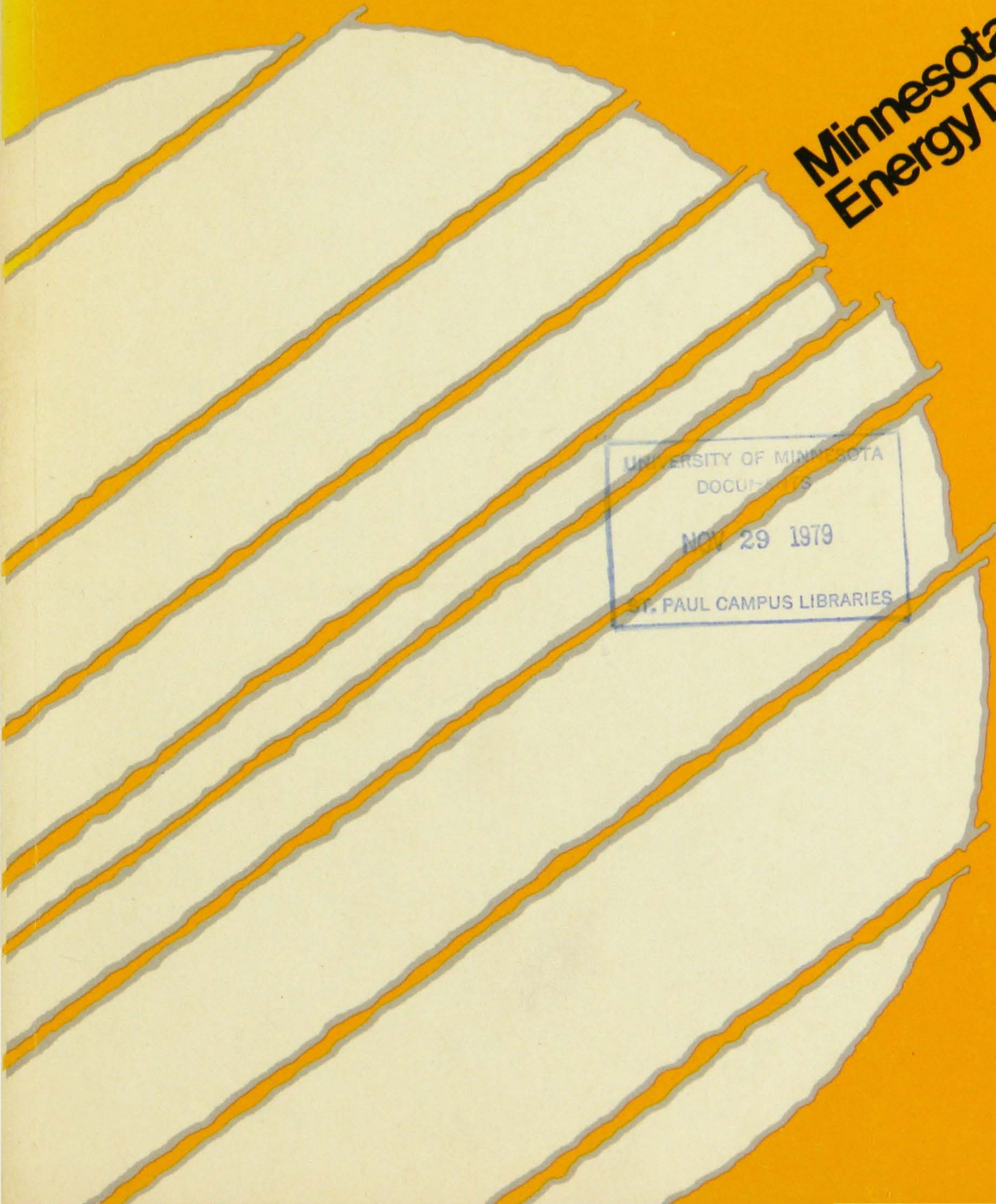
Minnesota Energy Design '79



$7 50

Minnesota Energy Design '79

A Competition

Staff

Project Director and Editor: Huldah Curl
Assistant Project Director: R. Scott Getty
Registrar and Editorial Assistant: Andrea Gilats

Editorial Note:

The one constraint placed on this project was that an entry was ineligible if it had previously been awarded by the Minnesota Energy Agency and did not have subsequent supporting performance data.

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MINNESOTA ENERGY DESIGN '79

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Minnesota Society, American Institute of Architects

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Judges

H F Fischer, Public Affairs Counsel, Savings League of Minnesota

Luther P Gerlach, Professor, Department of Anthropology, University of Minnesota

John S. Hoyt, Jr , Professor, Department of Agricultural and Applied Economics, University of Minnesota; member, Board of Directors, The MASEC Corporation

Bernard Jacob, A I A., President, Team 70 Architects

Lance A Lavine, Assistant Professor, School of Architecture and Landscape Architecture, University of Minnesota

Ronald R. Rich, Manager, Alternative Energy Projects, Minnesota Energy Agency

Darryl A. Thayer, independent energy consultant; inventor

Matt S. Walton, Director, Minnesota Geological Survey and Advisory Board, Underground Space Center, University of Minnesota

For further information contact·
MINNESOTA ENERGY DESIGN
Continuing Education in the Arts
322 Wesbrook
University of Minnesota
77 Pleasant Street S.E.
Minneapolis, Minnesota 55455
(612) 373-4947

Table of Contents

Foreword

STATE OF MINNESOTA
OFFICE OF THE GOVERNOR
SAINT PAUL

ALBERT H. QUIE
GOVERNOR

The Minnesota Energy Design '79 competition, sponsored by the University of Minnesota, the Mid-American Solar Energy Center, the Minnesota Energy Agency, and the Minnesota Society of the American Institute of Architects, has been highly productive. Hopefully, out of the many prize-winning entries, will come some far-reaching contributions to the solution of our energy problems.

Three things struck me about this competition: (1) I was heartened at the level of concern that was displayed. Obviously, Minnesotans are very aware of the energy crisis; (2) I was amazed at the range of the suggestions made by entrants — from the very simple entries to the real daring of others; (3) I was impressed at the immediate impact the adoption of some of these proposals could have on our energy problems.

Ideas brought forth by this competition should help us minimize disruption as we shift to alternative energy sources.

We need to look not only at the traditional conservation methods, but we also need to search for creative and bold ways to deal with our energy problems. We have been able to accomplish such unlikely feats as splitting the atom and landing a man on the moon, so surely we can solve our energy crisis.

The challenges are enormous and the transition will be painful. But Minnesotans are known for their ingenuity and their fortitude. We have a sound economy and one of the most stable and intelligent workforces in the country. If we cooperate and set our sights on a common goal, I am confident we will succeed.

Sincerely,

Albert H Quie

ALBERT H. QUIE
Governor of Minnesota

Residential — New Construction and Retrofit

Roof Mounted Wind Turbine

Berner Associates
Engineers
Minneapolis

Most positive advantages

1) The turbine makes use of existing structures.
2) Its pleasing appearance will be accepted by home owners.
3) It is easy to install.
4) It also works with reverse air flow.

The problem

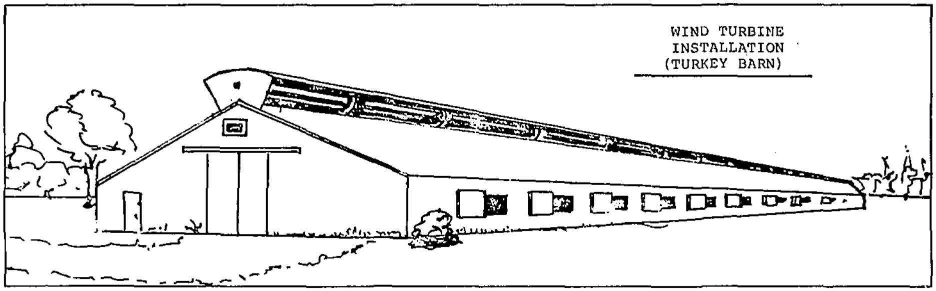
Present concepts of windmills have inherent negative characteristics.

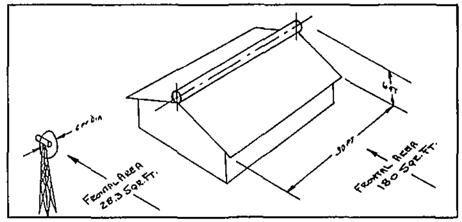
1) They are difficult and dangerous to erect.
2) They normally do not fit with the decor of the neighborhood.
3) They are difficult and dangerous to service after installation.
4) The tower may offer dangerous attraction to children.
5) The tower may require guide wires.
6) They operate in such a manner as to require tedious work and technical problems to transfer power to where it can be used.

The Solution

Use the existing shape of the typical residential structure to direct a large mass of air to a turbine mounted with its horizontal axis running parallel to the roof ridge.

1) General overall configuration blends well with residential structure.
2) Concept is readily adaptable to existing structures.
3) Rotating parts are enclosed and elevated to avoid danger to children.
4) Ease of owner installation because it is mounted directly onto the roof and requires no tower.





5) A number of local Minnesota organizations have the technology, plant and equipment, and financial resources to produce virtually all components on a medium to high volume mass production basis.
6) Unit would be mass produced in individual standard lengths which would connect together in a "plug in" manner — the number used per installation depending on the length of the structure.
7) Using this modular concept, units would be designed, produced, and marketed similar to any home appliance, targeted specifically at the do-it-yourselfer, with dealer installation available if so desired.
8) Minnesota would represent a sizeable share of this market.
9) Once established, the concept is readily adaptable to large scale installation or construction in open field areas, and could be mounted on barn roofs or vertically on corners of large buildings.

Technical Considerations

One of the problems associated with an augmenter diffuser used in connection with a wind turbine is the cost of the non-moving parts. Ours is simply a system which uses existing structures to accomplish this end — thereby eliminating a good portion of the cost and complexity. It just takes advantage of the roof slope to funnel the air.

Ideally the unit would be situated to take advantage of prevailing winds. Variations from this ideal could be more than made up for by the much larger mass of air being operated on.

The structure of the rotor is such that reverse air flow will also drive it, possibly with the aid of moveable deflectors if necessary. Deflectors could also be installed to allow limited power when wind blows lengthwise to the peak of the roof. The unit could be shut down by closing the hood; this could be done with an automatic device. By funnelling the air down to a smaller area and subsequently speeding it up, it should be possible to extract energy from winds normally considered too slow to provide usable energy. The throat area of the funnel could be adjusted to vary the speed of air impinging on the mill blades for optimum efficiency.

Due to the inherently substantial mounting system, a fairly sophisticated mechanical ratio variation could be used between the windmill axle and input shaft to the generator. This would allow the generator to operate it its optimum speed constantly.

The system could be arranged to allow direct mechanical hookup to a "helper" compressor to augment attic air conditioning. A smaller unit could be arranged behind the larger unit to allow further extraction of energy from downstream air.

The system allows very direct transfer of energy from the generator to fluid medium, either mechanically or electrically with very short wires.

Estimated Performance

(Note: this information was received too late for consideration by the judges.)

- Using a 3′ diameter rotor;
- Using a 40′ long turbine;
- Assuming a 50% use of wind energy — (calculation based on prevailing frontal wind direction being two times more likely than wind at a 90° angle, with other directions varying linearly between the two);
- Assuming a coefficient of performance of .35 — (% of energy extracted from wind);
- Assuming a well designed shroud system with an energy augmentation factor of 3.5 times);
- Assuming a 12 MPH average wind speed;
- *Assuming* 13 MPH average corresponds to $167 \frac{\text{KW Hr.}}{\text{Ft.}^2\ \text{Yr.}}$ — (NASA):

$$E = 167 \frac{(12)^3}{(13)} = 131 \frac{\text{KW Hr.}}{\text{Ft.}^2\ \text{Yr.}}$$

$$E_a = \frac{131}{12} = 10.95 \frac{\text{KW Hr.}}{\text{Ft.}^2\ \text{Mo.}}$$

Therefore, total energy is:

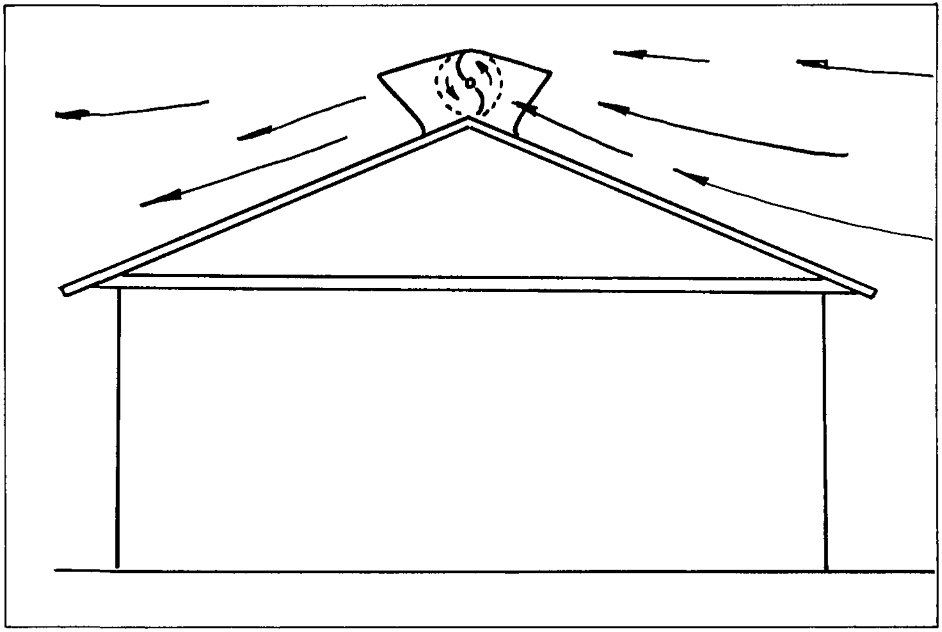
$E_r = E_a \times C_a \times C_p \times C_v \times L \times D$

E_r = Energy per month developed by turbine (KW Hr./Mo.).

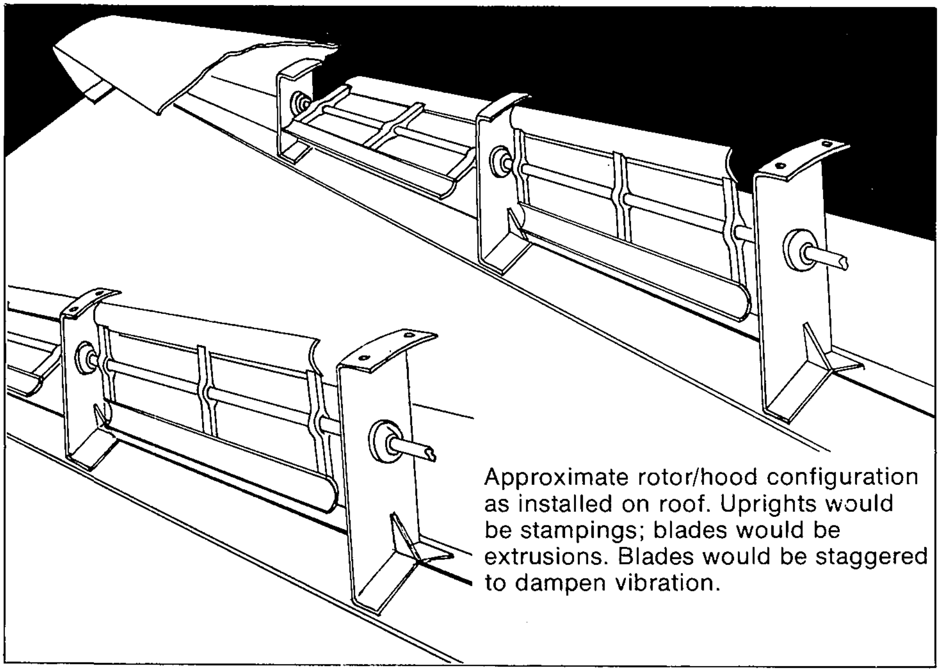
E_a =Energy per square foot per month of original air (KW Hr.) (Ft.² Mo.).

C_a = Energy augmentation factor of 3.5.

C_p = Coefficient of performance of .35.



Another possibility would be a spiral bladed rotor which would be another way to smooth out loads and dampen vibration.



Approximate rotor/hood configuration as installed on roof. Uprights would be stampings; blades would be extrusions. Blades would be staggered to dampen vibration.

C_v = Coefficient of use of .5.

L x D = 120 square feet frontal area of turbine (length times diameter).

E = (10.95) (3.5) (.5) (120).

E = 805 KW Hr./Mo.

Carrying this a bit further,

- Assume an average frontal wind of 15 MPH;
- Assume an even more prevailing wind such that C = .75,

$$E = 805 \frac{(15)^3}{(12)} \times \frac{(.75)}{(.5)}$$

E = 2,360 KW Hr./Mo.

Critical point: although much energy is lost due to the inability of the unit to follow the wind direction, this is more than made up for by the augmentation of the roof/cover combination.

Future

Carrying the concept of a sectioned, "cyclogyro"-type wind turbine, situated at a right angle to the prevailing wind, yet further presents some interesting possibilities.

1) Suspend a unit under a river bridge in an area where a fairly high velocity wind prevails; (a secondary benefit could be that the rotors might also dampen out undesirable vibration by absorbing part of the energy).
2) A horizontally mounted turbine mounted on a low mountain ridge perpendicular to the prevailing winds also presents some interesting possibilities: use the mountain ridge as a natural augmenter diffuser.
3) Build two skyscrapers so that the space between them forms an augmenter diffuser to drive a vertical turbine mounted between them. You might be able to provide full power for both buildings — and some left over.
4) The eddy currents off the corners of existing buildings might be put to good use.
5) Future homes could be constructed so as to optimize the augmenting effect and minimize losses.
6) A unit mounted on a pad floating in a body of water (natural or artificial) or mounted on a turntable could allow limited positioning of the turbine with respect to wind. We estimate that this could increase our use of wind energy from 50% to 90%. A ground supported system with 20′ diameter rotors in a 2,000′ long shroud could deliver 476,500 KW/HR a month.
7) The generator armature and field wires could be incorporated into the turbine blades and shroud to eliminate the generator housing, cooling system, and mechanical linkage from the rotor to the generator, making the rotor nothing more than an air driven generator armature. (We're not sure this is possible, but it is certainly worth investigating.)

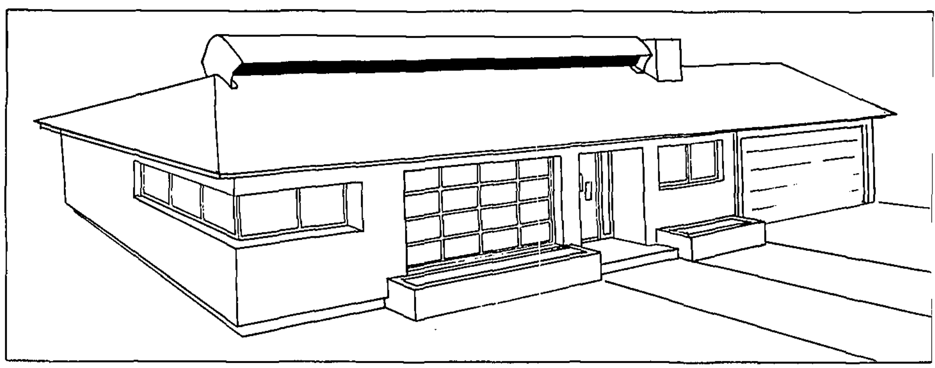
Further Notes

We could incorporate the unit currently being developed by Dr. James Yen of Grumman Aerospace. He is claiming some phenomenal power augmentation possibilities. His unit mounted on its side, inside our augmenting system, with an air exit off the end of the shroud, could prove our figures too conservative by an order of magnitudes.

One of the first problems we addressed concerning our unit was that of noise and vibration. Vibration-dampening techniques have been discussed earlier. We are quite certain that the sound transmitted into the interior of a typical residence, at maximum wind speed, would not exceed that of a typical clothes dryer.

The heating load in any building is directly affected by the wind: through overall heat transfer to the outside air and through air infiltration. It is interesting to note that air energy extraction is sort of an automatic "feedback" system in that you are drawing the energy when you need it most — in a bitter winter wind.

Design comment: The flurry of additional information on this entry is due to the fact that it is being developed and refined as, and after, we are going to press.



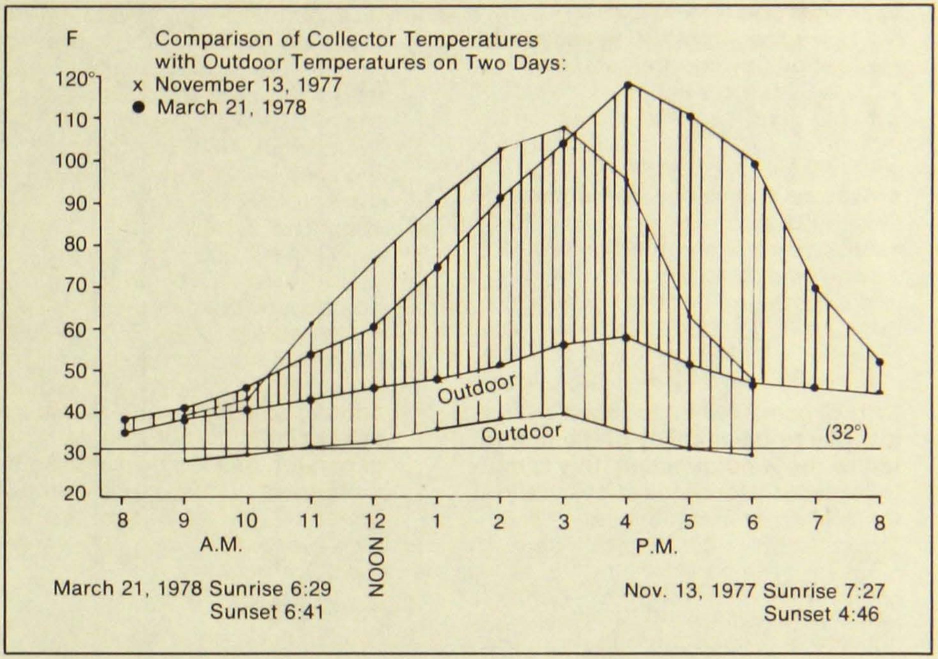
A $166.69 Passive Solar Collector
Gerald Jacobs
Teacher
Moorhead
Minnesota Energy Agency $1,000
Award

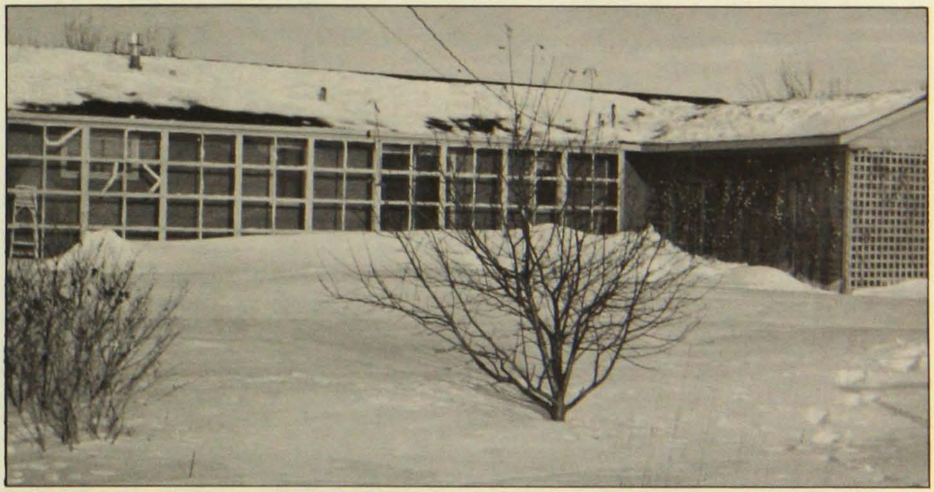
Made of nine old stormwindows, a sheet of plywood, and some wood framing, this solar collector was constructed at a cost of $166.69.

The advantage of the concept is that it is easily constructed by do-it-yourselfers, is relatively cheap, and can be used on many existing dwellings having the proper orientation to the sun. It also has the important secondary benefit of shielding one wall of the house from the winter winds twenty-four hours a day.

The collector is most effective in producing heat gains in September, October, and November in the fall of the year, and then again in March and April in the spring. During the coldest months of December, January, and February, the major benefit comes from reducing the temperature difference between the inside wall and the outside wall made of stormwindows.

The first graph shows two typical fall and spring days when heat would be required in the home. The configurations of each graph demonstrate the gains that took place on those days, but one must remember that if the house were oriented better in relation to the sun the benefits would be extended in time, and perhaps in peak temperatures.

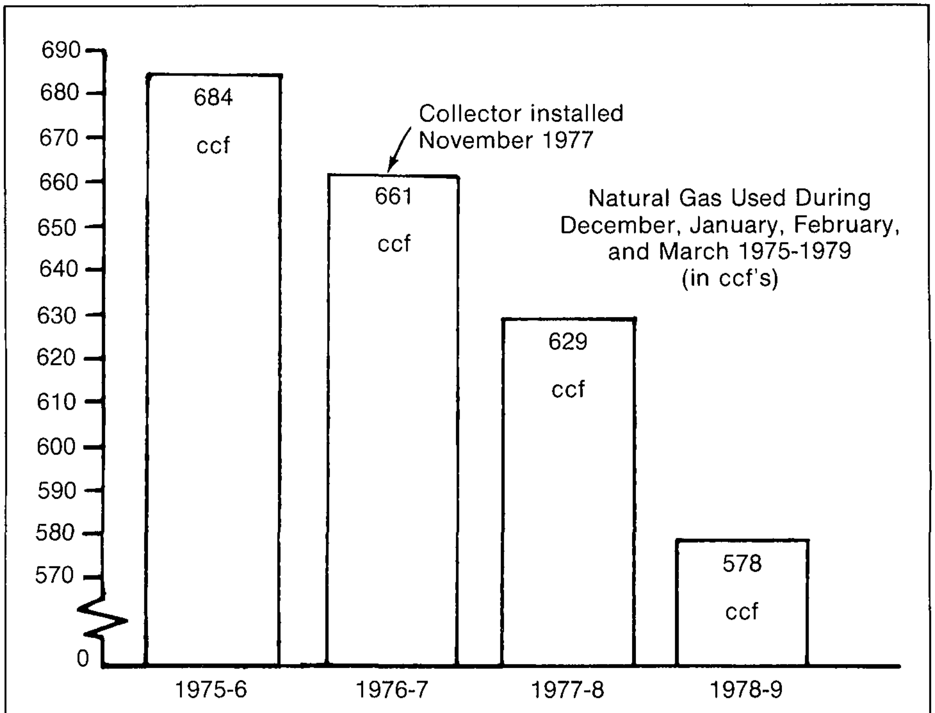


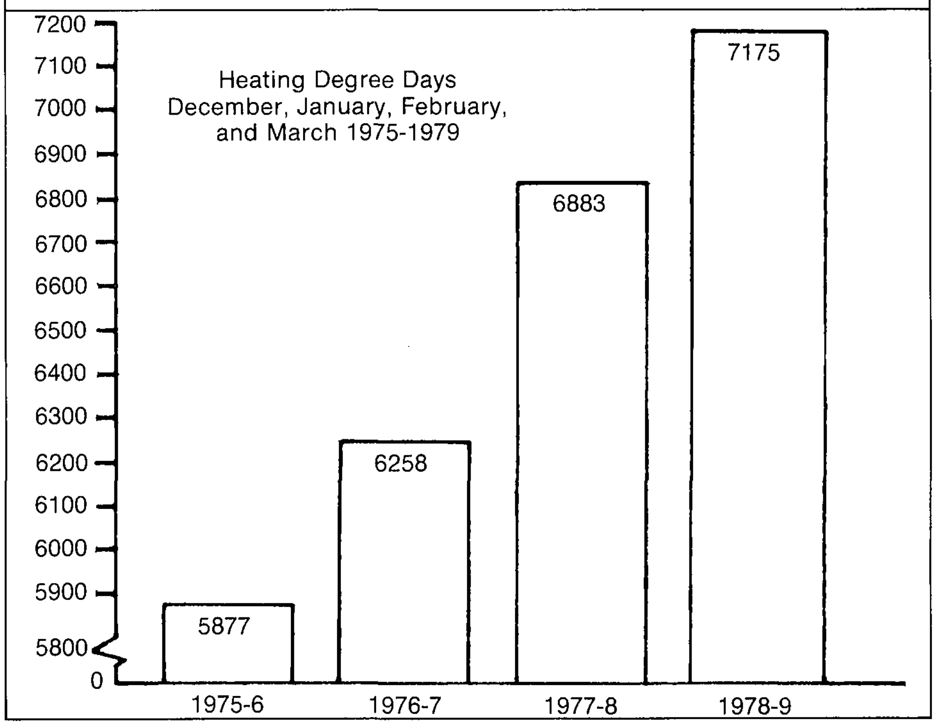


The other graph compares the natural gas consumption of the house during the four coldest months of the year for a period covering four winter seasons with the severity of the winter temperatures as reflected in degree days. As the graph shows, as the winters grew progressively colder, the amount of natural gas consumed decreased rather than increased. The first decline in consumption may be attributed to the installation of a clock thermostat, the latter two to the work of the solar collector. It may be that the second year of the solar collector was better than the first because the system was sealed better the second year and because the colder temperatures of that year increased the amount of sunny weather.

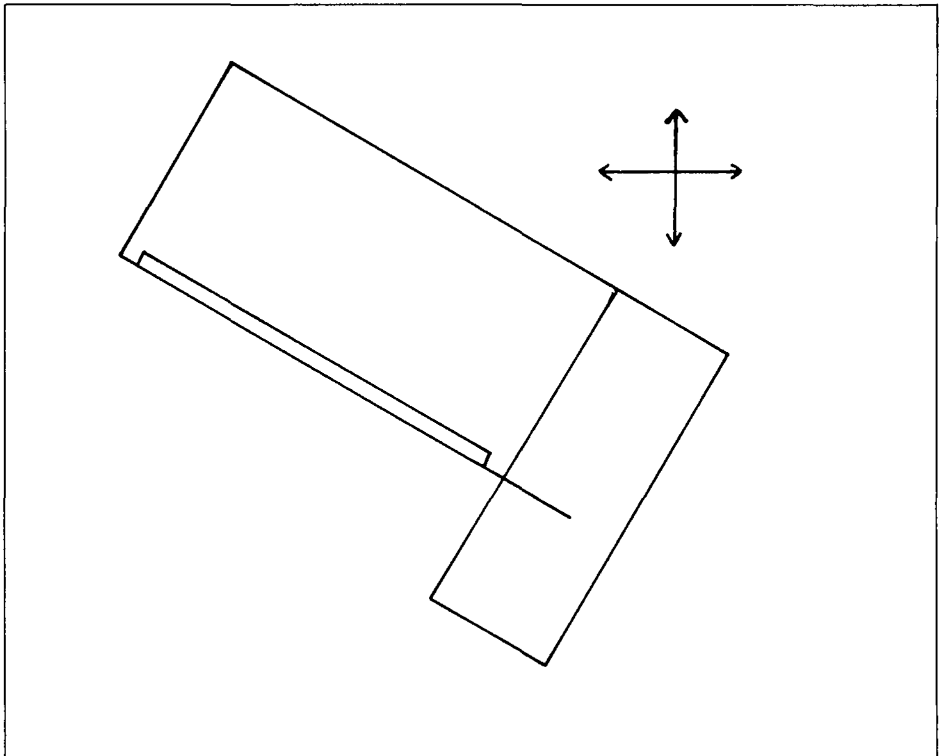
The collector could, and will, be made more effective by extending the two soffit vents down toward the bottom of the collector so that warm air will not flow into the attic; or by extending the vents into the house to directly capture the heat now lost.

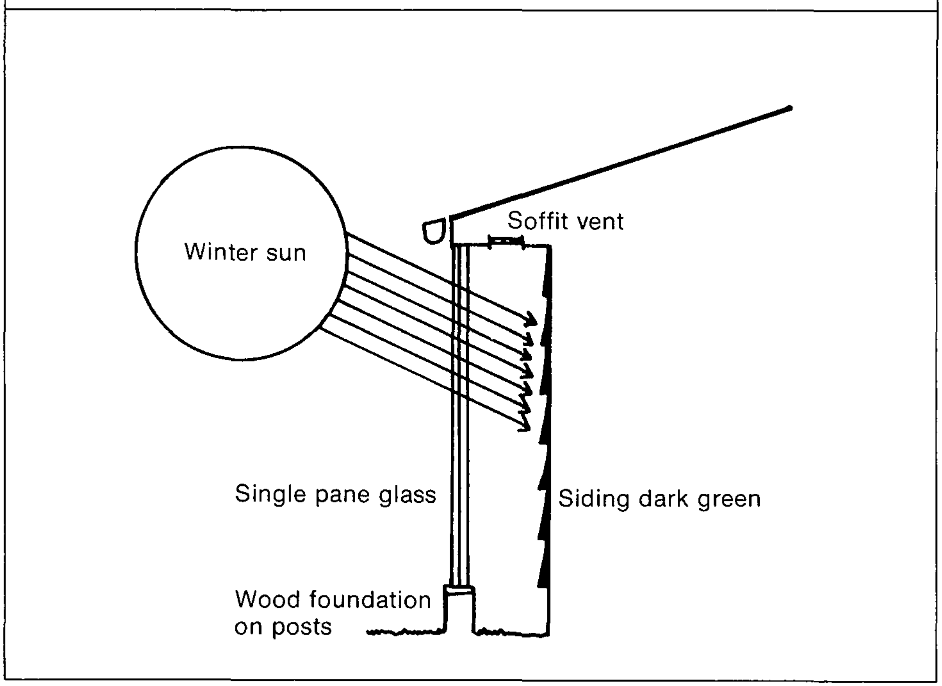
This system does not wear out, is cheap, and a sure fire energy saver and giver to supplement the normal home heating system. During the summer the windows can be slid aside to allow free passage of air.





This collector uses the warmth absorbed by the house wall to provide supplemental heat to the house. The wall and windows radiate heat to the inside on sunny days and when temperatures are sufficiently high in the collector (over 90°) the windows are opened and room temperatures are allowed to rise. The house furnace thermostat has shown heat gains of as much as 5-6° when the outside temperature is around freezing. The orientation of the stormwindow wall is almost due Southwest, obviously not the best. The morning sun potential is lost since it is partially blocked by the porch wing. Yet the temperature gains can be substantial in the afternoon.





Sunken Attached Solar Greenhouse
David Hilde
Energy coordinator
Moorhead
Minnesota Masonry Institute $250 Award

The following are calculations of heat gain, loss, and net heat gain by months in millions of BTU's.

	Gain	Loss	Net
January	2.151	.645	1.506
February	3.14	.535	2.605
March	3.492	.446	3.046
April	3.249	.24	3.009
May	3.177	.118	3.059
June	3.	.034	2.966
July	2.871	.004	2.867
August	2.997	.011	2.986
September	3.033	.082	2.951
October	3.24	.197	3.043
November	1.701	.385	1.056
December	2.358	.568	1.79

The calculations are from an F Chart program for a TI-59 calculator.

The following assumptions were used:

- Collector efficiency of flat black plate is the same as that of the greenhouse;
- Glazed surface, 168 square feet at 34° angle, with R = 20;
- Side walls, 68 square feet, with R = 24;
- Floor area, 140 square feet, same as over unheated crawl space;
- Fargo, North Dakota climatic data;
- Design temperature of -17°F.

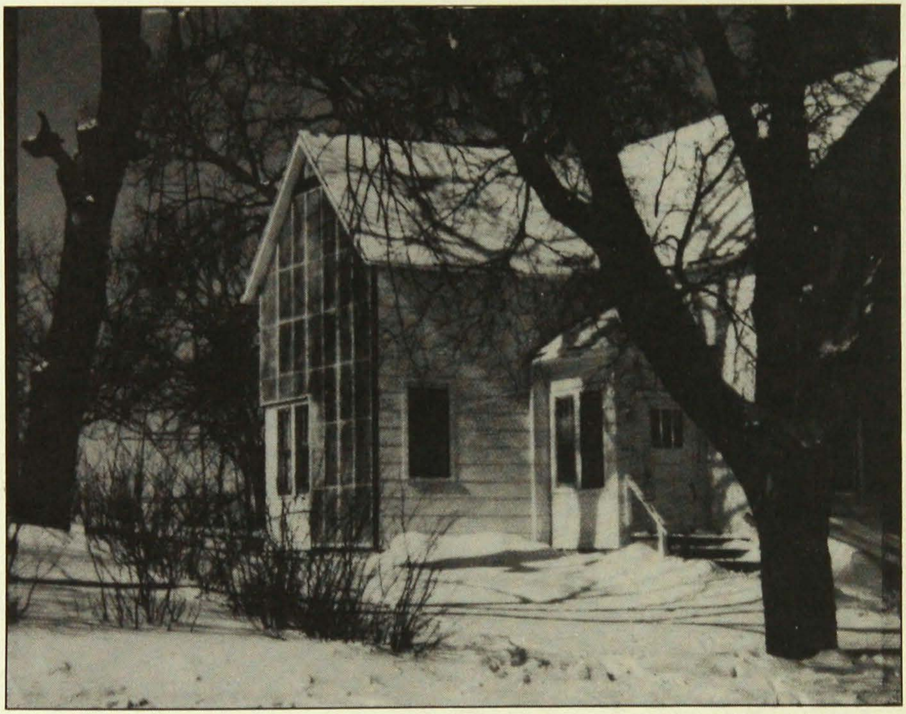
Storage capacities for heat:

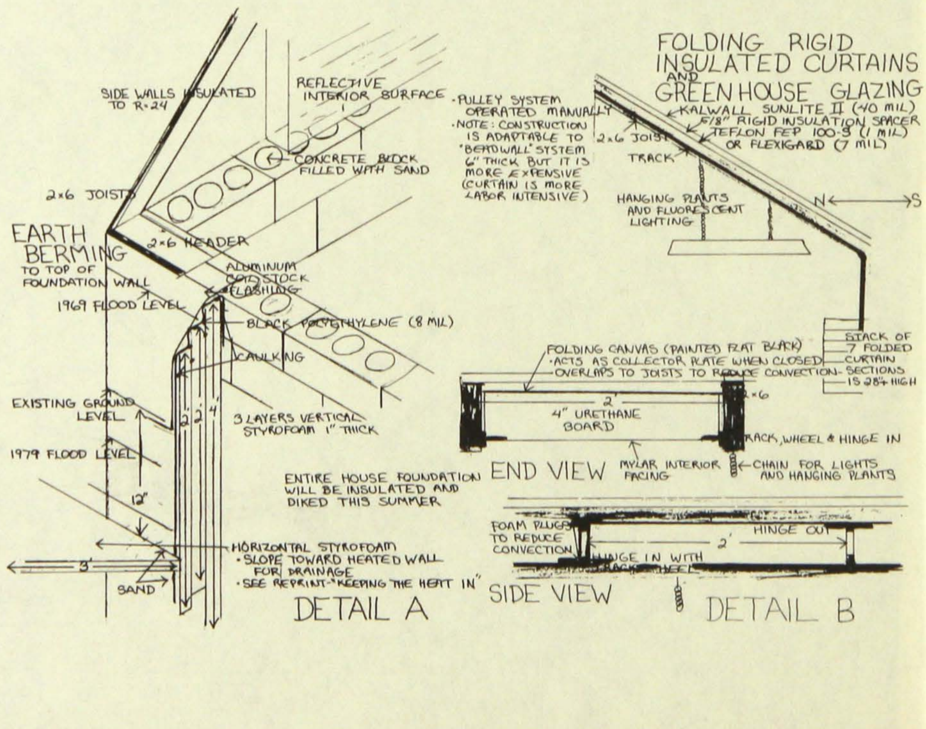
Water, 750 gallons	217,875 BTU's
Pea gravel, 7.7 cubic yards	130,977
Soil, 55 cubic feet	85,085
Block and sand	91,891
Total	525,828 BTU's

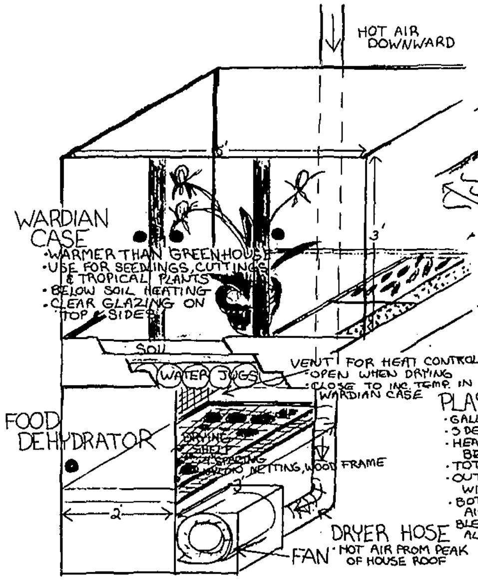
Cost estimate:

Glazing	$193
Lumber	200
Styrofoam	156
Urethane	336
Block, including labor	250
Excavation	500
Total	$1,635

Will do all own labor; also have scrap-junk which will be used.







