Systems Approach to Farmstead Planning, Site Selection and Facility Design

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Whether or not you have expansion intentions, your dairy farmstead should have a plan that is flexible and can accommodate your vision of the future, as well as the next generation's vision, and perhaps the vision of future buyer of your property as well. Your short term plans may be for a new machine shed but a long range plan that accounts for the possibility of accommodating two to three times the present herd size should influence where that shed is placed today. If short term decisions are made in a way that fits such development, the resulting farm assets will be more valuable to you, to your son or daughter, and to any future owner as well. A dairy operation, which plans to stay in dairying should have a multiphase plan in place to permit orderly expansion. This plan should include three elements.

- a short-term plan for what to rebuild if a fire or similar disaster destroyed the farmstead, or specific components of it. Since this is an unlikely event this is not something to spend a lot of time on but worth contemplating as a mental exercise. Should it happen, be sure to think through a detailed plan then, and avoid the very common temptation to rebuild what you had.
- a mid-term plan for gradual improvements or expansion over the next 3-10 years. This plan should incorporate existing facilities.
- long-term plan for what the farmstead may evolve to in 15-20 years. Since technology, and the economic climate are changing constantly the herd size and management system needed in 2030 is not easy to predict. Presently dairy herds are increasing in cow numbers at about 3% per year. Milk marketing policies have slowed this growth in recent years and the current trend is to improving efficiency without growth. This process tends to focus on incorporating newer precision technologies such as robotic milking, robotic calf feeding, and adoption of more cow comfort focussed housing principles aimed at increasing productivity, decreasing disease and generally increasing profitability through use of larger stalls, and more manger space. It is difficult to know when real growth in herd size will be possible again but it is inevitable that this time will return. Hence your long term plan needs to allow for expansion. While there are no clear "cut lines" for herd size there are appear to be some breaks at around 700 cows, which is roughly the maximum a one man parlour can handle for 3x milking, and a second cut around 3000 cows which works well with a 3 man external rotary.
- a plan for major renovations or new barn construction should be initiated at least 1 1/2 to 2 years before construction begins. Erasing and redrawing "paper" walls is a very valuable

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process and much cheaper than living with concrete walls that are in the wrong place. Good paper planning will reduce the risk of costly mistakes .

A detailed paper plan provides a reference point for further development. It can be used in discussions with advisors, comparison shopping on tours and open houses, operational planning of current farm activities, and implementation of initial stages of the project such as site preparation. once you have a plan on paper, consult with a wide range of people, since each can bring different experience to the issues. Having a good plan on paper for at least a year also allows you to do "operational planning". It is the details of how people, cows and materials move through a barn that make it work. While you work in the existing facilities, you can think through how the same tasks will be performed in the new barn.
If a plan has to be implemented in phases make sure they link together logically.

The Planning Process

While the planning process should increase in intensity several months before any new construction occurs, it should be ongoing, adjusting to new technology and management needs at all times. This will allow you to look at as many alternatives as possible. In planning a new freestall expansion, make sure it addresses the existing management problems in your present operation, and avoids new problems. Always be thinking, “if I was doing this in my new barn, how would I do it?” The following steps outline a planning process suitable for dairy expansion.

1. Establish needs and goals. You will need to determine your wants, needs, and goals as clearly and precisely as possible. Good plans recognize that there are four "cornerstones" or key factors to consider in the design of a good dairy barn. Since cows have to pay the bills, "cow comfort" has to be a priority. Since labour is the largest cost input in the dairy enterprise and since it is strongly linked to barn design it is the second cornerstone. Since sick cows require more labour than healthy ones, these corners are strongly linked because proving cow comfort will decrease the work of caring for problem cows. But in some aspects these goals may also conflict. For example, many large crossovers will increase cow comfort but also increase the daily labour required to keep them clean. A third cornerstone is the capital investment required, and the cost benefit of the specific choices you make. The fourth cornerstone that must be considered in every project is the capacity for future expansion. I recommend making a barn plan for twice as many cows as you plan to build for. Then take that plan and determine how you can logically build half of it today and file the other half for future consideration. In every decision all four of these key considerations should be weighed carefully.

2. Collect information. Collect as much information from as many sources as possible. Go to open houses. Attend tours. Read magazines. Talk to engineers, contractors, nutritionists, management specialists, suppliers, and other advisors about your plans.

