Design and Maintenance of a Bedded Pen (Pack) Housing System

David W. Kammel
Biological Systems Engineering
UW Madison
460 Henry mall
Madison WI 53706
608 262-9776
dwkammel@wisc.edu

Introduction

In an effort to find a lower costs housing system, discussion has returned to the bedded pen (pack) loose housing system for lactating cows. Synonymous terms describing the bedded pen system include bedded pack and the European term “straw yards”. Research out of Europe has focused on straw yard system design as compared to “cubicle” freestall housing. Other research has tried to develop management guidelines to improve cow comfort and welfare while striving to minimize the problems typically associated with the system of dirty cows and higher incidence of mastitis. Lessons learned over the years on the farm have demonstrated what works and what management decisions need to be implemented.

Bedded pack is the common term in the US implying that the manure and bedding accumulates for a period of time providing temporary storage of the manure bedding mix. The manure and bedding create a pack that generates heat as the material composts. The manure pack is removed periodically.

Costs associated with a bedded pen system include the capital costs for the initial construction of the building and the annual costs for maintaining a clean dry comfortable resting surface. Capital costs include the building shell, concrete, and equipment. Annual cost includes the daily management, labor and bedding costs used in the housing system.

It seems there is always a trade-off involved. In general the lowest capital cost systems will have the highest annual costs. Capital is often spent to decrease annual cost. In an economical analysis, the partial budget should reflect how the increased capital costs can provide annual savings to pay for the improvements over the life of the system. The payback may be in terms of decreased labor costs and enhanced management ability.

Perceived Advantages of the Bedded Pen System

There are several perceived advantages of the bedded pen system. European work has suggested that from an animal welfare perspective, a cow lying in an unrestricted space is preferable to lying in a freestall. Assuming the space is clean dry and comfortable this is certainly true, but this requires some control on the amount of space and the type of space the cow has access to. While some research has shown that lying time is higher on a straw yard as compared to a freestall cubicle, other studies have found no significant

difference in lying times between systems. Certain types of lameness is lower in straw yards as compared to freestall housing while other studies have shown little difference or just different types of lameness associated with both types of housing systems. Injuries are lower as compared to freestall housing which may be attributed to the fact there is nothing restricting an animal in the bedded pen system such as a stall divider, neck rail or brisket board. Cow comfort and longevity (likely related to lameness) are two advantages that have been noted by farms that are using the system.

Perceived Disadvantages of the Bedded Pen System

There are also perceived disadvantages of the bedded pen system. The amount of bedding used and thereby the cost of bedding is higher in a bedded pen system as compared to freestall housing. Research documents there is approximately 3-4 times more bedding used in a bedded pen system as compared to a freestall system. Experiential data from operating farms also confirm that the amount and cost of bedding is significantly higher in a bedded pen system. There is no doubt that the bedded pen system is a bedding intensive system. All this discussion assumes that cows are kept equally clean in either system.

While it has been observed in some research that cows are visibly dirtier in a bedded pen system as compared to freestall housing, it was also shown that this did not necessarily translate to higher somatic cell counts or higher incidence of mastitis. There are studies that show a higher incidence of environmental mastitis as compared to freestall housing and other studies that show no significant difference between the housing systems.

There is likely a higher risk of exposure to environmental mastitic organisms in a bedded pen system just by the nature of how the space is used by a cow. Cows are indiscriminate defecators which expose them to possibly laying in the same spot they or their herd mates defecated on. In a freestall housing system the freestall bed is designed to isolate the space the cow lies on from the space she defecates on. Manure is deposited in the manure alley. Some research has shown no significant difference in milk yield in straw yards as compared to freestall housing.

Daily labor needs are difficult to differentiate and document with either system. Some research showed that bedded pens do have higher labor costs compared to freestall systems. Experiential data suggests that it may be similar depending on what boundary is placed on the definition of labor. For example daily labor for bedding may be higher with the assumption that a larger mass of bedding must be moved per cow as compared to a freestall bed. Labor for scraping manure from alleys may be similar but there are more alleys in a freestall barn as compared to a bedded pen system. Hauling manure may be a daily chore in a freestall barn with no manure storage, where there would be no manure hauling from a bedded pen system until the bedding and manure mix is removed. It seems to be a question that can only really be answered on an individual farm comparing both systems and determining which labor system is more intensive. There are farmers on both sides of the debate that will argue their case for or against a bedded pen system as compared to a freestall system in terms of capital and annual costs.

