

Transitioning in Steps: Costs of Modernization

Modernization choices – spending your money wisely.

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Dairies in Wisconsin are continually transitioning their production facilities to more profitable and environmentally friendly systems. The dairy farm is a system comprised of several key functional areas. Each unique farm must balance existing resources including land, labor and capital. The components of the production system presented in this discussion focuses on milking, housing, feeding, and manure storage.

Every farm has a unique cost of production comprised of different costs associated with feed, labor, facilities and variable costs. Grazing systems may use a resource such as their land base. Confinement systems may use the resources of capital and labor. In the end, each producer wishes to maximize the use of their set of resources to make a profit.

Modernization can mean many things. In this discussion the definition;

“To accept or adopt modern ways, ideas, or style.”- The American Heritage® Dictionary of the English Language, Fourth Edition Copyright © 2000.

seems to be appropriate. Accepting, adopting and adapting new technology to the farmstead is a continual process as old technology is upgraded to new methods, facilities or equipment. Another modernization definition places modernization in the context of a business;

“Investments in systems, processes, equipment, and facilities that increases productivity, improves quality, and enhances customer support.”-MoneyGlossary.com

In this discussion modernization encompasses a variety of actions and issues mostly related to changing the dairy system on the farm by adopting new technology and management practices (hopefully proven) to be profitable and sensitive to environmental concerns of both owner and the public.

Profitability is enhanced by selecting low cost facility investments. Part of the discussion must define what low cost means. Some may define low cost as low capital cost. While others may define low cost as low annual cost.

We will discuss several options for modernizing the dairy farm related to housing, milking center, feed storage, and manure storage. We will try to compare several potential viable and representative options within each area to explore the capital cost, annual cost, and how the systems may fit into a modernization effort in your dairy. The business plan may incorporate some or all of these actions to facilitate a profitable dairy transition plan. This discussion is focused on the initial transitional growth of the farm,

but the capacity for future growth should also be considered in the long range plan of the farm.

Milking Center

The milking system is a key element in the dairy operation. Many farms are in a position where changing how cows are milked is a key decision in the future of the dairy operation. New and remodeled parlors are a capital investment that can pay for itself in several ways including labor efficiency, and personal and/or employee health.

The choice during a transition is how quickly the transition will occur and how much capital can be spent at the time of the transition. The low capital investment of a remodeled parlor fits into a slow step wise transition to fit the dairy's goal. In some cases the remodeled parlor is an interim step to a larger farmstead plan, including a new parlor on a new site in the future.

To demonstrate the capital costs and annual costs of changing the milking system from a stall barn the following assumptions were made:

- 120 milking cows (144 total cows)
- Production level at 60 lbs/day (18,000 lb/year)
- \$10/hour labor rate
- Tie stall barn milking rate at 25 cows per person hour for 2 persons
- Parlor milking rate at 60 cows per person hour for 1 person (~8 sides per hour)
- 2x milking
- Interest rate of 8%
- 8 on a side parlor stalls

Based on the milking herd size, rate of milking, and number of people milking the labor cost can be calculated for each system. The milking rate for an eight (8) on a side parlor was held constant on the initial analysis independent of the capital investment. Assuming no initial tie stall barn investment, the cost of milking is only for labor. All other system comparisons include the annual cost of the capital investment and the labor cost. The annual cost factor of approximately 17% (based on a 10 year payback) on the investment. A summary of the capital and annual costs are shown below:

Facility	Initial Capital (\$)	Annual Cost		
		Capital (\$/yr)	Labor (\$/yr)	Total Annual (\$/yr)
Tie Stall	----	-----	35,040	35,040
Low Cost Remodel Parlor	25,000	4,250	14,400	18,850
Medium Cost Remodel Parlor	50,000	8,500	14,400	23,100
High Cost Remodel Parlor	100,000	17,000	14,400	31,600
High Cost New Parlor	250,000	42,500	14,400	57,100

All the parlor investments except a the remodeled high cost parlor and new parlor have a lower total annual cost to milk cows compared to the labor cost of milking in a tie stall barn. There are additional benefits to the parlor including health and safety. The labor issue on stall barn systems is one of the roadblocks for many that would like to increase cow numbers but don't have the labor force to handle additional cows unless they change the system.

