Final Report
Grant No. DE-FG02-79R510127
Solar Heating Panel - Parks and Recreation Building
Saugatuck Township Park and Recreation Commission
Box 631, Saugatuck, MI 49453

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WITH PLANS
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SLIDES

MASTER

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The function of the system is to collect warm air from the solar collector and store the heat in a rock storage bin in the basement, then draw off that heat to supplement the forced air heating system.

Solar Collector Panel

Construct the solar collector as shown on the plans or here-in specified.

In the area of the collector remove the existing bevel siding. Install a 26 ga. galv. metal liner over the entire collector area as indicated on the plans. Construct framing as detailed. Apply rigid insulation at collector as shown on the plans using styrofoam insulation mastic #1 as recommended by the manufacturer.

Run a continuous bead of sealant (such as General Electric Silglaze) over exposed edges of 2 x 6's and 2 x 4's. Apply Kalwall Corporation's "Sun-lite" over couked edges and apply 3/4" wood blocking (paint black) over Sun-Lite as detailed on the drawings. Run a continuous bead of sealant over 3/4" wood blocking and apply second layer of Sun-Lite, then apply 3/4" batten strip and thru-bolt assembly with self-sealing, hex-head screws as manufactured by Kalwall Corporation, P.O. Box 237 Manchester, N.H. 03105.

Steel Angle Supports

Provide structural steel angles of size detailed on the plans. Angles shall be shipped to the site with one shop coat of paint. Securely fasten angles to existing walls with lag bolts - providing at least one fastener per stud. Anchor new collector frame to angles at 24" o.c.

Painting

Paint everything on inside of the collector (sheet metal and wood framing) with one coat of black primer and one coat of flat black, heat resisting paint and let dry as per manufacturers recommendations.

Coat all exterior wood surfaces with one coat of latex primer and on finish coat of latex house paint.

4 Batten Detail
1/2" = 1'-0"

South Elevation
1/4" = 1'-0"

all dimensions shall be verified by general contractor

3 Collector Head
1/2" = 1'-0"

5 Collector Jamb
1/2" = 1'-0"

2 Intermediate Sup.
1/2" = 1'-0"

1 Collector Sill
1/2" = 1'-0"

SAUGATUCK TOWNSHIP PARK AND RECREATION COMMISSION
BOX 631, Saugatuck, MI 49453

December 4, 1980

John J. Mahoney, Supervisor
Acquisition and Assistance Unit
Department of Energy
Chicago Operations and Regional Office
9800 South Cass Avenue
Argonne, IL 60439

Dear Mr. Mahoney:

Grant No. DE-FG02-79R510127, Solar Heating Panel,
Parks and Recreation Building.

Here is the final report on the above grant. The
packet includes:

1. Final report
2. Performance report by Peerbolt's Inc.
3. Statement of expenditures
4. Final Voucher
5. Form 427
6. Property Certification
7. Certificate as to inventions
8. Drawings of the solar collector
9. A dozen slides of the building and installation,
and explanation.

There are six copies each of the first 7 above, four
sets of drawings of the collector, and one set of slides
with explanation. The slides were requested by Roberta
Dalton, technical monitor. Would you please direct the
reports, vouchers, etc., to the proper offices?

Sincerely,

Arthur L. Lane Jr.
Chairman

Final Report
Grant No. DE-FG02-79R510127
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Box 631, Saugatuck, MI 49453

December 4, 1980

This project was to install a solar heating system on an existing building in order to demonstrate the possibilities of alternative energy, educate local craftsmen and make the building more useful for community purposes. We used existing technology and did not invent anything, but our carpenters made several suggestions about materials and construction methods which may be useful to others considering similar projects.

The building at 10 Mixer Street in Douglas was built in 1870 as a community church, the first church in the Village of Douglas. The settlement then was about 10 years old and had just become a village.

The church later was used by the Methodists until 1917 when they began going across the bridge to Saugatuck, then was sold to the Odd Fellows Lodge, which used it as a meeting hall into the 1930's. It was purchased in 1940 by the Douglas Athletic Club and was used as a gym, gameroom and meeting place. In the early 1960's it became the property of the Village of Douglas. Recently it has been used by the area Scouts and by the Saugatuck Township Park and Recreation Commission.

