Solar Heat and Light for Your Workshop or Studio

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These days, most of us are trying to figure out ways to reduce our energy consumption and our green house gas emissions. Here is a weekend project that will not only help you accomplish those goals, but will also make your shop (or studio) a much more pleasant place to work in – toasty warm and well lighted. It will cost you a weekends worth of work and set you back about $380. Depending on your climate and energy costs, you will probably save the $380 over the first winter or two in lower fuel bills.

The added glazed doors collecting sun in the afternoon.

Overview

The scheme starts with a conventional south facing, overhead garage door. A new set of glazed doors are added just to the south (sun) side of the existing garage door. These new doors are mounted within the existing garage door frame. There are four of the new doors, and they are hinged on the vertical edges such that they open outward. A new vertical column is added in the center of the existing door frame opening to support the edges of the middle two doors. The new doors are about 80% glazing to admit the maximum amount of sunlight.

Just to the inside of the existing garage door a screen of greenhouse shade cloth is installed. The shade cloth is suspended from a horizontal wire, such that the shade cloth can be pushed off to the sides when not in use. The shade cloth can be used on very bright days to cut down the glare while still allowing lots of light and a view out.

For this scheme to work, your garage door must face south. If it does not, then have a look at the "Alternative Solar Shop Heater".

View from the inside – the lighting is great.

Operation

On sunny days, the overhead garage door is opened. The shop is heated evenly by the solar energy absorbed by the floor and shop contents. The large glazed doors provide quite a bit of solar gain, and will heat the shop well without supplementary heat even on very cold days. The sun also provides good day lighting. The glazed doors provide a good view of the outside world -- it gives the feel of working outside (but without the bracing 10F breeze).

The shade cloth screen is normally pulled off to the side so that sun can shine directly into the shop, but if the sun lighting produces too much glare, the shade cloth curtain can be pulled out to reduce glare. Another use for the shade cloth is to keep people from seeing how messy your shop is.

On partly cloudy or thin overcast days, the collector still works well, but on really cloudy

days, you are better off to close the garage door to prevent heat loss.

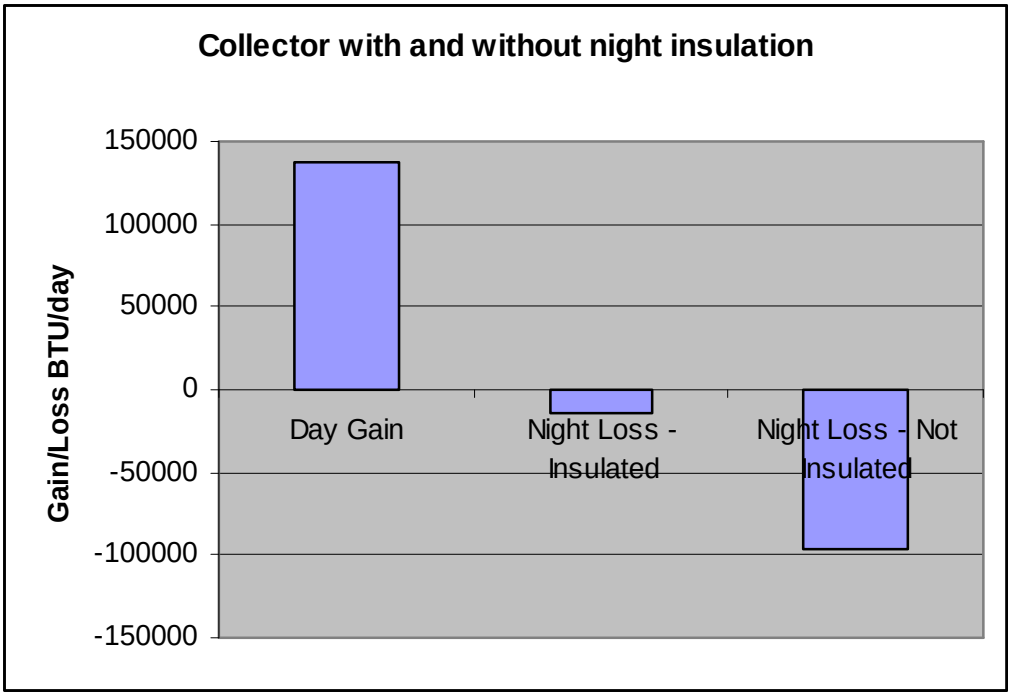
At night the garage door is closed to provide insulation and greatly reduce heat loss through the glazed doors.