Compared to tie stall barn milking this analysis shows an investment up to \$124,000 in the parlor will break even through labor savings. Any investment over \$124,000 requires additional benefits to pay for itself. This analysis is sensitive to several factors including assumed parlor throughput, and payback time frame.

Parlor Throughput Sensitivity

One could argue that you may have a higher parlor throughput in a new parlor compared to a remodeled parlor due to design compromises in a remodeled parlor or the ability to incorporate technology such as automatic takeoffs (ATOs) in the newer parlor. Table 1 shows how the labor cost for different milking speed assumptions impacts the total cost. The effect of milking speed only has a small affect (approximately \$0.30/cwt/yr between fastest and slowest milking) on the overall costs of harvesting milk.

One could also use this analysis to determine if the investment for ATO, for example, could pay for itself. Assuming that ATOs would allow 10 more cows to be milked per hour, shows to be a labor savings of approximately \$2,808 per year for this case. Over a 5 year period that is equivalent to over \$10,400. If an ATO cost less than \$1,300/each for 8 units used on the swing parlor, the investment would pay for itself.

Payback Time Frame Sensitivity

The assumption on the time frame that the investment is to be paid back also will have an effect on the total annual cost of harvesting milk. In general a lower capital investment can afford to be paid back over a shorter period of time compared to a large investment. This may be an issue depending on how fast the farm intends to grow. If \$25,000 is invested it may be desirable to recoup the investment in a short time period (5-7 years) to insure that when the technology needs to be updated we have paid for the previous investment. For example the difference between a 5 year and 10 year payback on a relatively small investment of \$25,000 only increases the total cost of milking per cwt \$0.11 /cwt/yr (13%). Moving from a 10 year to a 20 year payback on the same \$25,000 investment decreases the total cost by \$0.06/cwt/yr (7%). For the large investment of a new parlor (\$250,000) using a 20 year payback compared to a 10 year payback will decrease the total cost of milking per cwt by \$0.58/cwt/yr. (22%)

Table 1. Annualized Costs per Hundredweight Milk Sold (\$/cwt/yr)

	Tie Stall Barn	Low Cost Remodeled Parlor	Medium Cost Remodeled Parlor	High Cost Remodeled Parlor	High Cost New Parlor
Capital Investment (Ann. Cost of Capital)	NA	\$25,000 (\$4,250/yr)	\$50,000 (\$8,500/yr)	\$100,000 (\$17,000/yr)	\$250,000 (\$42,500/yr)
	(\$/cwt/yr)	(\$/cwt/yr)	(\$/cwt/yr)	(\$/cwt/yr)	(\$/cwt/yr)
Capital Cost 5 year	NA	\$0.31	\$0.63	\$1.02	\$3.12
Capital Cost 10 year	NA	\$0.20	\$0.39	\$0.79	\$1.97
Capital Cost 20 year	NA	\$0.14	\$0.28	\$0.56	\$1.39
Labor Cost (50 cows/hour)	\$1.62	\$0.80	\$0.80	\$0.80	\$0.80
Labor Cost (60 cows/hour)	\$1.62	\$0.67	\$0.67	\$0.67	\$0.67
Labor Cost (80 cows/hour)	\$1.62	\$0.50	\$0.50	\$0.50	\$0.50
Total Cost 50 cph		\$1.00	\$1.19	\$1.59	\$2.77
60 cph	\$1.62	\$0.87	\$1.06	\$1.46	\$2.64
80 cph		\$0.70	\$0.89	\$1.29	\$2.47
Total Cost (5 year)		\$0.98	\$1.30	\$1.69	\$3.79
10 year	\$1.62	\$0.87	\$1.06	\$1.46	\$2.64
(20 year)		\$0.81	\$0.95	\$1.23	\$2.06

Bold Indicates Original Assumptions

Cow Housing

There are a variety of options available for free stall barns for the dairy herd. Many good references are available to help in the design process and to help determine which option is best for your particular farm. This discussion focuses on several housing options and their costs. A survey of appraisal costs was used to update costs for complete free stall barn projects. This should help to set realistic budgets in the planning process, and business plan. Plan to build the basic structure. Additional features may be added later when money is more available.

Housing Barn Layouts

Table 2 shows four different free stall layout options and a bedded pack housing option. These layouts should be explored when determining what you need for a new building or what could be done in an existing building.

