

# The Attached SOLAR GREENHOUSE

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Attached solar greenhouses have gained considerable popularity, as an addition to an existing house or as an integral part of a new home. The attraction of the solar greenhouse is its adaptability.

Design, construction, and use involve a wide range of options which can be combined to meet many tastes, needs and budgets. However, for good energy performance under Alaskan conditions, the following standards should be incorporated into the design of the greenhouse: the greenhouse should face south if the north side is not transparent; heavy insulation in the end walls and roof; no glass in the roof; no glass in the end walls unless you are prepared to leave movable insulation over the glass permanently during winter months; and heavy insulation at the slab (or other floor) perimeter.

## How It Works

In the winter, sunlight passes through the windows and warms the darkened surfaces of the concrete floor, brick wall, water-filled drums, or other storage mass. Some heat is absorbed into the thick concrete and brick and the water, where it will remain stored until the indoor temperature begins to cool after the sun sets. The heat not absorbed by the storage

elements can raise the air temperature inside the greenhouse, during the day, into the 90° to 100° F range. As long as the sun shines, this heat can be circulated into the house by natural convection or drawn by a low-power fan.

It is extremely difficult to design and build a greenhouse in Alaska that can be used as an efficient solar heater AND at the same time, an environment for growing plants and / or food. If a lot of mass is used in the greenhouse to reduce the temperature swings that destroy plant life, the vast majority of solar heat will be used in the greenhouse, and never enter the main house. If the intended purpose is to provide as much heat as possible to the house, mass should be MINIMIZED. This is because the heating load of a house is much greater than the heat available from the sun at any given hour of the day for about six months of the year. All the heat from the sun can be used immediately in the house. Storing heat in thermal mass in the greenhouse and then transferring it into the house at night is simply not very effective in Alaska for most of the year.

One alternative is to make the thermal mass portable (usually water), so that it can be removed during the winter, then put back into place in the summer. The mass helps prevent overheating and the need for continuous venting.



## Five Passive Solar Elements

Any solar greenhouse must include the following elements in order to be considered a passive solar heating system:

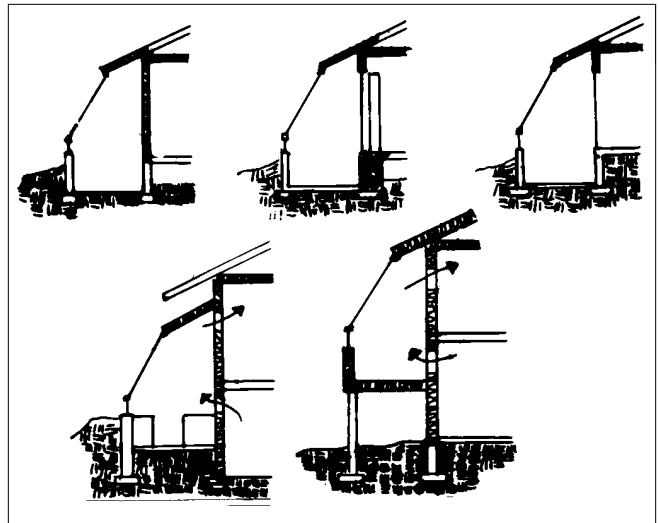
1. A **COLLECTOR**: such as the double layer of greenhouse window glazing (glass or plastic).
2. An **ABSORBER**: usually the darkened surfaces of the walls, floors, and water-filled containers inside the greenhouse.
3. A **STORAGE MASS**: normally the concrete, rock, and/or water that retains the heat after it has been absorbed.
4. A **DISTRIBUTION SYSTEM**: which is the means of getting the heat into and around the house; i.e., natural convective flows through doors or windows or high and low openings into the house. Fans can supplement and greatly improve performance and are considered to be active components.
5. A **CONTROL SYSTEM** (or heat regulation device): such as the movable insulation used to prevent heat loss from the greenhouse at night, and roof overhangs that block the summer sun are passive controls. Some controls are operated by occupants, some are automatic, such as temperature sensitive motors, which are activated to open or close vents without the use of electricity. Fans and thermostats that activate fans are active control systems.

