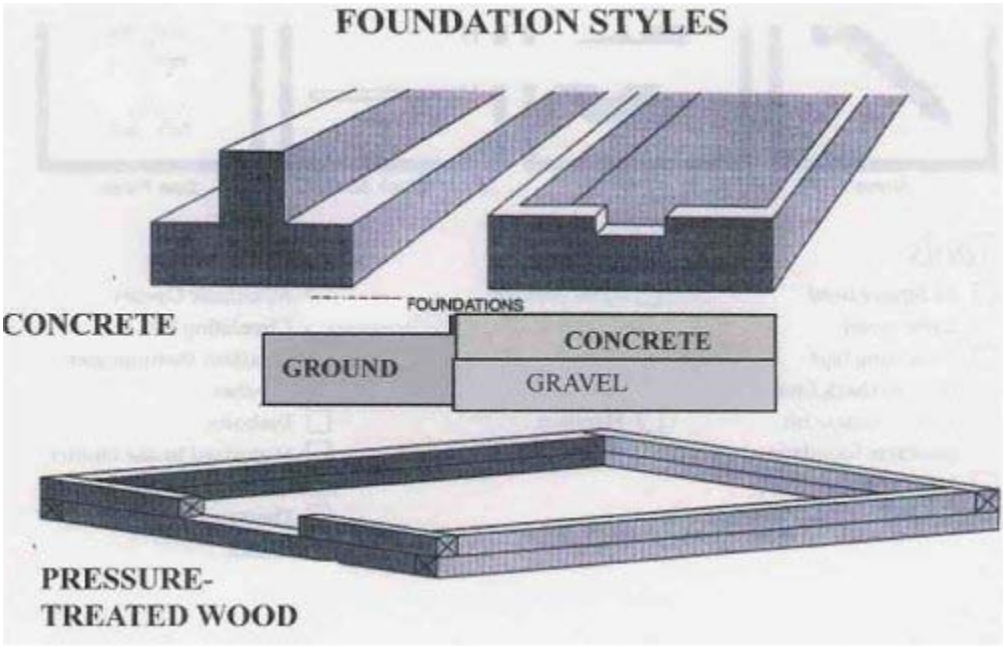
Locating Your Greenhouse

Freestanding greenhouses are generally located so that the long wall faces south for growers above the 40th parallel (all of Canada). However, for lean-to type greenhouses attached to your home, then it is usually what space is available. When thinking about getting maximum light, remember that in the winter, the sun is low in the sky and the sun rises and sets at a narrower angle than in the summer. What this means is that a greenhouse located on a west wall will get full sun a big part of the day in the summer, but will not get too much direct light in the winter. Hi-intensity lighting can be used to supplement the short growing days of winter. Some dappled shade from trees in the summer is often not a bad location: it keeps the greenhouse cooler while shading the plants from over exposure.

Check your location with a compass as even a 15% rotation makes a big difference. For example, a 15% rotation toward the southeast means that an east wall loses light earlier in the day, but the west wall increases its light significantly while the north wall for attached greenhouses starts to become viable for plants that like light shade such as Paphs and Phals . While the rule of thumb favors a straight southern exposure, it is best to remember that since you must protect greenhouses six to seven months a year with shade cloth to cut out excessive light with such an exposure--east, west or even locations under deciduous trees can be desirable.
East sun is important for warming your greenhouse in the morning with solar heat and getting photosynthesis going robustly after night rest. West sun extends the day and can raise you greenhouse temperature substantially summer or winter. For example, with a snow cover on the ground, my greenhouse can reach 25-30 C in January with 15 km wind and -10 C outside on a sunny day. Even overcast days can warm your greenhouse for the same reason that you can get sunburn on cloudy summer days.

Foundation

Before you begin, check with your local building inspector as to what sizes may be built without building permits. Usually if you stress that this is a non-permanent structure (it can be removed) for growing plants and is not a living space, e.g., a sunroom with chairs, bedroom, etc., the foundation requirements will often be more lenient. If inspectors become too fussy remind them that, frequently large commercial greenhouses only consist of rods driven into the ground with the glazing brought down to near ground level and dirt 'kicked' up to the edge to seal it.
Pressure treated wood foundations are usually satisfactory for freestanding greenhouses. Regulations become more complex any time a structure is attached to your home.



