The Complete Guide To
Building Your Own Greenhouse

By Max Clarke

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Recommended Resources

- **Web Site Hosting Service**
- **Internet Marketing**
- **Affiliate Program**

Please Read This First

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About the Author

Max Clarke has been a keen amateur gardener for several years.

He loves building things to help him with his hobby and has actually made several small greenhouses.

He is grateful to his friends, both amateur gardeners and commercial growers that have shared some of their experiences and knowledge to help make his gardening and his book better.

He says that everyone should invest some time to create and maintain their own garden even if they only have a small area available.

A small garden is within almost everyone's budget and there are many rewards.

You will only really understand what he means when you start eating fresh, flavorful and inexpensive fruit and vegetables that you grew yourself.

But Max also gets great joy by sharing the produce and flowers that he grows and the knowledge from his years of experience as a gardener with his friends, family and, now, with the readers of his first book.

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Part-I: Introduction

1. What is a Greenhouse?

A greenhouse is a small house-shaped structure made of glass or plastic. It is designed to maintain optimum temperature and moisture inside it to help grow a wider variety of plants than the local climate will normally support and to protect them from any extreme weather.

Certain gases in the atmosphere, like carbon dioxide, water vapor, methane and nitrous oxide do not allow heat to escape back into the atmosphere. This quality makes these gases popular in commercial greenhouses.

Greenhouse with Geraniums (Pelargonium sp)

All greenhouses function on the same principle; they store heat from the sun. The glass or plastic panels of greenhouse reduce the amount of heat escaping while allowing light to penetrate. This increases the temperature within the greenhouse and keeps your plants warmer in winter.

Lettuce seedlings grown in a greenhouse before planting

Greenhouses range from a small structure for keeping in your terrace garden to as big as a city building. Their glass panels are grouped according to their transmission rate. The energy trapped within greenhouses heats up both soil and plants. They prevent or reduce infrared radiation, convection of gases and arrest electromagnetic radiation too.

Greenhouses are used for growing vegetables, fruits, flowers, and even crops like tobacco. You can grow flowers and vegetables in late winter in greenhouses, then transplant them outside in early spring.

These houses have meant an increase in artificial pollination although using bees is preferred when practical.

You have to maintain specific levels of humidity and heat within your greenhouses and control any potential influx of pests and associated diseases.

You can irrigate the plants in greenhouses if the need arises. The increased temperature is essential if you try growing summer vegetables in winter.

Greenhouses maybe used to protect plants from blizzards and dust storms too. Such greenhouse cultivation proves useful in deserts, Arctic wastelands and other land areas with poor fertility.

2. Uses of a Greenhouse

A greenhouse helps you grow your plants at regulated temperatures and humidity levels. It is easier to regulate temperatures within small greenhouses. Greenhouses are not necessarily hot houses. They allow the required amount of heat to be present within so that plants do not suffer from extreme heat or extreme cold. Having a greenhouse need not be a luxury. With a little persistence and innovation, you can have a greenhouse anywhere.

Coriander seedlings in a greenhouse

The Main Uses of a Greenhouse are –

- Helping small and tender plants to grow from seeds earlier than usual

- Grow plants within indoor environment in winter months
- Helps carry forward garden plants to use as stock in the next season
- Increases the variety of plants and blooms
- Allows you to experiment with new varieties of flowering plants and vegetables too
- Helps cultivation of winter vegetables in pots
- Helps maintain a continuous supply of vegetables all year through
- Helps develop your hobby of growing plants even if there is a space crunch

Innovative Uses of Old Greenhouses Include:

- Bus-stop for children in a cold winter
- Proves to be a garbage bin without the possibility of animals or pests creating a nuisance with open garbage
- Useful as a pottery room for children
- Useful as a storehouse for holding skateboards, bikes, ramps, and other things
- Can be used as a hot water tub for bathing

Part-II: Greenhouse Selection

3. Greenhouse Types and Styles

There are many different styles and types of greenhouses.

Greenhouse with Geraniums

Some of the more popular are:

A Freestanding Greenhouse: This greenhouse has an independent structure, not attached to your home. It has independent sidewalls, end walls and a gable roof. You can make it in any size, shape and style that you like and that can get planning permission for.

The amount of sunlight penetrating your greenhouse depends on various factors in its construction. You could an need extra heating system if the free-standing greenhouse is completely separate from a heated building.

This freestyle greenhouse spreads over seventeen to eighteen feet. It can accommodate two walks, two side benches, and a center bench.

Business and Commerce Use

An Attached Greenhouse: These greenhouses are connected directly to your main building. Such greenhouses receive heat radiated from your home. Additionally, you can arrange for any necessary heat and light infrastructure from your home too. Also, be sure to take into consideration any special building restrictions that exist before constructing an attached greenhouse.

There are different types of attached greenhouses, including lean-to, even-span or window-mounted.

Attached, lean-to greenhouses lean against the building. They are supported because one of the sides is attached to the house. Lean-to greenhouses may have single or double-row plant benches with a total width between seven to twelve feet.

There is no absolute restriction on the length; it can be as long as the building. This type of greenhouse can get its water, electricity and heat from your home itself.

However, there are a few disadvantages too. These lean-to greenhouses may be constricted because of limited availability of space, light, and ventilation.

A Commercial User

Attached, Even-Span Greenhouses are an almost independent structure except that one end is attached to the house.

This type of greenhouse allows greater flexibility in arranging plants. It can easily accommodate two to three rows of plants. Attached, even-span greenhouses may be costlier to heat as they are larger. The exposed area of glass is likely to be greater.

Attached, Window-Mounted Greenhouses may be either a single unit or arranged in a stack on windows. You can construct a greenhouse to fit into your window by removing your regular window with simple tools and fit your greenhouse into the window space. You can use your imagination to fabricate your greenhouse in any shape you desire.

Portable Greenhouses: These greenhouses are available in many different sizes ranging from six feet to fifty feet in length and ten to a hundred feet in width. The largest of these are

still often called portable even though they are not portable in the true sense of the term.

Some of these use polythene sheeting and many have metal frames.

Commercial greenhouse

There are various portable greenhouse kits available. You can assemble and re-assemble them to fit changed circumstances. These portable greenhouses help you enjoy your hobby of gardening at any place and throughout the year.

When you purchase a portable greenhouse, check if it can withstand the most extreme temperatures and other weather conditions you can expect to experience in your area.

Permanent Greenhouses: These greenhouses are the most expensive greenhouses. They are more durable and can

withstand extreme temperatures and weather conditions. Enthusiastic gardeners can assemble a permanent greenhouse to suit their individual needs and preferences in many shapes and sizes from a number of self-assembly kits that are available.

Some of the most popular styles include:

- Lean-to - leaning on to the main building
- Classic A-frame with slanting sides
- Modified A-Frame with gable roofs and straight walls
- Quonset Hut with round walls and hoop style
- Gothic Arch with straight sides and curved roof pointed on top, and
- Barn-Style greenhouses

Conservatory greenhouse

Greenhouses for Your Area

Cool Greenhouses maintain temperatures of about 40 degrees farenheit and require less insulation and specialized structure than some other types. They are helpful for storing seedlings and a fairly small number of plants.

Warm Greenhouses have temperature around fifty degrees farenheit. According to outside weather conditions, these greenhouses could require additional heating equipment such as lamps. Houseplants flourish in this type of greenhouses.

Hot Greenhouses have temperatures around seventy degrees. You need special lamps to maintain these higher temperature levels within them.

Pit Greenhouses sets the houseplants at ground level. Then, you dig a below ground-level walkway about three feet deep and line it with plywood. This gives you easy access to your greenhouse plants.

Solar Greenhouses can be of almost any shape or style. They must be located to collect the most solar energy available to provide warmth to your plants at night. You may need to provide additional heat too.

How to Choose a Greenhouse

Your choice of greenhouse depends on your own desires.

Before deciding on any particular greenhouse, analyze the environment, your budget and the type of plants you want to grow.

Placement of Your Greenhouse

Greenhouses should be open to sunlight. The presence of deciduous trees is an asset. These trees provide necessary shade during summer and remain bare during winter. This allows all available sunlight to penetrate into your greenhouse when it is most beneficial.

Greenhouse interior

Protect your greenhouse from extreme weather conditions like high winds and high variations in temperature. Trees could prove useful in blocking high winds but will block some sunlight too.

The ideal placement of greenhouses should be to receive sufficient sunlight while remaining safe from high and devastating winds.

Greenhouses should be at a higher level than surrounding areas to allow easy drainage of precipitation and groundwater. Place your greenhouse where you, any visitors or customers and also vehicles have easy access. This also ensures easy supply of electricity, water, and heat too.

Choice of Greenhouse

Greenhouses are available in different shapes and sizes. You have to decide the best size and shape for your situation and desires. Think carefully what accessories and building materials are necessary for your greenhouse.

Size: Preferably, choose a greenhouse at least one size larger than you feel currently necessary. This helps you accommodate more plants in your greenhouse, should the opportunity to get them arise and also give you scope for further expansion too.

Portable greenhouses need to be compact while lean-to greenhouses can be of whatever size would be appropriate to the site you have available.

Hops growing in a commercial greenhouse

Type: Choose between freestanding and lean-to greenhouses. Freestanding greenhouses are independent structures that need their own support. Lean-to greenhouses are partly supported by a building wall and are also usually easier and less expensive to heat.

