

'Closed Greenhouse' and 'Heat-Producing greenhouse'

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Published in the *Grower* 61(10), 2006, p. 67-69

So far in this series we dealt with practical aspects of improving energy efficiency in greenhouses. This month we look at something foreign and futuristic: *Closed Greenhouses* and *Energy-producing Greenhouses*. They are still very expensive and hence not realistic for New Zealand growers, but parts of the technology have potential for application in NZ today. The pictures on the other pages tell how a Closed Greenhouse works. Below we describe some example projects.

Developments

Energy efficiency has been a key research topic in the Netherlands for three decades. Although huge progress was made, scientists thought that something more drastic was required and was possible. They knew that a greenhouse can harvest solar heat, and they found a way to store the heat. So the concept of the Closed Greenhouse was born. Then followed ten years of thinking, researching, developing, prototyping, trialling and investing. A great number of people is to be credited (see further). By now the concept is proven. For example, orchid grower Van Der Hoorn is building a 1.5 ha greenhouse in Ter Aar, with heat exchangers and heat storage in the ground, as well as artificial lighting. The novelty is that he has no connection to natural gas at all!

Themato

Themato in the Netherlands built the first 'Closed Greenhouse'. They tested the concept for a couple of years, and are now a demonstration site. Some of their results are: 22% more production, 30% energy saving, 40% sustainable energy production, 80% less agrichemicals, 50% less water use, better working conditions, compliance with legal norms for energy saving. Currently they grow capsicum on 14,000 m² Closed Greenhouse. They developed their concept into a brand called GeslotenKas® of Innogrow. At present a large tomato growers group, Prominent, is building this concept on a very large scale.

Fiwihex

Heat exchangers are being used for heat transfer: in summer heat is transferred from the warm greenhouse air to water, and in winter from warm water to cool greenhouse air. The technical challenge of the closed greenhouse concept is that the heat exchangers have to operate at low temperatures. Ground water is around 12 °C, which is excellent for cooling a greenhouse. Then in the cooling process in summer, it is warmed up to the temperature of the greenhouse air, say up to 28 °C. This luke-warm water is stored in the ground. In winter, this same water is used for heating. It is a lot colder than the usual heating pipe in winter. This requires a very efficient heat exchanger. Themato has dealt with that problem in their way.

Another developer produced the Fiwihex, which is short for **fine-wire heat exchanger**. It contains fine wires and tubes to create a very efficient transfer of heat from air to water or water to air. The fact that new projects are planned based on Fiwihex indicates that it works. (See schematic drawings on next pages).

Fiwihex is being tested since mid 2005 by Stef Huisman in Bergerden, a visionary grower of ornamental plants and trees. He built a 2,500 m² experimental Closed Greenhouse with Fiwihexes. The first reports are good: great controllability, excellent growing conditions, high CO₂, less insects and clearly higher plant growth rates.

This year a new much larger greenhouse is to be built for Aart Cornelissen in Berlikum. Several more projects are in the pipe-line and on the drawing board, also in other countries. Dutch governmental agencies have provided substantial financial support.

Energy producing greenhouse

Greenhouses catch more heat than the need (on an annual basis), so the idea is that greenhouses can supply heat to, for instance, houses. Noor van Andel, who invented the Fiwihex, has a far-sighted plan for a whole ecosystem that includes houses and a greenhouse. Resources like heat, water and CO₂ will be recycled or re-used, and waste will be converted to biogas. Four houses can be fully serviced by one hectare of glasshouse. A part of his vision is planned to become reality in the next few years in a project called 'Nieuw Amstel' in Nieuwveen. Here a large glasshouse for roses will become an Energy Producing Greenhouse supplying heat to 83 houses.

Electricity producing greenhouse

It does not stop here. Much more projects are underway. The latest very promising invention is a new type of solar cells for production of electricity, consisting of a thin layer of amorphous silicon. This development, known as Helianthos, is carried out by a consortium of universities, research institutes and Akzo Nobel in the Netherlands. Meanwhile the University of Wageningen is working on a greenhouse that indeed produces electricity.

Insiders say that the future looks sunny again for the Dutch greenhouse industry!

Acknowledgements: many people should be credited, and many sources quoted. I've tried to include the most significant names in the article.



Figure 1. Themato near Bleiswijk (Netherlands) is the pioneer of the Closed Greenhouse. After successful small-scale trials they expanded to 14,000 m² closed greenhouse, and are now a demonstration site. Initial crops were tomatoes, but in 2006 they grow capsicum on all 14,000 m². See text for results.

Compiled by Elly Nederhoff, Elly@CropHouse.co.nz.

The Closed Greenhouse

Source: Van Andel 2002

Figure 2 a, b, c, d
a) How it works
 A 'closed greenhouse' is not vented, so it gets very hot in the sun. Cold ground water is pumped through heat-exchangers to cool down the greenhouse air to normal temperatures. The water absorbs the heat. The then-warm water is pumped back into the ground. In winter, the warm water is pumped up again and sent through the heat-exchangers to heat the greenhouse air. More heat is stored than the greenhouse needs per annum, so the surplus heat will be used for residential heating (see house on the right).