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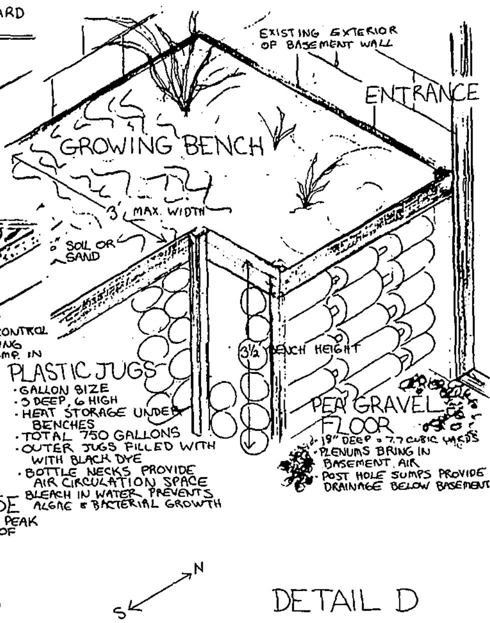

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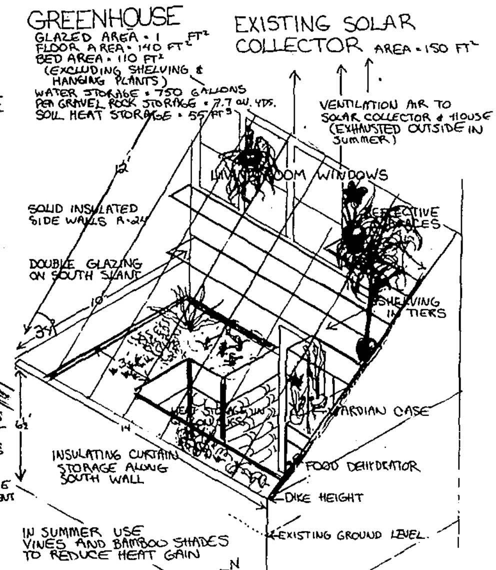
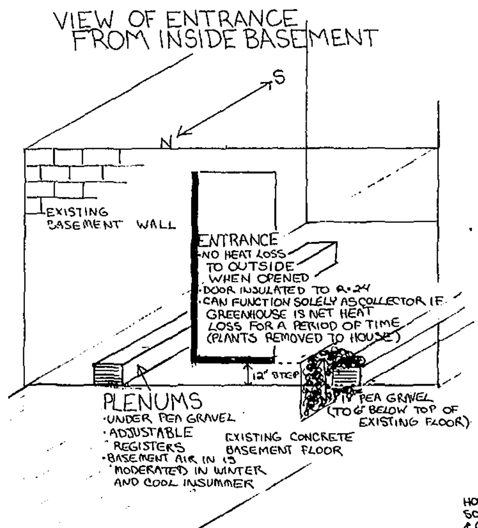


GROWING AREAS



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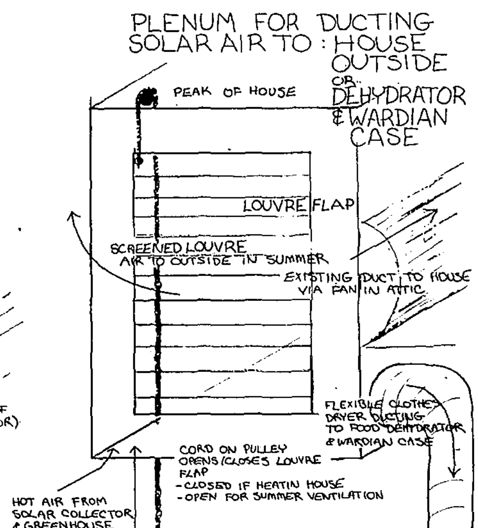

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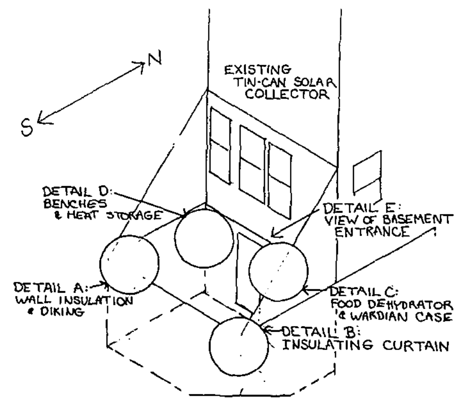


Benign Environment
C. Alexander
Teacher
Duluth

In this concept a passive solar collector system is used to develop a benign environment for a heat pump as well as certain portions of the house.

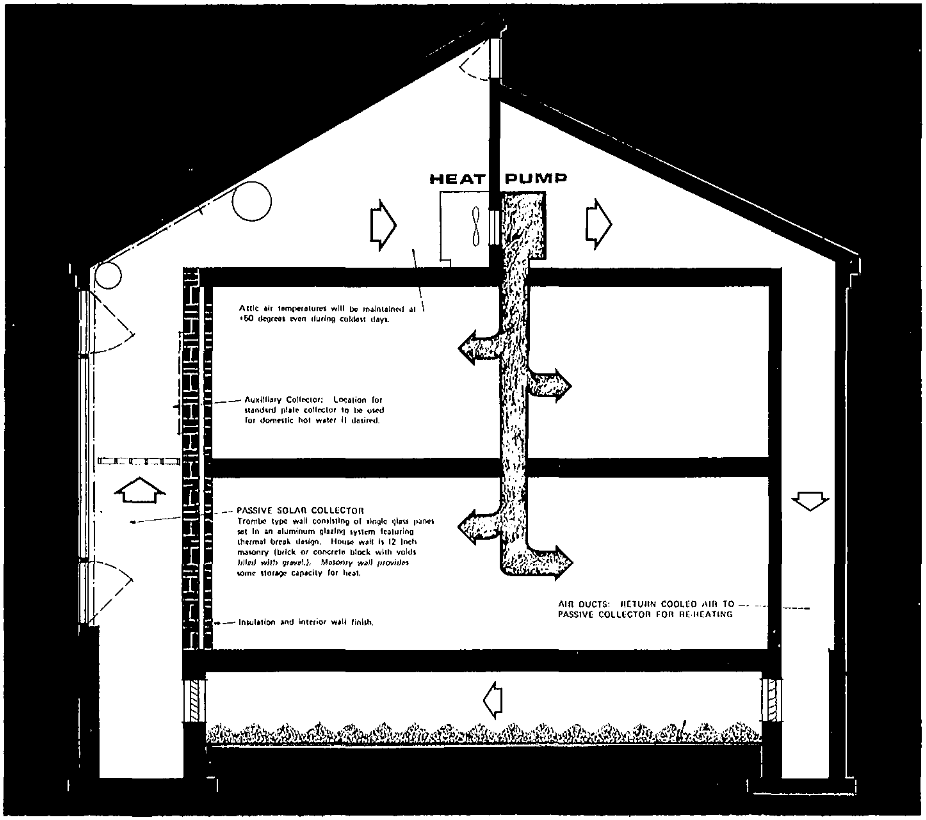
A Trombe wall is placed on the south side of the house, and the warm air generated is collected in the insulated attic space. As a result, heat loss through the interior south wall and the ceiling of the house is greatly minimized due to the low temperature differentials between the living space and the Trombe wall and attic space.

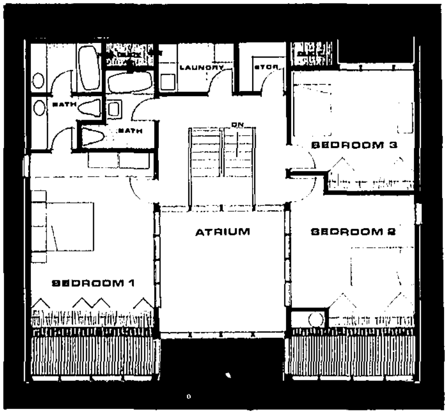
A heat pump is known to be an efficient device for converting electrical energy to usable heat, but its use in northern Minnesota has been impractical due to the drop in efficiency at temperatures below 40°. By placing the heat pump in the benign environment created in the attic space, it becomes feasible to use the heat pump throughout the heating season. On the coldest days the attic temperature will not drop below 50°.

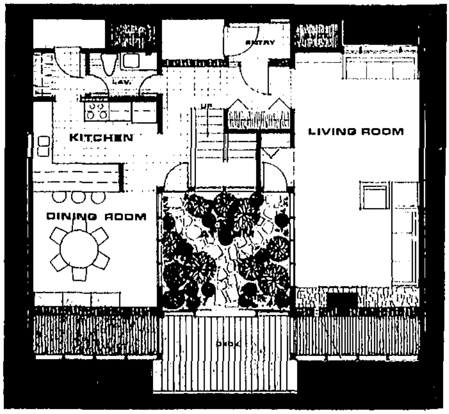
The exhaust from the heat pump is circulated back to the Trombe wall through ducts placed on the north wall of the house. All bathroom, laundry, and kitchen exhaust fans also vent into these ducts. Temperatures of the exhaust cycle would be only a few degrees colder than the attic temperature, and thus it would be possible to remove and store some of this heat by passing it over a gravel storage bed under the house.

During the night the Trombe wall would be closed and separated from the moving air current. Its glass could be shielded by a standard proscenium fire curtain as shown in the cross section, or insulated sliding panels could be used.

90% of the window areas in the living spaces open on to a protected atrium thus minimizing heat loss. Combustion air for the fireplace is drawn from the Trombe wall. During the summer, two vents in the Trombe wall and one in the attic can be opened. An active solar collector for domestic hot water could be installed inside the Trombe wall. Total area of the house is 2,080 square feet; 1,015 on the first floor; 1,065 on the second. The side of the house with the Trombe wall faces nearly due south.





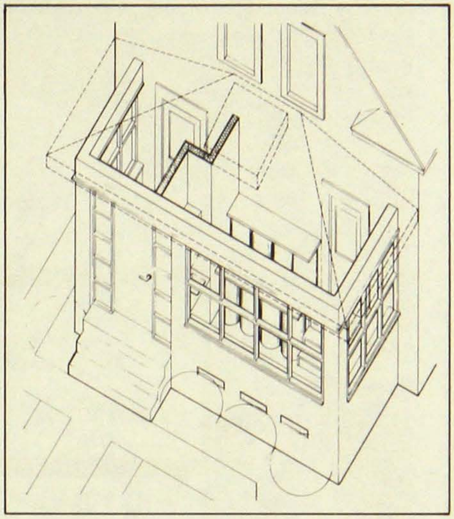


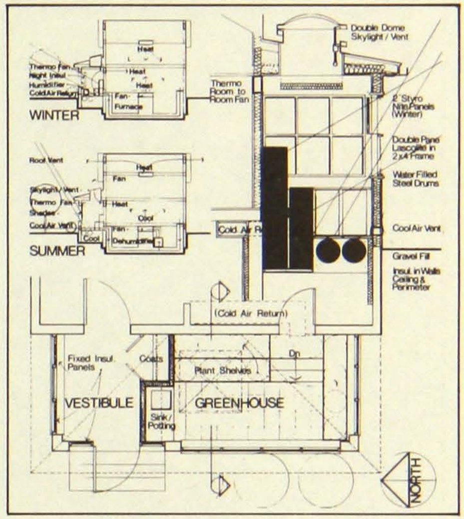
Solar Porch
David B. Gardner
Architect
Minneapolis
Land O'Lakes $250 Award

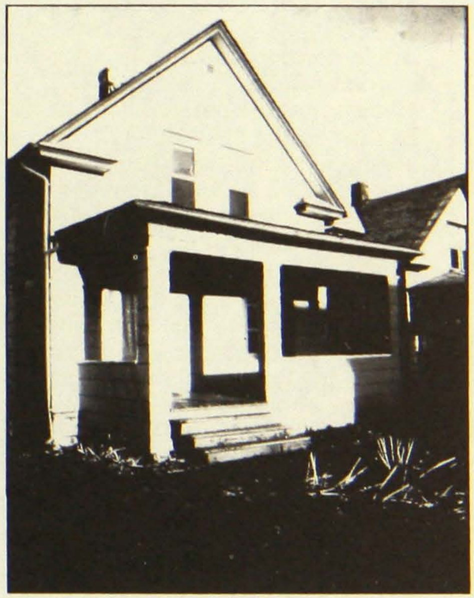
The house is a typical single family urban home. Built in 1915, it features a natural gas gravity furnace, no central air conditioning, sturdy construction, insulation, storm windows and doors, a heating bill of approximately $600 a year — and a large, uninhabited, underutilized porch. With a minimal investment of time and money, these porches, whether oriented to the south, east or west, can be redesigned to store not bicycles and old newspapers, but energy. Through the use of 38 metal barrels filled with water, massive materials such as gravel and concrete, insulation, the proper placement of fans and vents, and the heat of the sun, a solar porch of 100 sq. ft. can provide 10-15% of the energy needs of a 2,000 sq. ft. house and have a payback period of not more than 6 years.

The concept of a solar porch is to store heat in the winter, cut down on the exposure of an exterior wall of the house to the winter winds and to be a source of warm, moist heat to the house. In the summer, a solar porch acts as a buffer against the heat and helps to cool and ventilate the house. Because of greenhouse conditions in the porch, numerous vegetable plant seedlings can be started, and in some cases grown to maturity, throughout the year. Finally, as much heat and cool air is lost just by opening the door of the house to the outside elements, a vestibule is essential to act as a buffer.

In the winter, cold air from the cold air return system of the house is vented into the porch. The sun's rays enter the porch via south and west windows and through a skylight, and heat the water contained in 38 metal barrels located under the floor of the porch and along the walls. Heat is also stored in the concrete pavers making up the porch floor and greenhouse shelves, the basement wall, and in the earth and gravel below the porch. There is a total storage capacity of 372,860 BTU's. With the peak demand for a 24-hour period of 52,800 BTU's, the porch, due to its storage capacity, can maintain temperatures of 60°-80° for more than seven days with no additional energy input. By installing a thermostatically controlled fan set at 70° between the house and porch, heat will be siphoned into the house, supplying approximately 10-15% of the heating needs of the house based on a ratio of approximately one sq. ft. of solar porch to three sq. ft. of house heated. This will, however, have the effect of reducing the storage capacity of the solar porch to slightly more than three and one-half days. The warm air from the porch is added to the warm air from the furnace. A blower attached to the furnace will help circulate the warm air faster. A thermostatically controlled "whole house" fan located in the floor of the attic will recirculate the warm air which rises to the second floor. The use of a humidifier on the porch to raise the comfort level of the air, and the use of insulated panels on the







porch windows at night will add to the effectiveness of the system.

In the summer the reverse process will help to cool the house. Vents located in the porch walls at ground level draw cool air from behind foliage into the porch where it is vented into the house's cold air return system. The fan between porch and house is reversed and warm air from the house is blown into the porch where it is vented out of the skylight/roofvent. The whole house fan is also reversed and vents warm second floor air out of roof vents. The use of a dehumidifier on the porch and shades at the porch windows will also keep temperatures cooler.

The estimated cost of the project is $2,500. This breaks down as follows: $1,500 for materials for both the greenhouse area and the vestibule. At 100 sq. ft. of floor space, this represents a figure of $15 per square foot: $500 for labor, (most of this will be donated in this case), and $500 for environmental control systems. The whole house fan, humidifier/ dehumidifier and furnace blower unit are not part of the solar porch per se, but are vital additions to an energy efficient environmental system. Thus their cost has been included in the $2,500 budget.

By actively contributing 10-15% of the heat needed by the house and 10% of the cooling cost, fuel bills can be cut by $60-$90. By acting as a buffer to winter winds and summer heat, the porch and vestibule contribute an additional $55-$80 in fuel savings. Finally, by utilizing the greenhouse function of a solar porch, approximately $300-$400 in seedling vegetable plants can be produced each year. Thus the solar porch can earn $425 per year, making a payback period of 6 years. With fuel costs and food prices rising each year, this payback period can only be shortened.

Mobile Home Passive Solar Heater
Vincent Lipinski
Inventor
Chaska
Patent pending.

Material Costs

Lumber	$35
Hardware, paint, nylon rope	20
10 mil plastic	30
Canvas and metal tubing	75
Total	$160
Labor	30 hours

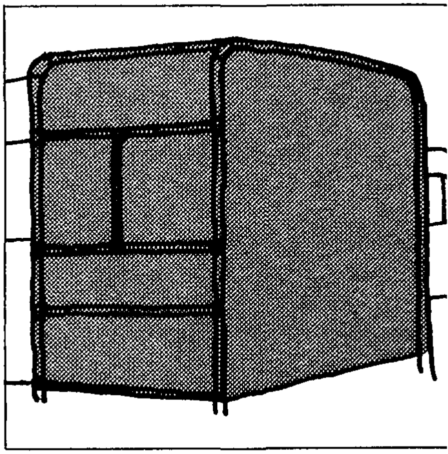
Performance

At 0°, full sunshine, heats 10′ x 50′ mobile home to 70°. Provides approximately 60% of heat for total heating season with earth integrated design.

Description

This is a collapsable, wood-framed, plastic bonnet attached to the south end of a mobile home. It is constructed of two or three layers of clear plastic, 4″ to 6″ apart, extending to the ground to create a heat chamber. Inside, an additional heat collector, made of tubing covered with black painted canvas, is mounted just below the window and also extends to the ground.

Options include a three-speed 12″ fan which starts at 70°, forcing air into the home, a 6″ fan which forces air into the space between the ceiling and the roof, and a 12″ fan which starts at 40°-50° and forces air through the 3′ air space under the home and behind the skirting.



The bonnet extends 10′ back over the home with a 10″ air space on the sides and roof. The remaining part of the home could have cement block supporting walls added which would hold a pre-cast cement slab top. This section of the home in turn could be earth bermed and covered with a sod roof.

Spiral Retaining Wall For Underground Housing
Joel E. Levie
Farmer
Evansville

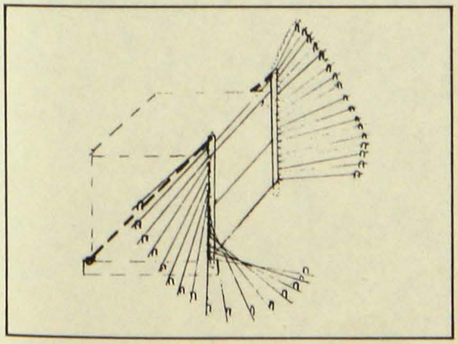
One major problem encountered in earth covered housing, especially two story constructs, is keeping dirt from sliding around to the front exposed south side of the dwelling.

I propose the following retaining wall which incorporates recycled wooden telephone poles and wooden fence posts as an alternative to traditional concrete materials.

First, erect a vertical telephone pole (pivot) adjacent to the front corner of the building. Bury the base in the ground and stabilize the top with a guy wire anchored to the house's rear footing.

Next drive a 5′ fence post approximately 15′ in front of base of pivot. Post should protrude a foot out of the ground. Lay another telephone pole, (18′ long for example), horizontally so one end is held back by the vertical pivot pole and the other end by the fence post. Back fill to top edge of the horizontal pole. Repeat procedure setting next fence post back a few degrees thus creating the spiral or fan effect. Continue backfilling.

The above can provide an inexpensive yet most aesthetically pleasing retaining wall further enhanced by using the terraces as flower planters.



Low Cost Solar Collector
V. P. Bollesen
Electrical Engineer
Fridley
Honorable Mention

Purpose

This collector is being designed and built to heat a swimming pool in the summer and a home in the winter.

Design Objectives

1. The collector must heat water.
2. The materials must be readily available.
3. It must be as low cost as possible.
4. It must have a minimum of ten years' life.
5. The average handyman must be able to construct it.

Design

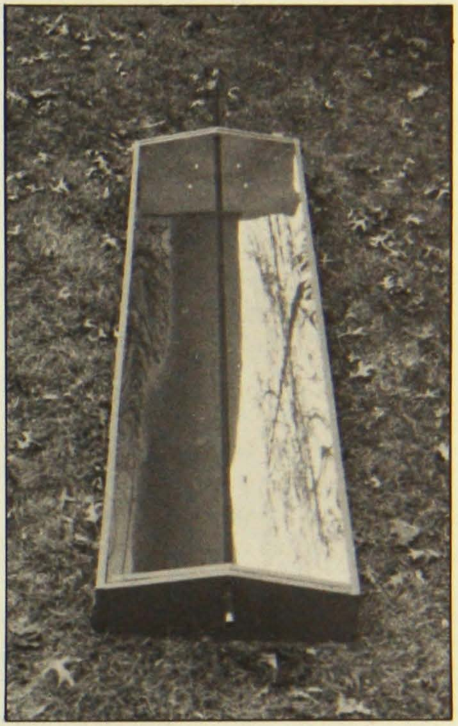
Much of the cost of flat plate collectors for heating water is in the copper plate and the insulation. For this reason these had to be eliminated from the design. A concentrating design was therefore chosen.

The collector is constructed from 1″ x 6″ treated pine and ¼″ chip board. The ends and the parabolic forms are constructed from ¾″ exterior grade plywood. The top is covered with .090 acrylic.

The wood was painted inside and out with elm leaf green to control moisture and protect the exterior grade plywood. This should satisfy the life requirements.

The reflecting surface is a silvered .005″ polyester film. The film is cut ½″ shorter than the inside length of the box and then bonded to the parabolic plywood forms. The forms are held in place by the collector pipe and two wood screws with springs. This is done to keep the film tight and allow for dimensional changes due to temperature and humidity. This has worked well in keeping the film focused on the collector tube.

The collector tube is ¾″ copper pipe painted with Nextel Velvet Coating 101-C10 Black.



System

It is planned that five rows of eight collectors connected in series will be placed on the roof of the house. The rows will be at such an angle that the sun will be focused on the collector most of the day. The collector will be rotated only to compensate for seasonal changes.

During the summer the swimming pool pump will circulate the water directly through the collector. For home heating a holding tank is planned for heat storage and pumps will circulate the hot water to the domestic hot water pre-heater and a radiator in the furnace cold air return.

Cost

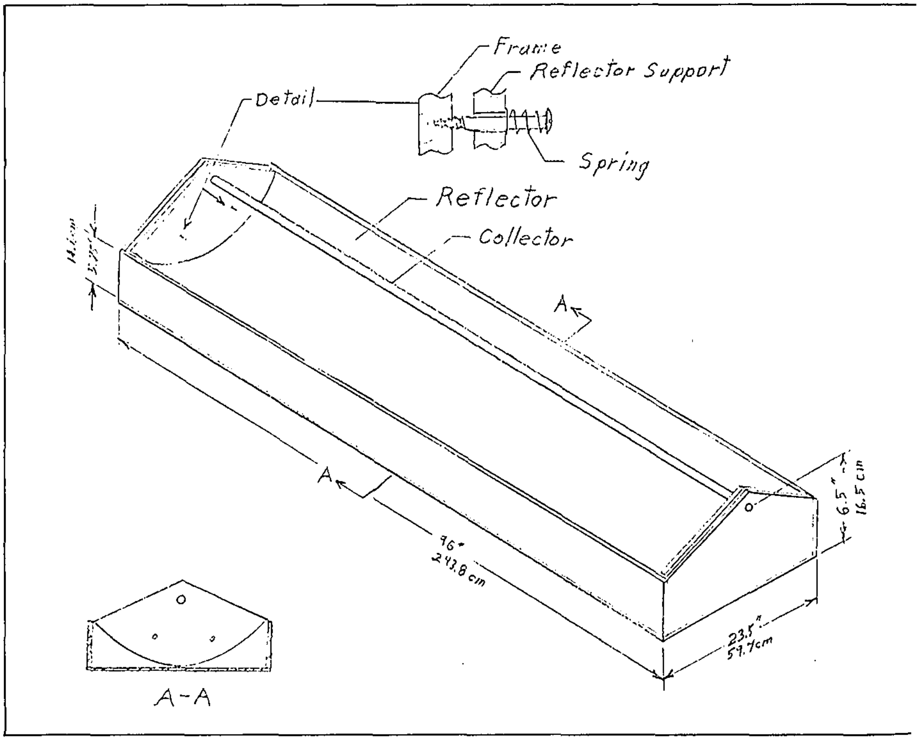
Each 2′ x 8′ (16′ square) collector will cost $35.43 plus two to three hours of labor. This is $2.58 per square foot. The total system cost for heating the swimming pool is expected to be about $1,550.

Tests

The prototype was tested on a sunny day at noon. The ambient temperature was 56°. The collector pipe was filled with water and a temperature probe was inserted in the water. The collector was aimed at the sun and the temperature was read each minute. The temperature of the water rose 20° per minute and was boiling in seven minutes. Based on the amount of water heated, 38 cal were collected per cm length of collector. I estimate that the forty collectors planned for the roof will supply about 80,000 BTU's per hour.

Materials Cost for Individual Collectors

¼″ x 23½″ x 96″	Particle Board	$ 2.48
1″ x 6″ x 192″	Treated Pine	4.32
¾″ x 22″ x 32″	Exterior Grade Plywood	3.75
.005″ x 25″ x 94″	Silvered Mylar	3.67
.098″ x 24″ x 96″	Acrylic	15.36
Four #10 2″	Roundhead Wood Screws	.25
Four ¼″ x 1″	Compression Springs	.50
¾″ x 100″	Copper Pipe	4.60
	Black Coating	.50
Total		$35.43



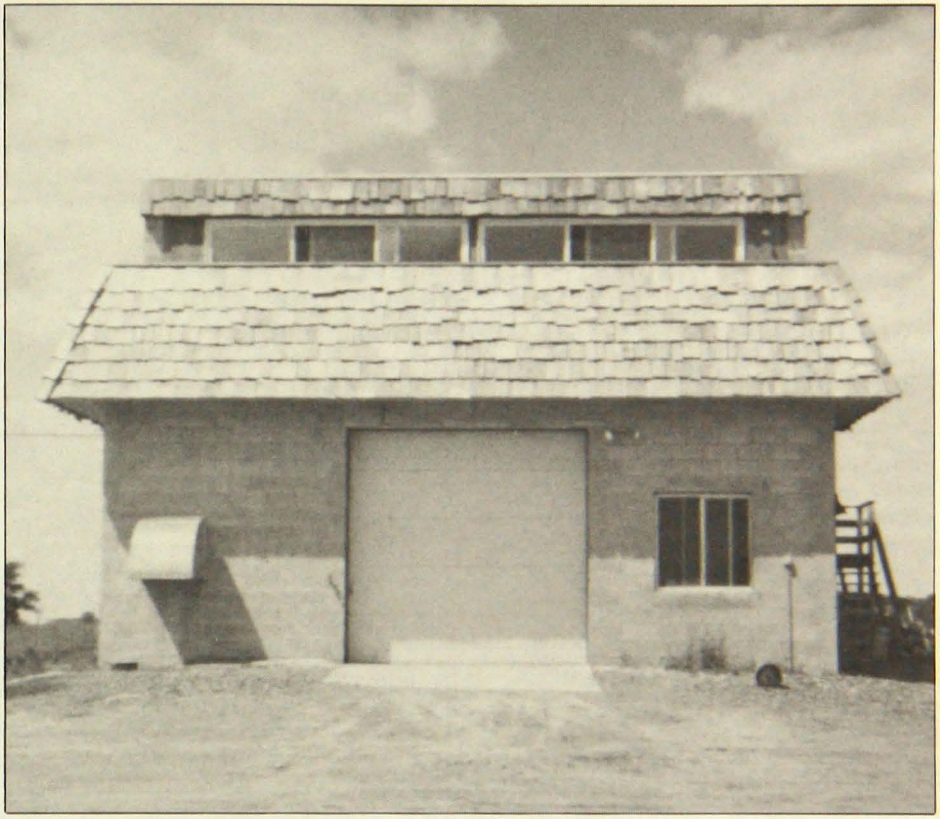
Energy Efficient Building: Auto Body Shop With Upper Living Quarters
Charles and Robert Andrews
Auto Rebuilding; Pharmacist
Princeton
Honorable Mention

The original building was built in August through November of 1975. It measures 30′ x 52′ and was built to meet Minnesota State Fire Rating Bureau recommendations and commercial building codes. Used as a body shop, the original structure was constructed of 12″ block walls with 1″ bead board and steel liner on the inside, steel doors, and pre-stressed concrete roof with an R rating of approximately 7.

This building was obviously energy inefficient and after two years of rising energy costs, it became evident that at least the roof would need to be re-insulated. The cost was approximately $4,000 for insulation and $3,500 for a new hot roof in 1975. The alternative was to build a second story living space which would be well insulated to conserve heat in the shop area, but also meet strict fire rating code so insurance rates would remain low. This second story would also be able to use the existing roof for a floor (pre-stressed concrete), and a foundation and walls strong enough to support added weight.

Walls of the living unit consist of 12″ concrete blocks on the outside; 1″ of blue styrofoam glued to the inside of the block wall; a 2″ x 6″ stud wall filled with 5½″ fiberglass batting; polyethelyne which was attached to the stud wall as a vapor barrier before Sheet-rock was installed; for a total wall thickness of 19″ with an R value of 30. Windows not facing south were kept near the local building code minimum of 10% of floor space in each room. These windows are all triple glazed, but for the '78-'79 heating season none were covered by shades or curtains.

The ceiling is Nilcon pre-stressed concrete planks which contain mineral



wool insulation for an R value of 40. On this was laid 1″ sheathing before hot tar roofing was applied, for a total R value approaching 45.

The passive solar heating system has two double glazed deck door units consisting of three panels each, 74″ x 44″, for a total of 135 square feet of glass. This allows sunlight to shine on up to 550 square feet of ½″ black slate, depending on the solar altitude. Over-heating in the summer is effectively prevented by a 6″ overhang on the outside wall 94″ above the floor; over-heating has occurred only once during an unseasonably warm period in November of 1978. The lower solar altitude of winter allows sunlight to fall on slate 18½′ into the house at the winter solstice and retracts with the higher solar altitude of summer to less than 1′ at the summer solstice. The slate is laid on the concrete beams that separate the body shop from the living unit. These beams serve as a heat sink. The total of heat sink for all sources is sufficient to prevent the temperature of the south end of the house from falling below 65° overnight. The bedrooms on the north end of the house are generally 55° day and night throughout the winter. The circulating fan which was intended to help prevent temperature fluctuations in the south end of the house, as well as provide heat to the north end, was not used much because of noise. 4′ x 8′ panels of 1″ blue styrofoam are placed inside the south windows at night to prevent heat loss. Back-up heating for the living area was provided by a wood stove at the north end of the slate area. It was used infrequently last winter for a total consumption of one cord of oak.

Total construction cost for the living unit was $32,014.53 for 1,134 square feet of living space, finished June of 1978. Of this, $7,500 would have had to be spent on roof insulation for the shop. The structure has a low exterior upkeep and a substantial portion of ordinarily expected heating costs were paid for in the purchase price by including passive solar heating and extra insulation. A mansard roof on the south end of the shop was stressed to support future possible active solar heating panels.

Electrical uses in the living unit were an insignificant source of heat as the maximum monthly bill (February, 1979) was $25.70, and shop usage has not fluctuated significantly. The '78-'79 heating season here of 9,809 degree days was more demanding than either the comparison year of '77-'78 at 9,121 degree days or the long term average of 8,879 degree days per year. Comparisons of percent of possible annual sunshine are not available; however, '78-'79 was a greater than normal snow depth season so we assume it had no more than normal sunshine. We anticipate that shop heating will continue to be about one half of a usual commercial building's, and the living unit heating will continue to be of insignificant cost.

If you deduct the cost of proposed insulation for the shop roof ($7,500) from the total cost of the living unit ($32,014.53), you arrive at a total cost of $24,514.53.

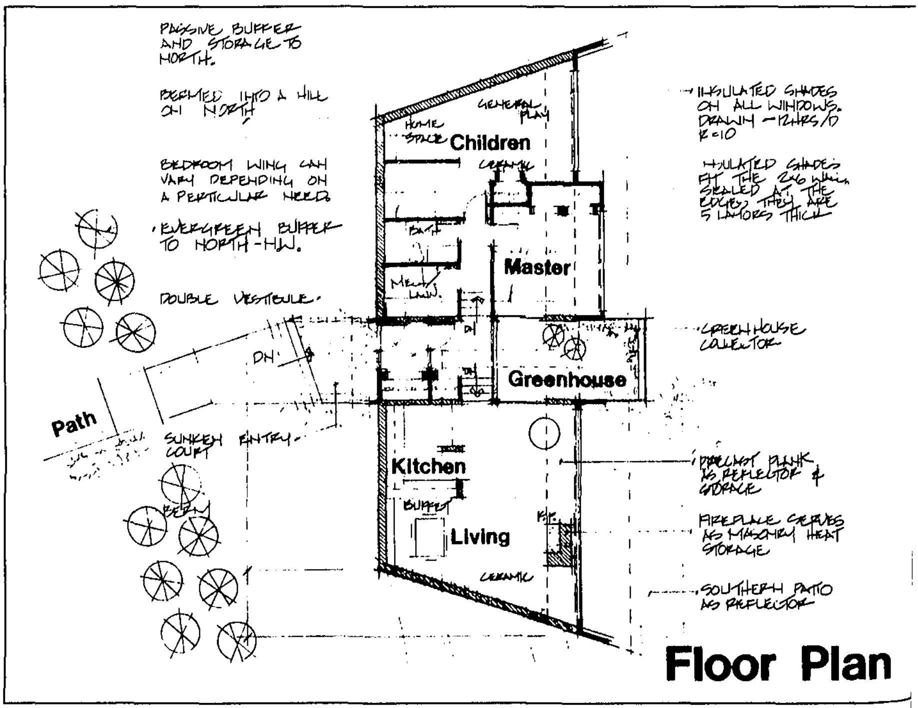
The L.P. Gas bill for the shop alone during '77-'78 was $1,313.63. During '78-'79 the bill was $663.16, a savings of $654.67. The bill for the second year also included domestic hot water, cooking, and clothes drying for a family of five. The difference in degree days was an increase of 628 for '78-'79. Shop heating per degree day was 14.4¢ during '77-'78; during '78-'79 it was 6.7¢; a savings of 7.7¢ per degree day. The heating cost for the living unit during '78-'79, the first year it was lived in, was $55 for one cord of Red Oak, cut, split, delivered, and stacked.

Energy Efficient House
Thomas Hoskens
Architect
Minneapolis

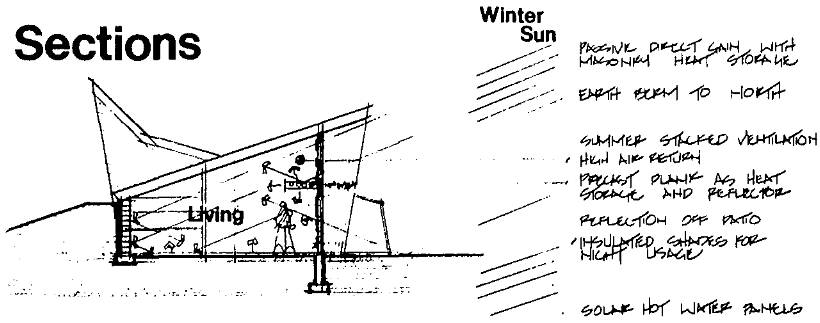
Exterior Envelope Calculations

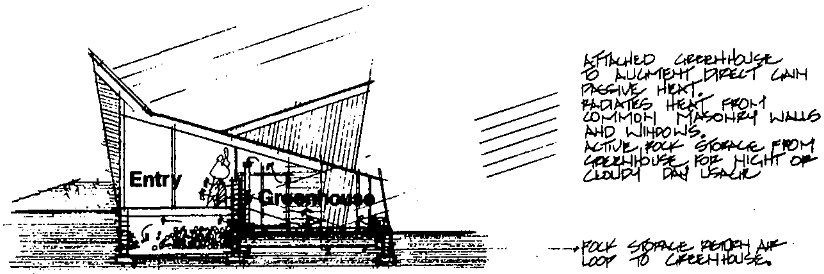
Glass Area	192 square feet	.45 U value	86.4 UA value
Patio Doors	280	.45	126
Wood Doors	20	.27	5.4
Masonry Walls	366	.051	18.7
Walls	470	.039	18.3
Wall Framing	52	.072	3.7
Roof	1,318	.025	32.8
Roof Framing	146	.071	10.4
Sub Total UA Value			301.7
Exterior Envelope Heat Loss per degree day			7,797.8 BTU's
House Infiltration Loss per degree day			1,949.0
Total BTU's per degree day			9,747.0

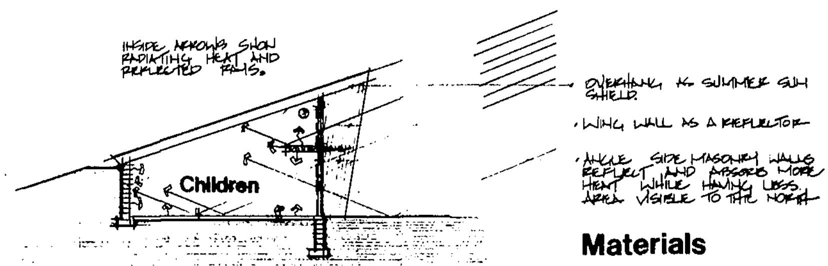
By using insulated shades with an R 10 for eight hours a day, the total BTU's per degree day is reduced by 1,370, giving a revised total of 8,377 BTU's per degree day. Additional solar gain from the south windows and attached greenhouse will give a further reduction. A savings of 4% to 9% in BTU's can be achieved with a timer thermostat; an additional savings of 4% to 6% can be achieved with the installation of a fan to recycle warm air in the house. If the house were earth sheltered with 2' to 3' of earth, it should be almost energy self-sufficient.



Sections







Materials

ROOF 240# SHINGLES
15# BUILDERS FELT
16" TJI's 24" OC.
2-6" BATT R=38
4MM POLY V.B.
5/8 GYP BD. AS REFLECTOR

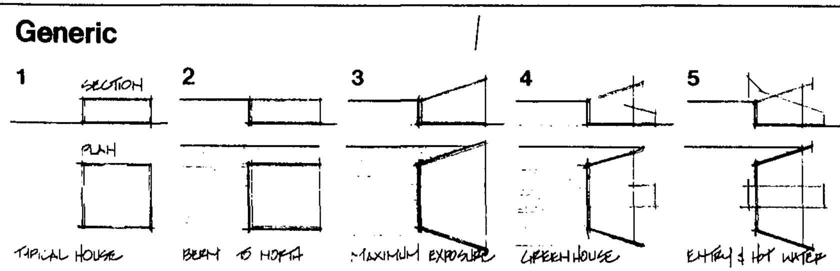
WALLS T&G CEDAR
2" HIGH ENERGY BD
12" BLOCK WALLS
4MM POLY
1/2" GYP BD

2" RIGID INSULATION 4' BELOW SURFACE

Earth Sheltered

THIS HOUSE IS SET UP TO BE CAPABLE OF USING PRECAST PLANK FOR THE ROOF. APPROXIMATELY 2' OF EARTH WOULD BE PUT ON THE STRUCTURE.

Generic



The System

Passive Direct Gain

THIS IS THE MAJOR SYSTEM USED. IT HAS AN EXPANSE OF SOUTH FACING GLASS.

THE GLASS IS TWO STORYS HIGH. IT IS SHADED BY TRELLIS AND OVERHANGS.

Masonry Heat Storage

MINIMIZES INDOOR TEMPERATURE FLUCTUATIONS.

THE INTERIOR FLOOR IS 4" OF CONCRETE MOST OF IT HAS CERAMIC TILE ON IT. THE WALLS ARE 12" BLOCK/GYP. BD. ON THE INSIDE, 2" OF STYROFORM ON THE OUTSIDE. THERE IS MASONRY PRECAST BETWEEN THE WINDOWS.

THE ROOF SYSTEM COULD BE MASONRY & SPAN SIDE TO SIDE.

Attached Greenhouse

EXCESS HEAT IS TRANSFERED TO THE BUILDING BY A THERMAL WALL OR VENTS AND WINDOWS.

Active Rock Storage

LOCATED BELOW THE ENTRY THIS SYSTEM PROVIDE EXCESS HEAT AT NIGHT OR ON CLOUDY DAYS.

Thermal Preformance

PASSIVE DIRECT GAIN
THE AREA OF SOUTH FACING GLASS
480 #

MASONRY HEAT STORAGE
THE AREA WITH 4" OR MORE MASONRY
2960 #

ATTACHED GREENHOUSE
THE AREA OF SOUTH FACING GLASS
120 #

ACTIVE ROCK STORAGE
ATTACHED TO GREENHOUSE
360 CU. FT.

Solar Collector
Floyd Rooney
Mechanic
Andover
Honorable Mention

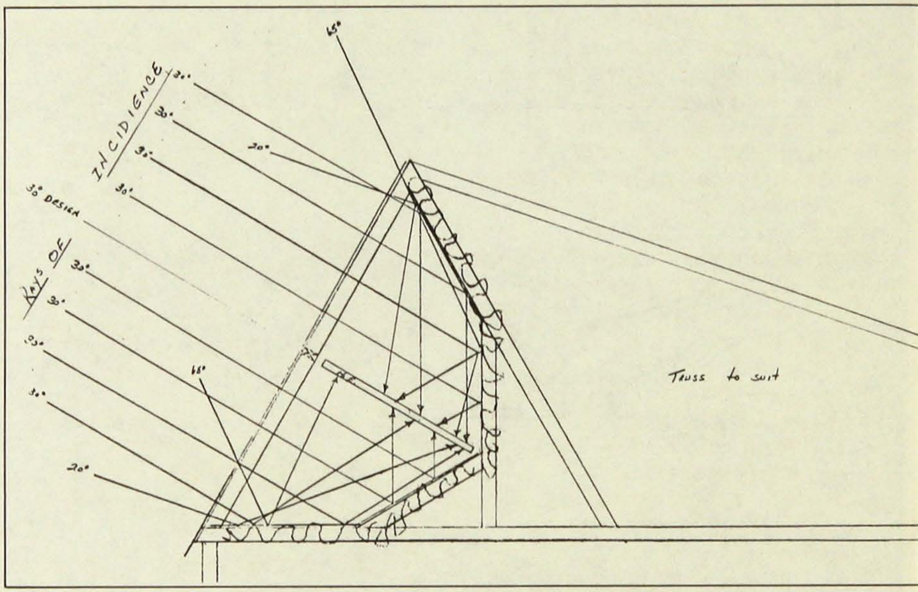
Registered with the U.S. Patent Office.

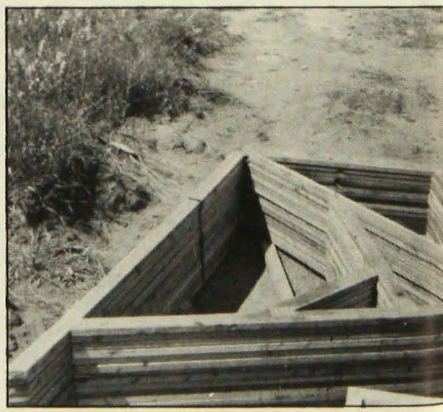
Solar Heat Collector System

The solar heat exchanger contains a working fluid. The framework holds a solar window and plane reflective surfaces. The physical size of the frame and/or truss is sized to suit building need, height, width, and length. The example shown in the section diagram is 4′ x 4′ x 4′.

It is designed for 30° solar incidence, but the incidental rays may strike the solar collector directly or reflect off one or more surfaces before striking the collector heat exchanger. The solar window is of a larger square footage than the solar collector, so it is mildly concentrating. The heat exchanger is struck by solar rays on all surfaces. Variations of angles due to differing construction materials will not reduce effectiveness.

The collector can be roof mounted or free standing. It is built from "off-the-shelf" materials, locally stocked, and from common labor. Added cost to new construction: materials and labor — $6.57 per square foot.





Solar Assisted All Electric Home

Nominal inside temperature 72°.

Total home energy costs:

12/18/78 to 1/12/79	2,740 kw	$113.52
1/12/79 to 2/10/79	3,080 kw	$128.11
2/10/79 to 3/10/79	2,240 kw	$ 95.44

House

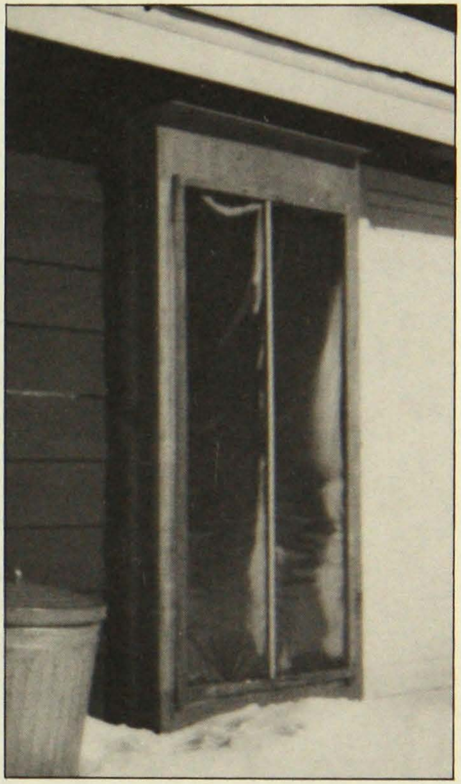
First floor garage 520 square feet
First floor living area 572 square feet
Second floor living area 1,114 square feet
Nominal 4″ stud wall, stucco exterior.
Double hung, double glazed with storm/screen windows.
Basic design: tuck under garage.

