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A Multi Mode Solar Collector for Your Garage/Workshop

This is an inexpensive and relatively simple project to convert a garage or workshop that has a south facing rollup garage door into a solar heated and lighted sunspace. This is accomplished by adding a new set of glazed doors just to the north of your existing rollup door. In the day time the rollup door is opened and the workshop space is heated and lighted by the sun. At night the rollup door is closed and greatly reduces night time heat loss. It will turn your workshop from a cold dark cave into the most pleasant to be in room in the house, and lower your heating bill!

Illustration 1View from inside with rollup door open

Illustration 2View from outside with rollup door closed

How it Works

The scheme starts with a conventional south facing roll-up garage door. A new set of doors are built 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 must be added in the center of the existing door frame opening to support the edges of the middle two doors. These doors are about 80% glazing to admit the maximum amount of sunlight. Just to the north 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. When deployed, the shade cloth absorbs a fraction of the suns light and heat, but is transparent enough to allow a significant amount of daylight light in, and some view out.

Sunny Day Operation -- Solar Heat and Light Direct to Shop

On sunny days, the existing rollup door is opened. The shade cloth absorber is normally pulled off to the side so that sun can shine directly into the shop. The shop is heated evenly by the solar energy absorbed by the floor and shop contents. The large glazed area provides quite a bit of solar gain, and will heat the garage 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 feels a bit more like working outside.

If the sun lighting produces too much glare, part or all of the shade cloth curtain can be deployed to reduce glare.

Night time or cloudy day Operation

At night, or on very cloudy days, the existing garage door is rolled down, and the added outer glazed doors are also closed. This configuration minimizes heat loss when there is no solar energy to be collected. The outer glazed doors add about R1.3 to the existing roll up door's insulation value (typically around R6), and also provide a 2nd barrier to air infiltration. On partly cloudy days, I leave the rollup door open to get the good lighting – it does not seem to take very much sun to at least break even on heat gain.

The fact that both sets of garage doors are closed during high heat loss periods greatly improves the overall efficiency of this setup compared to a conventional south facing window used for solar collection. A conventional window and this collector both gain about the same amount of heat during a sunny winter day (typically over a 100,000 BTU). At night a conventional window might lose 40,000 to 80,000 BTU out the window (depending on whether it is double glazed, the outside air temperature, ...). The closed garage door plus outer set of glazed doors might only lose about 10,000 BTU under the same conditions. So, the net heat gain for this set up is several times that of a conventional south facing window. At the same time, this setup still provides the lighting and view benefits of a window during the day. *The key to the improved efficiency is using the existing roll up garage door as a movable insulation panel to limit heat loss at night.*

The heating vents to the garage have been completely shut off since the outer doors were installed, and the garage is normally in the high 60's to low 70's.

The shade cloth screen serves a couple purposes: 1) it cuts the glare from direct sunlight when this would be too bright, and 2) on occasion, it keeps outside viewers from seeing how messy my shop is. My shade cloth screen is made from three six foot wide panels, so that all or part of the direct sun can be blocked by sliding the panels along the support wire.

Heat the House Operation

This is a potential mode of operation in which the heat collected by the attached workshop is used to provide some heat to the house. In this scheme, the rollup door is raised about 6 to 10 inches. This opens a gap between the floor and the bottom of the door, and also opens a similar size gap at the top of the door as the top door segment starts to pull away along the track. In this position, the sun heats the south facing surface of the rollup door, this causes air between the rollup door and the new glazed doors to heat up and rise. The heated air exits the gap at the top of the rollup door, and new cool air enters the gap at the bottom of the door. Effectively, the new glazed doors plus the partially raised rollup door make make a thermosyphon solar collector. A duct and fan could then be used to collect the heated air near the ceiling, and duct it to the house.

For this scheme to work the outside of the rollup door should be painted a dark color – I used dark blue. Any dark color will work fine – it does not have to be ugly black.

I have tried this mode to the extent of positioning the door with a gap at the bottom, and measuring the temperatures of the door surface, inlet air, and outlet air. It appears to be effective. The temperatures measured were:

Temp at gap between floor and door (inlet vent)	65F
Temp at gap at top of door (exit vent)	108F
Thermocouple on surface of rollup door	180F

This is with an average garage temperature around 70F, and ambient of around 40F.

I have not (as yet) installed the fan and duct to distribute the air to the house.