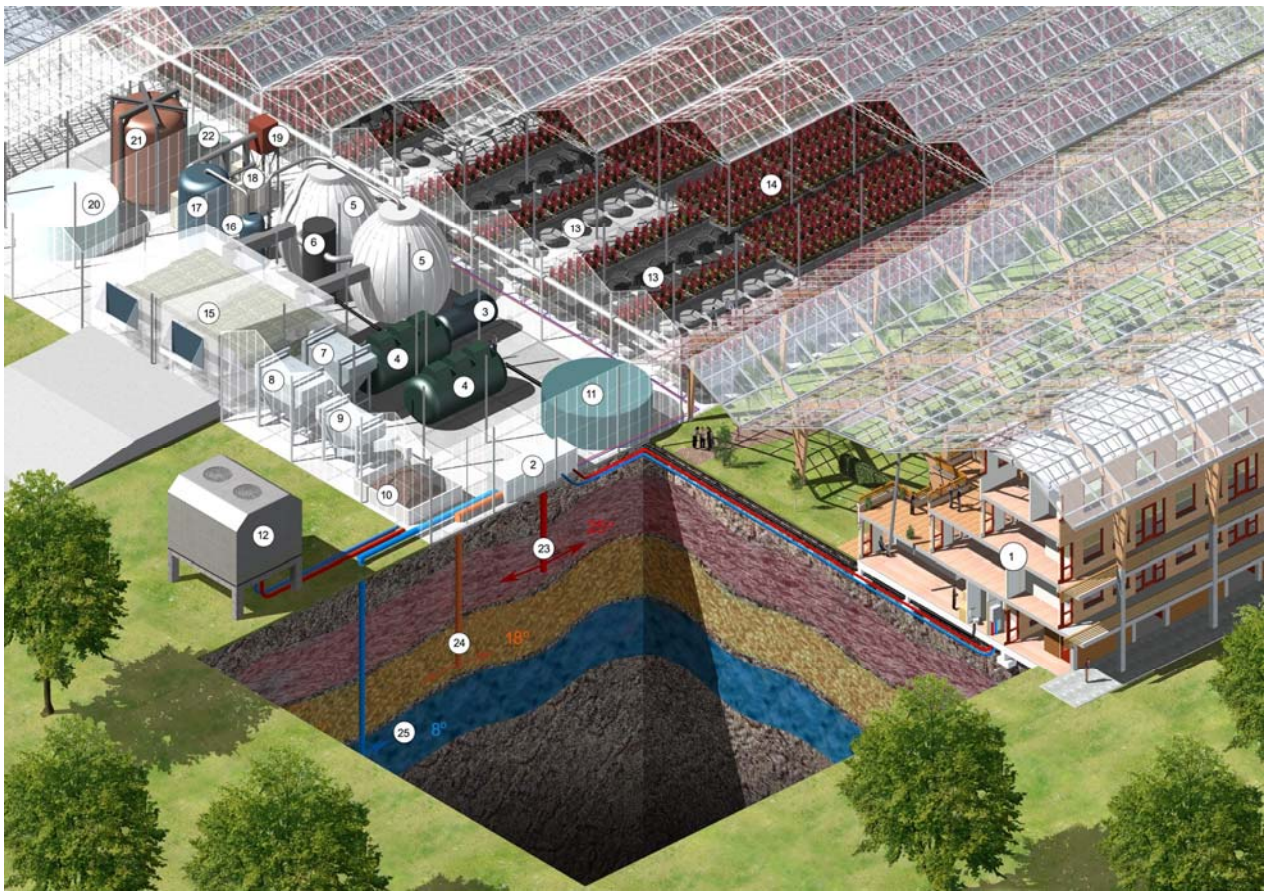
b) 'Fiiwihex' or fine-wire heat exchanger (scheme & photo)
 The heart of the closed greenhouse is a heat exchanger. This can be a Fiiwihex. A series of them is needed to transfer heat from air to water or from water to air. Invented by Van Andel, and produced by Ter Beek, Fiiwihex International.



d) Experimental Fiiwihex Greenhouse of Aart Cornelissen in Berlikum (Netherlands).
 - 1000 m² closed, as part of 12 ha.
 - 24 Fiiwihex's installed (1 per 40 m²)
 Results in spring/summer 2006:
 - no fossil fuel used
 - 15-20% more production due to high CO₂

Fig 3. Closed Greenhouse
 (with underground heat store)
 harvests more heat than it needs per annum. Houses will be built in conjunction to utilize the heat.





Picture provided by Fiwihex, The Netherlands

Figure 4: Schematic presentation of a closed greenhouse

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|------------------------------|---|
| 1 = Housing | 14 = Collective heat regulator system
also Aquifer management system |
| 2 = Condensate collector | 15 = Cooling tower |
| 3 = Drinking water operation | 16 = Warm spring |
| 4 = Drinking water storage | 17 = Lukewarm spring |
| 5 = Black water reservoir | 18 = Cold spring |
| 6 = Biomass supply | 19 = Humus |
| 7 = Digester | 20 = Irrigation water |
| 8 = Biogas purifier | 21 = Crop (vegetables, plants, flowers) |
| 9 = Biogas storage | 22 = Fat catch |
| 10 = Micro turbines | 23 = Bioreactor |
| 11 = Gas cooler | 24 = Subside |
| 12 = Warm tap water storage | 25 = Dehumidifier |
| 13 = Fiwihex heat exchanger | |