Solar Heating Unit
E. M. Leckband
Retired Carpenter
Brainerd
Super Valu Stores $500 Award

This solar heating system has two unique features. Number one, the aggregate cement blocks, besides serving as excellent solar collectors, also serve as a good heat storage facility, eliminating the need for rock pits or water storage. Secondly, it can easily be attached to the sunny side of any suitable building wall at floor level or higher up on a bracketed shelf or staging. Heightened parapet walls are suitable locations as are false walls located above partitions of flat roofed buildings.

The structure is made of two columns of nine 4″ x 8″ x 16″ cement aggregate blocks each. There is a ½″ space between each column. The back of the unit is a fiberboard panel approximately 40″ wide and 85″ tall. The back, top, and sides of the unit are insulated with 2″ styrofoam. The outside top, sides, and facing are ½″ cedar paneling. The front of the unit is covered with two sheets of 6 mil clear polyethelyne with a ⅜″ space between them. There is a 1⅜″ air space between the plastic sheets and the cement blocks. The front face of the cement blocks are painted jet black. Upper and lower plenums are constructed of 1″ x 6″s and provide ducts to the room being heated. A fan with a thermostat is adjusted to switch off when the temperature in the upper plenum drops to 60°; this also automatically closes a duct damper. The collector thus can continue to accept and store heat with the fan off and the damper closed.

The first test of this unit was made February 16, 1979 between the hours of 11:00 a.m. and 2:30 p.m. It was a sunny day with an outside temperature of 2° above. The temperature inside the uninsulated, unheated garage, the site of the unit installation, was 10°. Temperature in the top plenum was



73°; temperature of the air being exhausted at the fan was 45°; and in approximately two hours time the inside temperature of the garage had risen to 15°. The outside temperature remained steady at 2° above zero, so the 5° temperature rise in the garage was due solely to the efficiency of the solar heating unit, which has approximately 15½ square feet of collecting surface.

List and cost of materials used:

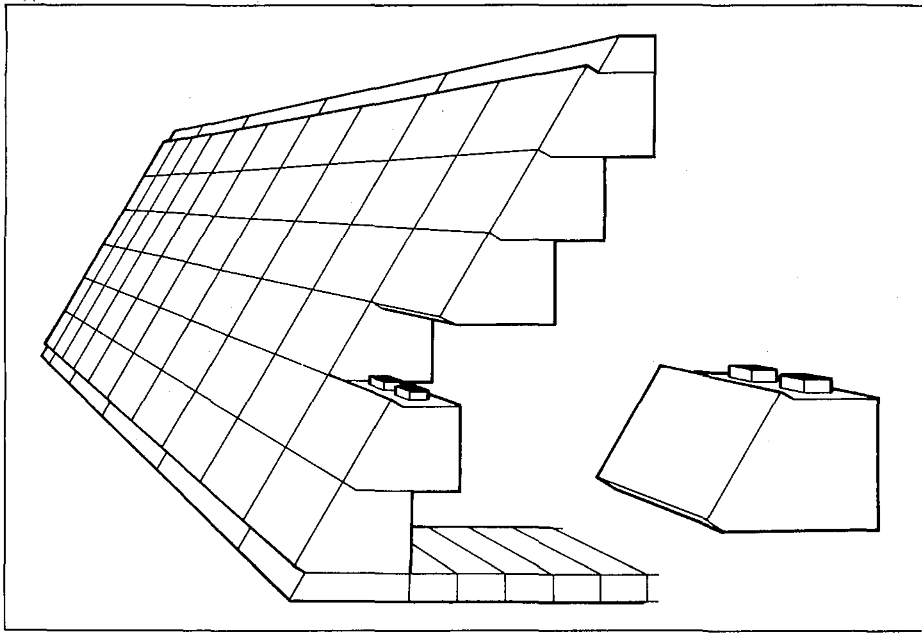
Eighteen 4″ x 8″ x 16″ hollow light-weight concrete blocks	$10.11
One 4′ x 8′ sheet of 2″ styrofoam insulation	7.20
Sixteen feet of 36″ wide polyethylene	4.06
Two cans of flat jet black spray paint	2.66
One 3″ wafer thermostat	1.49
	$25.52

Approximate cost of materials used but on hand:

One micro-switch	$1.75
Cedar paneling	5.60
Fiberboard	3.50
Two 5″ foot long ducts	1.00
One 5″ damper	1.25
One 5″ used electric fan	6.50
Stock material for lower plenum	3.00
Stock material for base	3.50
Miscellaneous: nails, screws, caulking,etc.	4.50
	$30.50
Total:	$56.02

Solar Energy Collection and Storage (SECS) Module

Christopher Pfeifer
Technical Writer
St. Paul
Ellerbe $250 Award

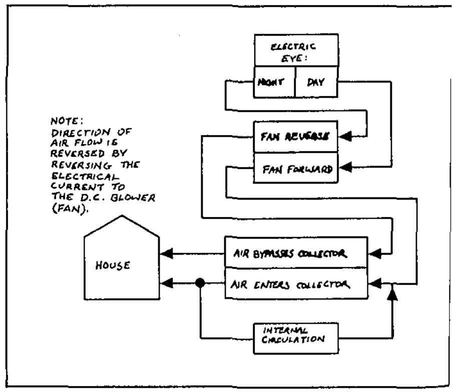


The problems with solar collection systems used in residential heating today are that they are custom-made, expensive, and must be constructed at the site. Such construction often involves large plates of glass, miles of tubing, and costly installation. Moreover, solar collectors for home heating require a large amount of space. If a roof-mounted collector is barely noticeable from the outside of a home, it is because the pipes, circulating pumps, and big tanks of water are stored inside the house.

Since there has yet to be a satisfactory standardization of parts in the solar industry, and since energy requirements differ in each application, the collector units built today differ in both size and design. Because parts of these collectors eventually need replacing, new parts must be manufactured to fit the specifications of each particular unit. This is costly and inefficient.

My Solar Energy Collection and Storage (SECS) system will be the first solar collection system for residential application in which contemporary mass-production techniques can be applied to its manufacture.

SECS modules are designed small enough to be produced in a factory environment, are identical (thus eliminating the need for expensive retooling), and can be connected together in rows to create collector systems of any given size and energy output. Instead of on-site construction costs, as with conventional solar systems, there would only be a small installation charge for the purchaser to pay. The SECS module system connects directly to the home heating system, and there would be no pumps, pipes, or storage equipment hidden within the house. Each SECS module has virtually no moving parts to wear out. If the system does become damaged, only the defective module would need to be repaired or replaced.



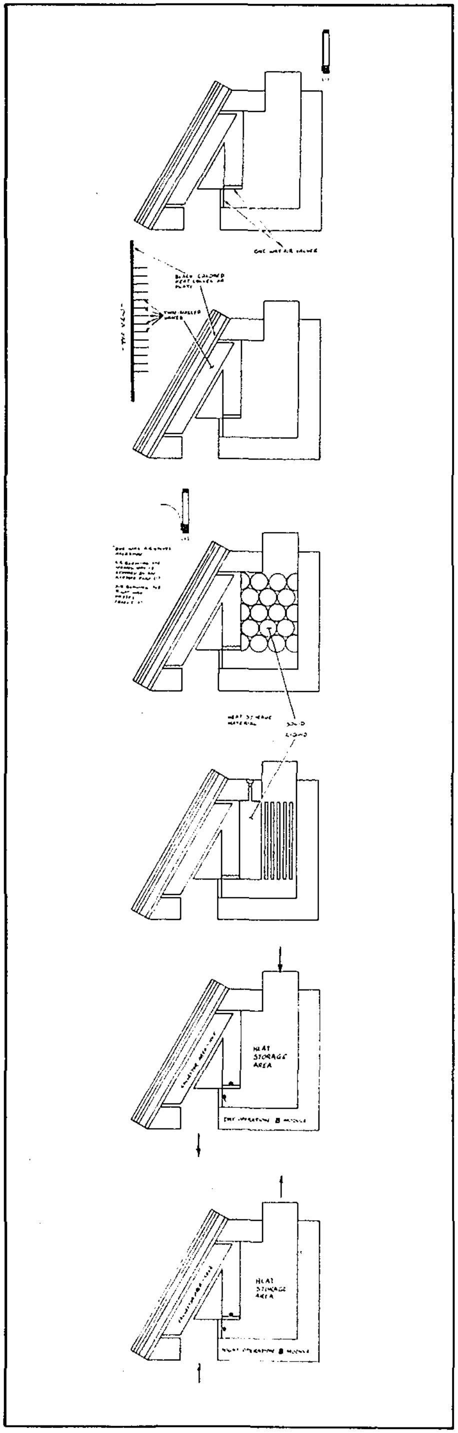
My invention relates to a modular unit capable of collecting and storing solar energy. The housing for the module comprises insulating materials within which are formed air channels. One surface of the module housing is made of a double layer of glass panes. Positioned beneath the glass panes is a black-colored heat collector plate with thin-walled vanes extending out from the back of the plate into one of the module air channels. Air forced across the vanes of the plate carries away heat radiated from the plate. Each module has two one-way air valves within the air channels and heat storage material positioned to one side of these valves. Warmed air that has passed over the heat plate vanes also passes through the heat storage material. The heat storage material absorbs heat from the warmed air until the temperature of the storage material approaches that of the air that passes through it. Conversely, the storage material releases heat when the temperature of the air that passes through it is lower than the temperature of the storage material.

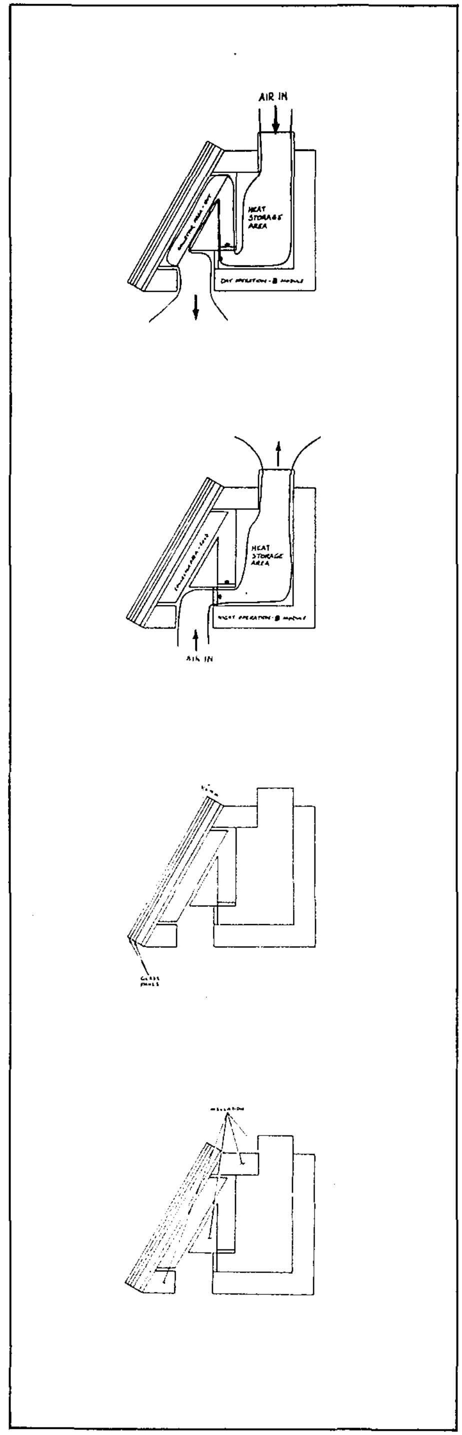
When the SECS module is collecting solar energy, forced air is blown across the heat collector plate vanes, through a one-way air valve, through the heat storage material, and into the next module. Alternatively, forced air could be blown through the heat storage material, a one-way valve, and then across the heat collector plate vanes and into the next module. In either configuration, the forced air absorbs heat from the collector plate area, and transfers that heat to the heat storage material. The direction of air flow is immaterial provided the air passes over both the collector plate vanes and through the heat storage material.

When there is no longer sufficient light for solar energy collection, the direction of air flow is reversed. Air enters the module, passes through the heat storage material, and then passes through a second one-way valve and into the next module. Alternatively, the air flow could initially pass through the second one-way valve, bypass the heat collector surface, and then flow through the heat storage material and into the next module. In either configuration, entering air is warmed by the absorption of heat from the heat storage material. Heat loss through the heat collector plate and glass panes is prevented by the operation of the one-way valves and the reversed air flow.

All of the modular units are constructed to fit directly into the next module without exposed connections. These self-contained units are sufficiently compact that they can be easily manufactured and installed.

Editor's Design comment: There may be heat loss through the absorber plate during night time operation; it should be possible to correct this.





Inground Solar Greenhouse/Collector
Terry L. Graham
Program Manager
White Bear Lake

Project has been designed and is currently under construction. Construction costs and solar energy performance gains have been calculated from design baseline.

Design Goals (Initial)

The initial goal for the design approach for the solar greenhouse was to develop a self-sustaining, low-cost, year-around unit that depended entirely on solar energy for heat.

Design Performance (Final)

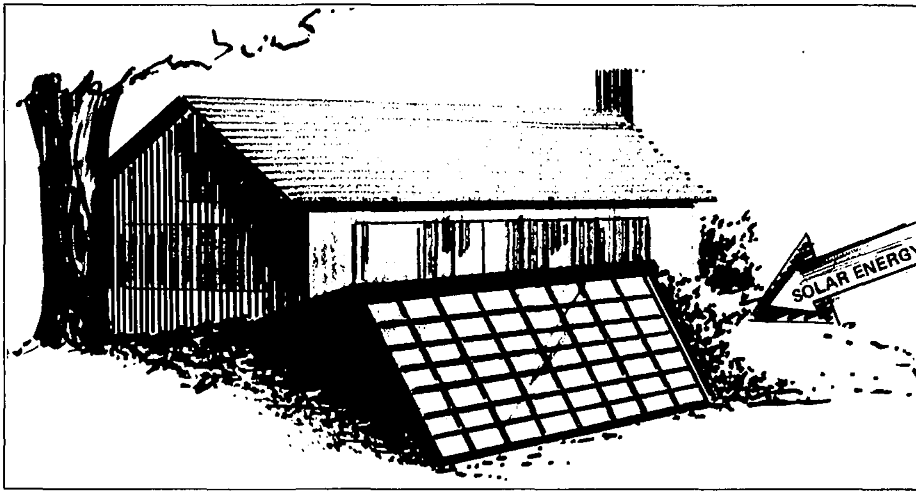
The final design, which evolved from eleven months of trial and error, achieved all three goals and, not only was self sufficient in solar heat generation and storage, but would provide heat to the adjacent home equivalent to 173 gallons of heating oil during the seven month heating season. An additional plus is the plant-yielding humidity available to the adjacent home.

Unique Design Features

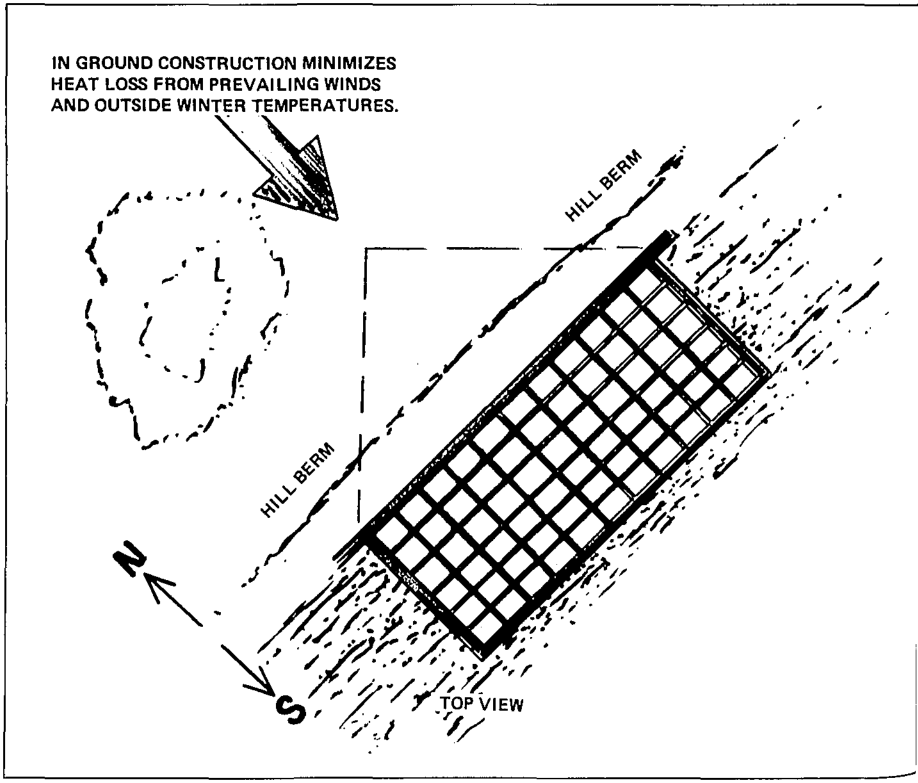
The harsh Minnesota climate and high construction costs forced the incorporation of a number of unique features which proved to be the pivot point in achieving the design performance gain.

Marginal solar performance normally expected in areas north of 40° north latitude dictated that the final design maximize, within cost limitations, solar energy heat gain and minimize structure heat transfer to yield the optimum net gain, in available BTU's, to support the greenhouse.

Maximum solar energy collection is achieved through the use of double-glazed, south facing windows, that incline at 60° to horizontal. The 60° inclination is perpendicular to the sun's rays, during the winter months, at 43° north latitude. Double glazing, using a 4″ airspace between glass panes, yielded the best heat gain and



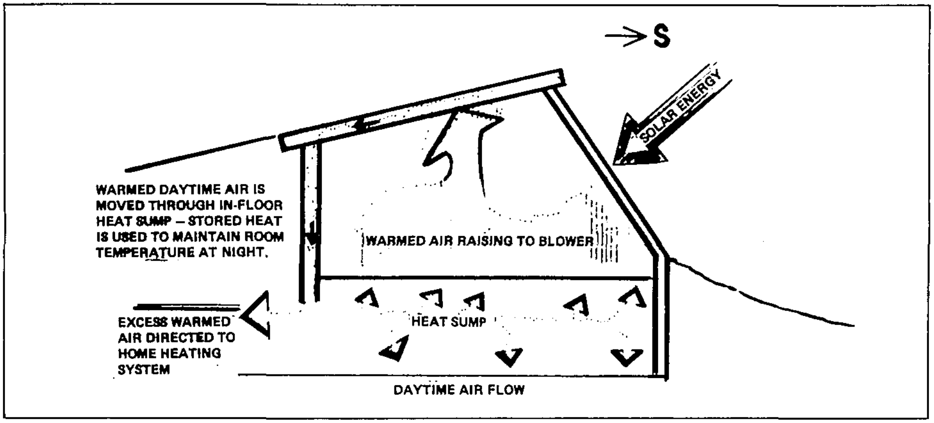
SOUTH FACING WINDOWS,
AT OPTIMUM 60° ANGLE FOR MINNESOTA
43° NORTH LATITUDE, COLLECT MAXIMUM
SOLAR ENERGY DURING WINTER MONTHS.



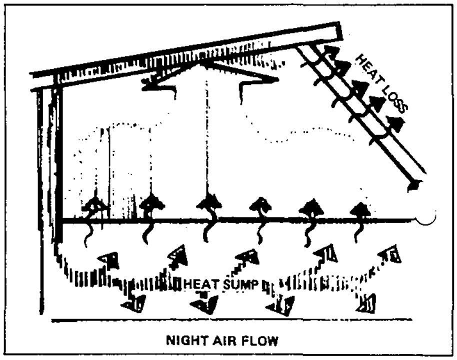
the night loss rate was minimized to an acceptable level without the use of bulky and troublesome night insulation curtains or panels. The high-cost normally associated with a "glazed greenhouse" was eliminated by using scrap 16" x 20" x ¼" Kodak photo plates (photo emulsion was removed using Hilex) set in wooden frames for the window system. The greenhouse triangular floor layout itself was chosen to minimize "cold spots" or areas that were not in *constant* contact with the sun's rays during daylight hours.

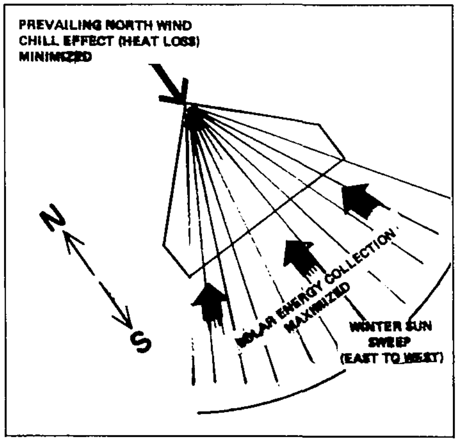
A passive heat storage system was selected over the active (or liquid) system simply based on initial cost and follow-on maintenance considerations. The system in the greenhouse utilizes a 30" thick rock floor as the heat storage sump. The sump is actually made up of "fly ash," a black crystalline byproduct from the NSP coal-fired power plants. It is a free-for-the-asking waste product which yields excellent heat retaining characteristics. Daytime heat is blown and dissipated into the sump, through black PVC drainfield (perforated) pipes, the blower being activated by a ceiling mounted thermostat set at 80°F. Heat is recovered from the sump, on an as-required basis, by the same blower, now activated by a floor mounted thermostat set at 55°F. The extra available daytime warmed air, not needed to charge the heat sump, is diverted via an insulated PVC pipe to the furnace cold air return in the adjacent home. This warmed air (about 70°F) reduces the heat differential needed to be made-up by the home oil-fired furnace thus reducing home heating costs. Humidity is also provided throughout the home by this approach.

Once the solar energy collection and storage design had been established and the average daily heat gain estimated, it was necessary to address the problem of holding the heat during the non-sunlight hours by minimizing the heat loss through structure



transfer. The heat loss could not exceed 85% of the heat gain, and had to consider a minimum of two consecutive "dark days," or no-gain days, if the net heat gain was to be sufficient to support the greenhouse. This heat loss minimization is achieved mainly through two design features: the in-ground placement of the structure, and the triangular floor layout and roof pitch which presents an aerodynamic profile to the north or prevailing wind direction. The only exterior structure actually in contact with the high loss outside environments, with the exception of the glazed south side, is the roof. Heat loss through the roof was minimized by pitching the roof at a low angle to reduce "wind chill" transfer losses and the use of 12" of insulation (R-38 factor). The other exterior walls are below grade, either truly below grade or behind an earthen backfill.





TRIANGLE FLOORPLAN ELIMINATES INSIDE "COLD SPOT" CORNERS THAT ARE NOT IN CONTINUOUS SUNLIGHT AND REDUCES NORTH FACING EXTERIOR AREA TO WIND CHILL.

Construction

The excavation was done by hand as the site was inaccessible to mechanical equipment. A continuous footing was not used due to concrete costs. A series of 8" diameter concrete pilings were poured (3' spacing) to a depth of 48" (frost line). The wooden greenhouse framing structure is then secured to these pilings via imbedded bolts. All wood framing is 2" x 6" native air-cured lumber pre-treated with a preservative (penta). Exterior and interior walls are penta-treated plywood. The wood framing for the glass system is also pretreated. Walls and ceiling are insulated with 6" and 12" of fiberglass, respectively.

Cost Analysis

This cost analysis was done for the sole purpose of determining if the solar greenhouse is cost effective and will pay for itself within a reasonable period of time.

Investment (Construction Costs)

Concrete	2 yards at $42.00 per yard	$ 84.00
Lumber	800 board feet at 15¢ per foot	120.00
Plywood	18 sheets at $10.00 per sheet	180.00
Penta	4 gallons at $10.00 per gallon	40.00
Insulation	4 bundles at $33.00 per bundle	132.00
Fan		40.00
PVC Pipe		60.00
Roofing		80.00
		$736.00

Maintenance

NONE — Under normal conditions

Return on Investment

1. Supplemental home heating: 173 gallons heating oil at 55¢ per gallon	$ 95.00
2. Supply of vegetables during winter months (8 months per year): 32 weeks at $4.00 per week (estimate)	$128.00
3. Home humidity — estimated yearly cost to maintain an in-furnace humidifier	$ 15.00
	$238.00

Payback point is: $736.00/$238.00 yearly or 3½ years to total assumption of initial investment

Analysis of Heat Gain/Loss

R values:

Siding (¾" plywood)	0.94
Building paper	0.06
Insulation	0.97
Siding (¾" plywood)	0.94
Inside air (still)	0.68
	3.59

U value = 1/R or .279

Heat loss = Area x U value x (inside temperature minus outside temperature)

Wall heat loss	3,616 BTU's per hour
Ceiling heat loss	2,695 BTU's per hour
Glass wall heat loss	1,411 BTU's per hour
	7,722 BTU's per hour or
	185,328 BTU's per day

Month	BTU's/sq ft/day*	For total area of 147 sq ft	Less structural heat loss of 185,328 per day gives net gain
Oct	2,074	304,878	119,550
Nov	1,908	280,476	95,148
Dec	1,796	264,012	78,684
Jan	1,944	285,768	100,440
Feb	2,176	319,872	134,544
March	2,174	319,578	134,250
April	1,956	287,532	102,204
			764,820 BTU's per day

764,820 BTU's per day x 30 days a month = 22,944,600 BTU's net gain during the heating season. This is the equivalent of 172.6 gallons of heating oil (#1 grade) saved per heating season.

*Based on data in table 1, p. 387 in 1972 ASHRAE handbook of fundamentals for 40°N. latitude at 60° window inclination.

A $75 Heating Bill: Simple Modifications of Current Building Practice Applied to the Construction of a Solar-Assisted, Super-Insulated House

David A. Robinson
Physicist
Northfield

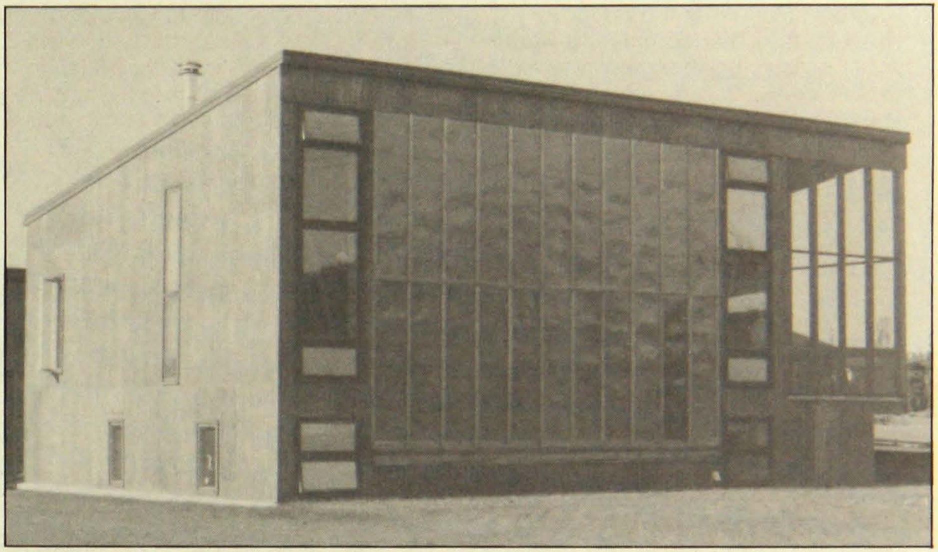
Note: this entry was received too late for consideration by the judges.

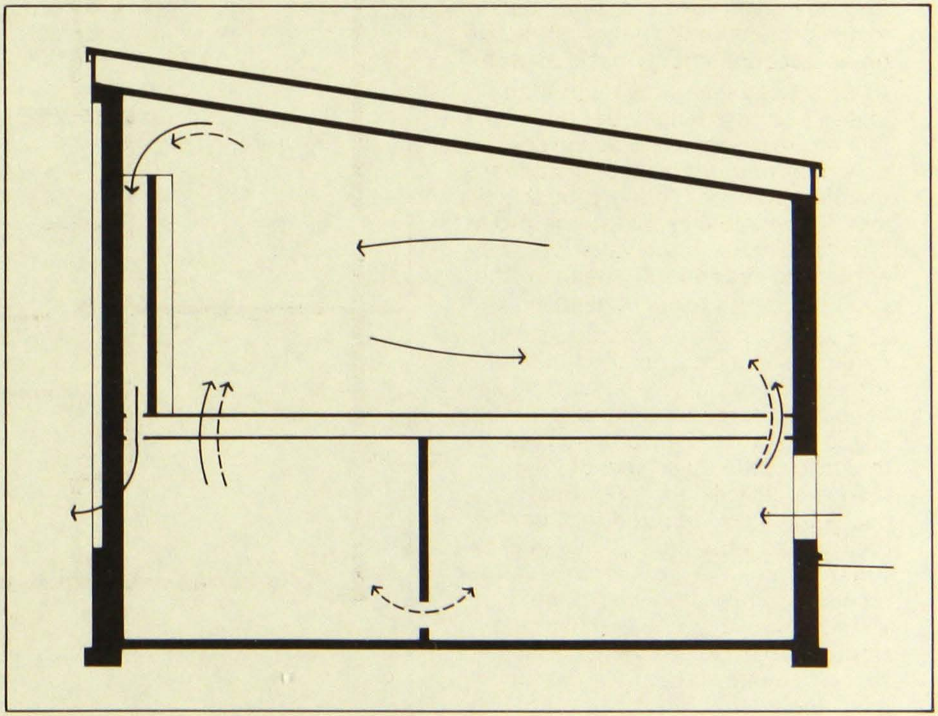
Abstract

The theory and practice involved in the construction of a life-cycle insulated solar heated residential structure indicate that simple modifications to current building practice can be used to reduce dramatically annual energy consumption in residential buildings. The use of intensive fixed insulation and minimum uninsulated window area to reduce conduction heat losses and careful sealing to reduce infiltration heat losses has resulted in a house with a total heat load of 2.3 Btu per ft^2 per degree day, and an infiltration rate of .12 air changes per hour. The direct solar gain heating fraction, summer and winter ventilation techniques, and the time constant and temperature control of the house are discussed.

1. **Introduction**

This paper discusses the theory and practice involved in the construction of a life-cycle insulated solar assisted residential structure located in southeastern Minnesota. Earlier work[1] has shown that minimum total cost for space comfort is achieved over any economic optimization period when the envelope insulation cost (including windows) is set equal to the present value of energy costs over the same period. Since this result calls for equal monetary investments in insulation and energy, including solar energy systems, it also seems to imply that the effort applied to the design of a solar heated envelope should be at least comparable to the effort applied to the design of its solar heating





system. The general recognition of this idea by the solar community would greatly assist in the appropriate design and construction of solar heated building envelopes.

2. Energy Implications

Energy conservation in residential construction calls for attention to detail in insulating the envelope against thermal conduction losses and sealing the envelope against air infiltration losses. A rational upper limit to the amount of insulation to be used in a residential structure may be provided by finding the amount of insulation which would be optimum on a net energy basis. Given data on the energy required to manufacture fiberglass insulation[2] it can be shown that energy-optimum amounts of insulation are greater than life-cycle amounts over any given period of time, thus making intensive insulation attractive on an absolute energy basis as well.

As discussed later, low infiltration losses (*.12 air changes per hour for* this house) seem to be achievable with only minor modifications to standard building practice. This is probably the most remarkable aspect of the project, and demonstrates the value of appropriate attention to detail in the construction of residential envelopes.

The use of intensive insulation and careful sealing has resulted in a house for which internally generated heat becomes a large fraction of the total space heat load, indicating a need for the development and use of heat recovery devices. Air-to-air heat exchangers are required for humidity control and ventilation, while gray water heat exchangers are needed for recovery of heat from warm drain water. Gray water heat exchangers would be particularly valuable for space heating, since on an annual basis the energy required to provide space heat and to provide hot water may be nearly the same for well sealed life-cycle insulated structures.

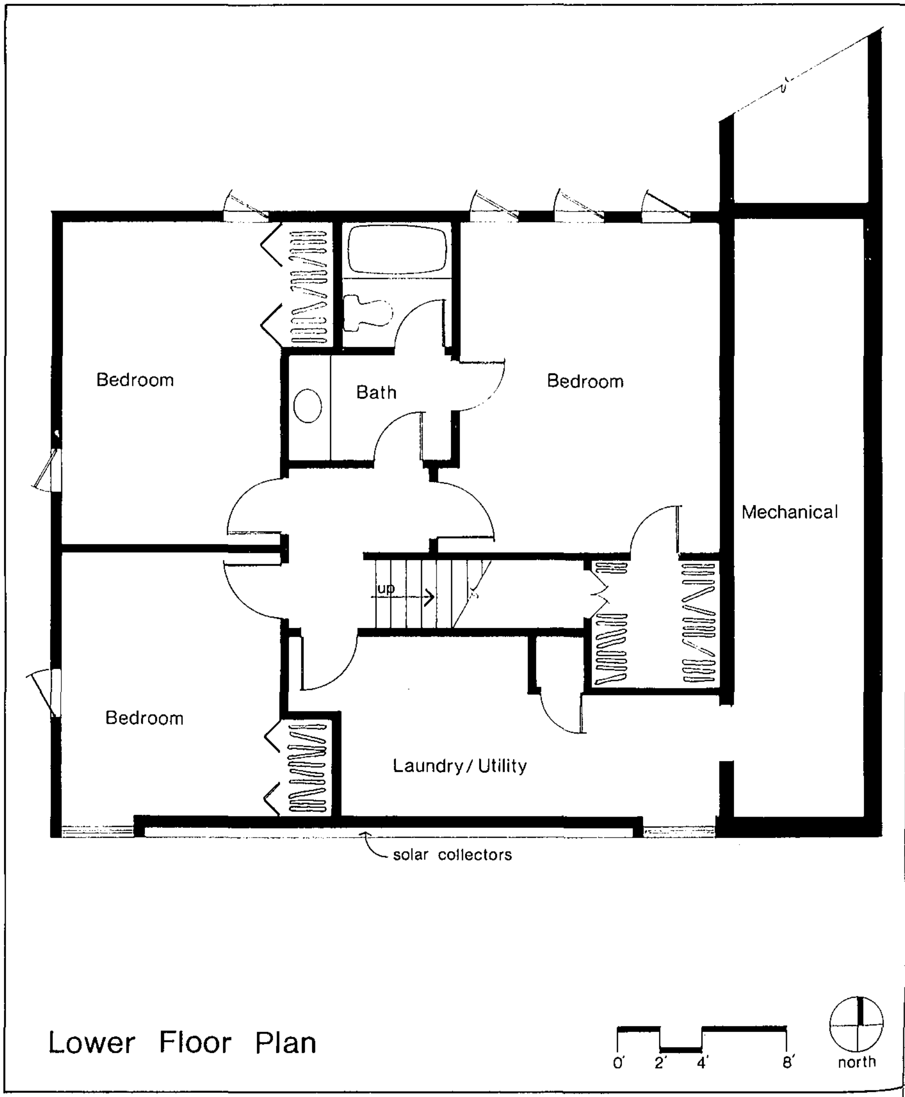
3. Construction of Envelope

The envelope was insulated for a minimum total cost for insulation and energy over a life-cycle period of 28 years. Attention to design detail included the use of thermal breaks in the frame construction of the house and appropriate sealing for the reduction of air infiltration.

3.1 Insulation Guidelines

The previously cited insulation cost analysis yields two results which can be used to assist in the sizing of the envelope elements of residential structures. Briefly they are as follows:

1) The amount of money spent on a heated envelope for all insulating elements (including windows) should be equal to the present value of all money to be spent on space heat (solar plus back-up) if minimum total cost is to be achieved over any life-cycle period.
2) Whether or not the optimum envelope (given by 1) is used, insulation R values for each



element (including windows) should be scaled in proportion to each other as the inverse of the square root of their cost per unit area per unit R value.

Annual cost curves which illustrate these rules are shown in the earlier paper. The general implication is that on a life-cycle cost basis most homes are underinsulated by a factor of two even when heated with inexpensive energy (natural gas at $2.00 per MCF).

3.2 **Use of Insulation**

Using the above two guidelines the house was insulated as shown in the Table. An examination of the building costs for this house has shown that use of the additional insulation increased the cost of the house by about $1 per square foot of floor area. Starting with a single glazed uninsulated house of standard construction, total insulation costs would have added about $1.50 to $1.75 per square foot of floor area to the cost of the house.

3.3 **Use of Thermal Breaks**

Attention was given to reducing the direct thermal conduction paths provided by the cement block foundation and the wooden framing of the house. Window headers were eliminated by placing single casement windows directly between the studs (24″ on center), and using 2″ x 8″ lumber as nailers at the top and bottom to complete a framing box to receive the window. The rim joist between the lower and upper levels of the house was recessed 1″ around the entire house, so an additional band of 1″ polystyrene could be added to reduce the edge losses of the upper level floor.

The foundation block was insulated on the inside so that the interior wall of the lower level which extends just below the frost-line (about 3 feet) would be insulated from the near freezing temperatures at the footing of the house. This decision was based on the data that in undisturbed soil there are on an annual basis about 6,000 heating degree days at the depth of the footing, and that cement blocks are good enough thermal conductors to cause an uninsulated wall to act as a fin which would conduct heat out of the structure and into the earth.

Roof trusses which allowed full depth ceiling insulation to the outside of the exterior walls of the house were chosen to provide minimum conduction losses at the ceiling-wall corners of the house. The wall-wall corners were framed using a single stud only so that these corners could be filled with fiber glass insulation.

3.4 **Infiltration Reduction**

Air infiltration was reduced by attention to detail in sealing electrical and plumbing runs which penetrated the shell of the house. Exterior openings in the envelope were well caulked; however, a notable exception to sealing detail was the conventional installation of standard electrical outlets throughout the house. Window frames were sealed using a portable kit to apply polyurethane foam between the windows and the house framing. A 4 mil polyethylene vapor barrier was installed on the warm side of the exterior walls, but no special attention was given to maintaining its integrity, and it was treated in about the same cavalier fashion as is done in most other new home construction. The house was sheathed with tongue and groove polystyrene, and further sealed by the application of 4′ x 8′ sheets of exterior plywood siding.

Insulation for Minimum Annual Cost

Surface	R(h-ft²-°F/Btu)	Construction/Insulation
Windows (South)	2 (day) 2.5 (night)	Double glazed with venetian shade between glazing layers
Windows (Elsewhere)	2.9	Triple glazed
Wall (below grade)	16	4″ polystyrene bead board
Wall (above grade)	30	8″ fiber glass in 2″ x 8″ stud wall plus 1″ polystyrene sheathing
Ceiling	60	16″ cellulose
Basement floor (perimeter)	16	4″ polystyrene bead board
Basement floor (interior)	8	2″ polystyrene bead board

Windows were chosen for their low infiltration characteristics, and exterior doors were equipped with magnetic seals.

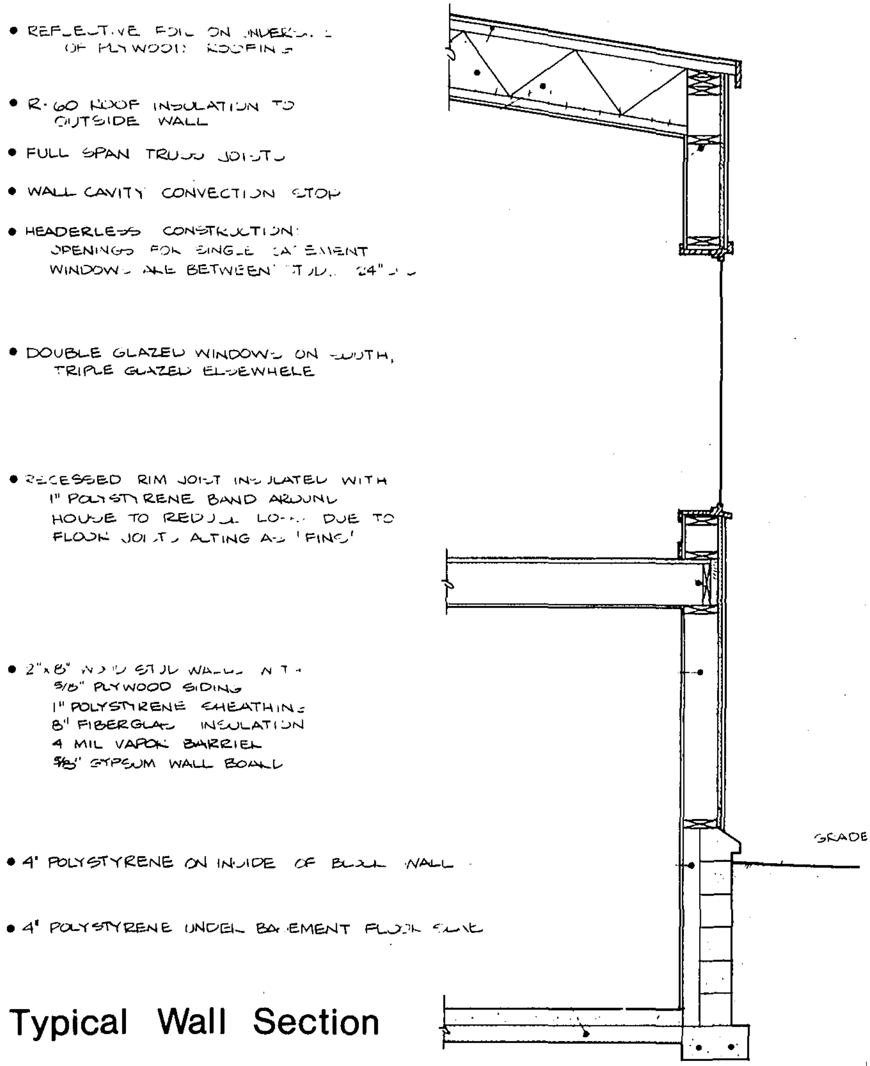
4. House Design

The house is designed to operate comfortably and efficiently on a year round basis, but has two basic seasonal arrangements, one for winter and the other for summer. The house has two levels, with about one-half of the lower level being below grade level. Living, dining, and kitchen areas are located on an open plan upper level; while bedrooms, bath, laundry, and mechanical areas are on the lower level. The bedrooms on the lower level have a natural tendency to be warm in the winter and cool in the summer.

4.1 Winter Operation

A double door entrance is closed off to provide for an air lock entry into the home. A long hallway assures that the outside door is closed before the door to the house is opened. A garage area to the north of the house shelters both the house and the front entrance from prevailing winter winds.