The layouts are intended to show the space utilization for various arrangements. Assuming space costs are approximately the same for all barns, the smaller the space needs to house and/or feed the animal, the lower the cost of the building. The layouts are presented from the lowest space need to the highest space need. The alley widths and stall dimensions are based on MidWest Plan Service (MWPS) recommendations. There are acceptable variations in some of these values depending on personal preference or experience, but for discussion purposes these values will remain constant here. It is also assumed that the building footprint is under roof. This could be post frame, or even a greenhouse frame. Seventy five square feet per Holstein cow and 60 square feet per Jersey cow seem to be common values for well-managed bedded pack systems.

The smallest space need per cow for housing only is a 2 (two) row barn with no feeding under cover. This has been a common method of adding cow housing to a herd if there is an existing place to feed the animals. In some cases this option may have additional costs if the manure and water that lands on an existing unroofed feeding area must be collected or treated in some way. Local manure regulations will continue to impact that decision and cost into the future. Although it poses management challenges in hot and cold weather, feeding outside can be designed into an existing concrete yard with post and rail or headlock feed barriers at a relatively minimal cost to allow the use of portable TMR feeding equipment.

If animals are to be fed under cover, then a 3 (three) row barn with drive-by feeding uses the smallest amount of space per cow. This may be a good option for a dairy that is expanding slowly, and has limited capital to work with. Multiple buildings of smaller size can be built to increase herd size in small steps.

For larger expansions, or where all the housing for cows must be constructed, other options like drive-thru barns may be a more suitable option. Drive-thru barns offer more protection for the feed platform and more protection for animals in the interior free stall rows.

Table 2 also shows the space needs per stall/head for these layouts separated into three areas; walking or alley space, resting space, and feed platform space. Walking space is defined as all walk alleys, cross alleys and curbs, and the roof that covers it. Resting space is defined as the free stall platform, and the roof that covers it. Feeding space is defined as the vehicle drive area and the roof or overhang that protects the feed platform. Total space is the sum of the three spaces. The layouts are presented in order of total space used per stall/head from lowest to highest. This assumes a one cow per stall stocking rate. If a barn were overstocked then the total space per cow could be decreased by the percentage of overstocking.

Table 2 Bedded Pack and Free Stall Layouts and Space Per Stall/Head ^a

Free Stall Layout	Walking Space ^b (Concrete Alleys) (ft ² /stall) (%) ^g	Resting Space ^c (Free Stall Platform) (ft ² /stall/head) (%) ^g	Feeding Space ^d and Bunk Space (ft ² /stall) (%) ^g [in./cow]	Total Space ^e ft ² /stall
2 row no feeding	20 (38%)	32 (62%)	NA ^f	52 (100%)
3 row drive-by feeding	41 (52%)	31 (40%)	6 (8%) [18]	78 (100%)
6 row drive-thru feeding	41 (47%)	31 (36%)	15 (17%) [18]	87 (100%)
Bedded Pack drive-by feeding	32 (28%)	75 (65%)	9 (7%) [27]	116 (100%)
4 row drive-thru feeding	66 (54%)	30 (25%)	25 (21%) [30]	121 (100%)

^a One stall per cow. ^b Walking Space is defined as all walk alleys, cross alleys and curbs, and the roof that covers it. ^c Resting Space is defined as the free stall platform, and the roof that covers it. ^d Feeding Space is defined as the vehicle drive area and the roof or overhang that protects the feed platform. ^e Total space is the sum of three spaces. ^f Not Applicable. ^g Percent of total space.

Cost of Free Stall Barn Construction

Cost information from appraisals of approximately 110 post frame construction free stall projects (3 row, 4 row and 6 row) completed in the last several years was collected and analyzed. The average cost of all the projects was \$13.00 per square foot with a 95% confidence interval of +/- \$1.00 per square foot. The average cost of these projects on a per stall basis was \$1,100 for 3 row barns, \$1,200 for 6 row barns, and \$1,350 for 4 row barns with a 95% confidence interval of +/- \$100 per stall.

The large range (minimum and maximum) of costs shows why it is difficult to give an accurate "ballpark" cost. So many things can affect the final cost. Not all these projects had exactly the same features, which is one reason why the costs can vary. But, in most cases, the costs shown here included excavation, building frame, concrete alleys and feed platform, stall divider(s), gates, doors, sand bedding or mattresses, curtain sidewalls, waterers, insulation, lighting, plumbing, and a small manure reception pit.

