Edmonson County Public Library

Washington & Green Streets

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Telephone (502) 597-2146

Grant, no. DE-FG44-80R410256

Multi-faceted Energy-Conservation Program
KY-131

FINAL TECHNICAL REPORT (AT) *DOE/R4/10256--T1*

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DOE/R4/10256--T1

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II. Summary

The purpose of this project was to design and build 19 solar thermo-siphoning air panels, insulate walls, generally tighten up the library building, and install other energy conserving devices. With \$14,665 from D.O.E. and an additional \$10,400 from the Kentucky Department of Library and Archives, we carried out a multi-faceted program for energy conservation. Another purpose of the project was to serve as a model to other libraries in Kentucky, to commercial buildings in this area, and to homeowners in the area.

After much discussion with architects and among ourselves, we chose a type of solar installation that would be visible to the public and easily replicated. We also carried out a number of procedures to make the library building more energy efficient: installed a 7-day programmable setback thermostat; insulated the walls; improved weather-stripping around the doors; added an economizer control to our air-handling system; and put an electric damper controlling supply air to a large but intermittently used meeting room. These changes resulted in approximately \$700 in savings from December, 1981, through February, 1982.

Thus far, we have carried out public education with a sign, brochures, press releases, and the purchase of appropriate books; librarians have received our brochure, and some have attended a workshop given here on energy conservation and solar energy.

III.

A. The objectives of this project were to:

1. Design and build a "visible to the public" solar retrofit for our building.
2. Reduce the library's energy load through other available methods.
3. Monitor the performance of the system and report the results.
4. Provide workshops and act as a public information center for energy conservation and solar energy.

B. The approaches we used to address our objectives.

1. Insulation: Before any building can effectively use solar heat, it must be relatively airtight and well insulated. We addressed this by building a false interior wall on three sides of the building and installing 4 inches of fiberglass insulation behind it. On the fourth wall, we insulated on the outside, behind the solar panels, using 3 inches of styrofoam insulation. (We also improved the weatherstripping on all doors and calked any drafty cracks.) Prior to this insulating, our brick and block wall had no insulation at all.

2. The solar panels: With the help of an architect, we designed 19 thermosiphoning air panels (see accompanying brochure for details on the panels) which were built and installed by a local cabinetmaker and helper. These panels are quite simple in design as well as function and easily replicable. We used only the highest quality materials as well as very expensive shatterproof "Exolite" glazing to protect against vandalism and the dangers of shattering glass. However, a homeowner could build a collector at a substantially lower cost using "patio door glass" and smaller dimensioned lumber. After we began our project, Rodale Press published a book, Solar Air Heater, by Ray Wolf, which we highly recommend for building an inexpensive thermosiphoning air panel. This book contains full plans, including materials lists, diagrams, and step by step instructions. Quite frankly, I feel that this collector is probably more efficient and less costly than our own. We have purchased 8 copies of the book and have cited it in our information leaflet.

Our collectors are performing quite effectively in spite of the fact that our south wall is actually ⁰ to the east of south. The panels are highly visible to the public and have sparked considerable public interest. An outdoor sign explains the operation of the system, and our brochure goes into added detail.

3. Other energy conserving measures and fine tuning the building: There are numerous other devices we installed to further conserve energy.

a. A 7 day, fully programmable setback thermostat. Since the library's hours change on different days of the week and we sometimes open for special meetings, we installed a setback thermostat that can be programmed to have four separate setback and setup periods each day of the week. This device, which only needs to be programmed once weekly (if there are any

changes), has saved us considerable amounts of energy.

b. A manual economizer control with automatic timer: If the outside air temperature is more desirable than the inside temperature, a damper can be opened to allow outside air to be drawn with the ventilation fan into the library. For example, summer night temperatures are frequently below 70°. The damper can be opened and the timer set to bring the fan on during the cooler night hours, cooling the building substantially. This, in combination with our increased insulation, helps us leave off the air conditioning until much later in the day.

c. A thermostatically or manually controlled electric damper motor to cut off conditioned air to a meeting room: The library has a fully enclosed meeting room which comprises nearly 1/3 of the whole building (excluding the garage). This room is utilized less than 1/2 the time that the library is open. Previously, heat or air conditioning was supplied to this space whenever it was on, automatically. With the damper control, conditioned air is supplied only when the room is being used. The result: a considerable reduction in heating or cooling loads.

d. Other measures we took included the following: installing watt miser fluorescent bulbs and ballasts as replacements (20% less energy consumption than conventional fluorescent); closing heating and cooling vents in hallways and entranceways; balancing the ventilation system; turning off the seldom used, distantly placed hot water heater; properly adjusting the temperature sensors on the multi-stage electric furnace; and observing the federal guidelines for building temperatures.