Materials: Materials that you use in your greenhouse determine the effectiveness of the insulation, amount of light available, and the amount and cost of maintenance required.

Paneling Materials for your greenhouse may include Polyethylene, Polycarbonate, Glass, PVC or acrylic.

Polyethylene is lightweight and cost-effective. It allows easy transmission of light and remains stable for two to five years. Normally, there is a UV-resistant coating for extra protection.

Polycarbonate is very durable and inexpensive. It is a very effective insulator and causes drastic reduction in costs of insulating a greenhouse against extreme temperatures.

Glass is the most durable of all paneling materials and forms an airtight structure. This helps to prevent high winds from causing some problems.

Acrylic is a lightweight and inexpensive paneling material. Combine it with polycarbonate roof paneling to receive greater insulation and better diffusion of sunlight.

PVC greenhouses are easy to transport and useful for small areas.

Framing Materials

Framing materials for your greenhouse may include aluminum, galvanized steel, plastic and wood.

Aluminum is probably the most durable; it does not deteriorate due to sun exposure or precipitation. It is a good conductor of heat and cold.

Galvanized Steel is currently inexpensive and provides a strong structural frame for your greenhouse. It allows greater sun exposure. However, it could rust with prolonged use.

Wood is very lasting and allows easy mounting of hooks and other greenhouse fittings. Most wood deteriorates due to exposure to humidity and insects although cedar and redwood

cope well and produce a more stable structure because of their weight.

Plastics are usually relatively inexpensive and easily portable as well as being more energy efficient than metal frames.

5. Buying a Greenhouse

Greenhouse gardening is gaining popularity because greenhouses help you to grow your plants throughout the year.

Empty greenhouse

Before purchasing your greenhouse, check on these factors:

Materials: Normally, greenhouse frames are either wood or aluminum. Wood requires extra maintenance like coating with wood preservative or painting. Bubble plastic sheeting can prove helpful when using wooden frames. Aluminum does not have any maintenance costs.

Access: Your greenhouse should have easy access. Sliding doors are good, providing a simple way to enter and manage your greenhouse. Doors should have a width of 2' 6".

Siting Your Greenhouse: Siting of your greenhouse should be to let it receive maximum sunshine for the better part of the day. Placing your greenhouse close to your house can ensure easier access in all types of weather.

Choose a greenhouse that can fit close to your house. This may bring down electricity and watering costs too.

Greenhouse Interiors

Before purchasing your greenhouse, check its interiors. The paths in it should, ideally, be about two feet six inches in width. They should be firm to reduce the chances of slipping.

Staging should be at the correct height for you to arrange pots on shelves with a minimum of bending.

Greenhouse with Dahlias

Heating: Options for heating your greenhouse could be through electricity, butane gas or paraffin. The minimum temperature necessary for your greenhouse is 45-47F. This helps grow almost all kinds of plants in any season.

The electricity supply should be sufficient to ensure adequate ventilation and warming of the soil too.

Electric Heaters available in greenhouses could be fans or tubular types. Fan heaters use more electricity. However, they encourage greater ventilation, especially in summer.

Paraffin Heaters offer a cheap alternative for heating your greenhouse. They provide a lot of heat but also generate lot of

water vapor. This could cause condensation, if the greenhouse has a polythene cover. If you opt for a paraffin heater, fix it outside your greenhouse to prevent circulation of its harmful fumes within the structure.

Ventilation: This is a very important factor to consider when purchasing your greenhouse. Most greenhouses have roof windows for hot air to escape. Cool air comes in through side windows or doors. Some greenhouses have automatic ventilators that open and close according to the temperatures within.

A thermostatically-controlled extractor fan can prove most effective to ventilate your greenhouse. These are easily installed and maintain continuous movement of air, thereby reducing condensation. But, they are relatively expensive.

Shading: Shading is essential to maintain the necessary coolness within your greenhouse to prevent excessive heat entering the greenhouse and maintain the ideal temperature within it.

Refrain from using shading on cloudy days. Roller blinds could prove to be the best choice.

If the shades you are considering have a painted finish, check that they are not likely to have any negative aspects because of the heat over a period of time.

Watering: Easy watering is the most essential requirement for your greenhouse. Manual watering with a plastic can that

has a long spout can prove easiest and best for a fairly small greenhouse.

Refrain from powerfully squirting water through hoses as it could lead to erosion of your expensive compost.

There are various semi-automatic and automatic watering systems available. They are a significant investment and you need to discuss the alternatives thoroughly before buying.

Trickle Irrigation supplies water to all plants according to predetermined rates. A **capillary** set-up allows plants to soak in as much water as they need.

Whatever form of irrigation you choose, ensure that all plants within your greenhouse are able to receive sufficient water. Check the system, especially the fine nozzles etc., regularly.

Hygiene: Hygiene is very essential in your greenhouse. Clean all parts of your greenhouse with a disinfectant once a year. Check all plants for pests and any disease symptoms regularly.

You might use any of several suggested pest control choices available across different chemical suppliers but keep in touch with the latest regulations on user safety and also with-holding periods for any chemical you apply to edible plants.

Ten Steps to Building a Greenhouse

Building a greenhouse does not have to cost a fortune.

Planning to minimize your set-up and recurring costs will be well worthwhile.

Your greenhouse could provide a superb environment with sufficient and appropriate sunlight for your plants. Early morning and late evening sunlight is the best. You should provide shade from the afternoon sun for your plants.

Building a greenhouse

A southeast location should be considered. The east-side location could receive maximum sunshine from November to March and this can help plants start with their food production earlier than usual.

Greenhouse planning also depends on the type and variety of plants you want to grow. Site selection for your greenhouse should include planning to have sufficient drainage to accommodate the heaviest type of rain to be expected in your location. If there is insufficient drainage around your greenhouse, think about placing it on a higher level so that excessive water can drain away more easily.

Lettuces in a greenhouse

Your greenhouse should also have sufficient space to keep all accessories and for you or your staff to do your potting and other gardening work safely and without stress.

Materials for Building Your Greenhouse:

1) Fifteen 5/8" x 6' lengths

2) Four foot lengths of schedule 40 PVC

3) Seven twenty foot pieces of schedule 40 PVC with a size 3/16 drilled hole at ten feet

4) Eighty pieces of 2 x 4 wood

5) Sixty 2” fence staples

6) Four eight-foot long fence posts

7) UV polyethylene 40” x 24 feet

Creating a beautiful greenhouse

Steps for Building Your Greenhouse

1) Erect the six feet pieces within a distance of four feet in marked area. Allow protrusion of 48” from the ground.

2) Use the fence staples to nail a 2 x 6 runner on rebar stakes.

3) Put twenty-foot rebar stakes on PVC pipes. You may need another person to hold one end while you do the other end. All drilled holes should be on a line parallel to the ground.

4) Slide PVC pipes over rebar stakes, making sure there are no sharp ends or rough pipes.

5) Carefully slide wire through all PVC holes and along the eight PVC pipes forming the roof.

6) You also have to wire together the four-foot PVC pipe lengths with copper or baling wire. Wrapped wire can force PVC pipe inward.

7) Use vertical 4x4 foot posts to construct end walls. Check that your end walls are vertically straight.

8) The door should be tight to prevent wind from entering the greenhouse possibly causing problems.

9) Fix nails on the horizontal posts and push them into the ground.

10) With help from others, slide the plastic over the cage and secure the ends by nailing it.

Your greenhouse is ready for setting up the internal climate. Then, you can add any of your own innovations.

Do You Need a Customized Greenhouse?

A customized greenhouse is specific to your needs and specifications. Many people do not like ready-made greenhouses, as they do not fit into their ideas and choices.

There are other factors that play a role in having a customized greenhouse. If the available site for your greenhouse is not even, you need to get a specially adapted greenhouse to fit the site.

Flowerpots in a greenhouse

Some could need a greenhouse that can be expanded regularly to accommodate more plants. Of course, if you are focused on commercial growing, prefabricated greenhouses would probably be a poor choice.

Building Your Own Greenhouse

Building your own greenhouse has its advantages. You can accommodate your preferences of size, shape and fitting out. You can design the placements of your plants for convenience and good work-flow.

More flowerpots in a greenhouse

The first consideration is the size of your greenhouse. More space means that you should be able to arrange all plants as you want them but it will increase the setting-up and ongoing maintenance costs.

Your greenhouse should be able to cope with the temperatures in your area. If you live in a hot, tropical climate, the greenhouse could require good cooling facilities and you need

adequate heating systems to keep your plants warm throughout the cold winter months if you live in a cold climate.

Growing tomatoes in a commercial greenhouse

Maintaining necessary heat and warmth requires adequate electricity. Check into available electrical voltage, cost per KWH. Also, look into other options for producing the necessary warmth, like LP Gas, Natural Gas, Wood, and any other options that are available economically in your area.

Next, check water quality in the area before starting your customized greenhouse.

The next step is to make an approximate sketch of your proposed greenhouse with all imaginable details. Also sketch a little of the exterior like roads, buildings, gas lines, trees, electrical poles, hills etc.

The important part of building your customized greenhouse is to decide first on the type of crop you plan to grow. You can also try growing multiple crops and vegetables.

Greenhouse with Garden Balsam

Further customization of your greenhouse to your preferred style might include vented or ground-to-ground enhancements or changing the type of covering for your greenhouse to polycarbonate, double poly, or something else.

