Spectrum

Reducing fuel consumption in greenhouses

Since the Arab oil embargo in the early 1970s, the practicalities of using solar energy as a substitute for our limited fossil fuels have been hotly debated. Scientists generally agree, however, that solar energy does have considerable potential for space- and water-heating.

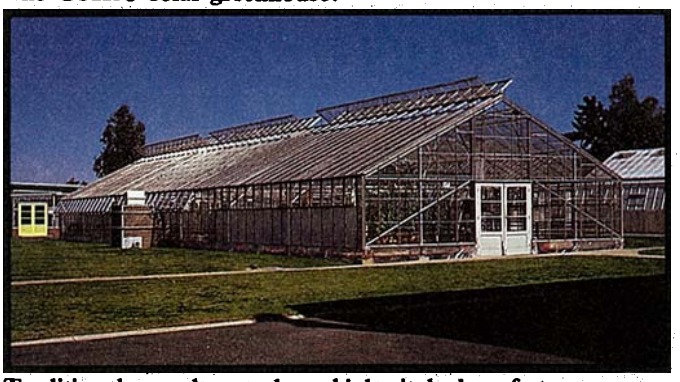
At the CSIRO Division of Irrigation Research, Griffith, N.S.W., scientists have been taking current solar heating technology and looking at ways of using it to control the temperature in greenhouses.

The concept of a heated greenhouse using renewable resources has been around for a long time. According to Sir Joseph Banks, the Romans of 2000 years ago force-ripened dessert fruit in pits under thin sheets of mica or 'Muscovy glass'. The heat source was not the sun but decomposing manure.

Unfortunately, the techniques used by the Romans would not be very practical for large-scale greenhouse production today.

Australia has some 250 ha of greenhouses producing a range of ornamental plants, cut flowers, and some vegetables. These greenhouses are generally designed along similar lines to their European counterparts, with high pitched roofs that maximize

The CSIRO solar greenhouse.



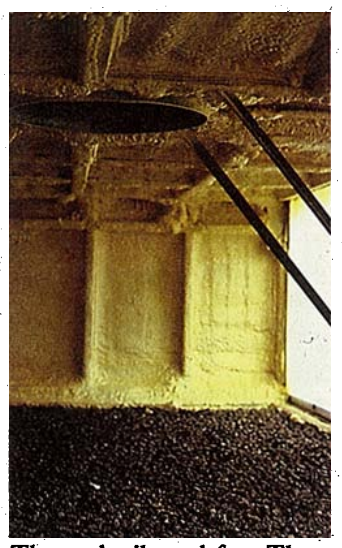
Traditional greenhouses have high pitched roofs to maximize available sunlight.

the amount of sunlight available to the plants.

For European winters, maximum sunlight is a very important criterion. In Australia it is less important; Griffith, for example, receives four times more radiation in mid winter than does Kew, in the United Kingdom.

The worst feature of the European design is the heat loss during clear winter evenings. If an owner is going to keep his greenhouse at a reasonably constant temperature during winter he needs to expend large amounts of fuel at substantial cost. The annual cost of heating Australian greenhouses is around $10 million, or roughly $40 000 per ha of greenhouse.

How can a greenhouse-owner set about reducing his dependence on traditional energy sources? Mr Keith Garzoli and Mr John Blackwell, of the Division, have found that it's possible to reduce fuel consumption by at least 30% simply by installing an inner lining of



The rock pile and fan. The outer walls are insulated to reduce heat loss.

transparent polyethylene film. This should be separated from the outer glass by an air gap of about 50 mm. In some greenhouses this can be simply achieved by pressurizing the air with a small blower like those used in car-heaters.

If the owner plans to put an entirely new covering on an old greenhouse, the researchers feel that he should consider some recently released materials that incorporate central air spaces. Their preliminary studies suggest that the use of double-sheet acrylic with a gap of 5 mm between the sheets should result in fuel savings of 40%. Use of materials with wider air gaps could lead to even larger savings.

However, construction of a new greenhouse offers the greatest scope for achieving high levels of thermal efficiency. One built at the Division of Irrigation Research has been designed specifically by Mr Garzoli and Mr Blackwell to keep fuel use to a minimum.

