Facility Management Considerations That Impact Profit

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INTRODUCTION

Dairy housing has evolved substantially in the last 20 years. The fundamental change in facility design has been a shift in emphasis from worker comfort to cow comfort. Another change has been the marked increase in the number of animals per site. Many of these changes have resulted from practical evaluation of animal performance in various housing situations, since university data are generally lacking for evaluating housing alternatives. Dairy housing research can be more difficult and costly than traditional nutrition, physiology, and genetic research. Evaluating different designs is difficult or infeasible for most university researchers, partially due to outdated dairy facilities at many universities. Aside from the few modern university dairy facilities, most research is conducted in the field on operating dairy facilities. Much of the research is focused on evaluating existing facilities rather than investigating new concepts or designs.

HOUSING ALTERNATIVES

In the United States, there are three basic design alternatives: open lot, confinement, or grazing. Climate and economics will largely dictate which option is feasible. Open lots will typically cost 30-40% of a free stall barn. Confinement is most typical, followed by open lot then pasture. Since investment is highest for confinement facilities, they are built in areas where the additional cost can be justified. Higher milk production, improved milk quality, enhanced reproductive performance, and lower cull rates from reduced environmental stress provide the additional income to offset the higher investment of confinement. Although open lot investment is considerably less, design consideration is still crucial. The authors have limited experience with grazing operations.

Many dairy producers and consultants debate the feasibility of open lot versus freestall in many areas of the county. Many dairy producers favor the lower initial investment of open lots. Some consultants favor confinement, citing improved animal performance and reduced risk as advantages. Data are lacking to help dairy producers make this decision.

Thus, this decision is usually made by dairy designers and dairy producers from their combined experience and expertise, and not from any published research.

Dairy producers and consultants that are debating confinement or open-lot need to address a fundamental question that is difficult to answer: will the additional investment for the confinement facility be returned in improved animal performance? In most cases, a confinement facility will require a larger initial investment higher monthly operating costs. With these assumptions, Table 1 displays the various cost differences, in dollars per cow per day, at varying investment and operating cost differences. Table 2 calculates the additional milk needed to justify the investment, assuming a given daily cost difference and varying milk prices. In Tables 1-2, it is assumed that additional milk production must cover all of the additional costs. These tables can be used to compare free stall versus open lot, or any other housing options. In a typical scenario, the initial investment will be $700 more for a freestall compared to an open lot, and operating costs will be $15/cow/month more. In this scenario, the additional costs are $0.76 per cow per day. If milk is $0.22 per kg, the dairy must produce another 3.45 kg of milk per cow per day over a 10 year period to justify building a freestall. This assumes that reproductive performance, culling, and herd health are not different. The assumption is that if milk production is sufficient to cover the investment and operational costs, other potential benefits such as reduced environment stress and reduced risk will favor confinement. Research is needed to identify, even crudely, the expected performance differences between open lot and confinement facilities.

Management of Facilities

Increasingly tight margins have forced producers to improve efficiency. There are many theories about what size dairy is most profitable, or what management approach is most profitable. One basic principle is true in most situations: the dairy needs to maximize milk sold given the investment that has been made. This a function of keeping the facility at capacity throughout the year, and maximizing milk per cow given the location constraints and management style. For some dairies capacity is one cow per stall or one cow per headlock, while for other dairies 10-40% overcrowding is normal capacity. Each dairy should determine how many cows represent full capacity.

During the design phase, decisions need to be made about milking frequency and cow numbers. These choices will dictate group size, parlor size, and number of groups. Many dairy producers, consultants, and researchers debate the feasibility of different milking frequency regimes. Three times (3x) milking studies suggest that milk production increases 3-39% over two times (2x) milking (Armstrong, 1997; Smith et al., 2002). In a review of milking frequency, Armstrong (1997) reported that four times (4x) milking is 8-12% greater than 3x, and 3x milking 10-18% over 2x. Large herds in the High Plains region of the United States have increased production 5-8% when switching from 3x to 4x (Bethard, 2003). Pearson et al. (1979) found that when cows were switched from 3x to 2x in mid lactation, milk production dropped the first week after switching but persistency was similar thereafter. They suggested that most of the 3x response was maintained throughout lactation after switching to 2x. In this study, cows were switched to 2x based on production level, and all cows were switched before 150 days in milk. More recent research (Bar-Peled et al., 1995; Sanders, 2000) suggests that frequent milking during early lactation, specifically the first 21 days, may improve total lactation yield, again suggesting a carryover effect of milking frequency.