The perceived and recognized disadvantages of the bedded pen system can be managed to maintain clean, comfortable cows with high milk yield and low somatic cell counts and low incidence of mastitis. The question for an individual farm is “Are they willing to provide the necessary inputs and management to create that proper environment for the cow?” and “Does the cost of doing so make a profit?” Research and experience both show that provided both systems are well managed there was no difference in cow comfort, welfare, health, or performance in a comparison of freestall system to a bedded pen system.

Dairy Herd Growth Strategy

For small herds a bedded system may be a way to incrementally grow and provide flexibility in housing various groups of cows in varying stages of lactation but consolidate how manure is handled and cows are fed.

Bedded pen systems can provide a flexible growth strategy. The initial system design is simple. As the farm grows cows can be added to the system without additional capital costs. This will effectively reduce the space per cow which requires an increase in bedding and management costs. As the herd increases in size the management and bedding costs will increase with increased intensity of bedding management. The limit of herd growth will be reached as the space per cow decreases to the minimum recommendations and/or the costs associated with the increased bedding and management show that the total cost of the system is too high. In the worst case scenario the system fails due inadequate management and bedding resources being used or a mastitis flair up occurs.

Bedded Pen (Pack) Housing Design

Loose housing allows the cow free access between the resting, feeding, and water spaces. There is some advantage to separate these spaces one from another to control manure deposition in specific areas to help maintain cleaner cows. Where there is feed and water there is more manure accumulation compared to the resting space. Where there is water there is also the possibility of mud. So it is beneficial to at least have improved surfaces around the feed and water areas. The bedded area does not require concrete since it provides the soft comfortable resting surface, although it does make cleaning out the accumulated manure pack a little easier. Consider the site carefully since ground water could be contaminated as seepage moves down into the soil under the manure pack. The space should be arrange so as to provide the required feed bunk length needed for the type of animal and feeding system that will be used. For example a dairy cow fed a TMR with feed accessible at all times may only require 18” of bunk space.

The eave height of the building should provide the necessary clearance for the size of equipment that will be used to clean out the pack with the assumed manure pack depth accounted for in the design calculation. In some cases the pack may be 3-4’ higher than the ground level of the building. Assuming a tractor and cab are used to clean out the

pack and requires an 11’ clearance the minimum eave height for the building would have to be at least approximately 15’ high. This may affect the capital cost of the building. The sidewall should also provide good ventilation to help dry the surface of the pack and allow the moisture and heat from the heating pack to escape without causing condensation in the barn.

The geometry of the bedded space should be rectangular with the alley along the longest side of the rectangular area. Space will not be used very efficiently if cows access the bedded space from the short side of the bedded space. There will tend to be a dirtier transition area between the bedded space and the alley if the width of the area is limited.

The bedded area should be rectangular with a maximum depth or width of 36 feet from the feeding alley to the back of the bedded area. (Figure 1) Cows tend to lie around the perimeter of the bedded space. The bedded surface can also be sloped down hill from the rear to the front of the space which will tend to make the cows all lie in the same orientation. Additional space for feeding and water access must also be included in the overall system design. The bedded surface should not have a slope down hill into a vertical wall as this could build up to a point where a cow could be trapped between the slope of the pack and the vertical wall.

The width of the barn should also be designed so as to allow for the potential change to a 2 or 3 row freestall barn with alleys to be developed under the space. This will provide an additional option for future potential growth to allow decreased space per cow in a freestall system should it be decided that a change is warranted. Table 1 shows building widths required for several freestall layouts that can be adapted to bedded pen design.

A bedded pen (pack) barn is a relatively simple design that can be adapted to many existing buildings. As long as the basic design principles are followed it can function properly. If those design guidelines are not followed it will likely cost more than anticipated to keep the cows clean. As with most designs, proper management of the system will make it work or poor management will result in utter failure.