While I use this scheme to heat my workshop, it would make a very comfortable playroom, studio, greenhouse, … Quite often it's the most pleasant room in our house to be in – warm and well lighted.

Why It Performs Well

A south facing window or glazed door makes a very good solar collector. The glazing transmits a high percentage of sunlight into the room. The materials inside the room absorb the sunlight and heat the room. A window can actually be more efficient at collecting energy than commercial solar collectors, because the absorber (i.e. the room surfaces) do not run at nearly so high a temperature, so, heat losses from the collector are lower.

The not so good side of using glazed doors or windows for collectors is that the heat loss at night is high. Without some form of insulation to reduce the night time heat loss, the glazed door can lose much of the days heat gain at night. This is where the existing garage door comes in to dramatically reduce night heat losses. Garage doors are typically insulated to between R6 and R9, and when you add this to the R1+ added by the new glazed doors, you get an R value that approaching that of an insulated wall. The new set of doors also adds a 2nd barrier to prevent infiltration of cold outside air.

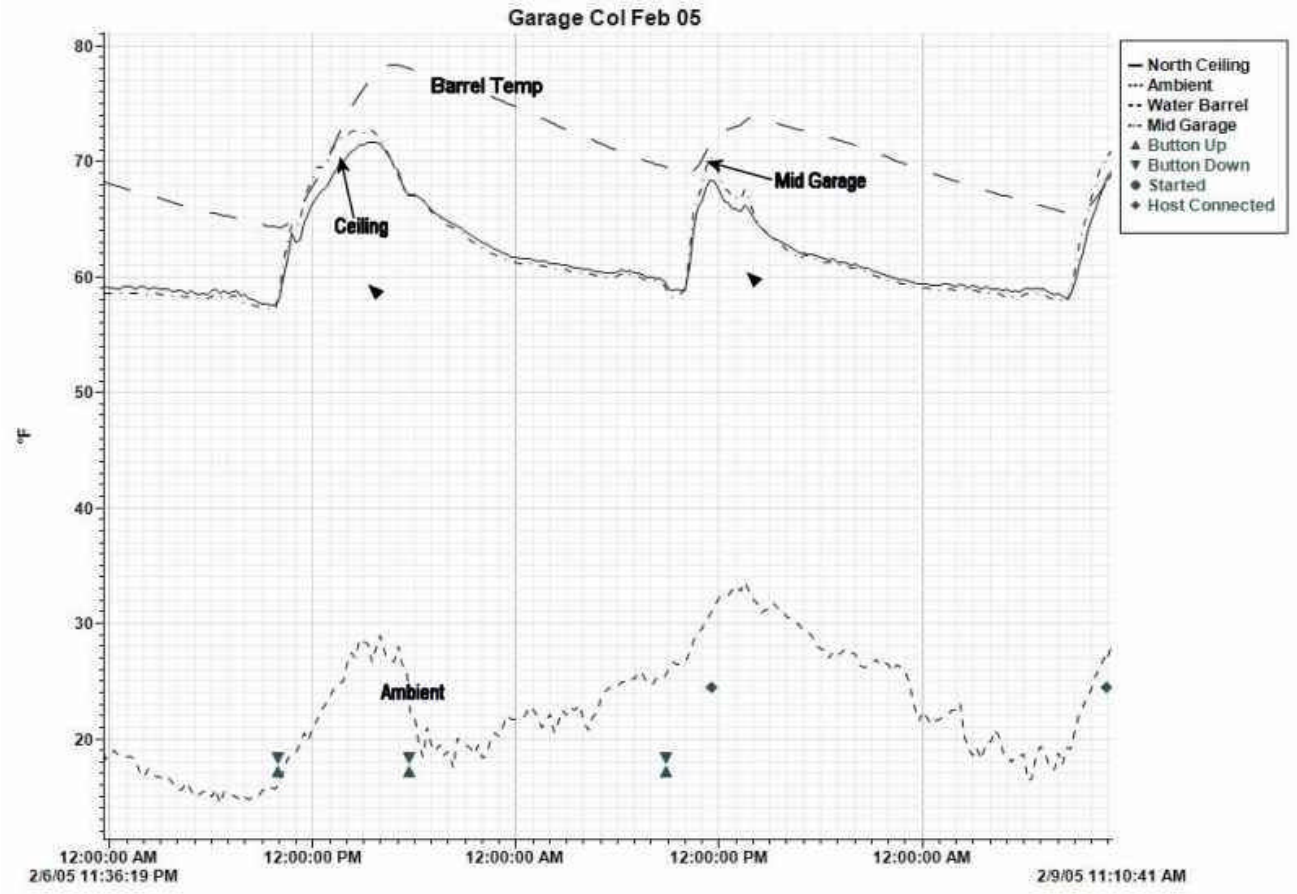


The key to the high efficiency of this arrangement is using the existing garage door as a moveable insulation panel to reduce night heat losses. Note the nearly tenfold drop in night heat loss.

The vertical orientation of this collector is very good for solar space heating. The low winter sun shines directly into the room and heats it efficiently. The sun is high enough in the summer to greatly reduce solar gain, so there is less of a tendency to overheat.

On partly cloudy or thin overcast days, the heater will still provide quite a bit of heat, but on days with a heavy overcast, you may need a supplementary heater.

Since adding the glazed doors, I have been able to close off the heat vents to the workshop altogether. So far, it has never been uncomfortable to work in. Temperatures are usually in the high 60's to low 70's. While the doors have a good payoff in terms of fuel saved, to me, the much improved environment they provide in the workshop is just as important.



Graph shows outside and shop temperature over a 3 day period with outside lows at about 20F. The temperature of some water filled barrels that were added as an experiment to even out temperature variations are also shown – more on that below.

Building the Doors

This is how I made the doors, but, feel free to adapt the construction to your needs.

I added a removable column in the middle of the existing double wide garage door opening to support the middle two doors. The column is made from three 2X4's nailed together. The top and bottom of the column are attached to aluminum plates, which are in turn lag screwed to the concrete floor and the upper door frame. The column can be removed by taking out the lag screws – this allows you to restore the full width opening if you need to move your 30 foot yacht in or out. Trim to match the existing door frame was added to the outside of the new column.