Older studies evaluated the economics of 3x versus 2x milking with smaller herds where the parlor was not fully utilized in a 24 hour period. Culotta and Scmidt (1988) reported that a 15.7% increase in milk production was needed to justify 3x milking. In the US dairy industry today, most larger herds are utilizing the parlor 24 hours per day, so changing from 2x to 3x milking will result in fewer cows given the same milking system capacity. Conversely, a herd will typically add cows when switching from 3x to 2x.

In today's US dairy industry, the new paradigm is trying to design the dairy for a milking frequency regime that maximizes total profit. Should the dairy milk 2x, 3x, 4x, or a combination of different frequencies such as 3x-2x, 4x-2x, or 4x-3x-2x? Table 3 is output from a spreadsheet that provides a simple analysis of this complex question for several scenarios. There are numerous assumptions for this type of analysis, and many different methods to determine an answer. In this example, most of the assumptions are detailed in the footnotes for the table. It was assumed that milking labor per day was similar for all scenarios, with non-labor operating costs and non-milking labor costs changing with cow number and milk production, respectively.

In the example outlined in Table 3, total milking time per day was 22 hours, and group sizes were 320 cows in most cases. Group numbers were not even in some cases (effectively creating one smaller group) to enable 22 hour per day milking time. Using total daily income over feed cost, the 2x or 3x-2x examples were most advantageous. However, the examples with 2x milking required more cows, which impacted replacement needs, non labor operating costs, non milking labor costs, and facility payments. Thus, the net per year calculation (income over feed cost minus replacement cost, non labor operating cost, non-milking labor cost, parlor payments, and facility payments) suggests that under the assumptions in Table 3, 3x is most profitable and 2x is least profitable. On a per cow basis, 4x is most profitable in this example.

Of course these results are highly dependent on response to milking frequency, cull rates, operating costs, milk price, and feed costs. If the 3x response over 2x is changed from 10 to 5% and the 4x response over 2x from 16 to 8%, the analysis looks very different. Under this scenario, net per year was $1,719,732 for 2x, $1,702,295 for 3x, $1,524,338 for 4x, $1,722,854 for 3x-2x, and $1,535,982 for 4x-2x, suggesting that 2x, 3x, and 3x-2x were similar, but 4x and 4x-2x were less profitable. Conversely, if response was changed to 15 and 20% for 3x and 4x, respectively, over 2x, the results more strongly favor more frequent milking (net per year was $1,719,732 for 2x, $2,300,399 for 3x, $2,116,558 for 4x, $1,941,831 for 3x-2x, and $1,928,181 for 4x-2x). Changing other variables such as costs and milk price did not appreciably alter the conclusion. It appears that response to milking frequency is the key determinant for this decision. Under the assumptions in Table 3, 2x, 3x, and 4x yielded identical net return per year when response was 5.3% for

3x over 2x, and 12.0% for 4x over 2x. Any responses over this amount favored more frequent milking. Further research is needed to more closely identify the carryover effects of milking frequency.

There are many practical factors that determine response to 3x or 4x milking. Walking distance from the housing area to the holding pen should be less than 172-201 meters (Armstrong, 1997; Smith et al. (2000). Armstrong (1997) recommended that milking time should be less than one hour per group. An industry recommendation is that total milking time per group should be less than 3 hours each day. Properly functioning milking equipment becomes increasingly critical with increasing frequency of milking. Robotic milking units may be well suited to a fresh cow pen on a large dairy.

Grouping

Group size and number of groups are critical design components for a dairy. The first fundamental criterion is that group size must match the parlor, or that the size of one is dependent on the other (Smith et al., 2000). Typically the groups are sized so that milking time is 45 minutes or less per milking. This allows any combination of 2x, 3x or 4x milking while still keeping total milking time per day under 3 hours. The number of groups is a function of milking frequency and management preference. In most cases the milking center is run near-continuously.

Group sizes are getting larger as parlors are getting larger. In a review, Grant and Albright (2001) concluded that there appear to be no problems with large group sizes (>200 cows), but there is little data about groups larger than 400 cows. For new dairies being built currently in the US, 300-400 cow groups are very common, and 500-600 cow groups are not uncommon. Research is needed to determine if larger group sizes pose any social or physiological barriers that will impair production or health.

There are numerous theoretical schemes for grouping lactating cows, based on production, nutritional needs, environmental considerations, and economics. All of these theories intend to lower feed costs by feeding a ration more similar to the needs of the cow at a particular level of production or stage of lactation. On a practical basis, it is difficult to feed numerous rations and continually sort cows by production. Thus, most practical schemes involve grouping cows by reproductive status (open cows before voluntary waiting period, AI breeding cows, bull breeding cows, pregnant cows), parity (first lactation and 2^{nd} and greater lactations), or production (low and high group). Grouping strategies change as a dairy evolves, so flexibility is important. Some dairies with mastitis and somatic cell count problems will house cows with contagious mastitis in a separate group. Grant and Albright (2001) reported that negative social consequences of moving cows between groups can last 3 to 7 days, so it is important that group movements are minimized during lactation. In most dairies, a cow is moved 2-4 times during lactation (Bethard, 2003).

