Reimagining greenhouses

The current situation…

Spring is just around the corner, and those of us bitten by the gardening bug are no doubt eager to start planting. Right now we all have our little tray or two of early plants under lights somewhere in the house, but in a few weeks it will be warm enough to start plants in greenhouses. I have been a backyard gardener for ten years and then a commercial farmer for another 10, and Ive noticed the poor construction of backyard greenhouse kits. Not to call anyone out here but the frames are ridiculously complicated to assemble and they blow over in the first windstorm. To put it bluntly, most greenhouse kits are flimsy, overpriced and inefficient.

Whereas there are a lot of greenhouse kits for sale, they are all roughly constructed the same. Polycarbonate over a metal frame. I'm referring to smaller propagation, backyard greenhouses, although commercial hoop houses are roughly the same deal, Current commercial greenhouses use a metal aluminum frame or galvanized steel frame driven into the ground and covered with 2 heavy greenhouse films This film is some form of plastic bringing up the issue of microplastic contamination in crops as well as the issue of solar degradation as said film has to be replaced roughly every 4 years. In addition, steel and aluminum are metals making them more conductive to energy, meaning they are acting as a radiator instead of an insulator, which is the exact opposite what we want in a cold climate. Currently air is driven between these two sheets of greenhouse plastic to create an insulating layer of air between the two. Taken as a whole. This design is monumentally inefficient at retaining heat.

Specific heat, roughly speaking, states that certain materials are better at storing energy than others. Intuitively we all know water heated to 90° stays warmer longer than the same volume of air heated to the same temperature. That being said, modern greenhouses are built out of some of the worst materials in terms of specific heat that they could have been. The curved design of most greenhouses also presents a problem in terms of refraction. Richard Feynman found that light that hitting at any other degree than perpendicular to the source it's trying to penetrate it will simply bounce off in a parabolic rate of energy loss dependent how further the angle is off from 90° Here in Wisconsin the sun is 69° above the horizon at summer solstice and 22° above horizon at winter solstice.

The greater implications…

Current commercial greenhouses only are capable of producing year-round with a heat source. Frost tender plants in the winter would require a massive influx of energy in the form of heat with the current designs being used, either wood stove or propane heaters. And again they are massively inefficient due to the poor choice of construction materials meaning most of that heat is just leaking out into the environment, costing the producer just that much more time and labor. As a result, vegetables that are American Staples such as tomatoes must be imported from warmer climates or preserved in some manner. Either way, is energy intensive either in the form of shipping costs or energy costs in canning. Costs that every farmer knows and understands. This has a direct impact on climate change as well as these heat sources and fuels are emitting

greenhouse gases warming the atmosphere causing global weather instability among other things. "The US agricultural sector contributes to 10% of greenhouse gas emissions annually" (https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions)

There are other things to be considered… the impacts of a globalized food system on food security with current geopolitical instability. The consideration must be made that perhaps total dependency on the global trade of food is ill-advised. I've spent a long time studying ancient city states. Civilizations such as Egypt and Babylon. They have lessons for anyone who would take the time to study our origins. One of the most fundamental lessons is that food and water are basic. It is a matter of security, and sustainable ag is a matter of longevity. We've been here before believe it or not. It's called the late Bronze age collapse. Ever wonder what happened to Sumerian, Babylon, Minoan Crete and all the other ancient great city states? Archeologists aren't 100% sure which came first, the Sea Peoples or the collapse, but around 1200 BC every great city fell within 50 years of each other. Evidence points to widespread violence, Egypt references marauders who showed up by sea. At the same time there were widespread crop failures due to climate change and what we would euphemistically refer to as 'supply chain issues'. All those ancient city states, from Thebes to Tyre, from Ur to Ninevah, were all interconnected by trade and all wholly dependent on each other. 3000 years ago we had 'globalization',and when one economy fell, they all did.