During construction. The added column is visible in the center. Trim boards were attached later to match the door frame.

I used two doors to fill each of the approximately 8ft high by 8 ft wide openings left on either side of the added column. Each door is hinged along one of its vertical edges. The door frames are made from wood, and are relatively light construction to allow a maximum of glazed area. If you plan to use the doors a lot, you might want to consider somewhat heavier construction.

The door frames are made from 5 inch wide by 1.25 inch thick boards. I milled these from rough lumber that I obtain a local saw mill, but carefully selected 2X6's from the lumber yard will work fine. The corners of the door frame must be reinforced. I used glue and biscuits to make the corner joints. Alternatively, pocket screws, plywood

gussets, or metal plates could be used to reinforce the corners. If you anticipate opening and closing the doors frequently, then good corner reinforcement is a must.

The glazing panels are 1/8th or 3/16th inch thick Acrylic. Each door used most of a 4 ft by 8 ft sheet of Acrylic. The Acrylic panels sit is a rabbeted groove that extends all the way around each glazed opening. The rabbet was made by simply routing around each glazing opening after the door frames were assembled. I cut the Acrylic panels with about 1/16th inch of clearance all the way around the opening to allow for thermal expansion of the Acrylic. The panels were installed by running a light bead of silicone caulk all the way around the bottom of the rabbet, and then placing the Acrylic panel on the silicone. A small wood molding was used to secure the Acrylic panels in the rabbeted groove.

As an option to using the Acrylic panels, you could use Twinwall Polycarbonate panels instead. The twinwall material is extremely tough, more secure, and provides a more diffuse view of your shop to people outside. You could even use Acrylic panels on top and twin wall on the bottom.

Door frame showing rabbet to receive glazing panel.

Since I don't expect to use the doors often, I elected not to put exterior handles on them. The doors are latched from the inside by simple plunger type catches on the top and

bottom.

Adding Weather-Stripping

The new doors are weather-stripped all the way around to prevent air infiltration. I used garage door weather stripping on the top and sides. This goes up quickly and seals well. Along the bottom, I attached a 1.5 inch wide by ½ inch high wood strip to the concrete floor using Tapcon concrete anchor screws. The bottom of the door butts against this strip when closed. The strip reduces air infiltration, but is still easy to drive over. The vertical joint between the pairs of doors is sealed by attaching a 1.5 inch wide strip of half inch strip of wood to one of the doors such that it overlaps the other door when the doors are closed, thus sealing the gap between the two doors.

