Greenhouse Comparison

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| Greenhouse | Description | Pros | Cons |
| A-Frame (stand-alone)$25 per sq. ft | Singular triangular A-frame with glass or translucent poly-carbonate glazing. Build South facing. Ideal location: open field/backyard | * Snow slides off roof without causing damage
* Simplicity of design
* Less material used compared to other designs
 | * Air circulation not ideal because of corners
* Narrowing side walls limits functional use
* Air circulation problematic in corners
 |
| Gothic Arch (stand-alone)$25 pr sq. ft | Walls bent over frame to create a pointed roof. Eliminates need for structural trusses with plastic sheeting for glazing. Ideal location: Open field/backyard, south facing | * Ideal for shedding snow and rain
* Less material used compared to other designs
* Simplicity
* Plastic sheet glazing reduces design cost and conserves heat
 | * Low side wall limits growth space and headroom
 |
| Lean-to / attached$10-25 per sq. ft | Shares the wall of another structure. Build south facing | * Costs less than stand-alone greenhouse
 | * Temperature difficult to regulate
 |
| Geodesic Dome (stand-alone)$33 per sq. ft | A dome with a triangular paneled frame made with polycarbonate or glass | * Structural strength
* Greatest snow load capabilities
* Max use of sunlight
* Aesthetics
* Growing can happen all year round
* Stable in wind and snow
* Good gathering place
* Similar to passive solar greenhouse
 | * Complex to build
* Expensive if using glass
* Heat retention
* Needs lots of ventilation
* Limits head room
* Needs a foundation
 |
| Hoop (Quonset design) (High tunnel)$5-10 per sq. ft | Common in commercial operations. Bent aluminum or PVC tubing to form an arch, usually covered in plastic sheeting. Ideal location: open field/backyard, south-facing | * Inexpensive and easy to construct
* Snow and water slide off roof
* Flexibility in sizing, small or large structure, can easily make structure longer
* Provides good sunlight
* Ergonomics
* Lots of space for plants
* Easy to get good ventilation
 | * Not as sturdy as A-frame
* Glazing needs to be replaced every four years
* Low insulation, higher heating costs
* May need a blower to keep the glazing inflated
* Glazing can be damaged by severe weather or heavy snow mass
 |
| Pit$6-$12 per sq. ft | Greenhouse roof over a hole in the ground framed with cement walls. Better option in places with extreme heat and little to no snow. Can use passive solar technologies/Chinese style | * Always stays about 10 degrees warmer than an above-ground greenhouse
* Fits with verge passive solar
* Makes use of natural cooling
 | * Receives poor natural light in the morning and evening
* Easy to damage because the roof is at ground level
 |
| Barn-style (stand-alone)$25 per sq. ft | Ground-level vents to improve air circulation. Used in places with hot summer months | * Sturdy and strong roof
* Lots of headroom
 |  |
| Passive Solar (lean-to)$20-30 thousand (Marty and Melanie)$65-70 thousand (Rob Avis estimate with builder)$30-40 thousands (Rob Avis estimate of materials)$25,000 (Carson’s estimate) | Similar to Chinese style. Lean-to style. Attaches directly to the side of another structure. Utilizes one solid wall to retain heat. | * Integrated design possibility
* Snow slides off roof
* Best thermal performance
* Good gathering place
* Good design for hobby greenhouses
 | * Not good for larger operations
* Expensive
* Likely to only receive midday sun
* Heating components (barrels of water, straw bales, etc.) take up growing space
 |
| Chinese Style$30,000 | Similar to passive solar. Structure always faces south. Has 3 supported walls. Only south side is transparent material. Solid north wall maintains consistent temperature and provides strength. Made from materials 30+ inches thick. South wall is arch shaped to absorb heat from the sun. Straw, soil, or cement insulation pads used on south side wall to hold heat. | * Energy efficient
* Productivity higher than high-tunnel style
* Work towards goal of reducing energy costs
* Permanent structure
* Strong building van withstand snow and wind
* Can be heated
* Retractable energy curtain saves energy
 | * No proven commercially viable models available
* Expensive
* Productivity lower than gutter-connected greenhouses
* Reduced yields and product quality due to irregular shape causing lack of uniformity in plant growth
* Inefficient land use
* Blocks morning and evening sun
 |
| Conventional (stand-alone)$25 per sq. ft | Cabin shaped frame typically with glass or poly-carbonate glazing. Ideal location: open filed/backyard, south facing | * Strong Structure
* Long side walls maximize space for growing
* Durable, long term option
* Can connect multiple structures together
* Excellent lighting
* Room to add vents or windows
* More efficient air circulation
 | * Needs an anchored base because it is top-heavy
* Expensive to heat
* High initial construction costs
* Requires a foundation
* Requires more material than other designs
 |
| Shipping Container$15,000 | Refurbished metal shipping container | * Easy to ship
* Compact and contained
* Cheap and available
* Best for lettuce
 | * Environmental control difficult
* Poor structural integrity of used containers
* High operational cost
* Need high intensity lighting (increases heat and humidity)
* Difficult to ventilate
* Poor ergonomics
* Low comparative output
* No natural light
* Aesthetics
* Not a good gathering place
 |
| Insulated Plant Factory | Similar to shipping container. High tech | * Potential to reduce energy costs with LED lights
 | * Not a good gathering place
* Costly
* May not meet visions for self-sufficiency and re-learning skills
 |
| High-tunnel style  | Unheated made of single covered poly on steel hoop structure. Most widely used greenhouse around the globe. | * Simplest and cheapest option
* Operating costs are low
* Low energy requirement
* Simple technology, low cost for tooling and training
* Low-cost products
* Wide variety of products
* Opportunity for greater community involvement
* Can be moveable
 | * Short growing season
* Low yields/revenue
* Low quality products
* Dependency on soil
* Low profile
* Low strength, to support the weight of tall crops
* Must be reglazed every year to prevent collapse due to snow
* All-year growing not possible
 |
| Stand-alone  | Double poly covering on engineered steel structure. Glass can also be used. Insulated with blown air between the layers. Forms much of the small-scale greenhouse industry in Canada. Can have soil-based production with little or no environmental controls or a high-tech facility with soilless production, grow lights, and full environmental control suitable for year-round production | * Good starting place for commercial greenhouse production
* Can be low, medium, or high tech
* Pros depend on technology employed
 | * More expensive than high tunnel
* Can do anything but wont necessarily be the most efficient
* Less energy efficient than gutter-connected
* Cons depend on technology employed
 |
| Gutter-connected | Norm for commercial production in Canada. High tech. Can range in size from small to large.  | * Highly productive
* Capable of year-round production
* Proven technology
* Withstand harsh winters
 | * High skill level required to use
* Expensive
 |