Table 3 uses the space values from Table 2 and the low, average, and high cost per square foot from the data above to determine the cost per stall/head of each layout. The lowest cost roofed free stall layout with feeding is a 3 row drive-by feeding barn at a cost of \$1014 per stall. The low cost is one reason this is a popular option. The 3 row barn has 78 square feet of space per cow and bunk space of 18 inches per cow. This would not allow all animals to be at the bunk at one time or allow lockups to be used for the herd since not all the animals could be locked up at the same time. In most cases this compromise can be managed with proper feed management and alternate handling facilities designed somewhere else.

The bedded pack barn actually requires more building shell space per cow compared to the freestall arrangements. Only a 4 row drive through barn requires more space per cow. The difference in space between a 3 row drive by and a bedded pack drive by system is 38 square feet (116-78). At a cost of \$13 per square foot this is a \$494 per head difference. This difference would have to be saved on the additional costs for a free stall layout such as additional concrete for alleys, stall mattresses, stall dividers and other features that would not have to be purchased.

The additional annual cost of bedding for a bedded pack versus a free stall barn would also have to be considered in the decision process. When planning a bedded pack barn, it is good practice to establish the building shell dimensions so the shell can be converted easily to a freestall barn layout in the future with minimal interior changes. For a bedded pack system and depending on cow weight, 15-25 lbs of bedding per day per cow should be added to the pen every day to maintain clean cows. Wood shavings, clean straw, corn fodder and waste grass hay are common bedding choices. Waste hay should be chopped before adding to ease cleaning the pack. Bedding can cost \$0.25-\$0.50 per cow per day for 4 months or more assuming the cows are on pasture during the grazing season. This would be equivalent to \$0.41-0.83/cwt during the bedding season or \$0.20-0.40/cwt over the year. Free stall barns are designed to minimize the annual bedding cost by increasing the capital cost of the system.

Stocking Rate Affect on Housing Costs

When comparing cost per cow of the free stall barn options, the stocking rate should be considered in the comparison. If a barn is overstocked (more cows than stalls), then the associated cost per cow could be reduced by the overstocking percentage rate. For example if a 4 row drive-by barn were overstocked by 20% (120 cows for 100 stalls) then the amount of space per cow would be reduced to $121 \text{ ft}^2 / \text{cow} / 1.2 = 100 \text{ ft}^2 / \text{cow}$. This would also reduce the amount of bunk space to $30 / 1.2 = 25$ inches per cow. The cost per cow would be reduced to $\$1573 / 1.2 = \1310 per cow. (This is $\$180/\text{cow}$ or 16% more than the cost of a 6 row drive-thru feeding barn at 100% stocking rate.)

Table 3. Free Stall Layouts and Cost Per Stall/head^a

Free Stall Layout	Low Cost per stall ^b (\$/Stall)	High Cost per stall ^c (\$/Stall)	Average cost per stall ^d (\$/Stall)
2 row no feeding	624	720	676
3 row drive-by feeding	936	1092	1014
6 row drive-thru feeding	1044	1218	1131
Bedded pack Drive by feeding	NA	NA	1160
4 row drive-thru feeding	1452	1694	1573

^a One stall per cow. ^b Free stall barn cost at $\$12.00/\text{ft}^2$. ^c Free stall barn cost at $\$14.00/\text{ft}^2$. ^d **Free stall barn cost at $\$13.00/\text{ft}^2$. Bedded Pack barn cost at $\$10.00/\text{ft}^2$, $116 \text{ ft}^2/\text{animal}$.**

Does the barn design provide for cow comfort? How much does it cost to provide that comfort? Remember the 3 C's of 4-row versus 6-row barn decision (cost, comfort, convenience) While 3 row barns fit well into the initial transition, they will take additional site space as the farm grows and cattle moving between barns becomes an issue. The trade off between comfort and cost is what every dairy farmer has to decide for their own operation. Can you build a cow comfortable free stall barn at the lowest cost or is cow comfort compromised when features necessary to comfort are cut from the budget. With careful planning, these questions can be answered and the best free stall barn for your farm can be achieved.

