ENERGY EFFICIENCY IN GREENHOUSES

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Energy is one of the highest cost factors for greenhouse growers, together with labour costs.

There is a drive to reduce the use of fossil fuels in greenhouses and thereby reduce the emission of carbon (CO_2). The objective is to be more sustainable, both financially and environmentally. Financially, it is necessary to cut costs and/or increase income to stay profitable. Environmentally, there are political aspirations to reduce the dependency on fossil fuel and to reduce carbon emission and air pollution. In a new series of articles, we will discuss methods of improving energy efficiency in greenhouses.

Energy efficiency

By far the biggest chunk of energy used in a greenhouse operation is for controlling the greenhouse climate. Firstly, energy (mostly fuel) is used for heating and CO_2 enrichment; secondly electricity is used for powering vent motors, fans, pumps and so on, and thirdly, energy is used for vehicles, sorting machines, work lights, coolstores. Although the third category is important too, it is outside the scope of this series. Our focus will be on heating (for temperature and humidity control) and CO_2 enrichment and using other control devices.

There are various approaches for improving the energy efficiency, such as:

1. Use less energy but maintain the normal yield.
2. Use the normal amount of energy but achieve higher yield and better quality (less rejects).
3. A combination: use less energy and despite that, increase the yield and quality.
4. Replace conventional fuels by sustainable energy sources.

A greenhouse that produces more kilograms per unit of energy (as in points 2 and 3 above) has an improved energy efficiency, which is good financially.

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Wide spectrum

The New Zealand greenhouse industry involves a wide spectrum of situations:

- Different climate zones: cold winters in the south versus mild in the north.
- Different seasons: winter versus summer, noting that greenhouses also use energy in the summer.
- Different greenhouse types: uncontrolled tunnel houses versus state-of-the-art glasshouses.
- Crops with different temperature needs: for example, lettuce versus cucumber.

We will not address all situations, for instance it is impossible to improve energy efficiency in a heated greenhouse that has no means of control. In contrast, corporate greenhouses probably have taken most energy saving measures and up-to-date knowledge on board. So we will focus on small to medium-large controlled greenhouses.

Greenhouse climate factors

Climate involves several factors such as temperature, humidity, CO_2, light, air movement and more. Tools to manipulate the climate include heating (pipes or hot air heaters), venting, screening, irrigating, fogging or misting, fans, CO_2 enrichment and in some cases lighting. One action can affect many factors. For instance, heating affects temperature, humidity and air movement. Closing an energy screen affects light, temperature, humidity and air movement. CO_2 produced from natural gas generates heat, so indirectly CO_2 enrichment affects temperature, humidity, vent opening, air movement, water use and of course energy efficiency.

Plant physiology

A greenhouse with advanced control and a good computer can create the optimal growing environment. It costs energy, and the challenge is to use it wisely. But what is optimal? Plants respond to their environment in various ways: there is an immediate response as well as medium and long-term responses. For instance, if the sun comes out, immediately the stomata (leaf pores) will open and there will be a sudden increase in water loss (transpiration) and CO_2 uptake (photosynthesis). In contrast, there are slow processes, such as the rate of growth, stretching, leaf area and thickness, the number of leaves that form in a week, formation of flowers, and fruit set. In the long-term, plant shape is a result of slow responses, and is related to the average climate conditions as well as extremes over a period of time.

Dynamics

A greenhouse is a dynamic environment. Conditions change all the time and controllers act swiftly. Plants depend on the greenhouse climate, but vice-versa, plants also affect the greenhouse climate. For instance, active plants bring a lot of water vapour into the air, thus increasing the air humidity and lowering the temperature. You notice this in summer when you walk into an empty greenhouse: it will be very hot and dry. In comparison, a greenhouse with fully grown plants is a lot cooler and more humid even in the middle of summer. Understanding the dynamics between greenhouse climate and plant responses will help towards successful cultivation and improved energy efficiency.

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Topics on energy efficiency

It will be clear that improving the energy efficiency is not just a matter of installing energy-saving equipment. It is a lot about opting for the right equipment and choosing energy-wise settings in the greenhouse control computer, especially for heating, vent opening, humidity control, CO_2 enrichment and optimal ways of operating an energy screen. In this series of articles, we will discuss several of those aspects, for instance:

1. Greenhouse physics: heat trapping, radiation and convection, air movement, humidity.
2. The interdependence of temperature and humidity.
3. Plant physiology: what the optimal climate is for a plant.
4. Temperature effects, long-term, short-term and immediate.
5. What air humidity is good for plants, when, why and how.
6. The importance of even distribution of temperature and humidity.
7. Better use of energy screens.
8. Using fans for air movement.
9. Combining screens and fans.
10. CO_2 enrichment and energy use.
11. The 'new way of growing'.
12. Biomass as an energy source.