Although the building was more than 100 years old (or perhaps because of it), it was very solidly built. The main floor is supported by massive columns and deep joists. The

walls were found to have three inches of wood sheathing, plus plaster, lath and clapboard. The walls have an inside space of eight inches. It occurred to us that it could be well insulated and, with a large, unbroken southern exposure, it would be well suited for a solar collector.

The grant proposal was sketched by Frank Pluta, superintendent of parks and forestry for the Village of Saugatuck, and written by Art Lane, chairman of the Saugatuck Township Park and Recreation Commission. After receiving approval of the grant we selected an architect recommended by a landscape architect who has done several park projects. His job was to translate our sketches into drawings a carpenter could use. However as time dragged on this architect never got beyond some preliminary drawings and he finally stopped returning my calls. We turned for design to a firm which had installed a solar heating system on its own building. I think there's an important message here: Solar is no longer completely new. There are people with experience in the field and it pays to find them.

Our mission was to heat, with solar assistance, a room approximately 40 by 50 feet with an 18-foot ceiling, originally a church sanctuary and now a basketball, recreation and meeting room.

The first step was to insulate the structure. We put 12 inches of cellulose on the ceiling, vented the attic, and blew 8 inches of cellulose into the wall cavity. Filling the walls was done from inside the building. This saved a lot of time and scaffolding.

Next came the solar panel. The south wall of the building afforded space for a panel 21 feet wide and 24 feet high-- a nominal 504 square feet to catch the sun.

The panel consists of metal pole barn siding installed on the sheathing after the clapboard was removed. The pole barn siding was one of the suggestions of the carpenters-- it comes already primed and is a material they are used to working with. It comes in convenient sizes. It does not require degreasing as do some steel sheets. After it was put up it was painted black.

The 21 by 24 foot panel was subdivided into six vertical ducts, each with a 4X14 inch outlet at the top and a similar return duct at the bottom. Vertically the panel was divided into three main sections with further latticework to support the cover.

The carpenters elected to build all this 2X6 framing and latticework on the ground, where it also was painted. Then they hired a crane to pick it up, slide it between the scaffolding and the building, and place it in its angle iron supports. That construction method saved a lot of time on the scaffold and a lot of material handling.

The perimeter of the collector got 3 inches of insulation. The cover was made of two layers of .040 Kalwall Sun-Lite, suitably supported, and all joints were sealed with silicone.

Inside the building, 14 by 14 inch insulated headers were built to collect the warm air and distribute the return air. The warm air was ducted to the basement.

In the basement a strong box was built to hold rocks to hold the heat. The box rests on preservative-treated 2X8's to keep it up off any possible dampness. It is made of 2X6's paneled on the inside with particle board. The lid is the same. It is insulated with 6 inches of aluminized

glass batts and the joints are sealed. Inside, it is a 7-foot cube. Hot air goes in near the top and is drawn for use near the top; the return is near the bottom.

Before the lid was put on, when it was time to fill it with rocks, it turned out that there was very little drop from the truck parked outside to the top of the box. The rocks would not slide along their chute but had to be shoveled on several of the hottest days of the year. A screen in the chute helped eliminate foreign matter.

A Carrier 125,000 BTU gas furnace was installed as an additional heating source. The collector, rock box, furnace and room were connected with insulated ductwork. Three motorized dampers direct the air. Thermostats tell the system when to start collecting heat from the sun, when the rocks are hot enough to provide heat to the room, when the room needs heat, and when the furnace must be called on to assist with the heating or shoulder the whole load. A circuit box shows which mode is in operation and how many minutes have been spent in each mode. The circuitry was developed with the help of experts from Jordan College of Cedar Springs, well known for its use of solar energy on campus.

Additional details of the system are shown on the drawings which accompany this report.

The system now is installed and in operation and has been accepted. An open house will be held to show the community how it works. The controls will be checked to see how much heat the sun provides. The engineer estimated that about 35 per cent of the heat would come from the sun.

The park commission was greatly helped by Peerbolt's, Inc., of Holland, where Morris and Jeff Peerbolt designed the system, having had several years of experience with their own solar system. The carpentry work was done by Squire-Troutman Builders, Inc. of Douglas. Robert Squire immediately put the experience to use by building a solar greenhouse.

By a happy coincidence the building has become more useful for community needs just when it is needed. The Saugatuck-Douglas District Library, which will have to vacate rented quarters next April, plans to move to the building and use it along with Scouts and the park commission.

