Greenhouse Barns for Dairy Housing

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Greenhouse barns are receiving attention as housing for calves and cows. People using these structures often identify three main reasons for choosing this dairy housing option: the bright atmosphere the building provides; the improved health of the animals housed in these structures; a cost advantage over other forms of dairy housing. Whether these perceived advantages are real or not is a matter of some discussion. An objective analysis of the topic must include an evaluation of ventilation and cost issues.

To help producers and designers resolve some of the issues involved in using a greenhouse barn, this publication summarizes information about greenhouse barn design. It discusses economic factors that can be used to analyze design layouts and construction alternatives, and it compares the costs of greenhouse barns to the costs of conventional post frame structures to help determine if a greenhouse barn is suitable for a particular situation.

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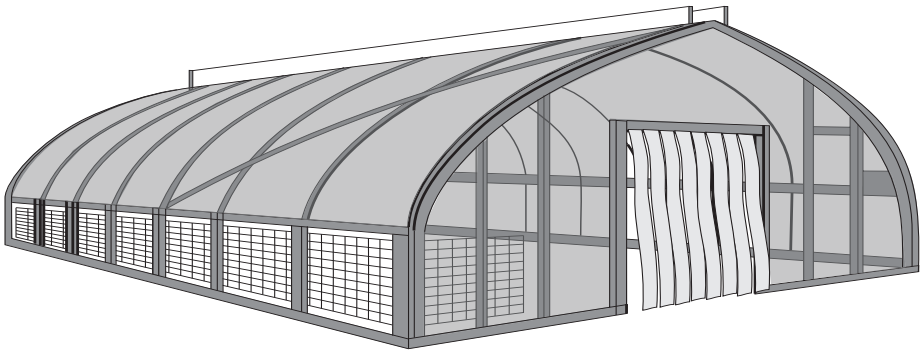


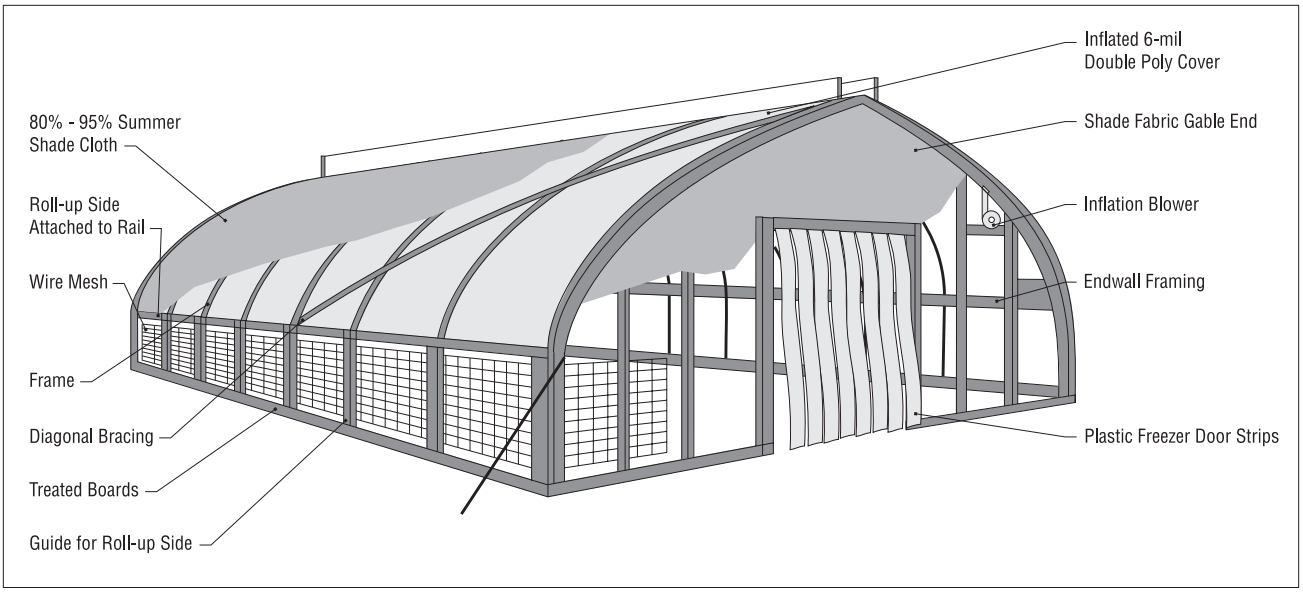


Figure 1. Basic components of a greenhouse barn

Overview

Greenhouse barns use a lightweight, galvanized steel tube frame to support one or two layers of a commercial-grade plastic film as a covering. The most common use for these structures is as heated chambers for growing plants. However, since about 1988 in the United States, earlier in Europe, greenhouse barns have been used for housing livestock. During the last five years particularly, interest in and use of these structures for dairy housing has increased significantly. Figure 1 shows the common components of greenhouse barns.

The increased interest in greenhouse barns as an alternative form of dairy housing has led to comparisons between greenhouse barns and conventional post frame barns.

In many ways, today's discussion and interest is similar to what dairy farmers faced when post frame barns first came into the market. Farmers wondered if post frame barns would replace two story barns. In fact, post frame barns did change the way animals were housed; post frame barns with freestall housing and a parlor replaced the conventional two-story, stone wall, timber frame, tie stall barn. At that time, post frame barns were considered to be relatively inexpensive compared to timber frame barns. Post frame barns were thought to be temporary structures but provided design flexibility that conventional timber frame barns could not offer.

Farmers today are asking: "Are greenhouse barns better than post frame barns?" and "Are greenhouse barns cheaper than post frame barns?" The answers to these questions are not clear cut and may depend on the type of comparison we make and on the objectivity and reasonableness of those comparisons.

Because using greenhouse barns as animal housing is a relatively new practice, little or no long-term research has been done on their suitability for this type of application, and questions have been raised about ventilation and about the durability of the construction materials. Many builders and engineers have extensive experience designing post frame barns for animal housing, but that level of experience is not yet available in designing greenhouse barns for dairy housing.

While the earliest plans and design criteria for greenhouses used for dairy housing have evolved to more fully developed designs, most of the information currently available comes from farmer experiences and comparisons in magazines and news articles. These experiences and case studies are valuable, but one person's success does not always translate into success at another operation. A greenhouse barn may be right for one operation but not for another.

Basic Questions

Producers thinking about building any kind of dairy housing need to answer questions like the following to determine if building the structure is indeed a good idea.

1. Does the design of the building make possible and convenient the use of optimal or preferred management practices for calves, dry cows, and milking cows?
2. Is the design conducive to providing for the animals' needs during all seasons in the climate of the area?
3. Is the design structurally sound and does it meet common tests of reliability and longevity?
4. Is the design cost effective?

Concerns and Limitations

In answering these questions for greenhouse structures used as dairy housing, the following concerns and possible limitations need to be considered.

- Greenhouse dairy barns do not appear to create an overriding economic advantage. The tables on pages 12 through 14 of this publication, based on estimates from three greenhouse suppliers in Wisconsin, indicate that the initial costs for greenhouse barns and post frame barns are about equal.
- When maintenance costs are included in a comparison between greenhouse and post frame barns, the greenhouse barn proves to be more expensive. Also, greenhouse barns may not have warranties, while post frame structures commonly have a minimum warranty of 30 years.
- Greenhouses used as dairy barns must be adequately ventilated; this includes the use of ridge and eave vents as well as side and endwall ventilation. Adding ridge vents to some greenhouse styles, particularly hoop or quonset styles, will be an extra cost item. If ventilation is inadequate, animals may be subjected to wide day-to-night variations in air temperature and humidity, which could adversely affect animal health.
- Hoop or quonset type structures without ridge vents may be difficult to ventilate naturally if longer than 75 feet.
- Natural ventilation with a greenhouse barn requires more careful management than with a conventional barn.
- The plastic covering of a greenhouse barn will need to be replaced every four to six years.
- In the summer, a greenhouse barn must be covered with shade cloth.
- The basic plastic cover along with all curtains and shade fabric must be protected from animals.
- Because the practice of using greenhouse barns as dairy housing is relatively new, little reliable data is available to help determine what designs will meet tests of longevity and reliability.
- Cold damp air will likely lead to excessive condensation during winter months, and even providing heat to dry damp resting places will not work if the ventilation is inadequate.
- The greenhouse frames must be able to resist corrosion, and they need to be sturdy enough to support pens, gates, and stall partitions.
- Snow and ice build up may be a problem in unheated greenhouse barns.
- Specially designed gutters are necessary between spans in multi-span buildings.
- Curtains in hoop or quonset type structures follow the curvature of the building when opened; this exposes the floor area to adverse weather.
- Greenhouses with sidewalls less than 8 feet high are probably not adequate for use as dairy barns.

