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I – A Brief History of Greenhouse Use and Design

In today's high-tech world, it can feel surprising to rediscover how ancient cultures once used the sun's energy for heating and cooling with remarkable success. Passive solar design, the art of orienting and building structures to work with the sun's path, has existed for thousands of years. The U.S. Department of Energy defines passive solar design as: "Taking advantage of a building's site, climate, and materials to minimize energy use. A well-designed passive solar home or structure first reduces heating and cooling loads through energy-efficiency strategies and then meets those reduced loads in whole or part with solar energy." (DOE, 2024)

Greek, Roman, and Native American builders all designed dwellings to maximize solar heat in the winter and minimize heat in the summer. In Canyon de Chelly, Arizona, for example, ancient dwellings were tucked under cliffs to take advantage of natural shading and solar gain, a reminder that passive solar wisdom is deeply rooted in human history.



White House Ruins in Canyon de Chelly on the Navajo Reservation in Chinle, Arizona. Photo: Carroll, 1978.

Early season extension

The Romans were among the first to extend crop production beyond the natural growing season. They used sheets of translucent mica as glazing to trap solar heat and protect plants in winter. By planting along south-facing rock walls or brick surfaces, they took advantage of the heat absorbed by masonry during the day and released at night.

In 16th-century France, the French Intensive system expanded on these ideas. Market gardeners near Paris used glass cloches, small bell-shaped covers, to protect vegetables. The knobs of these

heavy glass domes often broke, so plate glass in wooden frames soon replaced them, creating cold frames that were easier to use and maintain. Beneath the cloches and frames, beds of decomposing horse manure provided gentle bottom heat, further extending the growing season. At night, straw mats were added for insulation. These techniques supplied the royal courts with fresh vegetables year-round.



Glass cloches on 'hotbeds' of horse manure, being covered for the night with straw mats



Single slope cold frames in Naaldwijk (Netherlands), 1910. Source: Collectie Historisch Archief Westland)





Some farmers still use this system as shown in the pictures below taken on a farm outside Dyon, France. Photos courtesy of John Scalfi, 2009.



In Montreuil, near Paris, market gardeners built entire neighborhoods of walled gardens for fruit trees. Trees were trained in espalier form on south-facing brick walls, which absorbed and re-radiated heat to improve ripening. These gardens became famous for peaches, and vegetable crops filled the spaces between walls. One of the last of these historic walled gardens survived until 2012, when it was demolished for new development.

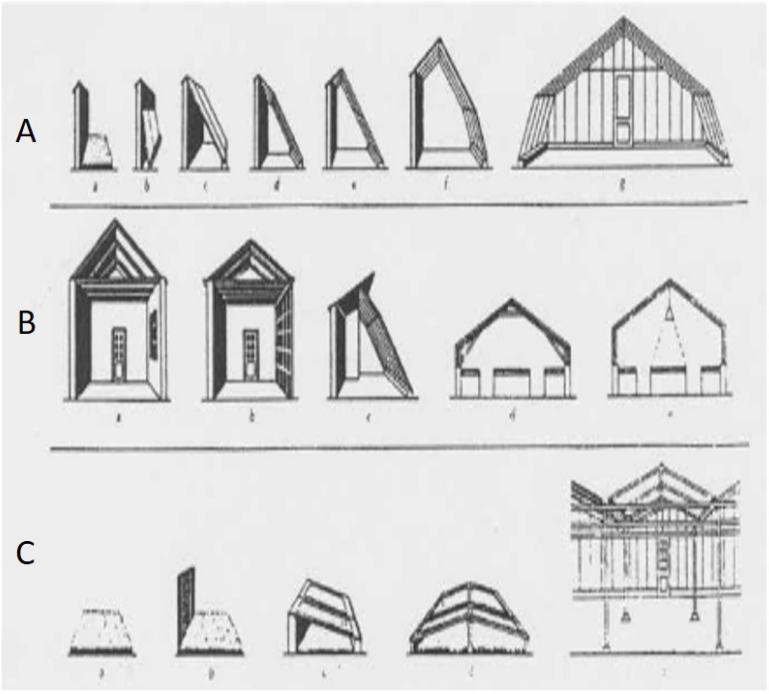
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From walled gardens to greenhouses



Over time, these early passive systems evolved into enclosed greenhouses. A schematic from van den Muijzenberg (1980) traces this progression:

- Walled gardens with glass added incrementally.
- Orangeries of the 17th and 18th centuries, in which citrus and exotic (sub)tropical plants overwintered.
- Glass houses of the 19th century, with expanded glazing and early heating.
- Warehouse-style greenhouses of the 20th century, large structures lit and heated by fossil fuels.