Building as big a greenhouse as your goals and resources permit may be the best option. You will inevitably accumulate more plants and the list of varieties could also start growing. The extra space within your greenhouse that you might have

been unsure that you would need when you started could help accommodate your growing brood.

Important Factors

1] Ventilation is a key factor for maintaining your greenhouse and the health of the plants which it protects.

Sufficient ventilation will help to keep your greenhouse free of pests and diseases that could harm your plants extensively.

2] Educate yourself about **proper disinfecting plans** to maintain proper hygiene within your greenhouse.

3] Covering of your greenhouse should, ideally, be glass. Although it is the best, it is also the most expensive. Plastic sheets may be used but do not last long. A cheaper alternative to glass is fiberglass or similar rigid plastics. You can fix the fiberglass on a straight or curved surface of your greenhouse. Some fiberglass is UV resistant too.

4] Flooring of your greenhouse could be concrete or even bare ground. You can make a gravel walkway or think of other innovative techniques to make the floor of your greenhouse both serviceable and easy on the eye.

Planning a Greenhouse Business

A Greenhouse business is similar to any other type of business and requires a similar amount of commitment, risk-taking ability and capital.

You need to gather:

1) Finance

2) Experienced staff, full or part-time

3) Materials for constructing your greenhouse

4) Plants

5) Pest control products, and ….

6) Reliable and economical sources of the above

You need to devote sufficient time and effort in caring for your greenhouse. It's pretty much a 365 days of the year and all seven days of the week business too.

Essentially, planning and running your greenhouse business will demand extensive passion and a strong desire to excel.

Tomatoes growing In a greenhouse

Essential Steps in Planning Your Greenhouse Business

Goal Identification: Starting a greenhouse business could be due to your interest in gardening, but it is impossible to prosper in business if you do not have a sure and secure profit-making objective. You must analyze costs very closely.

Also, gain as much knowledge through discussions with others that are more experienced in the greenhouse industry to find:

The best sources of products, supplies and finance

The most suitable varieties of each type of plant you grow or sell;

Suitable gross profit margins to help through the lean times.

Those who may help by joining you to save on advertising, bulk ordering and trading products with you when one of you has orders which they cannot fill from stock.

Boxed and suspended flowers in a commercial greenhouse

Market Study: This forms the core of any business. Study market demand for crops you intend growing. Study your competitors and identify opportunities which they are not exploiting. Of course, there may be good, but not obvious reasons why they do not offer certain varieties which you are asked for – they may avoid refunds and complaints by not selling a particular plant because they know it may need special care that their customers are not able or willing to give.

Writing a Business Plan: Draft your greenhouse business plan to carefully review all facets of your business. Don't try to do this in just one session. You will think of some things once you've stocked your sub-conscious with the facts you've gathered and you will need to review all your assumptions

when you have discussed your goals with professional advisers and people that are experienced in the industry.

Site Selection: The minimum area necessary for your greenhouse is probably at least two acres. If you are planning a commercial greenhouse, you will need as wide as possible an expanse of free land.

Carefully check accessibility to the site of your proposed greenhouse both legally and by carefully checking the whole area. Check with local government about any proposed changes or new developments already seeking approval.

Also, look for the best available sources of water, heat, electricity, labor and ventilation.

Look into environmental feasibility for protection against snow, hailstorms, rainfall, drainage, strong winds, and how you can legally dispose of waste materials.

Keep sufficient open space for further expansion in the future.

You should also look into the cost of land for your greenhouse so that it does not cause a huge debt on your business.

Greenhouse with Geraniums

Which Type of Greenhouse?

A freestanding greenhouse often proves to be the best choice if you plan a greenhouse of less than 10,000 square feet.

This type of greenhouse is one of the easiest types to build and maintain as it has its own cooling and heating systems. This is a big factor in non-level sites and areas of heavy snowfall or rain. Maintenance is easier and cost-effective with better possibilities for expansion.

A gutter-connected greenhouse is suitable if you have a cultivatable area of more than 20,000 square feet. This type of greenhouse usually requires fairly easy installation of the necessary utilities like centralized heat, increased labor efficiency, and better possibilities to adapt to the available environment.

Greenhouse Accessories

Have proper covering for the ground inside the greenhouse, whether gravel, heavy plastic, concrete or woven cloth. Bare ground encourages and houses pests and diseases.

Use proper benching for plants with movable aisles at the proper heights.

Have sufficient storage space within your greenhouse for storing plants, mixing, transplanting, keeping tools and pots.

Also, look into other administrative requirements like the local fire code requirements, building codes etc.

Checking the compliance costs in these areas is an essential part of your planning for a profitable greenhouse business.

Top Greenhouse Kits

Greenhouse kits help you set up your greenhouse in less time and usually require less labor than a set-up from raw materials.

Popular greenhouse kits include:

Weatherguard Greenhouse 6Hx6W: You can purchase either the 6.5' H x 6' W x 8' L model or a 12' L model. This greenhouse kit comes with a galvanized steel frame and three-layer polyethylene film on the sides. Side vents provide ventilation while the doors and roof have UV-protection. There is no need of any foundation and you can hang plants from the frame. This costs around $217 at time of writing.

King Canopy 10 x 10 Greenhouse: This greenhouse is currently available as 10.26'L x 9.30'W x 8'H. It is recommended for areas that do not have any snowfall; the galvanized steel frame, with polyethylene or plastic sides, may not provide sufficient insulation. However, easy installation of the kit makes it very popular. Ventilation is by unzipping rear and front panels. Brackets and shelves are available separately. There is no need for a foundation. It costs around $199 to $419.

Rion PolyGreenhouse: This greenhouse has 6-mil polyethylene sheeting rated for 93% light penetration for three years. The heavy gauge frame of extruded aluminum is weather resistant. It is easy to assemble this greenhouse with an easy lock system. This maintains perfect humidity and temperature levels. Insulation is better through the door and extraction vents than some others. This greenhouse measures 6x8 or 6x10 and costs around $599.

Flowerhouse FHCV900 Conservatory Greenhouse: This plastic round-shaped greenhouse, with a height of 10' and diameter of 9' has a three-year warranty. A galvanized steel frame with polyethylene sides offers complete protection. Additionally, a zippered front door and screened side windows allow easy ventilation**.** The kit is available with tie-downs, ground stakes and shade cover too. There is easy access for power and water. It does not require any foundation and is available in 10' H x 9' W x 9' D size, costing $349.

Gardman Complete Walk-In Greenhouse: This free-standing greenhouse has an aluminum frame with galvanized steel coating, roof venting and twin-wall polycarbonate siding. It is available in three sizes; 4x6, 6x6, and 6x8 and costs range from $559.99 to $719.99.

All prices and features may change at any time. Ratings are the writer's personal views and not guaranteed in any way.

Part-III: Basics of Greenhouse Construction

Planning Your Greenhouse Location

Location plays an important role in the maintenance and upkeep of your greenhouse. Ideally, you should plan carefully the whole area for locating your greenhouse. This helps in planning and deciding on other essentials of a greenhouse business.

Planning Your Greenhouse Location

Direction of Greenhouse: If you plan for an attached or lean-to greenhouse, it should be on the south side of the building, preferably on the southeast. This direction helps your

greenhouse to receive the cool early morning sunlight. It can start food production early and does not endure as much of the stronger afternoon sunlight. There is less of a problem of overheating, too.

Never place your greenhouse in the north. That direction can suit only those plants that require very little or no light at all.

If you choose a freestanding greenhouse, place it to the north of deciduous trees like oaks and maple. These trees provide the required shade during summer afternoons. In winter, they shed their leaves and the bare trees allow easy penetration of winter sun all day.

Do not place your greenhouse near shady evergreen trees. These could be useful in summer but will reduce the sunlight available in the winter months.

If there is a need, you can use “grow lights” to supplement available sunlight.

Slope: Although flat and level land is the best for your greenhouse, south or a south-east facing slope can prove advantageous too. You can dig around to form a suitable slope but this will increase your initial costs and set-up time too.

Orientation: Orientation of your greenhouse does not always depend only on the direction. It is also affected by the latitude where you are located.

A north-south orientation can help in better distribution of sunlight. But, in places above forty degrees north latitude, it is best to have an east-west orientation. This orientation allows the maximum surface area to receive sunlight.

Accessibility of Basic Requirements: Your greenhouse should have the best possible access to water, gas and an electricity supply. Using a hosepipe for the water supply can prove irritating. Use a proper circuit breaker for uninterrupted supply of electricity for your greenhouse.

Your greenhouse should be arranged to have easy access from your home.

Drainage: Easy drainage is essential so that water does not stay near your greenhouse. You can set or build your greenhouse at an elevated point for easy draining of water. A gravel floor can aid good drainage.

Placement of Greenhouse: You can place your greenhouse anywhere you want. It could be on a gravel base, lawn, wooden deck, brick patio, or a concrete slab too. Laying down landscape cloths on the surface helps to prevents growth of weeds in your greenhouse.

Type of Plants: The type of plants you intend growing in your greenhouse will define the best location for your greenhouse. Orchids and African violets need more exposure in the north. Most other types of plants will probably do better if the greenhouse is in the southeast.

Plants requiring northern exposure could incur higher heating costs for you.

Wind: Your greenhouse needs adequate protection from wind too. Although ventilation is essential, do not place the greenhouse where it receives the strongest winds directly. This might prove disastrous for your plants. Put your greenhouse where it is best sheltered from strong winds and windstorms. Base your level of protection on the strength of the worst winds you get in an average year.