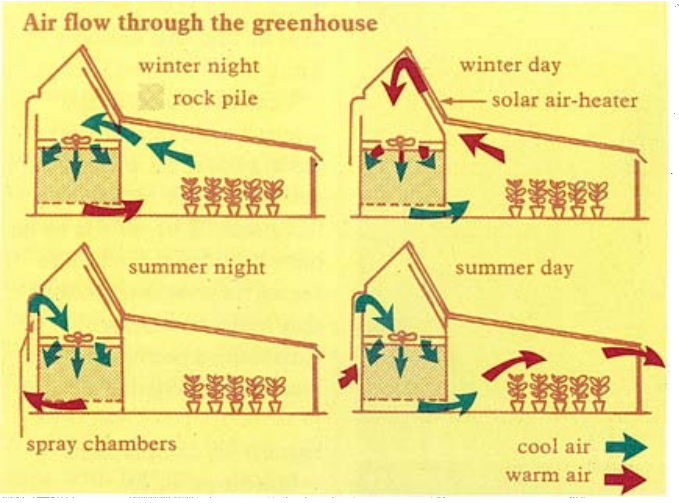
One way to reduce a greenhouse's heat loss is by increasing its ratio of floor space to surface area. While a hemispherical greenhouse is the theoretical ideal, some of the space would be unusable. So the researchers chose the next-best shape, a skillion roof and a square floor plan.

For the wall and roof cladding, they chose double-sheeted acrylic with 5-mm-square enclosed air channels. The acrylic is supported by an aluminium frame on a 12 m × 12 m concrete slab. They chose the slab because of its high thermal capacity, which helps reduce summer and winter temperature fluctuations.

The next aspect that Mr Garzoli and Mr Blackwell tackled was the possibility of using solar energy stored during the day for night heating in lieu of liquid fuel.

Basically, any greenhouse acts as a solar collector in that it traps solar radiation that is absorbed by the floor, plants, and interior surfaces. This raises their temperatures, and heat is transferred from them to the air in the greenhouse.

The difference between a greenhouse and solar collectors is that a



In winter, the rock pile releases at night heat gathered during the day. In summer, it is cooled at night and provides cooling the following day.

greenhouse has its own temperature requirements. So when the air inside reaches a certain temperature the ventilators are normally opened and the hot air is expelled. However, if that air is pumped through a thermal rock pile, much of the heat can be stored for release into the greenhouse at night.

The researchers calculated that, under inland Australian conditions, this rock pile need only be around 10% of the volume of the greenhouse to store enough heat during one clear winter's day to meet the heating requirements for two nights. To boost the heat taken from the greenhouse, they added four solar collectors with a total area of 23 square metres. The warm air from the greenhouse is drawn past the solar collectors and heated further, before being channelled through the rock pile.

In summer in inland Australia, simple ventilation is often inadequate as a means of preventing greenhouses becoming too hot, so some artificial means of cooling is desirable. The researchers were therefore keen to use the rock pile for storage of coolness, or 'coolth', as well as heat. They have achieved this by drawing outside night air through water-sprayed chambers. The evaporatively cooled air is drawn into the rock pile, which can then provide cooling the following day.

The researchers have now been growing tomatoes in the greenhouse for more than 18 months. Over that time the operating costs have been between 70 and 80% less than those of a conventional greenhouse. Mr Garzoli estimates that a solar greenhouse similar to the one built at Griffith would cost around $18–20 000, whereas a comparable conventional one would cost around $15 000. The extra cost should be repaid through energy savings in 3–4 years.

Construction costs for both conventional and solar greenhouses could be quite a bit lower if different structural materials were used.

The solar greenhouse has been designed with the nursery industry in mind and anybody interested in constructing one is welcome to visit the Division. Here they can see it in operation and discuss designs with Mr Garzoli and Mr Blackwell.

Two further solar greenhouses are under construction at the Division. The researchers will use these to look at the feasibility of producing perishable food crops in remote locations such as Alice Springs and the Pilbara. The time is approaching when it could be cheaper to grow tomatoes in solar greenhouses in remote locations than pay the cost of transporting them huge distances from traditional production areas.

Robert Lance

CSIRO low energy greenhouse design and operation. *CSIRO Information Service Sheet* No. 22–2, March 1980.