

Greenhouses in Cold Regions

Traditionally, cold regions practiced a variety of food preservation techniques intended to help stretch the food they grew and foraged in spring, summer, and fall to last them through the winter. This didn't stop them from looking for ways to grow food out of season, or outside its hardiness zone.

Long supply chains and rapid intercontinental transportation made cheap through subsidized fossil fuels have reduced our reliance on these practices, to the extent that some are outside living memory for large swaths of the population, but they're still around, and have even been updated with modern technology. Whether your solarpunk setting is recovering from a societal collapse and broken supply lines, or is just much more conscious of the externalities of globalized shipping and prioritizes local food production, there are a handful of options it could call upon to maintain access to fresh food.

The Current Default

We use greenhouses to manage the temperature, humidity, and even atmosphere composition for crops all over the world but the basic design is fairly consistent, regardless of location. The most common industrial design is a metal framework with single- or double-ply plastic sheets stretched over it, often with plywood or corrugated plastic siding nailed to stick frame walls on the ends (though these are sometimes concrete block or similar). These 'fully glazed' greenhouses often have a garage door on one or both ends. As you can imagine, given the lack of insulation, large openings from the doors, gaps, etc, operating these in cold climates, especially into the fall and winter is expensive. It's part of that one-size-fits-all-just-burn-more-gas approach a solarpunk society should generally reconsider wherever it finds it.

(Many greenhouses use glass instead of plastic, though they're usually single-pane and have similar problems with an overall lack of insulation. [Greenhouses made from salvaged home windows](#) especially [modern, double-pane windows insulated with a layer of air, argon, or vacuum](#) might get better results.)

In order to increase crop yield, growers usually aim to have the CO₂-level inside the greenhouse at least three times the level outdoors. Because they already use wood or fossil fuel based heating systems, they can obtain the excess CO₂ as a byproduct of combustion. This is part of why you don't see geothermal energy and electric heat pumps revolutionizing the modern glasshouse industry (outside of a few [really cool exceptions](#)) despite being far more efficient than diesel.

Passive Greenhouses

In colder climates, where low temperatures are your main concern, there are several ways to modify the basic greenhouse to greatly improve the heat absorbed and retained from sun exposure. Many of them are used effectively in <https://solar.lowtechmagazine.com/2015/12/reinventing-the-greenhouse/industrial-greenhouses-set-up-in-mainland-China>.

This design fits the same niche as aboveground, freestanding greenhouses elsewhere in cold climates, just with some improvements:

- They feature three insulating walls, often made of mortared brick, clay, or concrete block with

air pockets inside (although modern insulation such as polystyrene foam is seeing increasing use) and one taller plastic/glass wall/roof facing towards the sun (south, in the northern hemisphere, north in the southern hemisphere)

- The back and sometimes side walls are often backed with a earthen berm for additional geothermal mass insulation
- These thick walls also block the cold, northern winds, which would otherwise speed up the heat loss of the greenhouse
- At sunset, an insulating sheet/blanket is rolled out over the plastic/glass, increasing the isolating capacity of the structure. For best results, the insulation blanket has a reflective coating to further reduce heat loss from inside.
- The farther north the greenhouse is located, the steeper the slope of its sun-facing transparent wall/roof will be. The slope is angled to be perpendicular to the sun's rays when it's lowest on the horizon.

In many cold climates these structures aren't effective enough to be completely passive and will need some additional source of heat. Compared to the current design however, they are still far more efficient: one test found that to keep the temperature above ten degrees Celsius at all times a passive greenhouse required 3.6 kW for the building while a glass structure of equal proportions at the same interior and exterior temperatures would require a maximum capacity of 125 to 155 kW.

The downsides: Normal greenhouses are optimized for profits, and despite being more efficient to heat, the passive greenhouses produce less, making them two to three times less profitable per square meter.

Walipini / Pineapple Pit

Walipinis take these design changes a step further. Modern designs for cold regions use the same basic three-insulated-sides-one-glass-side format as passive greenhouses but set the structure down into the ground to use the earth for thermal regulation and to lower its exposure to the wind. They use insulated windows which are generally even steeper than those on passive greenhouses, and may even have a partial roof on the north side (south if located in the southern hemisphere).