All five of these elements must work together.

### The Attachment: Some Options

One of the more important questions to consider when designing a solar greenhouse is how it will be attached to the house. The following options demonstrate the adaptability of the greenhouse concept:

**Option 1:** The greenhouse is separated from the main structure by an uninsulated brick, block, or concrete wall. This wall will absorb and store solar heat that will—over a period of several hours—migrate through the wall, most of it reaching the main living space later in the day and after the sun has set.



**Option 2:** The greenhouse is separated from the main structure by sliding glass doors and stationary “door-size” windows. Behind the stationary windows, inside the living space, are tall water-filled tubes. Sunlight, passing through the greenhouse, then through the stationary windows, strikes the water tubes. These absorb and store heat for later use. (If the tubes are spaced apart, the room also receives direct sunlight for immediate warmth.)

**Option 3:** As in Option 2, the greenhouse is separated from the main house by oversized windows and sliding glass doors. The sunlight strikes the masonry floor of the living space. The floor should be at least four inches thick (typically, a concrete slab covered with ceramic tile or brick) and left uncarpeted (carpeting will prevent heat absorption).

**Option 4:** The greenhouse is attached below the roof line and covers a portion of two levels of the house. This option can, if properly designed, let the air circulate naturally between the house and the greenhouse and eliminate the need for fans for circulation.

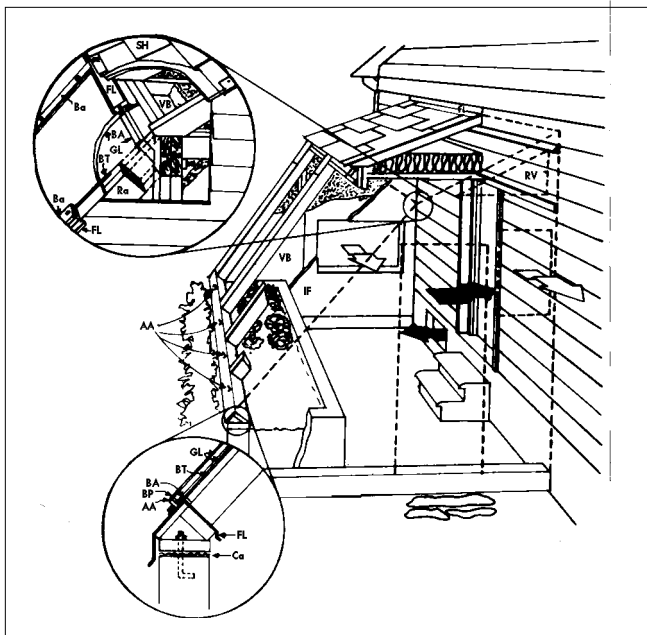
**Option 5:** The greenhouse is raised on pilings and insulated heavily in the floor, roof and other unglazed exterior areas. This option is suitable for permafrost areas and greenhouses that are attached to second story dwellings. Extreme care should be taken in permafrost areas to see that there is good air circulation around the pilings and that the pilings conduct as little heat as possible to the ground, or pilings and structure may settle.

A combination of these and other options may be the best overall approach. In any case, these are only a few of the things that ought to be considered when designing and building a solar greenhouse.

### More Design Considerations

For Alaskan conditions, one recommended design consideration is the use of vertical glass instead of sloped. Sloped glazing is more difficult and expensive to install, has a much greater tendency to leak, and is more prone to breakage. In the winter, the sloped glazing actually gets LESS solar gain, because of our low sun angles (maximum solar gain occurs when the sun is perpendicular to the collector surface), and has to be cleared of snow. Also, sloped glazing is angled such that the reflection from the snow is less effective (snow reflection actually increases solar gain on vertical glass). Finally, because you can't easily shade the glass in summer, continuous venting is necessary. With vertical glazing, the overhang helps shade the glass, and overheating is minimized.

The illustration below shows some important design concepts, and many of the same details apply to a greenhouse with vertical glazing. The vertical glazed greenhouse is easier to build, because the glazing details are simpler.