If you build with concrete, concrete block or stone, you will need to put concrete footings to below frost level. This obviously can add greatly to the cost of building a greenhouse, whether it is attached (lean-to type) or freestanding. A less costly alternative is to dig holes for 'sonotubes,' which are round, heavy-duty cardboard tubes 6", 8", 10" or 12" in diameter, and fill these with concrete to ground level. Placement is usually at 4,' 6' or 8' intervals. Then pressure-treated beams may be placed to span the sonotubes and your greenhouse built on top of the wood foundation. This is appropriate for both free standing and attached greenhouses. To simulate a rock or stone foundation, you can apply a product such as 'Mohawk' stone (located in Oshwegan, ON) to pressure-treated wood exterior. This is a 3/8" thick product that looks virtually the same as stone.

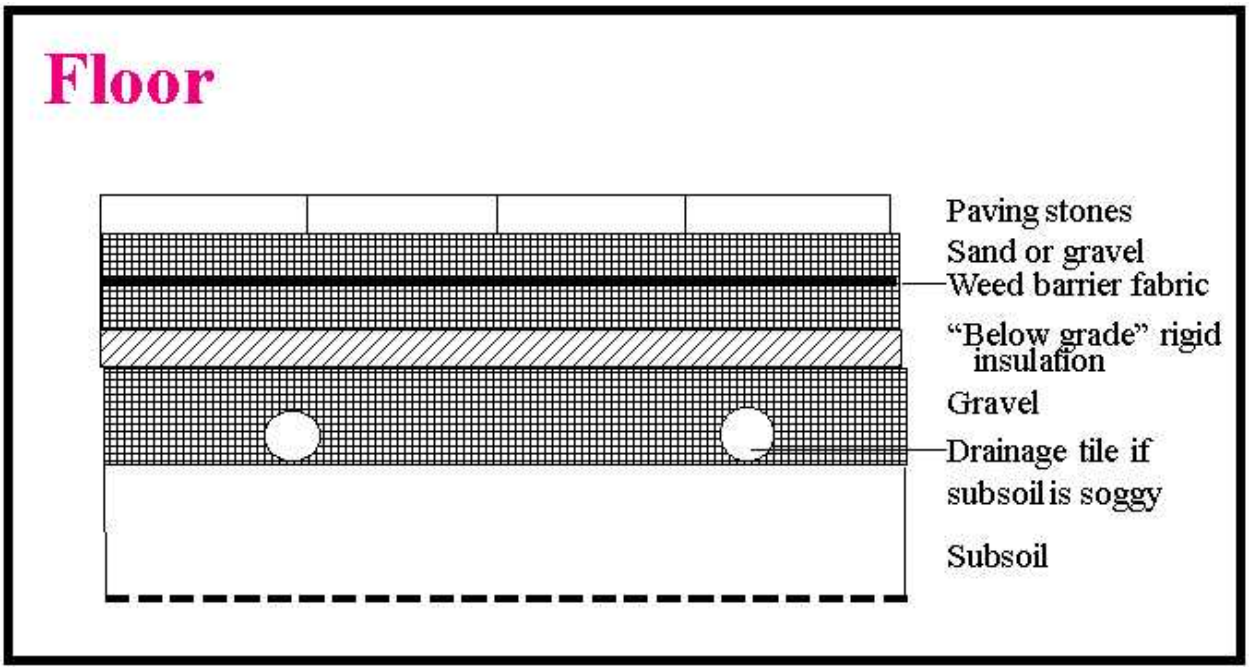
For freestanding greenhouses, the **simplest solution** is to use pressure-treated wood beams on top of a few inches of packed gravel. You can make the foundation only one beam thick to several high to increase the height of the greenhouse. I have three 6" x 6" beams, one below ground level and two above. Having something below grade is important to seal the bottom from wind. Having the greenhouse door at least a few inches above ground level makes it easier to open and close the door during the snowy winter months. Also placing a 9" or 12" patio stone under each corner insures that each side stays level at the corners. Anchor the foundation by driving steel rods such as rebar through the wood several feet into the ground. It is wise to lay plumbing, gas and electrical lines before you start to build your greenhouse. In addition, it is much easier finish putting in the floor before you build the greenhouse structure. For very **windy sites**, take extra care to anchor the foundation, use larger than standard screws or bolts between the foundation and base plate and consider purchasing an extra internal 2" steel truss available with our greenhouses.