3. Evaluate alternatives. Be as creative as possible. Evaluate all alternatives carefully, even the ones that seem "off-the-wall", "far-out" or impossible. What is "far-out" today, may be the accepted technology tomorrow.

4. Plan on paper. Once the best alternative is selected do as much planning on paper as possible. Discuss your plans with the people that contribute to your on-going operation such as employees, feed suppliers, A.I. technicians, veterinarians, etc. as each may have ideas which make their involvement with your operation more efficient. Many people find it easier to react to

a specific proposal rather than to abstract ideas, so try to provide good detail. Evaluate your plan for its flexibility for accommodating new technology. Revise and redraw as necessary.
5. Layout to scale. One of the best uses for "baler-twine" is to stake out a building to full scale. Often what appears to be a good fit on paper, looks much different when staked out on the site.
6. Build. When and only when you have "covered all the bases" is it time to build.
This process may not apply to every project, but many parts of it will. At any step in the process it may be necessary to "go back to the drawing board" and repeat a previous step or two when something doesn't work out the way you thought it should.

General Layout And Facilities Needed
Most dairy farm plans focus on the number of milking aged cows, but if all livestock are to be housed on the farmstead, facilities must be planned for many classes of animals. Management groups will be based on age, size, nutritional requirements, etc. On smaller operations several different groups may be housed in the same facility, but managed separately. On large farms, each group may be housed individually. Table 1 gives typical management group sizes for different sized herds. It assumes year-round calving, 12 month calving interval, first calving at 24 months , a 60 day dry period, all males sold at birth, a 30% culling rate, 0% mortality and a stable herd size.

Table 1: Typical Management Categories in a Dairy Herd

Herd Size (Total Cows)	75	100	250	400	Your Herd
Calves and Heifers (Total)	**75**	**100**	**250**	**400**	
0-3 months, 150 lb.	9	12	30	48	
3-6 months, 300 lb.	9	12	30	48	
6-9 months, 450 lb.	9	12	30	48	
9-12 months, 600 lb.	9	12	30	48	
12-15 months, 750 lb.	9	12	30	48	
15-18 months, 900 lb.	9	12	30	48	
18-21 months, 1000 lb.	9	12	30	48	
21-24 months, 1100 lb.	9	12	30	48	
Dry Cows (total)	**13**	**17**	**43**	**68**	
Far Off, first 40-45 days	9	11	15	44	
Close Up, last 15-20 days	4	6	28	24	
Maternity	**3**	**4**	**10**	**16**	
Milking Cows	**62**	**83**	**207**	**332**	
First Lactation	20	27	68	108	
Second and Later lactation	42	56	139	224	
High Producers (1-120 days)	21	28	69	111	
Med. Producers (120-210 days)	21	28	69	111	
Low Producers (210-305 days)	20	**27**	69	110	
Sick Cows	0-4	0-5	0-13	0-20	

In addition to housing for each of the groups in table 1, facilities need to include feed and manure storage and a place for milking and milk handling. While some functions may be combined in a single building, typical components include:

a: Milking Cow Barn
b: Milking Parlour and Holding Area
c: Milk House, Utility and Office
d: Maternity, Treatment and Handling
e: Dry Cows and Heifers
f: Calves
g: Feed Storage
h: Manure Storage

Once the goals and the master plan have been decided on, the interaction with the existing farmstead can be determined. For instance the relationship with the living area, existing buildings, if any, and other areas, such as machinery storage will need to be established.

Building New Versus Renovating

One tempting way to reduce building costs is to renovate existing buildings. Large single storey free span truss style buildings can be suitable for conversion to new uses. However, many of these buildings already have well defined and profitable uses. There is little sense in converting a machinery shed only to find that you now need to build a new machinery shed somewhere else. Older barns may have sentimental value, but low ceilings and variety of post spacings do not lend themselves to standard stall sizes and layouts. Achieving good ventilation in these older barns is a challenge, if not impossible. Older freestall barns narrower alleys and smaller stalls often make very good heifer housing. Since there is evidence that exposing dry cows to a shorter day length increases milk production after calving, it may be practical to convert an older barn to housing for dry cows and maternity space.

