

## CHINESE GREENHOUSE



The modern glass greenhouse requires massive inputs of energy to grow crops out of season. That's because each square meter of glass, even if it's triple glazed, loses ten times as much heat as a wall.

However, growing fruits and vegetables out of season can also happen in a sustainable way, using the energy from the sun. Contrary to its fully glazed counterpart, a passive solar greenhouse is designed to retain as much warmth as possible.

Research shows that it's possible to grow warmth-loving crops all year round with solar energy alone, even if it's freezing outside. The solar greenhouse is especially successful in China, where many thousands of these structures have been built during the last decades.

The quest to produce warm-loving crops in temperate regions initially didn't involve any glass at all. In Northwestern Europe, Mediterranean crops were planted close to

specially built "fruit walls" with high thermal mass, creating a microclimate that could be 8 to 12°C (14 to 22°F) warmer than an unaltered climate.

Later, greenhouses built against these fruit walls further improved yields from solar energy alone. It was only at the very end of the nineteenth century that the greenhouse turned into a fully glazed and artificially heated building where heat is lost almost instantaneously — the complete opposite of the technology it evolved from.

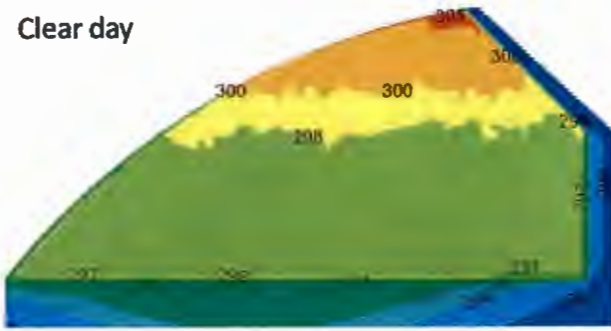
During the oil crises of the 1970s, there was a renewed interest in the passive solar greenhouse. [7] However, the attention quickly faded when energy prices came down again, and the all-glass greenhouse remained the horticultural workhorse of the Northwestern world. The Chinese, on the other hand, built 800,000 hectare of passive solar greenhouses during the last three decades — that's 80 times the surface area of the largest glasshouse industry in the world, that of the Netherlands.

### **The Chinese Greenhouse**

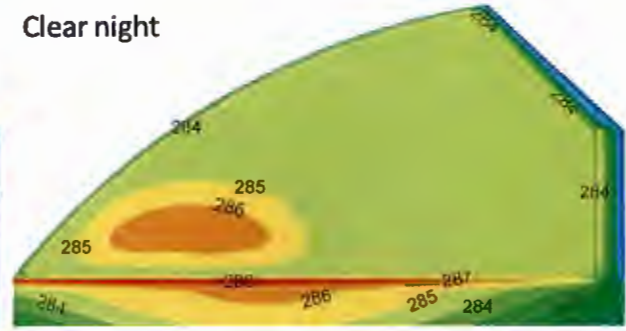
The Chinese passive solar greenhouse has three walls of brick or clay. Only the southern side of the building consists of transparent material (usually plastic foil) through which the sun can shine. During the day the greenhouse captures heat from the sun in the thermal mass of the walls, which is released at night.

At sunset, an insulating sheet — made of straw, pressed grass or canvas — is rolled out over the plastic, increasing the isolating capacity of the structure. The walls also block the cold, northern winds, which would otherwise speed up the heat loss of the greenhouse.

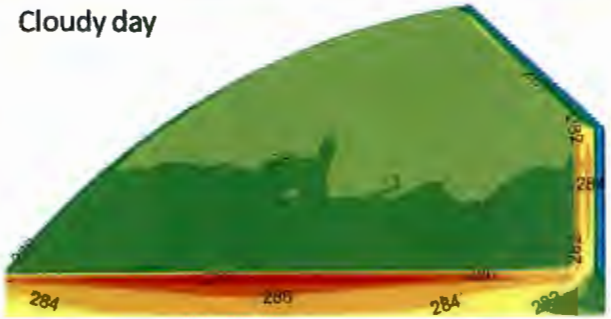
Clear day



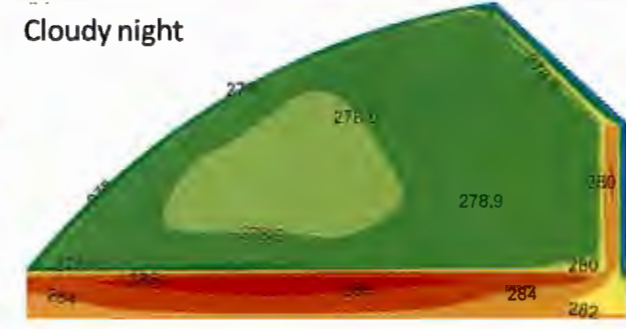
Clear night



Cloudy day



Cloudy night



Chinese greenhouses. Picture: HortTechnology.

