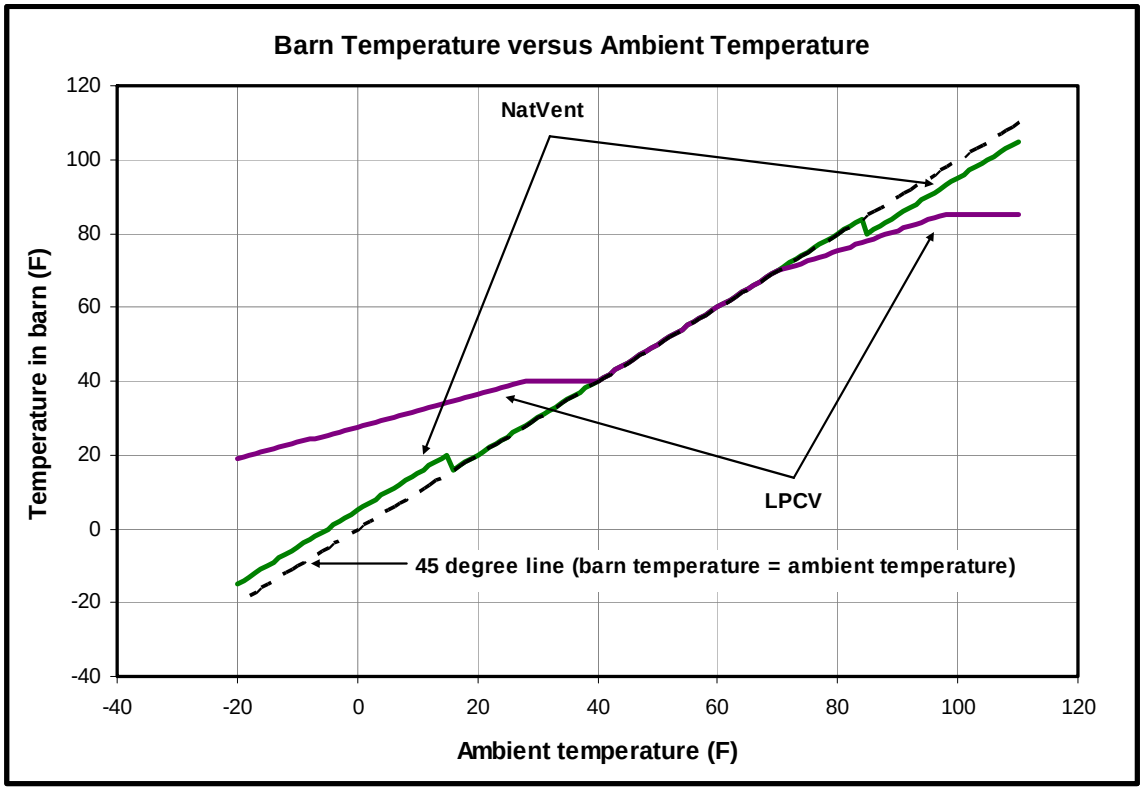

Figure 2.