<https://www.urbangardensweb.com/2017/08/26/transform-disused-swimming-pool-garden/>

<https://solar.lowtechmagazine.com/2020/04/fruit-trenches-cultivating-subtropical-plants-in-freezing-temperatures/>

Safety Considerations

There are several new risks introduced by the design of a walipini - none of these are dealbreakers but they should be accounted for upfront.

- **Engulfment** - many images online show walipinis from inside with bare earth walls, with no reinforcement. This means the structure is essentially an unlined hole in the ground.

a sunken structure like a pool that is roofed over, becomes a "confined space". Unlike a typical structure, heavier-than-air gases cannot escape from the pool. Such gases could originate from the drain system or flow from leakage outside the pool area. For examples, leaking propane or various gases from sewer lines in the vicinity. A sunken greenhouse would almost certainly be a building code violation for that reason. If you build it, ventilate it by means both active and passive and do not enter if you can't verify that ventilation is working.

Compatible (Symbiotic?) Practices

- **Thermal mass** is a big part of maintaining temperature in a passive structure with little or no additional heat. The back wall of a passive greenhouse or walipini usually absorbs heat from the sun during the day and radiates it at night. This can be increased by painting it black to absorb as much light as possible. A simple way to boost this heat storage further by is placing black-painted water storage tanks against the back wall inside the structure. These warm up during the day, capturing extra solar energy and release it during the night.

There are several ways to produce heat that also provide CO₂. This is helpful because it accelerates plant growth and boosts crop yields, and makes up for the

- **Compost** - Composting is an important part of agriculture likely already present wherever there's a greenhouse. As microorganisms break down biodegradable materials they naturally produces heat and CO₂. A compost bin can reach 140 degrees Fahrenheit or more inside the pile while it is in the hottest phase of decomposition. The effectiveness of the compost-as-heat depends on the amount of compost and how well the greenhouse is insulated - in some cases it may not be enough on its own to heat an entire greenhouse but might be built into the lower part of seedling beds to keep them warm and get a jump start on the growing season.
 - The downsides here are that using compost as heat requires some planning and monitoring - it's less convenient than a commercial heater. Additionally there's some additional risk: modern greenhouses are sometimes used to isolate and protect plants from threats like bugs and blights outside, and bringing compost into the greenhouse (especially in an open container) can cross-contaminate. If this is a concern setting up a [fluid exchange system with an outdoor compost pile](#) might make more sense.
- **Manure** The use of manure for heating small-scale greenhouses dates back several centuries in Europe, and in China it was practiced 2,000 years ago. A greenhouse can be [entirely heated by compost](#) if it is well-insulated, and that the method drastically enriches the CO₂-levels in the soil and in the greenhouse air. I haven't found a good breakdown on if there's a functional difference between using animal manure vs plant matter but all the ones I've found that claim decomposition meets all their heat needs appear to be using at least a mix of manure if not primarily that.
 - Downsides: still not as convenient as a furnace. Comparatively bad smell (though a layer of charcoal can help). Involves animals in agriculture which can be done ethically but vegan writers may prefer to avoid.
 - Manure-related fun fact: colonial farmers in the New England region of the US [added manure basements to their ever-changing barn designs](#), making removal and storage of animal waste easier (just shovel it down a hatch right indoors). The heat of this manure decomposing kept the barn (and especially its foundation) warm. As the barns fell out of use, part of their rapid collapse came from fieldstone foundations which were no longer protected from expanding ice.
- **Co-location with animals** Another way to meet this need is to go right to the source. Pigs, chickens, rabbits, and fish all produce CO₂ that can be absorbed by the plants, while the plants produce oxygen (and green waste) for the animals. The animals and their manure also contribute to the heating of the structure. [It is estimated that a commercial hen can generate about 10 watts of heat](#). Research of such integrated greenhouse systems has shown that the combined production of vegetables, meat, milk, and eggs raises yields quite substantially.
 - Downsides: additional work with caring for animals. Possibly more complex structures - as far as I can tell the animals might not be in a pen in the greenhouse but in an adjacent room with cross ventilation.
- And absolute worst case, there are [ways to make wood heat sustainable](#) (and to produce

biochar using [rocket stoves](#) or [rocket mass heaters](#) as a byproduct. This stuff can be tremendously useful in compost, and holds carbon for a comparatively long time.

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