Passive Solar

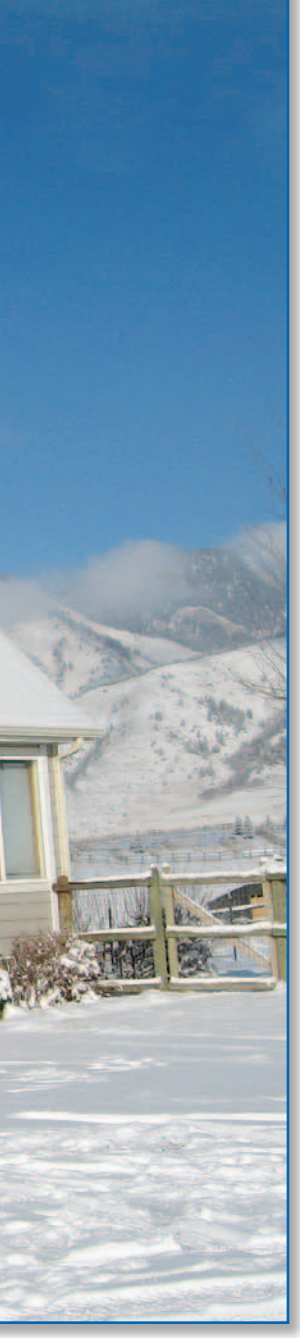
Retrofit

Custom-built glazed doors can turn your garage into a sun-warmed winter workshop.

...in a Weekend

by Gary Reysa

Having a shop or studio in the garage can be a great use of space, but garages aren't always pleasant places to work. They can be frigid in the winter, sweltering in the summer, and cavelike at any time of the year. This weekend project will make your garage a more comfortable work space, while reducing your energy consumption from lighting and space heating.



The biggest boon is that you can do this weekend retrofit yourself for about $400. Depending on your climate and energy costs, you can recoup that expense with utility bill savings over the first winter or two. At about $4 per square foot, these simple solar collectors can do as good a job of solar heating as commercial collectors costing $30 per square foot—and they give you the added bonuses of natural lighting and a view to the great outdoors!

Project Overview

This inexpensive and easy-to-build project converts a garage that has a south-facing overhead door into a solar-heated and lighted workshop, studio, playroom, sun space, or greenhouse, using readily available materials and hardware. If you're handy with a few power tools, you're good to go, with one caveat—if your garage door doesn't face south, this project won't work for you. (If you're still interested in heating the garage with solar energy, take a look my other article, "Build a Solar Heater for $350" in *HP106*, which details how to construct a solar hot air collection system.)

The solar "collectors" are a set of custom-built glazed doors mounted to the existing garage door frame, just outside of the garage door itself. Each set consists of two doors hinged at their vertical edges to open outward. The new doors are about 80 percent glazing to admit as much sunlight as possible.

The large expanse of glazing admits low-angled winter sunshine directly into the garage, warming the concrete floor and other surfaces. The thermal mass of the floor and shop's contents absorbs the sun's heat energy and then slowly distributes it into the space. On partly cloudy or thinly overcast days, solar thermal energy will still provide quite a bit of heat, but on heavily overcast days, you may need to use a supplementary heater. An optional screen of greenhouse shade cloth, suspended from a horizontal wire just inside the existing garage door, reduces daytime glare, while still admitting ample light and maintaining a screened view to the outdoors.

Project Pros & Cons

Pros:

- Makes the garage/shop a comfortable, well-lit place to work
- Reduces need for daytime electrical lighting
- Saves money and reduces greenhouse gas emissions by not using fossil fuels for heating and lighting
- Reduces the need for auxiliary heating
- Inexpensive
- Requires only basic tools and carpentry skills
- Is attractive (even better-looking than the original garage door)

Cons:

- You have to remember to raise the garage door in the morning and shut it at night
- By itself, provides less security than the garage door (substituting twin-wall polycarbonate glazing could help, because it's more impact-resistant than acrylic)
- On cloudy days, some form of backup heat may be necessary to keep the shop space comfortable
- Over time, the acrylic panels may become scratched, marring the glazing's appearance
- Outward-opening doors might be an inconvenience, especially if there is a lot of snow and ice on the driveway or it is necessary to park close to the building

Glazed doors provide passive heating and natural lighting for the garage–workshop.