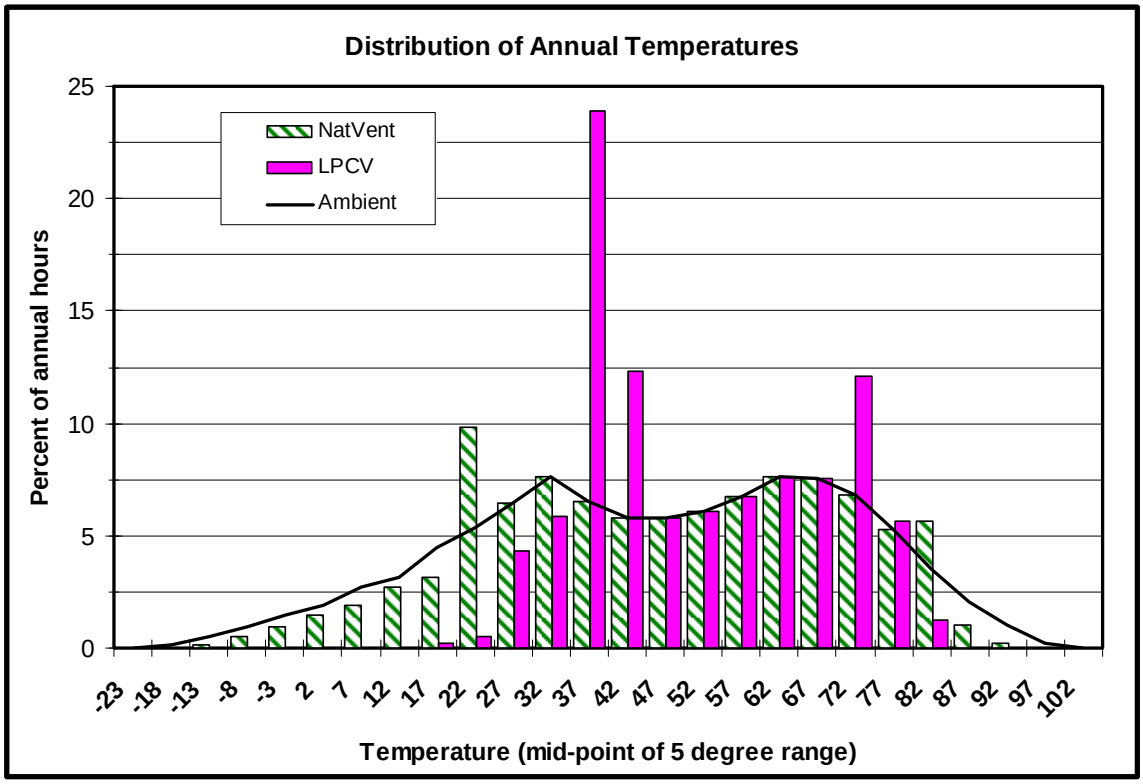

Table 1. Cost-Return Projection --- 2,400 Lactating Cow Freestall Dairy[1]

	Natural ventilation[2]		Cross ventilation		Difference[3]
	per cow	per cwt	per cow	per cwt	per cow
PRODUCTION LEVEL, lbs milk sold	23,000	230	24,000	240	1,000
RETURNS PER COW					
1. Milk sales @ $18.50/cwt.	$4,255.00	$18.50	$4,439.96	$18.50	$184.96
2. Volume premium	0.00	0.00	0.00	0.00	0.00
3. Government payment (MILC)	0.00	0.00	0.00	0.00	0.00
4. Calves sold: 95% x $246/head	233.70	1.02	233.70	0.97	0.00
5. Cull cows sold: $933,/head x 28.0%	261.20	1.14	261.20	1.09	0.00
A. GROSS RETURNS	$4,749.90	$20.65	$4,934.86	$20.56	$184.96
COSTS PER COW:					
6. Feed	$2,555.34	$11.11	$2,592.13	$10.80	$36.80
7. Labor	335.45	1.46	335.45	1.40	0.00
8. Supplies, drugs, and veterinary	140.00	0.61	140.00	0.58	0.00
9. Somatotropin (rbST)	0.00	0.00	0.00	0.00	0.00
10. Utilities and water	125.47	0.55	147.37	0.61	21.90
11. Fuel, oil, and auto expense	60.00	0.26	60.00	0.25	0.00
12. Milk hauling and promotion costs	230.00	1.00	240.00	1.00	10.00
13. Building and equipment repairs	116.25	0.51	116.25	0.48	0.00
14. Breeding/genetic charge:					
a. Capital replacement: 34% x $2000/head	680.00	2.96	680.00	2.83	0.00
b. Semen, A.I. services, and supplies	52.50	0.23	52.50	0.22	0.00
c. Interest	160.00	0.70	160.00	0.67	0.00
d. Insurance	20.00	0.09	20.00	0.08	0.00
15. Professional fees (legal, accounting, etc.)	12.71	0.06	12.71	0.05	0.00
16. Miscellaneous	22.66	0.10	22.66	0.09	0.00
17. Depreciation on buildings and equipment	230.03	1.00	230.03	0.96	0.00
18. Interest on land, buildings, and equipment	210.65	0.92	209.68	0.87	-0.97
19. Ins. and taxes on land, bldgs and equip.	77.46	0.34	77.34	0.32	-0.12
B. SUB TOTAL	$5,028.51	$21.86	$5,096.12	$21.23	$67.61
20. Interest on 1/2 operating costs @ 8.0%	140.71	0.61	143.06	0.60	2.34
C. TOTAL COSTS PER COW	$5,169.22	$22.47	$5,239.17	$21.83	$69.95
D. RETURNS OVER TOTAL COSTS (A - C)	-$419.32	-$1.82	-$304.31	-$1.27	$115.01
E. BREAKEVEN MILK PRICE, $/cwt:		$20.32		$19.77	$0.56
21. Lactating cow feed cost, $/head/day	$7.60		$7.71		$0.12
22. Dry cow feed cost, $/head/day	$2.27		$2.27		$0.00
F. ASSET TURNOVER (A/Assets)[4]	70.4%		73.4%		
G. NET RETURN ON ASSETS ((D + 14c + 18 + 20)/Assets)[4]	1.36%		3.10%		