Smith et al. (2000) proposed that a new dairy should be designed with four different types of lactating cows: healthy lactating cows (92%), fresh cows (4%), sick cows (2%), and slow milking and lame cows (2%). Normally the healthy lactating cows will comprise 8-12 pens, with the other groups maintained within a pen.

Grouping needs are considerably different for special needs cows. These are cows from about 21 days before calving to about 14 days after calving, sick cows, or high risk lactating cows. These cows require special management attention, and are at high risk for disease or injury. Smith et al. (2001) defined the special needs groups as close up cows and heifers (4-28 days pre-partum), maternity, fresh cows and heifers (calving to 14 days in milk), sick cows (milk is not sold), and high risk lactation cows (milk is sold). Since these groups require more labor and cow handling, design is critical. Reducing cow stress is critical during this phase.

The special needs cows that are lactating are often milked through a smaller hospital parlor, so the group size must be smaller. Many dairies are milking cows with saleable milk through the hospital parlor. This enables the main, larger parlor to run more efficiently by not having to milk slow and fresh cows. In this scenario, all fresh cows, sick cows with non-saleable milk, sick cows with saleable milk, slow milking cows, and lame cows can be milked in the hospital parlor.

CONCLUSIONS

A dairy must be designed as a system with all components considered simultaneously. Management philosophy largely dictates the design, so most dairies are unique. However, certain fundamentals are critical to all designs, such as cow comfort, labor efficiency, economic viability, and waste management efficiency. In the future, mechanization will likely decrease the labor needs for dairies and environmental considerations will greatly impact dairy design. An increasing emphasis will be placed on economic viability of various design and management schemes. Future research needs to lead and not follow the industry, and be more proactive and less reactive. In particular, more detailed research that evaluates cow performance in various management (such as milking frequency variations) and design (such as free stall versus dry lot) systems is needed. In addition, research is needed to evaluate the social and facility impacts of large groups.

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Table 1. Daily cost differences for varying initial investments and monthly operating costs, assuming a 10 year and 6% return on investment.

Monthly Operating Difference[1]	**Investment Difference**[2]						
	$600	$700	$800	$900	$1000	$1100	$1200
	Annual Payment Difference[3]						
$/cow/mo	$81.52	$95.11	$108.69	$122.28	$135.87	$149.45	$163.04
	----------------------Daily cost differences, $/cow/day[4]**----------------------**						
$0	$0.22	$0.26	$0.30	$0.34	$0.37	$0.41	$0.45
$5	$0.39	$0.43	$0.46	$0.50	$0.54	$0.58	$0.61
$10	$0.56	$0.59	$0.63	$0.67	$0.71	$0.74	$0.78
$15	$0.72	$0.76	$0.80	$0.84	$0.87	$0.91	$0.95
$20	$0.89	$0.93	$0.96	$1.00	$1.04	$1.08	$1.11
$25	$1.06	$1.09	$1.13	$1.17	$1.21	$1.24	$1.28
$30	$1.22	$1.26	$1.30	$1.34	$1.37	$1.41	$1.45

[1] The difference in operating costs between 2 different facility options

[2] The initial investment difference between 2 different facility options

[3] The annual payment, at 6% interest for 10 years, for the investment difference.

[4] The calculated cost difference, including investment and operating costs, between 2 different facility options.

Table 2. Kilograms of milk needed to cover daily cost difference at various milk prices.

daily cost Difference[1]	**Milk Price, $/kg**							
	$0.22	$0.24	$0.26	$0.29	$0.31	$0.33	$0.35	$0.37
$/cow/day	**-----------------kilogram milk needed to cover cost difference-----------------**							
$0.20	0.9	0.8	0.8	0.7	0.6	0.6	0.6	0.5
$0.30	1.4	1.2	1.1	1.0	1.0	0.9	0.9	0.8
$0.40	1.8	1.7	1.5	1.4	1.3	1.2	1.1	1.1
$0.50	2.3	2.1	1.9	1.7	1.6	1.5	1.4	1.3
$0.60	2.7	2.5	2.3	2.1	1.9	1.8	1.7	1.6
$0.70	3.2	2.9	2.6	2.4	2.3	2.1	2.0	1.9
$0.80	3.6	3.3	3.0	2.8	2.6	2.4	2.3	2.1
$0.90	4.1	3.7	3.4	3.1	2.9	2.7	2.6	2.4
$1.00	4.5	4.1	3.8	3.5	3.2	3.0	2.8	2.7
$1.10	5.0	4.5	4.2	3.8	3.6	3.3	3.1	2.9
$1.20	5.4	5.0	4.5	4.2	3.9	3.6	3.4	3.2
$1.30	5.9	5.4	4.9	4.5	4.2	3.9	3.7	3.5
$1.40	6.4	5.8	5.3	4.9	4.5	4.2	4.0	3.7
$1.50	6.8	6.2	5.7	5.2	4.9	4.5	4.3	4.0

