CHAPTER 13

GREENHOUSE ENERGY CONSERVATION AND ALTERNATIVES

INTRODUCTION:

*In northern latitudes (Canada, England, Holland, etc.) the cost for heating, especially, and cooling a greenhouse can amount to 70 – 85% of the total operating costs. In warmer areas (the Southwest United States, Mexico, Spain, Israel, etc.) the costs can still be around 50% of the total operating costs.

*Therefore, heating and cooling are obviously a significant part of the operating budget.

*Any measures that reduce the need for heating and cooling will reduce the costs for these as well, and will therefore increase profit (the bottom line for a commercial grower, schools and even home gardeners!).

*This chapter presents methods to conserve energy in a greenhouse as well as alternatives to "traditional" methods of heating and cooling.

GREENHOUSE ENERGY CONSERVATION MEASURES FOR HEATING

*__Greenhouse orientation:__

In northern latitudes single bay greenhouses can be oriented east-west to allow maximum light reception in the late fall, winter and early spring.

For multiple bay, gutter-connected greenhouses the orientation is usually north-south so that the shadows from the gutters track from west to east across the crop rather than shading the same areas all day.

In either case, the rows of plants within the greenhouse should run north-south to optimize equal light to all plants throughout the day.

***Windbreaks to save on heating:**

A wind of only 15 mph can double the heat loss from a greenhouse.

A wind reduces the thickness and therefore the insulating effectiveness of the thin air layer (boundary layer) along the greenhouse glazing. A wind will essentially "suck" heat away from a greenhouse faster than if the air was still.

Windbreaks, in the form of fences, trees, buildings, etc. can slow the wind and therefore cut heat losses from the greenhouse.

Windbreaks are most effective with older, leaky greenhouses or in high wind areas. However, older greenhouses should be upgraded since this will save far more money in heating costs than any windbreak.

***Use of double verses single layer glazings:**

Double layer glazings, with at least a ¼" insulating layer of air in between, can reduce the conductive heat loss by up to 40% over single layer glazings.

Using triple layered glazing or, for example, a double layer of polyethylene over glass, can further cut heat loss, but it will also reduce solar radiation, so this is very rarely done.

***Structural insulation:**

Insulating materials can be applied to the foundation of the greenhouse, to the north wall (in the northern hemisphere) and to the walls up to the height of the plants to reduce conductive heat loss.

Weather stripping and other insulating materials should be added where ever there are gaps in the structure. This includes around doors and vents and where glazing panels meet the structural supports.

If the glazing material is cracked (ripped polyethylene, broken glass panes or cracked poly acrylic or carbonate) replace immediately to reduce heat loss.

***Inflatable tube insulation:**

Polyethylene tubes (6-18" in diameter) can be hung from the greenhouse ceiling.

When inflated they create an effective insulating barrier to heat loss through the ceiling (up to 40%). Make sure the tubes fit snuggly along the walls.

Since polyethylene above the crop will reduce light transmission, tube systems have been designed to be retractable or removable during the day.

Though effective, these systems are rarely used in commercial operations.

***Retractable heat or insulating blanket or curtain:**

Porous, non-porous and aluminized materials are all used as insulation blankets.

The material can be single or multiple layers: more layers giving more insulation.

The material, placed between the ceiling and the crop, must be secured along the walls to minimize cold air above falling through onto the crop.

These curtains can be used during the day in the summer for shading as well.

These retractable curtains are perhaps the most cost effective.

***IR coatings on polyethylene films:**

These infrared barrier films allow heat into the greenhouse during the day (requiring a bit more venting or cooling) but significantly reduce heat loss at night by as much as 30%.

***Other insulating methods – experimental:**

Polystyrene beads have been used by blowing them into the air space between two glazing layers. Energy savings may amount to 60-90% annually.

Liquid foam (or soaps) can be blown into the air space between two glazing layers for an energy savings of perhaps as much as 50%.

A disadvantage of this is that most foams break down in cold.

Unfortunately, neither of these experimental methods are currently practical.

***Equipment operation and maintenance:**

Maintain the heating equipment (check for leaks, valve operation, thermostats, etc.) so that it operates at peak efficiency.

Insulate supply and return hot water/steam pipes. Inspect regularly.

Choose the most efficient and cost effective fuel: In most places, natural gas.

GREENHOUSE ENERGY CONSERVATION METHODS FOR COOLING

***Structural considerations:**

As with heating conservation, insulation and weather stripping can reduce infiltration of hot outside air into the greenhouse which will reduce cooling needs.

Damaged glazing materials should also be replaced.

Taller greenhouses (16-22 feet, about 5 to nearly 7 meters) are better since hot air will rise away from the crop.

***Equipment operation and maintenance:**

Maintain the cooling equipment so that it operates at peak efficiency.

***Passive measures:**

Energy savings can be realized by using shade cloth or paint as mentioned in Chapter 12.

ENERGY ALTERNATIVES FOR GREENHOUSE HEATING

***Compost energy**

The breakdown of plant material in a compost pile generates heat.

Example: Although the outside temperature can be 55^{o}F (~13^{0}C) or colder, the temperature within a compost pile can be as much as 120^{o}F (49^{0}C) or more.

PVC pipe, with an opening to the outside air, can be installed within the compost pile. The heat from the pile will be transferred to the air in the pipe which can then be drawn into the greenhouse with a small fan. Unfortunately, this technique also tends to add moisture and odors to the air.

Pipes filled with water can also be placed inside the pile and the heated water can be used to heat the greenhouse. This is much better and odor free.

***Solar energy**

During the day the sun can be used to heat either water or air.

This heated air or water can then be used during the night to heat the greenhouse.

However, at present it would take a solar collector at least 500 m^2 to heat a greenhouse 1000 m^2.

Also, solar collectors do not work effectively on hazy or cloudy days. Other types of heat generation would be needed.

***Geothermal energy**

Water heated by energy from the Earth's interior is being used extensively in Iceland to heat all structures including homes, businesses and greenhouses.

There are also several installations in the western United States that use geothermal energy.

Problems of using geothermal energy include corrosion and sealing of the pipes, toxic gases such as hydrogen sulfide, mercury, radon, ammonia and boric acid, silica deposition in the equipment, heavy metal contamination and complications with disposal of the waste thermal fluids.

***Waste heat utilization from power plants**

Large industrial units, electrical generating stations and nuclear power plants all produce waste heat mainly in the form of hot water.

During the 1970's and 1980's research was conducted to determine the feasibility of using this waste energy to heat greenhouses.

Facilities were tested in France, England, the United States and other countries.

Most tests showed that the cost of connecting the greenhouse and power plant could be too high and that the resulting heat source might be unreliable during repair and maintenance of the power plant.

***Co-generation**

These are total energy systems which produce both heat and electricity from the same unit.

It consists of an engine which turns a generator to produce electricity onsite. Small units can produce 20-100 kilo watts.

Reject heat from the operation of the engine can be used to heat the greenhouse.

One might also be able to obtain an extra added benefit by tapping the engine exhaust for carbon dioxide for use by the plants in the greenhouse.

REFERENCE MATERIAL

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