Solar heating in greenhouses

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Solar heating of greenhouses is the dream of every greenhouse grower. But it is considered uneconomic and unfeasible, if not impossible. However, what was impossible in the past may come true in the future. At present solar collectors are being used for greenhouse heating in Kenya, the Netherlands and other places too. However, the costs are huge, and these projects only came of the ground thanks to substantial subsidy. This second issue of 'greenhouse matters' is about some greenhouse solar heating projects.

Van Kleef Roses in Kenya
Van Kleef is a rose selection company owned by Zuurbier with sites in the Netherlands, Ethiopia and Kenya. The farm in Kenya consists of nearly 100 ha, of which 18 ha is covered by plastic greenhouses. Van Kleef first had simple plastic houses in Kenya for testing and demonstrating rose varieties, but then wanted to show the potential of their varieties in controlled greenhouses. So they built a greenhouse to European standards, complete with venting, substrate and recirculation. Heating was the problem. Previously they used oil, but the fuel price tripled in seven years. After three years of searching for alternative heating they settled for solar heating. The concept of solar tubes and a buffer tank were easily designed. At a later stage, a Dutch technical company (Van Zaal Totaal Techniek) was contracted to calculate the dimensions required and to design the support structure. One technical man assisted with constructing the system, but the work was largely done by local people in Kenya.

Climate
Kenya is located on the equator, and therefore winter and summer temperature are fairly even. Due to the high altitude the temperatures are not very high: roughly 25-28 °C at day time, and quite fresh at night: 8-12 °C. There is often early-morning dew on the plants. Wet leaves are prone to infection by fungi such as grey mould and mildew, leading to high dependency on agrichemicals. So heating is required in the morning.

Solar system and buffer
Van Kleef installed a solar heating system of 3,200 m2 to heat a 3 ha greenhouse. There is a heat buffer of 800 m3 volume. Solar collectors sit on piece of bare land, on a structure 0.8 m above the ground. The collectors consist of black plastic 'tubes' placed on a support structure and covered by glass. The tubes are rectangular instead of round, to catch as much radiation as possible. The water flows through a tube of 78 m long, and back through another of the same length. The glass sheets are connected by greenhouse profiles. Cold water (20 °C) from the buffer is pumped through the tubes and comes back at 50 °C. This warm water is pumped in the top of the buffer tank, raising the buffer temperature to about 40-50 °C. In the very early morning, warm water is pumped through a pipe heating system in the greenhouse, and the cold water comes back to the buffer. The old oil-fired heater is still stand by, and can be used in case of whole days of overcast weather.

Results
In the first half year of testing, it was found that the solar heating lifted the temperature in the greenhouse by about 3-5 °C. This helped preventing condensation on the plants. Botrytis on the flowers had disappeared, and mildew was reduced. The heating also helped to get the plants active earlier in the morning after a cold night, which had a considerable effect on the production (about 20%). Also the flower quality had improved. The owners were pleased with the solar system, and intended heating the full 18 ha of greenhouse with solar. The 3 ha greenhouse was already the largest project of solar heating in the world.

Eggplant grower in the Netherlands

Eggplant grower Peter Boekestijn in De Lier in the Netherlands was the first grower to install solar collectors for heating a greenhouse, in 2005. Solar collectors covering 560 m2 were placed on the roof of the shed. One half of the collectors face the morning sun, and the other half catch the midday and afternoon sun. The collectors are made by HRsolar in the Netherlands. They consist of an aluminium 'absorber' with a layer of titanium on the top, and with copper pipes laser-welded underneath. Water flowing through the pipes is heated up to as high as 65 °C in summer. This water goes to the boiler, so the solar collector pre-heats the boiler water. This saves about 10% of the annual gas use on his 1.5 ha greenhouse. The grower says he would like to have more solar heat collection, but doesn't have the space.

Flower bulb grower in the Netherlands

Nic Van Schagen and sons in Bergen in the Netherlands grow flower bulbs. They use a lot of natural gas for drying and storing the bulbs. In early 2007 they placed 1,100 m2 of solar collectors on the roof of their shed. The solar system produces hot water that is stored in an underground well. Two heat pumps of a total capacity of 150 kiloWatt are used in the process. They expected to save 60% on their gas consumption.

Economics

The solar heating systems discussed above are very expensive. The costs were given in Euros, with 1 Euro equal to 2 NZ$. The solar systems used in the Netherlands are reported to cost several hundred Euros per m2, e.g. in one case 350 Euro per m2. Those used in Kenya are 'only' 50-100 Euros per m2. The additional costs are huge too. Heat storage is essential, because heat is needed when the sun is not shining. Short term heat storage (e.g. for 12-18 hours) can be done in a buffer. Long-term storage (e.g. for 6 months) requires a huge storage capacity, e.g. in an underground well or aquifer. This is extremely expensive. Due to the high costs of storage, solar heating can only become feasible on a large scale greenhouse ('economy of scale'). Another aspect is heat transfer in several steps: from collector to water to storage to greenhouse air. Sometimes this is done by pumping water around, but often heat exchangers or even heat pumps are used. (These costs are related to the area, and hence 'economy of scale' does not apply).

Subsidy

In the above cases, substantial subsidy (in the order of 50%) was obtained from the Dutch government. The growers have to apply for the support, which is always a big task. The subsidy enables the growers to take risks and investigate the technology for the sake of the industry and the environment. There are funds with different objectives, such as sustainability, energy saving, carbon emission reduction, advancement of the greenhouse industry, foreign aid or a combination. For instance the project in Kenya received 50% subsidy from the Dutch government for sustainable projects in emerging markets.

Other projects

Obviously there are many initiatives on many places of the world in the quest for solar heating solutions. A new type of solar collector for heating greenhouses is developed by Wilk Van der Sande in the Netherlands. Other technologies are for instance solar panels or solar cells that produce electricity, but that is a different topic.

Needless to say that all greenhouses use solar heat anyway, because trapping heat is the nature of a greenhouse. The so-called 'closed' and 'semi-closed greenhouses' can harvest solar heat from the greenhouse itself. Also in those projects, heat transfer and heat storage are the crucial parts and are very expensive too.

The economics of solar heating depend on many factors: energy prices, costs of alternatives, investments, produce prices, climatic conditions (e.g. temperature, sunshine!), crop needs and more. Circumstances change, energy prices rise, and technology progresses. Hopefully the many initiatives and trials will produce new affordable technologies so that solar heating and heat storage become feasible in the greenhouse industry in the near future.

Construction of the solar collectors at Van Kleef Roses in Kenya. A total of 3,200 m^2 collectors supply heat to a 3 ha greenhouse. Black plastic rectangular 'tubes' are placed on a structure and covered by greenhouse frames and glass. Hot water pipe heating distributes the heat in the morning. Photos with permission www.vakbladvoordebloemisterij.nl.

Sources: www.energiek2020.nu; www.energieportal.nl; www.vanzaal.com/media/50.pdf; photos from www.vakbladvoordebloemisterij.nl.