As we sit in the aftermath of a global pandemic, as our global supply chains are reeling from the pressures of war, lockdowns, a greatly diminished workforce, It should be self evident that the global systems are near collapsing, not that they ever could be sustainable. We have globalized the food supply. Apples cross oceans twice before reaching us in some cases when apples grow where I live. China now owns Smithfield among others, one of the largest pork producers in America if not the largest. We commended food production into the hands of corporations… corporations who care about profits, not safety, not health and certainly not ethics. Corporations where majority stock can be owned by foreign investors, foreign investment in our basic food and goods supply. We opened the door to it. We developed this global web of supply, and we are as utterly dependent on it as everyone else is.

<u>A Solution…</u>
In such a scenario, the ability to produce as much food locally becomes an imperative.
I've written many times about the environmental, social & health impacts of big Ag and big food. We need to buy local. Nothing new there, local organic ag has quite the foothold already, but it remains largely a niche thing, whereas the majority of the population is still doing their food shopping from 'traditional' brick and mortar stores. I say traditional in quotations because grocery stores and convenience stores as we know them are a relatively new thing. Only 100 years ago your ancestors were growing and harvesting most of their food themselves, and went to a general store for things that couldn't be made at home.

There are 100,000 people roughly in the greater Wausau area, which is the closest urban center to my farm.. With only the 50 farms that exist in the main farmers market, that means that each farm needs to feed 2000 people per. No farm around here can feed that many. That means the

majority of the population is not eating local. Filling this gap between the aims of the local food movement, and the reality of consumer behavior will require not only more producers, but producers capable of growing year round. To bridge this gap of climate limitations vs needs, Ethereal Gardens has been perfecting passive solar greenhouse design for over ten years now.Our greenhouse is built out of wood and glass. Both are insulators. Furthermore, it is constructed with the stud brackets being equilateral triangles. This makes the south facing glass roughly perpendicular to the sun throughout late spring and early fall. Because it has flat glass instead of a curved surface, this also allows for maximum energy penetration in the form of not only light but infrared radiation AKA heat.

In northern Wisconsin, where Ethereal Gardens is located, production in Winter is all but impossible with temperatures reaching -30 in January. Using the afore mentioned principles of specific heat and refraction, our greenhouse regularly achieves +70℉ from ambient temps in direct sunlight. On a -30℉ day, that is a balmy 40℉. That is with zero external heat source. At night fully insulated, it keeps things +25 above ambient. This is good, but not good enough to keep tender annuals alive.

This past year Ethereal Gardens was awarded a grant through the USDA's SARE program to develop thermal batteries in greenhouses. Right now heating options in cold climates are either propane or wood heat, both producing greenhouse gases, both being expensive either in money or in resource use. Both heat the air which by the principles of specific heat cannot heat soil effectively. Thermal batteries take the concept of specific heat further and like a battery store energy, but in their case that energy its stored in the form of heat. They use high specific heat materials like sand stone or salt to store excess energy. Combine this technology with solar and or wind, and it becomes a viable, non-toxic, non-polluting greenhouse heating source that use the very same principles that normally work against growers in cold months, the soil and water, and directly heat the soil with materials of roughly equavalent specific heat to what they are warming.

The ground here freezes to a depth of 4 ft during the winter making any root penetration impossible. Our thermal battery prototype itself consists of a sandpit dug in the center of the greenhouse with a simple heating element run inside the pit and the sand itself contained with in standard 8″ by 16″ masonry cinder blocks. Originally the pit was supposed to go down down roughly 3 ft, but high water table in the greenhouse forced us to raise the level of the battery 1.5ft. Not sure if the water would affect it negatively or not, but we just decided to raise it just to be sure and for construction ease. This battery is charged currently by a 400w solar array run directly into a heating element within the sand of the battery. Theoretically, it should provide enough heat to keep the greenhouse soil and ambient temperature within the range of crop production overnight even on the coldest of nights. Target temperature is between 40 and 100. We are just now finishing the construction and will be spending the next year collecting data. If youd like further information, email etherialgardens@gmail.com.

Food independence is economic independence.