Animal Environment

Perhaps the most crucial concerns about greenhouses used as dairy housing are the issue of animal environment and the related issue of proper ventilation.

The primary goal of the animal housing environment should be to protect the animals from the weather. In the summer, the building should provide shade and allow cross ventilation by wind pressure. In the winter, the housing should allow for moisture removal and draft control. When a greenhouse is used to provide an environment for animals, the design must consider that the translucent plastic covering makes a greenhouse an effective passive solar collector. Although this is an asset in situations where solar heating is desired, this characteristic can be a serious liability in greenhouses used for dairy housing.

On a sunny day, radiation from the sun warms the air in a greenhouse. A natural tendency is to restrict ventilation to keep warmed air inside the structure. However, when the greenhouse is being used to house animals, restricting ventilation traps the moisture the animals produce along with the warm air. Because the air warmed by solar heating can absorb large amounts of moisture, air quality may not appear to be a problem, at least during the day (some odors may be noticeable).

At night the greenhouse barn acts in reverse from a radiation standpoint, losing heat to cold surroundings and the cold, clear, black sky. This cools the air in the barn, lowering its moisture-holding capacity substantially and causing relative humidity to rise. The result is cold, damp air and, most likely, excessive condensation. If adequate ventilation is not provided, animals will be subjected to wide day-to-night variations in air temperature and humidity, which could adversely affect animal health. In general, respiratory disease peaks in spring and fall when the daily minimum and maximum temperature fluctuations are at their greatest. The greenhouse effect may contribute to daily fluctuation.

Design and Construction Details

Design and construction criteria for greenhouse barns used as animal housing have not yet stood the test of time. Any design, however, must meet the animals' environmental needs and provide for proper ventilation. Additionally, the strength of the building materials used in the frames must be adequate, and the greenhouse frame must be designed and constructed to meet the snow and wind loads of a specific region. Also, frames must be straight and plumb because snow and wind loads applied to frames constructed out of plumb or off center may cause uneven loading of the entire structure thus risking failure.

Loads associated with the animals housed in the barn also must be considered in the design. The frames may be subjected to loads from supporting pens, gates, stall partitions, and any other features designed into the building to be used as animal housing. Animal pressure on the building frame and stallwork also must be considered in any design.

General Characteristics

Greenhouse frames are constructed primarily from 2- to 3-inch O.D. (Outside Diameter) round or square galvanized steel tubing. Aluminum also is used as a frame material. The thickness of the tubing used in greenhouse frames ranges from 16 to 12 gauge. (The lower the gauge number, the thicker the tubing.) Actual frame sizes depend on building width and frame spacing.

Frame widths for single span structures range from 18 to 36 feet. Building lengths range from 48 to 180 feet. Frames are spaced from 4 to 6 feet apart in single span buildings, and up to 8 to 10 feet apart in multi-span buildings. These frames support the roof and sidewall construction of the building. Galvanized steel tubing $1^{3}/_{8}$-inch O.D. is used for purlins and bracing to span and brace between the frames along the length of the building.

Because of the corrosive nature of an animal housing environment, high quality galvanizing is crucial when greenhouse frames are used for dairy barns. Some manufacturers use hot dipped galvanizing, which produces excellent results. Other types of galvanizing, however, may not be suitable for use in animal environments. Check the quality and amount of galvanizing in the frame tubing, and determine what type of warranty is available from the supplier. Aluminum frames are an option with some suppliers.

One or two layers of plastic film are attached to the frame for the roof and sidewall covering. In many cases, curtain material is used for sidewall ventilation openings. Shade fabric is used for the roof, sidewall, and endwall ventilation openings. Sidewall heights vary depending on the frame type and how the building will be used. A minimum sidewall height of 8 feet is satisfactory for calf barns. For larger animals, 10- to 14- foot high sidewalls are recommended. Higher sidewall heights may be necessary for maneuvering equipment for cleaning and feeding.

Sidewall openings can be designed into the frame with roll up plastic curtains or with a curtain fabric package offered by the greenhouse supplier. Access through the sidewall is difficult to incorporate into the design of a greenhouse frame. Almost all access to the building is designed into the endwall of the building.

Curtains, plastic, and shade fabric need to be protected from animals to prevent damage. Wire cattle panels, plastic snow fencing, and high tensile wire fencing can be used. Stall partitions and penning may need to be set back from the walls to prevent animal pressure on the sidewalls.

Some frames include a vertical wall attached to a steel frame. In other designs, the hoop or bow starts immediately from the foundation. To increase sidewall height for these types of frames, the vertical sidewall height can be increased by attaching the hoop frame to a vertical wooden post frame or concrete sidewall 4 to 8 feet high. Figure 2 shows examples of typical greenhouse frames.

Hoop Frames

Many greenhouse suppliers sell hoop, round, or quonset frames. These frames commonly use 2-inch O.D. galvanized steel tubing. (See Figures 2a, b, and c.) These frames have a maximum height of approximately 11 feet in the center and 6 feet on the sidewalls. The frames are spaced 4 to 6 feet apart and have clear spans that range from 18 to 30 feet. Some manufacturers can span up to 40 feet with 3-inch O.D. tubing.

Round or quonset roof designs have a design limitation. When the sidewall curtain is raised, the rolled up sidewall may not allow the roof to shed water properly. The curtain moves horizontally towards the center of the barn; this opens part of the roof to rain, and stalls or alleys can get wet. Figure 3 shows how the drip line of the building roof moves toward the center of the barn when the side curtains are rolled up.

Gable Frames

Gable frames start with a straight sidewall pipe that supports an elevated bow frame. This allows a minimum 8-foot sidewall height. Gable frames commonly use 2-inch O.D. galvanized steel tubing. The frames are spaced 4 to 6 feet apart and have clear spans that range from 18 to 30 feet.

The shape of the bow may be semicircular or peaked. The shape of the bow allows either an open ridge or overshot ridge to be incorporated into the design. (See Figure 2d.) The straight sidewall can support adjustable curtains for ventilation openings. Straight sidewalls are preferable to curved walls for shedding rain and preventing snow melt water from entering the building.

Multi-span Frames

Buildings wider than about 30 feet require multiple frames to span the width. A building of this type is commonly called a gutter-connect frame in the greenhouse industry. (See Figures 2e and 2f.) In this type of construction, interior posts support the multiple frames. This creates a roof with peaks and valleys. The sidewall and interior post supports are 3-inch O.D. round or square tubing supported on concrete walls or piers.

The gutter of the frame must be made of aluminum or stainless steel pans to increase corrosion resistance. Structurally, gutters must be designed to withstand rain and snow loads, as well as loads from sliding snow. Sidewalls can be as high as 14 feet for ventilation purposes. To increase building rigidity, light steel trusses are usually incorporated into this design, allowing ridge openings to be placed at the peaks.

Foundation Options

The foundation of the greenhouse frame must be able to transfer the loads applied to the frame to the earth. Wind applies horizontal and uplift loads to the sidewall frame, while snow, rain, and the weight of the frame apply vertical loads downward to the sidewalls. The foundation anchors the building to the earth and must resist corrosion from contact with manure, moisture, and the soil. For this reason, ground stakes used as part of a foundation must have good quality galvanizing.

