Energy study completed, opportunities assessed

Elly Nederhoff & Bert Houter
CropHouse Ltd, New Zealand
Elly@CropHouse.co.nz
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Project

Recently we completed a three-year project on 'Energy Efficiency in Greenhouses' funded by the Sustainable Farming Fund and the Fresh Tomato Product Group of Horticulture New Zealand. We worked with a number of 'test sites' in the Auckland and Christchurch regions that were a good cross-section of the industry. Here we report some general findings and try to put them in a realistic perspective.

Introduction

Typically, greenhouses have a very high input and a very high output. For example a tomato crop in a modern well-controlled greenhouse can produce 10-20 times more tonnes per hectare per annum than any outdoor crop. The high output of high-quality high-value products is achieved by a high input of capital, labour, fertilizers and energy. This is all necessary in order to capitalize on the high investments. Excessive reduction of input would reduce the output to the point where the investment costs are not earned back anymore.

Energy

One of the major inputs in a greenhouse is energy, mainly fuel for heating, or in fact for maintaining optimal growing conditions (temperature, humidity, CO2 concentration). Additional energy in the form of electricity is needed for pumps, motors, water treatment, irrigation, etc., but that is a much smaller quantity. Like other industries, the NZ greenhouse industry must reduce its energy input. Too drastic reduction of energy input for climate control may lower the output (production and quality). This can cause crop failure and can ruin the business. The question is how can energy input be reduced without sacrificing the profitability of a greenhouse operation?

Some research questions

1. How much energy is needed for temperature control?
2. How much energy is needed humidity control?
3. How much energy is needed CO2 enrichment?
4. What is the effect of the location on energy demand?
5. Is a thermal screen feasible?
6. What is the energy efficiency (ratio of energy input versus yield)?
7. What can a grower do to reduce energy input while keeping profitability?

We try to consider the many factors that affect the energy use, e.g. location.

Method

We started with ten test-sites that were different in everything: location (wider Auckland and Christchurch regions), greenhouse type (glass, double plastic), fuels (gas, coal, oil), crop (tomatoes, capsicums, cucumber), control computer (five brands), heating system (pipe-rail, hot-air), growing medium, growing practices and everything else. Some sites proved more suitable or more interesting than others for various reasons. Over a period of three years, we visited each greenhouse a number of times, often with an external specialist. We collected & analysed a lot of data. Where needed, we used additional data of NIWA on outside conditions, and data from Natural Gas Corporation on gas consumption (with permission of the growers involved). From two sites, one in the Auckland region and one in Christchurch, we analysed data of some whole years. Using simulation models, we tried to generalise some of the results.

Results
Below we present only some conclusions and discussion in a nutshell. Some statements are obvious, but now we can back them up with data. This article is too short to present any details though. Some details were published earlier and some will appear in following articles.

General conclusions
1. The breakdown of energy use for temperature control, humidity control and CO2 enrichment was estimated, and is shown in the pie-chart. This can help making decisions regarding improving energy efficiency.
2. As expected, the energy use and energy efficiency in greenhouses in New Zealand differs greatly between growers due to many differences (e.g. in location, greenhouse type, crop, growing season, climate control strategy, heating system, fuel, energy saving equipment, growing system).
3. Basically there are four possible ways for improving energy efficiency:
   3.1. Investing in energy saving technology
   3.2. Improving the greenhouse and equipment
   3.3. Improving greenhouse climate control
   3.4. Increasing the production

Investments in energy saving technology
The cost-effectiveness of energy saving technology (e.g. thermal screens) depends on many variables, one of them being the weather conditions. In the North Island, the climate in winter is mild. Lack of cold weather makes that high investment costs are often not outweighed by savings in fuel. On the South Island, the winter conditions are much colder, but fuel is cheaper (coal). Also here the high investments are not easily earned back by reduced energy costs.
For some sort of energy saving technology (e.g. thermal screens) it is more economic to install them when a greenhouse is newly built, than to retro-fit it in an existing greenhouse. Many existing greenhouses in NZ are too simple or too old or too small. Economy-of-scale is an important matter. Some large pieces of equipment, for example advanced computer or heat storage buffer, are never profitable for a very small operation. They are only affordable in multi-hectare greenhouse complexes, of which there are only a few in NZ.
In addition, NZ growers do not receive subsidy or tax deduction investments. In contrast, some European governments do financially support energy saving investments. This is partly the reason why such technology is common practice in those countries.
In summary, in NZ, investing in high-tech energy saving technology may be cost-effective in new greenhouses, but is often risky in existing greenhouses.