4. Monitoring the system and reporting the results: Although we did not budget money for specific monitoring equipment, we have monitored our energy consumption compare to degree days for this year and last. Although we fell short of our 75% figure in the original proposal, we had a net drop in energy consumption of 54% for December, 1981 through February, 1982, compared with the previous year. These are the months of our greatest power usage. These figures have been made available to the Kentucky Department of Library & Archives, as well as other interested parties.

5. Workshops and public information:

a. We have recently given a workshop on fundamentals of solar energy and on the specifics of energy conservation in libraries. The workshop was given to 10 public libraries in the Barren River Regional Development District, of which we are a part. Also attending our full day workshop were two officials from the Kentucky Department of Libraries and Archives. Attendees were given a tour of our facility and shown all aspects of our energy conservation program, and the solar heating system. There was discussion of specific problems and possible solutions for each individual library relating to energy conservation. I feel the people who came learned quite a bit and will hopefully put their newly found knowledge to some practical use in their own buildings.

b. We have printed and circulated a brochure on our project (enclosed) to all of the libraries in Kentucky, to interested people who come into the library, and to people who corresponded with us as a result of publicity in Library Journal and Library Journal Hotline. In addition, we have strengthened our collection of "how to" solar and energy conservation books. During the winter, they were in a special section highly visible to library visitors. Press releases, by the way, were sent to national and state library journals, and to area newspapers, some of which carried news of our project. Also in the education area, we have erected a sign outdoors by the solar collectors which explains the principles of our installation, and we have placed several directional signs in Brownsville pointing the way to the library and the solar project.

C. How did our end product relate to our objectives? Generally speaking, I feel that our efforts matched our objectives quite well. Our project, of course, was not without problems. Our primary problems came out of our involvement with our architects. The 75% power reduction figure given by our original architect was grossly overestimated and was a principal reason we switched firms. Unfortunately, our second architect lived over 2½ hours away, so that onsite work and inspections were insufficient. The major problems we encountered involved knocking 38 16" by 16" holes through the brick and block wall, and finding a material that worked successfully for a passive backflow damper. The material had to be very light, yet strong and resistant to heat cracking and deterioration. The material we ultimately chose was a very thin mylar film. Fortunately for us, our contractor was particularly skilled and conscientious and we were together able to work through some design problems. On the whole, however, we were able to achieve pretty much what we had intended. The project has saved the library considerable amounts of energy, has been well received by the public and State Library, and has stimulated interest in solar heat and energy conservation in the local community and in the state of Kentucky.

D. This project can benefit other individual groups by having a working public model of how solar heat and different methods of energy conservation can work together to save money and valuable natural resources. People will benefit from workshops and/or from literature on the "state of the art" of solar and other energy conservation techniques. The Kentucky Department of Libraries and Archives has followed our project with keen interest and will hopefully use what we have done and learned to help other libraries conserve energy.

E. Energy savings/production aspects.

1. The energy saved from December, 1981, through February, 1982, was about \$700, or 10,000 KWH compared with our consumption from the year before, taking into account the degree day differences. According to John Lee West, the Construction Administrator for the Kentucky Department of Libraries and Archives, we were the only library in the state to actually pay less money for power this year, even with the substantial rate increases. With the other conservation measures we have put into effect besides solar, we expect to save substantially on our cooling costs also.

2. Although construction of our exact solar heating system would be quite easy and straightforward, we are recommending the Rodale Press book, Solar Air Heater, which has a quite similar concept. This book is meticulously laid out for the amateur builder with excellent instructions and diagrams more easily followed than ours. We also feel that the Rodale collector has been more extensively researched and monitored than ours.

IV. Conclusions and recommendations.

In conclusion, I feel the overall project turned out as well or even better than planned. We have an attractive, highly visible solar heating unit on the outside of the building, drawing in people as well as warm air. Inside, we can refer patrons to other energy related materials and give them information on our specific solar and conservation program. (We intend to distribute our leaflets to Mammoth Cave National Park, 10 miles east, so that interested visitors can visit us. Directional road signs in Brownsville also point people our way.) We have an almost maintenance free solar system which will provide us with many years of free heat. Though our energy savings are not the 75% we projected in the original proposal, we are confident that we will have an annual average reduction of about 40%. This is substantial in light of all the constraints we had with our particular building.