Your greenhouse location should suit both summer and winter seasons.

The Best Frame for Your Greenhouse

There are different types and shapes of greenhouse frames.

Consider these for your greenhouse:

Framing Your Greenhouse

Gothic: As the name suggests, this frame has a gothic shape that allows greater headspace near the sidewalls. The ridge often supports wooden arches.

Quonset: This has a circular frame of galvanized steel. The side height of this frame is low and normally has a plastic sheet covering. The frame allows easy circulation of electricity but moving space is restricted due to the shape.

Rigid-frame: This frame has vertical sidewalls. Nailed plywood gussets connect the sidewalls to the rafters, forming a single rigid frame. There is no need for any columns to support the roof. This frame supports maximum air circulation and probably the most spacious interior too.

Post and Rafter Frame: This frame has a simple construction of rafters and embedded post. Strong sidewall posts can withstand strong wind pressures. Spacious sidewalls allow easy air circulation. This frame requires more wood and steel than other frames.

A-Frame: This is similar to the post and rafters frame. This frame supports various cross rafters from the ridge to the outer rafters. This frame is among the easiest to make. Diagonal bracing wires add to the strength of the A-frames.

Panel Frame: This frame is usually quite expensive as it involves extensive carpentry work. The panels are plastic. So, this frame can be easily dismantled during summer months to increase the lifespan of the plastic. Placing some vents can improve ventilation extensively.

Pipe Frame: You use a pipe within a greenhouse to let in air. Greenhouse chambers are made of two layers of 4 to 6 mil film. Air pressure forces the inner film layers over the circular pipes. This forms a circular shape on the outside. The top, outer layer bloats three to four inches from the top frame and one to two inches from the foundation. Air comes in through a six-inch plastic tube. A manometer (device that measures gas and vapor pressures) helps regulate static air pressure within the film layers.

Making an ideal choice of framing materials from available options of wood, aluminum, steel, and PVC can help you get the durable and economical frame for your greenhouse.

Choose the Covering for Your Greenhouse

There are many materials available for covering your greenhouse. Each of these materials has their own advantages and disadvantages. You can choose the most suitable covering from these:

Exterior of traditional Greenhouse

Glass: Greenhouses are traditionally covered with glass. This may be as straight, slanted or curved covers. Such glass coverings help to assure that you get an airtight structure that lowers heating costs.

Visibility within a glass-covered greenhouse is very high and maintenance costs are usually low too.

However, glass is very brittle and can break easily. Being very heavy, it may pose many problems during installation.

Excessive sun exposure through the glass could cause harm to your plants.

Plastic: Plastic coverings are becoming very popular. These incur very low building costs; about one tenth of the cost of glass. Therefore, assessment rates of plastic covered glasshouses for tax purposes are also low too.

It is easy to heat plastic greenhouses and many plants grow as well as those in glass greenhouses.

Tomatoes in a greenhouse

Fiberglass: These coverings are very light but very strong. They offer good resistance to hail. Choose the clearest grade of fiberglass for your greenhouse, as it allows extensive light penetration.

Cheaper and lower quality grades of fiberglass lose their colors fast and reduce light penetration. It is best not to use colored fiberglass.

Polyethylene: Polyethylene coverings are very light and allow a lot of light to penetrate inside your greenhouse. These coverings are useful in all types of weather. But, ultraviolet rays cause extensive breakdown of polyethylene coverings. You need to change them annually.

Ultraviolet-inhibited polyethylene has specific inhibitors to prevent quick break-down.

Special greenhouse panels: These special panels consist of UV-inhibited corrugated plastic. These strong and durable panels are very light in weight. The translucent panels allow soft diffusion of light at around 70% to 75%. They also offer full protection from snow and winds. These coverings allow extensive and lush growth of plants in your greenhouses.

Polycarbonate: These coverings are very light and allow appropriate light diffusion. This reduces plant damage due to excessive sun exposure. However, visibility within polycarbonate greenhouses is very low.

Footings, Flooring and Foundations

Greenhouse structures should be sturdy and a strong foundation is essential for your greenhouse. The foundation stores some of the warmth of the sunlight during daylight and releases it at night.

A greenhouse with a variety of plants

You should consider employing a professional to lay the foundations of your greenhouse. But, if you want to save money, exercise all necessary care and equip yourself with the necessary knowledge about the foundation and flooring of your greenhouse so you could try to do it yourself.

The foundation for your greenhouse could be brick, wood or concrete.

A concrete foundation is durable but may pose problems with drainage.

If you have a portable greenhouse, choose a gravel mulch foundation with a dirt floor.

Plan and build a brick foundation with adequate spacing between bricks. This helps in easing any drainage problems.

Wood could prove to be the most inexpensive of all foundations. However, you need to re-treat the wood regularly.

The Footings of Your Greenhouse

Educate yourself on specific building codes before making footings for your greenhouse. These codes are set up in

accordance to the weather conditions in your area. Strict adherence to these codes helps to prevent freezing or cracking of the foundation of your greenhouse.

Mark chalk lines across the ground area for your greenhouse and dig trenches according to your local building codes along the marked chalk lines. Set level concrete footings eight inches wide into the trench. Your steel rod footings should be tied horizontally or vertically inside foundation forms before the pouring of concrete.

Flooring of Your Greenhouse

Ensure the ground area across your flooring to be as level as possible. Dump in gravel and smooth it.

Next, pour in crushed stone and tar paper. You could use builder's heavy plastic too. Then, set the mesh and pour in the concrete.

In hot weather, cover concrete with plastic and sprinkle water intermittently to help the flooring become strong and sturdy.

Leave two-inch drainage holes four feet apart in the foundation. After the footings settle well into the foundation, remove your forms and fill the foundation with gravel or dirt. Installing gravel or tile drainage channels with drainage holes can allow easy drainage within your greenhouse.

Selecting the Right Lights

Greenhouse cultivation does not depend on natural weather conditions. It all depends on the artificial environment you create within your greenhouse. Therefore, your artificial arrangements should be in accordance with the natural requirements of plants for healthy growth.

Light Requirements

Sunlight forms the essence for the growth of any plant. All greenhouses allow easy penetration of sunlight. However, available sunlight may not be sufficient during the winter months and on cloudy days. Therefore, you need to arrange artificial lights.

Selection of artificial lights depends on:

Your plants' requirements

The area of your greenhouse

Availability and intensity of sunlight

Many different types of lights are available; fluorescent lamps, incandescent lamps, mercury vapor lamps, neon lamps, sodium vapor lamps and others.

Different color combinations of lights exist. Color choices depend on the requirements of your plants.

Lights could increase the temperature within your greenhouse if they are in addition to reasonable sunlight. Choosing lights that emit more light and less heat energy can help to maintain greenhouse temperatures at appropriate levels.

Types of Lights

Fluorescent lamps: These lamps are most popular for use in greenhouses. These lamps are available in various colors. The highest preference is for white fluorescent lamps. These lamps

provide more light with less heat. High intensity fluorescent tubes of 1500 ma can deliver a high wattage of around 2000-foot candles.

Soft lights of this type contain the entire spectrum of sunlight. Having such lights over seedlings with poor growth can boost their growth. Restricting use of these lights over smaller areas can be a good option.

Incandescent lamps: Incandescent lamps are available in different wattages, ranging from sixty to five hundred watts. These lights can make the plants think days are longer in your greenhouse. You can vary foot-candle levels by adjusting the spacing and mounting height of the lamps over your plants.

High-intensity discharge (HID) lamps: As the name suggests, these lamps provide high emission of light. These lights last for a long time; for over five thousand hours. Efficiency of these lights increases with the addition of sodium and metal-halides.

Metal Halide Grow Lights: These lights emit the blue and violet colors of the spectrum. Such light is normally available during spring. These lights best suit growing plants and support their early developmental stages to promote stronger roots, increased resistance to diseases and a more compact green growth.

High-Pressure Sodium Lights: These lights produce orange and red colors of spectrum that encourages plant growth like

you see in autumn and early fall. Therefore, this light suits plants in a mature stage.

You can use a convertible grow light system to alternate between metal halide lights and high-pressure sodium lights. You can use metal halide lights for starting seedlings and then shift to high-pressure sodium lights as they grow into mature plants.

This can save you money compared to purchasing separate lighting systems.

Part-IV: Environmental Systems

Cooling, Ventilation and Your Greenhouse

Greenhouses essentially lock in sunlight to provide a more suitable environment for plants to grow. But, trapped sunlight should not exceed required levels. Otherwise, your plants may wither. Use adequate cooling strategies within your greenhouse to maintain optimum temperature and humidity levels.

Cooling and Ventilation of Greenhouses by Plants

Plants have an inbuilt mechanism to cool themselves. They regulate their temperatures by evaporating water through the

process of transpiration. Plants can keep themselves cool in greenhouses if there are many leaf surfaces.

If your greenhouse houses plants with many large leaves, the atmosphere in the greenhouse can be cooled to a considerable extent.

To help plants transpire easily and effectively, you should supply them with lots of water. Irrigate your plants in the greenhouses extensively and frequently. This neutralizes salt levels in plant roots so that high salt levels do not interfere with their intake of water.

Next, provide sufficient ventilation within the greenhouse so that moist air transpired through leaf surfaces goes out and cool dry air enters greenhouse. Employing proper air

circulation techniques can help provide this environment for your plants.