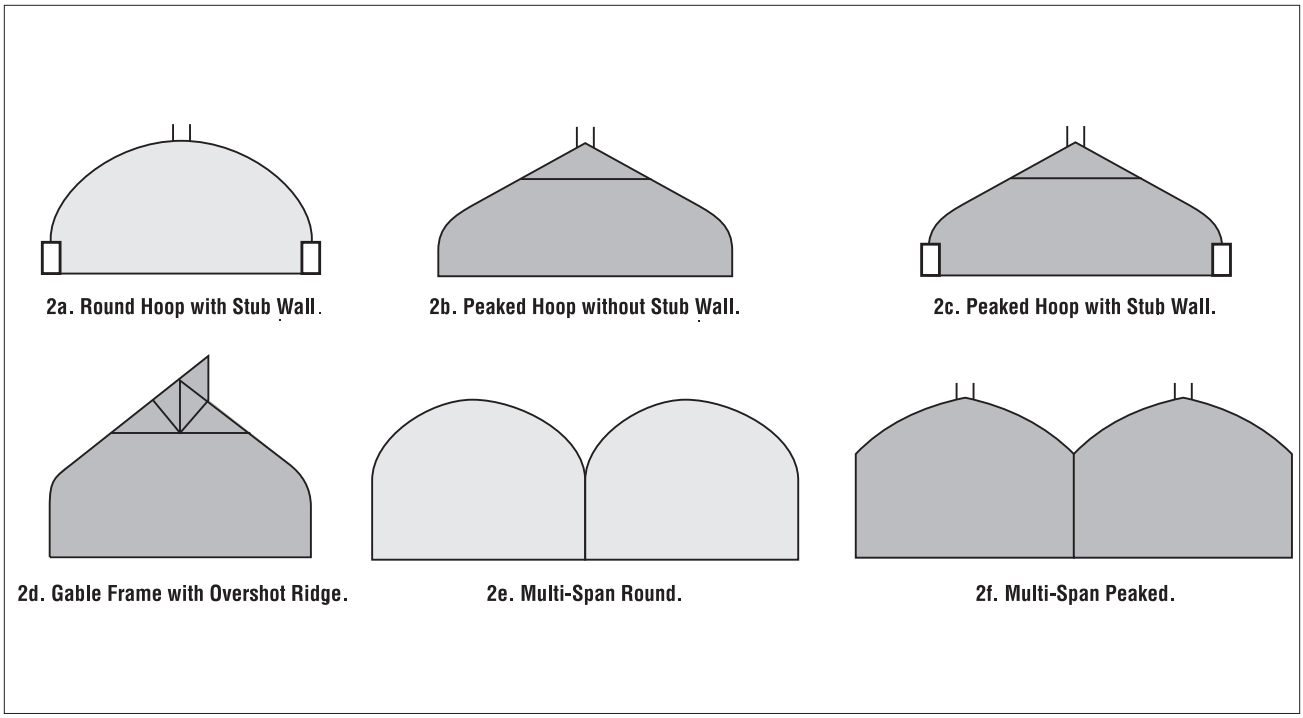


Figure 2. Typical greenhouse frames.

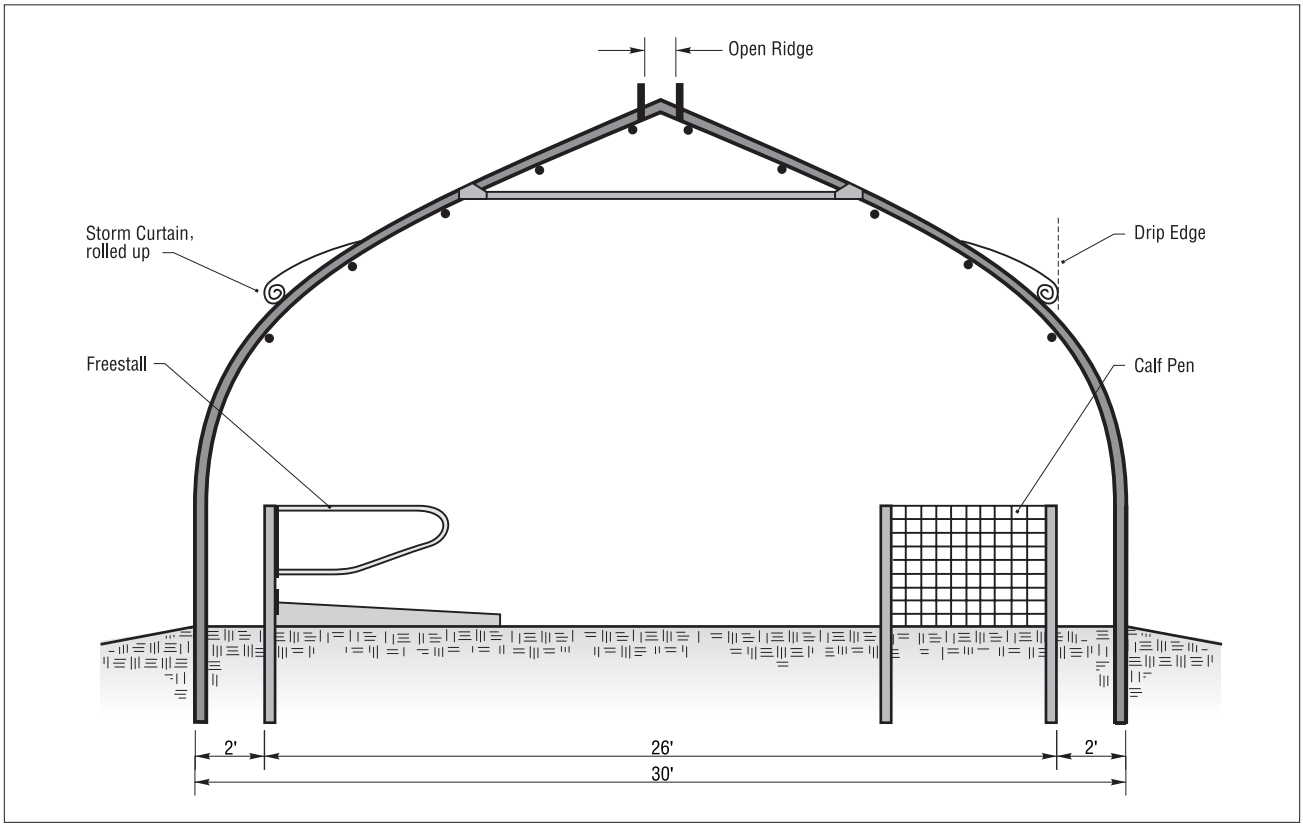


Figure 3. Example of pen and stall setbacks.

Extension of the steel tube frame

For most hoop frame greenhouses, the foundation is an extension of the tube or pipe frame. Galvanized ground stakes or pipes are driven into the soil approximately 30 inches depending on geographical location. The frames are attached to the ground stakes. Some designs require drilling or digging a hole for the ground stakes and then placing concrete around the stakes to set them in place. Figure 4a illustrates this technique.

Post frame foundation

Another option is to build a post frame foundation below the frost level and then construct a short wall along the sides of the frame. This wall can be used on the endwall framing as well. The pipe frame is attached to the top of this wall. (See Figure 4b.) This option also is used to increase a building's sidewall height.

Concrete pier foundation

Concrete piers placed below the frost depth of the region are another option. This technique is commonly used for multi-span frames. (See Figure 4c.) Holes are drilled or dug to below frost level. Cardboard tubes available from concrete suppliers are used as forms to place the concrete. The tops of the piers are usually 12 to 18 inches above the finished floor surface to protect the frame from equipment, animals, manure, and water. A frost footer also could be placed along the length of the barn.

Snow and Wind Loading

Snow and wind load designs for greenhouse frames should be similar to the design for other agricultural buildings in the area. Gutter connections in multi-span buildings need to be designed using double the typical snow load.

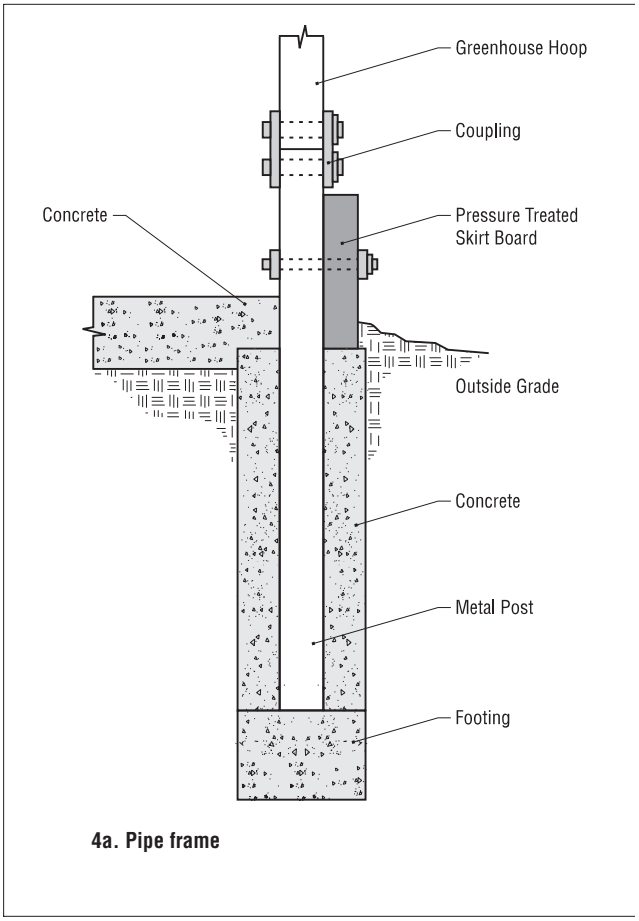
Many greenhouses used for plants in severe northern climates do survive the snow loads of those regions quite well; however, most of these buildings are heated, and snow does not stay on the roofs. This may not be the case with a cold calf or cow barn. Snow may slide off the roof, but it can hang up and freeze at the sidewalls of the structure, causing a loading of the sidewall frame. In multi-frame barns, the snow can slide into the gutter part of the barn and freeze, causing additional loading of the frame.