Subfloor and Floors

Plan floor for **drainage**, **humidity retention**, & **insulation from cold** winter ground. **Floors may be as simple as a bit of sand or gravel a few inches deep.** However, the single most important feature for a year-around, all-season greenhouse is to place under the floor an inch or two of 'below grade' rigid styrofoam insulation available from building centres. This is the same insulation that is placed next to or beneath basements. What it does is to hold the heat in your greenhouse floor that you build up during the day from solar heat and slowly release it at night. Even during the summer, soil temperature a foot or more below the surface is quite cool. In wintertime, cold soil temperatures migrate to the surface as well as horizontally from the outside. This works to cool the greenhouse: the last thing you want in the winter. In my greenhouse, a warm floor maintains my night-time temperature about 5 degrees C warmer compared to a cold floor.

Tile drains are desirable if you locate your greenhouse in an area that you know can be soggy. This is especially important if you are burying a cistern under the floor, you do not want it to float! Tiles are actually continuous flexible plastic tubing with slits so that water will seep into it. As it has less resistance than the subsoil, water flows into it and away to wherever you bring it to a low surface spot. It looks rather like vacuum cleaner hose with slits and is available from CO-OP farm stores or building centres.

A couple of layers of landscaping fabric will ensure that weeds do not grow in your favorable9 greenhouse environment. See the diagram below.



Cisterns: The first rule of growing great tropical plants is that rainwater produces the best results. Capturing rain is the easy part. The debate comes with storing it. In researching how best to do this for my greenhouse, I came upon several solutions. Concrete tanks, either buried or tucked into a corner of the basement are fine but they must be lined to prevent the concrete from leaching high levels of calcium. It is best to place some sort of cover over it to prevent evaporation from creating an overly humid basement.

I have also seen used a galvanized livestock water trough buried in the centre of a greenhouse. It has been in place for many years without rust being a problem.

I thought that plastic, agricultural spray tanks might do the trick. However, manufacturers will not guarantee them if buried. My local farm CO-OP store suggested plastic septic tanks. After investigation, it turns out that most are sold to be used as cisterns for greenhouses and are rated for potable water anyway. On these 'septic tanks,' the 'out' opening is set lower than the intake, making it useful for an overflow. I put an inverted 'U' in just past the 'out' so that I could get a bit more capacity and prevent spring water runoff from backing up into the cistern. It cost about $700 for 600 imp. gal., which I figured would hold about 4" of rainwater falling on my 12 x 18 greenhouse. I use the water off the house roof on my new greenhouse. It also has two plastic manhole covers on the top, each large

enough to get inside to clean it out if needed.

Shallow well pumps complete with small pressure tanks are available for about $300 in building centers. These allow you to have on/off constant water pressure. Less expensive mini-pond pumps are either always on or always off; they cannot be used to feed misters or foggers.
Greenhouse Construction Terms

Greenhouse types:

Attached or lean-to: One wall usually becomes the side of a house. The eave end may be attached so the greenhouse is perpendicular to the house or the attachment may be along the peak of the greenhouse running parallel to the house. Cheapest to heat; convenient to house.

Freestanding: Less complicated for foundation as doesn't need to be attached to a wall; house walls do not ever block sunlight; easier to add extensions to; more convenient if using insecticides.

Curved Eave: looks pretty but more difficult to built and to add on guttering; sheds snow more quickly

Straight Eave: traditional greenhouse style, easiest to build, easiest to add on guttering

Glazing:

Polyethylene Film: Inexpensive, structure needs frequent maintenance; but expensive to heat, negligible R (relative heat gain, a measure of insulating value, the higher the better); better if two layers + airspace is used; covering lasts typically from two to five years depending on the quality grade .

Glass, single pane: More expensive to build but structure is more permanent and needs less maintenance; still very expensive to heat in Ontario without additional insulation in winter; R = 0.8; single pane glass is great for England or Vancouver where the climate is mild and sunshine is scarce; the opposite is true in Ontario with abundant sunshine and long, cold winters. About 90% of light penetrates.

Glass, double pane: Most expensive and heavy to build, seals may leak with age and may cause clouding after 15 years and usually only have a five or ten year warranty against leaks in the seals; best for solariums; provides significant savings on heat; R = 2.0

Polycarbonate, rigid twinwall: Much better than glass for most Canadian conditions. Somewhat more expensive to build than single glass but

lightweight to handle and easier to glaze; also much easier than glass to modify for heater exhaust pipes, exhaust fans and vents, etc.; heat savings over glass are significant; stronger than most glass with higher snow load rating; easy to maintain; R = 1.5; usually 6 or 8 mm thick; guaranteed by polycarbonate manufacturer not to crack or yellow for ten years and rated to withstand a 16 lb. weight dropped from 25' without cracking; exterior UV treated; can be bent for curved eave applications; about 80% of light penetrates; light is diffused to help prevent plant sunburn.