Remodeling Buildings for Cow Housing

One advantage of the bedded system is that it may be less costly to renovate an existing building as a bedded pen as compared to s freestall system. To reduce the capital costs for cow housing, some post frame buildings such as machine sheds or loafing sheds can be remodeled into bedded pack or freestall pen arrangements. The typical width of a bedded resting area can range from 18’-36’. Additional space will be needed for alleys and feeding. Table 1 shows the minimum and recommended building width needed to accommodate different freestall barn row arrangements but also allow the space to be operated as a bedded pack system.

Bedded Resting Space Needs

A lying Holstein cow occupies approximately 25 square feet and needs almost twice that amount of space for lying down or rising. The space should be adequate to provide enough space for the cow to rest and move among other cows without causing injuries to other lying cows. Decreased space will increase the total height of the accumulated manure and bedding pack over time, which can possibly restrict access to the pack as manure and bedding accumulates.

Building Width	Freestall Barn Number of Rows and Feeding Location							
	1 row	2 row No inside feeding	2 row drive by outside feeding	2 row drive by inside feeding	3 row drive by outside feeding	3 row drive by inside feeding	4 row drive thru feeding	6 row drive thru feeding
Minimum Width, ft.	19	24	35	49	43	57	88	104
Recommended Width, ft.	22	25	38	52	48	62	94	114

Table 1. Building Widths needed for Remodeling Freestall Barns

The amount of bedded space per cow varies depending on animal size, stage of lactation, and nutritional status. To manage cow cleanliness, either the group size can be adjusted or the quantity of bedding used per day can be adjusted. As the bedded area per cow decreases the amount of bedding required to keep the cows clean increases. It is not known what the direct relationship is on a per unit area basis.

While early design recommendations ranged from 50-100 square feet and some suggested that 75 square feet was adequate, other farm experience have started with 100 square feet per cow as a minimum. This may be related to the observation that cows become visibly dirtier as the space per cow decreases.

75 square feet for a milking Holstein cow and 60 square feet for a milking Jersey cow seem to be common values for well-managed systems. 50 square feet per cow is minimal and is a common recommendation for a dry cow for example. 100 square feet per cow may be difficult to justify due to increased capital costs, but some would argue it helps minimize bedding usage and increases cow comfort and cleanliness.

Bedded Pen (Pack) Barn with Inside Feeding

Figure 1 shows a bedded pen barn arrangement in a building width that can eventually be remodeled into a freestall barn with the addition of concrete alleys, freestall platforms, dividers, and waterers. In either the bedded pen or freestall pen layouts, a concrete alley

is placed between the feed platform and the resting area. The waterer for the bedded pack arrangement is placed adjacent to the bedded resting space and should have a barrier to prevent cows from accessing the waterer from the bedded pack area to reduce wet bedding and excessive manure accumulation in the bedding around the watering site. Cows should only access the waterer from the alley adjacent to the feed bunk.

In either layout the manure alleys are usually scraped daily at each milking. The bedded space could have a macadam base to save costs and is sized for the number of cows which also matches the feeding space needed for the group. The options for roofing over the area include roofing over the bedded pack (33 feet wide) only, roofing over the bedded area and the cow alleys (47 feet wide), or roofing over the entire resting and feeding area (61 feet wide). Although the total roofed space per cow is increased with these options, the ability to manage feeding is improved. Roofing at a minimum the cow resting and walking areas can also eliminate the need to handle the contaminated rainfall runoff events from unroofed animal confinement areas.

Initial capital cost savings may be a benefit of the bedded pack barn but is hard to compare to a freestall system. For example the total building space will be higher for a bedded pen system as compared to freestall barn building space. The additional costs for alleys, freestall divider and mattress if used may still be lower than the space required for the bedded pens system.

As can be seen in Figure 1 the freestall arrangement uses less space per cow compared to a bedded pack system. That does not necessarily mean the cost is lower for a freestall barn, but the cost comparison between bedded pack and freestall arrangements for the same building space should be looked at carefully to make a fair comparison for the total system cost. In this case there is approximately a 44 s.f. per cow difference in space needs between the freestall barn and the bedded pen barn giving the advantage to the freestall barn for building costs per cow. On the other side the additional cost of concrete for alleys, stall dividers, possibly mattresses, and additional water and gates would have to be added to the freestall system to reflect a complete cost for the freestall system.