Cooling and Ventilation by Blocking Sunlight

You can maintain cool temperatures in the greenhouse by blocking sunlight. Fix retractable or fixed sunshades to restrict the amount of sunlight entering your greenhouse. Maintain an adequate supply of sunlight for plants to photosynthesize their food.

Light requirements of plants depend on the specific species and the intensity of available light too. If your greenhouse has many crops with dense foliage, use little restrictive shades so that these plants and their foliage do not suffer from lack of adequate sunlight.

Use semi-permanent shade materials like screens and coatings. These are very flexible in adjusting light requirements.

Ventilation Equipment

Roof vents help remove hot air from within the greenhouse and replaces it with cool outside air. Hand-operated roof vents require regular temperature checks. You have to open and close vents according to the changes in outside weather. This is necessary to prevent excessive cooling or heating of air within the greenhouse.

Install sidewall or gable exhaust fans underneath curtains to remove trapped, heated air.

Curtains pulled in an east-west direction prove useful in regulation of penetrating sunlight. Use curtains of open-weave materials so that hot air rises through the roof.

Ventilation systems function in relation to the area of your greenhouse. The height of your greenhouse does not play any role in effective ventilation. An effective ventilation system should be able to exhaust eight to ten cubic feet of air per minute from every square foot of your greenhouse.

Further, ventilation should be uniform all over your greenhouse. If outside temperatures are very high and dry, use ventilation systems in combination with the natural transpiration systems of your plants to maintain necessary coolness within the greenhouse.

This requires frequent regulation of the air in the greenhouse.

Another way of cooling your greenhouses is through use of mechanical cooling; refrigeration or air-conditioning. This technique could prove very costly.

Other cooling techniques include mists, fogs, pads and fan systems and sprinklers. All these work fine if moisture content in the air is not perfect.

Mists, fogs, and sprinkler systems can function independently or synchronize with other mechanical ventilation systems. But,

you should regulate air and humidity temperatures for these systems to function smoothly. You can switch them on and off intermittently.

These systems have their own problems too. Impurities in the water could lead to clogging and foliage could suffer from continuous wetting too. You can regulate the even dispersion of water by regulating the size of particles and avoid chances of over-wetting.

However, effective cooling depends more on the amount of evaporation.

Shading equipment includes roll-up screens of aluminum, wood, vinyl, paint-on materials or plastic shades. These shadings function with the help of nylon ropes or pulleys. You can adjust the shade according to outside weather conditions.

You can use shading compounds too. Apply them on the exterior of the greenhouse glass.

Plants in a greenhouse

Automated Cooling and Ventilation Techniques

Automated cooling and ventilation systems can offer systematic and controlled regulation of temperatures within greenhouses. These automated techniques do not require you to maintain personal controls. Systems have an in-built mechanism that manages irrigation levels, operate suitable shading systems and provide necessary ventilation by operating relevant cooling.

This occurs by coordinating various pieces of automated equipment in relation to the varying requirements of your greenhouse.

Automated vents have a special thermostat and electric motor systems that remain open to allow the necessary amount of cool air. They also allow warm air to flow out similarly.

Maintenance of such moderate temperatures within a greenhouse promotes healthy growth of plants.

Automated systems function independently and you do not have to keep changing them according to different seasons. You can use a single thermostat, or a controller with a temperature sensor. Sensors should always be in the shade and located at around plant height. White sensor boxes can reflect solar heat and give accurate temperature readings.

Understanding Heating Methods, Systems, Sources, and Distribution

Heating systems are essential for greenhouses to function normally. Solar energy is the main source of heat energy necessary for greenhouses. Nevertheless, you should have adequate alternative heating systems to maintain systematic heating all year through.

These heating systems can regulate temperatures within greenhouses and maintain a conducive environment for plants to grow and flourish.

Heating Systems and Methods

There are different heating systems for regulating temperatures within greenhouses. You can use that which best suits your greenhouse requirements.

Pipe Heating: This has many metallic or plastic pipes carrying steam or hot water spread across the greenhouse. These pipes heat the greenhouse through convection and later radiate heat directly to the leaves. Overhead pipes should be

closer to plant surface for effective heating without loss through radiation. Similarly, hot pipes passing near the ground in the greenhouse can stimulate better circulation of hot air.

Pipes passing through the middle of greenhouse can provide excellent radiation of heat. Take care to avoid scorching of plants through heat from the pipes.

Warm Floor Heating: This heating system involves placing hot water pipes below the concrete of the greenhouse. This system helps in uniform heating of the entire ground surface of the greenhouse and uniform distribution and circulation of heat throughout the plant canopy.

Heating the root system promotes plant growth. But, this system may be too expensive for many.

Bench Heating: This heating system involves placing hot pipes on, or under, the benches. This can assure uniform spreading of the heat across plant roots and improve air movement extensively. Although this system can reduce the incidence of root pathogens by warming soil, it can cause

excessive stress on the plants closest to heaters. Similarly, plants farthest from heaters may not receive equal benefit.

Air Heating: Overhead heated air directed through fans and perforated polyethylene tubes can heat greenhouses quickly. You have to maintain perfect on-and-off timings to regulate temperature within your greenhouse. This system could prove expensive.

Central Heating Systems: These heating systems generate heat from a centralized location, normally a huge boiler. This heating system proves efficient for huge commercial greenhouses, although installation and maintenance costs are expensive. Hot water produced in a boiler, pumps into your greenhouse at 180° F. This system also requires extensive plumbing and circulating systems to maintain the necessary supply of heat. You can use steam centralized heating systems as they provide heat at 215° F.

Radiant heaters: These heaters have aluminum tubes with reflectors. Combustion of fuel within the tubes cause temperatures to rise to around 900° F. Reflectors direct the infrared radiation downwards to plant surfaces and benches. These surfaces absorb radiation and heat. These heaters require low-flow or poly-tube fans to maintain necessary air circulation.

The number of heating units should be such that there are no cold spots. Initial costs are high.

Fuel Sources for Heating Systems

There are different fuel sources for heating systems of greenhouses. You can choose fuel according to cost, availability, pollution regulations, storage possibilities, boiler requirements and maintenance requirements.

Popular Fuels:

Natural Gas: This fuel source may be currently one of the most inexpensive and has low maintenance costs. It offers clear burning and there is no need for storage tanks.

Propane and Butane: Although similar to natural gas, they are more expensive and require storage tanks.

Oil: You need storage tanks to keep this fuel source. It requires regular boiler maintenance as it does not burn cleanly.

Wood chips or Logs: These fuel sources require huge storage area and extensive handling with regular boiler maintenance and cleaning.

Coal: This low-cost fuel requires extensive storage space and generates immense pollution too. You require regular boiler maintenance.

While using coal, oil, or gas heaters, there should be a constant supply of fresh air to avoid any build-up of carbon monoxide. Fans can help to maintain the necessary air circulation within greenhouses.

Heat Distribution inside Greenhouse

Even distribution of heat inside a greenhouse is as essential as generation of heat. Uneven distribution can cause many problems.

Some of the most important are:

- Irregular growth of plants
- Improper maturation
- Excessive dry regions, and
- Stunted growth of plants

Different heating systems generate and distribute heat in different ways. Centralized heating systems can be through hot water or steam. Heat distribution takes place through a network of aluminum, cast iron, or copper pipes. Steam offers less resistance and therefore you can use pipes with a smaller diameter. Steam additionally delivers higher heat than hot water. Efficient distribution of heat requires proper placement of pipes. This can increase heating and reduce heat loss.

Potted plants in a greenhouse

Placing pipes in layers can reduce heating efficiency. Instead, place pipes singly.

Unit heaters are not very efficient in distributing heat. Temperature differences occur along the length of a greenhouse. Temperatures close to the heater are high. Use of multiple unit heaters across each other can solve this problem. It helps to maintain uniform heat across the entire length and breadth of the greenhouse.

Additionally, you can use horizontal airflow fans to promote movement of air within greenhouses.

Unit heaters mounted onto greenhouse gables and connected to polyethylene jet tubes can distribute heat evenly. In cooler seasons, you can switch off the fuel source and firebox and use a fan of unit heaters with polyethylene tubes with outside louvers.

Heating systems placed low in the greenhouse can help to maintain warmer temperatures. Leaf surface temperature above dew point can prevent condensation. It helps prevent various greenhouse diseases.

Other heating systems should be as close to the canopy as possible. This saves lots of energy too.

Calculating Energy Requirements for Heating Systems

Energy requirements for heating greenhouses are not the same everywhere. It depends on various factors, including:

Size of the greenhouse

Difference in outside temperature and temperature within greenhouse, and

Single or double layered covering of glasshouse in plastic or glass.

Normally, greenhouse sellers educate you about heating requirements of your specific greenhouse so that you can make use of these systems too. You can calculate heat energy requirements through simple processes.

You must seal all cracks and holes in your greenhouse as soon as they are located.

Energy Requirements for Your Heating System

The most important factor is to calculate the temperature difference between the lowest outside temperature and the temperature you want to maintain in your greenhouse. If the coldest temperature outside is around -10 degrees while you want to maintain sixty degrees within your greenhouse, the temperature difference is around seventy degrees.

Find the total surface area of the inside of your greenhouse including roof ends and the sides in square feet. The area should essentially be of exposed plastic or glass of your greenhouse.

