Energy saving measures – options listed

Elly Nederhoff
CropHouse Ltd, New Zealand
Elly@CropHouse.co.nz
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Energy prices are high and still rising. Many growers search for ways to overcome the rising costs of heating their greenhouse. In this second article we give an overview of technical measures that can be taken to reduce the energy consumption. This is largely based on information from the Netherlands. For New Zealand the principles are the same, but the saving percentages can be different, as the winter conditions are milder in most of the country. The economics are different too, because of different price structures and different benefits. Below follows a list of basic actions with a very brief description. Later articles will look in more detail in each measure.

Sealing the greenhouse and adjusting the vents
A lot of energy can be lost through leaks in the greenhouse, especially through vents that do not close properly. Repairing any broken glass or plastic is obvious. Less obvious but far more important is to check if the vents close properly. If not, they have to be re-adjusting. This can reduce unwanted heat loss by several percents.

Insulating greenhouse roof
A greenhouse roof of single polyethylene plastic or single glass looses a lot of heat. Other cladding materials loose less energy. For instance double glass or double non-flexible synthetic panes can save up to nearly 40% on heating costs compared to single glass, while coated glass can save 6-21%. The energy saving of inflated double poly-ethylene is not given. Some types of insulated cladding material can have a lower light transmission though.

Insulating greenhouse walls
The walls of a greenhouse can be insulated in various ways, e.g. with foil or other material, coated glass, double layer of cladding or double glass. In large greenhouses it can save up to 4%, while in small greenhouses it can be much more.

Insulating greenhouse foundation and poles
The concrete foundation and poles supporting the greenhouse roof can conduct energy to the (cold) underground. Insulating these concrete structures can save 0.5% of the heating costs in cold climates.

Fixed thermal screens
Transparent polyethylene plastic foil is put in place in late autumn and removed in early spring. They are placed high above the crop supported by wires. These screens can save 16-19% on heating. However, the build-up of moisture under such screen is a huge disadvantage. Growers often cut holes in the plastic when the high humidity causes problems.

Moveable thermal screens
These are curtains that can be opened or closed when needed. They can be made from a range of materials from polyethylene foil to woven materials with aluminium in it, and more. Some can be used as shade screen in summer as well, or some growers have a separate screen for shading in summer. Moveable screens can save 15-44% in heating costs.

Condensor
A condensor is a device placed in between the boiler and the stack of the boiler. Its function is to cool down the flue gases and to condensate the water vapour in the flue gas. The energy from cooling and condensation is transferred to water that is used in a hot water pipe heating system. This can be a special heating net with lukewarm water. A so-called combi condensor has additional functionality. The savings can be 4-8% on heating costs.

Transport ducts insulated and underground
The main heat transport duct should be insulated where ever possible, as this saves a lot of energy. Secondly the transport duct can be placed underground (and of course must be insulated then). Putting it underground reduces light loss and hence increases the yield, which in turn increases the energy efficiency.

Boiler serviced and insulated
Boilers that are not well serviced and fine-tuned can be unnecessarily waste a lot of energy. In addition, insulating the boiler can give a considerable energy saving. Air supply to the boiler is critical. Insufficient air is dangerous and harmful, but too much cold air going trough the burner reduces its efficiency.

Modulated pumps and vents
In a hot water pipe heating system, it pays to use modulated pumps. In such pumps the frequency can be controlled. In periods of high heat demand, water needs to be pumped around fast, whereas in periods of low heat demand the pumps can run slower. Modulated pumps can save 17-26% on the electricity bill.

Large-surface heating pipes
Some heating pipes do not have the standard round shape, but a flatter shape with fins. This creates a larger surface compared to the volume of the pipes. The advantage of this system is faster heat transfer. In some cases it may save a bit of heating energy in the order of 1%.

Optimal heat distribution
Many greenhouses have cold spots, or have a vertical and horizontal temperature gradient. The danger is that a cold spot is a humid spot, where fungal diseases start. The grower often tries to maintain the required temperature at the coldest spot, and meanwhile gives too much heat on the other places. A proper lay-out of the heating system helps to avoid this, and may save 2-5% of heating energy.

Optimal minimum heat pipe
Some growers use a minimum pipe temperature to stimulate plant transpiration on a dull day, and to keep plants dry to avoid diseases. This heating is often combined with venting. More sensible use of the minimum pipe settings may save up to 10% of the heating costs.

Cogeneration
A co-generator is an engine on gas or oil for example that generates heat and electricity. The heat is used for greenhouse heating and the electricity can be used for pumps or elsewhere on the property, or can be sold. In some countries growers have an arrangement with the power company to put the electricity in the grid. Sometimes the power company owns and operates the co-generator, and sometimes the grower is the owner/operator and sells the electricity. Savings percentages vary from 16 to 28% on heating costs.

Using waste heat or other sources of heat
Heat from a power plant or other heat source can be used. Geothermal heat can be an option at some places. New technology is developed to utilise low-temperature heat from the soil or the underground. In the Netherlands heat that was captured in the summer is stored in an underground water layer (aquifer). In winter the warm water is pumped up again and used for heating.

Heat buffer
This is an insulated tank with water, that is connected to the hot water pipe heating system. The buffer can be heated up to about 100 °C to store energy; and later the heat can be retrieved and used for greenhouse heating. The size of a heat buffer can be well over 100 m^3 for a greenhouse of 1 ha (10,000 m^2). Heat buffering is mostly used for CO_2 enrichment: it allows burning fuel at daytime for CO_2 supply and using the heat at night for greenhouse heating. Overseas, buffers are also used to create flexibility, e.g. burning fuel when it is cheap and using the heat when needed.

Temperature integration
This is a way of managing the greenhouse temperature that is offered by advanced greenhouse control computers. It is based on the fact that most mature plants do not need the exact temperature all the time. They can accept a lower temperature in a short period, as long as it is compensated by a higher temperature later. So the heating is tuned down when it is expensive to heat. This way of temperature control can save 5-10% on heating costs, without loss of production.

Recording energy consumption and efficiency
Recording energy consumption and relating it to the conditions and situation helps to understand energy demand. It is useful to calculate the *energy efficiency*, being the amount of yield per amount of energy. Recording alone without doing any investments may lead to 5% energy saving. By comparing own data with reference data, growers can decide if there is a need for energy saving actions.

Other options
The above list is not complete by far. Other options exist and are being developed that may help reducing the use of conventional energy. Some examples are heat pump, capturing and storing solar heat (e.g. underground, seasonal storage), solar panels, heat from the soil, biogas, biofuel, combustion of biomass, dehumidification of greenhouse air, and more. Some have huge potential. Moreover, there are many actions that don't require a huge outlay, but require a change in crop management or climate control. These will be discussed later.

Acknowledgements: *the percentages mentioned above are taken from the 'Handbook environmental measures greenhouse horticulture' (in Dutch), Novem, 2000.*