Uplift of the frame because of wind loads needs to be considered in the design of the frame and the foundation anchoring. Diagonal bracing of the sidewalls from the endwalls and along the roof line must be incorporated into the design. Diagonal bracing is important to keep the frame from racking or deforming out of plumb. Frames off center are likely to be loaded unevenly and are subject to failure.

Endwall Framing

In many cases, the greenhouse frame package does not include endwall framing. Depending on the application, additional construction materials may be needed to frame in the endwalls. These materials can be purchased as an option with the package from the dealer, or the dealer may supply information on what materials are needed to frame the endwalls. Wood post frame or stud wall construction is commonly used.

Access to the building for animals, humans, and equipment is commonly designed into the endwall of the greenhouse frame. Large openings for animal and equipment access can be framed with a door, but typically a piece of plastic, curtain, shade fabric, or freezer door strips are used in large openings to block the wind. (See Figure 1.)



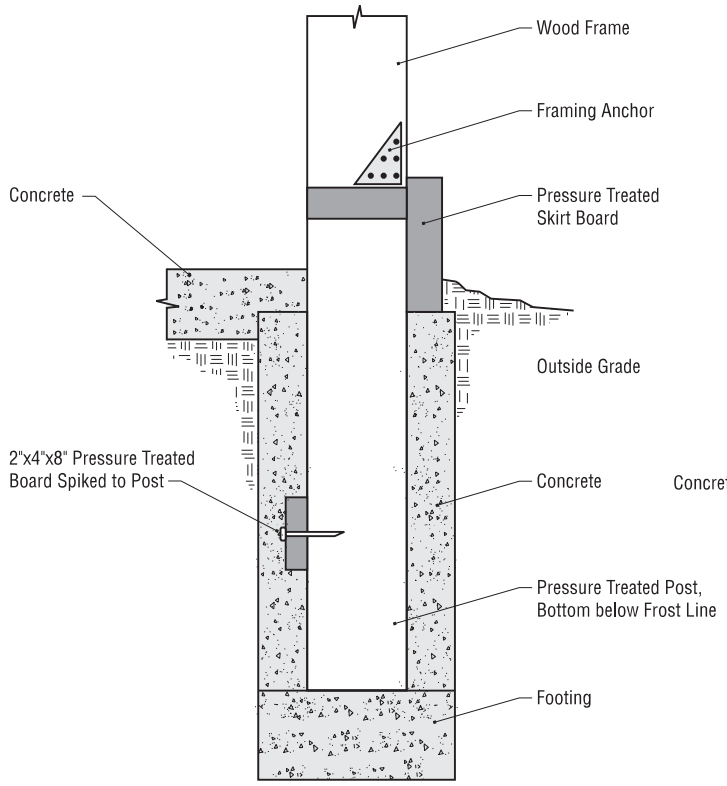
4a. Pipe frame

Figure 4. Frame foundation connections.

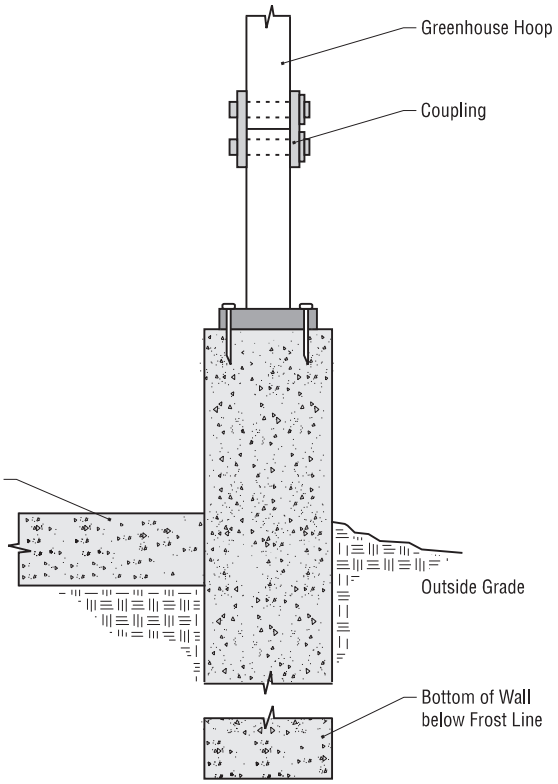
Roofs

Clear or white polyethylene plastic with a 6-mil thickness is the most common roof covering for a greenhouse barn. Clear (translucent) plastic allows about 87% light transmission, while white allows about 30% light transmission. The plastic should be a high quality greenhouse grade plastic with UV (Ultra violet) stabilizers. Plastic of this quality typically costs $0.20 to $0.25 per square foot. The expected service life of most of the plastic coverings used on greenhouse structures is four to six years.

Covering the frame with plastic can be difficult and is best accomplished with the help of several people. Experience has shown that the best method is to roll the plastic out to the length of the building and then pull it over the frame until the plastic is tight. The best time to attempt to cover the greenhouse is in the early morning or late evening when the wind has died down and the temperature is above 50 F. Aluminum extrusions supplied from the manufacturer or double furring strips with double-headed nails can be used to secure the plastic. (See Figure 5.)



4b. Post frame.



4c. Concrete pier.

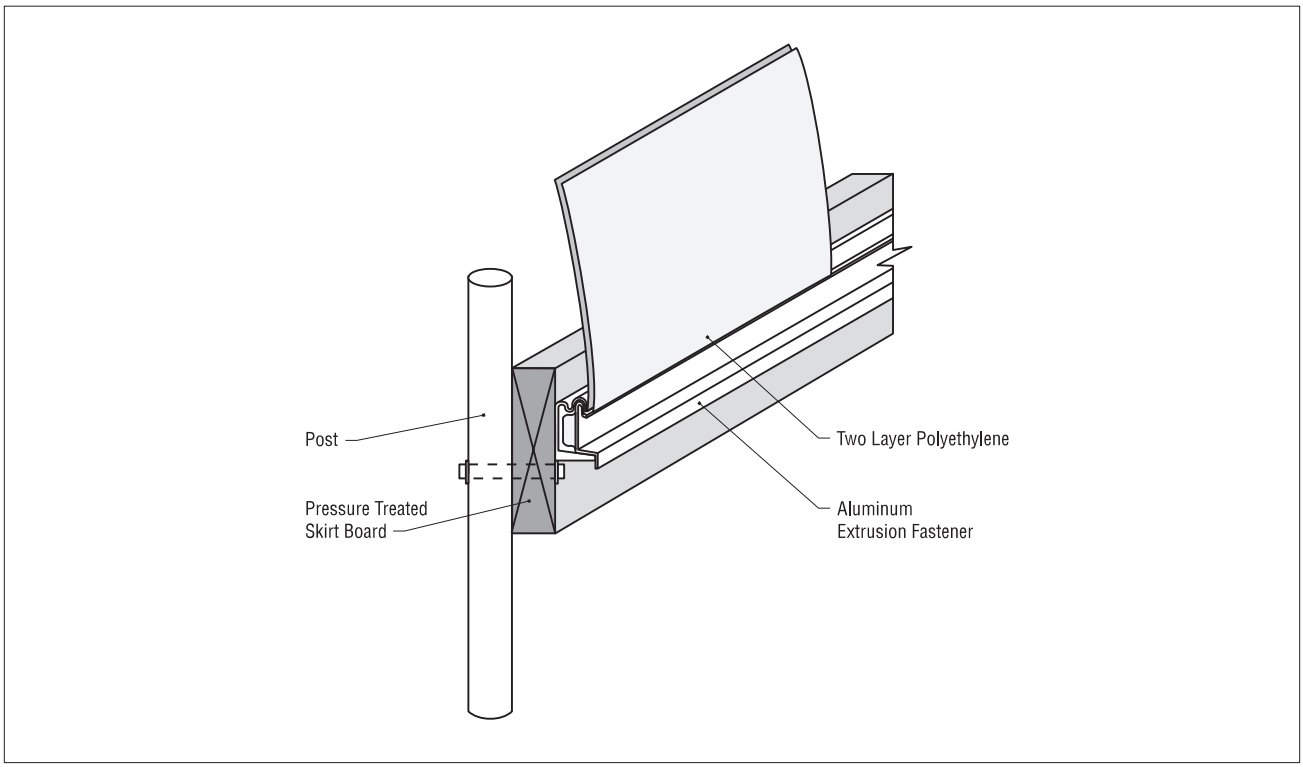


Figure 5. Common method of anchoring plastic covers.