Bedding Management

One of the major costs of the bedded pen system is the cost of bedding with an appropriate material of the proper quantity and the required frequency. The cost of the system is directly correlated to the cost of bedding and the labor required to apply the bedding to the pen.

Equipment for easing the bedding chores includes skid loader or other equipment for moving the bedding. Bedding throwers on the bucket of a skid loader, or spreaders/wagons are used to deliver large quantities of bedding relatively quickly.

There is management flexibility inherent in the bedded pen system. To manage cow cleanliness producers can adjust group size or the quantity of bedding added per day.

Since in most cases the number of cows is fixed or growing the only management opportunity to maintain cow cleanliness is to adjust the bedding amount and frequency.

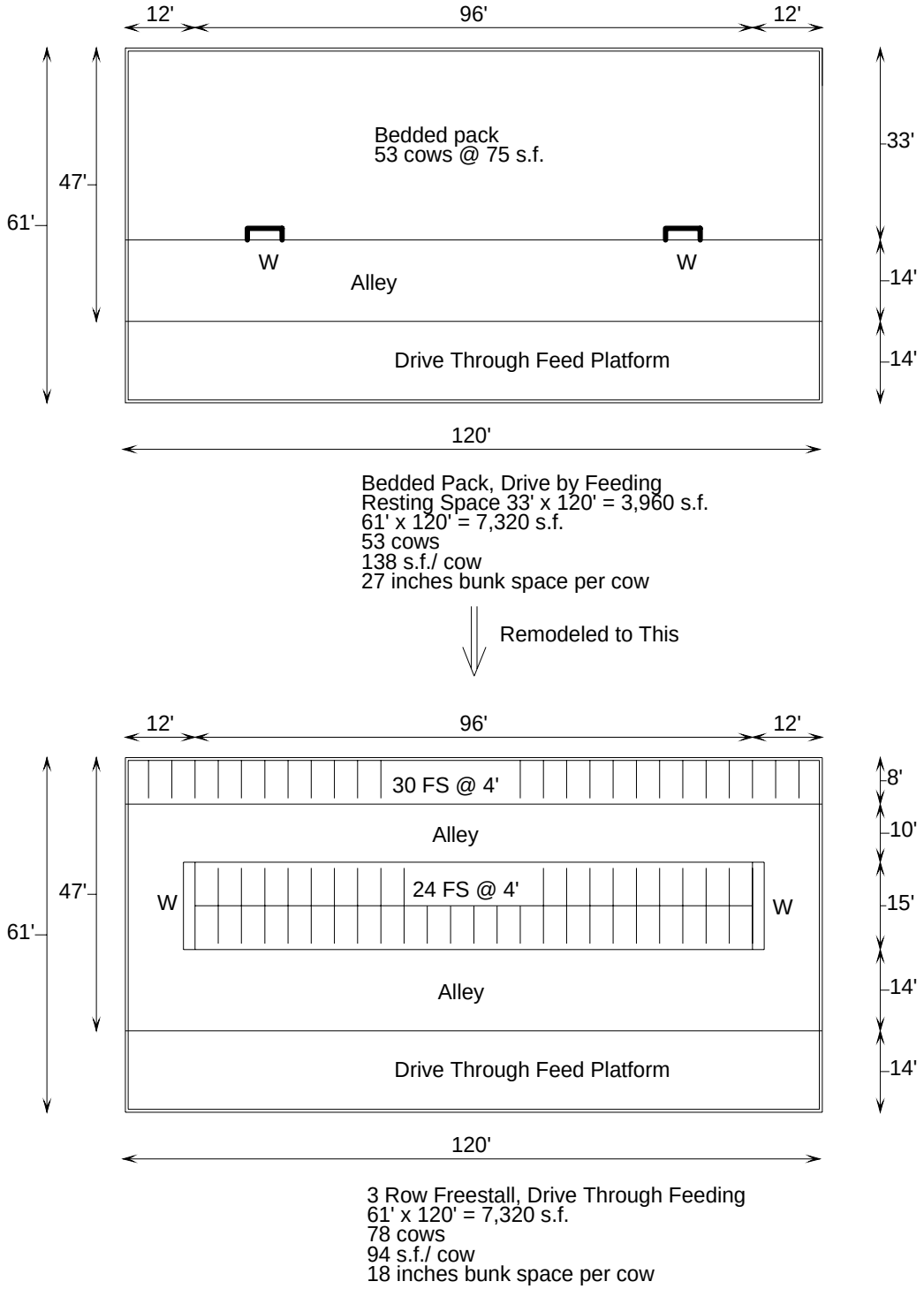

Figure 1. Bedded Pack or Freestall Pen Layouts with Feeding

Bedding Types

Research has shown that pine, cedar, and other softwoods support minimal bacterial growth. Oat, barley, corn stalks (fodder), straw, waste hay and hardwood sawdust support bacterial growth more readily. Straws and hay should be chopped to 3-4 inches maximum particle size to allow easier removal of the manure and bedding mixture. Particle size is also important in that small particles have increase surface area which can enhance bacterial growth. Small particles can also be irritants on the teat end. Large particles have less surface area but also are potentially less absorbent.

Finding a consistent source of high quality bedding is one of the challenges in the system management. Bedding should be dry (< 15% m.c.) to help maintain low bacterial counts. Wet bedding just enhances the environment for bacterial growth. The addition of urine, moisture and manure from the animal enhance the risk of high bacterial counts and the risk to the cow of being exposed to environmental mastitis organisms. This in turn increases the risk of high somatic cell counts and mastitis incidence. Due to the nature of the housing system, it is impossible to have zero exposure to mastitis causing organisms. The main defense strategy to minimize the risk is management of the system to decrease or minimize the exposure as much as possible within the constraints of the system.

Bedding Amounts and Frequency

There is little documentation available on the actual bedding amounts used on a daily basis. The best information would be considered ball park numbers. Depending on cow weight 10-35 lbs of bedding per day per cow is used in bedded pen system. The wide variation in recommended bedding amounts will depend on several factors. As one would expect a Jersey cow will need less bedding than a Holstein. The stage of lactation also will influence the amount needed to maintain cow cleanliness. Lactating cows will produce a larger quantity and possibly more liquid manure and require larger amounts of bedding as compared to a dry cow producing a lower quantity and drier manure.