Improving the greenhouse and equipment
What can be done in the many existing greenhouses in NZ, especially smaller ones? Three things remain (see 3.2-3.4 above). Improving the greenhouse and equipment includes (amongst other things):
- Repairing leaks and gaps in vents. Especially an accidental gapping of all vents (due to slipping of the closing mechanism) can cost considerable amount of in winter.
- Improving light transmission in the winter will assist plant growth and can just make the difference between a good and a poor crop.
- Insulating hot surfaces and hot pipes, as well as insulating part of the walls (e.g. on the south side) and insulating auxiliary buildings
- Energy can be saved by improving the burner efficiency by good maintenance and servicing, creating optimal air supply (too much air costs energy!), installing speed control on the burner.

Improving greenhouse climate control

Another option is improving greenhouse climate control. Temperature settings can be improved, so that enough heat is inserted when it is necessary and most effective. Timing of transitions can make a big difference in energy use.
A lot of energy is involved in humidity control to prevent diseases. This requires heating and venting, but it should be done in an energy-smart way. Based on automatic measurement of the conditions, the venting and heating must be set to achieve optimal growing conditions at the lowest energy input. Simple computers have limited options, while more advanced computer offer very good solutions.
Also a lot of energy can be involved in CO2 enrichment. It can be integrated in heating (for temperature and humidity control), by the use of a heat buffer. The set-up and control of heat storage and heat retrieval is complicated. On many sites this does not happen in the most energy-efficient way, and often the grower is not aware of the short-comings.
Often improvements are possible in the flows of hot water and return water. The return water temperature must be cold enough to take advantage of the condensor and heat buffer.
Improvements can be made in many cases, but quite often you need an advisor to point them out.

Knowledge and understanding

Greenhouse climate control requires good understanding of plant physiology, physics and control theory. Since the modern greenhouse industry in NZ is small and fairly young, there is a limited body of experience and knowledge available, and also limited education and training in advanced greenhouse management.
Advanced greenhouse climate control computers are bought from overseas. Generally the grower does not get (or buy) any training on how to use this computer. They find the computer manual unreadable. So most growers don't make optimal use of their control computer. Education & training is a key to improving energy efficiency in greenhouses.

Improving the production

The high costs of a greenhouse, including the high energy input, must be earned back by the sale of products. Energy efficiency is in fact the ratio between energy input and production. There are many ways to increase the production without increasing energy input. This can be by improving: variety, pest and disease control, water quality, light level in winter, nutrition (pH, EC, all nutrients) and much more. One way of learning how to improve the production is by applying 'Crop Recording' or 'Crop Registration'. This shows what the plant is doing, and it explains what needs to be done to achieve optimal plant performance. A higher production improves the energy efficiency. Recommendations on crop-recording, plant management, etc can be found in other sections.

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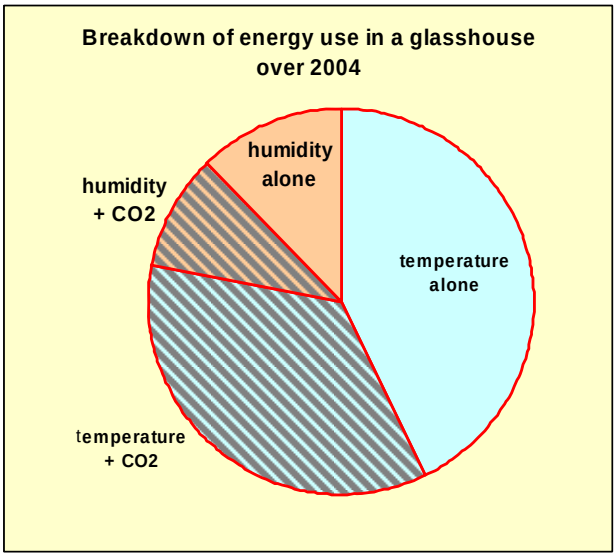

Figure. *Pie-chart showing the breakdown of the energy use in a glasshouse in the Auckland region that uses natural gas as a fuel, and uses a buffer for heat storage. This is based on one case study, but the relative figures can be used as an indication for other greenhouses on the North Island. Note: Greenhouses on the South Island generally use coal which does not produce CO2 pure enough for CO2 enrichment.*