\*Will need heat and artificial light sources to grow throughout the winter in all greenhouse styles\*

\*Insulation and ventilation are key design components\*

Equipment required for winter growing

* Heating
* Artificial lighting
* Single- or double-layer thermal screens
* Double layer polyethylene film
* Heating system at plants level

**Heat cost calculator:** <http://www.littlegreenhouse.com/heat-calc.shtml>

**All year-round Chinese style passive solar pit greenhouse in Nebraska using Climate Battery**

* 26-year-old greenhouse in Nebraska. Heated solely using geothermal technology (climate battery)
* 17 6-inch tubes, 8 feet deep, 230 feet of tube
* Blower to blow air around
* Reflection wall
* No glazing on north only on south and top, polycarbonate glazing 3/8 inch thick
* Galvanized metal walls, ¾ walls
* Floor dug four feet below ground
* Roof slanted to catch southern sun
* $25,000 USD or $31,860 CAN to build without labour costs
* Averages 80 cents USD or $1.02 CAN per day year-round for energy
* Grows warm weather produce in the snow – citrus, figs, pomegranates
* Second version has a pond (hydroponics)
* Uses a simple forced air propane heater, only has had to turn it on three times in the last 23 years
* Plants that do not like cool nighttime temperatures can benefit from a back-up heat system



Figure 1 Inside newly built Pit Style Passive Solar Figure 2 External View – roof at ground level