Arthur L. Lane Jr.
Chairman

November 3, 1980

SAUGATUCK TOWNSHIP DAC BUILDING

SOLAR HEATING SYSTEM RETROFIT PERFORMANCE REPORT

On October 17, 28 and 29 we finished the air balance and system analysis of the new solar system installed on the township DAC building in Douglas, Michigan. This report includes the measurements and calculations made to check system performance. Other information included is: Air Balance Summary (Table I); Solar Measurements (Table II); Equipment Schedule (Table III) and Sketch of Heating System.

Perhaps the most important measurements needed to calculate the actual system performance are the intensity of the solar insolation perpendicular to the collector area and the amount of air and its temperature rise passing through the collector. Even though the sun was not shining on October 17, we were able to simulate the different modes and balance the system air flows. We went back on October 28 at 4:00 P.M. to measure the solar performance. The system had been turned off (no fuse) for some reason and this combined with the sun going in and out of the clouds did not allow for complete steady state operating conditions. When the sun was out, direct sunlight measured 250 BTUH/ft² whereas the actual amount perpendicular to the collector was 100 BTUH/ft² due to the large angle of incidence of the sun at 4:00 P.M. This taken over the area of the 21x24 collector (504 ft.²) gives an input energy of 50,400 BTUH. When the system was first turned on, the air temperature out of the collector was at 78° because of the buildup temperature in the collector, but after running awhile it evened out at 72.5° F. Using the latter figure we have a temperature rise of 21.5° F for the 1030 CFM in the collector. This gives a collected energy of 23917 BTUH. From these figures we see the approximate overall instantaneous efficiency is 47.5%.

To observe the operation under more direct sunlight we returned on October 29. Again the collector had been left off, so when it was turned on at 1:30 P.M., the built up heat in the collector produced a temperature rise of the air flow from 52° to 101.5°. After running for an hour it settled down to a steady 95° out of the collector. Calculations using the figures from Table II give us an input energy of 100,800 BTUH, a collected energy of 47833 BTUH, and an instantaneous efficiency of 47.5%.

From these initial tests it would seem that the system is performing well and is ready for colder weather. We are anxious to see how well the collector works all winter. It will be extremely difficult to check it since continuous recording of air temperature, storage temperature, amount and intensity of solar insolation is not practical economically speaking. The time clocks being used should provide enough information for estimates of system performance.

The time clock readings when the system was left on at 2:30 P.M., October 29 were: 1177.0/38.5/56.4/274.3 (reading the dials from left to right--in minutes)--(not indicative of what has been happening in the past).

After our tests were completed, we left the system running to operate automatically. The space thermostat was set at 45°F.

Attached please find a plan view sketch of the installed heating system showing the locations of the system components and the location of the test holes used.

The following is a brief description of the control sequence of the system:

MODE 1: Heating storage with solar:

A differential thermostat measures the difference in temperature between the top and bottom of the collector. When sunshine is incident on the collectors the temperature differential increases (due to hot air rising in the collector). When the difference becomes greater than 20°F, the solar blower (AH-2) turns on. Damper MD-1 closes and MD-2 opens forcing the heated air into the storage. BDD-1 damper closes against the air pressure thus directing the air out of storage back into the collectors to be heated, and thus the circulation continues until the storage is charged (140°F) or until the differential thermostat senses a temperature difference less than 10°F and turns off the blower.

MODE 2: Heating the space from storage:

If the space temperature falls below the setting of the thermostat in the space, the furnace blower (AH-1) is turned on. If the temperature of the top of the storage rocks is above the setting of a remote bulb sensor implanted in the rocks (now set at 90°F) damper MD-2 will close, MD-1 will open, and MD-3 will close to a minimum position. This setup forces about one-half of the air being drawn from the space above to be drawn through the storage rocks to be heated (storage cannot handle all the air needed to circulate the heat in the space above) which then mixes with the other half at the furnace and is pushed into the space to heat it. If the air drawn out of storage still isn't enough to bring the space up to temperature, the furnace flame will also turn on until the space stat is satisfied.

November 3, 1980.

Saugatuck Township DAC Building

Solar Heating System Retrofit Performance Report - Page 3

MODE 3: Heating the Space with Furnace Only: (Bypassing Storage)

If the space stat is calling for heat, but the storage temperature is below the setting of the remote bulb sensor, AH-1 will turn on, AH-2 will remain off, MD-1 will close and MD-3 will open. This setup draws air out of the space, bypassing storage, and heats it only with the backup gas heat, pushing it back into the space until the stat is satisfied.