The interior of the 1,800 ft^2 house is heated by direct gain from 90 ft^2 of south facing double glazed windows which have been sized for daytime heating during the winter months. Beyond this direct solar gain, space heat is also provided by an air tight wood-burning stove, as well as by miscellaneous internal heat sources such as cooking. Air warmed by these sources of heat rises to a cold air return located near the top of the house from which it is circulated by a central blower system to outlets near the floor on the interior walls of the lower level. Air is returned from the lower level bedrooms to the upper level of the house via ceiling/floor grills which allow for whole house circulation. These grills are offset in the direction of the floor joists so it is not possible to see directly from one level to another. This system provides an effective way to heat the entire



Typical Wall Section

home using a single wood burning stove, and during the day it prevents the upstairs from overheating due to direct solar gain.

The intensive insulation of the house when coupled with its thermal capacitance yields a measured time constant[3] of 65 hours. The major thermal capacitances of the house appear to be its wood framing, gypsum board wall covering, and lower level concrete floor. Including all of the gypsum board and concrete, but only the internal wood framing, the thermal capacitance of the house is calculated to be 17,000 Btu/°F. About one-half of this value is contributed by the concrete floor with the remainder being about equally divided between the gypsum board and internal framing. Interior household furnishings have been neglected here, but could add from 10-20 percent to the thermal capacitance of the house. Dividing the total thermal capacitance by the measured heat load of 170 Btu/hour-°F yields a time constant of 100 hours, considerably longer than the observed value given above. This discrepancy is probably due to the fact that the concrete lower level floor is largely carpeted and only indirectly heated by warm air circulated from the upper level.

4.2 Summer Operation

During the summer sliding glass doors open up the winter entry so that it forms a breezeway for a screen porch attached to the southeastern corner of the house.

The interior of the house is cooled using the same forced circulation system as used for winter, except that the air circulated from the top of the house is now exhausted to the outside. Cool make-up of air is drawn in at ground level through bedroom windows on the lower level and is circulated to the upper level via the ceiling/floor grills mentioned earlier. Free convective cooling is possible by opening windows at the top of the house, allowing the warmest air to rise and flow to the outside. However, because it offers greater control and is independent of the prevailing winds, forced cooling has been used the majority of the time during the summer.

5. Operational Results

The heat loss of the house was measured to within 10% by observing the running time of its electric furnace. The heating load as measured this way was 4,100 Btu per degree day or 2.3 Btu per ft^2 per degree day. Another way to express this heat load is in terms of the number of air changes per hour required to produce an equivalent load. Using a house volume of 17,000 ft^3, it can be shown that this measured heating load is equivalent to .56 air changes per hour.

The average heating load may be calculated using monthly values for energy usage and degree days. Using these data from last winter the average load was found to be 2,870 Btu per degree day. Presumably the difference between the average heating load and the measured heating load is due to direct solar gain and internal heat gain. The fraction of the space heat load met by these sources may be calculated as follows:

$$\text{Direct Solar plus Internal Heat Gain Fraction} = \frac{4{,}100\ \text{Btu/DD} - 2{,}870\ \text{Btu/DD}}{4{,}100\ \text{Btu/DD}} = .30$$

Including these direct solar gain and internal heat gain factors the seasonal heating requirement is about 23 million Btu per season. This would yield a heating cost of about $70 per season for $2.00 per MCF gas burned with 65% efficiency. For electricity costing 4¢/Kwh the annual heating cost would be about $270.

Using an ethane gas tracer technique the natural infiltration rate of the house was measured to be .12 air changes per hour in a 15 mph wind.[4] This test was made with all the natural vents open (bathroom fan, clothes dryer, air-to-air heat exchanger); however, according to air pressurization tests conducted at the same time, the natural infiltration rate would probably be about .06 air changes per hour if these vents were sealed off. This last number agrees well with that found earlier using a crack length infiltration calculation method.[1]

During the first winter in the house this low infiltration rate allowed for the accumulation of water vapor, and a dehumidifier was required throughout the first heating season for the control of window condensation. During this current heating season an air-to-air counterflow heat exchanger[5] has been used successfully to control the accumulation of moisture and to provide ventilation air for the house. This heat exchanger provides about .2 air changes per hour and is turned on for about two hours each morning and evening. The heat exchanger typically will provide 80-90% of the heat required to warm the incoming flow of fresh air for a 40-50% relative humidity in the house. The two fans on the heat exchanger require a total power of about 250 watts, so for electricity costing 4¢/Kwh, the total monthly operating cost is about $1.20.

6. Discussion of Results

The measured heat load of the house is about 80% of the calculated load, and speculations concerning this behavior have been given previously.[1] However, it can be noted that even more insulation is justified, since its cost per R value is reduced by its better than expected performance.

The achievement of a very low infiltration rate with only moderate attention to sealing detail is remarkable. Since the achievement of this low infiltration rate required only about $200.00 of materials and two man-days of labor, it appears that it would be cost effective to include such sealing detail as a part of standard construction practice. Beyond the tracer gas method discussed earlier the infiltration rate of the house was also examined using a pressurization test which measured the number of air changes per hour when the house was pressurized to 50 pascals (.20 inches of water). Swedish standards for this test limit the air leakage rate to 3 air changes per hour. It is generally thought that it is difficult to build to this standard; however, the house discussed here had a leakage rate of less than 1.8 air changes per hour, indicating that this Swedish standard is an accessible goal for good building practice in the United States.

7. **Conclusions**

Experience with a super-insulated house indicates that attention to detail in envelope construction is central to good performance. Life-cycle cost amounts of insulation and careful sealing dramatically reduce annual energy consumption and call for a more careful consideration of internal heat management techniques, since internal heat sources become a large fraction of total space heat needs for these structures.

8. **Acknowledgement**

The value of this project was immeasurably enhanced by the enterprising spirit of the general contractor, Dallas F. Haas, and by the problem solving skills of the architect, Robert Quanbeck.

9. **References**

1. D. A. Robinson, "Insulating a Solar House," Proceedings of the 1978 Annual Meeting American Section ISES, Vol. 2.2, 196 (1978).

2. B. Hannon, R. G. Stein, B. Z. Segal, D. Serber, "Energy and Labor in the Construction Sector," *Science* Vol. 202, 837 (1978).

3. G. L. Moore, "Fitting a Handle and Scale on Thermal Time Lag," Proceedings of the 2nd National Passive Solar Conference, Vol. 2, 565 (1978).

4. D. T. Grimsrud, Lawrence Berkeley Laboratory, private communication, data to be published later with this structure identified as the "Ivanhoe House."

5. This is a finned heat pipe thermal recovery unit, Model TRU-120M, manufactured by Q-Dot Corporation, 151 Regal Row, Suite 220, Dallas, Texas 75247.

Passive Solar Home Heating

Jack Wobig
Mobile home rentals
Pine Island

My entry is on passive solar energy. When completed it will cover the south side of the house and also the west. I have had an experimental collector of only about 140′ sq. for two years now. I have learned a lot from this panel. The distance for air circulation should be great enough to lower the collector temperature to 100° or less instead of running 140° or more. Too much radiated heat is lost at the higher temperature. The experimental panel is only single fiberglass only about 4″ from the side of the house. This panel is using the wood siding painted flat black. This takes longer to release the heat than the plastic black sheeting I will be using in the new panel. We have approximately 1,300′ sq. of space downstairs here. The experimental collector on a good sunny day will keep the temperature at 68° to 75° from 1:00 until 6:00 at night with only about 140′ sq. of surface, and on the west side of the house. It would be much more practical to have it on the south side also, for the greatest heat is from 10:00 to 4:00 in the afternoon. The experimental collector is operated manually by the two windows that you see in the pictures. The windows are opened on good days and a small hole has been made in the lower part of the collector where the central air from the furnace forces cool air from the house over the solar collector. The fan is set on continuous run to do this. The new collector will be fully automatic with a thermostat control on a 20″ window fan. The idea of the fan allows for three different fore speeds to control the flow of air over the panel.

My idea is to get double duty plus from the new solar collector. I will list but a few things that it will accomplish when it isn't heating the house.

1. On cloudy days or days of little sunshine it will stop the escape of heat from the home because of the insulating quality of the dead air space produced in the construction of the collector.

2. It will reduce the wind chill factor on the wall of the house. I could list much more but I must close out this last page. The only moving parts are the 20″ window fan with a cost of $15 to $20. The total estimated cost of materials would be approximately $325. I will furnish the labor.

This plan could heat a good half of the homes and garages and other buildings that need heat. It can be 0° outside in March on a sunny day and collector on the side of the house will be 120° to 140°. Believe me, it works!

I am considering using black plastic louvers at an angle every 16″ inside the new collector. This will effectively double the collector surface.

Solar Energy System
William James
Insurance Underwriter
Northfield

The following criteria are requisites for an economic home solar energy system:

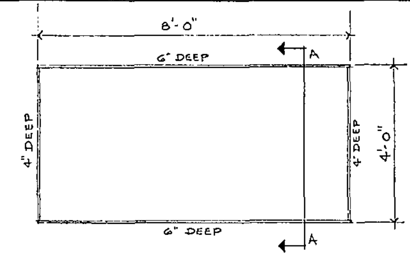
1. Simple design easily built by any homeowner.
2. Construction of commercially obtainable low cost materials.
3. Easily expandable for use in variable sized areas.
4. Should heat outside fresh air to achieve slight positive pressure inside home.
5. Minimal cost of automatic controls to move air from collector into home when solar energy is available.

My home-constructed system embodies all of the above criteria. Only one temperature switch and one small electric blower are required to move approximately 500 cubic feet of fresh heated air per minute into the air chamber of our hot air heating system. Average winter temperature allows the collector to produce air temperatures ranging from 100° to 145° with the automatic controls starting about 9:00 and continuing until around 4:00 — depending on the sun. These temperatures are greater during spring and fall days and the produced heat totally heats the house during daytime hours.

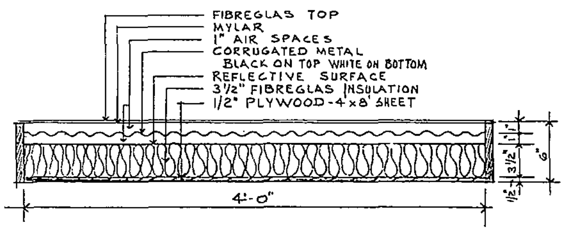
Using fresh air heated by the collector to produce positive pressure within the home minimizes all drafts of cold air from any source. There is also a side benefit of quickly dissipated foul cooking or smokers' odors.

We have an average size three-bedroom house. From November 1st to April 1st of the recent heating season, using our solar system for auxiliary heat, our gas consumption (including space heating, hot water, and a clothes dryer) was about one fourth less than anticipated for a house of this size. And this was during a colder than normal heating season.

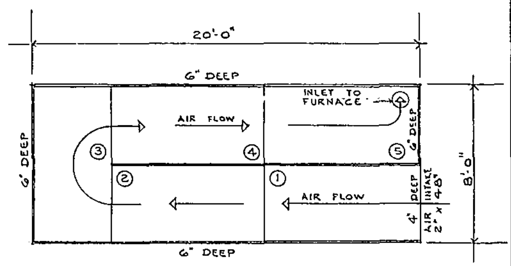
The total cost of materials for this unit was $525.00 at the time it was built in September of 1978.



PLAN - TYPICAL MODULE
SCALE: 1/2" = 1'-0"



SECTION A-A THRU TYPICAL MODULE
SCALE 1 1/2" = 1'-0"



PLAN - 5 MODULE ARRANGEMENT
SCALE: 1/4" = 1'-0"

Getting Our Act Together

Lance Lavine, architect

Getting Our Act Together
Judge's Statement
Lance Lavine
Architect

Let me begin with a few brief observations about the competition itself before proceeding to more substantial matters. It was a gas. I had a great time participating in this jury. What I had expected to be two days of work were transformed into two days of education. The diversity of projects entered and backgrounds of entrants were the kind of stuff of which learning is born. It was fascinating to discover that the man who recycles paper, cans, and bottles from the ECCO neighborhood in Minneapolis was just as aware of energy issues as the mechanical engineer who submitted an abstract energy game. Project diversity was compounded by jury diversity. It's hard to imagine geologists, anthropologists, engineers, architects, and representatives of financial institutions and state agencies gathering in a single space, let alone attacking a common problem. Each furnished me with information which would have been unavailable under normal circumstances enriching both my understanding of submissions and my sense of the energy issues of the world in general. Finally, the enthusiasm of all the people involved in this competition was infectious. If just a small portion of this commodity could be distributed to some of the decision makers who are directly confronted with our technological dilemma, I'd feel a bit more optimistic about the future.

On to more serious matters. In retrospect, my thoughts concerning our task fall into three major areas: the operational gap between appearance and performance; the methodological gap between grass roots applications and energy theory; and the ethical gap between efficient technologies and social needs.

The operational gap between appearance and performance which became apparent to me over the two days of the judging might be subtitled "What Makes Farmers Great." We saw a number of projects during the course of this competition which looked as if they *should* or *could* work. Closer examination usually revealed that the "could" or "should" was based on various degrees of mindless reapplication of solutions developed for other projects or purposes. The result was normally a lack of integration of the technology in question with the overall operation of the proposal. Technologies which might have been gangbusters when appropriately applied dwindled into energy cosmetics when arbitrarily superimposed on inappropriate systems. The entries of farmers were consistent exceptions to this general observation. Whether it was a passive solar collector constructed from recycled storm windows or a piece of rigid insulation with holes cut in it to protect animal drinking troughs from freezing, our rural brethren concocted solutions to their energy problems which stood up to close scrutiny. Farmers seem to have a talent for seeking out ingenious, creative, efficient, and economical responses to their problems. Thorough documentation of the performance of these projects demonstrated a keen pragmatic rural eye for the difference between energy cosmetics and performance. Problems which elicited complex, expensive, and technologically sophisticated solutions from their urban counterparts were frequently solved in no-nonsense, economical terms by farmers who practiced what they preached.

Practicing and preaching brings me to my second observation. There currently exists a deluge of small scale energy demonstration projects implemented by a small band of people with a high level of concern for environmental issues. A correspondingly weighty body of theoretical thermodynamic information is housed in the scientific domain. What appears to be missing is the mid-ground: a body of knowledge that is capable of converting theory to new and more appropriate energy strategies and technologies. Grass roots applications have certainly outshown theoretical approaches in coping with our most immediate energy problems, but this movement suffers from the same limitations that any process based primarily on individual experience does. Trial and error improves what exists but is not a noted methodology for going beyond these limits in either scale or scope. Thermodynamics, on the other hand, apparently hasn't seen fit to allocate major resources to solving such mundane problems as low temperature space heating. The gulf widens when those who might fall between these polar positions are to be identified. The engineers, architects, economists, legislators, bureaucrats, etc. who might be responsible for converting theory to method in the search for more appropriate technologies are a rare breed indeed. If we are in a survival mode as some people claim, this gap must be filled if time, scope, and quality of environmental solutions are to be served.

Finally, my most distressing observation concerning this competition was that few, if any submissions tied technology to social purpose. Apparently machines are machines and people are people. The closest approximation of an entry which mixed social consciousness with technological efficiency was a solar air bag which could be attached to the front of a mobile home. I would imagine that mobile homes represent both high energy per square foot users and housing for populations with generally lower than average incomes. Not a bad idea but one that was met by cries of "ugly," "inefficient," and "crude" from the jury. The solution was all of these but it was also, I think, a great deal more. Perhaps it represented an inexpensive energy solution for populations who could least afford to pay the rent on high utility costs. At any rate, this entry was not one of a number of proposals which might have been submitted by representatives of disadvantaged populations nor was it surrounded by projects which touted potential social impact. It remains an example of an isolated, almost socially conscious, energy conversion technology.

My thanks again to Huldah Curl and her compatriots for asking me to participate in this jury. I came away from the experience a bit richer and wiser as I hope you, the readers of this book, will be after examining the myriad of energy solutions included.

Farming

Biomass Crop Dryer
Greg Wieweck
Farmer
Buffalo Lake
Minnesota Energy Agency $1,000 Award

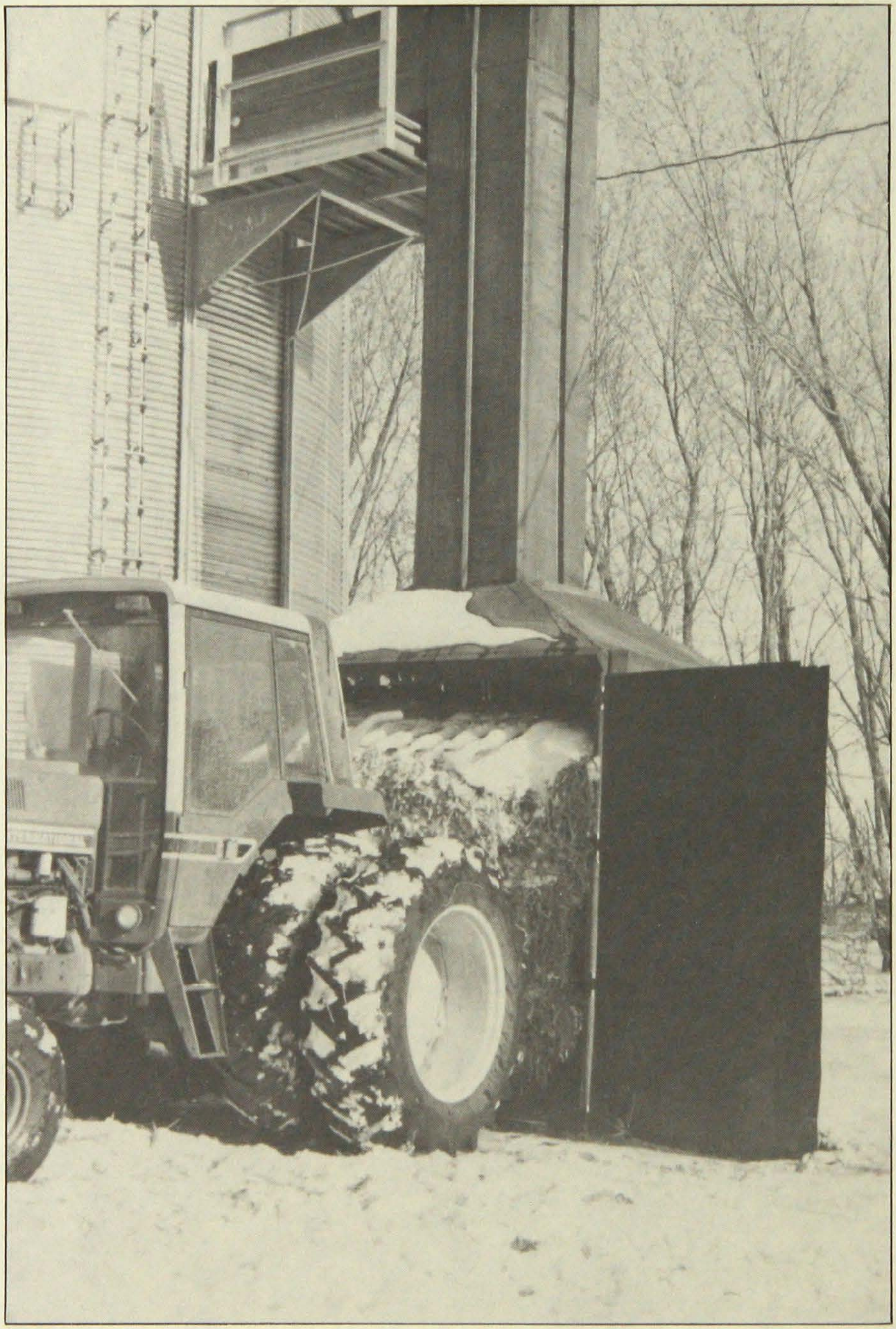
(The following is taken from an article by Mark Newhall, Associate Editor, Farm Show, Volume 3, Number 1, 1979, 8500 210th Street West, Lakeville, Minnesota 55044. Since the article was written, Mr. Wieweck has sold the patent for his crop dryer to Stormor, Inc., P.O. Box 198, Fremont, Nebraska 68025. Stormor plans to have units ready for distribution in the fall of 1979. They plan units not only for grain drying but also for supplying heat to a variety of farm buildings.)

If you knew you could dry your entire corn crop with just five acres of cornstalks, would there be any reason to keep buying LP gas? "Absolutely not" answers Greg Wieweck, a 27 year old farmer with an engineering background who appears to have beaten just about everybody else in the race to develop a practical way to fuel crop dryers with corn stalks, straw, and other low-cost residue. He's designed and tested a crop residue burner that could well revolutionize the crop drying industry.

Last fall he used his new stalk-fired furnace to dry his entire corn crop (16,000 bu.) with one ton stacks of corn stalks fed into the huge throat of the furnace, one at a time.

"I'm not experimenting" Wieweck said. "This is the only crop-drying system I own and it's the only one I need. I've proved, at least to my satisfaction, that we can get steady, productive heat from stalks, straw, and other crop residues. This burner will burn big round bales, square bales, or trash — anything around the farm that's combustible. And, because it uses a heat exchanger, there's no contamination of the crop being dried with smoke, soot, or other debris."

Wieweck used only five acres of stalks



to dry his corn, which came in from the field at 24 to 25% moisture and was dried to about 13%. "Think what could be done with 200 to 300 acres of stalk residue. In addition to drying all my crops, I could heat my barn, my house and have enough left over to distill alcohol for running my tractor and more."

Wieweck didn't start building his burner until last September, but had spent months working the design out on paper. A trained engineer who recently left industry to farm full-time, he says he knew, once he had the design drawn up, that it would work. "I couldn't believe that no one had done it before."

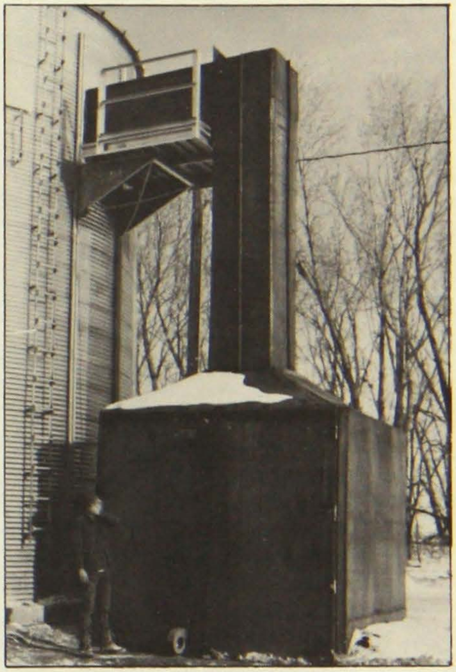
The burner combines a controlled burning chamber with a forced-air heat exchange system, meaning there are two layers to the furnace and chimney. Inside, residue burns and gives off heat. The heat passes through the inside walls to the second layer, completely sealed off from the burning chamber and filled with fresh air. That air heats up and is passed up the outside layer of the chimney and into the bin. Any smoke and ash exits through its own section of chimney outside.

It takes Wieweck "about a minute" to load the burner with a stack of corn stalks using his Hesston stalk mover. One stack will burn for seven hours — more than enough time to take out 10 points of moisture in 1,000 bu. of 24% moisture corn, says Wieweck.

Although his residue burner is built for his Stormor overhead bin dryer, he feels it will readily adapt to other bin drying systems. "I've already got plans for building a furnace for other types of bin dryers," says Wieweck, who has applied for a patent on his residue burning crop-dryer. He figures he saved about $1,000 in fuel costs last year by using stalks to dry the 16,000 bu. of corn produced on his own farm. He invested $2,000 worth of materials into the residue burner and "countless hours of engineering."

Here's a closer look at how it works: individual stacks of corn-stalks (or straw or other crop resudue) are loaded into the furnace and lit. If the fire isn't already burning, Wieweck uses a match, but says he would use propane to light hard to burn materials, such as moldy hay bales.

The furnace doors are shut and a small 1/10 hp. fan mounted at the bottom of one door is started. It feeds



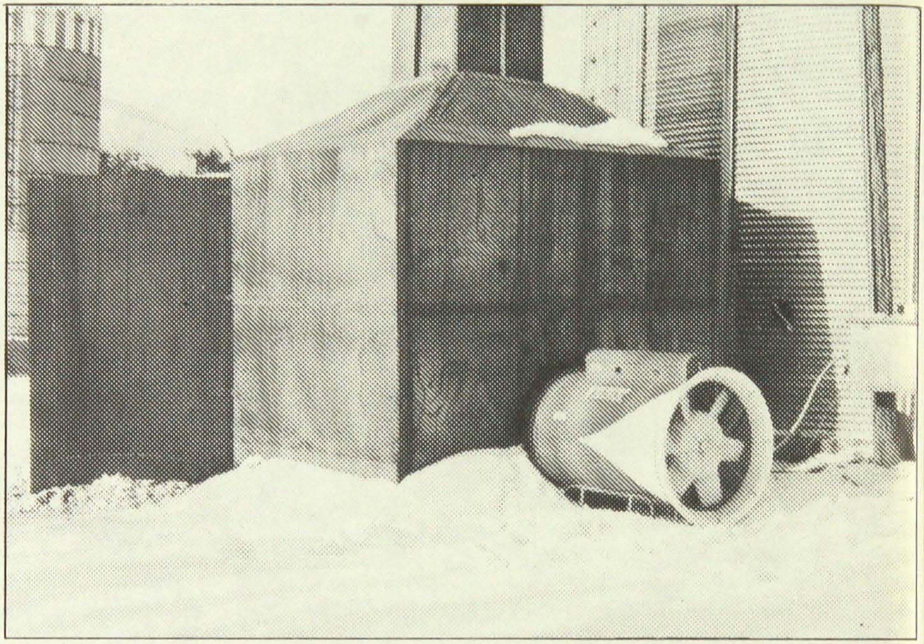
the fire oxygen and is connected to a thermostat measuring the temperature of the air leaving the burner and entering the dryer. When that air reaches drying temperature, the fan stops, stopping the fire. Wieweck says the fan runs 30 seconds out of every 5 minutes to maintain a 120° temperature. Three sides of the burning chamber (everything but the doors) are covered with a secondary chamber, with 4 inches of space between. A high-speed 36 in. fan forces air into the secondary chamber, up the chimney and into the bin. The air is warmed by the fire inside which reaches temperatures of 1,500°.

Ash and smoke inside the burning chamber are carried up and out of the chimney by nine 6-in. pipes. Fresh air on its way inside to dry corn rises in and around the pipes but is never exposed to smoke leaving the chimney.

That's all there is to it, explains Wieweck. "You control the burning of crop residue by controlling the amount of oxygen that reaches the fire. This system does it with a tiny fan, a simple thermostat and a sealed system."

The burner is 80 to 90% efficient. Attempts in the past to build residue burners have only been able to get around 10% of the heat possible out of the residue. As a result, according to Wieweck, they were wasteful and had to be filled too often. He adds that "one problem with using corn stalks is farmers say they don't have time to make stacks during harvest. Well, it took me 2 hrs. to make 18 stacks. I think that when the price of LP gas goes to 75c a gal., there will be plenty of time."

Wieweck says his residue burner can be used to provide heat anywhere it's needed on the farm. Bigger burners, and higher density balers and stackers, will make the system even more useful. For instance, he thinks stacks made by the new Hesston high-density stacker will burn 20 hours or more.



Insulate Your Water Too in Minnesota

E. C. Miller
Agricultural Engineer
Crookston
Honorable Mention

There are many ways to house livestock in northern Minnesota. Many types of livestock are housed in relatively cold buildings, but if they have shelter from the elements and ice-free water to drink, they usually do very well. In fact, in some cases they are healthier than their counterparts in warm, humid buildings.

Various combinations of heated waterers are on the market, floating electrical units and wood fired tank heaters seem to be coming back in some parts. In all of these, heat energy is lost to the air from the water surfaces.

The author of this test theorized that energy could be saved in many of these watering situations by floating an insulating material in the stock watering tank, leaving just a small 4-6 inch hole for the stock to drink through. This arrangement would prevent a large amount of heat loss from the surface of the water and require less energy to maintain.

Procedure for Testing Theory

Two identical styrofoam coolers were placed out of doors on a cold February day. They were filled with water to the same level. The water temperature was the same in each cooler at the start of the test. Weight of this amount of water was 22 lb. 4 oz. (10.09 kg).

A piece of styrofoam was cut to fit one of the coolers. It just floated free of the sides of the cooler and had a small hole cut to simulate the livestock drinking hole.

The coolers filled with water were placed outside on February 10, 1979 with air temperature at 2°F. The test was started with water temperature at 62°F. Loss of heat through the cooler wall was equal and not calculated.

	Outside Air Temp.	Uncovered Water	Water With Foating Insulation
Start	2°	62°	62°
One Hr.	3°	52°	58°
Two Hr.	4°	44°	56°
3 Hrs.	7°	43°	52°
4 Hrs.	7°	39° — Ice Formed on Top	52°

Temperature of the water in each cooler was taken every hour until the surface of the water froze. The record of data collected is shown above.

Results

The floating insulator retarded heat loss and resulted in a high saving of energy.

After four hours of exposure to the outside air temperature the uncovered water froze over. Water temperature under the ice was 39°F. In this same time period the water with the floating insulator still showed 52°F. The difference in Btu's lost in this time period was 289.25 over .703 ft² and the loss per square foot of water surface was 727.5 Btu's over the uncovered sample as compared to 317 Btu's lost over the sample with the floating insulator.

The author checks his own practical test of his theory at his outside watering location which serves six horses through temperatures of 20° and 30° below zero in northern Minnesota. An old deep freezer serves well as the insulated tank, but the author cautions horsemen that some newer deep freeze chests don't hold water.

The horses accepted the floating section easily and when snow piled up on the floater the author just picked it out and put the snow side down in the warm water.

The insulator could just as well be used to keep water cool in the summer. It could also be adapted in hot climates for flat roofs which hold water in the summer; it would act as a reflector and reduce water evaporation during the day.

Solar Heated Stock Tank

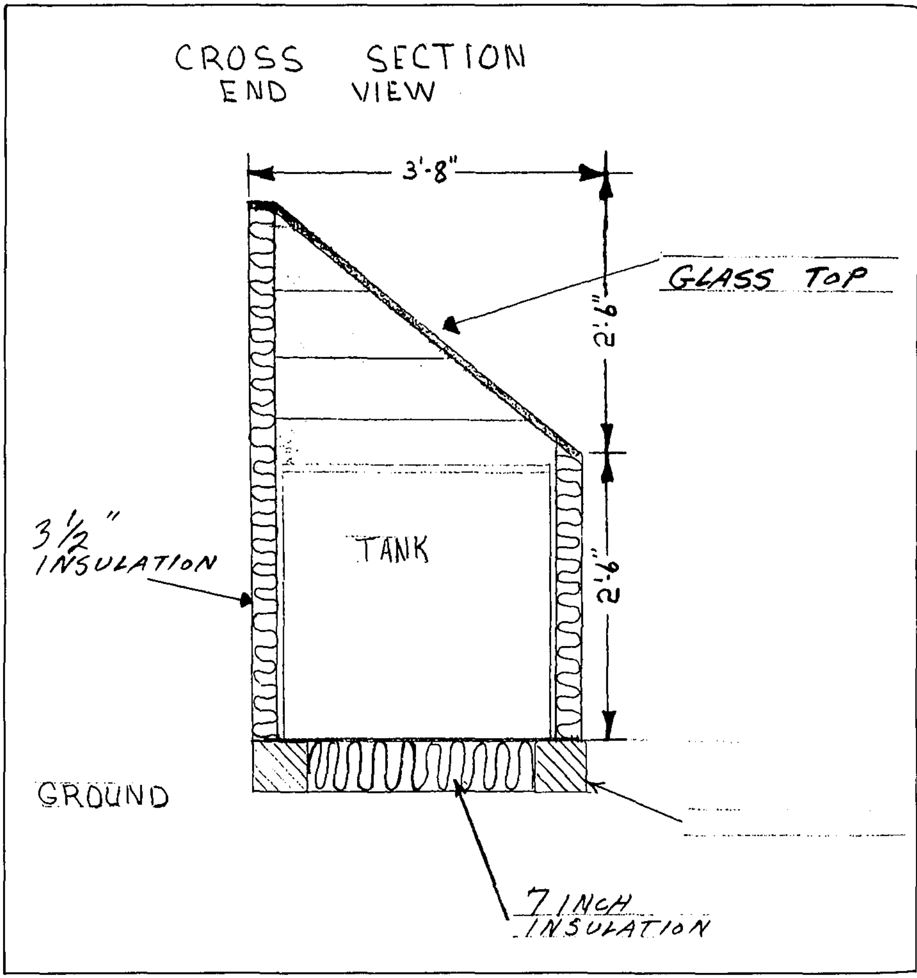
Maurice Faust
Clerk and Part Time Farmer
Pierz

I have a herd of 20 beef cows. They are outside all winter. Their only source of water is a stock tank that we fill once a day with a hose from a freezeless hydrant. This tank had a 1,000 Watt thermostatically controlled float type water heater. Most of the winter this heater would be activated and still ice would form in the tank. This, by simple figuring, convinced me it was a large and wasteful use of electricity.

I decided to let the sun help me with this problem. I started by making a base for the tank on the ground. This I made out of old 8″ x 8″ beams. I dug these into the ground about four inches. I then built the frame for the tank enclosure using 2″ x 4″ studs. The inside was lined with matched boards. Insulation was then put between the studs. Then another layer of boards and building paper, then siding. One end was left open to slide the tank in. Before the tank was put in the bottom, the 8″ space was filled with insulation. The far end of the tank was left 1″ lower, and an overflow pipe was put through the wall.

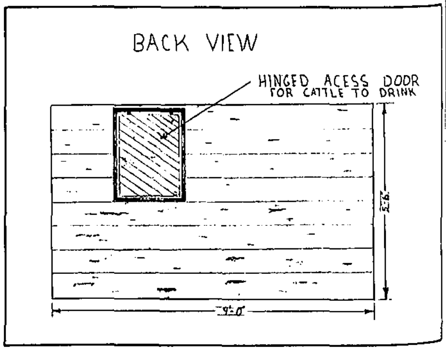
The top of the structure, south slope, is built out of glass. I used triple glazed glass from a discarded old grocery store showcase. The entire structure except glass is painted flat black inside and out.

The end I put the tank in from is enclosed on the bottom half with an insulated removable panel. The upper part has a hinged insulated door. If I have to replace the tank for any reason I can take off the end panel, slide out the tank and replace it with a new one. The back side of this structure has a door wide enough for a cow to put her head through and drink. When she is finished she pulls her head back and the door closes by gravity.

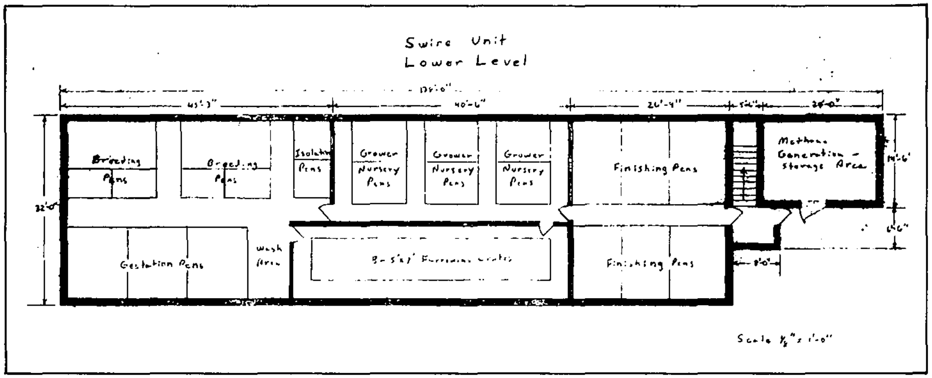


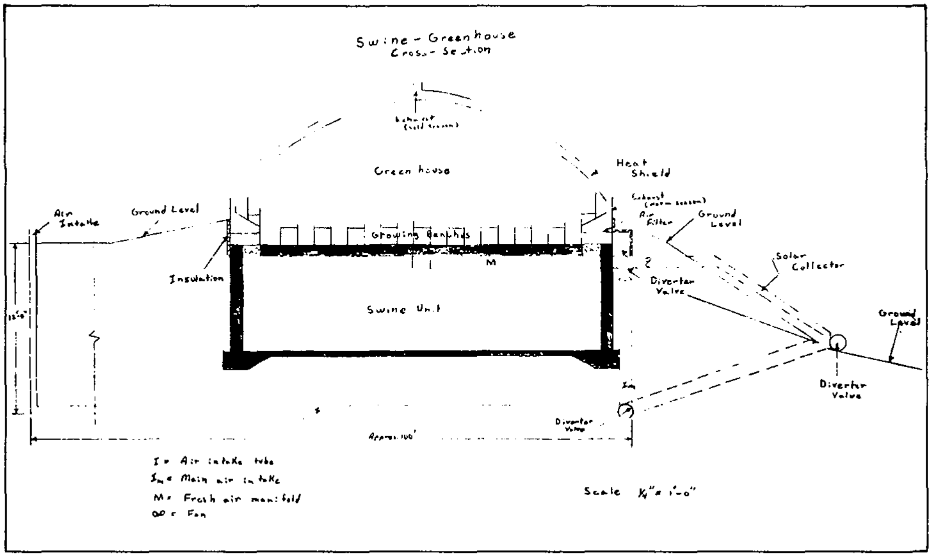
When the sun is shining the rays go through the glass top and heat the inside same as a hot bed. With insulation and the triple glass there is very little heat loss. In January on a clear cold day of 10° below and a wind chill of 40° below the air temperature in the enclosure got to 90° above. With the daily filling of 42° well water and very little heat loss we cut our electricity use by 75% or 1,800 K.W.H., saving about $72.00 per heating season.

The structure was built almost entirely from scrap, and paid for itself in the first winter season.



Energy Efficient Food Production Unit
Chuck Biggar and Jerry Nechville
Teachers
Waseca





Each year there has been a steady increase in the amount of energy used in producing plant and animal products. Production practices and the direction taken in construction have been largely responsible for this increase. This is exemplified by separated and two dimensional construction along with environmentally controlled livestock production units. With this plan we hope to show how tradition or current thinking may be changed to produce an economical and energy efficient unit using existing technology.

Objectives

To develop a commercial swine and greenhouse production unit that is energy self-sufficient and yet able to maintain optimum production. The unit design will provide for a sole-income enterprise for a family with average expectations. The attainment of an energy self-sufficient status will be accomplished by incorporating contruction design, methane generation, use of low energy or energy tempering concepts, and system design. The design would also be adaptable to other animal or plant systems.

Specific Objectives:

1. Recycling of waste for energy production, the remaining material to be used as a source of plant nutrients.
2. Make use of as many energy sources as possible (solar, geothermal, and methane generation).
3. Encourage efficient use of land by "stacking" production units.
4. Coupling units of varying requirements and/or production potential.
5. Cycling waste energy of one unit through another production unit for efficiency.
6. Making use of land that has limited crop productional potential (i.e. erosion problem).
7. Unit to be aesthetically acceptable.
8. Provide a healthful environment for the animals grown and the laborers.
9. Providing alternative income sources for economic stability and cash flow.

Plan and Operation

A farrow-to-finish swine unit built below ground level with a greenhouse located above is the basic production unit. The swine unit is large enough to finish 60,000 pounds of pork and the greenhouse would produce 14,000 pounds of tomatoes per year plus a summer crop of mums. The basic production unit may be adapted to different types of livestock production, lettuce production, bedding plant production, or others.

Air will be tempered by drawing it through the soil, from the solar collector, or in combination depending on energy requirements and the time of day. It will then be directed to either production unit depending on energy demands. Tempered air will also be drawn from the swine unit, filtered and then blown between two layers of plastic 4" apart forming a 4" thermal shield around the outside of the greenhouse. This shield will significantly reduce heat loss from greenhouse without serious condensation. This will be done by maintaining a low relative humidity in the swine unit (the source of the air), thus the problem of condensation should be removed.

Sample Operation Modes

Mode 1 — Night and Cloudy Days
Environmental Air→Soil Tempering→Livestock Moisture & Heat Removal→Greenhouse Heat Shield→Exhaust to Environment

Mode 2 — Cold Sunny Days
Environmental Air→Solar Collector→Livestock Moisture & Heat Removal→Greenhouse Heat Shield→Exhaust to Environment

Mode 3 — Summer Operation
Environmental Air→Soil Tempering→Livestock Heat & Moisture Removal→Exhaust to Environment

Methane will be generated using an anerobic digestor designed for ease of operation and low initial cost (insulated silo 12′ in diameter and 10′ high with insulated roof using a twice-a-day loading system — Penn State design). Methane gas will be used for heating water all year plus supplemental heat for cold nights in the greenhouse and/or swine unit. Calculations would indicate a balance of energy within the total unit (loss equals production). This would indicate a surplus of energy in the form of methane that may be used in heating a home or generating electricity and enough available for heating when temperatures fall below the temperature used in our calculation (−15°). A five day methane storage is built in for these times.

Estimated Costs

Construction costs: structure $100,000; generator $20,000; total $120,000
Gross Returns: swine $27,000; tomatoes and mums $9,000; total $36,000
Expenses including investment payback: $20,000
labor returns: $16,000
It is designed so that labor costs may be decreased by labor input of owner.

Summary

Estimates indicate the plan of an underground swine unit with greenhouse above appears to be energy self-sufficient, (methane energy would be produced in excess), and economically feasible. The construction cost and labor requirements are very close to that of conventional construction if methane unit is excluded. It also appears that the specific objectives will be achieved with this plan.

Technical Data

Swine Unit Size: 3,900 square feet,
Greenhouse Unit Size: 4,100 square feet,

Estimated inside temperature:

Greenhouse — minimum	70°F
Methane generator	95°F

Swine —	Finishing area	50°
	Farrowing area	65°
	Nursery area	75°
	Gestation & breeding area	50°

Livestock Data

	Number	Average Weight
Finishing	140	135 lb.
Farrowing (sow & litter)	8	300 lb.
Gestation & breeding	42	275 lb.
Nursery	70	40 lb.
Total	260	

Heat Balance Swine Unit

Assume soil temp. = 52°F @ 10′ below the soil surface

Total heat production of swine unit	127,000 BTU/hr
Conductive heat loss	30,000 BTU/hr
Minimum excess heat production — exhaust ventilation	97,000 BTU/hr

As temperature increases excess heat production will increase.

Methane digestor size −1,200 cubic feet will provide 30 day detention time, with twice a day loading generation potential = 900 cubic feet day = 540,000 BTU/day. Storage capacity for 4,500 cubic feet of methane will also be supplied. 25% of energy produced will be required to maintain generator at operating temperature.