[1] The difference in daily costs, including investment and operational cost differences, between 2 facility options.

Table 3. Economic comparison of varied milking frequencies.

	2x	3x	4x	3x-2x[1]	4x-2x[2]
Parlor side[3]	40	40	40	40	40
Turns/hr 2x	4	4	4	4	4
Turns/hr 3x	5	5	5	5	5
Turns/hr 4x	5.5	5.5	5.5	5.5	5.5
Cows/hr 2x	320	320	320	320	320
Cows/hr 3x	400	400	400	400	400
Cows/hr 4x	440	440	440	440	440
2x milk/cow/day, kg[4]	32.0	-	-	33.0	33.5
3x milk/cow/day, kg[5]	35.2	35.2	-	35.2	-
4x milk/cow/day, kg[6]	-	-	37.1	-	37.1
Number groups 2x[7]	11	0	0	7	3.75
Number groups 3x[7]	0	9.15	0	3.35	0
Number groups 4x[7]	0	0	7.55	0	5
Cows per group	320	320	320	320	320
Total Milking Cows	3520	2928	2416	3312	2800
Dry Cows	528	439	362	496	420
Milking time/day, hours	22.0	22.0	22.0	22.0	22.0
Downtime/day, hours	2.0	2.0	2.0	2.0	2.0
Milk shipped per cow, kg	32.0	35.2	37.1	33.7	35.6
Milk shipped per day, kg	112,640	103,066	89,682	111,654	99,560
Milk Income[8]	28,160	25,766	22,420	27,914	24,890
Average DMI, kg/cow/day[9]	22.9	24.1	24.9	24.3	25.4
Feed cost/milking cow/day[10]	$3.66	$3.86	$3.98	$3.88	$4.06
Milking cow feed cost per 45 kg milk	$5.14	$4.94	$4.83	$5.18	$5.13
Feed cost/dry cow/day	$2.00	$2.00	$2.00	$2.00	$2.00
Total feed cost per day[11]	$13,929	$12,186	$10,352	$13,847	$12,197
Income over feed cost per day	$14,231	$13,580	$12,068	$14,066	$12,693
Replacement cost/day[12]	$3,327	$2,768	$2,284	$3,131	$2,647
Non labor operating costs/day[13]	$2,933.33	$2,440.00	$2,013.33	$2,760.00	$2,333.33
Non-milking labor cost[14]	$1,252	$1,145	$996	$1,241	$1,106
Parlor payment costs/day[15]	$444	$444	$444	$444	$444
Facility payment costs/day[16]	$1,563	$1,300	$1,073	$1,471	$1,243
Net per day	$4,712	$5,483	$5,258	$5,020	$4,919
Net per year	$1,719,732	$2,001,347	$1,919,151	$1,832,342	$1,795,405
Net per cow per year	$489	$684	$794	$553	$641

[1]3x in early lactation, 2x in later lactation
[2]4x in early lactation, 2x in later lactation
[3]Double 40 parlor used in examples
[4]Milk per cow base level is 32 kg for 2x. For herds switching from 3x to 2x, the 2x milk is assumed to be higher due to carryover effect.
[5]3x milking is 10% higher than 2x.
[6]4x milking is 16% higher than 2x.
[7]Number of groups set to equalize total milking time per day for each scenario.
[8]milk price $0.25/kg
[9]The base dry matter intake is 22.9 kg for 32 kg milk. Dry matter intake increases 0.4 kg for each 1.0 increase in milk production.
[10]Feed cost is $0.16/kg of DM
[11]Milking and dry
[12]A 30% cull rate was used in examples, assuming replacement animals cost $1400 and culls are valued at $400 for a net replacement value of $1000.
[13]$0.83 per cow per day
[14]$0.50 per 45 kg milk
[15]Milking parlor investment $15,000 per stall, payments based on 6% interest over 10 years.
[16]Housing facility investment $1200 per cow, payments based on 6% interest over 10 years.