Some of the variation can be attributed to the fact that experiential farm data is inaccurate. The management decision on how much bedding is needed is usually based on the observation of dirty cows and udders. This is subjective and translates into large variances.

Another confounding error that might explain the variation is the unit of measure used to quantify the amount of bedding used. Bedding amounts are usually measured in terms of buckets, loads, bales, or spreaders with little documentation of how much is really being applied on a daily basis. Another confounding error is the type of bedding used and the moisture content. The amount of wet hay needed compared to dry sawdust will be different. That being said for someone trying to pencil out the cost it would probably be wise to assume the average value or above. The bedding amounts used on a daily basis will be adjusted based on personal experience and other management criteria.

A simple and relatively accurate way to document bedding usage on a specific farm is to use inventory management. Document when a load of bedding comes in, and how many animals are being bedded and changes in cattle numbers over time. Document when the load is gone in number of days and then back calculate the daily amount from those values.

In most systems the management scheme is that bedding be added daily. Bedding management from European research suggests that 1/3 of the bedding be distributed in the AM and 2/3 in the PM.

Bedding Costs

A recent personal survey in Wisconsin showed a range of costs from $.01-.05/ pound for dry sawdust and a range of costs from $.03-.05/ pound for straw. Since there are several variables (amount and cost per pound of bedding) with a range of values Table 2 was developed to calculate the daily, monthly, and annual bedding costs per cow. Only the material cost is shown.

For example assuming 25 pounds of sawdust is used per cow per day and the sawdust cost was $.02/per pound the cost would be $.50/day. $15/month, or $180 per year. The equipment costs and labor to bed the pen is not included in this cost.

In a grazing operation the bedded pack is commonly used during the winter housing period between December through the end of March or approximately 4 months In this situation, with the costs above the cost of the bedding would be approximately $60 per cow for that period.

Manure Management

The manure alley adjacent to the bedded area should be scraped at least twice a day to reduce the amount of manure tracked onto the bedded area. Cows should be allowed to access the pack from the adjacent alley along the entire length of the alley.