Silage Storage Costs

There are many choices for silage storage. One should consider how the current storage system can be used while evolving into a different system. The evolutionary process of modernization needs to use a storage system that is flexible and expandable. It should allow for feed inventory management, labor efficiency, and feed value protection while minimizing capital and annual costs.

This analysis was developed using the *Cost of Forage Storage* spreadsheet available for download from the UW Extension Team Forage-Harvest and Storage web site located at URL:

<http://www.uwex.edu/ces/crops/uwforage/storage.htm>

Three types of commonly used silage storage systems were considered. Three herd sizes were looked at to show the effect of increasing herd size.

An economic analysis is only as good as its assumptions. Some of the assumptions used in this forage analysis are listed as follows.

COMMON VALUES FOR ALL SYSTEMS

Herd Size (cows with replacements)	T Hay DM/yr	T Corn DM/yr
100	741.0	364.4
200	1448.4	721.9
400	2896.8	1443.8

Feed Value: Hay Silage \$85/T DM
Corn Silage \$70/T DM

Tractor	Herd Size (cows)		
	100	200	400
Bagger filling tractor	105 hp	105 hp	150 hp
Pile filling tractor	105 hp	105 hp	150 hp
Bunker filling tractor	105 hp	105 hp	150 hp
Unloading, all storages	72 hp	72 hp	72 hp

Engine capacity (hp)	Tractor Initial Cost (\$)
72	55,000
105	65,000
150	112,700

Filling and Unloading Bucket Initial Cost: \$10,000

Herd Size (cows with replacements)	Bagger Initial Cost (\$)
100	30,700
200	30,700
400	118,480

Item	Ownership Cost (% of initial cost)
Bagger	16.7
Tractor	15.7
Structures	12.0
Bucket loader	23.8

Item	Dry Matter Losses (%)					
	Filling	Seepage	Gaseous	Spoilage	Unloading	Total
Bagger	1	0	7	2	3	13
Pile	2.5	0	8	10	3	23.5
Bunker	2	0	8	5	3	18

Labor Cost: \$10/person/hr

Fuel Cost: \$1.00/gal

Forage Storage Used	Herd Size (cows with replacements)											
	100			200			400					
Bag silos												
Number	11			13			8			39		
Diameter (ft)	10			10			10			10		
Length (ft)	250			250			200			250		
Piles												
Number	2	2	2	2	2	2	3	2	3			
Top width (ft)	0	1	0	17	0	9	19	24	18			
Bottom width (ft)	60	49	54	77	60	69	85	84	78			
Length (ft)	107	106	107	135	135	135	150	150	145			
Height (ft)	10	8	9	10	10	10	11	10	10			
Bunker silos												
Number	4			2			3			3		
Average width (ft)	24			20			32			30		
Length (ft)	136			112			135			135		
Wall height (ft)	10			10			10			10		

Bag Silos – Common Characteristics

Dry matter density: 13 lbs DM/ft ³	Plastic bag cost: \$505/250 ft \$410/200 ft
Distance between bags: 9 ft	Asphalt storage pad with base: \$1.54/ft ²

Silage Piles – Common Characteristics

Dry matter density: 14 lbs DM/ft ³	Pile side slope – 3 horizontal:1 vertical
Distance between piles: 6 ft	Asphalt storage pad with base: \$1.54/ft ²
Plastic cost: \$0.037/ft ²	

Bunker Silos – Common Characteristics

Dry matter density: 14 lbs DM/ft ³	Excavation/fill cost: \$0.40/ft ²
Walls: T-panels loaded two sides	Wall cost: \$75/ft
Plastic cost: \$0.037/ft ²	Asphalt floor with base: \$1.32/ft ²

Results

In Figure 1, it is apparent that initial capital costs increase with herd size (quantity of feed stored). The hay portion is larger than the corn silage portion because there is about 2/3 hay and 1/3 corn silage stored. The initial capital investment is generally lowest for silage piles and highest for silo bags. The unusually high initial capital investment for silo bags on the 400-cow herd is due to the selection of a bagging machine capable of receiving forage into a tray from dump trucks and capable of using a 150-hp tractor at an initial cost of about four times that of the bagging machine used for the 100- and 200-cow herds.

