

# Reducing greenhouse heating costs by low-cost energy saving actions

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The major portion of energy used in greenhouses is used for heating. There are several ways to reduce the heating costs, for instance installing a flue gas condenser, heat buffer, insulation material, energy screen, etc. These require considerable investments. Other energy saving measures do not need a huge outlay but are based on proper set-up and maintenance. This article deals with the latter sort of measures, including temperature gradients, heat delivery, heat distribution, air-tightness.

## **Vertical temperature gradient**

Most greenhouses will have temperature gradients in vertical as well as horizontal direction. A vertical gradient means that the temperature is different between the bottom and the top of the plants. This is often considered inevitable and inherent to a type of heating system. It is largely due to the height of the heat outlet. Heat can be delivered 'overhead' (e.g. hot air heaters), or half way the crop, or at ground level (e.g. pipe-rails from a boiler), or even below the crop (i.e. under a bench).

Overhead heating does not easily penetrate into the canopy, and as a result the lower leaves stay cold and wet and are prone to grey mould. Another serious disadvantage of overhead heating is that a lot of heat is lost through the roof.

Under-bench heating is not always efficient either. It warms the roots but may leave the heads of the plants too cold, which may cause undesirable effects on the plants. Moreover a certain amount of heat is lost to the soil under the bench.

The most efficient heat delivery is low in the canopy, either by heating pipes or hot air ducts. The heat rises up through the canopy and warms the leaves. Very little energy is lost through the roof, in contrast to overhead heating. Figures from the Netherlands indicate that heat delivery low in the crop is 33% more efficient than overhead heating. The difference is even much more in greenhouses with a leaky roof.

## **Horizontal temperature gradient**

A horizontal gradient means there are cold spots and warm spots in the greenhouse. This is undesirable as it causes uneven plant growth and different harvest times. It also means that energy is wasted because a part of the greenhouse receives too much energy. Horizontal temperature gradients should be avoided as much as possible. The wind has an effect on the horizontal temperature gradients, and so has the location: greenhouses on a slope will have warm spots on high places. But the temperature pattern is determined to a great deal by the type and lay-out of the heating system. Hot-air heaters are notorious for creating uneven temperatures in horizontal direction. Many pipe heating systems create horizontal temperature gradients too due to unbalanced lay-out of the pipes.

## **Avoiding temperature gradients**

The most obvious and easy way to alleviate temperature gradients is to use big fans to stir the air. But they require energy, and their effect is restricted to the open space above the canopy. Fans will resolve the horizontal gradients, but vertical gradients inside a high canopy such as tomatoes can be harder to break.

With hot air heaters, the vertical gradients can be overcome by ducting the heat through plastic tubes and releasing it between the plants.

Heating pipes, especially pipe-rail systems create a clear vertical gradient: warm feet but cold head. It would be useful to have an additional heating pipe higher in the crop. This is especially effective in cold climates. Such a pipe can assist in controlling the plant growth, and can reduce Botrytis on stems and leaves. Ideally this pipe higher in the crop is controlled separately, and is connected for instance to the flue gas condenser.

With pipe heating, horizontal gradients can arise due to a heat transfer duct that is not insulated. This causes higher temperatures locally which have an effect on the plants. It is also a waste of energy. Even more energy is wasted if a heating duct is located along a side wall. Relocating the duct to a place where heat discharge is useful is an option, but clearly the best option is to insulate the duct.

With under-bench heating the temperature pattern depends on the lay-out of the benches and the heating system. Some combinations may work well and in other situations there is room for improvement. Generally when the temperature gradients disappear the energy efficiency improves.

### **Air-tight or leaky cladding**

Greenhouses differ greatly in air-tightness. Inflated double poly cladding is very air-tight (and it provides excellent insulation too). In contrast, some old glasshouses are very leaky with large gaps between glass and groove or between partly overlapping glass panes. In some greenhouses the mechanisms to open and close the windows, when faulty, can create serious gaps. Moreover, some houses are in terrible state of repair with broken and displaced glass panes or large pieces of plastic blown away. It is not surprising that any gaps and holes in the greenhouse cladding are major energy wasters.

Air-tightness is expressed in air exchange rate. Well sealed greenhouses have a low air exchange rate of 0.2 per hour, whereas old greenhouses can have a value of 2 per hour (at standardized wind speed). It can be 4 or more in glass or plastic houses in poor condition. The meaning of air exchange value of 1 per hour is that the whole greenhouse volume is replaced by fresh outside air once per hour. A value of 4 means that the whole greenhouse is refreshed four times per hour.

To improve the air-tightness, holes must be repaired, cracks may be sealed, vents adjusted, etc. Unless a greenhouse is beyond repair, generally the costs of repair will be earned back over time by reduced energy consumption and better plant growth.

### **Insulating the south wall**

Ideally, the cladding material of a greenhouse has a high insulation value as well as a high light transmission. But light transmission is less important for the walls, especially on the south side. It often pays to use insulating material on the south wall even if this compromises the light transmission. With limited investments a grower can add an extra layer of material to the wall, and the air between the two layers acts as insulator. Transparent material is preferable but less translucent material is also used. The benefits of energy saving may outweigh the disadvantage of light loss. Obviously this energy saving measure is most important in winter, and more in colder areas.

### **Computer setting**

In a computer controlled greenhouse, the computer settings have a great effect on the energy consumption. Small mistakes can make a difference. For instance check that the clock is set for day light saving time when relevant. Make sure that heating and venting are harmonized, to avoid unintentional heating with the vents wide open. For the same reason, the temperature for venting should be set higher than the temperature for heating. The difference between heating temperature and venting temperature must be at least 0.5 °C to avoid that venting and heating are switched on and off all the time.

## Energy in greenhouses - part 5

All sensors need regular calibration. Make sure that your measurements of temperature and humidity are true. Verify that the vent opening is monitored correctly: that means measure the opening of a number of windows on various places and check if this agrees with the reading on the computer (e.g. 5%). If windows are systematically open wider in one compartment compared to another, it can cause a significant difference in climate control and energy use. Also the sensors used by the control computer must be placed on a good location (not a cold or a hot spot), because this influences the amount of heat pumped into the greenhouse.