This experience has led me to a few recommendations. In particular, finding a suitable architect is quite difficult. The client needs to make sure that the architect has knowledge of and experience with both active and passive solar designs. The client should look at the architect's previous work. Especially on a retrofit, it is important that the architect be able to visit the worksite frequently. There are many problems that arise that cannot be easily solved by looking at and changing the blueprints. Make sure that materials specified in the plans are readily available. We were delayed a week waiting for some stainless steel screws that we thought it would be easy to find. If we were to do the solar heat system again, I think we would ventilate all 19 collectors together, cut two holes in the wall rather than 38, and use a circulating fan rather than going strictly passive. I feel for our application this approach would have saved us many headaches and would have resulted in less system maintenance.

V. Materials, equipment, and drawings.

Following is a list of the distributors from whom we obtained the few "hard to find" items used in our project.

1. Exolite double skinned acrylic glazing and related hardware:
B & R Plastics
1018 Nandino Blvd.
Lexington KY 40511
(606) 252-2228
2. Dupont ultra thin mirror finish Mylar for the passive dampers:
B & R Plastics
3. 4' x 8' corrugated aluminum roofing, used in the collectors:
Southern States Cooperative
Rt. 14, Box 688
Bowling Green KY 42101
(502) 843-1146
4. Honeywell proportional damper motor and thermostat:
Brock-McVey Refrigeration Supply
Box 1540, 704 31W Bypass
Bowling Green KY 42101
(502) 842-5609
5. Passive damper assemblies:
Rademaker Corporation
2400 Watterson Trail
Bluegrass Industrial Park
Louisville KY 40299
(502) 267-9636
6. Hex head stainless steel lag screws for mounting glazing system:
Southeastern Bolt and Screw
Box 17122, 2106 Hahn St.
Louisville KY 40217
(502) 637-4793
7. Autospace fully programmable 7-day setback thermostat:
Autotronics, Inc.
323 Hilltop
Richardson TX 75081
(214) 231-5984

Enclosures: blueprints, news articles, spec sheets, brochure on project.

VI. Bibliography.

Mazria, Edward. The Passive Solar Energy Book. Emmaus, Pa. : Rodale Press, c1979. 687 p.

Wolf, Ray. Solar Air Heater. (Rodale Plans. Emmaus, Pa. : Rodale Press, c1981. 64 p. ✓

VII: Appendix.

Enclosed are blueprints, news articles, spec sheets, and the brochure on the project.

Cross Section Of One Panel

How It Works

The sun shines through the clear glazing and heats the black metal surface. The warmed air behind the metal rises and exits into the library at the top. This air movement draws cooler air from the library at the bottom. This air flow is called convection, or thermosiphoning.

That's all there is to it. The design is based on two simple principles: (1) Warm air rises; (2) Heat is trapped when the sun shines through materials such as glass (*the greenhouse effect*).

Solar Heat — Only One Part Of Our Strategy For Energy Conservation

In this project we also:

1. Caulked and weatherstripped the doors, and adjusted or replaced the door closers.
2. Insulated formerly uninsulated walls.
3. Installed a 7-day programmable setback thermostat. (We only heat or cool the building when we need to).
4. Installed a motorized damper control with thermostat for the meeting room of 850 sq. ft. (Why heat or cool a room when no one is in it?)
5. Installed a manual damper and a fan timer, so that outside air can be drawn in to warm or cool the building. This is used most often on cool nights in the summer.

***Energy Saved
Is Money Saved!***

Credits

This project was initiated by Richard Slone, a solar energy enthusiast and friend of the librarian. Grant applications were drawn up by Richard Slone and David Dukart, the librarian.

In addition to the people listed below, thanks are due to Evelyn Richardson, Regional Librarian, and to John Lee West, Construction Administrator for the Kentucky Department of Library and Archives.

Thanks also to the library staff, numerous volunteers, and other contractors who aided in completing the project.

Project Administrator:
Richard Slone

Contractor:
Charles Whitley, Smiths Grove, Ky.

Architects:
Sarah House Tate
Greg Fitzsimons
Nicholasville, Ky.