Figure 2 shows the results of converting capital investments to annual costs as well as accounting for other expenses such as plastic, fuel, labor, and dry matter loss. Here the bunker silos tend to have the lowest annual cost while the lowest investment system (silage piles) tends to be a higher annual cost system. The main reason for this reversal is the assumption that dry matter loss is highest for the silage pile (due to larger top surface area). The significance of this dry matter loss is seen in Figure 3. The higher annual cost attributed to hay versus corn silage is due to the larger quantity of hay stored and the high value (\$85/T versus \$70/T) assigned to the hay.

Various cost components are presented in Figure 3 which shows how important dry matter loss is to the total annual cost. The analysis presumes good management with these systems. If less than good management were used, the dry matter loss could have been higher and the total annual cost of the other components could be dwarfed by this one cost component.

Structure cost is probably the next largest cost component. This points out the need to size the storages well (not oversize) and to shop around for a low initial cost. Labor is a somewhat large component in all systems. Plastic is a large

component in the silo bag storage. The large investment in the bagging machine for the 400-cow herd size shows up as a large annual cost for that one system. Had the lower initial cost bagging machine been used for this herd size, bigger annual cost would have been much smaller, thus reducing the total annual cost to a value less than that of silage piles.

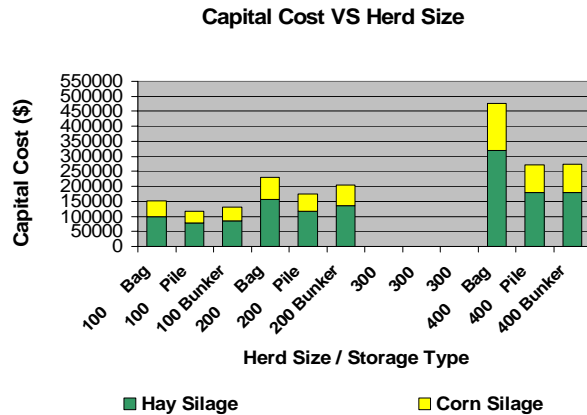


Figure 1. Initial capital cost versus herd size and storage type for three herd sizes

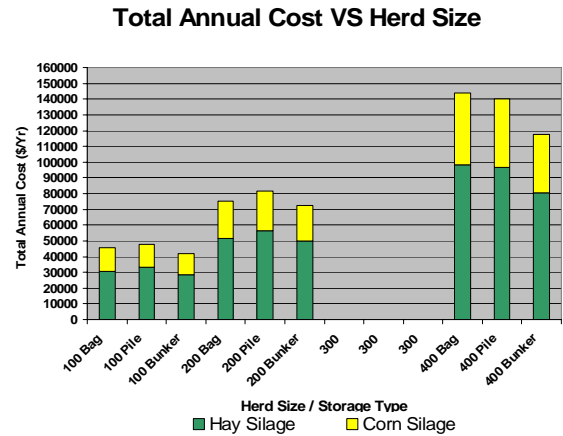


Figure 2. Total annual cost versus herd size and storage type for three herd sizes.

Conclusions

Of the three storage types studied and the assumptions used, bunker silos have an intermediate initial cost but a lowest annual cost and the lowest annual cost per ton of dry matter. This suggests that a bunker silo should be given careful consideration as a storage system. If one is limited on capital to invest and/or needs a system that is flexible, consider the silage pile system. This system could be adapted to the addition of walls in the future as it is converted to bunker silos. If a bagging machine could be rented out to neighbors, one might justify the higher initial investment to help reduce the annual costs by producing income. The bag pad could also be converted to bunker silos in the future. However, a 200-250 ft long storage pad will not make for a good bunker silo length. Consider a pad one half to two-thirds as long.

Figure 4 shows a decreasing cost per ton of dry matter stored as herd size increases. This reflects the economies of scale with increasing quantity of feed stored. Values range between \$25-45/T DM. The bunker silo tends to be the lowest cost per ton system with silage piles being the highest except in the case of the 400-cow herd size. The cost for corn silage is lower than that of hay silage, probably due to the lower value assigned to corn and thus the lower cost of feed loss for the same percentage of dry matter loss.