The bedded pen system does provide for a short term integral manure collection and storage system within the building shell. Since the bedding and manure that accumulates in the resting space is only removed periodically this system does provide for manure storage and the possible composting of the mixture as compared to handling slurry manure from scrape alleys. But there also is slurry manure from a scrape alley in a bedded pen system which must be managed as well. In a bedded pen system there are actually two different manure streams that must be managed as compared to a freestall system.

Bedding used /cow-day Pounds/cow day	Bedding Cost per pound						
	$.01	$.02	$.03	$.04	$.05	$.06	$.07
10	$.10/day $3/month $36/year	$.20/day $6/month $72/year	$.30/day $9/month $108/year	$.40/day $12/month $144/year	$.50/day $15/month $180/year	$.60/day $18/month $216/year	$.70/day $21/month $252/year
15	$.15/day $4.50/month $54/year	$.30/day $9/month $108/year	$.45/day $13.50/month $162/year	$.60/day $18/month $216/year	$.75/day $22.50/month $270/year	$.90/day $27/month $324/year	$1.05/day $31.50/month $378/year
20	$.20/day $6/month $72/year	$.40/day $12/month $144/year	$.60/day $18/month $216/year	$.80/day $24/month $288/year	$1.00/day $30/month $360/year	$1.20/day $36/month $432/year	$1.40/day $42/month $504/year
25	$.25/day $7.50/month $90/year	$.50/day $15/month $180/year	$.75/day $22.50/month $270/year	$1.00/day $30/month $360/year	$1.25/day $37.50/month $450/year	$1.50/day $45/month $540/year	$1.75/day $52.50/month $630/year
30	$.30/day $9/month $108/year	$.60/day $18/month $216/year	$.90/day $27/month $324/year	$1.20/day $36/month $432/year	$1.50/day $45/month $540/year	$1.80/day $54/month $648/year	$2.10/day $63/month $756/year
35	$.35/day $10.50/month $126/year	$.70/day $21/month $252/year	$1.05/day $31.50/month $378/year	$1.40/day $42/month $504/year	$1.75/day $52.50/month $630/year	$2.10/day $63/month $756/year	$2.45/day $73.50/month $882/year

Table 2. Bedding use and costs on a daily, monthly and annual basis.

For small herds (30-40 cows), policing the bedded area daily by removing manure patties can help maintain cleaner cows and minimize the amount of bedding required to maintain clean cows. Some experiential data suggests the amount of bedding needed to keep cows clean can be reduced by 50% by policing the area. Removal of accumulated manure from adjacent alleys near feed and water areas during each milking and at a minimum daily can also help maintain cleaner cows. It is helpful to have an area designed to collect the scraped manure temporarily for easy handling.

The bedded pack acts as a manure storage system. It is common to clean out the pack at the end of the winter housing season or 2-4 month intervals if used continuously. The manure and bedding mixture (pack) is removed periodically and either applied

immediately to the land or sometimes stockpiled to continue a heating and composting period before spreading on the land.

Stirring the pack is a possible management practice that can enhance the ability to keep the animals clean and possibly reduce the surface bacterial load in contact with the cow's udder. In some recent management adaptations on farms in Virginia, Pennsylvania and Minnesota sawdust bedding is used in what is called a compost barn. The bedded pen is groomed with a spring tooth harrow or other type of tillage tool to mix the manure and bedding at the surface and effectively turn the top 6-8 inches of bedding and manure to introduce oxygen to enhance the composting process and possibly reduce the bacteria load at the surface of the pack.

Cow Management

The goal is to keep the pack as clean and dry as possible. The standard for cow comfort and cow cleanliness for dry cows and calving cows should be as high as for milking cows. Mastitis control for springing heifers, dry cows and lactating cows is a necessary part of the management protocols. Since there is exposure to mastitic organisms, lowering the risk of exposure is the main goal. Encourage cows to eat after milking and not lay down immediately after milking to allow teat orifices to close. Using a barrier teat dip is also suggested as part of the management protocol to control mastitis.

Summary

Achieving a low cost housing system for cows is not as simple a decision as it might seem. All the costs, including the capital and annual costs must be considered in the decision. Bedded pen systems have advantages and disadvantages and these should be considered in the decision process for an individual farm.

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