Solar Collector
Covered plate unit constructed of 2″ insulation, ½″ plywood, corrugated metal collector plate and fiberglass cover.
Size 10′ x 120′ = 1,200 square feet
Estimated heat generation during January = 300,000 BTU/day

Soil Air Tempering Unit
10 — 8″ tile, minimum length of 100′ each

Greenhouse Heat Balance

Heat loss	98,000 BTU/hr
Total minimum heat gain[1]	114,000 BTU/hr
Estimated heat gain from solar collector — 8 hour day[2]	300,000 BTU/day
Energy from methane generation[3]	405,000 BTU/day

[1]97,000 BTU/hr from swine unit+17,000 BTU/hr from methane generator

[2]Excess energy from solar collector will be passed through heat shield during daylight hours to provide additional moisture control.

[3]Methane gas will be held as reserve fuel for extreme conditions when heat balance cannot be maintained.

Look Before You Leap

Look Before You Leap
Judge's Statement
Luther Gerlach
Anthropologist

There is the old proverb that necessity is the mother of invention. If that is so, then in respect to energy and environment, there should be considerable inventions, for the necessity is there. Some people seem to be counting on invention to save them and the country from the energy crisis, and, indeed, some are doing some inventing as the contributors to this energy design competition help illustrate.

Yet others say that the answers lie not in a technological solution or "fix" but in a lifestyle change. Many agree that both are important. Some people envisage technological change which gives us more energy to meet ever rising energy use and need. Others envisage such new technological shifts which require us to make do with less. Some envisage lifestyle change which enables us to achieve a higher quality of life which is still somehow more in harmony with the natural environment by using our resources more efficiently to achieve a peaceful and "soft" transition to a new era. And they seem to feel that we can make such adaptive change without being forced into it.

Others envisage a lifestyle change which will not be so soft and harmonious, but will instead be traumatic and painful. Some of these say that this painful transition will be forced on us inescapably by a major crisis or system of crises, to which government must respond by becoming increasingly authoritarian. Some even think such a change to using less energy is a kind of inevitable justice, a necessary purgative which the western industrial world has long deserved. They warn that unless we change in ways which are more wise, and unless we do so quickly and voluntarily, then we *will* indeed face a harsh future of living with scarcity under a stern and centralized government.

Of course, some people feel that there *is* no crisis because there *can* be no crisis, since energy shortages, especially of convenience fuels, threaten their whole image of themselves as Americans and their sense of well-being. Some feel the problem is political and can be solved if people in leadership demonstrate the proper political will, establish the correct policies, support the appropriate technologies, build the adequate facilities, and take the necessary international steps. Some feel the problem is in the economic sphere and feel that the answers lie in letting the market work.

Of course, it is likely that many people share a number of these ideas or alternate or fluctuate in their emphasis on any one of them. It is a time of uncertainty, of trial, of necessity, and indeed of invention or exploration, not only of physical technologies, but of social, political, and economic adaptation.

The various contributors to the Minnesota Energy Design '79 contest would appear to share a fair sampling of these diverse attitudes and suggestions for adaptation. Most proposed energy technologies which could provide new sources of energy supply or new efficiencies or savings to enable their users to maintain present high energy lifeways. A few suggested lifestyle change and one simply called for authoritarian government to control what that person regarded as energy wasting behaviors. A few offer models of technological changes in the style and mode of increasingly high density and living within concrete or earth envelopes. These models might well create in many people a sense of regimentation that would mean giving up various single family lifestyles and spatial freedoms to obtain energy security.

One of the winning inventions had a social rather than a technical focus. It was a group game to teach players through simulation and role playing, how social, political, and economic decisions create energy use decisions and conflicts. Presumably, people who played this game would learn how rational individual or micro decisions can add up to maladaptive macro or social decisions and, in the process, could learn how to make the necessary micro changes. Even more importantly, the players could understand energy flows more as a product of the way our whole society structures roles than a product of conspiracies or the behavior of specific individuals.

Strictly speaking, most of the submissions were not inventions which proposed whole new concepts or materials, but rather were innovations adapting established technology and hardware to new purposes. Examples were the retrofitting of homes to capture the warming sun, incorporating a proven wind turbine to ventilate an earth sheltered home, insulating a cattle watering trough to prevent water from freezing, and using agricultural residue as a fuel to dry corn. Some of the little inventions might have potentially big payoffs. For example there may be no need to heat large spaces for cattle if simple means have been found to prevent their drinking water from freezing. People may be helped to think and learn how their style of driving affects miles per gallon if a vacuum gauge is attached which shows them how many miles per gallon they are getting much as a speedometer shows them how fast they are going. The unspoken question in such cases is what would it take to get enough people to use these innovations to have a positive impact on energy supply and conservation. Is a proverbial "better mousetrap" just naturally accepted? Or would there need to be various types of political action to encourage such large scale use, such as outright government mandate or simply some type of tax incentives?

On the other hand there were innovations proposed which seemed desirable, if they were considered as operating in a kind of controlled situation instead of proliferating among many users, kept apart from the feedback and complex interactions which characterize the everyday world. As might be expected some inventions called for the use of wood as a fuel, and stressed that it is a renewable energy source. Like so many people who are now doing this, some proposed improvements in the way wood could be burned by modifying conventional fireplaces or in the way heat from conventional or modified fireplaces could be used more effectively to heat space or hot water in ordinary homes. In theory, this could reduce the amount of wood needed and used by each person burning wood, since each cord would produce more usable energy for heating. But is it not likely that once people make the investment to build such systems and then come increasingly to rely upon them for home space or water heating, they would significantly increase their use of wood? While this might reduce the consumption of other fuels, it would also contribute to the depletion of wood reserves. At the very least, such activity could call up the need to control wood cutting and burning. Will people look hungrily upon neighboring wood lots as a source of fuel? Will they look at wooded stretches of land and feel that the trees are just sort of going to waste, or that a little thinning won't hurt anyone, or that the wood there is almost like a free good? There are signs that owners of such wooded areas are already feeling the impact of such thinking. Look, for example, at the signs next to the "No Trespassing" and "No Snowmobiling" posters which say "No wood cutting or wood hauling here, Private Property." Would a major switch to wood burning require a system of annual chimney inspections and an infrastructure of chimney sweeping such as, for example, exists in Germany in order to control fire and pollution? What would a major use of wood or other biomass mean for the paper and wood products industry? Would it mean more market for some of its wood and wood residues or less supply for its needs and greater costs for its product? A product identified as wood waste or refuse is being used to fire a boiler for a school heating system in one innovation submitted to the contest. As "waste" which otherwise would have to be disposed of as a liability at a hard to find landfill, it would indeed be a most appropriate and inexpensive fuel. Presumably, the chief costs will be initially in the construction of the machinery and system to burn the wood and fire the boilers and also perhaps to process and transport the waste. But when does the use of such a waste product become so widely adopted that this becomes no longer a liability, but instead a valued resource which becomes increasingly short in supply and ever higher in cost? Will the innovators then have to turn increasingly to more efficiency to make such a system pay? When do the innovators or users then feel that efficiency can only be achieved by moving to ever larger scale, with increasingly standardized or mass produced equipment, and with decisions about use increasingly governed by net energy audits. Do we have here a process which will inevitably move away from the initial decentralized, do-it-yourself features which are now so prized by the innovators or the advocates of such projects? In short, are any of these technologies really so "soft" as to be practically without negative environmental or social impact? Probably not.

Perhaps the factor which most contributes to negative impact is the use of innovation by increasing numbers of people. Thus, the very thing which can be seen as proof of the efficacy of an invention, increasing adoption, can become that which jeopardizes its viability. For example, the introduction of a few automobiles probably seemed to be a wonderful answer to those worried about the problems of dealing with the overcrowding and fecal contamination caused by animals used in urban transportation at the turn of the century. The rapid growth of the automobile eliminated this problem, but . . .

In Southeast Asia and Africa in the early 1960's, experts worried about the air pollution and health hazards created by the fact that most people did their cooking using charcoal or wood. They also worried about how the increasing use of charcoal and firewood was depleting forests and woodlands in the developing countries, and how this was leading to erosion and the silting of dams. They encouraged a shift, first in the urban areas, and then in rural areas, away from wood and charcoal burning to the burning of kerosene in small stoves, including those made quite innovatively, often by local handicrafters and often from cast off tin cans and scrap metal. Now, suddenly, when increasing numbers have made this shift, kerosene has skyrocketed in price and dropped in supply. Were those experts who proposed the shift to kerosene foolish, guilty of not realizing that the petro age was perhaps ending before some people had even entered it, or were they simply looking at the problem too narrowly instead of thinking about the way many individual actions can add up to a maladaptive situation at the macro or large scale level? I suspect that the latter is more the case than the former, and I suspect that people continue to view problems and seek solutions in this non-systemic way. Thus, it seems best to look at each innovation contributed to this contest and ask, what are possible systemic consequences of each? Will they lead us to new traps? But first, most innovations do appear to be so small in scale and often to have such trouble surviving that the chief question is not what will the sum total effect of these be, but rather how can they be deployed on sufficient scale to have any effect at all.

It seems that one of the best ways to estimate the systemic impact of a technology is to see examples of it operating in real situations, and then to be sufficiently free from ideological, economic, or political commitment to it to observe its impacts and to project how they might grow and intersect with other systemic factors to create new and otherwise unanticipated problems. Some of those who feel that our country is indeed facing major energy crises, urge that we jump to large scale crash programs, or even crash legislation to provide the new hardware and software technology necessary to save us. But once so much time, effort, ideology, and so many political careers have been invested in a big solution, it becomes increasingly hard to perceive flaws in it or to estimate maladaptive system consequences.

Probably, the best way to avoid falling into new technology traps and making new big mistakes, is to experiment with lots of little projects or small scale prototypes and explorations, quite diverse in their characteristics and scope. For example, it is one thing to jump to a major use of peat as an energy source, and another to include it in experiments with a variety of biomass conversion projects. It is one thing to mandate a shift to gasahol, or to solar drying, or to the use of agricultural waste as the fuel for such drying; it is another thing to encourage many different individuals to experiment in these areas and to communicate their findings in some relatively open, but also systematic fashion.

Those impatient with this kind of piecemeal trial and error approach and worried that crisis and collapse is imminent, might, indeed, urge radical change on large and rapid scale. Those who don't think that there is a real energy problem might scoff at any attempt to try different approaches and to stimulate innovation, particularly at the grass roots. But those who know that there are, indeed, many energy-related problems and that they are not simply technological, but also social, political, and ethical, all interweaving in a complex system of life, will indeed be motivated to seek many *different* ways to make change, to adapt, and to innovate, remaining as *flexible* as possible, keeping *options* open, accepting *uncertainties* and *fluctuations,* yet always trying to find better ways. As part of this process, it will be important to communicate what has been found, to provide the innovator with feedback, but also to encourage others to press out on their own. The contributors to the Minnesota Energy Design '79, and indeed, the project itself, contribute to this process of adaptive change.

Larger Scale, Industrial, Planning

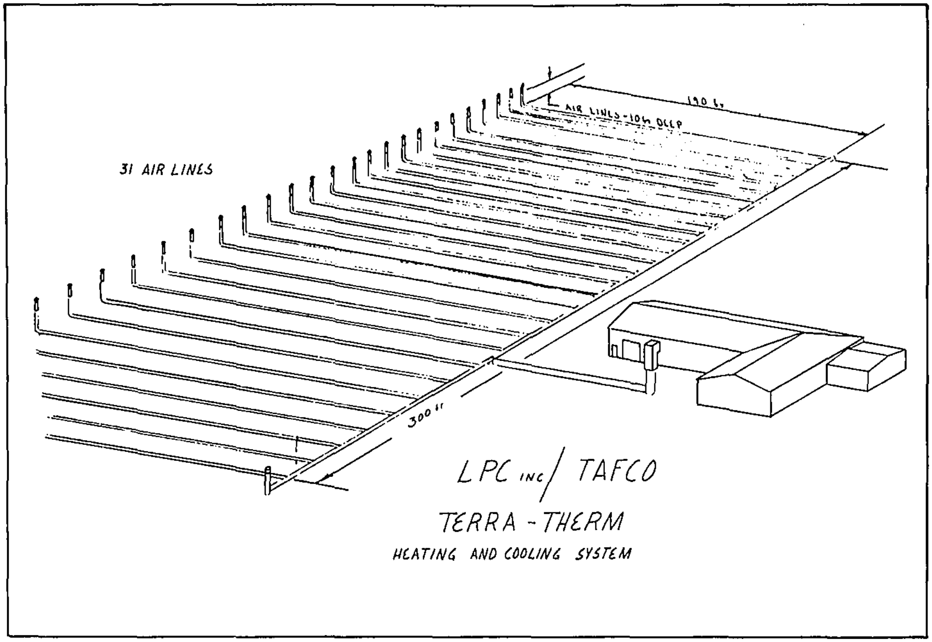
Earth Energy Heating, Cooling, and Ventilation System
Darrell Pearson
Engineer
Installation by The Lord's Power Company at Tafco Equipment Company, Blue Earth
Minnesota Energy Agency $500 Award
Patent pending.

Earth energy ventilation is a system for providing heated ventilation air in the winter and cooled and conditioned ventilation air in the summer. The system basically employs an underground network of pipes through which all ventilation air travels before it is introduced into a building. The winter heating and summer cooling are provided by the earth either giving heat or accepting heat from the passing air.

An earth energy ventilation system was designed by me for the Fabrication Division building of Tafco Equipment Company, Blue Earth, Minnesota. This system was installed in November, 1978. Metal welding and other industrial operations are performed in this building requiring the relatively continuous input of ventilation air for satisfactory building air quality. According to data supplied by Tafco the earth energy ventilation system reduced their winter heating costs by more than one half. This same system will, of course, provide summer air conditioning for the plant. Other earth energy systems designed by me have demonstrated their conditioning performance and value.

The production area of the building is approximately 24,000 square feet. Approximately 5,000 cubic feet per minute of treated air was provided the building about 16 hours per day, every day, this past heating season. The building, during the work day, was maintained at about 58° F.

Conventional heat was provided by a direct-fire make-up air heater. Earth energy air is supplied to the inlet of this heater and the heater blower is used to pull air through the earth system as well.



Date	Time	Outside Air Temp	Earth System Air Temp	Temp Gain
Jan. 6, 79	8:00 AM	− 8° F	+33° F	41° F
Jan. 6, 79	4:30 PM	− 3° F	+38° F	41° F
Jan. 7, 79	8:00 AM	−10° F	+34° F	44° F
Jan. 8, 79	8:00 AM	−14° F	+30° F	44° F
Jan. 8, 79	4:30 PM	− 1° F	+39° F	40° F
Jan. 9, 79	8:00 AM	− 6° F	+33° F	39° F
Jan. 10, 79	8:00 AM	−20° F	+30° F	50° F
Jan. 10, 79	4:30 PM	−12° F	+32° F	44° F
Jan. 11, 79	8:00 AM	− 9° F	+32° F	41° F
Jan. 11, 79	4:30 PM	+ 5° F	+37° F	32° F
Jan. 12, 79	8:00 AM	+10° F	+39° F	29° F
Jan. 12, 79	4:30 PM	+ 5° F	+37° F	32° F

Temperature data was recorded this winter and a sample of the data is included above. The earth energy air temperature is the air temperature as it leaves the system but before any furnace heat is added:

You will notice a substantial and continuous temperature gain. With a temperature gain of 40° F to a 5,000 cubic feet per minute air flow the heat energy produced per hour is:

Q = CFM Density Cp T 60
Q = 5,000 (.075) (.244) (40) 60 =
219,600 BTU/hr

This is equivalent to burning about 2½ gallons per hour of LP gas. This is substantial heat production and resultant savings of exhaustible fossil fuels. For the months of December, January, and February this past winter this Tafco building heating costs (natural gas and standby LP gas) were $2,211.00 instead of a computed cost of over $4,600.00 without the system.

The enclosed drawing shows the system layout. A total of approximately 6,000 ft. of 8″ dia. field tile are trenched in. Each 190 ft. long tile line has its own protected air inlet. The lines connect to a galvanized steel pipe manifold which connects to a steel header pipe which feeds to the building. All the tile, manifold, and header lines are nominally 10 ft. deep in the ground.

The whole underground system is on grade to a low point where a sump pump is installed to remove summer condensation and ground water leakage.

The earth energy ventilation system can be used on virtually any building that needs ventilation air. Reduced heating costs and essentially free air conditioning are available with this system. In terms of energy produced, both heating and air conditioning, the earth energy ventilation system will pay for itself within five years. Data and computations are available to substantiate this.

The wide incorporation of earth energy systems can make a substantial contribution to Minnesota's and other states' reduced use of fossil fuels and electric power. Their comparatively short pay back period and return-on-investment profile make them attractive investments to energy consumers.

The energy is there in the earth now. It is totally renewable. All we have to do is lay the pipe.

A Water Powered Heat Pump

Cob Burandt and Dean Tharp
Manufacturer, heavy duty starting units; co-owner, fabric shop
Stillwater

Honorable Mention

Technical Description

Concept

Our design proposes harnessing the kinetic power and the thermal differential of the Rum River at the Rum River Dam in Anoka, Minnesota. Specifically, we propose to adapt the present dam to vertical turbines coupled by flat belting to a heat pump. The heat pump would heat and cool adjacent city-owned buildings.

Background

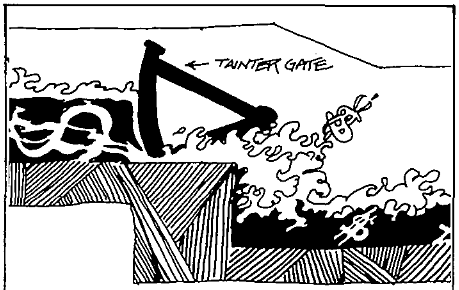
Harnessing the power of falling water is certainly no novel idea. Its applications and versatile uses were widely known in past civilizations. However, in this century hydro power has come to be regarded as a curious relic from another time. Consequently, in the rush to develop new, glamorous alternative energy systems, hydro power has been largely ignored.

A closer look reveals that hydro power is well suited to the conditions of modern society. Remarkable improvements in heat transfer systems lend themselves effectively to hydro mechanical applications. Yet, the marriage of these two deceptively simple technologies is relatively unexplored.

Many small communities such as Anoka have within their grasp all the elements desirable to make efficient use of this local resource. Among the elements: readily available water, increased demand for power, abandoned dams. In these elements lies an area that investigation, analysis, and experiment can make productive for the needs of today.

Specifics

The water powered heat pump



Dam at present

concept allows the harnessing of kinetic energy from the movement of water as well as use of the thermal differential. Consequently, the total energy produced at a given site is more with the heat pump than with that of a conventional hydroelectric facility.

Our design would allow removing heat from the river during cold months and disposing excess heat into the river during warm months. The proposed design would supplement the present heating and air conditioning systems in the adjacent buildings.

The design uses one of the oldest concepts known in water power: the flow-through powerhouse. The flow-through powerhouse is, simply, a turbine pit with a removable back wall. During high water, or if the reservoir requires draining, the back wall is removed and the tainter gate raised. Water will then flow through unrestricted.

The design requires no new technology. The technologies needed have been proven over 100 years. Vertical axis turbines were chosen because of their relatively long life, low cost, and uniform availability. Heat pump systems are available from many manufacturers across the United States.

Innovative

The proposed design is innovative in that it combines hydro power for heating and air conditioning with efficient use of air to moving water heat exchanger, whereas traditional uses of water power have been direct mechanical or conversion to electricity.

The advantages of heat pumps are widely known. However, at present, the efficiency of heat pumps is severely limited by the fact it takes electricity to run them. Our proposal eliminates this inefficiency. Conversion of moving water to direct mechanical heat pump is over 90% efficient.

It is interesting to note that steam powered heat pumps were in use many years ago. The primary problem encountered in the past was winter freeze-up. This occurred because the heat exchangers were placed in stationary bodies of water. Our design obviates freeze-up difficulties by locating the heat exchanger directly in the turbine pit. The action of moving water prevents freeze-up.

Wide-spread Application

It must be remembered that water power played a vital role in the growth and development of many Minnesota communities. In fact, many dams are located a few short blocks from the central business districts of these communities. As competing fuels and methods of producing power become expensive and oft-times destructive, it is worthwhile to reassess the uses of old dams.

The potential of water powered heat pumps has wide-spread application at many dam sites located in smaller communities. There are over 500 dams in Minnesota yet, at present, less than 30 are used for power production.

Environment

Since the Rum River Dam is an existing structure, it is not expected that negative environmental effects should be particularly important. The environmental compatability is excellent since no fuel is used and there is no pollution. The difference in water temperature caused by the submerged heat exchanger is negligible.

The average annual stream flow at the Rum River Dam measures approximately 300 cubic feet per second. It would require 60 million BTU's per hour to change a flow of 300 cubic feet per second 1° F. Since the total capacity of the proposed heat pump would be less than 5 million BTU's per hour, it can be clearly seen that the effect of the heat pump on the river's temperature would be minimal.

Economic Viability

The economic viability of installations of this type is very attractive since many of these water powered heat pumps can be installed in existing water passages at unused dams. This eliminates costly civil construction.

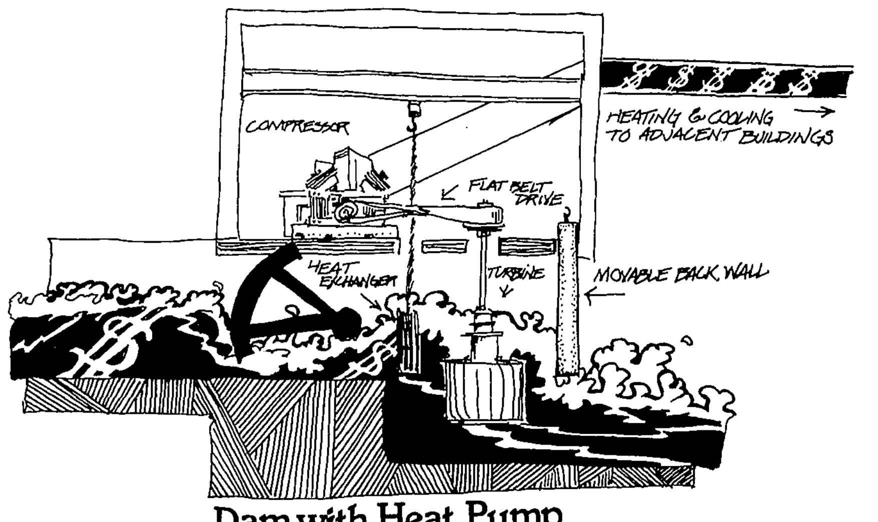
Capital costs of equipment would also be considerably lower than that of conventional hydro electric because electric interface equipment and turbine speed governors would not be necessary.

It is estimated by calculation of head and stream flow that the annual power produced would average 1 million killowatt hours per year. This power would be worth roughly $50,000. But in converting this power to BTU's with a water powered heat pump, the value of power produced would increase at least three times, or $150,000.

It could be said that the most attractive economic aspect of a hydro heat pump is totally unrelated to energy. The reactivation of a hydro site for energy production would convert existing dams from revenue consumers to revenue producers. Most abandoned dams, like the Rum River Dam, are maintained and replaced at taxpayers expense. The costs of replacing the Rum River Dam 10 years ago exceeded $750,000. This tax burden could be greatly reduced if the assets of energy production were applied against the costly liabilities of maintenance.

Practical Use

The energy of moving water is totally wasted at the majority of dam sites in Minnesota. One of the objectives of our design is to illustrate the range of possibilities for community energy production. The design serves to foster other efforts at viewing our energy problem creatively, using imagination and ingenuity in the place of large investment, and combining old techniques with small-scale technologies of the present.



Dam with Heat Pump

Air Conditioning Health Care Facilities
AEI Design, Inc.
Architects
Mineapolis

Statement of Problem

In future years, many existing health care facilities throughout the state will have to be air conditioned to meet state licensing requirements. This problem has been presented to AEI Design, Inc. and PACE Engineering, Inc., architectural and engineering consultants for the St. Peter State Hospital. Our goal was to air condition the buildings at a minimum original construction cost and also to maintain minimum operational costs in future years.

Concept

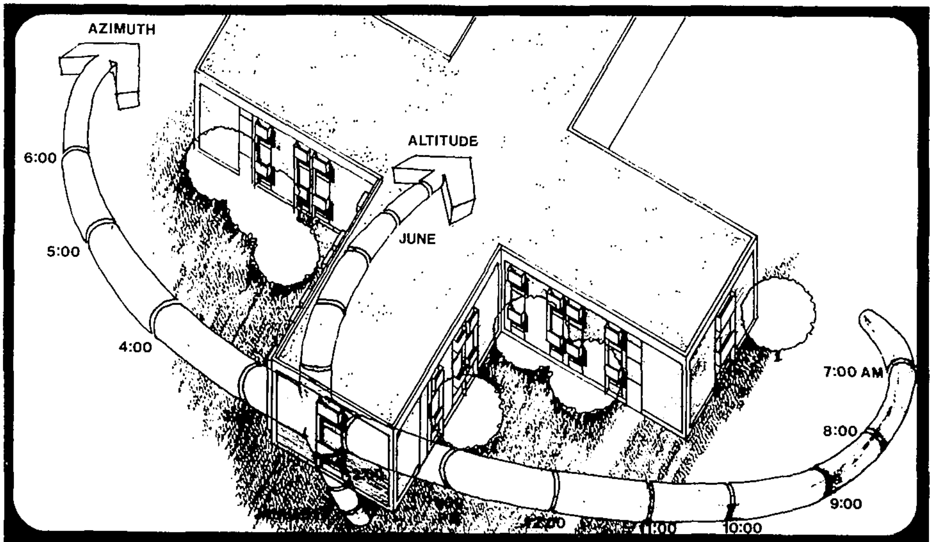
When calculating the initial heat gain for the building, it was documented that a major portion of the heat gain was through the windows. This gain was almost immediate, but the heat gain through the walls was delayed. If the windows could be shaded, the summer heat gain in the building would be substantially reduced and the necessity for variable control of air flow would be reduced. The reduced heat gain would allow a substantial reduction in the size of equipment, which would lower original construction costs for the mechanical equipment.

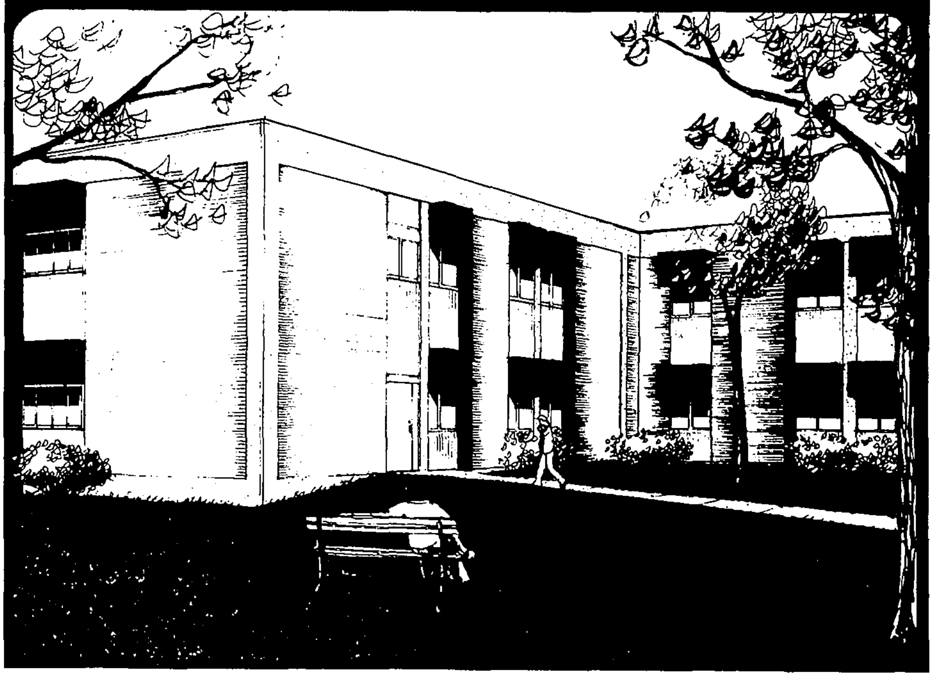
Goal

To design a shading device for the existing windows that would eliminate most of the summer solar gain through the windows, allow passive solar heat gain in the winter, and be aesthetically pleasing.

Process

The solar orientation of each window was determined and the altitude and azimuth of the sun were documented for each hour of the day on June 22, July 23, August 24, and January 20. The form and dimensions of shading devices for each orientation were





established to give maximum shading in the summer and minimum shading in the winter. Various materials were studied with the criteria that the sunscreens must enhance the appearance of the buildings, be economical to construct, be durable, and require little maintenance.

Design of Sunscreens

The sunscreens will be constructed of dark grey glass and steel angles with an enamel finish. The glass will reduce 86% of the solar heat gain. Sunscreens are free of windows to allow heat to dissipate into the outside air. Sunscreens are above or beside windows and do not block the view. Existing shade screen which has been installed on the windows can be removed to allow additional natural light to enter the building. Sunscreens have side panels to control the low angle summer sun in the morning and evening but are located so they will not block winter sunlight. The sizes of the sunscreens vary depending on solar orientation. Screens oriented to the east project 18", to the south 24", and to the west 36". Locations where the low angle of the sun is blocked by other wings of the building have no side panels. Because of the varying design of the sunscreens, the appearance of the building begins to respond to the environment.

Construction Cost Savings

1. Reduction in capacity of condensing unit and cooling coils.
2. Reduction in the number of variable volume control dampers required to maintain even temperatures within the building.
3. Reduction in interior construction required for access to ductwork for installation of dampers in ductwork.
4. 75% of the cost of shading devices was offset by savings in mechanical construction costs.

Energy Savings

1. Summer peak load reduction for cooling from 114,000 BTU/hour to 47,700 BTU/hour.
2. Reduced air movement requirements needed to handle reduced peak loads.
3. Reduction of 2.8 horsepower in fan energy. The fans on air handling run continuously.
4. Net savings of 24,000 kilowatt hours per year for each air handling unit.

Shading of Typical Windows Oriented to the Southeast

	June	January
7:00 AM	70%	—
8:00 AM	46%	4%
9:00 AM	58%	10%
10:00 AM	81%	16%
11:00 AM	100%	20%
12:00	100%	21%
1:00 PM	100%	20%
2:00 PM	—	—
3:00 PM	—	—
4:00 PM	—	—
5:00 PM	—	—
6:00 PM	—	—

Shading of Typical Windows Oriented to the Southwest

	June	January
7:00 AM	—	—
8:00 AM	—	12%
9:00 AM	—	24%
10:00 AM	100%	32%
11:00 AM	100%	36%
12:00	100%	32%
1:00 PM	100%	34%
2:00 PM	100%	24%
3:00 PM	88%	28%
4:00 PM	88%	30%
5:00 PM	100%	—
6:00 PM	100%	—

Shading of Typical Windows Oriented to the Northwest

	June	January
7:00 AM	—	Windows Not Exposed to Sun
8:00 AM	—	
9:00 AM	—	
10:00 AM	—	
11:00 AM	—	
12:00	—	
1:00 PM	—	
2:00 PM	100%	
3:00 PM	100%	
4:00 PM	91%	
5:00 PM	72%	
6:00 PM	100%	

Minnesota Multi-Housing Prototype
Robert Diedrich
Architect and Engineer
Minneapolis
Honorable Mention for Concept

Minnesota Multi-Housing Prototype

What appears is less a specific design than a technological/social response to this climate. It is probably most suitable for dormitory, motel, and beginning household needs. This requires getting used to the idea of sharing the elements of shelter that have major construction and energy implications while respecting the need for individual privacy.

Building Construction

An apparent redundancy of the double envelope permits each to find optimum structure and form to fill its need.

Exterior envelope must resist the extremes of weather; a light weight pole structure with insulated metal roofing and operating clerestory glazing is capable of providing a cost effective answer.

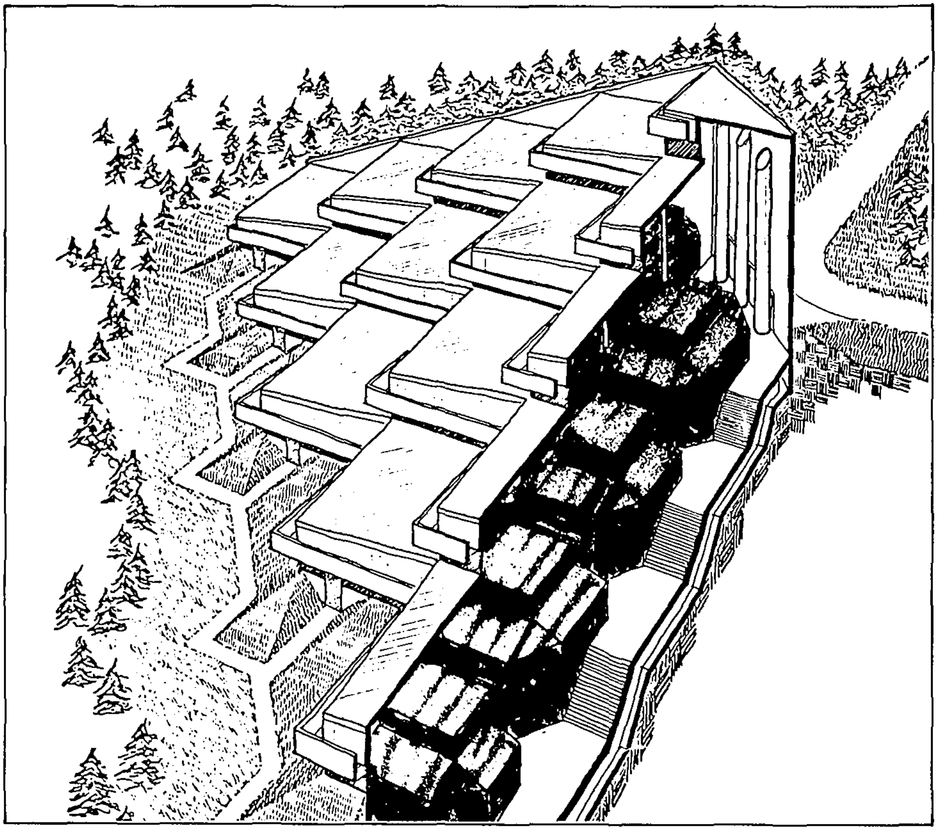
The interior enclosure should contain a radiant environment for human occupancy and is subject to the thermal and vapor stresses resulting therefrom. Low cost framing of steel studs and C-joists with an acoustical and fire rated covering such as sheet rock is highly adaptable; insulation and vapor barrier can be easily added.

Passive Energy

The building has an obvious orientation and shaping to control solar gain and maximize earth sheltering.

The exterior surface is extended only where it can enhance winter sun penetration, daylighting, and thermo-syphoning.

Doubling the envelope succeeds in controlling the radiant environment which has the most significant effect on human comfort.



Cost Estimate

DWELLINGS				
Mezzanine	400 sq ft	@	$ 3.00	$ 1,200
Top	600 sq ft	@	3.00	1,800
Wall	450 sq ft	@	5.00	2,250
Glass	150 sq ft	@	10.00	1,500
Doors	6	@	300.00	1,800
Electric	1,000 sq ft	@	1.50	1,500
Plumbing	5 fixtures	@	400.00	2,000
TOTAL				$12,050
EXTERIOR				
Shell	1,000 sq ft	@	$ 3.25	$ 3,250
Concrete Floor	1,000 sq ft	@	2.00	2,000
Walls	440 sq ft	@	3.50	1,540
Glass	300 sq ft	@	10.00	3,000
Mechanical	1,000 sq ft	@	1.50	1,500
Electrical	1,000 sq ft	@	.75	750
TOTAL				$12,040
Per Dwelling Unit				$24,090
Per Square Foot				$24.09

Solar Shielding — Summer

High Angle South

Low Angle East & West

Solar Shielding — Winter

High Angle South

Low Angle East & West

Thermo-syphoning — Summer

Thermo-syphoning — Winter

Radiant Conditions — Summer Day

Solar radiant intercepted by exterior envelope so that the highest surface temperature on the interior enclosure would be about 81° F.

Radiant Conditions — Winter Night

Radiant loss from interior enclosures to exterior would cause surface temperature to be 68° F minimum.

Mechanical System

Allows capture of excess heat at high point of space and introduction into earth storage as a normal part of system operation, (collection and storage therefore are not add-on costs).

Large scale of system can attain a lower first cost (40% to 60% per dwelling unit); higher operating efficiencies (10% to 15%) and potential use of alternate fuels.

Depending on what acceptable range of temperatures is between the envelopes (45° to 90° maximum) the supplementary fuel required would be 10% to 40% of the total.

With a significantly better radiant environment approximately 2,000 fewer degree days will have to be overcome with the heating system.

Infiltration can be introduced mostly during the day, the period of activity and when excess heat is available.

Cooling demand in summer could be reduced to a point close to internal load.

Energy Usage

Heat Loss (per unit)

Interior (t = 25)	
Top (600)	1,170
Wall (450)	855
Glass (150)	2,175
Ventilation (30 cfm)	810
Total	5,000 BTU/H
Exterior (t = 55)	
Roof (1,000)	3,300
Wall (440)	2,420
Glass (300)	9,570
Infiltration (150 cfm)	8,900
Perimeter	1,500
Total	25,700 BTU/H

Fuel Consumption (per unit)

Interior — Electric Heat

$\frac{5{,}000 \text{ BTU/H}}{(25 + 55)} \times 6{,}100$ Degree Days $\times$ 24 Hours/Day = 9.06×10^6 BTU

Electric Cost = $9.06 \times 10^6 \times \$6.74/10^6$ BTU = \$61/Year

Exterior — Gas Heat

$\frac{25{,}700 \text{ BTU/H}}{(25 + 55)} \times 0.4 \times 6100$ Degree Days $\times$ 24 = 18.75×10^6 BTU

Gas Cost = $18.75 \times 10^6 \times \$2.65/10^6$ BTU = \$50/Year

Total Energy Cost for heating per unit per year is \$111.

Step Backwards Into The Future

Wilbur Smith
High School Principal
Grand Marais

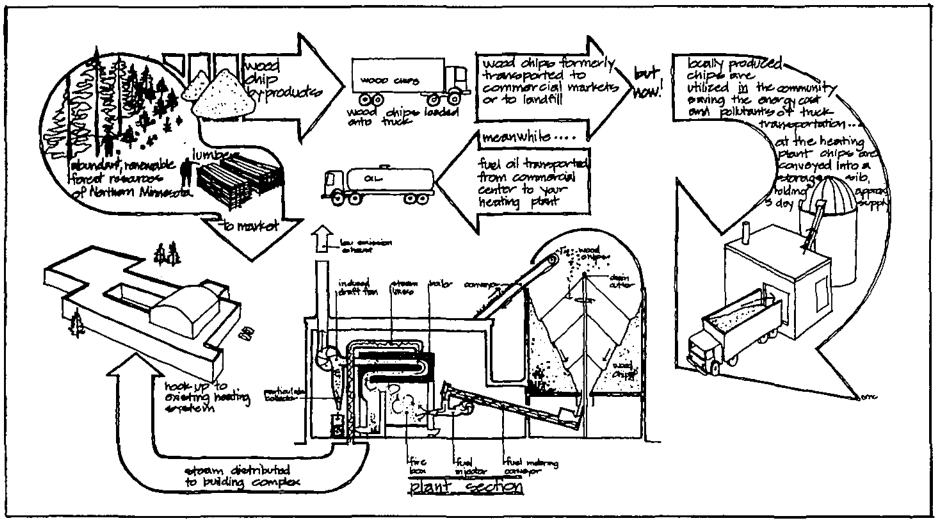
Note: this entry was received too late for consideration by the judges.

The Grand Marais School has built a wood chip fired boiler to meet future crises in heating oil and to cut heating costs. The school's existing low pressure steam system was not altered. The existing oil fired boilers are used as automatic back up for the wood boilers.

Construction of the boiler building and the change-over cost were approximately $300,000.

The school used to use approximately 65,000 gallons of (#2) fuel oil per year with an original estimated price of 40¢ per gallon. School fuel costs were estimated at $26,000 a year. The 1,000 ton BTU rating on waste wood was comparable to the 65,000 gallons of fuel. Waste wood, shaving chips, and bark from the Hedstrom Lumber Company, which set up the system, cost $6.50 per ton. Total cost for the waste wood would be about $6,500 a year, a theoretical savings of $19,500. The theoretical savings would pay for the unit in 15 years.

The boiler unit installed has a higher rating than needed by the school. This enables other low pressure steam users to make use of the school's



plant. The County Hospital and the County Office Building are both planning on buying steam from the school. This will replace their dependence on fuel oil.

Green wood chips can be used in the boiler interchangeably with waste wood. This gives the school the opportunity of using green wood should the source of waste wood cease operation.

This solution to the threatened shortages of fuel oil and rising prices are paying dividends in both monetary and fuel savings.

Traffic Powered Generator System

Nicholas Sanders
Graduate Student, Mechanical Engineering
Hastings

In 1985 the transportation industry is projected to consume 21 percent of our nation's energy. Within this industry, automobiles, trucks and buses will consume 75% of the total fuel used. This will amount to about 10,000,000 barrels of oil per day — a huge amount of energy. A device which would retrieve just a fraction of this energy would be very valuable. But how could it be done?

How the System Works

The system which is proposed and described herein utilizes the vehicle's weight and momentum to retrieve energy from the vehicle. The energy retrieved from the vehicle can be energy which would otherwise be lost, such as braking energy, or it can be energy which is retrieved as a form of tax on the vehicle, such as energy which is gained in going down a hill. The location and extent of the required system will depend upon the amount of traffic, the speed of the traffic, the slope of the road and the amount of braking energy that is used.

An ideal spot for such a system would be, for example, on the exit ramp of an intercity freeway. This spot is desirable because of the usual amounts of heavy traffic and the braking which is normally required.

The envisioned system consists of a high pressure hydraulic pump, which is actuated by an incident vehicle, a high pressure hydraulic accumulator, a pressure regulator and a hydraulic motor, which turns an electric generator. There are of course pump and motor controls, pressure regulators and sensing devices for automatic control.