Annual Cost VS Herd Size Hay & Corn

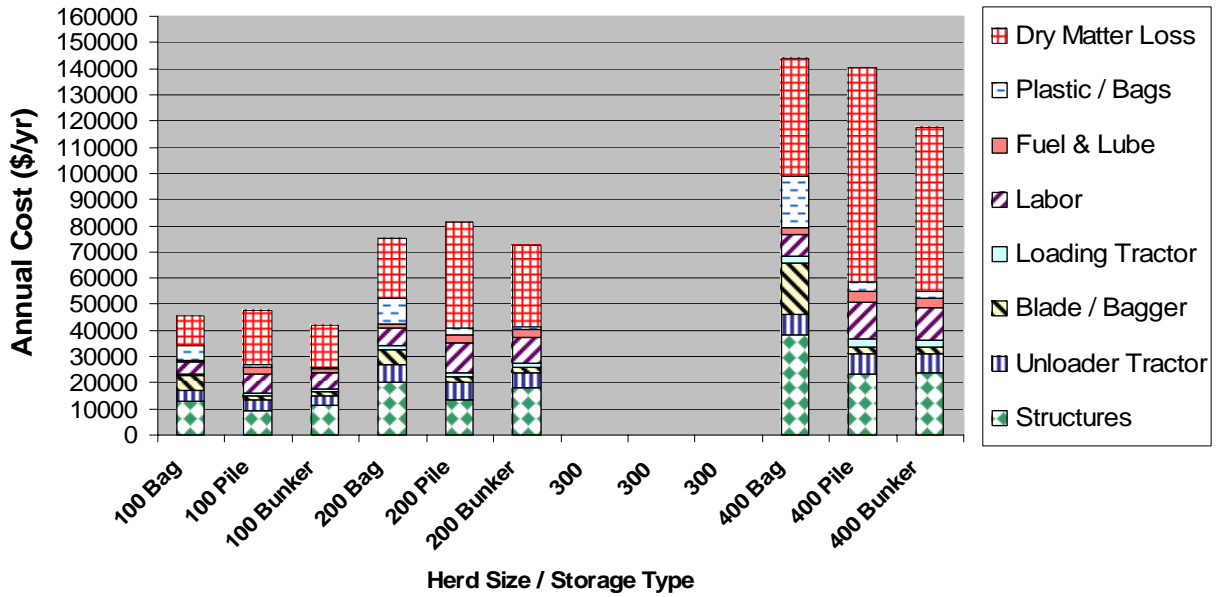


Figure 3. Annual cost of all forage versus herd size and storage type distributed by various cost components.

Annual Cost / T DM Stored VS Herd Size

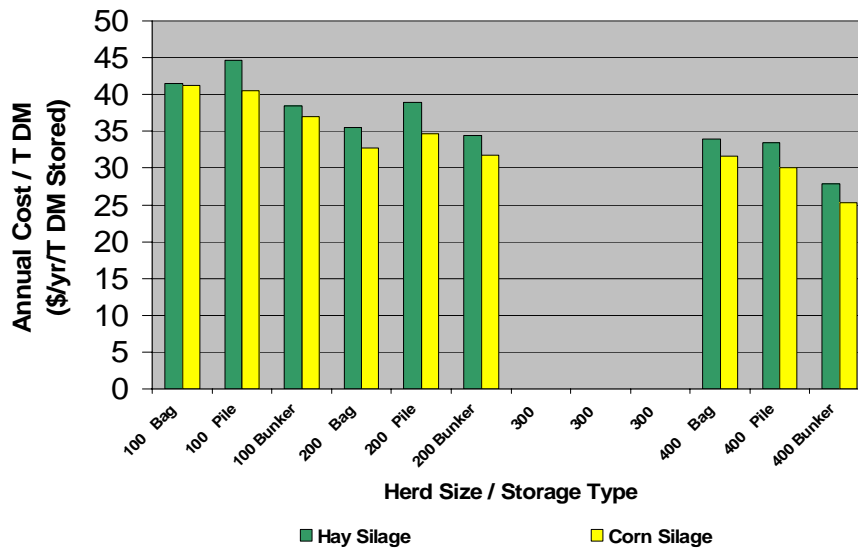


Figure 4. Annual cost per ton of dry matter for hay and corn silage for three herd sizes and storage types.