Door stop and sealing strip where doors meet. The white Vinyl weather stripping is just visible along the top of door. One of the Acrylic panels is visible in loser right.

Shade Cloth Screen

The optional shade cloth is supported on a 1/16 inch diameter multi-strand steel cable that is stretched across the garage and anchored to the east and west walls. A turnbuckle allows the cable to be stretched tight. The shade cloth I used comes in a 6 ft width. I cut three panels 6ft wide and 83 inches tall to fit across the 18 ft door width. Each panel is attached at the top to the cable in such a way that it can be slid along the cable off to the side when not in use. I used plastic shower curtain hangers for the sliding attachment.

The shade cloth I used is rated as 85% blocking cloth. This is a relatively dense cloth, but it still allows light to enter the shop, and allows a very diffuse view out. The shade cloth comes in a wide selection of colors and densities.

Shade Cloth, shade cloth support wire and turnbuckle. One of the shower curtain sliders is also visible near the top of the picture.

Controlling Summer Overheating

While the vertical orientation of the doors tends to reduce heat gain with the high summer sun, there is still a tendency to overheat in the summer. Here are some ways to control this:

- You can simply close the garage door. This is effective, but you lose the nice daylighting and view.
- You can open the garage door and the glazed doors to allow more ventilation.
- You can build an overhang above the doors that blocks the high summer sun, but still allows the winter sun to enter. See http://www.builditsolar.com/References/SunChartRS.htm#Overhangs
- My solution is to install highly reflective 1/8 inch thick white panels just behind the glazing in the lower glazed panels – this reflects most of the sun back out, but still gives you daylight and views through the top panels. Lumber yards carry 1/8 inch hardboard with a gloss white finish already applied that works well and costs little.

Additional Possibilities

Other Spaces: The concept of large, south facing glazed areas insulated at night with an overhead garage door is not limited to shops and garages. You could apply the same

method for a sunroom, plant growing area, studio, or playroom. The combination of solar heating, natural lighting, and views make for a very pleasant place to spend time. The overhead garage door can be a cost effective way to provide good, moveable insulation and extra sealing.

House Heating: Another possibility would be to use the heat from the collector to help heat the house. This can be as simple as opening the door between house and shop, but a duct and blower to pick up heat near the ceiling would be more effective. You can make the collector Produce lots of hot air near the ceiling by raising the garage door slightly (6 to 8 inches) to form an intake slot below the door. Cool air enters the intake slot, is heated by the garage door surface, and rises out the gap at the top of the door near the ceiling. You can pick up this hot air by setting up a duct and fan near the ceiling. This will work better if the garage door is a painted in a dark color, but it does NOT have to be black.
Caution: Do not use this heat transfer scheme if you still park vehicles in the garage, or store noxious chemicals or materials that constitute a fire hazard in the garage. This would be seriously unsafe and a violation of building codes.

Thermal Mass: If you find that the shop space tends to run a bit warm in the afternoons, and is a bit chilly in the mornings, you can try adding some thermal mass to even out the temperature variation. One straightforward way to do this is to add several 55 gallon dark colored water barrels just inside the garage door. They should be positioned such that the sun shines directly on them during the day. When filled with water, the barrels will take up some of the heat during the day, which will lower the afternoon high temperature. The barrels will give back heat at night to make the morning temperature warmer. Based on a bit of experimenting, I think you will need about 4 of these water barrels to make a significant difference. You can think of them as the emergency water supply you know you should have.

Testing water barrels for thermal mass.

Insulated thermocouples taped to sides to log temperatures

It's hard to overstate how much more pleasant this makes the shop to work in -- on sunny days its toasty warm and very well lighted. I think it would also work well as a studio, kid's playroom, a place to grow a few plants, or maybe just a place to sit and read the newspaper.

I really like the way the existing garage door is used as movable insulation to reduce night heat loss. The combination of the new outer glazed doors, the existing overhead garage door, and the simple shade cloth sliding screen make a simple but very effective way to control the shop environment and harvest some free solar heat.

Pro:

- This makes the shop a really nice place to work.
- Reduces green house gas emissions
- Saves some heating cost – providing a one or two year payback
- It's an inexpensive project to build.
- It's fairly easy to build.
- It does not look ugly -- I think it actually looks a bit better than the original door.