Find the product of the greenhouse area and the temperature difference. If the total exposed area of your greenhouse is 3,400 sq. ft. the product would be 238,000.

Your greenhouse could have two layers of glass or plastic or have a single layer. If it is a single layer, multiply 238,000 by 1.2. If it is a double layer, multiply 238,000 by 0.8. This product is the required BTU capacity of your heater per hour. For a double-layered greenhouse, it would amount to maybe 190,400 BTU per hour while it could be around 285,600 BTU per hour for a single-layered greenhouse.

You can calculate heat energy requirements of your greenhouse by calculating the total heat loss.

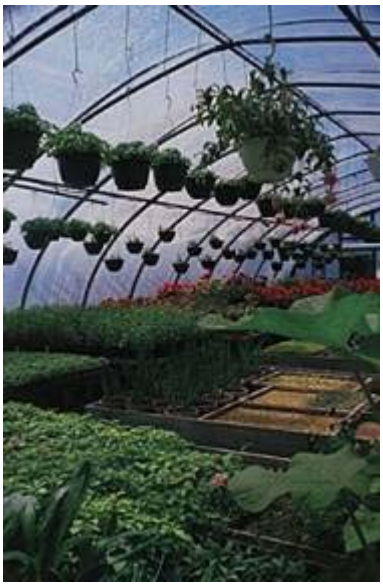
First, determine the total exposed surface area of your greenhouse covering, be it glass, poly, fiberglass, or other

material. Also, determine the exposed surface area of other materials like brick, poured cement, concrete block etc.

Next, determine the maximum difference between the outside lowest temperature and the optimum temperature necessary within your greenhouse.

Calculate the conduction heat loss factor for materials used in your greenhouse.

Using relevant tables, calculate the air filtration heat loss. According to the volume of greenhouse, calculate the total heat loss of your greenhouse. You need similar energy to heat your greenhouse and maintain optimum temperature for the best possible growth of plants within the greenhouse.



Normally, the heat requirements are less in double-glazed greenhouses like those of polycarbonate or glass. Similarly,

the types of crop you want to grow within the greenhouse affect the heat energy requirements.

Summer crops normally require more heat than winter crops.

While calculating outside temperatures, always keep an extra margin for seasonal variations from the recorded averages. At times, it could turn out to be much colder than the average minimum temperatures you use in your calculations. Procuring heating equipment with a larger load is advisable to adjust to odd weather changes.

Watering Systems and Insulation Techniques

Greenhouse Watering Systems

Water is an essential ingredient for growing plants anywhere, equally so in your greenhouse. Having a water source close to your greenhouse can prove beneficial.

Different types of watering systems include:

Capillary Matting: Capillary mats through bottom of trays or pots can supply the water requirements of seedlings across the floor of your greenhouse. You can use an automated system for capillary matting or a hand-filled reservoir.

Drip irrigating systems: These provide a continuous water supply to plants within the greenhouse by flowing down in drips. This helps conservation of water and supplies the necessary amount of water to each plant directly.

Self-Watering Tray Kits: These kits are available in different sizes. They consist of a black plastic water reservoir fitted with an aluminum tray. This creates a raised flat surface for capillary matting. This system can help water your plants for around two weeks, depending on the number of plants within the greenhouse and the type of plants too.

Watering Cans and Garden Sprayers: You can use plastic watering cans available in different sizes. You can also use these for spraying fertilizers and chemicals.

Tropf Blumat Drip Irrigation System: This watering system helps plants to control the amount of water. This can prevent excessive watering.

Greenhouse Misting Systems: These systems provide a mist of water over your plants in the greenhouse. Water mists can help plants absorb water according to their requirements.

Insulation Techniques in Greenhouses

Effective insulation systems are essential to maintain necessary warmth within greenhouses. They also are excellent energy savers. They can help you save around thirty percent

on your heating costs. You can extend greenhouse productivity periods by around six weeks.

This allows greater flexibility in choosing sowing times and the type of plants for growing in your greenhouse.

The best way to insulate your greenhouse is to use bubble wrap. Bubble wrap retains maximum heat for a considerable period too. Wrapping your greenhouse in bubble wrap could reduce light levels within the greenhouse. However, such reduction is minimal and does not cause any worry.

Use UV-stabilized and tri-laminated bubble insulation. UV treatments prevent your bubble wrap from becoming hard and brittle. Therefore, you can use it year after year during the cold winter months. Additionally, tri-laminated bubble wrap retains more heat of the day and provides better insulation.

Fixing bubble wrap around your greenhouse is not a big job. Aluminum framed greenhouses have glazing bars with a channel down the center. This has many cropped bolts in addition to spacers, alliplugs and corner adapters.

These accessories help secure bubble wrap to your greenhouse easily. Spacers create a gap of 25mm between glass and material. This helps keep warmth in during cold days.

Part-V: Upholding Your Greenhouse

Basic Greenhouse Care

Essential Accessories and Equipments for Maintenance

Regular daily maintenance of your greenhouse can help you have a clean and attractive greenhouse. It does not take much time if you fit it in within your daily routine.

Simple accessories that will help in your maintenance work on a small greenhouse might include:

- Mist sprayer
- Watering can
- Canes
- Shade nets
- Trowel or hand fork
- Pesticides
- Washing-up Gloves

- Garden Disinfectant
- Scrubbing Brush
- Old toothbrush for scrubbing corners
- Clean Bucket and Water

You should keep your greenhouse neat and tidy. This ensures the greenhouse to be free of pests and associated diseases. It also ensures a good and healthy environment for your plants to grow and flourish.

Diseases often develop in greenhouses due to the hot and humid conditions within.

Follow these essential maintenance tips to ensure a clean and healthy greenhouse:

- Water all plants regularly
- Do not allow compost to dry and harden
- Take off weeds around plants and plant beds. Weeds grow very fast. Therefore, weeding is essential every few days.
- Place canes for plants that require support to grow well. You can tie emerging shoots together loosely. This prevents shoots from mingling with plants in other pots and creating a jumble.
- Pruning is essential in summer to remove dried twigs and flowers. Prick out and take off drying plants when required.
- Fix shade nets to safeguard plants from scorching sunlight. Alternatively, you can spray shading washes on outside of greenhouses during summer and wash them off in autumn.
- Never water plants in mid-afternoon when the sun is hottest as it scorches plant leaves.
- Some plants require humid conditions. Splash the floor with water through a handheld mist sprayer during the summer to create humid conditions.

- Pests like mealy bugs, red spider mites and aphids and diseases like mildew and botrytis thrive in humid conditions. Refrain from making your greenhouse too humid to protect your plants from such diseases.
- Sterilize flats and pots with disinfectants before re-using them.
- Annual thorough cleaning of your greenhouse is essential. Take out all your plants from the greenhouse and clean the shelves, benches, and walkways of your greenhouse thoroughly. Use a spray hose to take away dirt and debris and wash down surfaces. Next, apply a disinfectant. Allow the disinfectant to soak in. Rearrange the greenhouse the next day.
- Remove stubborn algae spots from greenhouse glass with disinfectant or a household bleach.
- Use lubricants on metal frames, vents and door hinges. This prevents rusting and jamming of doors and vents.
- Take away insulation in the summer and preserve them well for use during winter.
- Keep all greenhouse tools in their proper places.

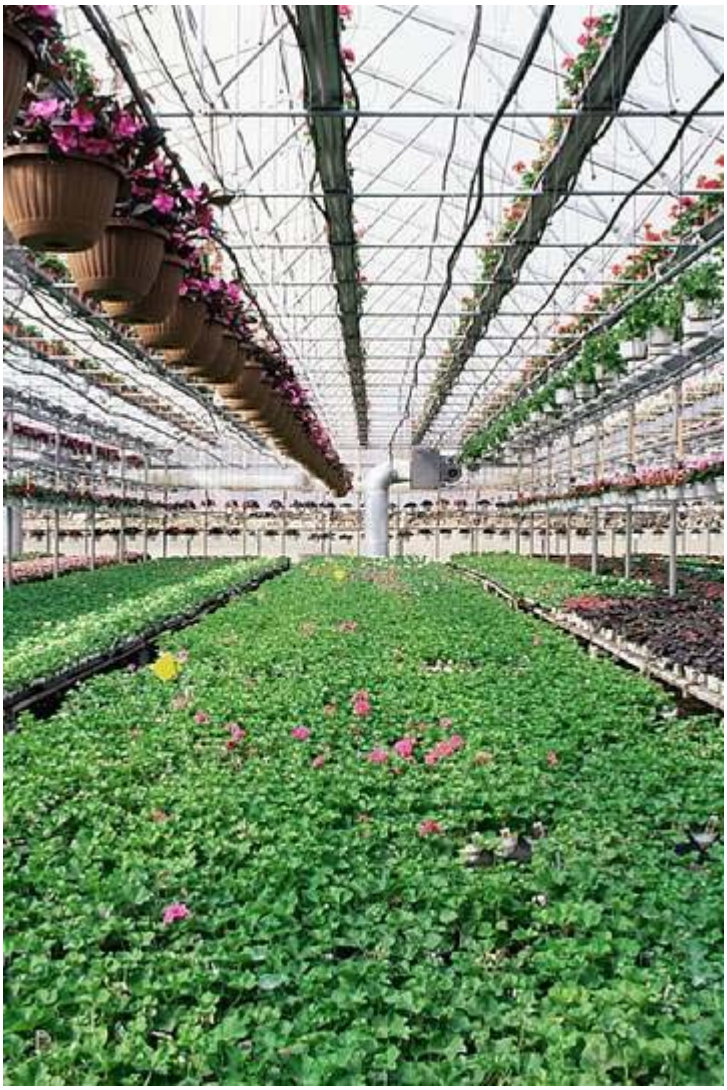
Greenhouse Maintenance Checklist

Maintenance is of key importance in any greenhouse.