Manure Storage

A manure storage adds capital investment to the business but offers very little return on that investment. Economic benefits can include: value of conserved nutrients (if credited), improved timing of manure application to cropped fields, use of custom manure hauler, and reduced likelihood of water pollution. However, most producers of smaller herd size will find it difficult to pay the relatively high cost of a manure storage by direct economic benefit of owning a manure storage. Consequently, producers who are in an expansion mode should give very careful consideration to the decision of when to invest in manure storage and how much to invest.

Farm Credit Services has collected cost of construction data for projects built by their clients. This data has been analyzed by David Kammel. The costs of manure storages based on values up to the year 2002 were used as a basis for the following analysis. Kammel summarized the cost of manure storage with the following equations.

<u>Storage Type</u>	<u>Initial Cost Equation</u>
Earthen Basin	Cost = [Volume (gal) × \$0.008/gal] + \$26,676
Concrete Tank	Cost = [Volume (gal) × \$0.04/gal] + \$36,185
Concrete Tank & Slatted Floor	Cost = Volume (gal) × \$0.16/gal

In the following analysis, the material stored was assumed as:

Cow	2.5 ft ³ manure/cow/day	18.70 gal/cow/day
Replacement	1.0 ft ³ manure/cow/day	7.48 gal/cow/day
Other	2.2 ft ³ material/cow/day	16.46 gal/cow/day
TOTAL	5.7 ft³ manure/cow/day	42.60 gal/cow/day

The "Other" category tries to account for bedding, milking center washwater, sprinkling water, waterer drain-down, rainfall, etc. The total value was used to establish the volume to be stored for the various herd sizes and storage periods shown in Table 4.

TABLE 4. Storage Volume Required for Various Herd Sizes and Storage Periods*

Herd Size (cows)	Storage Period (days)					
	30	60	90	180	270	365
Storage Volume (millions of gallons)						
100	0.13	0.26	0.38	0.77	1.15	1.55
200	0.26	0.51	0.77	1.53	2.30	3.11
400	0.51	1.00	1.53	3.07	4.60	6.22

*Assumes 5.7 ft³/cow and replacement/day.

Tables 5-7 were developed using the equations for initial investment and the volumes to be stored as given in Table 4. In Table 7, only one storage period with initial cost was established as the storage size is limited to the size of the barn, and a depth of 10 ft of storage was assumed. For any given volume, one can observe that a concrete tank is appreciably more expensive than an earthen basin. There may be good reasons (site limitations, type of bedding used, etc.) for investing in a concrete tank over an earthen basin, but this decision should be made after careful consideration of the need for a tank. This is more readily apparent for the larger volumes stored than for the smaller volumes.

TABLE 5. Cost of Earthen Basin Manure Storage

Herd Size (cows)	Storage Period (days)					
	30	60	90	180	270	365
	Initial Capital Cost (\$)					
100	27,700	28,700	29,700	32,800	35,900	39,115
200	28,700	30,800	32,800	38,900	45,000	51,600
400	30,800	34,900	38,900	51,200	63,500	76,400

TABLE 6. Cost of Concrete Tank Manure Storage

Herd Size (cows)	Storage Period (days)					
	30	60	90	180	270	365
	Initial Capital Cost (\$)					
100	41,300	46,400	51,500	66,900	82,200	98,381
200	46,400	56,600	66,900	97,500	128,200	160,600
400	56,600	77,000	97,500	158,900	220,200	285,000

TABLE 7. Cost of Slatted Floor and Concrete Tank Manure Storage*

Herd Size (cows)	Storage Period (days)					
	30	60	90	180	270	365
	Initial Capital Cost (\$)					
100						122,700
200						245,400
400						490,800

*Difficult to compare directly to outside storage as the slatted floor and its support structure are included in the cost.

From a planning perspective, it is important to try to keep initial cost low, especially for smaller operations. This concept tends to make people try to limit the storage period to a low value with plans to empty more frequently. This has

good merit except in the case where there are plans for expansion. For example, someone building for a 100-cow herd and 30 days' storage will have only 15 days' storage when expanding to 200 cows and only 7.5 days' storage when reaching 400 cows if the storage stays a constant size. The case where a producer had selected a 180-day storage period for 100 cows would require an additional \$5,100 or \$25,600 for an earthen basin or a concrete tank, respectively. When the same size storage is used after expansion to 400 cows, the storage period becomes 45 days, a much more manageable period than 7.5 days. Thus, selecting a short storage period at a smaller herd size may be a false economy in an expansion mode.