The system works in the following way. An incident vehicle activates a hydraulic ram by moving across a raised flap. The moving ram creates

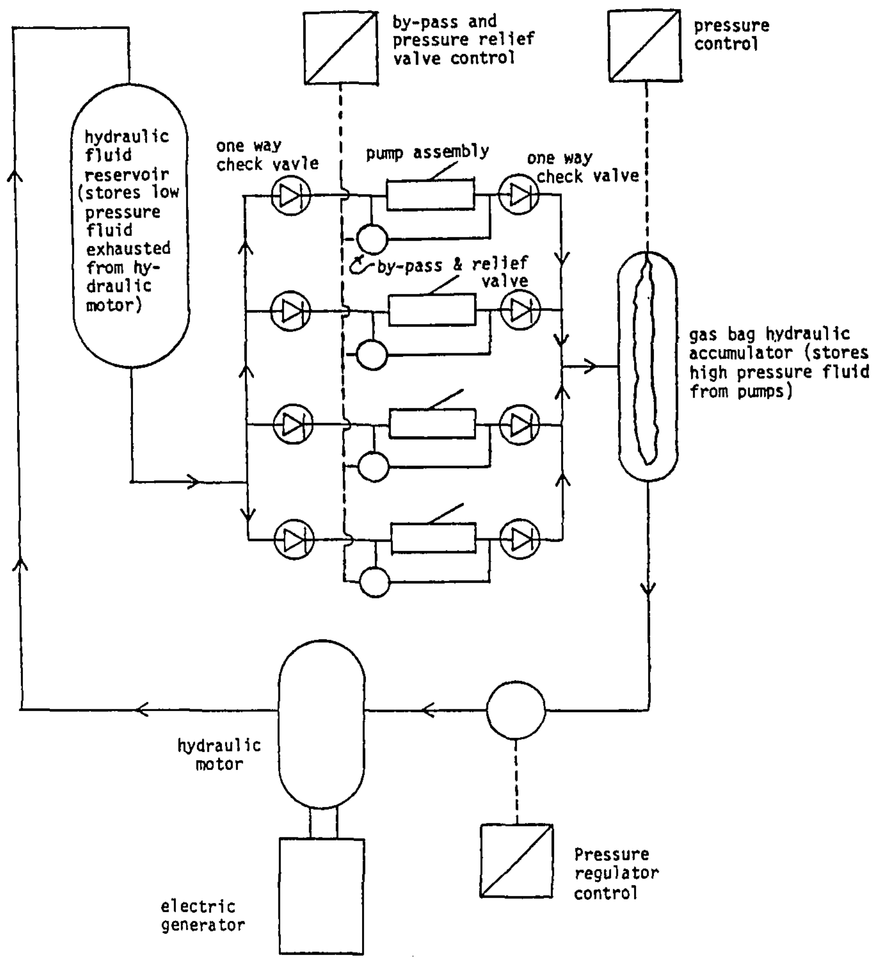


Figure 1. Schematic view of a traffic powered generator system. The arrows indicate the flow direction of fluid.

high pressure fluid which is stored in a hydraulic accumulator. The high pressure fluid is bled out of the accumulator at a constant but lower pressure and fed to a hydraulic motor which in turn turns an electric generator. From the hydraulic motor the low pressure fluid flows to a reservoir which in turn feeds the ram (or rams). A substantial amount of energy can be retrieved from a vehicle by requiring it to move over many flaps.

There are many engineering and design considerations which, due to space limitations, cannot be presented here. There are a few points though, that should be mentioned. Due to shock problems (taking energy too quickly from a vehicle) there is a limit imposed on the amount of energy which can be taken from a vehicle per pumping station (flap). The flap will also be required to return to its raised position fairly quickly, an estimation is about 1/10 second. This is so the flap will be in the up position for a rear set of tires and also so the station can handle heavy traffic.

There are many changes and/or modifications which could be made to the system without departing from the spirit or purpose for which it is intended. One such modification could be automatic control which would compensate for different vehicle weights and velocities.

The maintenance and repair costs of the system would depend upon its size and extent. It is projected, however, that these costs would be comparable to the maintenance and repair costs experienced by any equivalent sized power plant.

It can be seen then, that for a city the size of Minneapolis, with our extensive intercity freeway system, a power plant of 10 Mw (about 80 freeway ramps) seems very reasonable. One more point, the energy is of high grade and essentially free.

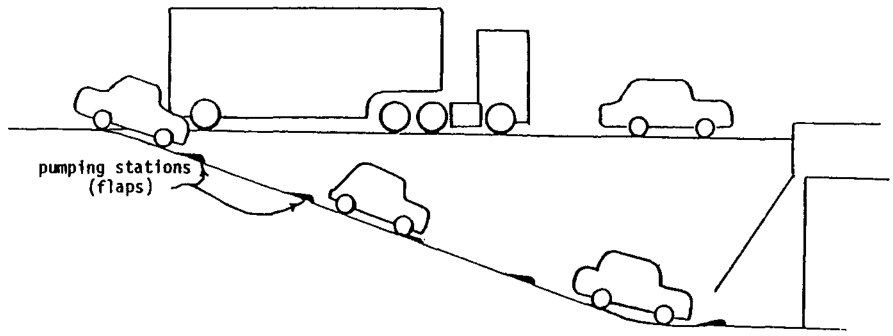


Figure 2. This figure shows the pumping stations installed on the exit ramp of a freeway.

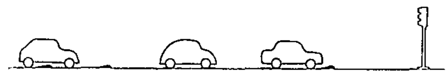


Figure 3. This figure shows the pumping stations installed on an approach to a traffic light.

Solar Evaporator for Waste Treatment

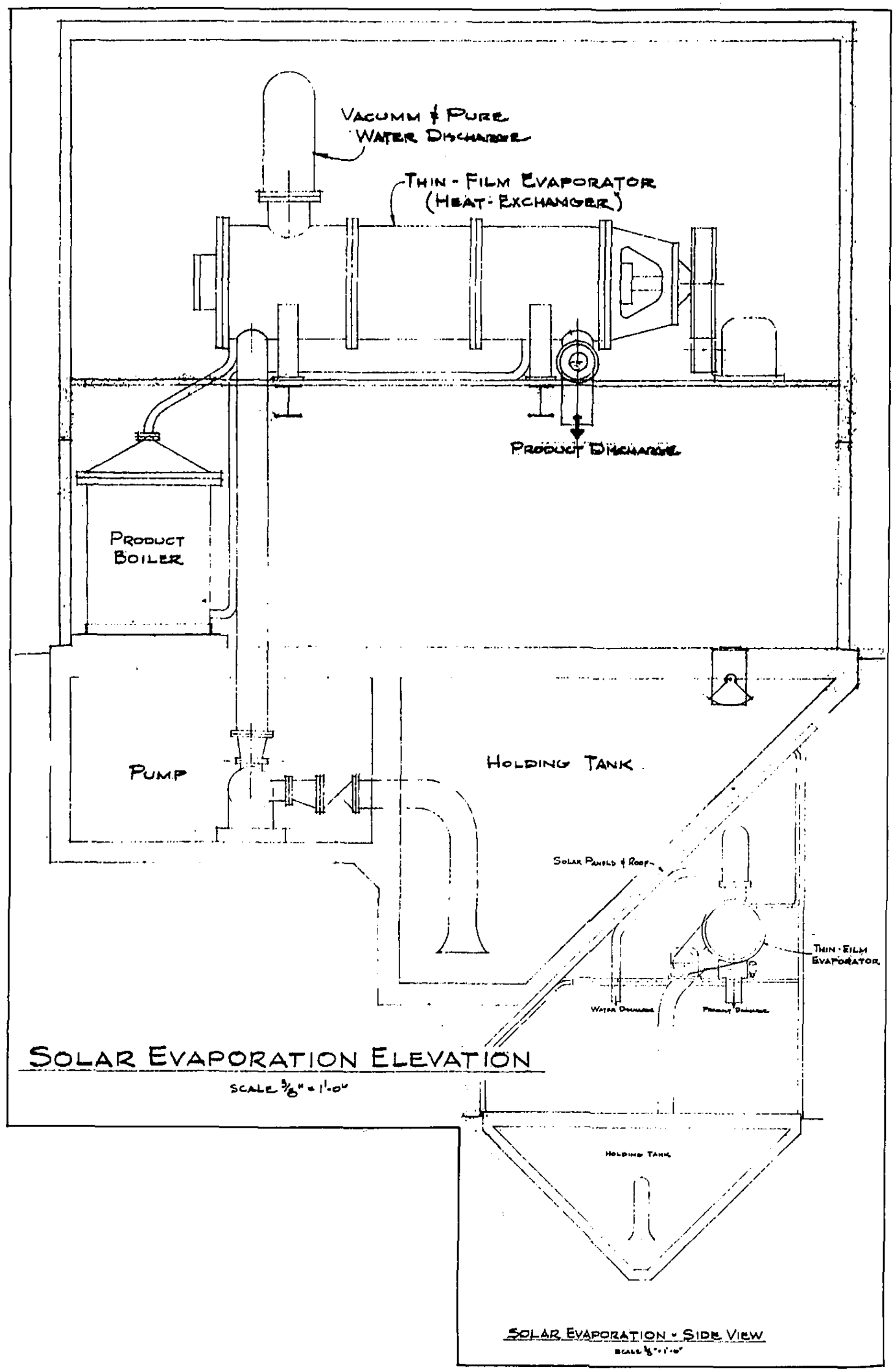
Albert C. Nunn
Civil Engineer
Wayzata

The thin film evaporator provides a high efficiency, low heat use of solar energy for a needed production process of dewatering and pasteurization of sludges. It replaces incineration with a method that produces from waste a useful product of fuel (10,000 BTU/lb) organic fertilizer, and pure water.

The solar panels shall be constructed to double as the roof (which will be acceptable in an industrial environment). The assumed temperature inside the building is 70° F. The panels shall use heat transfer oil (which has low specific heat, a high flash point, and will not freeze at low temperatures) to produce 350° F temperature for the heat exchanger.

The foundation of the building is a holding tank for the process and doubles as a larger heat sink. The sloping walls required for the tanks allow construction by placing the tank foundation into an excavated hole eliminating sheet piling. The foundation acts as a boat, eliminating leaks, cracking, and permitting the use of poorer soils.

As a back-up to the solar system, the 80% dry sludge fuel (heat value 10,000 BTU/lb) will be used in a hot-oil transfer boiler (better heat transfer, *safety, no freezing problems, easier* maintenance). The thin film evaporator will operate equally well with both heat sources and is the most efficient dryer known to man (being twice as *efficient as the present dryers used).* The thin film evaporator duplicates nature's method of separating water and resources, but in sufficient production to keep up with increasing amounts.



Process Evaluation Estimate

Heat supplied by solar panels = (350°-70°) × 0.8 specific heat × 39 gal/min × 8.34 lbs × 60 mins = 4,370,000 BTU/hr.

The proposed plant will produce 4,000 lb/hr of evaporated water and 16 ton/day of dry product.

Used as a fuel, the dry product will produce

$$\frac{16 \text{ tons} \times 2{,}000 \text{ lbs} \times 10{,}000 \text{ BTU/lb}}{130{,}000 \text{ BTU/gal \#2 fuel oil}}$$

= 2,400 gals of #2 fuel oil which, at 60¢ a gallon = $14,440/day.

As a fertilizer, 16 tons × ($100-$5 transportation) = $1,520/day.

Product worth: $1,500 × 365 × 0.8 (process off-line) = $438,000/year.

Process Cost

Labor (2 men)	$50,000
Utilities and miscellaneous	30,000
Capital	
Solar Equipment: 2,000 sq ft at $15 per sq ft	30,000
Building: $80 per sq ft × 1,200 sq. ft	100,000
Equipment and mechanical	370,000

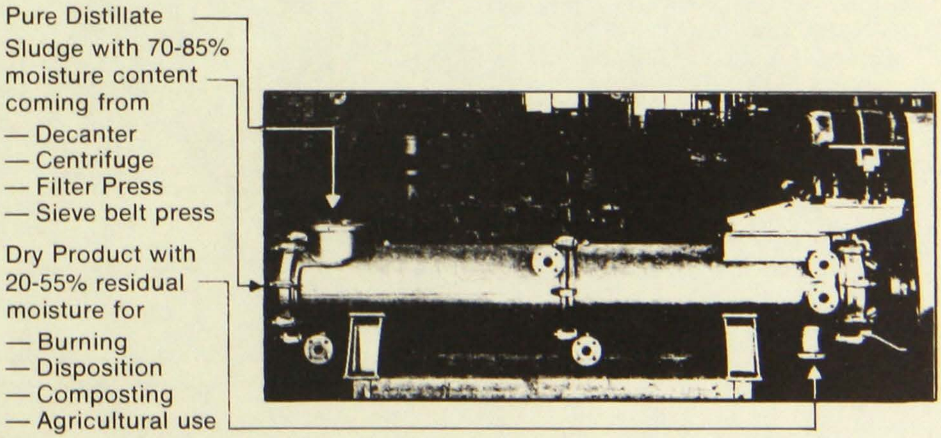
Capital and interest cost (using 7% interest E.P.A.) 1.145 × $500,000 = $572,500.

Pay back $= \frac{\$652{,}500}{\$438{,}000} = 1.5$ years.

The main features of this equipment of very reliable design, which has been tested industrially under most severe conditions are the following:

- — Contact drying, therefore no air pollution and no odour problems.
- — Independent of the preceding process stage (filter press, centrifuge, etc.).
- — Independent of the following stage: dry products with 45-80% total solids can be obtained with the same machine.
- — Clear distillate free of solids is obtained. Therefore, no additional treatment required.
- — High specific throughput rates result in rather compact installations and low investment.

	Current Method	Solar Evaporator Method
Product Worth	Incinerator ash must be disposed in specially constructed and soon overloaded landfills at added cost $15 per ton.	Net worth $95/ton as a fuel or fertilizer.
Total Operating and Maintenance Cost	Incinerators operate at 1500° to 2000° F. High maintenance cost. Require special operator skills. Use oil and gas as back-up. Cost $100 per ton.	Simple rugged equipment low temperature and pressure applications. Maintenance low. Solar operation cost extremely low. Cost $20 per ton.
Capital Cost	Capital intensive; inflexible use of materials; costs higher than industrial.	Additional funding available. Cost in line with industrial construction.
Safety	High temperatures and pressures; complex operation; noise and air pollution; chemicals cause high corrosion.	Simple operation; minimal noise and air pollution; no chemicals.
Energy Cost	High energy cost of removing moisture by incineration. Use of scarce heating oil and gas. Materials of construction energy intensive. Expensive and scarce chemicals used.	No fuel required.



Program Center, Girl Scout Council, St. Croix Valley
Delano Erickson
architect
St. Paul

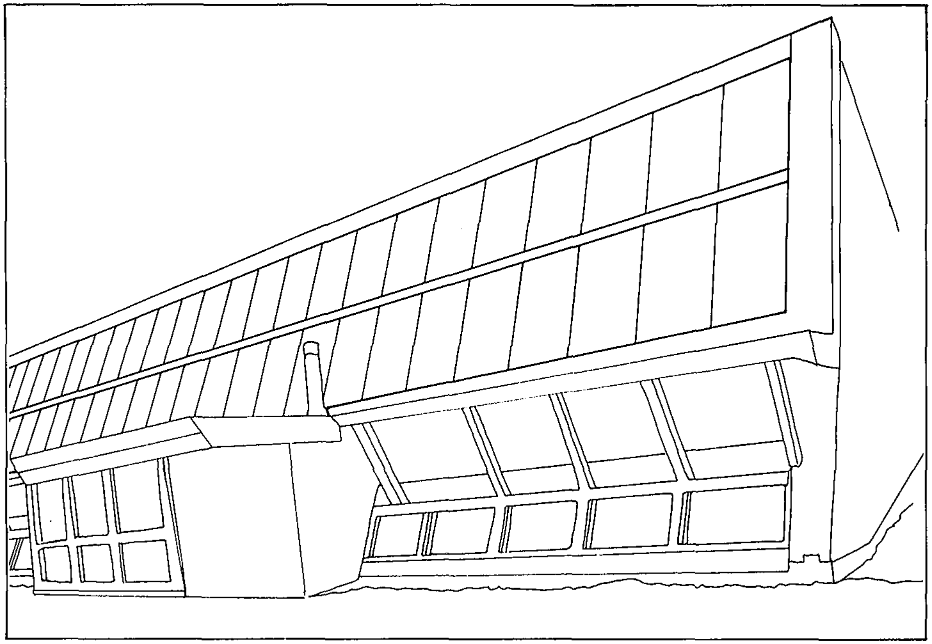
Design note: the building also has a wind generator funded by the Minnesota Energy Agency.

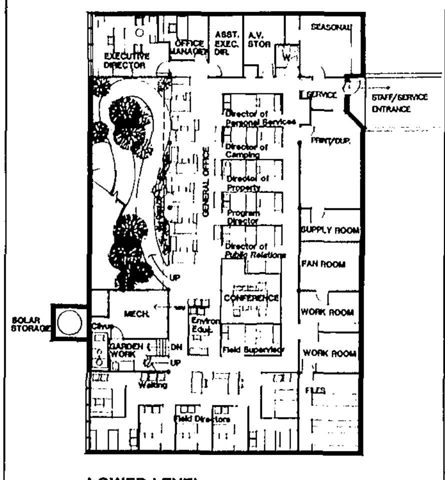
Solar Heating

The building heating system is described as a solar-assisted heat pump system. The heat pump also provides cooling during the summer by reversing its cycle. The main components of the system are the solar collectors, the heat pump with its associated chiller and condenser, the electric boiler, the heat exchangers, and the hot water storage tanks.

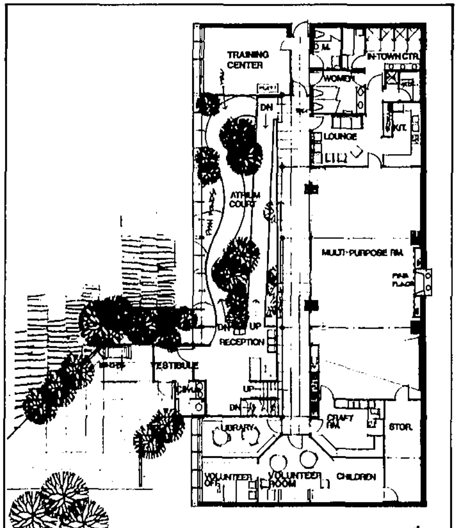
Air-to-air heat pumps do not work efficiently when the ambient temperature goes below 10° F. Also, the efficiency of solar collectors decreases as the temperature difference between the fluid inlet and the ambient temperature increases. In this solar system, both of these problems have been solved by utilizing an air-to-water heat pump as a booster for the fluid temperature coming off from the solar collectors.

The operational modes are as follows: the ethylene glycol solution is circulated through the solar collector panels, picking up heat from the rays of the sun and transferring this to the building's fan coil units. The fluid is passed through the heat pump condenser and the electric boiler. If the temperature obtained from the sun is adequate for heating, no additional heating is provided by either of these devices. If the temperature is lower than required, the condenser will transfer heat from the heat pump to raise the fluid to the required temperature. If the outside air temperature is such that the heat pump cannot work efficiently, the electric boiler will provide the additional heat required. The system also includes a direct heating bypass





LOWER LEVEL
GROSS AREA 7344 sq. ft.



UPPER LEVEL
GROSS AREA 4620 sq. ft.

line which can provide heat from the solar collectors directly to the building's fan coil units.

The heat storage mode is utilized when the building's heating requirements are answered. The fluid is directed to the first heat exchanger whereby the heat is transferred from the glycol solution to a water solution which is stored in a 1,500 gallon storage tank. This water loop also passes through another heat exchanger which transfers heat to the domestic water system, thereby providing the heated tap water for use in the kitchen, bathrooms and showers. When the sun is not shining and heat is required, the same storage loop will transfer heat to the building's heat system via the heat exchanger. The reason for two heat exchangers in the domestic water supply is to guard against any pollution from the ethylene glycol solution to the building tap water.

The total system combination of heat pump and solar collectors will provide approximately 65% of the building's heating requirements as compared to a conventional building. The equipment in the building and its related piping is color coded to better understand the distribution and working of this system.

Design Criteria

Number of Collectors 72
Area of Collectors 1,296 sq. ft.
Energy Collected by Solar Collectors 152×10^6 BTU/Year
Energy Needed 306×10^6 BTU/Year
Solar Contribution (approx.) 50%
Solar Storage Tank S-1 1,500 Gallons (Heating)
Domestic Water Storage Tank S-2 200 Gallons

Heat Pumps

Cooling Capacity 283,000 BTU/Hour
Heating Capacity 152,000 BTU/Hour

Chiller

Capacity 25 Tons

Condenser

Heat Exchanged 200,000 BTU/Hour

Electric Boiler

Capacity 30 K.W. = 102,000 BTU/Hour (approx.)

Conservation

Designing with and for the environment were the prime criteria for this structure. Placement and orientation of the building on the site was done for maximum solar energy gain. The south-facing sloped wall is at approximately 65° to accommodate maximum winter sun angles for the solar collectors. Triple-glazed windows located below the solar collectors allow maximum solar energy to penetrate the structure during the winter, and with the design of the roof overhang, minimize solar gain in the summer.

The prairie grass roof berming around the building and concrete structure create a heat sink and thermal lag for the building envelope which tends to moderate the interior environment. The prairie grass roof also cools the building in the summer by transpiration and acts as a collector for snow in the winter, which increases the thermal insulation value of the roof.

The skylight for the plants is well insulated with a "U" value of 0.24. The building envelope likewise is highly insulated against heat loss in the winter and heat gain in the summer, with an average "U" value of 0.084. This results in saving 43% of the energy required for heating and cooling a conventional building of the same size.

Ecology-Exterior

One of the principal requirements of the site is to allow the building's solar system access to the sun now and in the future. As such, the building is located toward the north side of the property, providing open space to the south to eliminate shading from our neighbors. As a conservation measure, the building is built into an existing hill. Earth forms are used to provide earth sheltering for the building, earth roof covering, earth berms to provide screening from surrounding area, and a sloped amphitheater as an exterior program area. Plant materials are utilized to further enhance and protect these components of the site.

- Shrubs and ground cover provide an easily maintained surface which controls erosion on the sloped berm areas against the building.
- The canopy trees provide a definition of the site space.
- The evergreen trees provide screening for parking areas and the building entrance in relationship to the residential neighbors.

- The ornamental trees provide color and beauty for the building setting without producing shade for the solar collectors.
- The fruit trees provide shelter and attraction for birds and animals which are part of our environment.
- The prairie planting provides an easily maintained, controlled growth height of grasses in areas of the roof and berms. Along with the prairie flowers, this is a demonstration of the native prairies that were common in Minnesota prior to farming.

As a total experience, this landscaped concept will help you understand the function of various plant materials as man has utilized them in our environment.

Ecology-Interior

A climatic region is an area which has been defined to have similar environmental characteristics. These regions tend to have smaller areas of a more specialized nature which are known as microclimates. The microclimate generally serves the extremes of the climatic region, thus offering some diversity to the area. A building can be a microclimate also. This structure's microclimate is tropical in nature (non-dormant) with light penetrating the insulated windows and skylight, giving energy to tropical plants. Photosynthesis can begin. This process includes plant growth, oxygen generation and humidification among other things essential for more sophisticated forms of life. The fish pond also acts as a humidification source and as a possible food source. With these basics, life could go on.

This microclimate is geared to attract and stimulate people and make them more aware of the complex environment we live in. It further produces comfort for the building's occupants by providing oxygen, humidity and visual beauty.

Waste System

Clivus Multrum is a Swedish term meaning inclining compost, which is an alternative and perhaps a solution to our waste disposal problems. The system works by having organic wastes moving down an inclined plane at a very slow rate of two to four years. Wastes from humans (excrement) and plants (leaves, grass, vegetables) are introduced to the chamber through separate chutes in the room above. The proportion of these two types of waste should be 1 animal to 3 vegetable. The system must be kept above freezing to work properly. When the material, "humus," has reached the storage chamber, it is at 5% to 10% of its original volume. The other material has been vented as carbon dioxide and water vapor. This humus has had disease organisms destroyed by normal soil bacteria and is now ready for use as a fertilizer in gardens.

Recycling Just About Everything

Emil Schlottke
Trash Collector
Minneapolis

I have two proposals.

If I had the money for expansion, I could collect trash for the entire city of Minneapolis at a cost of about $4 or $5 a unit. I've got the working model. In addition to picking up trash from industries, hotels, and restaurants, I collect all the glass, cans, paper, old tires, and scrap lumber for ECCO, a neighborhood organization that covers 36 square blocks. I use the scrap lumber to heat my plant. I recycle about 65 tons of glass a week; that's the equivalent of 65 cubic yards that don't go into a "sanitary landfill." We run a 7:00 am to 7:00 pm business and we are the only self-supporting recycling company in the city. 95% of the rubbish from the entire city could be recycled; what's left could be burned for fuel. It would save the city money; it would save important resources; it would make new jobs; it would help eliminate the blight of ever increasing dumping grounds. The key is a convenient, well-publicized pick-up service and I've demonstrated that with ECCO.

My second proposal is to the plastic industry. We should be able to recycle plastic — or we should ban it altogether before we turn this country into one huge garbage dump. I've got the machinery to recycle plastic. *All it would take* is for the plastic industry to be willing to stamp one little code number on their containers so they could be sorted by the type of plastic. Think of the amount of petroleum we could save. Recycled plastic could be used for all sorts of stuff, not just new containers: paints, car chassis, toys, and packaging, to name a few. There's some plastic "recycling" going on now, but it's pretty half-hearted. Do you know what happens when you take one of those recyclable milk containers back to the supermarket? Either they tell you they can't take it, or they say take it back to the creamery, or they toss it in the trash can by the cash register. If you have the time and the gasoline to take them back to the creamery, I'll lay odds that a great many of them end up at the dump.

I figure I owe this country something, and if I can leave it in a little better shape for my grandchildren, I'll have done my part.

Note: Some of the information in this entry was excerpted from an article in MPIRG's "Statewatch," March, 1978, Volume 1, Number 4.

Leaf Power
Gary Bye
Teacher
Jackson

Using leaves as a source of power is so simple, the idea is almost ridiculous.

Every fall as I stand knee deep raking leaves, I can't help but think, what a waste. Here we have a crop that grows every year, costs nothing, and we haul it to the dump. Everyone knows leaves burn, why not use them to heat our homes.

I envision leaves being compressed into the shape of logs or briquettes and used in fireplaces and wood burning stoves.

People could turn in leaves much as they turn in aluminum cans. Who knows, we might create a new industry and clean up Minnesota at the same time.

What happens when leaves decompose? Could there possibly be a leafahol?

I know that the idea of using leaves for energy is far out, but wouldn't it be ironic if one of the answers to the energy problem was *right in my own back yard.*

Minnesota Refrigerator
Robert J. Martz, Jr.
Police Officer
Elbow Lake

This refrigerator could save money during Minnesota winters especially in food stores where they have open displays. The idea is simple. When the temperature control in the refrigerator calls for cold air it sends this message to an outside hood. If the outside temperature is right, a switch opens a pipe door, turns on a suction fan, and draws cold air through a filter into the cooler. If the outside temperature isn't right, then the relay sends the message to the compressor and you still have cold air. Possible savings for industrial uses could be high and even home use could be economical.

Around The House

Energy Appetite Stickers
Edna R. Bernstein
Water Pollution Control Specialist
Minneapolis

Why: To involve each one of us in conserving energy, it is not enough to aid the buyer of *new* appliances through the Energy Efficiency Rating system, although that certainly helps. Every day each family member switches on lights, washers, fans, heaters, cleaners, etc., all *existing* equipment with no indications as to each one's energy demand. Because of their number, some 35 smaller appliances, 15 or more lights, and four or more major appliances, and their frequency of use, energy would be conserved if the user would merely ask "Do I need this, or could I do without, or could I use an alternative, perhaps?"

What: Needed is some impersonal note attached to each electric switch or point of use, defining that appliance's appetite for electricity. (See Northern States Power Company's "NSP Explains Your Electric Bill," 1978, available upon request.) The units *must be consistent,* not watts on light switches but KW on heaters! In fact the very large range in watts demanded among appliances makes savings immediately apparent, as in choosing the desk lamp (60 watts) over the room light (120 watts); and requires but intuitive mathematical skill to choose the microwave oven (1,450 watts) over the regular oven (1,000 watts) because the latter would take three times as long; or in choosing a space heater (1,500 watts) over whole house heating (thermostat — 27,000 watts demand). Numbers should be kept to as few significant figures as possible to facilitate comparisons for even the youngest members of the household.

Solution: The Energy Appetite Sticker — a gummed, light colored label, perhaps 3 cm. × 1½ cm. in size, with peel-off backing, a surface that accepts pencil or pen notation, and divided into three sections. They could be produced by the sheet, perhaps one sheet of 100 to a customer, and distributed in the monthly electric bill, with instructions and examples.

Section 1 — *Watts.* Wattages could be entered once, using the previously referenced NSP booklet as a guide, for every single switch or point of use such as thermostat setting. Some estimates are made, as in using a typical time period for a shower, or estimating hot water energy demand for dishwashing cycles. The range of watts is huge, from seven watts (nite lite), through 1,500 watts (room heater), to a 5,000 watt wall air conditioner. Some houses will have 27,000 watt electric furnaces. Dramatic differences will stimulate, not repress, conservation and care should be taken not to hide the appliance's appetite by using KW figures for heaters.

Section 2 — *Advisories.* This block of the sticker will be the variable bulletin board for the homemaker, and will carry timely messages such as:

Summer rate 8% higher, seasonal advisory, NSP.
Avoid use 1 to 5 pm, peak advisory, NSP.
Dry towels outside (on dryer).
Do not use 3 to 6 pm (on TV).
Limit heat to 65° (on thermostat).
Limit cooling to 78° (on thermostat).
Limit shampoo to five minutes.

Section 3 — *Expansion Space.* Possible future use.

Criticisms and Answers: Rounded off figures will lead to erroneous calculations in savings; use-time is largely ignored and therefore certain appliances with high wattage but short use-time will be misunderstood (i.e., the microwave oven); energy use life styles are unalterable, so this effort must fail, as has all the past preaching on the subject. *But,* the EAS label is a method, not a cost-calculating device, a method of changing behavior. It is more effective than preaching because it is impersonal and consistent at each point of use. Its virtue lies in being EAS-y to comprehend, and it shows exciting gains to be made by not using electrical energy.

The same sticker (colored red = danger) could be used for energy loss situations: the refrigerator door "if opened for four seconds," outside doors, bedroom windows "if opened five inches for seven hours," etc. It could be modified to stick onto car bumpers showing MPG/rider, with bus riding the obvious winner as you compare vehicles on that freeway ride to the office.

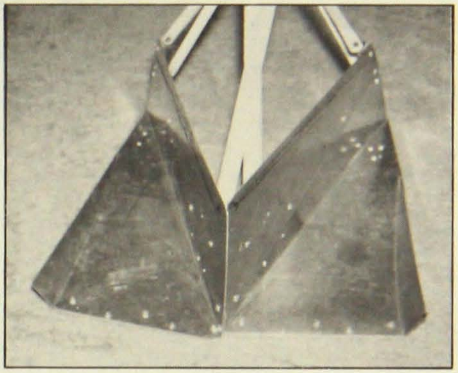
Gas-Less Snow Plow
Bert M. Carlson
Retired Music Teacher
Minneapolis
Honorable Mention
Patented.

Years ago, when snowmobiles and snowblowers first came in, I foresaw the problems that would confront us and spent considerable time and money to contribute, at least partially, to the solution.

The illustration shows my gas-less snow plow closed to plow the first furrow, 20″ to 24″ wide. On the return trip it can be expanded to plow a furrow 40″ to 48″ wide. If you get out before anyone has walked on the sidewalk, usually before 7:30 in the morning, my plow will clean right down to the concrete leaving no film of snow to turn into ice. It's lightweight, made of aluminum, wood, and steel and is easier to push than most snowblowers. It works best in a snowfall up to 3″; in a heavier snowfall you would have to use it more than once or get out the shovel. But if you are at home and retired like me, you can easily handle a heavy snowfall during the day. Anyone who can handle the smallest lawnmower can handle my plow. Push it fast enough and the snow flies off the slanted sides.

I received four awards for it at the Inventor's Congress in Redwood Falls. Barbara Flannagan tried it out and was sufficiently impressed to do an article on it for the *Star*. Now that people are really beginning to believe there's an energy crisis, maybe it will catch on.

This past year the biggest problem was roof dams. Heated wires not only use energy but also just help build up more ice. Maybe black edging on the roof would do the job, attached under the inch or two of the lowest protruding shingles.



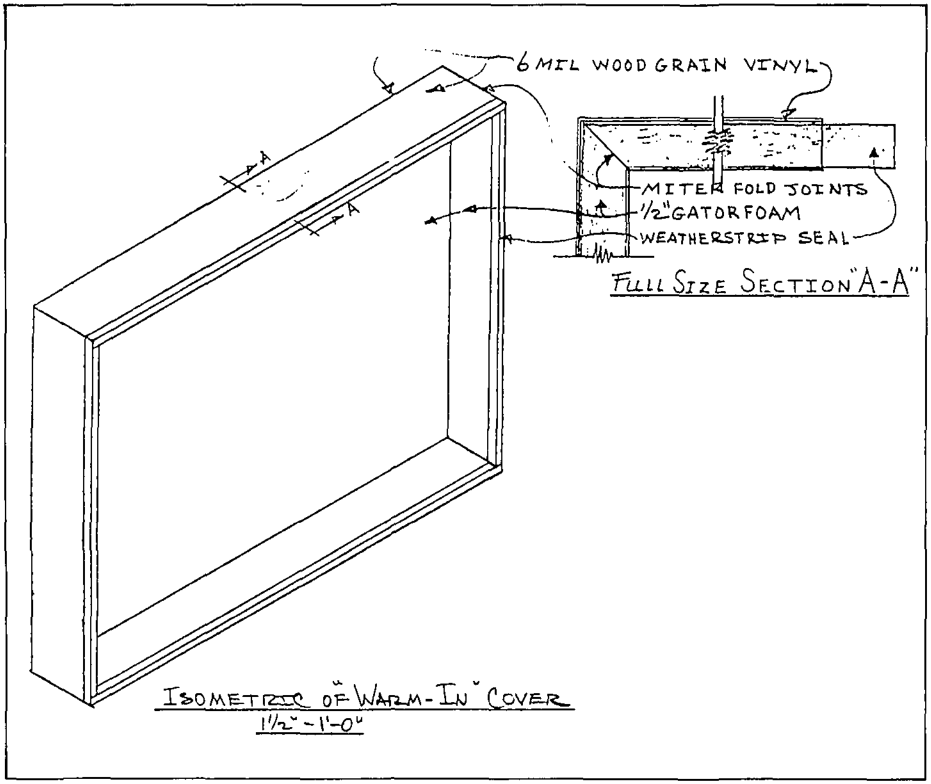
We moved south for awhile when I was in my early 80's. Poisonous snakes, fire ants, bugs, "stink," and too darn hot at times. Good old Minnesota! That's why we moved back — only to find the price of housing doubled! But it's a wonderful world! The only problem is to have enough money to be at the right place at the right time, and only our elected officials can vote themselves that kind of income!

Air Conditioner Cover
Raymond Dreier and Virgil Goebel
Cabinetmakers
Hutchinson
Honorable Mention

The purpose of this invention is to conserve heat by covering air conditioners which are installed permanently through exterior walls of buildings. The proper covering of air conditioners is especially necessary during the winter in the northern part of the United States.

The cover is installed around the air conditioner on the inside. It will blend in with most furniture and decor as it is covered with a walnut colored vinyl similar to what is used on many stereo speakers. It, therefore, is much more convenient to put on and remove from one season to the next. It is especially useful in cases where a cover cannot be used on the outside of the air conditioner to a good advantage; an example would be when wood or metal braces are used to help support the air conditioner on the outside of the building. Another example would be on multi-storied buildings. These covers can be used in homes, apartments, motels, and commercial or industrial buildings.

In the past people have attempted to keep out the cold and drafts with makeshift methods. Some have covered their air conditioners on the outside with garbage bags or other vinyl, paper, or any material they may have on hand. In most cases the wind blew these covers off, including some of the ready-made covers. The ready-made covers do not cover the air conditioner completely. They do not fit tightly against the building and some are open on the bottom to fit around the exterior braces. The only cover available for the inside of the air conditioner is a cheap clear plastic cover with an elastic band to hold it in place. It does not, however, seal it, so cold air still comes in and warm moist air can escape.



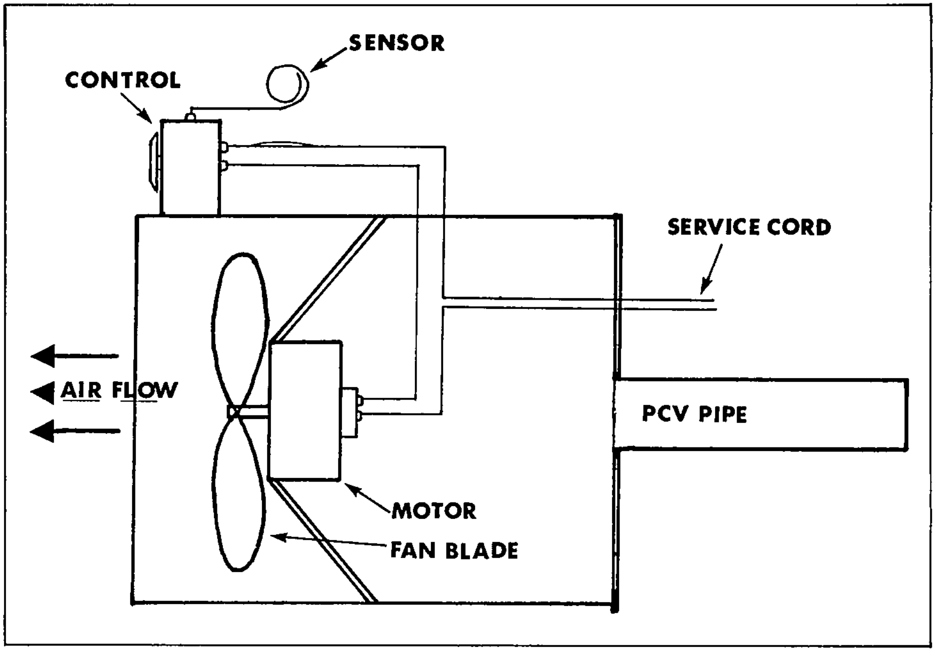
Our "Warm-In" cover insulates as well as seals tightly against the wall. It is made of a Poly-styrene type material with a covering of 6 Mil Walnut grained vinyl. The back edge has foam weatherstripping on it to give it the seal against any wall surface. It has fastening clips that can be screwed to the wall to hold it firmly in place but it still can be removed easily in spring. The cover is durable enough to last many seasons — probably the life of the air conditioner.

Refrigerator Economizer

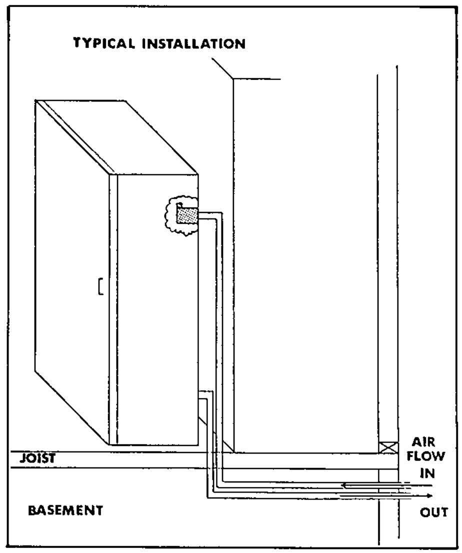
Richard and Bradley Daniels
Refrigeration Technicians
Isanti

Many people think of Minnesota climate as an extreme burden not to mention the fact that during the winter, large amounts of energy are needed to heat an average home. Some of this energy use is unavoidable no matter what measures are used to save it. One area where a Minnesotan could effectively save is the household refrigerator. Now doesn't it seem a little redundant to try to cool an enclosed cabinet with electrical energy when a valuable resource is right outside your door? If someone could suck this cold air from the outside into the refrigerator, a great deal of electrical energy could be saved. That's where the Economizer comes in, and it could be easily built with materials from around the house and/or your nearest hardware store.

Here's how it works. A fan is mounted inside a cylinder and controlled by an air temperature control (thermostat). This device is installed inside the refrigerator section (somewhere near the top) and piped to the outside. When the temperature outdoors is 40 degrees or below, cold air is sucked from outdoors through an insulated pipe going into the refrigerator section. A return pipe (the same size as the incoming pipe) is installed near the bottom of the refrigerator section for proper air circulation. The fan that circulates the air uses approximately 28 watts of electricity per hour. In comparison, the compressor on an average refrigerator uses approximately 660 watts of electricity per hour. If you now pay 4 cents per kilowatt, it costs you $9.60 per month to operate your refrigerator, while with the Economizer, the cost would be about 44 cents to do the same job.



Quantity	Parts
1	5" or 6" diameter circular stove pipe or duct pipe
1	Lid from one-gallon paint can
1	6" long PVC drain pipe — 1½" inside diameter
1	Freezer fan motor with blade
1	Air control
1	Wire service cord and connectors which push on to control leads
1	Can of spray paint
4	Mounting brackets for fan motor
1	Tube of silicone seal to seal paint can lid to cylinder
12	Sheet metal screws
	Screen to cover front and pipe outlets
	PVC pipe, elbows, etc. to plumb Economizer to outdoors



Most of these items are fairly easy to obtain and after the unit is assembled, it can be used four to six months out of the year. During the summer, you could switch back to regular cooling functions and disconnect the winter unit from power.

Ventilation Shaft for Underground House
Joel Levie
Farmer
Evansville

From theories contained in the publication "Earth Sheltered Housing Design" by the University of Minnesota's Underground Space Center, underground structures are most energy efficient when only the south side is exposed and the remaining walls and roof are covered with earth. In such a tight configuration, air circulation, especially cross-ventilation, may be difficult to obtain during summer months without electrical fans. But for those who wish to reduce their electrical consumption, a shaft located on the exterior of the rear wall of the dwelling will provide a solution. Fitted with a silent rotary roof turbine ventilator, such a shaft could draw up to 2,350 cubic feet of air per minute through the house. (Wind rotates the turbine causing a vacuum in the shaft. A four MPH breeze could pull 2,350 cubic feet of air per minute with a 24" shaft. See W. W. Grainger, Inc. catalog, 2616 27th Avenue South, Minneapolis 55406.)

During the cold winter months, insulated doors can be closed at the shaft's room inlets; the turbine can also be covered. Since the shaft does not penetrate through the roof, there is less difficulty with flashing and insulating.

Earth-covered houses are intrinsically cool. The addition of a good cross-ventilating shaft and turbine will further increase comfort. Also construction and material (steel culvert for the shaft, the turbine, and insulation for a total of less than $200) make them very competitive with noisy, energy consuming fans.

Solar Powered Window Shade
Edward H. Cook
Mechanical Engineer
St. Paul
Honorable Mention

A window shade can perform many functions of which two are noteworthy in terms of energy usage:

- Prevent solar radiation from entering a building during summertime;
- Reduce heat loss by conduction during cold weather.