Librarian:
David Dukart

Funding for this project was provided by the Kentucky Department of Library and Archives, and by the U.S. Department of Energy, under its Appropriate Technology Small Grants Program.

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Box 219
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Edmonson County Public Library

SOLAR RETROFIT

Nineteen 4' x 8' collectors called Thermosiphoning Air Panels (TAP's), mounted vertically on the southeast masonry wall.

**Constructed
1981**

Funding Provided By:
The Kentucky Department
Of Library & Archives
And
The U.S. Department
Of Energy

Questions And Answers

Q. Does anything move the air other than the heat of the sun?

A. *No. The natural convection is sufficient. However, if too much of the heated air remains near the ceiling, the library's heating/cooling system fan is available to blow air from the ceiling downward.*

Q. Will this system provide for all of the library's heating needs?

A. *No. On many days, there will be no sun, or only partial sun. Electric heat will then be used.*

Q. How much of the library's heating needs will this system provide?

A. 25-30%

Q. Does this system make use of storage?

A. *No. The heat is taken directly from the air and is not stored in rock, concrete, water, etc. In fact, the space between the collector and the masonry wall is insulated so that heat will not go into the wall.*

Q. Why is there no storage?

A. *Because this system will not provide an excess of useable heat except during some borderline times in fall and spring when outside temperatures are pretty warm.*

(Continued on right inside flap)

Cost Factors

For Homes and Businesses

Would it be cost effective for you to build similar solar air-to-air collectors for your home or business?

The following figures are taken from **Solar Air Heater**,* by Ray Wolf (Rodale Press, c1981), using the plans given in that book. The plans are geared to the do-it-yourselfer, using simple techniques and readily available materials. The figures presume no labor cost, and a due south collector orientation.

Cost Per Collector:

\$250, or \$7.81/sq. ft.

The cost will be even less to you if you take advantage of the Federal tax credit for solar construction (40% tax credit for residences; variable for businesses.) Counting a 40% tax credit, the cost would be \$150 per collector, or only \$4.69/sq. ft.

Annual Savings Per Collector:

Electric: \$43.86 at 6¢/KWH

Propane: \$32.04 at 90¢/gal.

Fuel Oil: \$34.50 at \$1.15/gal.

Payback Period

Straight Cost With 40% Tax Credit

Electric: 6 Years 3½ Years

Propane: 8 years 4½ years

Fuel Oil: 7 years 4 years

(Unit has life expectancy of 15-20 years)

*Available at the Edmonson County Public Library. Figures used with permission.

Cost Factors

Edmonson County Public Library

(Solar portion of project only)

Cost for 19 collectors:

\$650 each, or \$20/sq. ft.

Cost for collectors including cost for holes in the masonry wall:

\$740 each, or \$23/sq. ft.

These costs are considerably higher than the cost of the panels mentioned on the preceding page, for the following reasons:

1. We did not do the work ourselves. The construction was done by skilled professionals.

2. The holes for the masonry wall were costly. Most homes have easier walls to cut. Again, we used professionals to do this work.

3. We used acrylic glazing instead of glass.

The solar part of the project is not strictly cost effective, because our wall orientation is southeast rather than due south. We get approximately 70% of the heat we would get if we were facing due south.

However, this project has considerable value beyond its heating contribution to the library, in demonstrating to the public an unfamiliar but practical approach to energy conservation.

Questions and Answers

(Continued from other flap)

Q. How will you deal with the heat during the summer?

A. *The system will be shut off to the inside by closing the holes, while vents on the outside top and bottom will allow the heat to escape. The insulation between the collector and wall will prevent heat transfer into the library.*

Q. If the air in the collector is cooler than the library air, what is to prevent the convection loop from reversing?

A. *We are using backdraft dampers to prevent this reverse air flow. They only open one way—when the warm air is coming in.*

Q. Would it be cost effective to install TAP's on my house or business?

A. *On the page to the left we examine cost factors in constructing similar collectors.*

Q. Where can I find more information on solar energy?

A. *The Edmonson County Public Library carries many books on solar energy design and construction, as do virtually all public libraries.*

1. MASONRY WORK:

Cut 38 16" x 16" holes in the brick and block wall.

Patch the plaster around these holes.