Due to being limited on installation cost of the system, it was not possible to include a fourth mode of heating the space directly with air heated in the collector. But this is not a real problem, since most of the occupied hours of the building will probably occur when no direct sunlight is available.

We would like to thank the township for allowing us to participate in this project, as it has probably been the most cost effective solar project yet built with federal funds.

Sincerely,

PEERBOLT'S, Inc.

Jeff Peerbolt

JP:ln
Enc.

TABLE I

System Balance Summary

MODE 1: Heating Storage with Solar:

(AH-1 off; AH-2 on; MD-1 closed; MD-2 open; MD-3 unused; BDD-1 closed)

Storage & Collector Air -	1030 CFM
Static Pressure Across Storage -	.35" WC
Static Pressure Across Collectors & Duct -	.35" WC
Total S.P. Across Solar Blower -	.70" WC

MODE 2: Heating the Space from Storage:

(AH-1 on; AH-2 off; MD-1 open; MD-2 closed; MD-3 at minimum; BDD-1 open)

Air Through Storage -	915 CFM
Air Bypassing Storage -	685 "
Air into Space -	1600 CFM
Total S.P. Across Furnace -	.75" WC

MODE 3: Heating the Space with Furnace Only: (Bypassing Storage)

(AH-1 on; AH-2 off; MD-1 closed; MD-2 unused; MD-3 open; BDD-1 closed)

Air into Space -	1900 CFM
Total S.P. Across Furnace -	.40" WC

TABLE II

Solar Analysis Summary

Date -	<u>10/28</u>	<u>10/29</u>
Time of Day -	4:00 P.M.	2:30 P.M.
Ambient Temp (°F)	42	45
Basement Temp (°F)	51.5	52
Direct Normal Insolation (BTU/Hr-Ft ²)	250	270
Insolation Perpendicular to Collector (BTU/ Hr-Ft ²)	100	200
Temp into Collector (Out of Storage) (°F)	51	52
Temp out of Collector (Into Storage) (°F)	72.5	95
Air Temp Rise - (°F) -	21.5	43
Input Energy (BTU/Hr)	50,400	100,800
Collected Energy (BTU/Hr)	23,917	47,833
Efficiency (%) -	47.5	47.5

TABLE III

Equipment Schedule

- AH-1: Carrier 58GS125-4 Gas Furnace - 125,000 BTU/Hr Input Capacity
½ HP Motor 115v.
- AH-2: Dayton Single Inlet, Belt Drive Blower 10-5/8" Wheel Dia., ½ HP
Motor, 115v
- MD-1,2,3: Honeywell Motor Operated Dampers - Size as per Duct
- BDD-1: Honeywell Backdraft Damper - Size as per Duct
- S.A. Reg.: Hart & Cooley 12x36 92VHO Supply Air Register mounted on
Chase in Gym
- R.A. Reg.: Hart & Cooley 30x14 #265 Return Air Register in Floor of
Gym
- Rock Storage: 7'x7'x7' (Inside Dimensions) Constructed of 2x6 Lumber
(2x8 Wolmanized Base) Lined with 3/4" T & G Redex &
Insulated with 6" Foilbacked Fiberglass Batts (2" Sty-
rofoam on Base); Filled with 13½ tons of 1½" stone.
- Solar Collector: (Construction Previously Submitted) Total area
21'x24' = 504 sq. ft.

SAUGATUCK TOP
DHC BLDG
SOLAR HTG SYSTEM
SCALE: 1/4" = 1'-0"
O. ⇒ TEST PORTS

12 Slides

Grant No. DE-FG02-79R510127

Solar Heating Panel - Parks and Recreation Building

Saugatuck Township Park and Recreation Commission

Box 631, Saugatuck, MI 49453

1. The building at 10 Mixer St., Douglas, showing the east and north sides.
2. The south side, with the red pole barn siding in place for the back of the collector and the wooden framework under construction on the ground.
3. The wooden framework in place, the back painted black, and insulation being put on the perimeter.
4. The south side with completed collector.
5. The collector.
6. Detail showing latticework supporting the two layers of plastic glazing.
7. The insulated rock storage box, a 7-foot cube inside.
8. Control panel on the box.
9. Inside the control panel.
10. Furnace, ductwork and motor.
11. The area to be heated. Note holes for installation of wall insulation.
12. Enclosed duct and warm air opening.