Renovation always involves compromises. Many people get so focussed on overcoming the limitations that the alternative of building new is not properly reviewed. In renovation planning make a list of all those compromises as they come up and ponder that list thoroughly before you start spending money on an old barn. You are doing this to save labour, and cows need to be healthy for this to work. If renovating involves serious compromises in these areas, you need to think "new barn"

Site Selection

Although we would normally think of site selection as an exercise involving a single farmstead, in the broader context it could mean building in the Fraser Valley vs. Alberta, Idaho, Australia or anywhere else in the world. If your decisions are driven primarily by economics it may be very worthwhile to assess the economic climate including milk prices, land values, production quotas, feed production capabilities and taxes in other jurisdictions. Present and future restrictions such as environmental regulation, and urban rural conflict may also be factors in considering alternative “sites”.

Most of us are strongly influenced by social, cultural and community factors and will not likely look at site selection from a global perspective. This does not mean we need to restrict ourselves to the present farmstead. If the lack of a suitable site, inadequate land base,

restrictive zoning, or any number of other factors, make the existing farmstead unattractive for long-range plans, it may be very advisable to relocate now, perhaps within the same farming community.

Selecting the site for new facilities is an integral part of the farmstead planning process. The topography and soil type of available sites may influence building design. Conversely the building type can dictate where it should be located. For example, if the available sites require a lot of fill to bring them to a desirable elevation, a slatted floor barn with under the barn manure storage may look more attractive than other manure handling options. On the other hand, if a high well drained site with clay soil is available, a gravity flow manure system with earthen storage becomes more attractive.

While existing buildings may be part of the plan they should not unduly influence the location of new ones. It may be convenient to renovate and connect buildings together, but this may adversely affect ventilation as well as creating an increased fire hazard in the new building. It may also limit future expansion and increase traffic problems. Particularly for dairymen with a tie stall background, choosing the right site for a freestall barn involves a change in philosophy. In freestall systems, most work is done from a tractor cab. Having things close together is of little benefit. In fact “not enough room to turn around” is more commonly a concern than “too far to walk”.

Important factors in site selection and development include zoning and regulations, topography and drainage, wind and snow control, capacity for expansion, location of roadways, electrical service and existing buildings, security and visibility, availability of water, soil type, and access to land especially relative to manure application.

Topography And Drainage

An ideal building site for livestock housing will be higher than the surrounding area to promote good ventilation and provide natural drainage of rainwater and snow melt away from the building. Keep floors in buildings above the surrounding grade for the same reason. It is desirable to incorporate sloping floors into most livestock facilities Using the existing slopes and undisturbed soil to advantage can reduce excavation cost and minimise risk of variable settling. In a freestall barn a 1% slope throughout the length of the barn will encourage manure liquids, holding area wash water and spills from water troughs to drain away to a manure collection system at the low end of the barn. A 2% slope will also permit present or future use of a flush manure system. A slope of 3% or greater will encourage cows to lay with their backs uphill. When all cows lay the same way in the free stalls, there is less contact between hooves and udders and cows are cleaner. There are three construction options for incorporating the slope in the building. It is possible to slope the floor and not the roof line, creating a variable height in the side wall. A second option is to slope the floor and roof line but keep the posts vertical. This means roofing steel does not go on square. Lastly the entire building including vertical posts can be built rectangular, but off level. All three options can be structurally sound and the choice is one of individual preference. 1% or greater slope in a bunker silo or commodity building will ensure liquids drain away from the face of the feed. Where the site permits it, there are definite advantages to locating manure storage downhill from the barn so that manure can be moved by gravity. If the storage is part way down a slope it may also be possible to unload it using gravity. Lastly to minimise the risk of pollution, it is preferable if a barn site does not drain directly into a surface water course.

Soil Type

A stable soil is needed to support buildings, bunker silos and driveways. With soils of higher clay content, site preparation such as regrading should be done a year or more in advance if possible to permit settling, or alternatively the site should be thoroughly packed. Manure storage design criteria will vary with soil depth and clay content.

Wind And Snow

Freestall barns that depend on natural ventilation should be located on an exposed site away from other buildings, and oriented so that the sidewall catches the prevailing westerly wind. Ideally, attached parlours or cross alleys will be located on the downwind side and have open side walls to minimize interference with air flow. Where this orientation is not practical additional openings in the end walls should be provided. Use of chimneys instead of open ridge ventilation outlets is advised for all barns but more critical when the ridge is not perpendicular to wind direction. Buildings or trees within 200 feet upwind will interfere with light summer breezes which are essential to summer ventilation. Try to determine the pattern of wind and snow around proposed buildings, when planning. Wind is important for carrying odours, noise and dust away from living areas. Ideally, manure storage should be downwind from nearby residences.