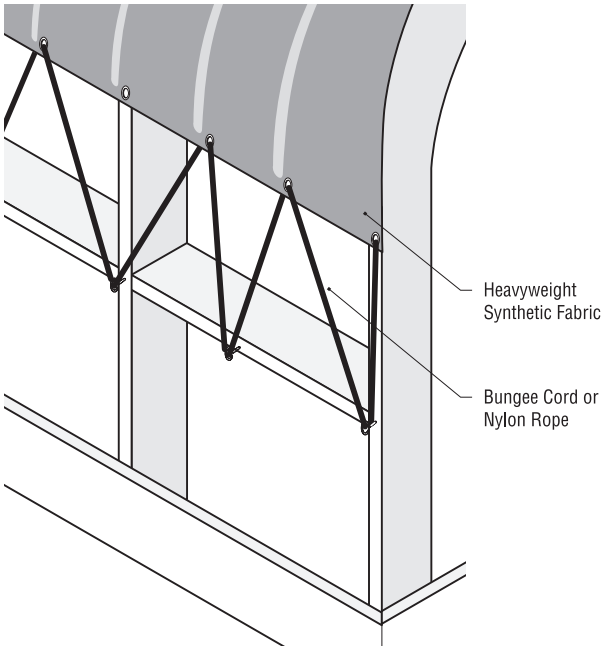


Figure 6. Common method of anchoring heavyweight synthetic fabrics.

Heavier weight synthetic fabrics like tarps also are options used in some designs. These materials are approximately 16 mil thick, giving a higher strength and heavier weight. UV stabilization is provided with a black and/or reflective layer incorporated into the fabric to provide shade. The coverings have grommets approximately every two feet and are attached to the frame with bungee cords or nylon ropes threaded through the grommets and tied to the sidewall construction. (See Figure 6.)

Blowers

Many frames use a double layer of plastic with a small blower inflating the space between the plastic sheets. (See Figure 1.) This keeps the plastic films tight and reduces the flapping of the plastic in the wind. This reduces the potential tearing of the plastic covering. The manufacturer usually supplies the blower used to inflate the two layers of plastic. Duct tape and 4-inch clothes drier hose are the plumbing materials most commonly used to attach the blower to the cover.

Blowers should have a capacity of 60 to 80 cfm for greenhouses less than 50 feet long and 100 to 150 cfm for structures 50 to 150 feet long. The blower size is approximately 75-100 W and operates 24 hours a day, consuming 1.8 to 2.4 kWh of electricity. At a cost of $0.07 per kWh, the cost of operating the blower is $0.12 to $0.17 per day.

Shade material

With a plastic cover, shade material will be necessary. Shade material is made of polypropylene and comes in many different percent opening ranges. For greenhouse barns, a minimum 80% blocking shade is recommended. Anything less will cause heat stress in the building. The material costs $0.10 to $0.15 per square foot and is usually fitted with grommets in the edge. Commonly, nylon rope or bungee cords are threaded from the grommets to anchoring points on the sidewall to hold the fabric in place. (See Figure 6.)

Cover protection

The plastic, shade cloth, or fabric used to cover a greenhouse barn can be damaged easily by wind and animals if not properly installed and protected. The plastic film must be protected from sharp edges on the frame. One way to protect the film and prevent sharp edges from puncturing it is to use adhesive backed foam insulation or duct tape on the frame's sharp edges and connectors. The plastic also must be protected from animals. Setbacks for pens and stallwork and protection of the plastic with fencing or wire panels should be incorporated into the design layout. Penning may be needed to keep the animals one to two feet away from the sidewall. (See Figure 3.) Freestall partitions and penning can be supported on posts set back from the sidewall.

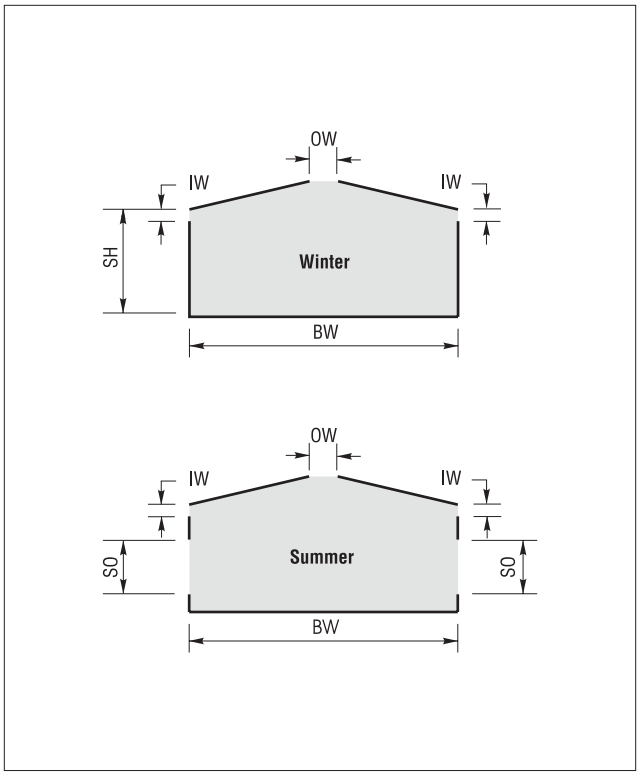


Figure 7. Configurations of natural ventilation openings.

Table 1. Minimum sizes for natural ventilation openings.

Openings are defined in Figure 7.
Use for single or individual spans.
Openings are continuous along building length.

Building Width, BW, ft	Outlet Width, OW, in	Inlet Width, IW, in	Minimum Summer Sidewall Opening, SO, in[a]	Minimum Sidewall Height, SH, ft[b]
to 20	4-6	2	60	10
22	5-6	3	60	10
24	5-6	3	72	10
26-30	6	3	72	10
32-34	7	4	72	10
36-40	8	4	72	10

[a] Recommended opening entire sidewall for summer ventilation.
[b] Multi-span structures require 10 to 12 ft. sidewall height.

Ventilation Practices

To reduce risks to animal health from poor air quality, greenhouse barns must be well ventilated, and the ventilation must be well managed. In greenhouses used as dairy barns, ventilation must not be restricted to trap solar heat; any efforts to contain the heated air by restricting ventilation will result in high humidity, especially during the night.

If the objective is to provide a warm calf barn, the greenhouse barn still needs to be equipped with a well-controlled ventilation and heating system. Solar heat acts only during sunny periods to supplement the installed heating in this case.

Natural Ventilation

Natural ventilation of a greenhouse barn must be managed just as in any cold, naturally ventilated barn. In fact, the ventilation system must be better managed because of the additional risk to the animals' environment introduced by the daytime heating effect.

Wind is a major force in the ventilation of any naturally ventilated barn. Orient the greenhouse to intercept the prevailing summer wind patterns through the largest openings available in the barn design. Do not construct a greenhouse barn where buildings, trees, or other large obstructions block the prevailing summer winds. For buildings less than 150 feet long with a sidewall height of less than 14 feet, the minimum separation distance from obstructions is 50 feet. For buildings longer than 150 feet, the recommended separation distance is 100 feet.

Ridge and eave openings

Natural ventilation depends on an open ridge and open eaves during extreme winter weather and adjustable sidewall and endwall openings for other times of the year. The ability to control the ventilation with these openings must be added to conventional greenhouse construction. Some greenhouse frames have an open or overshot ridge outlet and eaves inlets designed into the frame; however, the lack of overhangs on some styles of frames may cause problems with wetting of bedded packs or freestalls on the outside walls. Figure 7 and Table 1 show opening dimensions and locations.

Sidewall openings

In summer, a greenhouse barn must be covered with shade cloth to reduce incoming radiation. In addition, initial construction must include provisions for opening the sides and ends to take advantage of the wind.

Just like any cold barn with natural ventilation, a greenhouse barn should

- Serve as a sunshade when temperatures are high.
- Serve as a windbreak when temperatures are low.
- Have adjustable openings to help manage the natural ventilation for in-between weather.

Because radiant heat exchange (both gain and loss) has an important effect on interior air temperature in a greenhouse barn, management of ventilation openings is even more critical in a greenhouse barn than in a barn of conventional construction. Avoiding wide swings in air temperature and humidity helps avoid problems with animal health. Sidewall openings should follow recommendations of Table 1.

Endwall ventilation

Hoop, round, or quonset style frames may not provide overhangs, eaves inlets, or ridge outlets, thereby making natural ventilation difficult. Narrow, two-row freestall cow or calf barns may be naturally ventilated through the use of endwall and sidewall curtains. Hoop or quonset type buildings without ridge vents cannot be ventilated naturally if they get too long. A hoop barn longer than 75 feet filled with animals is difficult to ventilate naturally. The tendency of greenhouse structures to warm during the day and cool at night will require considerably more labor adjusting curtains than would be required with a post frame building.