Polycarbonate, rigid triple wall: somewhat less expensive than double pane glass; highest R value, R = 2.5; usually 16 mm thick; same advantages as twinwall but higher insulation value; cannot be bent for curved eave applications; about 78% of light penetrates; light diffused; best for windy, exposed areas and colders locations. Least expensive to heat.

Combination glazing: If you have a view that you want to be able to see from your greenhouse, you may order one or all four walls in glass and the roof in higher insulation value and better snow load rating polycarbonate. Twin wall polycarbonate may be combined with single pane glass; triple wall polycarbonate with double pane glass.

Fibreglass panels: become brittle and yellow with age, not recommended

Glazing Bars:

Cedar: looks pretty; does not transmit cold but recommended that glazing be removed and cedar resealed, painted , etc. every five years to prevent rot; expensive to build with.

Aluminum alloy: most common hobby and commercial greenhouse structural material; strong, durable, will not rust; usually comes with a lifetime guarantee; but will wick cold.

Galvanized steel: a special variety impregnated with galvanizing so that cut ends, drilled holes, etc., do not rust; commonly used in hoop houses. Less expensive than aluminum alloy.

Hardware: Should be galvanized at least; stainless steel is preferable

HEATING:

How large does my heater need to be?
For electric or gas heat:

Multiply total wall & roof area in sq. ft.
Times
The ***difference between*** lowest, outside winter night temperature in F

AND the night temperature desired in your greenhouse.

The ***result equals*** the Btu (British thermal units, a measure used to rate the heat produced by a particular heater: small portable electric heaters are typically 4000-5000 Btu's) heater output required for a standard glass greenhouse.

BUT
Reduce by 25% for twin-wall polycarbonate
Reduce by 25% for attached-to-home greenhouse
Reduce by 35% for double-pane glass
Reduce by 40% for triple-wall polycarbonate

Note that the physical size of your heater has nothing to do with its output or Btu rating. Electric, 220-volt construction-trade heaters produce 15,000 Btu's, but are only the size of a smaller waste basket and cost less than $100 at Home Depot. They have the advantage that they take up little valuable greenhouse space. However, if the power goes out, you lose your heat unless you have a standby gasoline generator.

Propane or natural gas heaters typically cost $800 or more and require external exhaust and ventilation. Ones with millivolt thermostats still come on and turn off without electricity. These thermostats operate on AA batteries. Therefore, if the power goes out, the heat stays on. Some come with fans to help circulate heated air, increasing their efficiency but these are not necessary to keep your greenhouse warm. These heaters have become increasingly popular since the great Ice Storm of 1997. Propane and gas heaters usually produce heat at a lower cost than electric sources but are usually bulkier and take up more room in your greenhouse. Hunter and Empire are the most common manufacturers. Shop around as residential installers can be expensive. Lennox makes commercial duty heaters.

Boilers and hot water heat are a popular alternative. Victorian greenhouses and conservatories were traditionally heated this way in England. Wood or pellet stoves are a possibility. However, they take up much room because of the necessary clearances and might be better in an attached and insulated addition with the heat pumped in.

You may also consider buying a portable propane heater that screws into the top of a bar-b-que propane bottle. You must provide some external ventilation for these but they work well in an emergency. They are not designed to be used on a daily basis.

VENTILATION:

Greenhouse doors frequently have sliding glass panels with screens

behind them for manual ventilation. Roof or wall vents with automatic vent openers are the best passive air movers. Wall-mounted exhaust fans with motorized intake vents on the opposite wall provide active air exchange and operate via a thermostat. High speed fans for such setups can completely exchange all the greenhouse air in a minute or two. Exhaust fans with several speeds are preferable. Very fast evacuation also removes humidity too rapidly requiring foggers or misters to run frequently. A slower speed cools the greenhouse without removing valuable humidity. You need to build covers in the wintertime for exhaust vans and vents to prevent air leakage: construct a wood frame with a piece of rigid styrofoam inside and a poly covering around the frame. CO-OP agricultural stores sell livestock building fans that are less expensive than greenhouse fans but designed for humidity; check output for appropriateness.

Circulating fans are a must for most plants to help prevent disease, mold, etc.; commercial ones are about $200; ceiling fans quite a bit less; variable speed an advantage: better to have higher speed in summer than winter.