A. Grape house
a. Wall
b. Wall with windows
c. Walled greenhouse
d. "Desk" (lessenaar)
e. Headhouse
f. Double headhouse
g. Grape house
B. Orangery
a. 6th century - Shed, no glass
b.17th century – Orangerie with 1-sided glass
c. 18th century – Walled greenhouse with glass on 2 or 3 sides
d. 19th century – Two-sided greenhouse, all glass
e. 20th century – All glass with artificial light
C. Warehouse
a. Seedbed
b. Seedbed with solar shield of woven reeds
c. One-sided coldframe
d. Double-sided coldframe
e. Warehouse

Schematic of the development of modern greenhouses from wall, orangery or covered raised beds. Adapted from E.W.B van den Muijzenberg. 1980. A History of Greenhouses. Wageningen: Institute for Agricultural Engineering.

Single- and double-sided glazed cold frames, were used by Dutch growers well into the 1950s. Each stage reflected advances in materials and labor efficiency, but also a gradual movement away from passive solar design toward reliance on technology and cheap fossil fuels. The importance of passive solar design became obsolete, and the knowledge was all but lost in building design.

Modern Conventional Greenhouses

In areas with long and/or more extreme winters, high tunnels (plastic-covered structures not actively heated) serve to lengthen both ends of the growing season by a few weeks in Spring and Fall, and offering a greater measure of control over growing conditions. But they do not support year-round production. Conventional greenhouses, actively managed for optimal growing conditions, allow year-round production but at the cost of high energy consumption for heating, lighting and ventilation. This extra energy is typically supplied by fossil fuels such as fuel oil, natural gas, propane or electricity from fossil fuel burning power plants. While this was affordable in times of cheap energy, rising costs have made conventional greenhouse production unsustainable for many growers.

As a result, many farms use greenhouses only seasonally, abandoning year-round production because of heating costs. Some regions, particularly in Europe, continue to experiment with lower-energy solutions, but much of the ancient wisdom of passive solar design has been forgotten.

A return to passive solar

In the 1970's, two oil embargos triggered an energy crisis in the US. Among a variety of energy saving innovations, homes and businesses used attached passive solar structures (south-facing windows, tromb walls, thermal mass) to provide extra heat to reduce their energy consumption during the winter. Only in rare cases were the spaces used for growing crops. This was the dawn of passive solar greenhouses, but when energy prices came down in the a 1980's, hte support and new construction of PSGs faded.

Today, with climate change, volatile energy markets, and supply chain disruptions, there is renewed interest in re-localizing food production and reducing reliance on fossil fuels. Passive solar greenhouses (PSGs) offer a simple, time-tested solution. By investing in a free-standing well-insulated, tightly built PSG, growers can produce food with minimal outside energy input year-round. The alternative—building a cheaper, conventional greenhouse—often leads to decades of high operating costs, maintenance challenges, and vulnerability to energy price swings.

The promise of passive solar greenhouses is clear: A one-time, long-term investment in smart design can yield fresher, local food, reduce emissions, create local jobs, and keep more money within communities. In doing so, PSGs bring together ancient wisdom and modern necessity.

The economic logic, once a grower decides to build a PSG, comes down to a single choice. You can:

> Invest once in a tight, well-insulated passive solar greenhouse and accept higher construction costs up front in exchange for very low energy bills for the life of the building.

OR

> Build a less expensive conventional greenhouse and pay rising energy and maintenance costs every year it operates.

Further reading

- U.S. Department of Energy, Passive Solar Homes.
- Erwin W.B. van den Muijzenberg 1980. A History of Greenhouses. Wageningen: Institute of Agricultural Engineering.
- John Weathers. 1909. French Market Gardening, including practical details of "intensive cultivation". London: J. Murray.
- Gian Luca Brunetti. 2025. The passive solar greenhouse blind spot: A historical review of book literature and the cultural gap in Western design discourse. Journal of Energy and Buildings 348: 116397. DOI:10.1016/j.enbuild.2025.116397