Install steel lintel plates for damper openings:

$\frac{1}{4}$ " steel plate: 3" x 18" for brick, 6" x 18" for block

Install dampers:

(We modified
the dampers)
Top: 19 louvers and dampers PRD-220 Frame "L"
16" x 16" w x 12" d collar-backdraft.

Bottom: Louvers and dampers (19) PRD-220 with CD 500 TSD tight
seal manual shut off 16" x 16" x 12"d.

Miscellaneous fasteners

High temperature silicone caulking

(On your bid, you can include the dampers and louvers, or specify that you
want us to procure them.)

Reminders:

We are asking bidders to give us two bids, one for labor only, and one
for materials and labor.

Bids must be returned before the opening of bids ~~Friday, July 31,~~ ^{Thursday Aug 20,} at 4:30 p.m.

Thanks for your interest.

2. INSULATION OF INTERIOR WALLS

Northwest wall: 104' x 10' high

Southwest wall: 40' x 10' high

Northeast wall: 24' x 10' high (framing for bay window needed here).

168' x 10' = 1680 sq. ft.

(Southeast wall as shown on prints will not be insulated.)

Materials:

3" foil faced batts

2 x 4 plates x 8' (construction grade or better)

2 x 4 studs x 10 ft. (construction grade or better)

$\frac{1}{2}$ " drywall

4 mil plastic vapor barrier

Paint, sealer and two finish coats

Misc. fasteners

Studs will be on 16" centers.

The bottom molding where the wall meets-the floor will probably have to be replaced, as well.

Reminders:

We are asking bidders to give us two bids, one for labor only, and one for materials and labor.

Bids must be returned before the opening of bids ^{Thursday Aug 20,} ~~Friday, July 31,~~ at 4:30 p.m.

Thanks for your interest.

3. CONSTRUCT AND INSTALL SOLAR COLLECTORS; INSTALL GUARDRAIL

Nineteen panels, each with 4' x 8' glazing.

Materials:

Bottom and top sills: pressure treated pine 2 x 12 milled with bevel and water drip. 12 pc 12'1

2 x 10 vertical framing members, notched. 34 pcs x 10' 1.

2 x 4 spacers cut to 2 3/4" x 1 1/2 ". (#7 tag) 34 pc x 10'1

Corrugated wood end caps, redwood (tag #9) 40 pcs 8' 0"

USG Glazing System for Exolite (340 lf). (We will procure.)

Exolite clear acrylic (4' x 8' panels). (We will procure.)

Corrugated aluminum absorber plate . Alcoa Aluminum 2 1/2" with stucco embossed finish. 19 sheets, 51 1/3" x 10' 1 (tag #8). (We can procure.)

2 x 4 blocking under flashing, 6 pc x 8'

Aluminum flashing: two 20" x 50' rolls.

Steel angle brackets, 6" x 6" x 1 1/2" x 1/4", 40 pc.

2 x 6 sills, pressure treated, 8' lengths (tag #23). 19 pcs.

2 x 4 framing in vent area, top and bottom. 8' lengths, 44 pcs.

2 x 10 x 8' horizontal framing, 19 pcs.

Screen frames: 1 3/4" blind stop, 228 lf.

Screen moulding, 228 lf.

Screening, 38 lf.

Infill siding, 3/4" beadboard, 106 sq. ft.

Hinged door vents: (38):

6' - 2 x 2 frame
beadboard outside, 2 sq. ft.
masonite inside, $1\frac{1}{2}$ sq. ft.
 $\frac{3}{4}$ " styrofoam, 2 sq. ft.
hinges
thumblatch
hook and screweye

Silicone sealant

Miscellaneous fasteners.

Notes:

All exterior wood will be pressure treated.

All interior wood must be #2 or better.

The collectors will be screwed together rather than nailed; rather than using glue, as is stated in the blueprints, silicone sealant will be used.

Guardrail : see prints for materials, construction methods.

Reminders:

We are asking bidders to give us two bids, one for labor only, and one for materials and labor.

Bids must be returned before the opening of bids ~~Friday, July 31,~~ ^{Thursday, Aug 30,}
at 4:30 p.m.

Thanks for your interest.

4. ELECTRICAL WORK

Extend 16 outlets and two 3-switch banks out 4 ", according to code.

Reminders:

We are asking bidders to give us two bids, one for labor only, and one for materials and labor.

Bids must be returned before the opening of bids ^{Thursday, Aug 20,} ~~Friday, July 31,~~ at 4:30 p.m.

Thanks for your interest.

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