Figure 3 Pit Style Passive Solar Greenhouse Model Figure 4 Russ Finch with his oranges

<https://www.youtube.com/watch?v=ZD_3_gsgsnk>

**Le Jardin des Funambules (Quebec)**

* Hoop house with insulated foundation
* $25-30 thousand to build
* Investment of knowledge to grow
* Rocks with French drain around greenhouse
* 32 x 100 ft, 35 x 100 ft, 35 x 105 ft
* Make most money on cherry tomatoes
* Accessibility to farm, greenhouses, and inside the greenhouse super important
* Grow ginger for $40/kilo
* Bring in beneficial insects
* May through October do not need to heat with propane
* Expensive to heat through winter due to designs lack of insulation
* Can produce the most food, best for commercial farming
* Least likely to be a good gathering space



Figure 5 Bird’s Eye view of Hoop house Greenhouses Figure 6 Inside view

http://lejardindesfunambules.com/

**Lida Farms Deep Winter Greenhouse/Root Cellar**

* Located in Northern Minnesota
* Passive-solar design with solar panels
* Growing cold-tolerant greens
* Storage crops stored in an attached root cellar
* Small cottage provides back wall for greenhouse
* Hillside topography to provide more constant temperatures
* Building well below the frostline
* Greenhouse stands 16 feet tall
* Four feet below grade have an insulated foundation with tiling and rock for a solar air heat sink and the radiant floor tubing connected to the solar panels
* Ties into existing infrastructure with an outdoor wood boiler for back up heat source
* 32 x 16 feet
* Double-walled polycarbonate (retains more heat than plastics)
* Root cellar 9 x 14 feet beside the greenhouse
* Made with simple timber construction
* Using evacuated solar thermal tubes for heat
* Costs
	+ Greenhouse
		- Excavating: $1841 USD
		- Labour: $1330 USD
		- Plumbing: $1837 USD
		- Materials: $4273 USD
		- Lumber: $7589 USD
		- Solar: $7057 USD
		- Total: $23,928 USD or $30,494.44 CAN
	+ Root Cellar
		- Excavating: $789 USD
		- Labour: $570 USD
		- Materials: $649 USD
		- Lumber: $2710 USD
		- Total: 4,719 USD or $6014.01 CAN
	+ Propane in the winter: An average of $300 USD or $382 CAN



Figure 7 Earth Tubes Figure 8 Pit Style Passive Solar and Root Cellar

<https://practicalfarmers.org/wp-content/uploads/2019/04/Ryan-Pesch-Deep-Winter-Greenhouse.pdf>

https://www.researchgate.net/publication/280882501\_Winter\_Greenhouse\_Enterprise\_Analysis

**Rob Avis Passive Solar**

* Ventilation
	+ Vent wall consisting of low and high vents
* Insulation
	+ Standard pink
	+ Plastic vapour barrier
	+ Sheet metal on outside
	+ Side walls are white sheet metal for reflecting
* Knee Wall
	+ Where the snow will accumulate, place low vents on top of knee wall
* 12% glazing, 90% of heating comes from this
* Rainwater harvesting
	+ Free fertilizer
	+ Bison pumps to pump rainwater that is just below the surface of the ground
* Plant pollination crops at front of greenhouse in front of vent wall so pollinators will go into the greenhouse
* Problems in greenhouses
	+ Pollination, spraying fish emulation to attract pollinators
	+ Not having enough air flow
		- Need cross ventilation with windows and door
* Overhead insulated garage door
	+ Provides easier access for heavier work
* Foundation
	+ Insulated concrete forms down four feet from soil level
* Structure cost
	+ $65-70 thousand with construction
	+ $30-40 thousand for just materials
* Heat storage
	+ Climate batteries
		- Store thermal energies, diurnal system
* Solar Air Collector
	+ Soffit – sheet metal with perforations to allow air flow
	+ Used as solar air collector
* Energy stored in fall keeps greenhouse warm in winter
* Does not grow all four seasons because he does not want to use external heating sources



Figure 9 Rob Avis First Passive Solar Design Figure 10 Rob Avis Second Passive Solar Design

https://vergepermaculture.ca/passive-solar-greenhouse/