[1] Replacements purchased

[2] Includes costs and investment associated with heat abatement

[3] Per cow value for cross ventilated facility minus per cow value for natural ventilation facility.

[4] Assets equal total value of breeding herd and land, buildings, and equipment.

Table 2. Return on Assets (Line G) versus Production and Facility Investment -- NatVent

Milk	Total investment in facilities and equipment, $/lactating cow*						
production	$4,737	$4,987	$5,237	**$5,487**	$5,737	$5,987	$6,237
21,500	0.23%	-0.08%	-0.38%	-0.65%	-0.91%	-1.15%	-1.38%
21,750	0.60%	0.27%	-0.03%	-0.32%	-0.58%	-0.83%	-1.07%
22,000	0.97%	0.63%	0.32%	0.02%	-0.26%	-0.52%	-0.76%
22,250	1.34%	0.99%	0.66%	0.36%	0.07%	-0.20%	-0.46%
22,500	1.71%	1.35%	1.01%	0.69%	0.39%	0.11%	-0.15%
22,750	2.08%	1.71%	1.36%	1.03%	0.72%	0.43%	0.16%
23,000	2.45%	2.07%	1.70%	**1.36%**	1.05%	0.75%	0.46%
23,250	2.82%	2.42%	2.05%	1.70%	1.37%	1.06%	0.77%
23,500	3.19%	2.78%	2.40%	2.04%	1.70%	1.38%	1.08%
23,750	3.56%	3.14%	2.74%	2.37%	2.02%	1.69%	1.38%
24,000	3.94%	3.50%	3.09%	2.71%	2.35%	2.01%	1.69%
24,250	4.31%	3.86%	3.44%	3.04%	2.67%	2.33%	2.00%
24,500	4.68%	4.22%	3.78%	3.38%	3.00%	2.64%	2.31%

* Investment per cow in herd equals investment per lactating cow times 84.7%.

** Costs vary by production level due to varying feed and hauling and promotion costs.

Table 3. Return on Assets (Line G) versus Production and Facility Investment -- LPCV