Con:

- You have to remember to raise the garage door in the morning and shut it at night. This could be automated, and a friend of mine is working on a gadget to do this.
- It may be less secure during the day time when the existing garage door is open – using twinwall polycarbonate glazing would help this.
- On cloudy days, you might have to revert to some form of backup heat to keep the shop space warm.
- The Acrylic panels may be subject to scratching over time.
- Outward opening doors might be a pain if there is a lot of snow and ice on the driveway. But, we get quite a bit of snow, and so far this has not really been a problem.

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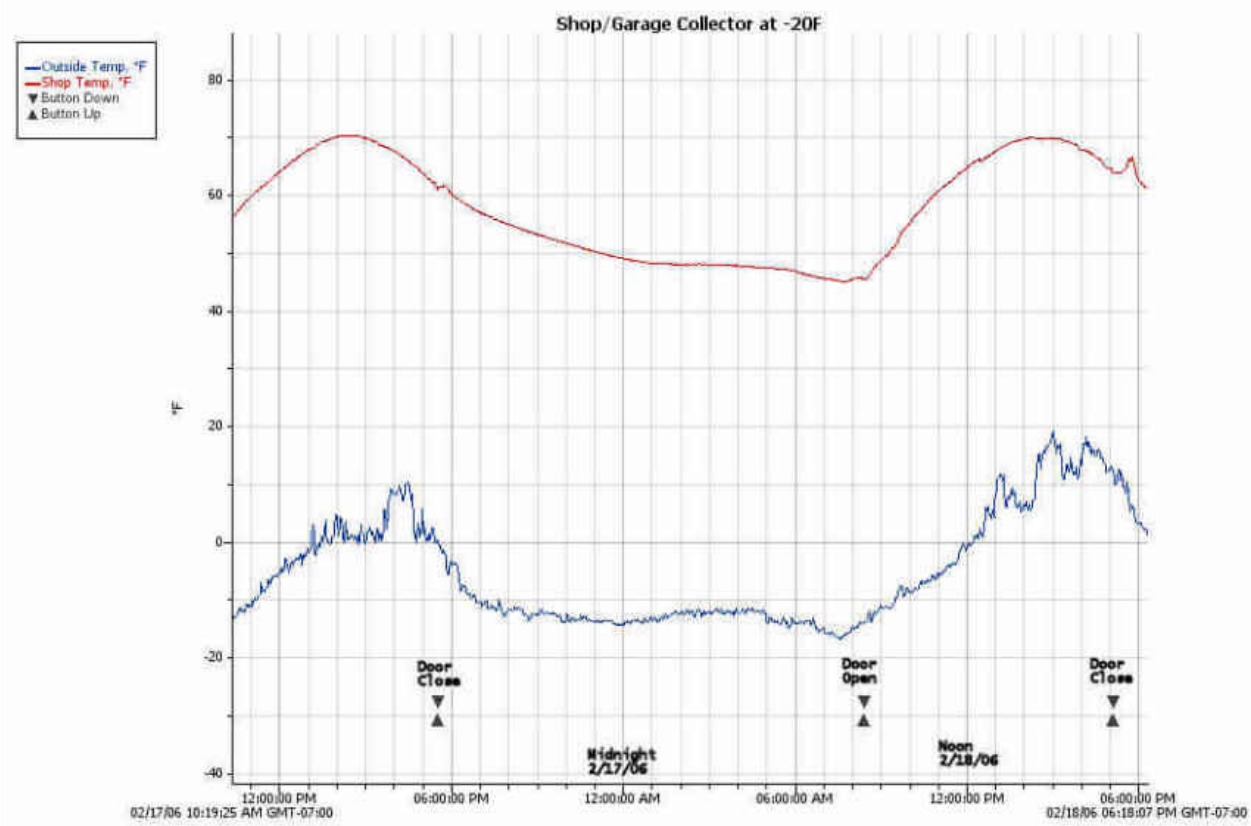
Performance at -20F

Occasionally, I hear the comments to the effect that solar can't possibly work when it's really cold out – wrong!

The plot below shows the temperatures inside the shop during a period of cold, clear weather we had last winter. The night time outside temperature dropped to -20F, but the daytime shop temperature with just the solar collector for heating still reached 70F.



Blue = outside temperature
Red = shop temperature