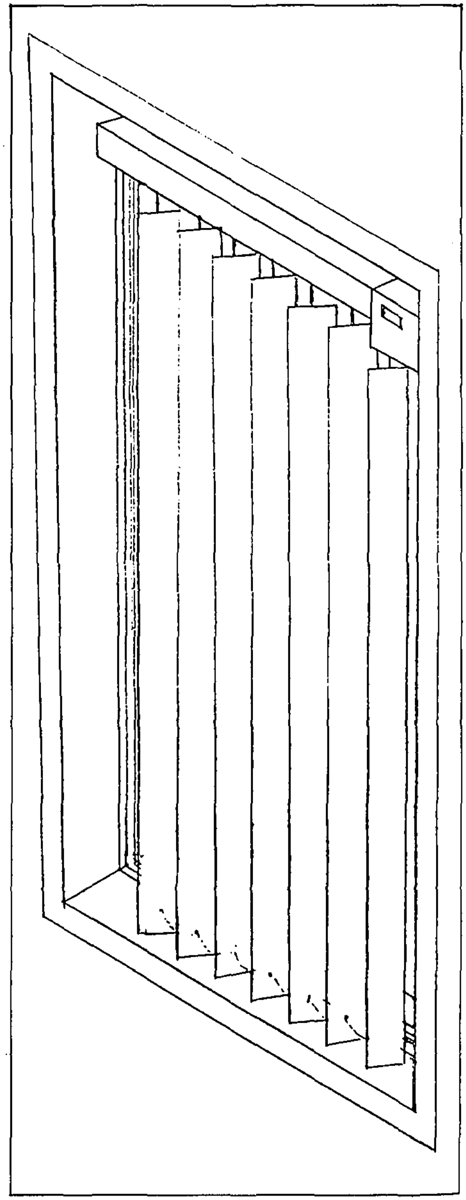
The solar-powered window shade takes advantage of both of these characteristics by using the sun's rays to provide power for automatic control. It performs this function in the following manner:

a. Sun's rays strike photovoltaic cell causing current to flow to the self-contained direct current motor.
b. The motor through a gear reducer turns a shaft connected to a series of vertical slats and at the same time winds a spring connected to the shaft.
c. When sun's radiation is no longer available to power motor, the spring overtakes the drive and returns it to its original position.

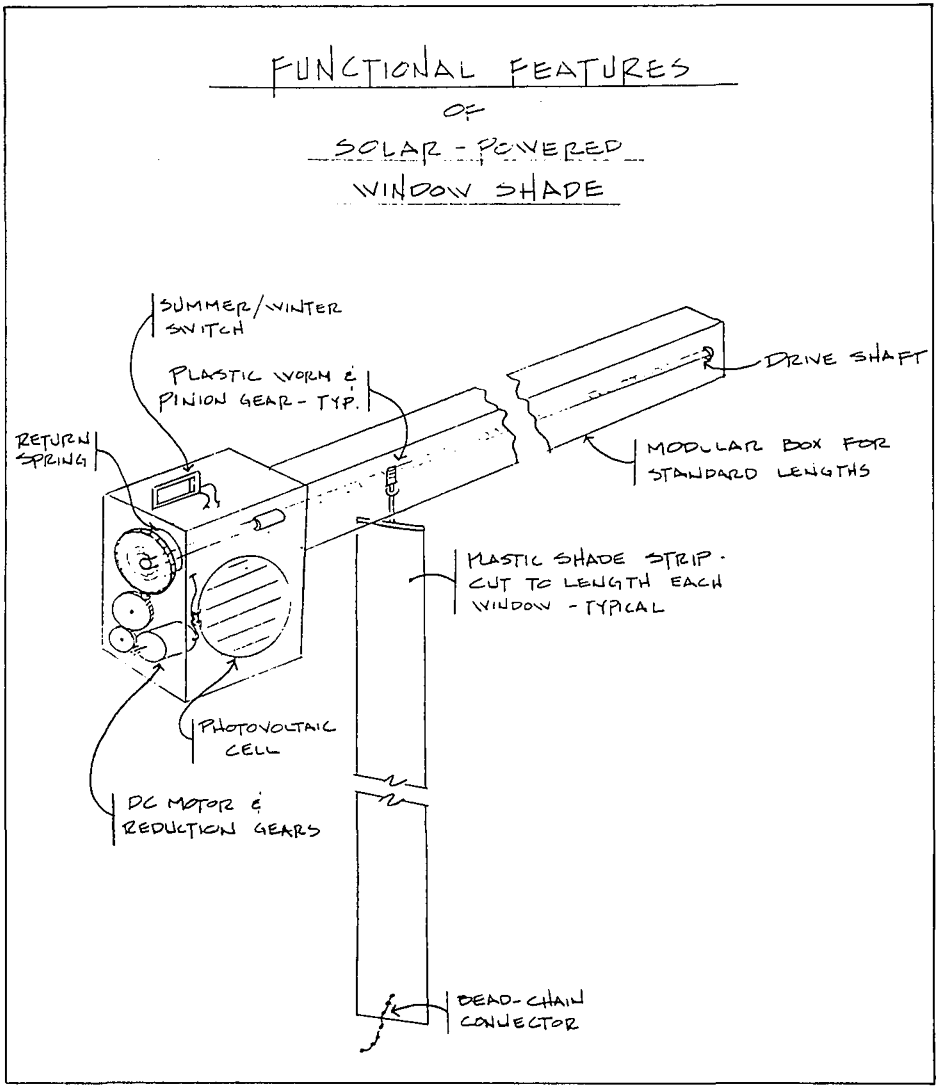
Its ability to save energy is best described in its two modes of operation which are selected by a manual switch on the enclosure:

Summer: During the daytime when the sun is at its hottest the motor will automatically power the shade closed. As the sun lowers in the sky the shade will again open and afford the occupant a view. On overcast days the shade will remain open.

Winter: During the day as the sun strikes the window the shade will open and allow the radiation to enter the building and provide solar heat. As night approaches the shade will automatically close to reduce heat loss both by conduction and radiation to a black body.



The shade is intended to be installed on the east, south, and west sides of a building and could be easily adapted to both new construction and the retrofit market. Such a device could be stocked in standard lengths and widths and would fit together with the power module at the time of installation. Probably the most significant aspect of this invention is that the cost of the power module would be under twenty dollars.



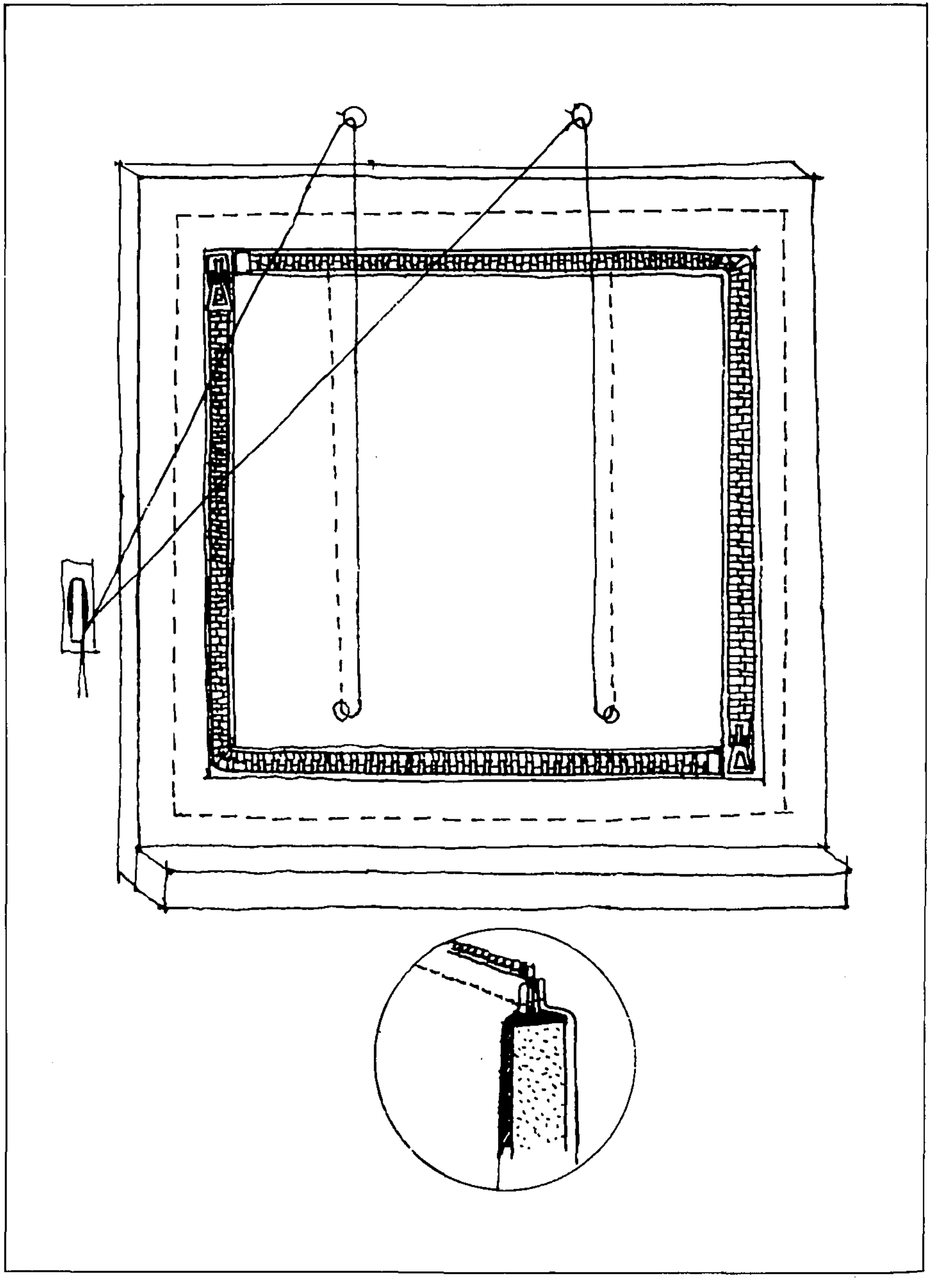
Window Blankets
Joel Levie
Farmer
Evansville

Draperies are commonly used over glazed wall surfaces to prevent excessive heat loss during winter nights. With their loose fit to the wall, drapes still have great heat loss due to the convection currents around them. An insulated "blanket" might be considered a more energy efficient alternative.

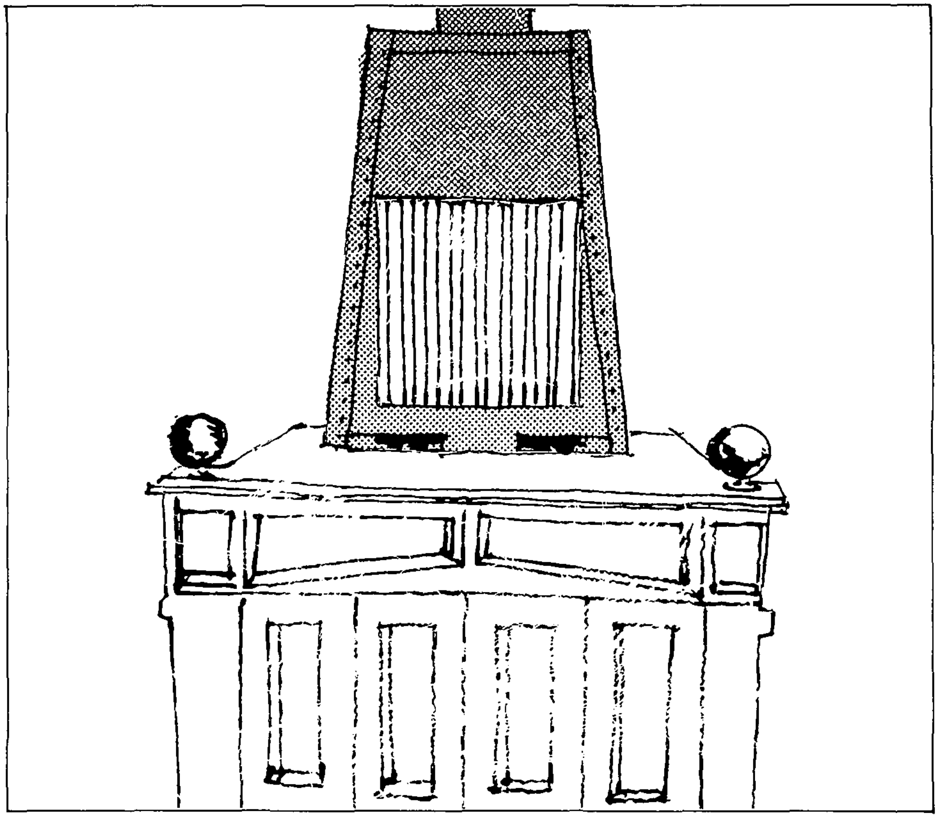
Materials and installation procedures are as follows: a piece of nylon tent-type cloth, a piece of 1" insulating batt such as is used in sleeping bags, a piece of decorative cloth, all cut to the same dimensions as the window, and two heavy zippers, each equal in length to the height and width of the window. After sewing up the "blanket," with half of the zipper around the edge, the outer tabs of the zipper are stapled to the interior of the window frame. To finish, trim boards are applied.

The "blanket" can be opened upward using drawstrings or downward using a "stuff" box or bag. (Upward, left zipper completely unzipped and right zipper unzipped only on its height; downward, right zipper completely unzipped, left only on its height.) The "blanket" can be totally unzipped for dry cleaning. Approximate time to open or close a "blanket" on a 4′ × 5′ window is 30 seconds.

Tight fitting shutters would be as energy efficient but more elaborate and expensive to install. Some folks may not like the overall "mountain tent" appearance. But, window "blankets" surpass conventional curtains for energy savings with R values of 10 and up. In addition, the costs are competitive: $45 for a 4′ × 5′ window "blanket."



Heat Recovery
Albert V. Johnson
Rancher
Erhard



This invention is used on a Franklin fireplace. It sets directly on the fireplace, eliminating the need for the standard boot on the Franklin. It has a triangle shape with a flat removable top. The core consists of about 53 pipes of light gauge steel which the smoke and gas pass through. This core is about 8″ x 14″ and 16″ high. The stove pipe attaches to the back on top, therefore leaving a chamber opening, where the pipes stop, on the upper part. On the front side the pipes show. The back and sides are encased with a squirrel-type blower attached to circulate heat out and around the tubes. We have an automatic furnace switch wired to the blower which turns the fan on at a certain temperature and off when it reaches a lower temperature.

It has a heat shield that extends down the back side of the fire box and a short way along the sides. The removable top is for cleaning. This is done with a long handled stiff bristle brush run down the tubes. The residue is then pushed down into the fireplace or can be vacuumed out. It is a good idea to vacuum off the blower switch to keep it working more efficiently. It is no different in installation than putting on the regular heat boot.

We have had this unit on our fireplace since March, 1977. With the plain Franklin fireplace we burned 1,536 gallons of oil for the twelve months of 1976. With the heat boot in 1977, we used 767 gallons; for 1978 we used 978 gallons. We didn't have good dry wood in the spring of 1978 and we didn't really burn it too steady in November and December; as you can see, we used more oil that year. It costs about 13¢ a day to run the fan, but also saves a lot of electricity by not having the furnace blower running all the time. This unit makes a Franklin fireplace one of the most efficient wood burning stoves. We have saved about $800 on our fuel bill over the last two years. The cost of our heat boot is about $105 by a manufacturer, keeping in mind it replaces an $18 boot and a $30 heat shield.

Our Franklin fireplace is one of the smallest ones made and we heat our nine room home with it. The average temperature is 70°. When there is a strong north wind and a minus 20° or so outside, the temperature runs around 68°. You get 100% savings of fuel while you are using the fireplace.

We no longer have the worry of a fire in our chimney. Before, we could see sparks going 4′ up the chimney. Also with this unit we burn less wood and get more heat. The stack temperature runs about 500° to 600° on a low to medium fire, so there is no problem of creosote building up.

Wood Fired Space Heating, Domestic Hot Water, and Clothes Drying

Ernest Komula
Electrician
Sebeka

Honorable Mention

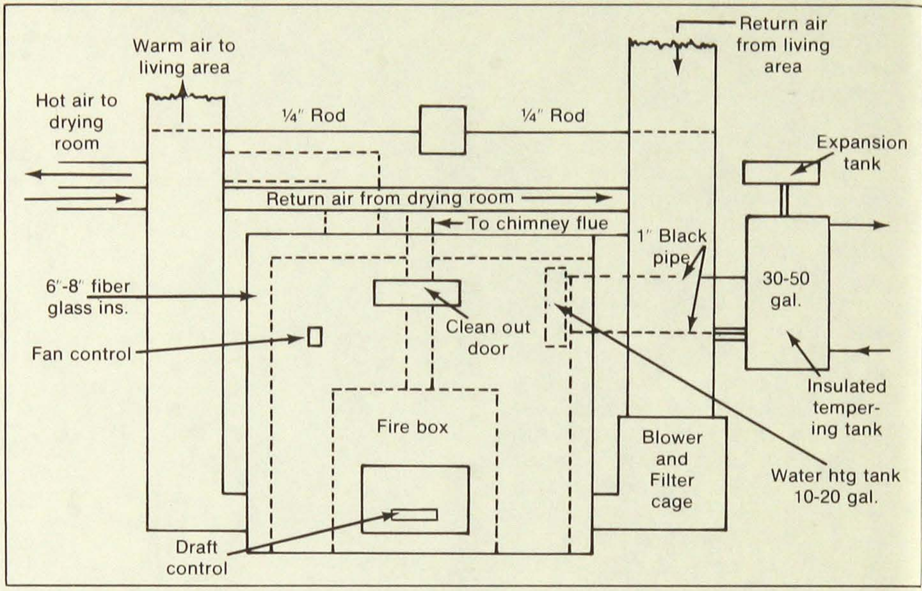
Since this plant is attached to the house but has its own chimney flue there is no heat loss up the house chimney and associated loss of house humidity. With the "rock pile" heat storage feature the plant would have enough "carry over" through the night so the furnace firing could be done during the day. The problem of sooting of chimneys is eliminated because with this design the plant can operate at full capacity whenever it's burning. By having both hot and cold air entering at the bottom a "heat trap" is produced to heat up the rocks. A remote bulb thermometer could be installed with the indicator in the living area thereby alerting the occupant for need of firing.

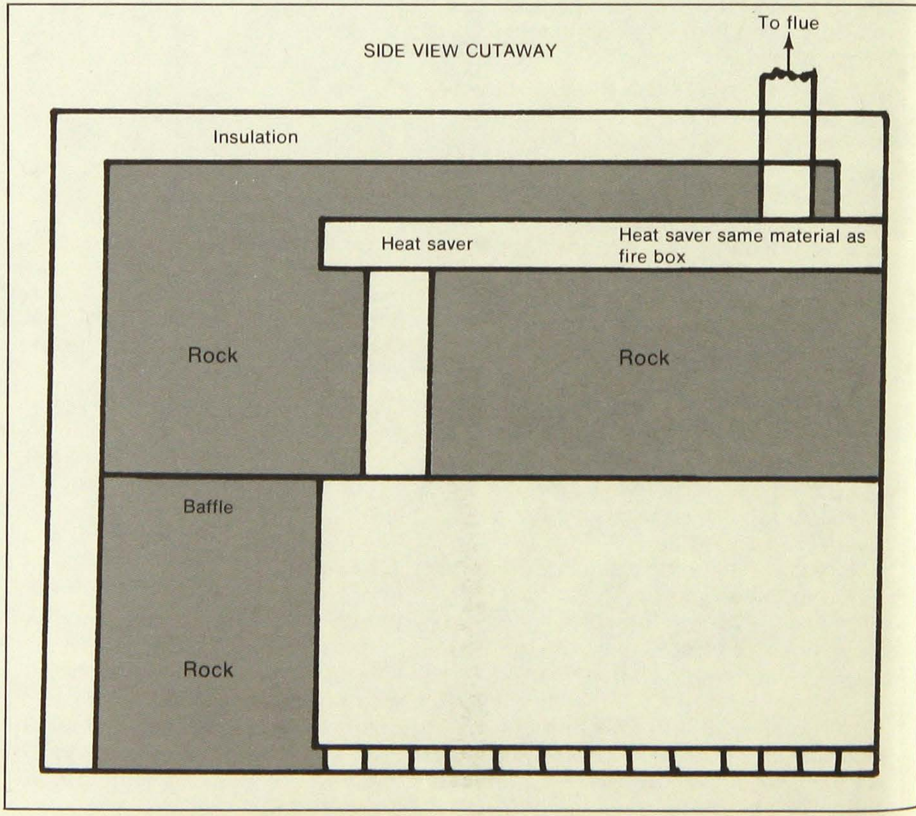
The clothes drying room would have a manual over ride switch and a manual hot air register to be used only when drying is needed.

In my application the plant is located adjacent to the house in an area 10′ x 34′; basement type construction with a pre-cast concrete ceiling that forms a patio and entrance to the back door. This also provides a wood storage for periods of stormy weather.

With the large fire door and combustion chamber (24″ high x 30″ wide x 48″ long) it is practical to burn scraps, small stumps, etc.

An "out fire" draft control could be installed so the draft will close when the temperature in the furnace is down thereby preventing heat loss during "off" periods. If this plant is installed in the basement of a home, a combustion air duct must be installed from the outside into the combustion chamber. This can be 4″ round galvanized pipe with a manual draft control.





Cost estimate for new materials (blower and motor, motorized damper control, room thermostat, plenum control, wiring devices, and duct work): $500 to $600.

Cost estimate for used and salvaged materials from scrap yards: $100.

Labor supplied by owner.

Free Hot Water During the Winter

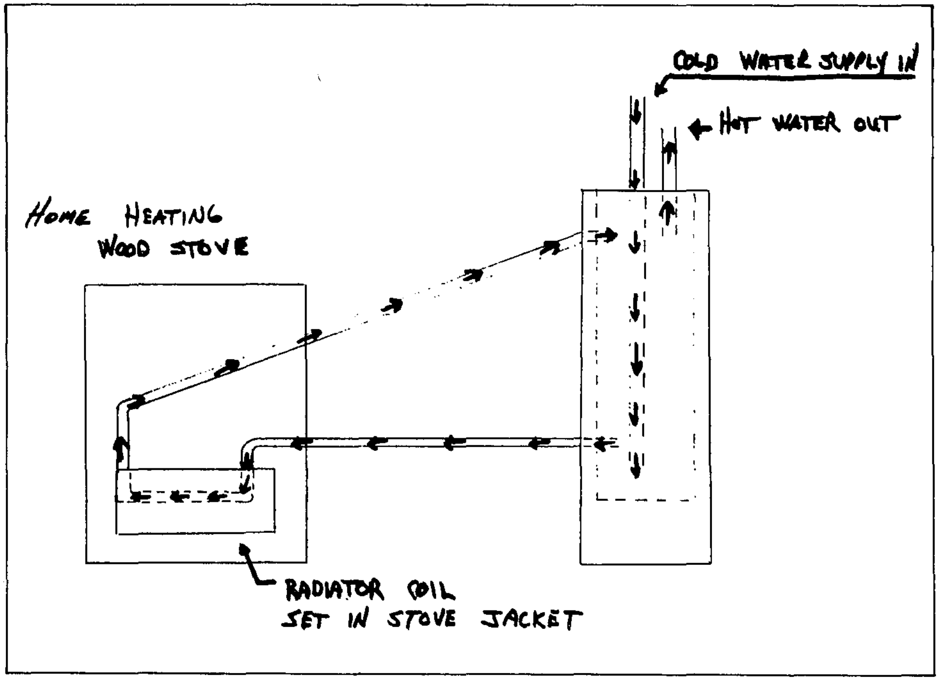
Ron Johnson
Technician
Blaine

Free hot water may be obtained during winter months using the method shown in the diagram. A normal wood heating stove will circulate water through the hot water connection. No pumps are necessary. This system may be used as a supplement only by running the system's hot water out into your regular hot water heater. Water would need very little re-heating, if any. My Father has this system up and running in his house in Wisconsin.

Estimated cost for parts $100.

Estimated cost for labor $100.

Estimated savings for electric heating for a month for a family of four is $30 to $40.



Further Statements

Judge's Statement
Bernard Jacob
Architect

Ten years ago this country turned fantasy into reality and fulfilled ancient dreams by landing a man on the moon. Today, the poet, the story-teller, the merchant, the brooder, the autocrat, but above all the inventor in all of us are directing our imaginations and fantasies to ever more creative means of conserving energy and capturing solar power.

The broad range of proposals submitted to the Minnesota Energy Design competition demonstrate the depth of awareness and the almost unlimited interest and imagination that exists in these matters. Many of the proposals deserve to be encouraged, many should be further developed, and many remain to be rendered more efficient. A few will probably reach the mass market and be available to a broader public.

But, in our new missionary zeal we must balance the need for conservation and responsible consumerism with the relative and too often intangible need for beauty, delight, and the joy of communion with our neighbors and with nature. The quality of our built environment is going to depend on this. An earth sheltered house should not be allowed to become a basement anymore than the conservation of body heat should lead to the construction of portable cocoons. In a headlong rush for energy conservation we must not regiment ourselves into low-income (or, for that matter, high-income) dungeons. Our options are narrowing quickly, but that only further emphasizes our need for thoughtful decisions.

Judge's Statement
Hank Fischer
Financial Consultant

In studying the myriad ideas expressed in the exhibits entered into the Minnesota Energy Design competition, one is struck by the realization that when we think of solving our energy problems we cannot look for the quick fix. To say there are no panaceas may be trite but profoundly true. The solutions to our energy needs will inevitably be a culmination of hundreds, perhaps thousands, of mostly minor incremental changes in ways to save energy: ways to use what we have more efficiently, and ways to capture and use new sources of energy.

The entries in the competiion, while applicable to energy problems over large areas, generally are particularly apt for Minnesota. They are excellent examples and useful tools in moving us in new and necessary directions. The ideas expressed provide something for literally everyone to incorporate into a way of dealing with the energy problems, whether the do-it-yourselfer, the technologist, or the planner-developer.

The continuation and increased exposure of the Minnesota Energy Design competition should be encouraged. The ideas brought forth, as well as future ideas given exposure by future competitions, should help our state to continue to provide "the good life" and be a model for others. The dedicated staff of Continuing Education in the Arts deserves our gratitude for their determination and energies in making the project the success it is.

Letter of July 27, 1978
Rudy Perpich
Former Governor, State of Minnesota

In response to your letter of July 14, I am happy to endorse your project "Minnesota Energy Design." I believe that design competitions of this type are a valuable tool in expanding Minnesotans' interest in energy conservation and the use of new energy sources and design techniques.

I have asked the Minnesota Energy Agency to provide you with any assistance they can in insuring that the project is adequately publicized and is a success.

Transportation

Improving a Minnesota Electric Car

Tom Walker
Plant Manager, Tinkerer
Eagan

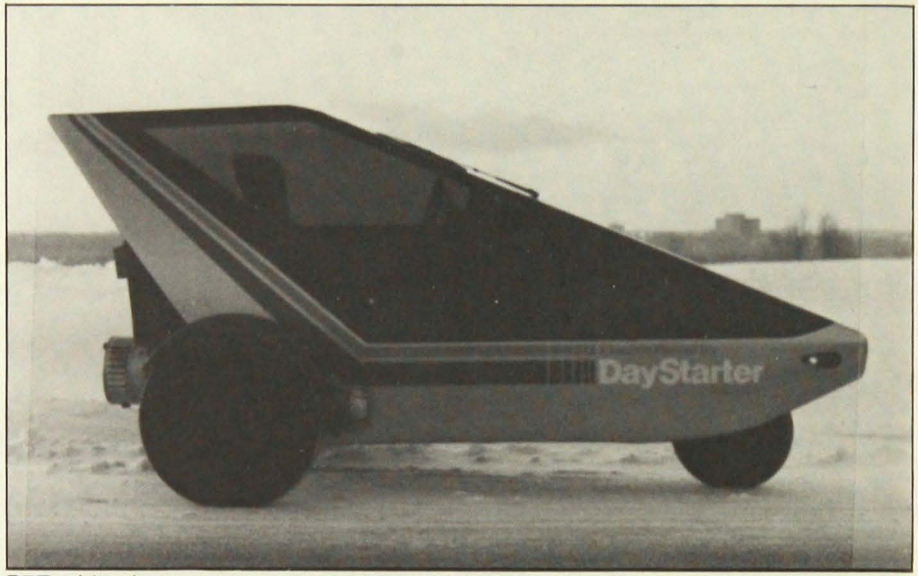
Honorable Mention

Electric cars are quiet, simple and efficient. They do not require petroleum and they are pollution free. Electric power for electric cars can be generated from coal or nuclear power or from Minnesota fuels such as: wood, peat, methane, alcohol, wind, solar and hydro power. Pollution can be monitored and controlled at single generating plants instead of at a million tailpipes. Our electric energy distribution system already exists and recharging electric cars after peak hours would improve electric utility efficiencies.

However, everyone knows that electric cars are slow, have very limited range, and could never survive a Minnesota winter. In the spring of 1975, however, a new electric car called the Ampeater III made its first appearance on Minnesota roads and began to dispel these negative notions. Before Ampeater III was dismantled in the fall of 1978, it had traveled over 20,000 electric miles, was used daily through two Minnesota winters and was never kept in a garage.

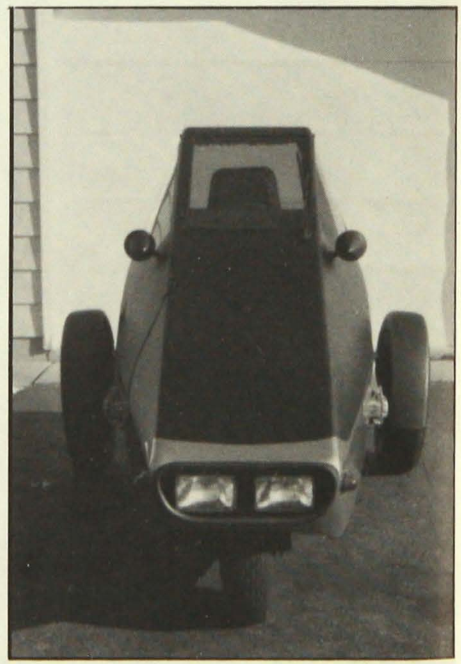
The design goals of the Ampeater III project had been met so a new project was started aimed at improving performance and efficiency. The result is the Personal Electric Transport (PET) which has now been in operation for one year.

The PET is also an all weather vehicle and employs an identical battery pack and drive train. However, the PET can accelerate and travel faster and has a much longer range at high speed. This is possible because the PET weighs 700 pounds less, has 8 sq. ft. less frontal area, and has a much lower drag coefficient (streamlined). The following information compares the two cars and shows the rewards of efficient design.



PET, side view


Ampeater III, going strong at 32° below


PET, front view

With its better design and lower air resistance, and its lower weight and lower rolling resistance, the PET beats the Ampeater III for horsepower requirements at all speeds.

Specifications

	AMPEATER III	PET
Type	4 wheel modified VW	3 wheel original design
Seating	2 passenger, side by side	1 passenger (or modified 2 passenger 1 fore and 1 aft)
Weight w/batteries	3,000 lbs.	2,300 lbs.
Frontal Area	20 sq. ft.	12 sq. ft.
Est. Drag Coefficient	.458	.3
Traction Battery Pack	17 — 6 volt lead-acid batteries	
Battery Weight	1,150 lbs.	
Motor	10 HP series wound	
Transmission	4 speed with clutch	
Acceleration 0-30 MPH	15 sec.	12 sec.
Approx. Top Speed	55 MPH	65 MPH
Max. Range at 50 MPH	40 miles	81 miles
Approx. energy cost at .04/kwh	1.3 cents/mile	1 cent/mile

A Personal Transportation Vehicle Capable of 136 MPG
Dave Edmondson
Engineer, Manufacturer
Bloomington
Honorable Mention

Patent pending.

(Former Secretary of Transportation Brock Adams: The American people will give up almost anything before their automobile — wives, children, food, houses — just about anything you might think of.)

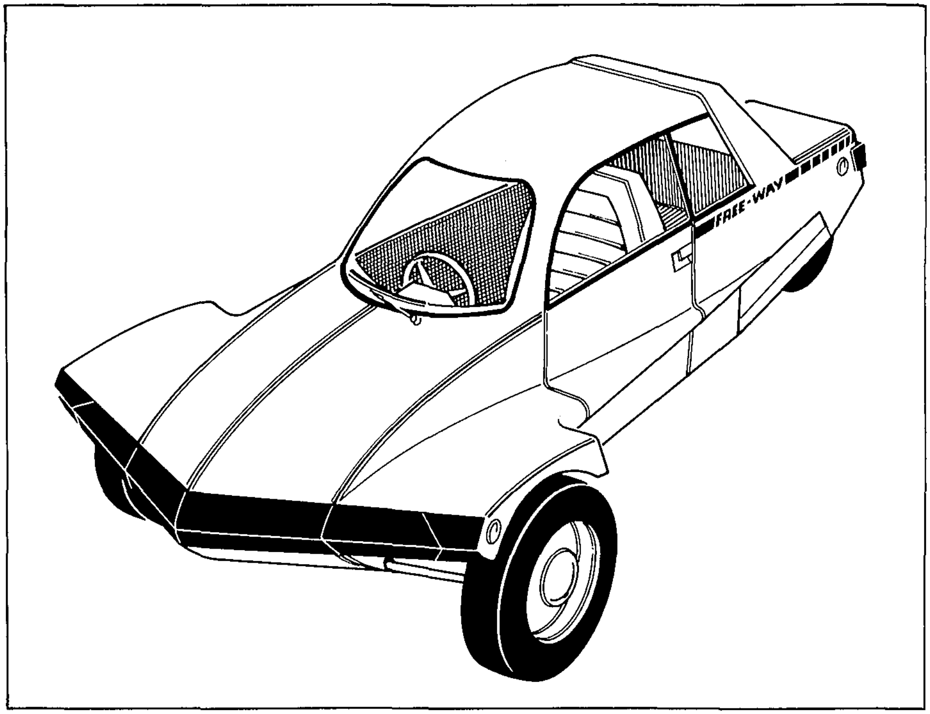
Detroit has ignored the needs of the American commuter for decades. They have produced large, beautiful, family cars for all purposes, but they have never produced a 110 mile per gallon vehicle like the "FREE-WAY." They have held an absolute monopoly over the industry and have refused to build a special vehicle for driving to work economically. After all, it's the bottom line that counts, and not the needs of the public. It's no wonder they can't seem to find a solution for rusting cars or that they need to come up with gimmicks like turbo-charging.

The "FREE-WAY" is:

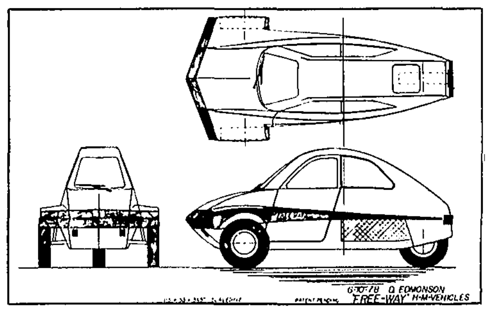
- The only vehicle guaranteed to get 100 miles per gallon.
- Capable of 900 miles of driving on one tank full of gas.
- Made of durable fiberglass body that won't rust.
- The only year-round vehicle that gets better mileage than a moped or a motocycle.
- Designed to be serviced by the owner with an estimated 75,000 miles of use before basic engine work will be required.
- Available with several modes of power.

All prices are base prices for April, 1979 and are subject to change without notice.

- Gas engine, up to 100 miles per gallon, top speed 65 mph, $2,695.
- Electric, up to 40 miles on a 20¢ charge, top speed 55 mph, $2,895.
- Diesel, up to 140 miles per gallon, top speed 60 mph, $3,295.



A 52 page booklet "High Mileage Vehicles — A New Technology" is available from H-M-Vehicles, Inc., 6276 Greenleaf Trail, Apple Valley 55124 for $4.95.



Encouraging the Use of Vacuum Guages in Minnesota Cars and Light Trucks

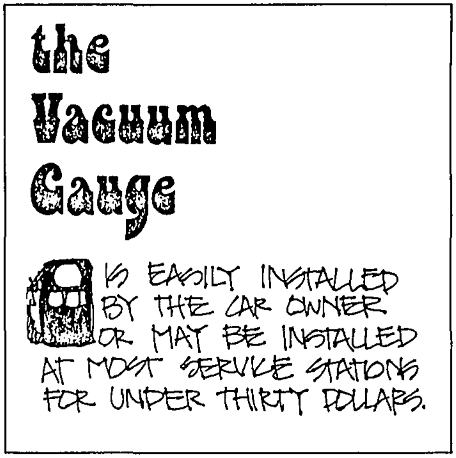
Doug Benson, Louise Miner, Jeff Morrow
Student, Banker, Student
St. Paul

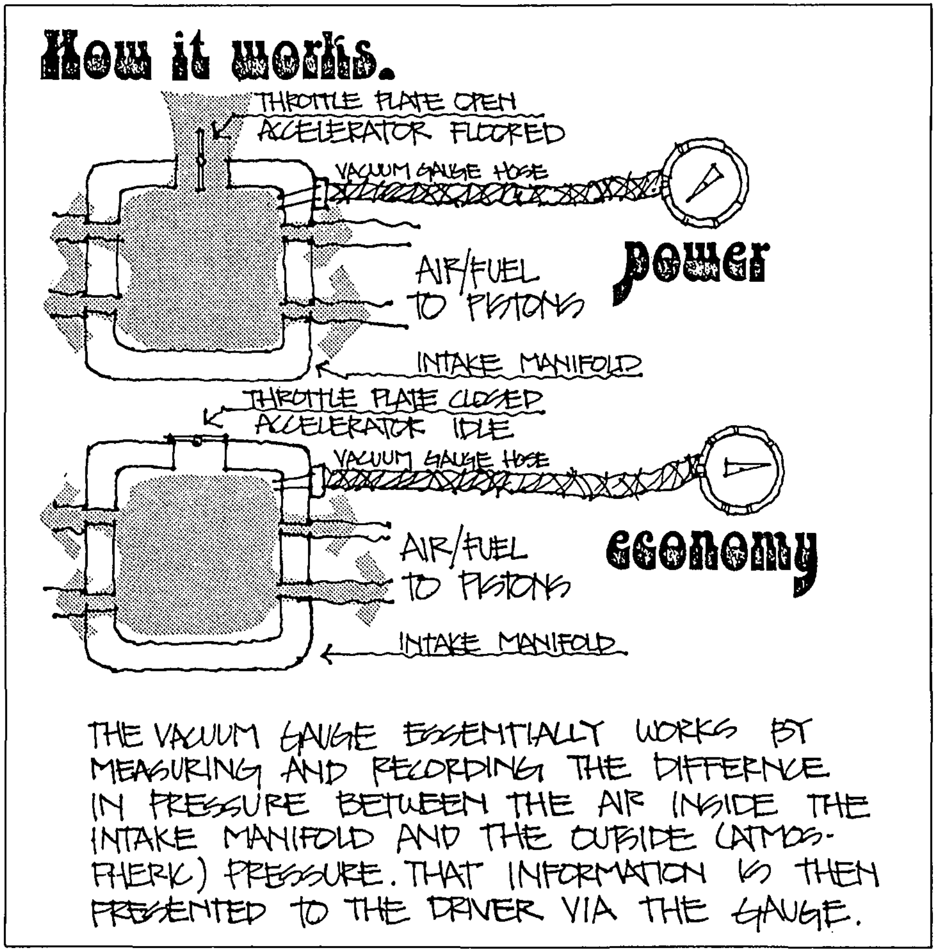
Honorable Mention

The 1973-74 oil embargo caused a 7.8% (adjusted for extrapolated growth in demand) shortage of gasoline in Minnesota. The most recently published Minnesota Energy Agency "Gasoline Situation Briefing" (30 March 1979) projects a nationwide shortfall in gasoline supply of 10% to 12%. The Minnesota shortfall may be as much as 16%. More recently, the gasoline supply situation has been described as "even worse than projected in the March 30 'Briefing' " by an MEA Transportation Analyst. For the average motorist, finding gasoline may be even more difficult than these figures indicate. Federal Fuel Allocation Regulations require that available gasoline be used for meeting agricultural demand at 100% of last year's levels and this may squeeze the retail gasoline market even drier. Minnesota motorists face a gasoline shortage that may be twice as bad as the last one.

The MEA has called on Minnesotans to save 10% of the gasoline which would be used over the next six months and has proposed that we observe speed limits, car pool, ride buses, tune our engines, cut down on unnecessary errands, and drive "in an energy efficient manner".

No one of these methods is the answer but the potential savings accruing as a result of efficient driving habits may be at least as great as all of the other *combined*. Adoption of good driving habits does not necessitate the "major" changes in transportation habits required for increased car-pooling, bus riding and errand curtailment. Furthermore, adoption of good driving habits is the only means of substantial gasoline use





reduction for those who *must* drive a car for commuting.

In order to establish these good habits, what the average, well-intentioned motorist needs is direct feedback as to instantaneous fuel economy *while driving*. In this manner, good driving habits may be ingrained as second nature. Such feedback exists now and is available as a low cost retrofit for almost any car. It is a standard manifold vacuum gauge with a dial calibrated to approximate instantaneous miles per gallon. These gauges are currently for sale at under $10.00, installation not included, at many automotive supply stores and catalogue order firms. Installation is simple and can be accomplished by anyone with a minimal amount of mechanical aptitude or, at low cost, by any automotive mechanic.

According to *Popular Science* (March 1975), an editor of that magazine who installed a vacuum gauge on his (large V-8 powered) automobile raised his gasoline mileage from 13.8 mpg to 19.7 mpg. This is an increase of over 40%. Thus, if only one fourth of the drivers in Minnesota used a vacuum gauge carefully, the announced MEA goal of a 10% gasoline conservation would be reached without any other form of savings.

Therefore, we suggest that, if possible:

1) A brochure describing and encouraging gasoline conservation be mailed with each automobile tax bill.

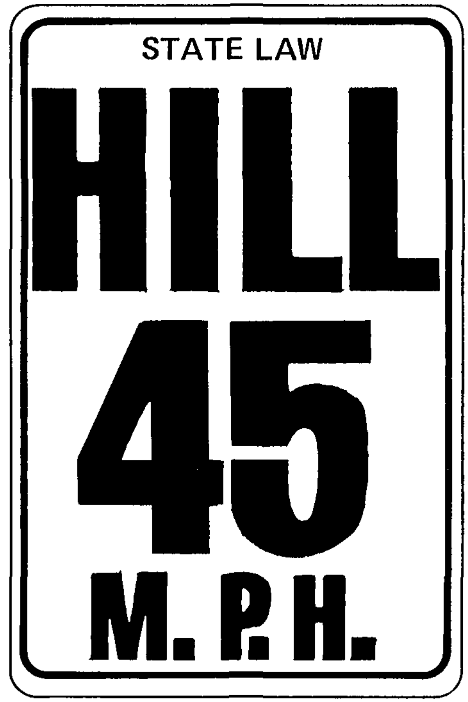
2) An automobile tax rebate, up to the amount of the tax for one year, be given for proof of installation of a vacuum gauge.

3) Automobiles with vacuum gauges be given preferential treatment in the event of rationing.

4) Newspaper and television "human interest" reporters be given vacuum gauges and encouraged to report (in writing and via video) their results.

Speed Limit 45 on Hills
Peter Simms
Inventory Control
Minneapolis

If your ears "pop," don't speed to the top! Taking some hills at 55 mph can be compared to going 70 mph on a level stretch. Let's keep the roads safe for those who help us stretch our fuel supplies. In the process we'll make everyone conscious of how driving habits affect fuel consumption. A change of pace should keep drivers alert too, just like curves.