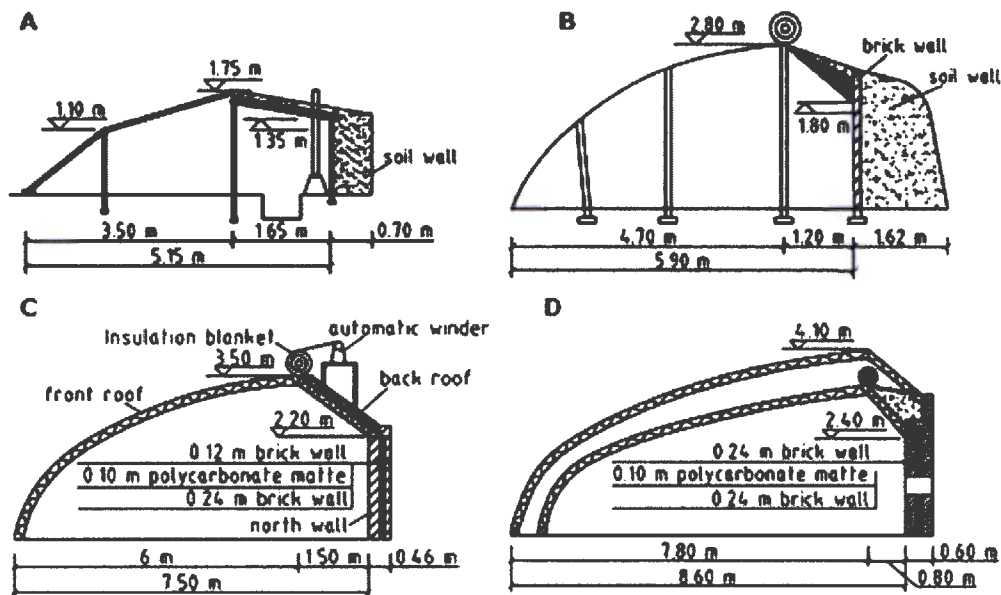


Being the opposite of the energy-intensive glass greenhouse, the Chinese passive solar greenhouse is heated all-year round with solar energy alone, even when the outdoor temperature drops below freezing point. The indoor temperature of the structure can be up to 25°C (45°F) higher than the outdoor temperature.

The incentive policy of the Chinese government has made the solar greenhouse a cornerstone of food production in central and northern China. One fifth of the total area of greenhouses in China is now a solar greenhouse. By 2020, they are expected to take up at least 1.5 million hectares. [1]

## Improving the Chinese Greenhouse

The first Chinese-style greenhouse was built in 1978. However, the technology only took off during the 1980s, following the arrival of transparent plastic foil. Not only is foil cheaper than glass, it is also lighter and doesn't require a strong carrying capacity, which makes the construction of the structure much cheaper. Since then, the design has continuously been improved upon. The structure became deeper and taller, allowing sunlight to be distributed better and ensuring that temperature fluctuations are decreased.



A: The original design from the 1980s with a glass canopy. B: An improved design from the mid-1980s, with plastic foil, a night curtain, and better insulated walls. This design is the most widespread. C: An improved design from 1995. The walls are thinner because they are insulated with modern materials. Automatic handling of the night curtain. D: The most recent design from 2007, which has a double roof for extra insulation.

In addition, cultivators are increasingly opting for modern insulation materials instead of using rammed earth or air cavities for the insulation of the walls, which saves space and/or improves the heat absorption characteristics of the structure. Synthetic insulation blankets, which are better suited for dealing with moisture, are also seeing increased use. The old-fashioned straw mats become heavier and insulate less when they become wet.

In some of the more recent greenhouses, the insulation blankets are rolled up and down automatically, and more sophisticated ventilation systems are used. Some greenhouses have a double roof or reflecting insulation installed. In addition, the plastic foil used for the greenhouses — obviously the least sustainable component of the system — is continuously being improved, resulting in a longer lifespan.

### **Performance of the Chinese Greenhouse**

The performance of the Chinese greenhouse depends on its design, the latitude, and the local climate. A recent study observed three types of greenhouses in Shenyang, the capital of the Liaoning province. The city is at 41.8°N and is one of the most northern areas where the Chinese-style greenhouse is built (between latitudes 32°N and 43°N).

The research was conducted from the beginning of November to the end of March, the period during which the outside temperature drops below freezing. The average temperature in the coldest month is between -15°C and -18°C (5 to -0.4°F). [1]



*Air cavities in a ruined solar greenhouse. Picture: Chris Buhler, Indoor Garden HQ.*

The three greenhouses studied all have the same shape and dimensions (60 x 12.6 x 5.5 m), but the walls, the plastic foil, and the transparent layer vary. The simplest construction has walls of rammed earth and an inside layer of brick to increase the structures' stability. The covering is a thin plastic film that is covered at night with a straw blanket.

The two other greenhouses have a northern wall of brick with extruded polystyrene foam as insulating material, whereby the width of the wall can be cut in half. They are also covered with a thicker PVC plastic foil. The best greenhouse adds to this a reflective coating on the insulation blanket, further reducing heat loss at night.