Two of the four "solar" doors installed on the right side of the center column (not yet finished). The original garage door can still close, providing some nighttime insulation.

Project Details

This is how I designed my doors, but you'll need to customize the construction details to suit your garage door opening's specific dimensions.

Center column. A removable column in the middle of the existing double-wide garage door opening supports the two center doors, which are hinged on the center column. The column is made from three 2 by 4s nailed together. The top and bottom of the column are attached to metal plates that are lag-screwed to the concrete floor and the upper door frame. To restore the full-width opening of the garage, the column can be removed by taking out the lag screws. To mask the ganged 2 by 4s and match the existing door frame, you can add trim pieces to the outside of the column.

Door Frames. The column divides the open garage door frame into two spaces, which can be further divided by door panels, depending on the width of the openings. In this case, two doors were designed to fit each of the approximately 8- by 8-foot openings on either side of the column. In each opening, one door is hinged to the existing garage door frame, and the other door is hinged to the new column.

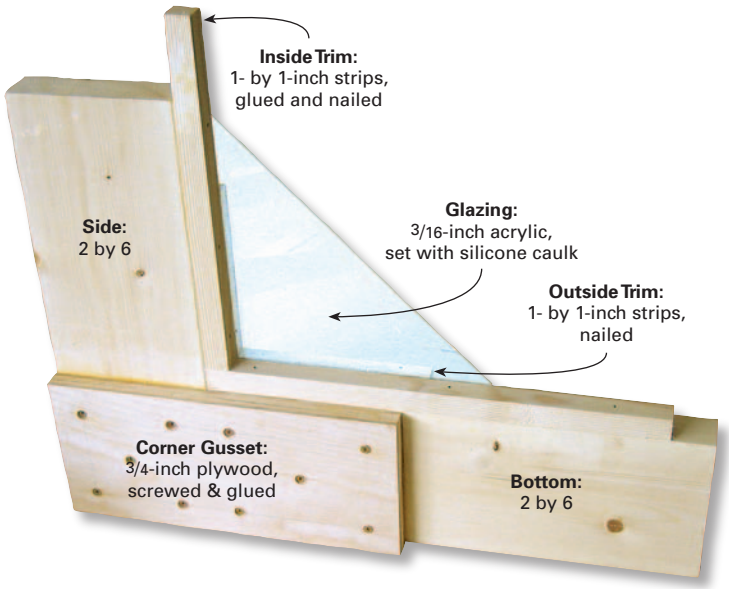
The door frames' minimal construction allows for maximum glazing area. If you plan to open and close the doors a lot, consider somewhat beefier construction. My doors are made with 5- by 1¼-inch pine boards milled from rough-sawn lumber, locally purchased. They can also be constructed using 2 by 6s.

Be sure to reinforce the corners of the panel frames. I used glue and biscuit joinery to make the corner joints, but you can also use pocket screws, plywood gussets, or metal plates. If you anticipate opening and closing the doors frequently, good corner reinforcement is imperative. Before gluing the corner joints, make sure that the door frames are square by checking that the diagonal corner-to-corner distances are equal. Use a high-quality, water-resistant carpenter's wood glue (also known as "yellow glue") or, for even better weather protection, polyurethane glue.

Glazing. The glazing panels are 3/16-inch-thick acrylic. Each door panel required most of a 4- by 8-foot sheet of acrylic. The glazing sits in a rabbeted groove that is cut around the inside of each framed section. I made the rabbets by simply routing around the inside of each door frame. To allow room for thermal expansion, cut the acrylic panels to leave a 1/16-inch clearance all the way around. Secure the glazing to the door frame by running a light bead of silicone caulk in the rabbeted groove, setting the glazing in the frame, and then nailing a small piece of 1/2- by 1/2-inch wood molding to the frame.

If you don't have access to a router and biscuit joiner, you can construct the door frames as shown at left, using 2 by 6s for the framing, and plywood gussets glued and screwed to the door frames at the corners. Two 1- by 1-inch frames, attached to the 2 by 6s and spaced apart, hold the glazing in position. This technique results in a strong and attractive door frame.

Alternative Frame Construction Details



As an alternative to using acrylic glazing, you can use twin-wall polycarbonate panels. The twin-wall material is extremely tough and more impact-resistant than acrylic. Although the polycarbonate panels will obscure the view, they'll still allow up to 85 percent light transmission. Another option is to use acrylic panels on the upper frames and twin-wall on the lower frames to preserve some view, while providing some privacy.