Milk	Total investment in facilities and equipment, $/lactating cow*						
production	$4,737	$4,987	$5,237	**$5,487**	$5,737	$5,987	$6,237
22,500	2.10%	1.73%	1.38%	1.05%	0.74%	0.44%	0.17%
22,750	2.48%	2.09%	1.73%	1.39%	1.07%	0.77%	0.48%
23,000	2.86%	2.46%	2.08%	1.73%	1.40%	1.09%	0.79%
23,250	3.24%	2.82%	2.44%	2.07%	1.73%	1.41%	1.11%
23,500	3.62%	3.19%	2.79%	2.41%	2.06%	1.73%	1.42%
23,750	3.99%	3.55%	3.14%	2.76%	2.39%	2.05%	1.73%
24,000	4.37%	3.92%	3.49%	**3.10%**	2.73%	2.38%	2.05%
24,250	4.75%	4.28%	3.85%	3.44%	3.06%	2.70%	2.36%
24,500	5.13%	4.65%	4.20%	3.78%	3.39%	3.02%	2.67%
24,750	5.50%	5.01%	4.55%	4.12%	3.72%	3.34%	2.98%
25,000	5.88%	5.38%	4.91%	4.47%	4.05%	3.66%	3.30%
25,250	6.26%	5.74%	5.26%	4.81%	4.38%	3.98%	3.61%
25,500	6.64%	6.11%	5.61%	5.15%	4.72%	4.31%	3.92%

* Investment per cow in herd equals investment per lactating cow times 84.7%.

** Costs vary by production level due to varying feed and hauling and promotion costs.

Table 4. Returns over Total Costs per Cow (Line D) versus Production and Facility Investment -- NatVent

Milk	Total investment in facilities and equipment, $/lactating cow*						
production	$4,737	$4,987	$5,237	**$5,487**	$5,737	$5,987	$6,237
21,500	-$463.21	-$492.22	-$521.23	-$550.24	-$579.25	-$608.25	-$637.26
21,750	-$441.39	-$470.40	-$499.41	-$528.42	-$557.43	-$586.44	-$615.44
22,000	-$419.57	-$448.58	-$477.59	-$506.60	-$535.61	-$564.62	-$593.62
22,250	-$397.75	-$426.76	-$455.77	-$484.78	-$513.79	-$542.80	-$571.81
22,500	-$375.93	-$404.94	-$433.95	-$462.96	-$491.97	-$520.98	-$549.99
22,750	-$354.12	-$383.12	-$412.13	-$441.14	-$470.15	-$499.16	-$528.17
23,000	-$332.30	-$361.30	-$390.31	**-$419.32**	-$448.33	-$477.34	-$506.35
23,250	-$310.48	-$339.49	-$368.49	-$397.50	-$426.51	-$455.52	-$484.53
23,500	-$288.66	-$317.67	-$346.67	-$375.68	-$404.69	-$433.70	-$462.71
23,750	-$266.84	-$295.85	-$324.86	-$353.86	-$382.87	-$411.88	-$440.89
24,000	-$245.02	-$274.03	-$303.04	-$332.05	-$361.05	-$390.06	-$419.07
24,250	-$223.20	-$252.21	-$281.22	-$310.23	-$339.23	-$368.24	-$397.25
24,500	-$201.38	-$230.39	-$259.40	-$288.41	-$317.42	-$346.42	-$375.43

* Investment per cow in herd equals investment per lactating cow times 84.7%.

** Costs vary by production level due to varying feed and hauling and promotion costs.

Table 5. Returns over Total Costs per Cow (Line D) versus Production and Facility Investment -- LPCV

Milk	Total investment in facilities and equipment, $/lactating cow*						
production	$4,737	$4,987	$5,237	**$5,487**	$5,737	$5,987	$6,237
22,500	-$350.39	-$379.40	-$408.41	-$437.41	-$466.42	-$495.43	-$524.44
22,750	-$328.21	-$357.21	-$386.22	-$415.23	-$444.24	-$473.25	-$502.26
23,000	-$306.02	-$335.03	-$364.04	-$393.05	-$422.06	-$451.06	-$480.07
23,250	-$283.84	-$312.85	-$341.85	-$370.86	-$399.87	-$428.88	-$457.89
23,500	-$261.65	-$290.66	-$319.67	-$348.68	-$377.69	-$406.70	-$435.71
23,750	-$239.47	-$268.48	-$297.49	-$326.50	-$355.50	-$384.51	-$413.52
24,000	-$217.29	-$246.30	-$275.30	**-$304.31**	-$333.32	-$362.33	-$391.34
24,250	-$195.10	-$224.11	-$253.12	-$282.13	-$311.14	-$340.15	-$369.15
24,500	-$172.92	-$201.93	-$230.94	-$259.94	-$288.95	-$317.96	-$346.97
24,750	-$150.74	-$179.74	-$208.75	-$237.76	-$266.77	-$295.78	-$324.79
25,000	-$128.55	-$157.56	-$186.57	-$215.58	-$244.59	-$273.59	-$302.60
25,250	-$106.37	-$135.38	-$164.38	-$193.39	-$222.40	-$251.41	-$280.42
25,500	-$84.18	-$113.19	-$142.20	-$171.21	-$200.22	-$229.23	-$258.24