Without adequate and proper maintenance, it is not possible to have the necessary environment for optimum growth and development of plants. Maintenance of your greenhouse requires you to write out a detailed plan and adhere to it religiously. Efficient maintenance includes regularly inspecting all components of your greenhouse. You can hire maintenance specialists if you lack any necessary specialized equipment and expertise.

Maintenance Checklist for Your Greenhouse

Fiberglass Covering: Repair all cracks and holes, change damaged and darkened panels, clean all sides of dirt and algae and make glass clear for proper light penetration. You can fix a polyethylene inner layer when required too.



Glass Covering: Fix new panes in place of damaged ones and adjust panes if they are out of place. Scrape and paint all bars

and seal panes where necessary. Clean glass pane sides of all dirt and algae and make all panes free of shading compound when no longer required, to allow maximum light penetration. You can use a double layer inflated film inside the glass if the expected light intensity does not seem likely to cause any problems.

Double Poly Covering: Clean all inflation fans and put in new poly to replace old, discolored and damaged poly. Repair all holes by fixing the poly tape. Use dry inflation air to remove condensation between poly layers.

Vent System: Check vents for free movement and operation. Adjust vents to reduce all cracks on matting surface. Repair loose vents.

Plastic Seals: Remove all dirt and algae from plastic sealing and replace dirty and worn-out plastic films. Seal all joints to prevent wind penetration.

Doors: Check all door closures and springs. Seal door moldings and frames, and weather-strip them.

Thermal Blankets: Check that the opening system operates through a complete cycle. Check that all seals, wires and pulleys are tight. Repair all holes, lubricate them and tighten all loose drive-shaft couplings. Remove all dirt and algae and check lubrication of motor and gears.

Standby Generator: Clean all parts of your battery and check it's working. Drain generator fuel tanks and refill them

too. Check for any leaks in fuel tanks. Ensure all lubricants are at the correct levels. Check all wires (for any looseness) and switches and ensure the alarm system is functioning properly. Service the cooling system of your generator.

Heater: Use the correct fuel and maintain an adequate supply of fuel throughout the heating season. Check fuel pressure and burner nozzles. Clean burner nozzles. Adjust and clean all pilot lights and make sure outside air is available to burners. Check all fuel lines for any leaks, cracks, carbon and dirt build-up. Ensure good quality water is available for the heaters. Clean fan motors and lubricate them. Check the condition of the wiring and heat exchangers for any build-up of dirt, carbon and fix cracks.

Boilers: Check for any mechanical damage in the boiler and pipes. Adjust air-fuel ratio and check if all relief valves are working properly without any signs of leakage. Clean blower fan blades and repair all cracks, patches. Clean the fireside and waterside tubes thoroughly. Lubricate all bearings and maintain accurate water treatment records. Replace all inoperative and leaking valves. Check all back-up boilers which should function just like the main boiler. Ensure good quality water is available for the boiler so that it has a long life.

Getting the Most from Your Cooling and Ventilation Systems

Cooling and ventilation systems are essential to maintain optimum temperature and humidity levels within greenhouses.

The following tips can help you get the best from your systems and ensure their sustained performance:

Excessive Ventilation: Refrain from over-ventilating your greenhouse, especially in summer months. Hot air from outside could prove too much for your plants. They may die if you do not employ suitable humidifying techniques. Over-use of the ventilation systems may harm them.

Retractable Shade Curtains: These curtains function according to specific light levels. During cloudy days, curtains could have excessive movement due to unexpected changes of light and shade. This can cause a breakdown of these systems. Fix a specific time-delay so that there is no excessive pressure on your curtains. If your plants are extremely sensitive to sunshine, use external shading compounds or fixed curtains.

Pad and Fan Temperature Gradients: Air temperature at the pads is always cooler than near exhaust outlets, irrespective of the length or size of your greenhouse. Place fog or mist lines at right angles at two thirds and one-thirds of your greenhouse to get the maximum benefit.

Ventilation with Shade Systems: Place shade curtains in such a way that they allow extensive air exchange. Keeping little gaps between shade curtains is a good idea.

Mineral Residues: Cooling water may contain minerals like iron and bicarbonates. Similarly, roof sprinklers and mist

systems could also leave deposits that could pose problems with pad and fan systems and the functioning of the electronic humidity sensors. Regularly clean off residues.

Maintain Proper Air Balance: Do not operate evaporative systems continuously. This could cause lack of sufficient dry air. Stop evaporative cooling early in the day. This can ease problems of excess humidity and wet foliage.

Roof Sprinklers: These may be best in greenhouses with low evaporative cooling requirements and natural ventilation systems. Limit roof vent opening angles so that they do not drip on to your plants within your greenhouses. Mineral deposits through such sprinklers could stain greenhouse coverings.

Humidity and Temperature Sensors: Place the sensors midway between inlet pads and the fan exhaust. Do not place them in the direct path of fog or mist nozzles. This helps in efficient circulation of air within your greenhouse and maintains proper humidity and temperature levels.

Dust Cleaning: Dust accumulation on fan blades and shutters reduces their efficiency by more than thirty to fifty percent. This restricts free movement of the blades too. This could cause irregular and insufficient ventilation within the greenhouse, leading to accumulation of stagnant air in specific pockets. This, in turn, also increases heating costs.

Lubrication: Lubricate all fan bearings, shutters, motors and all free-moving parts of your greenhouse equipment.

Inspection of Ventilation Systems: Check all electrical cords in your greenhouse. Replace any splits and cracks in electrical wiring immediately with approved insulated wires. Check rotation of fan wheels. Improper installation could cause reverse movement of fans. This restricts fan movements and results in inefficient circulation of air within the greenhouse.

Humidistat and Thermostats: Check functioning of these systems in accordance with environmental conditions. Remove any dust accumulation from sensing elements of the controls of these systems before re-calibrating them. These should always be at plant height to provide the best environmental control.

Pads and Frames: Check these to ensure their perfect condition. Seal all cracks around the pads to prevent entrance of air from places other than cooling pads.

Restricting Growth of Algae: Use fungicides in the water supply to reduce growth of algae and possible accumulation of it on cooling pads. Algae can destroy cooling pads and increase airflow.

Maintaining the Heating Systems

Heating systems in greenhouses are most often hot water heaters, unit space heaters or steam heaters.

Unit space heaters normally use oil or gas as fuel. **Hot water** and **steam heaters** use boilers to produce heat. Fans help to distribute heat uniformly throughout the greenhouse.

Tips for Maintenance of Heating Systems

Ensure good air circulation through installation of auxiliary fans, if needed.

Your vent stack of fossil-fueled unit heaters should extend to more than four feet above any nearby house ridge or obstruction.

Restrict exposure of the thermostat to any heat source through a protective shield. Use the fan to aid thorough air movement and maintain proper air temperatures at bed levels.

Ideally, place thermostats near plant level.

Check and clean fan blades, burner nozzles and oil fan motors according to the manufacturer's instructions.

Check all pipes of hot water or steam heating systems for any possible leaks.

Check the capacity of your boiler or furnace before extending bench hot water lines or increasing the number of hot water units. The boiler needs to have sufficient capacity to handle the additional load.

Keep all hot water pipes clean, without any accumulation of dust. Dust accumulation definitely retards efficiency.

Check the movement and efficiency of fan blades in the unit's hot water system. Lubricate them regularly and check orientation of each of them to assure systematic and thorough heat and air distribution within the greenhouse. In some cases, fans could be belt or pulley driven. Check these systems to ensure smooth functioning.

It is best not to use fossil fuel heaters without vents. If it is necessary to use such heaters, provide extensive mechanical or natural ventilation. This helps to remove all by-products of combustion and assures a healthy environment for plants to grow.

In poly tube heat distribution systems, check the length of the tubes, spacing, and location of tube openings in accordance with your plants' heating system. Perfect configuration of the

heating system is essential for efficient heating of the greenhouse.

Ensure all boiler components are in perfect condition before the start of the heating season. Also, contact your fuel dealer before the season starts to check costs and assure continuous supply of fuel.

Control Greenhouse Pests and Diseases

Humid conditions in greenhouses can be a breeding ground for various pests and diseases that will prove harmful to your growing plants and seedlings. Maintain a clean, regularly disinfected greenhouse to curtail such problems. Clean your greenhouse in either late winter or early spring.

Cleaning Materials and Tools for a Small Greenhouse

- Washing up Gloves
- Brush or Mop
- Wire Wool
- Scrubbing Brush

- Domestic Cleaner
- Disinfectant
- Fungicides and Insecticide with necessary biological controls
- Non-Drying Glue

Cleaning and Disinfecting Your Greenhouse

First, empty greenhouses of all pots, plants and other accessories.

Then, clean greenhouses of any weeds, dead plants and rotting leaves.

Wash all accessible glass with warm soapy water.

Clean all pots with disinfectant.

Use fresh compost in pots for sowing seeds and seedlings. Use a covered watering can with copper-based fungicide in the water to water your seedlings.