Mounting. After the doors are completed, prop them into the openings, and trim as needed to make them fit properly. Mount the doors at least 1/4 inch above the floor so they will open without scraping on the concrete. To allow for thermal expansion, I left 1/4-inch gaps all the way around and between the doors—the weather stripping you will install later does a good job of sealing these gaps. Check carefully that there are no clearance problems with the existing garage door or frame.

Outside view of the removable center column, trimmed to match the existing frame.

Inside view of the bottom of a door pair, without trim strip installed. Toggles hold summer reflector panels in place.

Inside view of the top of a door pair with stop block. A trim strip and weather stripping reduce air infiltration.

Keeping Cool in the Summer

Lots of thermal gain is great for keeping your workshop warm in the winter, but what about preventing overheating in the summer? Without an adequate roof overhang on the building's south side, the temperature within the work space can become uncomfortably hot. Here are some ways to control summertime temperatures:

- Keep the overhead garage door closed. This is effective, but you'll lose the daylighting and view.
- Open the garage door and the glazed doors to allow more ventilation.
- Build an overhang above the glazed doors that blocks the high summer sun, but still allows the winter sun to enter (see www.builditsolar.com/References/SunChartRS.htm#Overhangs).
- During the summer, install reflective, 1/8-inch-thick, white hardboard panels just behind the glazing in the lower sections of the doors, using "toggle" strips to secure them. These panels will reflect most of the sun, and the upper door sections will still allow daylight in and views out. Most lumberyards carry inexpensive, 1/8-inch hardboard with a glossy white finish that works well. Attach flat wood strips horizontally across the back of the frame to keep the panels from warping.

To prevent your shop from overheating in the summer, install 1/8-inch, white hardboard panels on the inside of the lower door panels.

Once you are satisfied with the fit, use three door hinges to attach each door to the existing garage door frame and new post. As a general rule, use one hinge for every 30 inches of door or fraction thereof. I used ordinary door hinges, which have worked fine, but heavier hinges could be used if the doors get a lot of use.

Weather Stripping. Once the new doors are in place, they should be weather stripped to help curb air infiltration. I used vinyl "garage door" weather stripping around the top and sides of the doors. To prevent drafts from entering below the doors, I attached a 1 1/2- by 1/2-inch wood strip to the garage floor using concrete fasteners. The doors butt against this strip when closed. The strip reduces air infiltration, and is still easy to drive over. To seal the vertical joint between the doors, I attached a 1 1/2- by 1/2-inch wood strip to one door so that it overlaps the other door when closed. Don't forget to search for other areas where air could enter, and seal them up.

The doors are latched from the inside by simple door bolts attached to the upper and lower portions of the doors—one set of latches per pair of doors. The bolt seats into holes drilled into the concrete floor and into the garage door frame. I use the west-most two doors so infrequently that I just screwed them to stop blocks mounted on the floor and door frame—this is simple, and it only takes a couple of minutes to remove the screws if a door needs to be opened.

Finishing Touches. A 1/16-inch steel cable stretched across the garage's width and anchored to the side walls supports the shade cloth. The support cable is about 7 1/2 feet above the floor, and runs just under the opened overhead garage door. A turnbuckle at one end allows the cable to be stretched tight. The shade cloth I used is 6 feet tall; I cut three 83-inch-wide panels to overlap a bit and fit across the 18-foot door width. Shower-curtain hangers suspend the cloth from the cable, allowing each panel to be drawn to the side when not in use. Shade cloth comes in a wide selection of colors and densities. Even a dense cloth, rated to block about 85 percent of ultraviolet light, still allows light to enter the shop while permitting a very diffuse view out.

Solar Retrofit Costs

Needed Items	Cost
4 Acrylic sheets, 4 x 8 ft., 3/16 in. thick	$280
Glue, screws, caulk, hinges, latches, paint, weather stripping, etc.	70
14 Studs, 2 x 6, 8 ft. long	50
Total, Needed Items	$400

Optional Items	
Greenhouse shade cloth, 120 sq. ft.; plus 18 ft. of steel cable	$60
2 Hardboard panels, white, 4 x 8 ft.	16
Total, Optional Items	$76
Grand Total	$476

Operation

On sunny days, I open the overhead garage door, leaving the glazed doors shut. The thermal mass in the garage floor and the shop's contents absorb solar energy and redistribute it to heat the space evenly. The large glazed doors also provide excellent daylighting, eliminating the need for supplementary electrical lighting during the day, and provide a good view of the outside world—creating the feeling of working outside, without the bracing winter breeze or blazing summer sun.