(Above) Flashing and other details where the roof, end wall and glazing meet. (Below) The Flashing overlaps the sill both inside and out. In the large drawings, the dark arrows show winter airflow. The white arrows mark summer venting.

First, this solar greenhouse has an insulated roof. If the roof were glass, much more heat would be lost because warmer air rises and accumulates near the roof. Glass provides very little resistance to the conduction of heat back outdoors.

Another point about the design is its simple relationship to the main structure. Heat can be drawn from the top of the greenhouse by a fan, or heat can circulate naturally from greenhouse to house via an open window or door. Heat stored in the wall between the greenhouse and the house will radiate as the temperature falls.

### Movable Night Insulation

When the sun sets, the window through which heat has been efficiently collected during the day, becomes a problem. The flow of heat back through the glass at night may result in losses greater than the daytime solar gain. It is important to block these night losses.

The traditional solution has been the use of movable night insulation. However, mechanical systems are expensive and manual systems don't get used with any regularity, as the thrill of the new structure dulls and the job of moving new shades becomes boring. But, they are essential if you intend to grow plants in the colder months. You can get by without shades if the greenhouse acts solely as a heater, and you allow that space to cool down at night. The greenhouse will buffer the wall it's attached to, reducing heat loss from the house. There is no question that there would be less heat loss with the movable insulation, but the economics are questionable because of the cost of shutters and shades.

Another alternative is the use of the new high R-value glazings that are now available. Low emissivity glass increases R-values as well as reduces summer heat build-up through selective filtering of the sun's rays. Though not as effective as movable insulation, they are better than a double pane window with unused shades because the homeowner forgot or wasn't around to close it!

## How Much Heat Can Be Provided To The Home

The Alaska Department of Transportation and Public Facilities (DOTPF) Research section has studied the annual performance of a greenhouse attached to a building in Alaska. The study was conducted using computer simulation of the performance at wide-ranging locations throughout Alaska from Homer to Barrow. The conclusions are stern and conservative. The results show that it is not possible to justify the expense of an attached solar greenhouse in any climatic region of Alaska. It is important to consider this fact in the design, as there will be periods of the year when the greenhouse space will be a net loser of energy, regardless of the location.

Frequent problems have also been noted when a greenhouse, originally intended to be operated only in the warm months, is used year-round. The result is that condensation problems become rampant. The greenhouse acts as a large cold condenser for house air which finds its way into the greenhouse. Always assume that a pleasant and available space such as a greenhouse will in fact be used year-round because to do otherwise can cause condensation problems.

Air fans and air handling systems in a greenhouse are areas of special difficulty. These systems are especially difficult to seal and often exacerbate condensation problems.

Experience in Norway indicates that wood frames for greenhouses are subject to deformation, shrinkage, warping, and are difficult to protect from water damage, especially if they have roof joists where wood can become easily exposed to water penetration. These designs are popular in Alaska, but the consumer should be wary of these vulnerabilities.

Excess heat can be used to heat domestic hot water prior to the water going into the hot water tank. In Alaska, the ground temperature (and water) is often in the 35° to 40° F range. If the excess heat can

be used to raise these low temperatures instead of dumping the excess heat, you will be conserving the energy source you are presently using to heat your domestic hot water. (Note: the average urban family of four can use up to 25% of the total energy used in the household just to heat domestic hot water.)

Solar greenhouses can be linked to a remote rock storage bin. Heat is ducted from the greenhouse to the rock bin with the help of fans and blowers. The rocks absorb and store the heat until it is needed. The bin is usually located in the basement or crawlspace of the house or underneath the greenhouse.

The introduction of active elements—the forced air duct to and from the rock bin and the rock bin itself—turns a greenhouse into a hybrid system, a combination of active and passive solar.

### Construction

Some homeowners prefer to do it themselves, other prefer having it done for them. Some have their greenhouses custom-built, other buy packaged assemblies. The design presented in this factsheet is principally a tight solar heater; it can be adapted to both new and existing buildings. It can be built to whatever size and specifications are required. The cost of a greenhouse depends on the overall design, the materials used, and the need for and cost of professional labor.

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