* Investment per cow in herd equals investment per lactating cow times 84.7%.

** Costs vary by production level due to varying feed and hauling and promotion costs.

Figure 3.

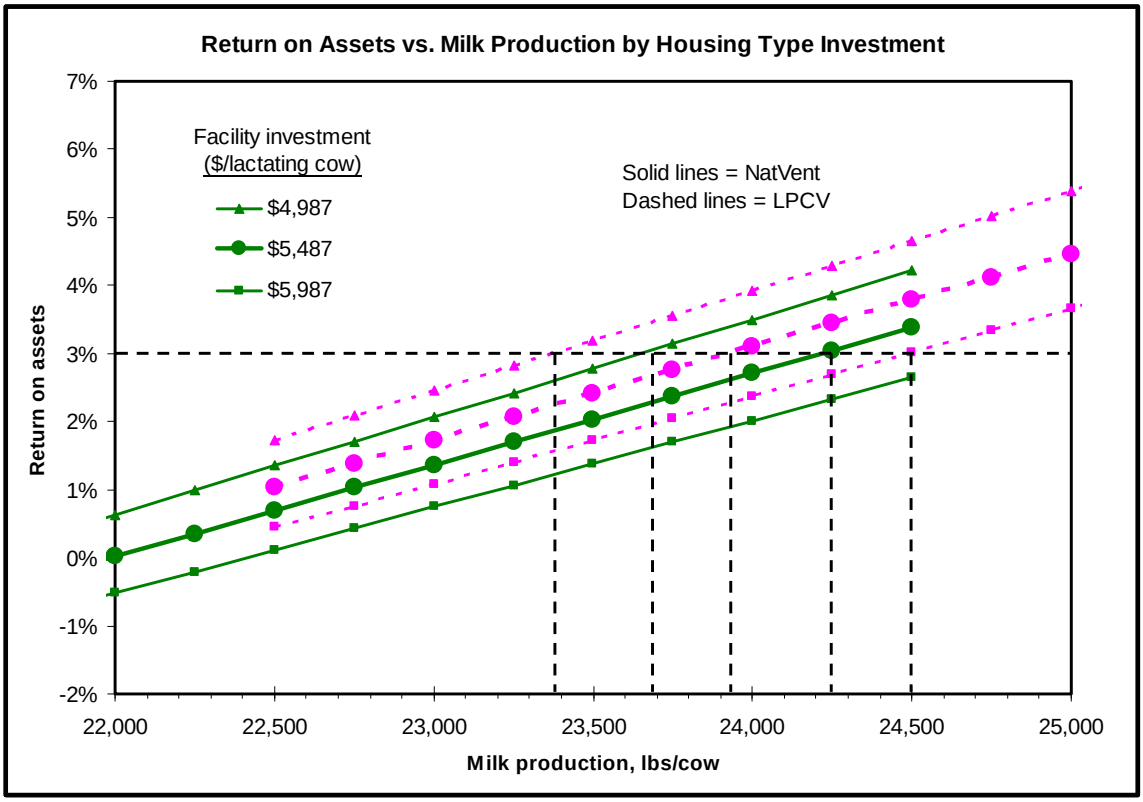

Figure 4.