Manure Storage And Disposal

Choose a site that has adequate space for the size and type of manure storage that is presently needed plus room for expansion. Be careful to select a site where prevailing winds will blow offensive odours away from the living area of the farmstead, and away from neighbouring residences. The site should also be selected where possible to provide for gravity transfer of the manure from the livestock barns to the storage. It is also necessary to have easy access for transportation from the manure storage to the fields.

Feed Storage And Handling

Just as with manure storage it is important to have adequate space for the present feed storage and for room for possible future expansion. Feed storage must be located for easy access to the source of feed, and for easy access for mixing and delivery. With the use of mobile feed mixers, feed can be conveniently moved greater distances. While trailer TMR mixers used in larger herds, make it possible to locate feed storage further from livestock buildings, do keep in mind that convenient feed preparation happens when there is a “feed centre” where the mixer can be parked while a loader adds most ingredients. This means commodity storage, bunker silos and small ingredients need to be planned into one site.

Regulations and Guidelines

You need to seek local advice on building regulations since they may be different in each municipality.

Water

An adequate water source is necessary not only to supply drinking water to the cattle, but also for sanitation and manure dilution. Tables 2 and 3 give some ideas of the quantities of water that are required. Not only is it necessary to be able to supply the total water requirements, but also the peak water requirements that occur while milking or feeding. For instance plate coolers require a tremendous amount of water to operate properly. For larger dairies a reserve of fresh water in a pond or cistern in the barn may be advisable to ensure peak demand is met. Such a reservoir is also valuable in the event of a fire. Water re-use or recycling should be practised where possible to reduce use.

Table 2: Water Requirements (MWPS-7)

Animal	Gal/Hd/Day
Calves	5 – 8
Heifers	8 – 13
Dry Cows	15 – 25
Milking Cows	30 – 40

Table 3: Approximate Milking Centre Wastewater and Flush Volumes (MWPS-7)

Washing Operation	Water Volume
Bulk Tank	
Automatic	40 – 50 gal/wash
Manual	25 – 35 gal/wash
Pipeline in Parlour	60 – 105 gal/wash
(Volume increases for long pipelines in stanchion barns)	
Pail Milker	25 – 35 gal/wash
Miscellaneous Equipment	25 gal/day
Cow Preparation	
Automatic	0.75 - 3.75 gal/washed cow
Estimated Average	1.75 gal/washed cow
Manual	0.25 - 0.5 gal/washed cow
Parlour Floor	
Cleaned with a Hose	15 – 35 gal/milking
Flush*	650 - 1,650 gal/milking
Well Water Pre-Cooler	1.75 gal/gal of milk cooled
Milk house Floor	8 – 15 gal/day
Toilet	4 gal/flush

*Amount of water needed depends on width of flush alley. To convert to Cubic feet, divide gallons by 6.24.

Expansion Potential

When selecting a site always keep expansion in mind. Ideally a site should provide for unrestricted extension of barns, and commodity sheds at both gable ends. Bunkers should have the option of becoming longer or having additional silos added to the sides. As stated earlier an ideal site should be expandable to about 700 cows without major problems. Leave lots of room to turn at both ends of the drive through and in front of bunkers and commodity sheds. The barn plans in Fig. 2 provide illustrations of design aspects that provide flexibility for future expansion.

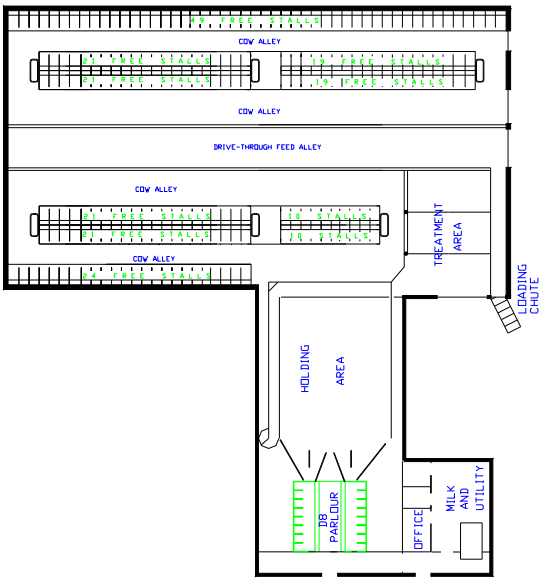

Figure 2-A. Layout permits expansion of barn to right, parlour to the bottom and holding area to the drive through.