ACCESSORIES & USEFUL TIPS :

Automatic vent openers: mostly solar powered, open when greenhouse becomes too warm.

Vents in walls rather than roof: an advantage is that these do not interfere with shade cloth but do not exhaust hot air at the roof during the summer heat.

Circulating fans, exhaust fans and automatic intake shutters: plants can take higher heat and sun levels if there is generous air movement. Leaves easily sunburn where air movement does not stir the heat buildup off the leaves.

Max/min thermometers: several of these placed at ground level, bench level and ceiling.

Temperature Alarm: hi-lo alarm sounds in your house when greenhouse temperature reaches dangerously high or low temperatures; some with general power failure alarm to alert you before hi/lo temperature has been reached.

Foggers/misting systems: foggers have the advantage that unfiltered rain water may be used; misting systems require filters as the nozzles have rather small openings that clog; both turn on and off by a humidistat with desired humidity settings or timers; foggers work best to maintain humidity and cool the greenhouse in the summer; misters may be set below the benches or close to the ceiling and are helpful in cooling the

greenhouse in the summer; foggers produce a finer water 'mini-droplet'.

Benches/roll benches: benches may be made of cedar or pressure treated wood; I prefer that what roots touch not to be made of pressure treated; "rabbit cage wire" in heavier gauge is available as a bench covering from CO-OP or farm stores and is easy to cut; wood slats look nice but rot more quickly than galvanized wire rusts; commercial roll benches save space by the top rolling side to side so that only one alley is open thereby converting an entire alley to available bench space: roll left and you have access to plants on the right of the centre bench and right wall, or roll to the right and you have access to plants on the left side of the centre bench and the left wall; concrete blocks make the best bench legs: they never rot!

Heat: electric, gas or propane, boilers, external wood stoves .

Soil cables or mats: great for annual seedlings or to selectively warm plants.

Backup emergency heat: propane heaters that screw into a bar-b-que propane bottle produce heat on hi/lo settings for up to 20 hours but need some external combustion air (open door screen slightly, etc.); kerosene heaters also need external air, some people will tell you that plants produce all the air needed for combustion: only true if they were able to photosynthesize at a high rate 24 hours a day and your greenhouse was packed floor to ceiling with plants! May buy at big box building centers.

Sinks/potting benches: sinks may drain on the greenhouse floor.

Fertilizer proportioners: "Dial-a-setting" that are a plastic container that attaches to a garden hose provide various concentration levels, these are cheap and easy; commercial duty ones cost $350 and up.

Additional winter insulation; bubbles or liners: twin wall flexible poly 'bubbles' are available to be placed over greenhouses; air in pumped continuously between the two layers producing an 'air space' or bubble; mostly used on older single pane glass greenhouses; trickly to put up, reduce light levels with clouding with age; BC Greenhouse Builders manufacture small plastic clips that snap into the vertical glazing bars on the inside of the greenhouse allowing a 2-4 mil flexible poly sheet to be attached to form an additional insulation layer; cheap and handy, especially in emergencies or very extreme winters; must be applied around shelving or baskets attached to the glazing bars; fits Jacobs greenhouses also; 'double bubble' used for insulating water heaters is like bubblewrap with foil on one or both sides works well for the inside of glass doors or to create a microclimate on the north side of your greenhouse. Buy it in building centres or Lee Valley Tools.

Lighting: a simple fluorescent for evening inspection; high intensity lamps for additional growing light in winter for light loving varieties such as Vandas; available on tracks that the lamps travel on by motor back and forth; try hydroponics suppliers for these such as Frank's Magic Crops in Burlington, ON (see his WEB site). <insert web address>

Shade cloth: available from 30% shade to 80% shade; black most common but white and green available; woven fabric unacceptable as it unravels if you get a tear in it; buy only knitted fabric; order slightly oversize as it will pull or stretch either direction like a sweater; 50-60% if in full sun for Catts, Oncidiums; 70% or more for Phals, Miltonias and Paphs. I use two- one for spring and fall and then add another for the brightest part of the summer.

Rods for hanging plants: galvanized plumbing pipe hung from the ceiling with S-clips (like on the ends of bungee cords but heavier); clips available in Canadian Tire.

Clearing snow off the greenhouse roof: telescoping, light weight aluminum poles with 20" brushes are handy for this job: these are made for swimming pools and available in any pool store. Many of these stores shut down for the winter, but often will phone you back if you leave a message.

Reflective fabric: silver on one side, black on the other; can be used to increase light levels in winter by placing on the floor or north wall