I have also tried the same scheme just using the shade cloth curtains as absorbers to see if they can heat the air and cause it to rise in the same way. This appears to be much less effective, with ceiling temperatures only reaching the 80's.

!!Important Warning!!

Heated air from the garage/workshop should NOT be ducted to the house if the garage is still used for vehicles (or anything that can generate noxious fumes). It is not worth risking carbon monoxide poisoning just to save a few BTU.

Construction

Doors

I have outlined below how I made the doors, but many variations are possible.

I added a removable column in the middle of the existing garage door opening to support the middle two doors. The column is made from two 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. Trim to match the existing door frame is added to the outside of the new column.

I used two doors to fill each of the approximately 8ft high by 8 ft wide openings left on each 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 members used to make the door frames are 5 inch wide by 1.25 inch thick. I milled these from rough lumber that I obtain a local saw mill, but I believe that lumber yard 2X6's could be used if selected carefully. 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 inch thick Acrylic. Each door used most of a 4ft 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 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 into the rabbet groove.

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

A recent edition of Fine Homebuilding Magazine (late 04 to early 05?) has a nice technique for building large doors that might be of interest if you want doors that would stand up to a lot of heavy use.

Illustration 3New center column and hinge

Illustration 4Note filler on frame to allow door to open fully

Illustration 5Door frame showing rabbet for glazing

Illustration 6Detail of doors showing gap sealing strip and stop

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 1/2inch high wood strip to the concrete floor using Tapcon concrete anchor screws. The bottom of the door butts against this strip when closed. 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.

Shade Cloth Screen

The 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 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 (whatever that means). This is a relatively dense cloth, but it still allows light to enter the shop, and allows a very diffuse view out. The cloth is dark green in color. There are many kinds, colors, and densities of shade cloth available -- I would choose one that is fairly dark in color so that it does not reflect too much sunlight back out the glazing. Although, I supposed one could use light colored shade cloth in the summer, and dark in the winter?

Illustration 7Shade cloth curtain hung on cable using shower curtain rings

Illustration 8Next door neighbor come to help out

Summer Overheating

Even during warm weather, I like to raise the rollup door to let more light in. On hot days this can lead to some overheating. Last summer I made panels that fit in the space just behind each of the 4 lower panes. These are 1/8 inch thick hardboard that comes with a highly reflective white finish. In the hot part of the summer, I usually put in either two or all four of these panels to reduce the radiation that gets into the garage. This still allows good lighting and views. The upper panels admit little direct sunlight with the high summer sun, so putting the reflective panels in the lower panels pretty well solves any overheat problem.

Another way to prevent overheating would be to add an overhang that above the door that blocks the high winter sun, but allows the low winter sun to shine in.

You could also just open the outer doors for lots of ventilation.

Performance

Since adding the outside doors, I have been able to close off the heat vents to the workshop altogether. So far, the workshop is rarely uncomfortable to work in. Temperatures are usually in the high 60's to low 70's. While I suspect that the added doors have a good payoff in terms of fuel saved, the real benefit to me is the much improved environment they provide in the workshop.

Feb 06 Update:– How well does it do at -20F?