Winter ventilation openings for this style of barn use a double layer of porous material, like shade cloth, separated by a space of 4 to 6 inches on the endwall and/or high in the gable end. This provides for air exchange by wind ventilation. There are concerns this design can cause cold air to drop down onto young animals, causing a draft. Additional precautions such as hovers or wind baffles on gating may need to be used to reduce drafts. These precautions must still allow ventilation and moisture removal to occur.

Mechanical Ventilation

Mechanical ventilation may be necessary in some cases. Mechanical ventilation increases both initial and operating costs. Usually the mechanical ventilation system is designed as a wind tunnel system with fans on one endwall of the barn and an inlet/outlet opening on the other. Sidewalls would need to be closed to prevent the air flow from short circuiting through the barn. The designed air velocity is approximately 2.5 mph through the cross section of the barn. The system could be designed to push (positive pressure) or draw (negative pressure) air down the length of the barn.

For minimum ventilation needs and moisture removal in the winter, a negative pressure fan could be placed in the endwall, and inlets could be placed in the opposite endwall or high in the gable end.

Shade and Natural Light

Owners of greenhouse barns frequently comment positively about the bright atmosphere the natural light entering the barn produces. While natural light is a benefit, direct sun may not be. Any attempt to shade the building for the animals' needs will reduce the amount of natural light entering the building. Shade and natural lighting may seem to be in conflict with one another, but even in shaded structures, the majority of the natural light is entering through the open sidewalls.

Whether a greenhouse barn is naturally or mechanically ventilated, some type of shade material on the roof will be needed to decrease heat stress in summer for both cows and calves. Shade also may be necessary and even beneficial in the spring, fall, and winter. If the greenhouse is orientated with the long axis east and west, only the south half (the part that receives direct sunlight) needs shading. If the barn runs north and south, the entire roof should be shaded.

A compromise between shade and natural light should always be determined by the animals' environmental needs. Although the sun can help dry bedding and provide a sanitizing effect, the direct sun may not be beneficial to the animals' needs. Warming the barn to dry out the resting space will not work if poor ventilation traps moisture in the barn.

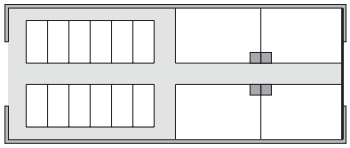
Layouts and Cost Comparisons

Three different layouts are shown as examples for dairy housing systems. (See Tables 2 through 4 and Figures 8 through 10 on the following pages.) These are common layouts for greenhouse barns and post frame buildings. The layouts show simple and cost effective housing arrangements for particular situations. The producer's planning process should determine what is most appropriate for an individual farm.

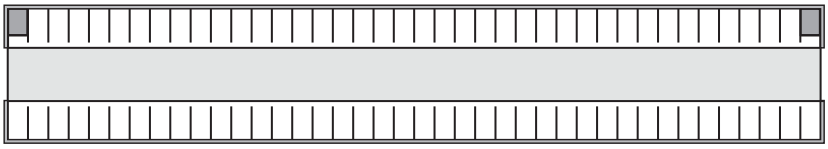
The attached worksheets attempt to calculate the entire cost of the system designed, including materials and labor. The worksheets present the estimated materials and constructed costs for a greenhouse frame and a post frame building.

These costs can be adjusted. An individual producer may choose not to include all the features that are listed or may wish to add or substitute features to the plan. Prices were compiled based on estimates from three post frame builders and three greenhouse frame suppliers located in Wisconsin. Costs do not include site preparation and utilities because of the site specific nature of these items.

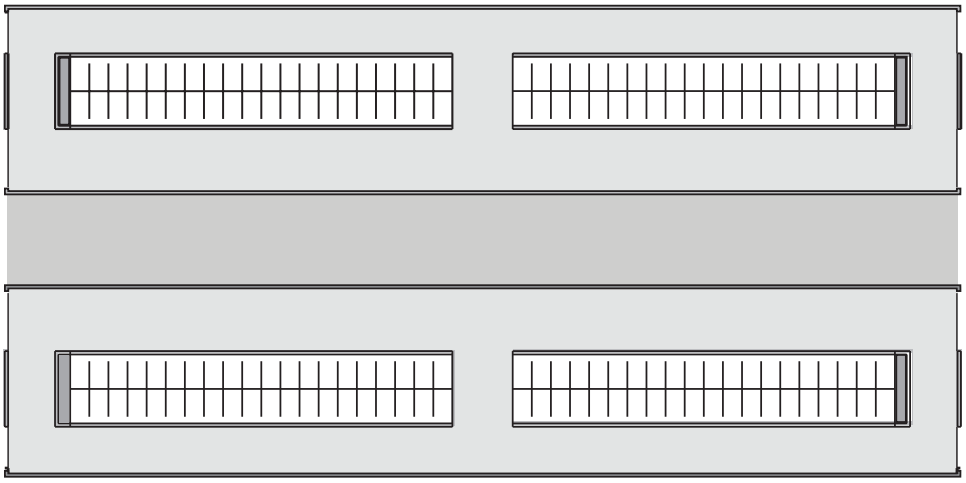
Use the attached worksheets for your own cost analysis, and compare system options for your own situation. Develop several building system options, and get complete and accurate cost information from reputable dealers. Determine what the total cost of the system is depending on what you want. Cost estimates that show up in popular press articles don't always include all the costs of a building, or those cost estimates may be for a building that does not meet your needs. Compare cost estimates for buildings with equivalent features, and be sure that those buildings meet your needs.



26 ft x 64 ft Building Layout



26 ft x 154 ft Building Layout



94 ft x 190 ft Building Layout

Table 2. Greenhouse vs Post Frame Cost Comparison [a,b,c]
36 Calf Barn
26 ft x 64 ft

Component	Description			GREENHOUSE FRAME [d]				POST FRAME			
				Materials only		Installed		Materials only		Installed	
	# of units	Dimensions	Total Area	$/unit or $/sq ft	$	$/unit or $/sq ft	$	$/unit or $/sq ft	$	$/unit or $/sq ft	$
Basic Frame (see Fig 8)	1	26 ft x64 ft	1,664 sq ft	$2.50	$4,160	$3.00	$4,992	$3.00	$4,992	$4.00	$6,656
Concrete floors and Group pens	1	26 ft x32 ft	832 sq ft	$1.50	$1,248	$3.00	$2,496	$1.50	$1,248	$3.00	$2,496
Sand based floor (individual pens)	1	26 ft x32 ft	832 sq ft	$0.25	$208	$0.25	$208	$0.25	$208	$0.25	$208
4' Sidewall curtains and controls	2	4 ft x64 ft	512 sq ft	$1.00	$512	$1.50	$768	$1.00	$512	$1.50	$768
8' End wall construction	2	8 ft x26 ft	416 sq ft	$1.50	$624	$2.00	$832	$1.50	$624	$2.00	$832
Freezer doorstrips for doors (3 in. overlap of strips)	2	8 ft x10 ft	160 sq ft	$2.40	$384	$2.40	$384	$2.40	$384	$2.40	$384
Welded Wire Calf Pens	12	4 ft x8 ft		$24.00	$288	$24.00	$288	$24.00	$288	$24.00	$288
Steel Gates between pens	4	10 ft		$60.00	$240	$80.00	$320	$60.00	$240	$80.00	$320
	4	16 ft		$96.00	$384	$125.00	$500	$96.00	$384	$125.00	$500
Waterers	2			$400.00	$800	$600.00	$1,200	$400.00	$800	$600.00	$1,200
Welded wire panels (protect curtain)	2	64 ft	128 lineal ft	$1.00	$128	$1.00	$128	NA	NA	NA	NA
Shade fabric (greenhouse only)	1	26 ft x64 ft	1,664 sq ft	$0.25	$416	$0.25	$416	NA	NA	NA	NA
Misc. Items (ADD 5% to Materials only)	1				$470				$484		
Total cost					$9,862		$12,532		$9,680		$13,652
Cost Per Calf				$274		$348		$269		$379	

NA = Not Applicable
[a]Prices compiled based on estimates from three post frame builders and three greenhouse frame suppliers.
[b]Does not include site preparation, utilities, driveways, etc., due to the site specific nature of these items.
[c]Cost does not include manure storage. Manure handled by daily scrape and haul.
[d]Plastic needs to be replaced every five years at $0.26 per sq. ft. ($433 every five years)