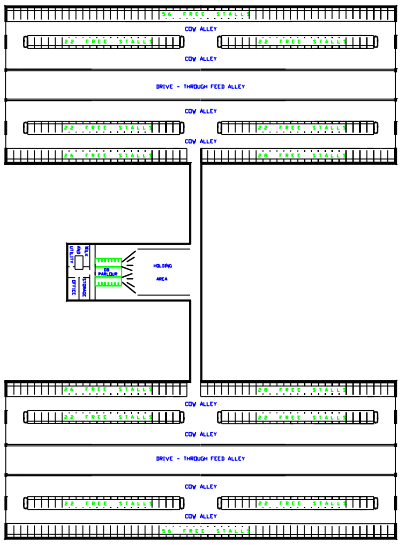

Figure 2-B. Layout permits expansion from 100 to 400 cows in four stages, top left and right and bottom left and right.

Designing a Housing System

For a dairy facility to work well the pieces have to fit together in a logical fashion. For example the choice of sand bedding, automatically eliminates slatted floors and manure storage below the barn. Each decision will impact on many others.

One of the main areas where this affects the organization of a barn is in relation to group size, and that decision starts in the milking parlor. Cows should never wait more than an hour for milking, because long standing times contribute to lameness and longer times away from feed decrease production. Cow groups should fill a specific number of turns of the parlor so it is always full. So the hourly throughput of the parlor and parlor size are the defining factors in group size. If a 2 x 12 parlor can put through 100 cows per hour then the barn should be divided into 96 cow groups since this is an hour of milking and divisible by 12. The holding area should hold about 120 cows, so a new group can be added with one turn of the parlor remaining from the previous group. Every herd will have fresh cows, lame cows and weak/sick cows. If these compromised animals are left in a large milking group they are the last to be milked and will be highly stressed by the wait in the holding area. A good barn provides a comfortable place close to the parlor for these cows, so they can be milked and returned to their bedding pack or big comfortable stalls with minimum walking and no waiting. The logical size for such a group will be also be 1/2 or 1 turn of the parlor or in this case 12 or 24 cows. Other features of "housing system" include straight lines with no dead ends for handling feed, manure and bedding, logical handling systems along the normal route of the cow to facilitate sorting cows in the return lane and convenient return to their groups after handling. In ideal layouts the route to the parlor does not cross the return path so cow flow from the barn to the parlor and back is never in conflict.

Housing System for Robotic Milking.

Good robotic milking barns are also designed with a systems approach that includes many of the same elements. Straight lines for materials handling apply here as well, and they are often sacrificed in the process of placing the robotic milking stalls. Group sizes of 60 cows for 1 robot or 120 cows for two make the most sense today, but as the technology improves perhaps 70 and 140 will be more appropriate. Logical cow routing with no dead ends is just as important here as in parlor barns, and the ability house fresh and lame cows in a special area close to the robot is also important. Central handling with a convenient and logical route back is also important here. But while the goals remain very similar the fact that cows never leave the barn results in very different barn designs to meet these same objectives. For example perimeter feeding, which has few benefits in parlor barns is preferred in robotic barns because it allows for central handling near the robots.

Learn from others

As a closing comment I encourage you to critically examine the thought processes you apply to decision making. Your own experience, your regular advisors, other farmers, consultants, and salesmen can all bring value to the decision making process. Each of these sources come with their own limitations. For example you may place great trust in your own experience but if it is with a different system of management (like parlor milking rather than robotics) it may not be useful or applicable. You may have great respect for your vet but if he has no clients using the technology he may less about it than you do, and while sales people should be knowledgeable about their products their enthusiasm my blind them to weaknesses in your specific application. Even other farmers may not always be honest with themselves as well as with you about the success of past choices they have made. As project manager, all the final decisions are yours and while it is critical to see as much as you can and gather information from as many sources as possible, gleaning the wheat from the chaff will also be a key part of the process.