www.builditsolar.com/Projects/SpaceHeating/SolarGarageCollector/GarCol20F.htm

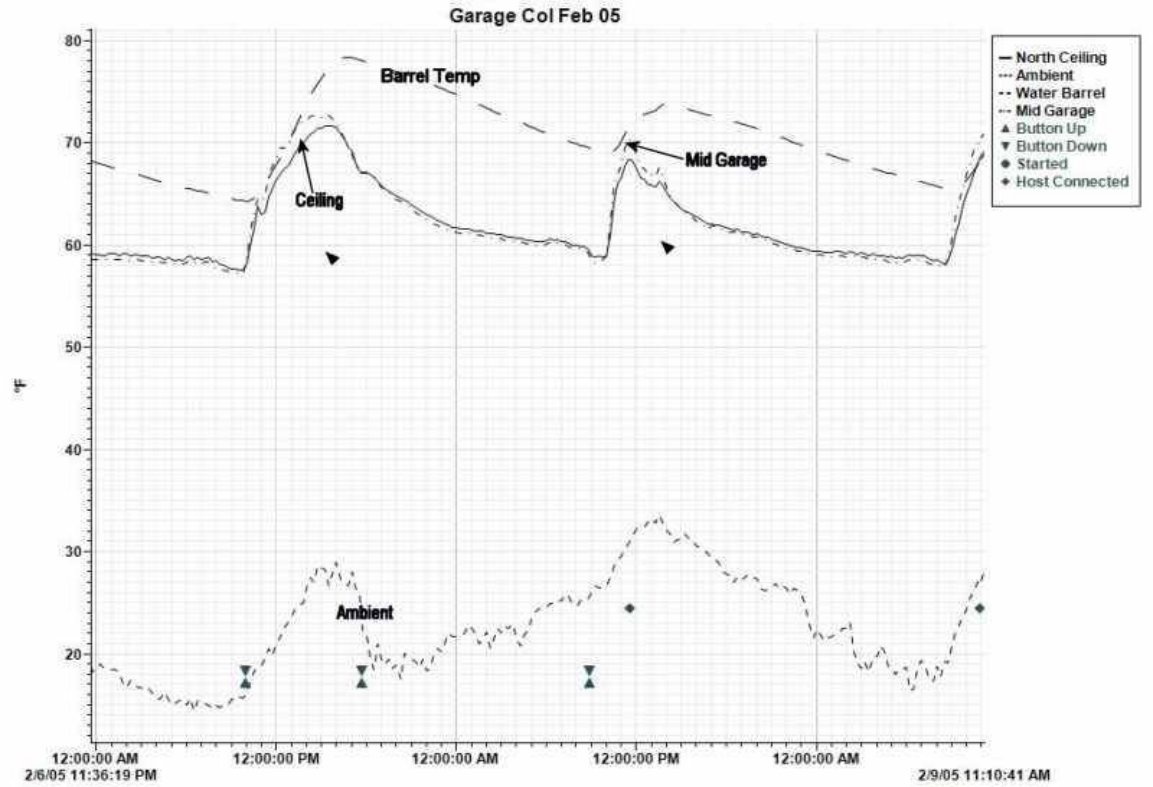

Illustration 9Temperatures in the workshop for a couple days with the rollup door open during the day, and closed at night. Day 1 was cold and clear, day 2 as warmer, but more cloudy.

Thermal mass:

On sunny days when the outside temperature is not extremely cold, the garage collects more heat than can be used during the day. If this excess heat is not sent off to heat the house, it could be stored in thermal mass in the garage. This would radiate out during the evening and keep the garage from cooling as much during the night.

My impression (supported by only very rough temperature measurements) is that it is not very efficient to allow the sun to heat the garage floor slab to store heat. The temperature of the slap drops rapidly after the sun is off it. This may be because the slab has no insulation under it (not sure), and heat is lost to the ground.

I experimented with a couple 55 gallon barrels of water for thermal storage, just to get an idea how well water barrel storage might work. The barrels are positioned such that they receive direct sun through the glazed door during the day. Based on the barrel temperature profile, and the estimated heat loss for the garage, I estimate that about 10 to

20% of the night heat loss is being supplied by the barrels. It would probably take several more barrels to make a significant difference. The barrel temperature profile is shown in the temperature plot.

Cost

If you have none of the materials on hand, the cost might be about:

Acrylic Glazing panels	4 @ 60	$240
Added central post and trim		$20
Door Framing		$80
Hinges	12@ 2	$30
Silicone sealant and misc		$10
		$380

I am guessing at some these costs – you can check at your hardware/lumber store.

Overall Assessment

Its 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, kids 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 rollup 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.
- Saves me some heating costs and reduces green house gas emissions.
- Its a relatively inexpensive project to build.
- Its relatively easy to build.
- It does not look ugly -- I think it actually looks a bit better than the original door.
- Summer overheating is easily managed as discussed above.

Con:

- You have to remember to raise the garage door in the morning and shut it at night. This probably could be automated, but we haven't done this yet.
- It may be less secure during the day time when the existing garage door is open -- not a big problem in rural Montana. One could make the glazing bombproof by using (say) ¼ inch Polycarbonate (Lexan).
- On cloudy days, you might have to revert to some form of backup heat to keep the shop space toasty warm.
- With the shade cloth pulled back, outside viewers get a good view of how good of how neat your shop is (usually not very in my case).
- The Acrylic panels may be subject to scratching over time.
- Outward opening door can probably be a pain if there is a lot of snow and ice on the driveway.

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Updated: 5/24/06