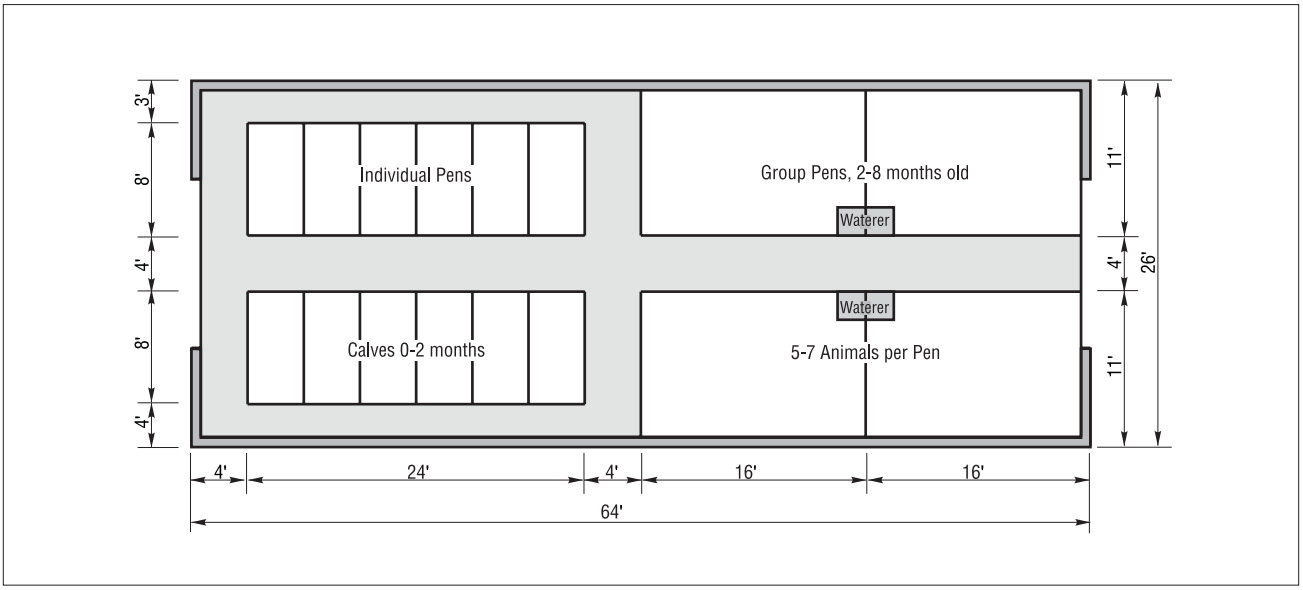


Figure 8. Example layout for a 26 ft x 64 ft building.

Table 3. Greenhouse vs Post Frame Cost Comparison [a,b,c]
80 Stall Freestall Barn
26 ft x 154 ft

	Description			GREENHOUSE FRAME[d]				POST FRAME			
				Materials only		Installed		Materials only		Installed	
Component	# of units	Dimensions	Total Area	$/unit or $/sq ft	$	$/unit or $/sq ft	$	$/unit or $/sq ft	$	$/unit or $/sq ft	$
Basic Frame (see Fig 9)	1	26 ft x154 ft	4,004 sq ft	$2.00	$8,008	$2.50	$10,010	$3.00	$12,012	$4.00	$16,016
Concrete scrape alleys and curbs (Total Floor area minus freestall area)	1	10 ft x154 ft	1,540 sq ft	$1.50	$2,310	$3.00	$4,620	$1.50	$2,310	$3.00	$4,620
8' Sidewall curtains and controls	2	8 ft x154 ft	2,464 sq ft	$1.00	$2,464	$2.00	$4,928	$1.00	$2,464	$2.00	$4,928
10' End wall construction	2	10 ft x26 ft	520 sq ft	$1.50	$780	$2.00	$1,040	$1.50	$780	$2.00	$1,040
Freezer doorstrips for doors (3 in. overlap of strips)	2	10 ft x10 ft	200 sq ft	$2.40	$480	$2.40	$480	$2.40	$480	$2.40	$480
Open Ridge	1	154 ft	154 sq ft	$6.50	$1,001	$6.50	$1,001	NA	NA	NA	NA
Gates to protect doors	2	10 ft		$60.00	$120	$80.00	$160	$60.00	$120	$80.00	$160
2" x 6" front of freestalls (3 high)	2	154 ft	308 lineal ft	$2.70	$832	$4.00	$1,232	$2.70	$832	$4.00	$1,232
2"x10" brisket board	2	154 ft	308 lineal ft	$1.75	$539	$2.25	$693	$1.75	$539	$2.25	$693
Freestall partitions (with neck rail and post)	76			$70.00	$5,320	$100.00	$7,600	$70.00	$5,320	$100.00	$7,600
Waterers	2			$400.00	$800	$600.00	$1,200	$400.00	$800	$600.00	$1,200
Welded wire panels (protect curtain)	2	154 ft	308 lineal ft	$1.00	$308	$1.00	$308	NA	NA	NA	NA
Shade fabric (greenhouse only)	1	26 ft x154 ft	4,004 sq ft	$0.25	$1,001	$0.25	$1,001	NA	NA	NA	NA
Misc. Items (ADD 5% to Materials only)	1				$1,198				$1,283		
Total cost					$25,161		$34,273		$26,940		$37,969
Cost Per Cow				$315		$429		$337		$475	

NA = Not Applicable
[a]Prices compiled based on estimates from three post frame builders and three greenhouse frame suppliers.
[b]Does not include site preparation, utilities, driveways, etc., due to the site specific nature of these items.
[c]Cost does not include manure storage. Manure handled by daily scrape and haul.
[d]Plastic needs to be replaced every five years at $0.26 per sq. ft. ($1,041 every five years)

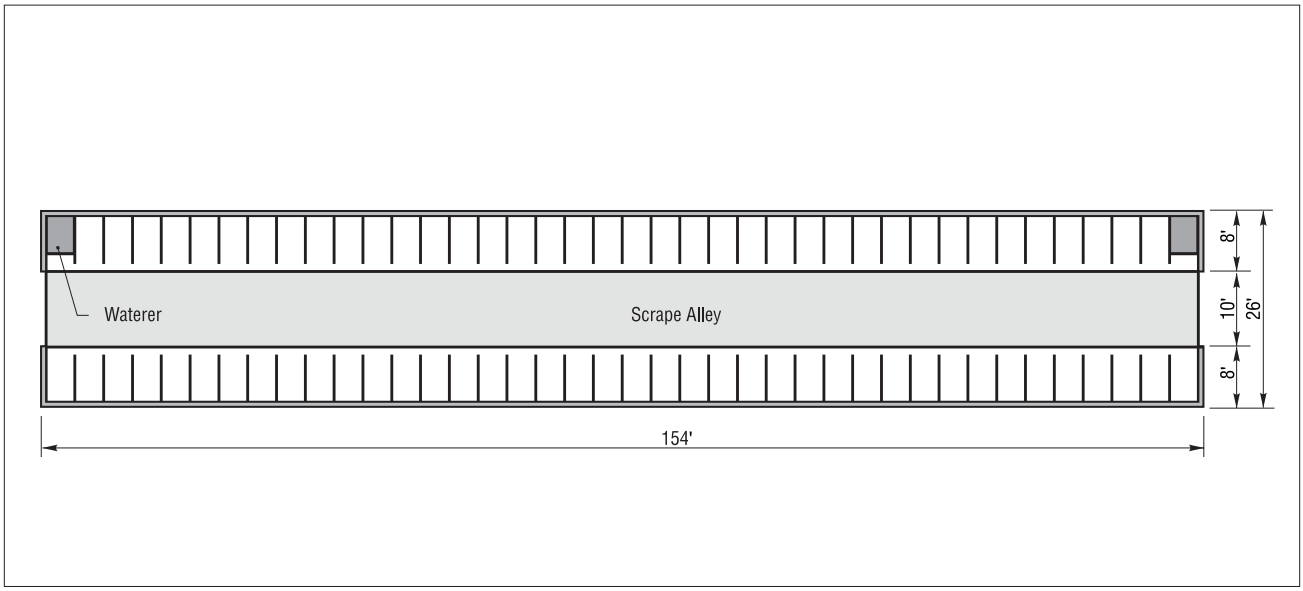


Figure 9. Example layout for a 26 ft x154 ft building

Table 4. Greenhouse vs Post Frame Cost Comparison [a,b,c]
4 Row 160 Stall Freestall Barn
94 ft x 190 ft