Hang yellow sticky traps near plant tops in your greenhouse. These prevent build-up of different flying pests like the white fly.

Vine weevils often attack the roots of plants in pots. Check for these pests while re-potting your plants. Applying non-drying glue as a band across pots can stop any influx of adult weevils. You can also use soil drenches, composts and other biological controls as protection against adult weevils.

Allow as much air circulation as possible within your greenhouse. Keep open roof vents and windows to prevent air stagnation. Powdery Mildew and Grey Mold are common diseases in greenhouses with stagnant air. Fan heaters blowing in cool air can act as a good remedy.

Spider mite populations thrive in a hot and dry climate. In the summer, greenhouses present this sort of atmosphere that allows spider mites to multiply rapidly. These appear as yellow and brown specks with fine webs on the leaves of your plants. Move out as many plants as possible from the greenhouse during such weather. Use handheld mist sprayers to increase humidity levels within the greenhouse. You might use systemic insecticide spray too.

Grow different crops and plants every year in your greenhouse to prevent growth and spread of soil pests and diseases.

Cover potted plants with sand or grit to prevent an influx of sciarid fly or fungus fly. This greenhouse pest eats off the plant stems just above ground. Grease a yellow card and hang it near the plants.

Botrytis is the most common greenhouse disease causing brown spots and patches of gray mold over the plants. The best way to control this pest is to increase air circulation and avoid planting seedlings in pots kept in damp and shady parts of the greenhouse.

Mildews affect young shoots, like those of rose, fruits, poppies, begonias etc., in your greenhouse. Remove and burn affected leaves. Increase air circulation within the greenhouse and, if the problem is very severe, spray dispersible sulfur or copper fungicide.

Part-VI: Greenhouse Accessories

Greenhouse Accessories Guide

Numerous greenhouse accessories may be helpful to maintain an efficient, productive greenhouse.

These accessories play an equally important role in growing plants in greenhouses.

Wireless Thermometer: This is a digital thermometer that helps you find the temperature within your greenhouse without you actually moving out of your house.

Budding/Grafting Knife: These knives have special hand-made blades that help you cut and graft your plants with precision.

Cleaner: Cleaners with no toxic properties are the best for cleaning your greenhouse. They prevent spreading of any poisonous fumes within the greenhouse.

Greenhouse Shade Netting: This provides temporary or permanent protection to your plants and crops within the greenhouse. The netting has strong tying points with eyelets woven into their seams.

Traditional Wooden Riddle: This common greenhouse tool can help you clean gravel for paths, remove stones from soil, provide fine layered soil for sowing seeds and do similar work in your greenhouses.

Warming Pads: These pads help in quick germination of seeds within the greenhouse. Space crunch is common in greenhouses. These pads speed up the germination process and offer more free space.

Garden Track: This accessory consists of heavy-duty plastic tiles linked with clips. Join these to form wide outdoor walkways. Making many pathways within greenhouse does not take much time.

Magic Seeder: This accessory helps you dispense seeds in plug trays and pots easily. All you need is little bit of thumb pressure for accurate planting.

Aluminum Staging Foot Plates: Use these plates in greenhouses with soft floors. These prevent seed tray rack legs from sinking into the ground.

Small Fixing Support: These small supports help you tie growing vines and similar creepers. These supports have cropped bolts to help easy fixing.

Glazing Spring Clips: These steel wire clips are W-shaped. They help to hold glass in aluminum greenhouse frames.

'S' Hooks: These hooks provide necessary support for hanging baskets within greenhouses.

Aluminum Lap Strips: You can bend these strips in any shape you want. They are very useful within greenhouses.

Greenhouse Door Wheels: These wheels are best for use in a greenhouse with sliding doors. You can change the wheels to suit your preferences.

Greenhouse Fix Clips: These clips prove useful in many ways in your greenhouse. You only need to insert the clip in the bolt slot within the glazing bar and twist it to make it secure. These are easy to use and can help fix insulation and shading in aluminum greenhouses. You can use spacers with the fix clips to create small gaps of about an inch between lining material and greenhouse glass.

Greenhouse Seed Tray Racks: These racks help you grow numerous seedlings within a minimum space. They can prove very useful in crowded greenhouses. Normally, these trays hold four full-size seed trays on each tier.

Cropped Head Bolts & Nuts: These bolts are rectangular in shape and fit into slots of the aluminum glazing bars. They help you fix things without having to dismantle anything first.

Greenhouse Shelving: These aluminum shelves create extra space within the greenhouse. These are available with suitable brackets and bolts. They can hold numerous extra structures within your greenhouse to add options and save space.

Greenhouse Propagators: These offer the necessary amount of heat for every part of the plants within greenhouses, especially to ensure healthy growth of plant roots. Use propagators that best suit your requirements.

Garden Netting: There are different types of garden netting available for use in greenhouses. These include insect mesh, butterfly netting, anti-bird netting, windbreak netting, greenhouse shading and others. They offer protection for your plants within your greenhouse.

Know Your Equipment and Supplies

Greenhouse gardening is becoming very popular. You can have a greenhouse on a commercial level or have it as your hobby. Certain essential equipment and supplies are necessary in any greenhouse to help the plants in the greenhouse to grow healthily. Greenhouses are like chambers. You regulate light and temperature within your greenhouse to promote optimum growth of the plants.

Essential Greenhouse Supplies

Fog System and Watering System: Water is essential for all plants in the greenhouse. According to the type of plants, they may require daily watering or watering on alternate days. You should have a proper watering system - a can for a small

greenhouse, ranging up through a capillary system, dripping system, etc., to provide the necessary water to your plants. Fog systems help maintain essential humidity levels in greenhouses.

Heating System: Although the glass panes on greenhouses bring in essential heat, it may not be sufficient during the cold winter months and at night. You need a heater to regulate temperatures within your greenhouse. You can use a fuel heater or electric heater according to your choice, depending on costs and other factors.

Ventilation: This is very essential to aid proper air circulation within the greenhouse. Heaters release fumes and you need to push out this air.

Greenhouse thermometers: Help to detect the prevalent temperature within your greenhouse. You can then act according to temperature readings on your thermometers.

Lighting Arrangements: Light is essential for proper growth of plants within your greenhouse. Normal sunlight may suffice for your plants' requirements. You can have additional lighting arrangements with fluorescent bulbs and other lamps for cloudy days and the winter months.

Shading Equipment: However, excessive light can prove harmful too. Therefore, you require special shading materials like shading compounds, blinds or plastic curtains to filter any unwanted light from entering your greenhouse.

Flooring and Benches: Use a functional, non-skid flooring for your greenhouse with gravel. Non-skidding surfaces can prevent accidents during watering. Additionally, place benches within the greenhouse for you to rest and take in the beauty of your greenhouse while caring for it.

Cold Frames and Hotbeds

Cold Frames

Cold frames are boxes without bottoms, but they have removable tops. These prove helpful in protecting plants from the extremities of weather; cold temperatures and harsh winds. Cold frames use sunlight to heat soil within the box during daytime. This heat radiates back to the plants at night and keeps them warm.

You do not usually need any artificial manure or fertilizers within cold frames.

Cold frames help you start your growing season early. You can grow seasonal vegetables and flowers within these cold frames. Such protected growth lets you transplant your plants

early too. These cold frames provide the ideal environment by allowing you to save your seedlings from the winter frost. The setting is similar to that within a portable greenhouse.

Anthurium and other plants in a greenhouse

There are different types of cold frames available, like Juliana Cold Frames, Halls Cold Frame Kits and others.

These kits are available in two models. The single cold frame has two sliding and hinged vents with polypropylene glazing. The double cold frame has polypropylene glazing with four hinged and sliding vents.

Hotbeds

A bed of soil within a plastic or glass frame constitutes a hotbed. Steam, electricity, manure or hot water pipes heat the bed of soil. Hotbeds prove useful for growing seedlings and small plants early and easily too. You can sow seeds of flowers and vegetables long before you could sow them in the outside weather.

Hotbeds prove to be a good initial sowing ground for propagating growth of your seedlings. The hotbed should normally be on well-drained soil. In some places, you need a three-inch gravel base underneath the prepared soil mixture of hotbeds.

If you use electricity for heating hotbeds, lay cables at the bottom of the bed or on a bed of sand and cover it with gravel. There should be a covering of two inches of sand over the cable. If you intend sowing seeds directly into the hotbed and not in pots, use wire screening mesh covering of inch-wide overheating tape to prevent any damage from cutting tools.

Facts about Famous Greenhouses

1) Greenhouses have different names across different countries. The British prefer calling greenhouses “conservatories” as they conserve plants. The French call their greenhouses “orangeries” as they prevent oranges from freezing.

2) Leamington in Ontario houses the largest greenhouse complex in the world. More than two hundred acres of land is under glass for commercial cultivation of tomatoes.

3) The concept of the modern greenhouse started in Italy in the sixteenth century. It then spread to Netherlands and England. Samuel Cocking built the first greenhouse in Japan in 1880. David Chelf from the University of California in Berkeley designed the first air-supported and wind-assisted greenhouse.

4) The Palace of Versailles houses a huge greenhouse with a length of five hundred feet that is forty-two feet in width and has a height of forty-five feet.

5) The New York Crystal Palace, London's Crystal Palace, Kew Gardens in England, and Munich’s Glaspalast are among the different greenhouses that have been used for horticultural and non-horticultural exhibitions.