I usually draw the shade cloth screen off to the side so that sun can shine directly into the shop, but if the sunlight produces too much glare, the shade cloth curtain can be used to reduce it. (Another use for the shade cloth, if you're the disorganized type, is to keep people from seeing your messy shop!)

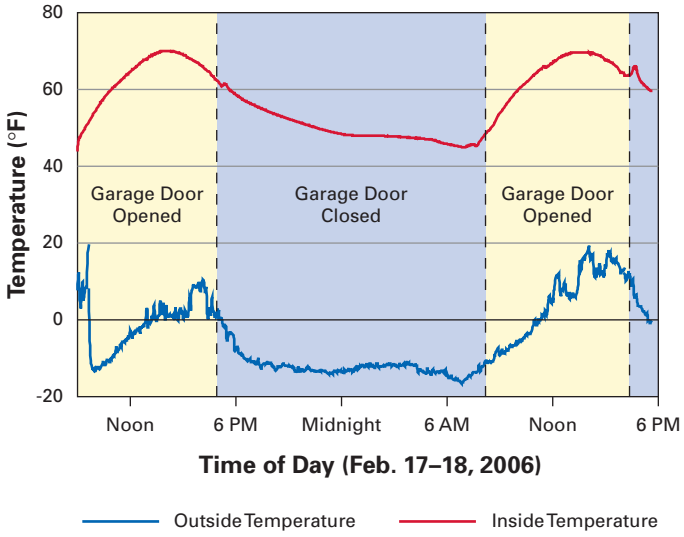
On partly cloudy or thinly overcast days, the collector still works fairly well, but on really cloudy days, keep the overhead garage door closed to slow heat loss. At night I close the garage door to provide additional insulation and reduce heat loss through the glazed door panels.

Performance

Occasionally, I hear comments that passive solar thermal heating can't possibly work when it's really cold out—wrong! Since I added the glazed doors, the temperatures in my workshop are usually in the high 60s or low 70s—without additional heating. I monitored the temperatures inside the shop during a period of cold, clear weather. The ambient temperature dropped to 20°F below zero, but the daytime shop temperature—just relying on the solar collector for heating—still reached 70°F (see graph). So far, the shop has never been too cold to work in.

Water barrels set inside the solar doors act as thermal mass, helping minimize temperature swings from day to night. (Here, temperature sensors monitor heat gain.)

Solar Workshop Heating Performance



The downside of using glazed doors or windows for collectors is that the heat loss at night can be high. Without some form of insulation to reduce nighttime heat loss, the glazed door can lose much of the day's heat gain. This is where using the existing garage door can dramatically reduce heat losses at night. Garage doors are typically well sealed to prevent drafts, and insulated to between R-6 and R-9. When you add this to the R-1 (or above) of the new glazed doors, you get a *whole-wall* R-value similar to a typical, fiberglass-insulated, 2 by 4 wall. Closing the garage door after a cold, but sunny, day increases the workshop's net heat gain by a factor of 2.5. The garage door also adds a second barrier to help prevent air infiltration.

If you find that the shop space tends to be a bit warm in the afternoons, and a little chilly in the mornings, try adding some thermal mass to even out the temperature swings. One strategy is to place several dark-colored water barrels just inside the garage door. Position the barrels so that the sun shines directly on them. They will absorb heat during the day and temper afternoon temperatures inside. Once the space starts to cool, the barrels will slowly release their stored heat, making the space warmer and more comfortable at night and the next morning. Based on my experience, you will need about four 55-gallon water barrels to make a significant difference.

With or without water barrels, the combination of the new outer glazed doors, the existing overhead garage door, and the sliding screen is a simple but very effective way to harvest some free solar heat and to control the temperature in the shop. Invest a weekend creating your own passive solar workshop, and you'll spend many an afternoon thereafter basking in the warmth of your reward.

Access

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