	Description			GREENHOUSE FRAME (Five Spans) [d]				POST FRAME			
				Materials only		Installed		Materials only		Installed	
Component	# of units	Dimensions	Total Area	$/unit or $/sq ft	$	$/unit or $/sq ft	$	$/unit or $/sq ft	$	$/unit or $/sq ft	$
Basic Frame (see Fig 10)	1	94 ft x190 ft	17,860 sq ft	$2.75	$49,115	$3.75	$66,975	$3.00	$53,580	$4.00	$71,440
Concrete scrape alleys and curbs (Total Floor area minus freestall area)	1		13,180 sq ft	$1.50	$19,770	$3.00	$39,540	$1.50	$19,770	$3.00	$39,540
10' Sidewall curtains and controls	2	10 ft x190 ft	3,800 sq ft	$1.00	$3,800	$2.00	$7,600	$1.00	$3,800	$2.00	$7,600
12' End wall construction	2	12 ft x94 ft	2,256 sq ft	$1.50	$3,384	$2.00	$4,512	$1.50	$3,384	$2.00	$4,512
Freezer doorstrips for doors	4	10 ft x10 ft	400 sq ft	$2.40	$960	$2.40	$960	$2.40	$960	$2.40	$960
(3 in. overlap of strips)	4	12 ft x10 ft	480 sq ft	$2.40	$1,152	$2.40	$1,152	$2.40	$1,152	$2.40	$1,152
	2	18 ft x10 ft	360 sq ft	$2.40	$864	$2.40	$864	$2.40	$864	$2.40	$864
2"x10" brisket board	8	75 ft	600 lineal ft	$1.75	$1,050	$2.25	$1,350	$1.75	$1,050	$2.25	$1,350
Freestall partitions (with neck rail and post)	152			$60.00	$9,120	$90.00	$13,680	$60.00	$9,120	$90.00	$13,680
Waterers	4			$400.00	$1,600	$600.00	$2,400	$400.00	$1,600	$600.00	$2,400
Welded wire panels (protect curtains)	2	190 ft	380 lineal ft	$1.00	$380	$1.00	$380	NA	NA	NA	NA
Open ridge	1	190 ft	190 lineal ft	$6.50	$1,235	$6.50	$1,235	NA	NA	NA	NA
Shade fabric (greenhouse only)	1	94 ft x190 ft	17,860 sq ft	$0.25	$4,465	$0.25	$4,465	NA	NA	NA	NA
Misc. Items (ADD 5% to Materials only)	1				$4,845				$4,726		
Total cost					$101,740		$145,113		$100,044		$143,498
Cost Per Cow				$636		$907		$626		$897	

NA = Not Applicable
[a]Prices compiled based on estimates from three post frame builders and three greenhouse frame suppliers.
[b]Does not include site preparation, utilities, driveways, etc., due to the site specific nature of these items.
[c]Cost does not include manure storage. Manure handled by daily scrape and haul.
[d]Plastic needs to be replaced every five years at $0.26 per sq. ft. ($4,644 every five years)

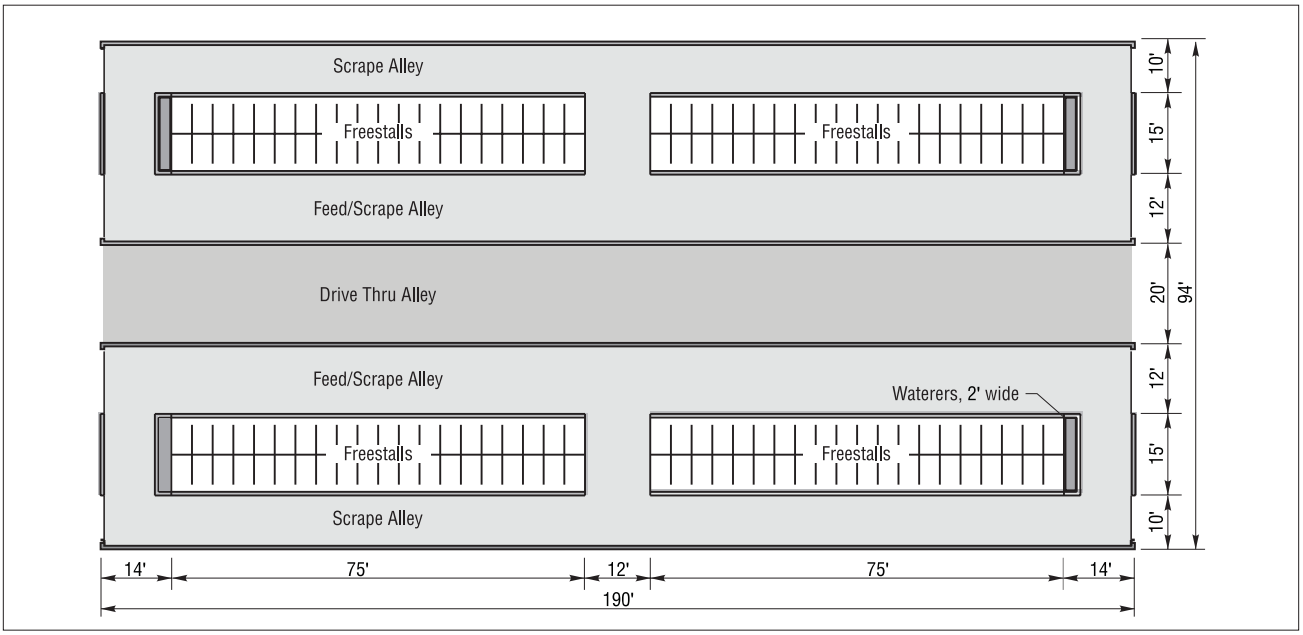


Figure 10. Example layout for a 94 ft x190 ft building.

Summary

The full impact of new dairy housing alternatives such as greenhouses needs to be evaluated for short- and long-term effects. Producers considering a greenhouse barn need to evaluate initial costs and operating costs for each alternative. They also need to gather as much information as possible about animal performance in different types of housing.

Among the major issues that a producer thinking about building a greenhouse dairy must consider are the following:

- Greenhouses used as dairy housing are not fully proven. Little history exists to show how reliable and durable these structures will be.
- Providing adequate ventilation is a crucial factor in using a greenhouse dairy successfully, and many designers lack knowledge and experience with ventilation for this type of structure.
- Ventilation management is more difficult and more labor intensive in a greenhouse barn than in a post frame structure.
- Long-term costs for a greenhouse barn may be greater than long-term costs for a post frame barn. Factors such as a short service life and poor control over the environment leading to poor animal performance may cause adverse economic effects.
- For greenhouse barns expected to be in service longer than five years, cover replacement costs need to be included in cost calculations.

The information compiled for Tables 2 through 4 in this publication suggests that for a particular design, choosing a greenhouse frame over a post frame building does not create an overriding economic advantage. In many cases, however, economics may not dictate the choice of using a greenhouse frame or a post frame building. Instead, personal preference and perceived benefits of one style over another may sway a producer to choose which housing type is more appropriate for a specific situation. For example, a producer who wants to expand quickly may find a greenhouse barn to be the best alternative, while another producer might conclude that the longer history and proven attributes of a post frame building are more appealing.

References

Those interested in additional information about the topics discussed in this publication should consult the following sources.

John W. Bartok. "Greenhouses for Calf and Heifer Housing." Pages 114-126 in *Calves, Heifers, and Dairy Profitability*, published in 1996 by NRAES. 152 Riley-Robb Hall, Cornell University; Ithaca, New York, 14853-5701. Figures 1, 4 and 5 of this MWPS publication were adapted from drawings in that article.

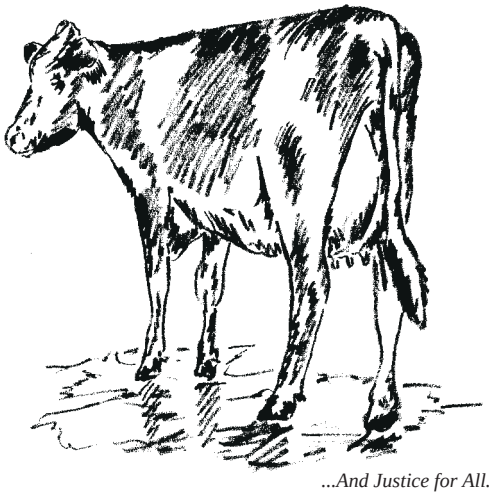
MWPS-7. *Dairy Freestall Housing and Equipment*, fifth edition, 1995. MidWest Plan Service, 122 Davidson Hall, Iowa State University, Ames, Iowa, 50011-3080.

MWPS-33. *Natural Ventilating Systems for Livestock Housing*, first edition, 1989. MidWest Plan Service.

MWPS-32. *Mechanical Ventilating Systems for Livestock Housing*, first edition, 1990. MidWest Plan Service.

MWPS-34. *Heating, Cooling and Tempering Air for Livestock Housing*, first edition, 1990. MidWest Plan Service.

MWPS-35. *Farm and Home Concrete Handbook*, first edition, 1989. MidWest Plan Service.



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