Steam Hydraulic Engine/Internal Combustion Alternative

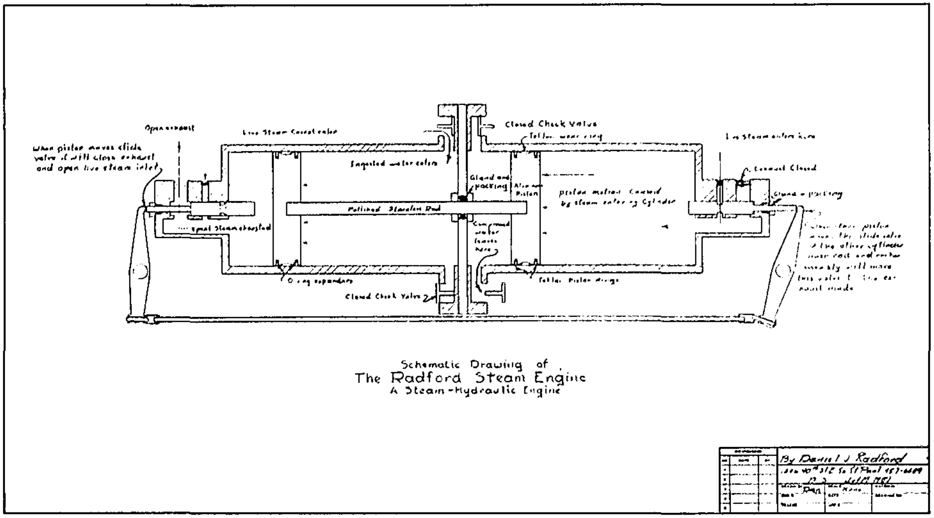
Daniel Radford
Builder
St. Paul

Premise: the internal combustion engine has not significantly changed in over 50 years and is an inefficient use of energy, lubricants, manufacture, and maintenance.

The following is a more efficient method of using the heat energy of *any suitable fuel in a device that needs* little lubrication, no adjustments, and no maintenance. This device is a laterally opposed, two cylinder, water-lubricated steam pump capable of converting steam energy to hydraulic pressure. Please refer to the enclosed schematic diagram and study the functions of the different parts. This should show the following features:

- The device cycles by itself and in any position starts itself.
- Water lubricates cylinder walls, pistons and center gland.
- Operates silently at any speed and delivers hydraulic force at the same pressure as the steam.
- Hydraulic energy is available constantly and instantly upon the release of steam in the cylinder.
- Very low profile and weight. Can be installed anywhere in a vessel or vehicle.
- With automatic controls a boiler can use almost any fuel, and if the combustion chamber's temperature is high enough, emissions should be cleaner than any internal combustion engine's.
- Adpated to marine use and using simple filters, the device can ingest lake water and with proper jets and venturi, propulsiòn can be accomplished with no drive shaft, clutches, gears, propellers, etc.
- Adapted to vehicular use, hydraulic motors or turbines can be installed in two or all four wheels.

Advantages over internal combustion engines:



- Uses more heat energy from any fuel that burns hot enough to produce steam. Internal combustion engines use a narrow range of suitable fuels.

a. Less pollutants with high combustion chamber temperature.
b. Less heat escaping from exhaust.
c. Radiator to cool engine not necessary, (only minimal radiator necessary to condense steam to recharge boiler).

- Oil produced glycol would not be used as antifreeze because alcohol solution would be less expensive and will boil at a lower temperature in a boiler.
- Less complicated and less expensive to manufacture.
- Fewer moving parts.
- Cycles at much slower speeds so wear should be less of a problem.
- No exhaust sound.
- No necessary electrical system with accompanying spark plugs, points, timing, etc.
- Nothing to start, instant heat in cold weather, no idling at stops. Energy not consumed unless vehicle is in motion.
- No oil to furnish or change.
- No filters necessary except with marine use.
- If an internal combustion engine runs out of fuel it stops. If a boiler runs out of fuel it would be possible to run some distance on residual steam pressure.
- No automatic or conventional transmissions, transfer cases, drive shafts, or universal joints necessary with all resulting lubricating and service problems.

The drawing shows a schematic cross section of the engine. The engine has been built and is not just a theory on paper. The working model differs slightly from the drawings in ways important in its operation. Any prototype engine to a production model would be quite different; especially in the center flange, porting and check valves.

Fact: An internal combustion engine wastes at lease ⅔rds of the heat energy created by the burning fuel out the exhaust system and radiation system. Another 15% is lost due to overcoming compression and internal friction. This amounts to more than 80% of fuel energy created by the burning of the fuel in the engine. It is *estimated that if even half of this heat* could be transferred into power an efficiency rate of over 4 or 5 times that of an internal combustion engine could be accomplished.

Education

Minnesota C.A.R.E.S.
(MINNESOTA Consumers' Anti-Consumption of Reserve Energy Sources)
Roxann Knutson
Customer Service
Crystal Bay

For this year's energy saving competition, I would like to submit the following suggestion: the creation of two or three "MINNESOTA C.A.R.E.S." Days to be observed at various weather-permitting times (spring, summer, and fall) of the year.

With proper P.R. work, (as is done on Stop Smoking Days, etc.), perhaps we could take a day off from energy use on a state-wide basis. With a well-publicized campaign, people could plan to stay at home, bike, or walk; plan to do without heating and cooling fuels; plan energy saving meals and activities. The public relations angles for such a campaign are many and varied (i.e., Pioneer Days, Physical Fitness Activities, Nature and Natural Living, etc.).

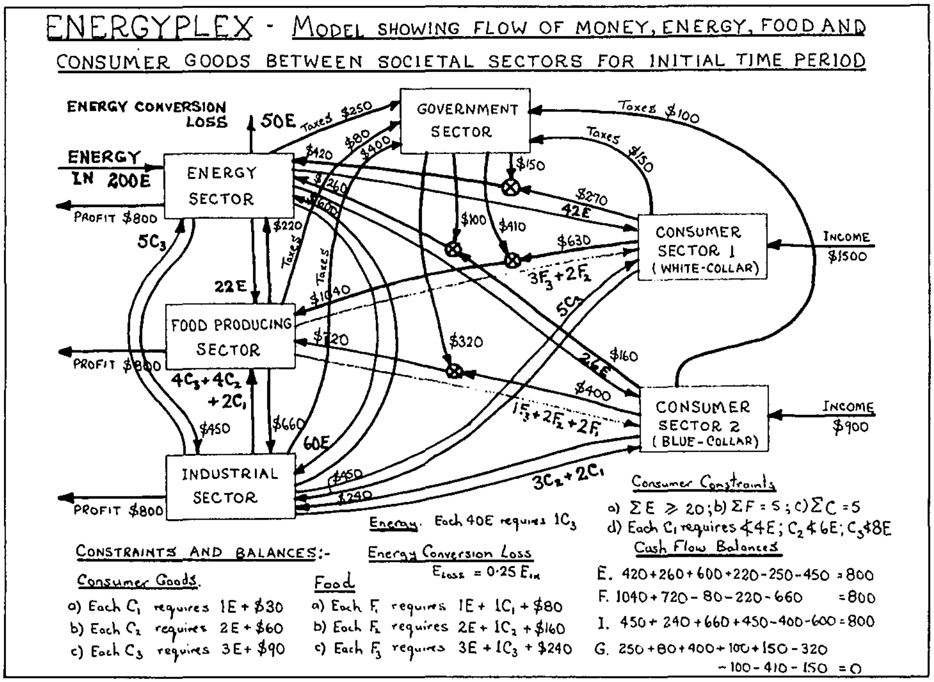
A percentage of state-wide cooperation with such a campaign could mean enormous savings. Another benefit of this kind of program might be the fact that these scattered days, (even just one time a year), *might help draw attention to our* enslavement to over-consumption and might have a carry-over effect with many people, especially if it could be demonstrated that the state's observance of one of these days enabled us to save a substantial amount of energy for use in the days to come.

I submit that the development of alternate energy sources is absolutely essential, but I also feel that some basic changes in our attitudes about consumption are going to be necessary for this state and this nation. I am convinced that if we do not make an effort to correct some of the errors in our thinking concerning the use of energy of all kinds, these changes in attitude will eventually be forced upon us by the very conditions we create.

I submit that Minnesota does care and would support a day (or two) under the slogan — MINNESOTA C.A.R.E.S.

Energyplex
Roger Aiken
Research Fellow, Mechanical Engineering
St. Paul

Northwestern Bell Telephone Company $500 Award



ENERGYPLEX is a new energy-lifestyle simulation game. It has been designed specifically as a tool for planners, corporate executives, energy administrators and policy makers, and energy systems analysts to help them understand the complex interactions which take place as energy flows through an economy. Though its greatest value will be as a learning and interactive instructional tool for the above, there is no reason why it could not be modified for use in schools and training centers and as a game for clubs and associations.

It has been said that the greatest barriers to the solution of our energy problems are not technical or even economic ones, (financing is always found if the ideas are convincing enough and the motivation compelling enough), but institutional ones. Institutional barriers are in turn the consequence of mindsets, characteristic of and usually unique to a given sector of society. Thus city dwellers, (that is, if they even think about it), see good in the ability of utilities to obtain easements over farm land for their transmission and pipeline rights-of-way. But farmers see this as an unmitigated evil. Likewise, long-distance commuters living on the St. Croix see it as a divine right that they be able to purchase fuel for their gas-guzzling cars; the pensioner on a fixed income going without a meal a day in order to pay his utility bill has a completely different viewpoint.

The interactive nature of ENERGYPLEX simulates the flow of energy, food, and consumer goods between industry and the consumer in such a way that the participants vicariously experience the expectations, motivations, and role-playing of the individuals in that sector of society which they represent. Furthermore, by external control of the energy and income inputs to the energy and consumer sectors, respectively, a number of possible energy-lifestyle-social interaction scenarios can be generated and simulated as they would occur in real life situations. It is particularly important to debrief after each game so that each sector has an opportunity to describe its expectations, motivations, and realizations. Social interaction will occur both within groups and between groups. In this way particularly useful insights will surface.

Participants in the game are divided arbitrarily into six groups representing the energy, food producing, industrial, government, and two consumer sectors. The consumer sectors are not identical; one representing white collar workers receives a higher income than the other which represents blue collar society. Ideally each group should contain from four to eight players, sufficient for internal group dynamics, interaction, and lines of command to emerge. Consequently the simulation exercise is appropriate as a learning tool for groups of about 25 to 50 people.

Appropriate paper money and tokens for energy, food, and consumer goods are needed. All units of energy, E, are equivalent but food and consumer goods are available in three different categories. Units F1 and C1 represent basic staple foods and mass produced consumer goods; F2 and C2 somewhat "more desirable" items; and F3 and C3 the luxury and/or high priced items. The energy, food producing, and industrial sectors set their prices with a view to maximizing profit. The consumer groups aspire to a higher standard of living, which means greater energy consumption and purchase of "more desirable" consumer goods. And the government group endeavors to maximize the overall good by setting policies, legislating laws, collecting taxes, and distributing subsidies.

The game is played by time or trading period. Each period is divided into two parts: first, negotiation during which policies are made, prices are set, and inventories calculated; and second, trading, during which actual transactions take place.

A large blackboard should be provided so that the energy, food producing, and industrial sectors can publicize their prices in advance for all to see and the government sector can advertise its proposed taxes and subsidies. Accounting sheets should be provided to each sector to assist them with calculations and negotiations.

Besides the usual accounting balances required on cash flow and goods, certain limit constraints are also required if the game is to be played properly. Some of these are external to the system and can be manipulated to generate and simulate various scenarios. These are the levels of energy in (initially 200E) and income to the consumer sectors (initially $1,500 and $900). Other constraints are internal to the system; see equations at the bottom right of the chart which depicts the ENERGYPLEX model; e.g., bare existence level for each consumer group corresponds to the purchase of five F1, five C1, and twenty E units respectively.

The chart lends itself beautifully to operations research analysis using the linear programming technique. All the constraint equations are already available. All that is needed is a utility equation or objective function to maximize the "overall good" in some appropriate way. Furthermore, by using dynamic linear programming, the "overall good" can be continually maximized through successive time periods, while the external inputs are varied. In particular, the model can be used to predict what might happen sociologically if there were a sudden drop in energy availability from 200 to 150 units, as an example.

ENERGYPLEX has been played a couple of times by the University of Minnesota YMCA's Future Lifestyle Planners Group. On the second occasion it was played at an Energy Workshop on the St. Paul Campus over a period of about three and one half hours. It proved to be the highlight of the whole workshop. During debriefing a number of very interesting comments emerged. A member of the blue collar consumer sector stated: "We found we had no flexibility, all our decisions were forced upon us, we felt totally shafted". A member of the government sector said: "I'm glad I was a member of that group, it gave me an overall view of the interactions which take place in society which I had never appreciated or even thought about before".

A number of modifications and refinements are possible. The cash flow loop could be completed by making the energy, food producing, industrial, and government sectors responsible for the support of the consumer sectors, and other societal sectors like transportation and communications could be added. However, it is believed that the initial design strikes a reasonable balance between accuracy of societal simulation and complexity of play.

It should be emphasized that the game, to be played effectively, needs a trained game director. For assistance, contact the University of Minnesota YMCA's Future Lifestyle Planners. (Mr. Aiken donated half of his prize money to their program.)

Energy Sector Accounting Sheet

Time Period:	1	2	3	4	5	6
Energy Input	200E					
Energy Surplus from Previous Time Period	OE	→ OE				
Energy Total	200E					
Energy Loss (25% of Total)	50E					
Energy Available	150E					
Energy Units to: Industrial Sector	60E					
Food Sector	22E					
Cons. Sector #1	42E					
Cons. Sector #2	26E					
Total	150E					
Energy Surplus (Avail. — Total Used)	OE					
Prices per Energy Unit to: Industrial Sector	$10					
Food Sector	$10					
Cons. Sector #1	$10					
Cons. Sector #2	$10					
Income from; Industrial Sector	$600					
Food Sector	$220					
Cons. Sector #1	$420					
Cons. Sector #2	$260					
Total	$1500					
No. of C_3 Units Needed	5					
Price of C_3 Unit	$90					
Expenditures: C_3 Units	$450					
Taxes	$250					
Total	$700					
Trading Period Profit	$800					
Initial Capital	$700	→ $X				
Final Capital	$1500					
Initial Capital for next Trading Period (Must not Exceed $1000)	$X					
Net Amount Invested in Bank	$(1500-X)					

Food Sector Accounting Sheet

Time Period:		1	2	3	4	5	6
Food Units to: Cons. Sector #1	F1	0					
	F2	2					
	F3	3					
Cons. Sector #2	F1	2					
	F2	2					
	F3	1					
Food Unit Totals	F1	2					
	F2	4					
	F3	4					
Energy Units Reqd. for Total Food Units	F1	2E					
	F2	8E					
	F3	12E					
Total		22E					
Cons. Good Units Reqd. for Total Food Units	F1	2C1					
	F2	4C2					
	F3	4C3					
Prices per Food Units to: Cons. Sector #1	F1	$80					
	F2	$160					
	F3	$240					
Cons. Sector #2	F1	$80					
	F2	$160					
	F3	$240					
Income from: Cons. Sector#1	F1	0					
	F2	$320					
	F3	$720					
Cons. Sector #2	F1	$160					
	F2	$320					
	F3	$240					
Total		$1760					
Price of energy Unit	E	$10					
Price of Cons. Good Units	C1	$30					
	C2	$60					
	C3	$90					
Expenditures: Energy	E	$220					
Cons. Good Units	C1	$60					
	C2	$240					
	C3	$360					
Taxes		$80					
Total		$960					
Trading Period Profit		$800					
Initial Capital		$960	←$X				
Final Capital		$1760					
Initial Capital for next Trading Period. (Must not Exceed $1200)		$X					
Net Amount Invested in Bank		($1760-X)					

Industrial Sector Accounting Sheet

Time Period:		1	2	3	4	5	6
Cons. Good Units to: Energy Sector	C3	5					
Food Sector	C1	2					
	C2	4					
	C3	4					
Cons. Sector #1	C1	0					
	C2	0					
	C3	5					
Cons. Sector #2	C1	2					
	C2	3					
	C3	0					
Cons. Good Unit Totals	C1	4					
	C2	7					
	C3	14					
Energy Units Reqd. For Total Cons. Good Units	C1	4E					
	C2	14E					
	C3	42E					
Total		60E					
Prices per Cons. Good Units to: Energy Sector	C3	$90					
Food Sector	C1	$30					
	C2	$60					
	C3	$90					
Cons. Sector #1	C1	$30					
	C2	$60					
	C3	$90					
Cons. Sector #2	C1	$30					
	C2	$60					
	C3	$90					
Income from: Energy Sector	C3	$450					
Food Sector	C1	$60					
	C2	$240					
	C3	$360					
Cons. Sector #1	C1	0					
	C2	0					
	C3	$450					
Cons. Sector #2	C1	$60					
	C2	$180					
	C3	0					
Total		$1800					
Price of Energy Unit		$10					
Expenditures: Energy		$600					
Taxes		$400					
Total		$1000					
Trading Period Profit.		$800					
Initial Capital.		$1000	←$X				
Final Capital.		$1800					
Initial Capital for next Trading Period. (Must not Exceed $1250)		$X					
Net Amount Invested in Bank		($1800-X)					

Government Sector Accounting Sheet

Time Period:	1	2	3	4	5	6
Previous Trading Period Profits: Energy Sector.	$0	$800				
Food Sector.	$0	$800				
Industrial Sector.	$0	$800				
Income Taxes from: Energy Sector.	$250					
Food Sector.	$80					
Industrial Sector.	$400					
Cons. Sector #1	$150					
Cons. Sector #2	$100					
Surplus from Previous Round	$0	←$0				
Total	$980					
Expenditures: Food Subsidy to: Cons. Sector #1	$410					
Cons. Sector #2	$320					
Energy Subsidy to: Food Sector	$0					
Industrial Sector	$0					
Cons. Sector #1	$150					
Cons. Sector #2	$100					
Cons. Good Subsidy to: Energy Sector.	$0					
Food Sector.	$0					
Cons. Sector #1	$0					
Cons. Sector #2	$0					
Total Expenditures.	$980					
Surplus= Income - Expenditure	$0					

Consumer Sector #1 Accounting Sheet

Time Period:		1	2	3	4	5	6
Energy Units Purchased	E	42E					
Cons. Good Units Purchased	C1	0					
	C2	0					
	C3	5					
Food Units Purchased	F1	0					
	F2	2					
	F3	3					
Prices per Unit	E	$10					
	C1	$30					
	C2	$60					
	C3	$90					
	F1	$80					
	F2	$160					
	F3	$240					
Income: Basic Income		$1500					
Energy Subsidy		$150					
Food Subsidy		$410					
Cons. Good Subsidy		$0					
Savings from Previous Time Period.		$0	→ $0				
Total		$2060					
Expenditures: Energy	E	$420					
Cons. Goods	C1	$0					
	C2	$0					
	C3	$450					
Food	F1	$0					
	F2	$320					
	F3	$720					
Taxes		$150					
Total		$2060					
Savings = Income - Expenditures		$0					

Consumer Sector #2 Accounting Sheet

Time Period:		1	2	3	4	5	6
Energy Units Purchased	E	26E					
Cons. Good Units Purchased	C1	2					
	C2	3					
	C3	0					
Food Units Purchased	F1	2					
	F2	2					
	F3	1					
Prices per Unit	E	$10					
	C1	$30					
	C2	$60					
	C3	$90					
	F1	$80					
	F2	$160					
	F3	$240					
Income: Basic Income		$900					
Energy Subsidy		$100					
Food Subsidy		$320					
Cons. Good Subsidy		$0					
Savings from Previous Time Period.		$0	→ $0				
Total		$1320					
Expenditures: Energy	E	$260					
Cons. Goods	C1	$60					
	C2	$180					
	C3	$0					
Food	F1	$160					
	F2	$320					
	F3	$240					
Taxes		$100					
Total		$1320					
Savings = Income - Expenditures		$0					

Think It Over . . .

E. F. Schumacher in Minnesota

Russell Dahlner
Entrepreneur
Minneapolis

Note: this entry was received too late for consideration by the judges.

The idea came from "Small is Beautiful." Energy is getting short. Businesses that require enormous amounts of energy are going to become difficult to sustain. A good example is a nuclear energy plant that shuts down and may never make it back on line.

In trying to apply some of Schumacher's ideas to my immediate situation, I looked around the neighborhood to see if I could identify what it really needed. Gardening became immediately apparent. Another of Schumacher's principles that came into play was the idea that a small business, to be viable, should not require more than one year's income for capital investment. This meant that the amount of machinery had to be limited and the business would require more of an investment in labor. The gardening business does not require a large investment of either machinery or buildings; even though it expands, the same basic tools will suffice. A gardening service immediately and visibly improves the neighborhood; providing the service to a few establishments has a snowball effect as other landlords or commercial lessors notice the improvement. I solicited from commercial establishments within my normal social orbit, no more than one and one half miles from my home. The effort to generate business increases pride in the person directly doing the work. Your reputation is visible and obvious to your neighbors as well as yourself.

The services which can be provided through a small business of this nature are unlimited. You cannot exhaust the market and its needs within any small geographical area. There are more places than you can possibly service which would like to be able to afford expert care. My initial focus was commercial establishments but two neighbors have recently pressured me into gardening for them at their homes. So increasing business is a matter of more activity within the existing service area rather than expansion to other parts of the city.

The basic service includes lawn mowing, trimming shrubbery, weeding, etc. (Interestingly, weeding is in particular demand; it is very difficult to get people who do it dependably and well.) Whenever machinery is used the extra cost has to be justified by increased output. This basic gardening service could expand indefinitely to all sorts of activities around each property. Things never seem to get done by themselves; the list is as long as the things people haven't done yet in their own homes. I see a great future in additional services because so much retrofitting for energy conservation is needed.

I feel the maximum potential could be as much as $1,000 a week. That would mean working like hell during the spring, summer, and fall. But then, if you felt like it, you could knock off entirely during our rather long winters.

Or It May Come To This

Judge's Statement

Judge's Statement

Technological/Resource Changes and Their Implications for our Future
Judge's Statement
John Hoyt
Economist

We are running out of the catalytic resource that has made possible the industrial and post-industrial revolutions. That catalytic resource is derived from one of the three basic resources on which mankind has grown and developed over centuries. You know what they are: air, water and sunlight.

Air and water are essentially ubiquitous and free — or at least they have been treated as such for much of recorded history. True, in recent years we have begun to recognize that we have damaged these two resources — through the uncontrolled release of pollutants but the damaging processes are controllable and, in many cases reversible.

The third resource — sunlight — is universally the most ubiquitous of the three and is quite literally free. We haven't found a way to control it, to tax it, or to pollute it. Maybe we've finally identified something that is too hot for even the politicians to handle.

The problem really is that we haven't used it. Instead, we have built our post-industrial society on the base of the by-product of sunlight — fossil fuel energy resources — and we are literally running out of useable energy resources.

I've personally been involved — both frustratingly and with fascination — with the issue of solar energy as a potentially useable energy resource over the past two years. I want to expose my own thoughts about the impact of the current, and massively pending, energy resource shortage on the lives of the American citizen.

Let me make some projections — not predictions *but projections* — to 1990. They are intuitive I admit, but they are based on logical extrapolations of today. And they are, I believe, relevant in the context that they will impact on the institution of education, as we have come to know it, on the institution of leisure, as most of us have come to enjoy it, and on many of the other institutions of society we have come to experience.

Picture, if you will, a society where the use of a personal car as a means of transportation to and from *any* place, other than a place of employment, is illegal.

A society where five or six families in a residential neighborhood draw lots for the order in which they will live together in one home, a month at a time, during the Minnesota winters while the heat is turned down in the empty houses to a level just high enough to prevent damage to already drained water and sewer pipes.

A society where power boats, snowmobiles, and even power mowers are proscribed in their use, or even outlawed. A society where Monday night football and baseball is played Monday afternoon in an empty stadium and then is telecast Monday night, replete with a dubbed-in stadium crowd and "instant" replays.

A society where, with the support of the communications and computing (comcom) revolution that is being driven by the shortage of electrical power, the public school classroom is quite literally your "homeroom" (meaning a room at home) where discipline, testing, and individualized instruction are the responsibility of the parent. Where interactive cable television makes teacher conferences easier, but much less personal. And where, in fact, the issue of class size becomes totally irrelevant. The best teachers will be canned, on videotape. And all but the best will also be canned, but in the more colloquial sense of being fired; I believe we now call it "unrequested leave of absence" and apply strict seniroity rules to put it into effect.

What I suggest for education may also apply to religion. The still somewhat unique radio and TV ministries of today may well portent the future of religious congregations, where the link is not only the message but also the cable TV wire that takes a minister into his congregation's homes at their discretion rather than into his edifice at his urging!

Not all of the effects of what I am describing will necessarily be bad effects. Discomforting, yes. But they do imply a basis for a return to the "nuclear family," a return to neighborhoods of "friends" who are mutually interdependent, an era of more leisure time with family; (after all, if I don't need physical contact with the people I work with or for, I can use the comcom technology for business communications and pick up 30 to 90 minutes a day of "saved" commuting time — and have my "three martinis" with my spouse!) That may take a little adjustment for some of us; there is the danger of a societal "soused spouse" syndrome developing if we are not careful.

My point is simply this:

Technological and resource changes are impacting on our society at an accelerating rate. Some of these changes would occur whether or not we, in fact, suffer an energy crisis of gigantic proportions, and we should be planning now about how we might manage those changes so that we maximize their potential for good and minimize their probability of grossly negative impact.

But what stands in the way?

The single, most important, barrier is a nearly total lack of belief on the part of the general public that there is a real urgency about the national energy situation.

To put it in perspective for Minnesotans we can illustrate the magnitude of the potential problem in the following way. As a state we produce only two tenths of one-percent of the energy we consume. In other words we could support a population of only 8,222 persons with our own energy production — or we could support the entire current population with enough energy to survive for three minutes out of every 24 hours!

There are some other comments that should be made.

For example:

1. We have no existing solar energy industry infrastructure to support a residential or commercial/industrial implementation effort. We need major training programs for HVAC engineers and technicians for both installation and, most importantly, maintenance services.

2. We have only embryonic standards, certification, and warranty developments in solar and in conservation. Some progress has been made, thanks in large part to the Minnesota Energy Agency, but much more needs to be done.

3. Architects, building engineers, and contractors and developers need to begin to actively communicate with one another about design, site location, and aesthetics in the context of solar and conservation parameters.

4. And banks and savings and loan mortgage personnel need training, and incentives in order to be able to respond to requests for solar financial assistance. They need to have a better assessment of financial risk, life-cycle costs and payback, and operating savings potential of existing technological solar applications.

5. Finally, we need an overt, and agressively active, national, state, and local government commitment to support the private sector in the risks it appears willing to take on behalf of finding a solution to our energy problems.

I actively joined an effort to help find solutions to these barriers about 24 months ago. I believe we are making some progress, but it is frustrating. Sometimes I feel like that noted deep-sea diver who was sent down from a research ship to explore the bottom of the ocean. He was going about his work on the ocean floor when suddenly he received an urgent message from the ship; "come up quick," the voice said, "the ship is sinking!"

Frustrating parable, isn't it? One's chances of drowning are pretty good whether one stays on the bottom or rises to the surface, climbs aboard, and sinks with his ship.

However there is a third, less apparent alternative. Go up, not to the surface but to the hull of the boat, find the leak that is causing the ship to sink and then fix it. In short, define the problem first; then implement a solution.

We need action now. The Minnesota Energy Design competition is a beginning. I am also reminded, and encouraged, by a line I found in Forbes Magazine the other day. It read "It wasn't raining when Noah built the ark." Maybe we moderns should look ahead as well.

Saving Energy
Ellworth Simon
Occupation Unlisted
Utica

1. Everyone must live within walking distance of job — (final goal).
2. No one is allowed to build a house or move unless it is to a location closer to job.
3. 1,000 or more people per square block — large apartments — would eliminate heat loss because of less exterior walls, less doors and windows.
4. Prohibit weekends at lake homes, fishing trips, etc. — only vacations in a solid block of time.
5. Cities of first and second class (over 20,000) people are not allowed to use cars for intercity travel, only bus.
6. All people must buy at store closest to residences regardless of price.
7. Close all eating and entertainment businesses at 10:00 at night. I believe Canada does now.
8. Elimination of Union rules that cause featherbedding and waste energy by unnecessary travel, work rules, inspection, etc.
9. Increase profit for all businesses and eliminate red tape to build and arrange work and workers to save energy.
10. Increase rail service to small communities to reduce trucks.
11. Use all burnable waste products in home or business for heat and energy. Waste collection is wasting energy by trucks and loss of local source of energy. I burn wood and paper in a small heater and use ashes for fertilizer in garden.
12. Huge increase in the U of M ag research fund so to more quickly use local and available energy efficiently.
13. Eliminate desegregation busing of school children. As a hog farmer, you discriminate against me by eating a hamburger.

The Challenge

On Getting Energy Down to Earth
Judge's Statement
Matt Walton
Geologist

Ever since muscle power went out of style, Minnesota has supplied little of the energy it uses. Fossil fuels (oil, gas and coal) are the major conventional energy sources, and we don't have any. The small, rare occurrences of natural gas encountered once in a while in water well drilling are not related to the geological conditions and processes that produce the world's useable fossil fuel deposits. Nor is there any scientific basis for thinking such deposits could exist in Minnesota. The geology of Minnesota is simply not the geology that produces significant fossil fuel.

Although Minnesota has good water resources we have limited hydro power, because the state is relatively flat, and the "head" or fall of water needed to generate a lot of power is not available.

Nuclear energy is a special problem. Minnesota relies on nuclear generation for almost a third of its base-load electricity, so in a sense it is now a conventional energy source. Geologically speaking there are very real possibilities for uranium deposits in Minnesota. Active exploration is under way, though at this writing no discovery has yet been disclosed. But the future of nuclear power is in a tangle of political and technological uncertainties. Even if this jungle were cut through, and uranium mining became viable in Minnesota, uranium ore must be sent to a national facility for processing into nuclear fuel. Our local utilities purchase this processed fuel and it would make little difference whether the original uranium came from Minnesota, Wyoming or Timbuctoo. Therefore uranium mining, while it would add to our local economy, just as any other mining industry does, (and incidently add to our energy demand), it wouldn't really give us indigenous energy that we could produce and use directly.

So it would seem that for the kinds of energy Minnesota has grown to depend on, we are destined to subsist at the farthest end of the pipeline, shivering in the winter, perspiring in the summer, and wondering how we are going to get to work when the tank goes dry, at the whim of Arab Sheiks, multinational-corporate tycoons, devisive politics, instant experts, and most of all facing the plain and simple fact that the oil and gas that always filled the upstream end of the line is starting to peter out. Let me add, as a geologist, that you had better believe it is starting to peter out. No amount of tinkering with regulations and allocations, price controls and exploration incentives is going to change, or even mercifully conceal for long, that fundamental fact.

Fossil fuel will become less reliable, less available, and more costly for the rest of our lives. Not that it won't be around for a long time, available for critical uses, if we do what we need to do to use it wisely. But even if we started out tomorrow to do everything right, which we all know is not about to happen, we are in for many decades of profound and disturbing change as society goes about making readjustments in a way of life that can no longer depend on cheap fossil fuel.

These changes will have to be just as far-reaching as the change we experienced in less than a century as we moved from the horse and buggy world to the automobile world. But this does not lead to a logical prediction that we are simply going to retreat back down the same path we followed and that the horse and buggy are coming back in style. It is a prediction of change, great change, the shape of which is now shifting and but dimly seen.

Public awareness of our dilemma is increasing, and it too is taking shifting and ill-defined forms. For many people, impending change is just a threat, a source of vague anxiety, to be denied and forestalled, or aggressively combatted until the last drop of domestic oil dribbles out of the pipe. Unfortunately this characterizes much of the political response; Nixon's Project Independence, congressional action or inaction on energy pricing, buck-passing on effective conservation. The one thing that can be said for sure about such responses, which deny the dynamics of change, is that they will hasten the day of total dependence on foreign fuels, eat up the resources and the time needed to make an intelligent response, and bring about more catastrophic changes in the end.

It is from this perspective that the Minnesota Energy Design '79 competition is important, not because it is likely that a couple of neat ideas will emerge from it that will save us from the need to change our ways, but because the response to the competition is a genuine expression of growing public awareness that the times call for new adaptations. In fact to me the theme of the competition is *adaptation* — ideas to save energy by new ways to do ordinary things, to use energy that now goes to waste, to capture energy from the natural fluxes of the sun and the earth, and to increase the level of public awareness of the need for adaptive change.

Adaptation to nature went out of style along with muscle power in the brief century of cheap energy we have so blithely skipped through. When power is cheap, adaptation is unnecessary; it is too easy to create an artificial environment. Thus we have countless buildings which have no means of natural ventilation whatsoever, utterly dependent on air-conditioning, many of them hermetically-sealed glass boxes that deliberately challenge the natural flux of solar energy. The elegant geometry of the modern skyscraper may well be the culminating esthetic expression of the industrial age and its obsessive use of power. The exuberance that created the glass skyscraper and the 400 horsepower private automobile will be regarded as arrogance in a new age in which the subtle intricacies and natural harmonies of environmental adaptation will become the central theme of an emerging esthetic, if not the practical pathway to economic survival.

This is the message implicit in the ideas evoked by the Minnesota Energy Design '79 competition. No place is this more clearly seen than in the large number of entries devoted to the adaptation of housing to the natural flux of heat and cold; passively, especially through various earth-sheltered designs to insulate the house from climatic extremes, and actively through the capture and storage of solar energy and also by the use of the ground or of groundwater as a heat reservoir or sink. Many of these systems are well adapted to the day-to-day challenge of Minnesota weather, where winter days of bright sunshine and bitter cold are common, as are alternating spells of bright and overcast skies. There is something esthetically satisfying as well as economically rewarding about a house that will capture and store free energy when the sun shines and release it when it is dark and cold. The beauty of such houses is bound to grow on us.

There is another challenge of Minnesota climate which is vastly greater and potentially even more rewarding. This is the great seasonal flux of energy that pulses annually through the state. Minnesota has the greatest difference between average winter and average summer temperatures of any state. The Twin Cities have the largest average annual temperature range of any urban center in the world of more than a million population. To cite these facts seems at first glance to confirm our worst fears about Minnesota climate, but the second law of thermodynamics, which is a basic law of nature that even Congress and the President cannot tinker with, tells us that where you have a temperature difference you have a potential source of useful energy, and the bigger the difference the better the potential. You have to have a waterfall to make water power and you have to have a temperature fall to make thermal power. Thermodynamically, Minnesota is the richest state in the union, if we can find effective ways of capturing even a small part of this enormous natural flux.

Grandfather used to capture some of that energy. Every winter he went down on the pond, cut ice in big blocks, and buried it under sawdust in the ice house for use all summer. Now we make ice with electricity, and the work of our climate goes to waste. The flip side of storing winter cold is to store summer heat. This takes more technology, but it is not conceptually unfeasible. In fact, one of the ideas in the '79 Competition embodies a full annual cycle of using both summer heat and winter cold to save energy. An extensive duct system is built several feet below ground under a large parking lot for a commercial building. During the summer, air is drawn through this labyrinth for ventilation. The warm summer air is cooled by heat exchange with the cold ground and all or part of the air-conditioning demand of the building is satisfied. In the process the ground warms up so that as winter comes on the air drawn through the duct grows colder than the ground, and the ground supplies the heat it accumulated all summer to heat the building. By the end of the winter, the ground may well be frozen solid around the duct system, especially toward the cold-air intake end, and even greater cooling capacity will be available for the following summer. In the spring and fall, when outside temperature is moderate, the system can be bypassed by another clever invention called windows that open.

This is one of those marvelously simple "why didn't I think of that" ideas that has a lot of potential for Minnesota. Like most such ideas, it probably needs a certain amount of tinkering and engineering to get it working right. For example, condensation and ice build-up in the intake ducts may become a problem when hot, humid summer air is drawn through ducts embedded in hard-frozen ground, but if an idea is sound in principle such problems are not insurmountable.

The exciting aspect of this very simple technology is the promise it has for seasonal heat-cycling systems when really advanced technology is applied to systems of heat capture and storage, systems using heat pumps, for example, for energy intensification and very large capacity heat reservoirs. Then we can think in terms of producing industrial heat or the conversion of heat into other forms of power. We can even have a little fun imagining Minnesota attracting industry from the sun belt because our tough climate is such a cheap energy source. Far out? Maybe.

I get excited as a geologist because even small, simple applications of these ideas involve the use of the large heat capacity and low thermal conductivity of the ground for energy storage. To make it work, the geology has to be right, because not all geological environments lend themselves to such systems. When we consider large applications, then we have to evaluate the geology very carefully to determine the mechanical and chemical stability, structural strengths and weaknesses, porosity, permeability, and hydrology of the ground. I can visualize the Minnesota Geological Survey at work on the geology needed to develop a whole new natural resource, good ground for energy storage and retrieval systems.

I bring this up to make one last and most important point. The changes and adaptations that are going to be necessary as conventional energy becomes less available are bound to be very distressing and disruptive to established values and life styles. Large segments of our economy are going to be under severe stress. At the same time, new adaptations are going to present great opportunities. Are we going to exhaust our resources trying to pump up enterprises that are no longer economically viable? Or are we going to direct our resources toward new opportunities?

It is important to remember that for the last century and a half, life styles and the economy have been involved in the most headlong process of change the world has ever known. A lot of it, like pollution and the destruction of nature, we haven't always liked, but for the most part it has been regarded as the most fantastic period of economic opportunity the world has ever seen. Nevertheless, it was not without its hardships and failures. People used to joke about things going out of style like the buggy whip business, but it is no joke what happened to our railroads as the automobile, highway construction and airplane industries made billions. And whatever happened to the great ocean liners?

The point is that change is a two-faced coin. Tails is failure. Heads is opportunity. We had better start using our heads. We are going to need them more than ever now, because the change we are facing is quite different than the change we have just been through. That was a change based on an explosion in technology as coal, and then oil and gas fueled an industrial revolution. The great bonanzas of cheap energy made it easy to create the capital growth needed for change. We hardly noticed when the buggy whip business failed. Now we are faced with the need to make enormous capital investments to build the infrastructure for an economy based on entirely different kinds of energy at a time when the energy we rely on is getting dearer instead of cheaper. Where and how will we find the savings to do it? We won't do it if we use our resources in a desperate, last ditch battle to do business as usual.

But let us look at the heads side. Our forefathers started with great untapped resources of fossil fuel and very rudimentary science and technology with which to use it. These resources are now running down, and headlong economic growth dependent on them is slowing down and may be even about to turn around. But we have been left with an enormous legacy with which to do something besides fight to the last ditch and then retreat back down the horse and buggy trail. Our legacy is the science and technology created in the process of change. This resource could be worth more than all the oil and gas burned since Watt invented the steam engine if we have the will to use our wits to make new adaptations. This is the meaning to me of Minnesota Energy Design '79.

What We're Up Against
Judge's Statement
Darryl Thayer
Energy Consultant

There are many, many excellent ideas on many topics. The contest and the ideas presented give hope for the solution to the energy crisis. However, the *ideas will stop here.*

The person who submitted a freon "steam engine" will not ever connect with either the money to develop the idea or the person with a solar freon "steam" source. The idea is somewhat novel. The power base, either the government or private industry, will not steal the idea. In fact, they won't even recognize this as an idea. The private money will say, "You have only part of the hardware, and you have no market". The government will say, "We have 265 million crackpots and we want only ideas from people with demonstrated financial wherewithall and corporate backing".

The person who invented an easier snow shovel, to cut back on the uses of power snowblowers, will never see the consumer using his device.

Perhaps the point can best be made by considering a solar concentrator submitted. It did not receive a prize. This backyard mechanic built a concentrator of reasonable quality better than some I have seen after half a million dollars of corporate development. This person will not be provided with the avenue to complete development. This person has technique, or "genius," but the society that plunges headlong into an energy crisis with flags waving and lights flashing surely can't be looking for, or have a way of responding to a wee small voice. The faith in the great scientific-engineering knowhow and government planning won't be altered or abated until a Three Mile Island goes all the way and we really freeze to death in the dark.

Ten years ago I believed there was a technical fix. I still believe there was a technical fix then. Today I only see more or less severe disasters. Technology will be part of the fix if there is a fix, but it has to be the technology of the grass roots. I believe there are solutions and the solutions are in societies. And society — people — will pay the price for failing to face the energy crisis. Technology can soften the punch, not take it away. Those technologies are in the *now unusable* technologies submitted to this contest.

You might ask, and what is the reason for the contest? Do I believe there is a technical fix? And what do I see as solutions to the problem? The contest is a forum for ideas to be presented, a kind of "Hello, I have an idea". A forum to start other minds moving: "He has an idea; why can't it be used?" A forum to open questions: "If he has an idea that is exciting maybe there are other exciting ideas. And what changes need to be made to make his idea available?"

That discussion will make apparent: "Unless the grass roots . . ."

Renewable Energy Resources in Minnesota
Judge's Statement
Ron Rich
Engineer

Minnesota is in a unique position among the states in terms of its energy resources. We are a large state, relatively populated, and have a high need for and use of energy. Our energy needs are caused not only by our severe climate but also by our relative affluence and recreational opportunities. We have no "conventional" sources of energy within our borders (unless the prospect of uranium is counted). In fact, we have no "alternative" sources of energy at all that are non-renewable with the exception of peat (and even this resource "renews" in 2,000 to 10,000 years). Our real uniqueness however stems from the potential of our "renewable" energy resources. We have the capability of producing *all* our current energy requirements from a wide spectrum of Minnesota-available renewable energy forms at a level of technology available now or in the near term future (five to ten years).

With our unique situation and potential (and because of our unique dependence on outside energy resources) it is important for us as Minnesotans, perhaps more than any other state, to develop renewable resources as rapidly as possible, and to be as intelligent as we can concerning which of these resources we elect to use, and the consequences of their use. In order to develop the "best" of the renewable energy resources at least five factors have to be considered:

1. The availability of the resource: is there enough of the resource consistently available so that all the efforts applied toward its use can result in a significant, reliable energy production method.

2. The environmental consequences of the resource: how would widespread use of the resource affect the natural environment both in the short and long term, and if such effects are serious how best to deal with them. (Fortunately, most renewable technologies are relatively benign.)

3. The economics of the resource production and use: is the cost of energy from the renewable system competitive with other potential energy systems. (Fortunately, many renewable technologies are very cost competitive.)

4. The social/institutional consequences of the resource production and use: will the resource be acceptable to our society and can our institutions cope with their introduction. (Fortunately, most people seem to feel that renewable energy resources are at least "acceptable" if not "desirable".)

5. The "state-of-the-art" of the renewable production and conversion technology: how certain is it that the resource will actually produce usable energy if efforts are made to develop it and with what conversion efficiency. (Fortunately, almost all renewable technologies generally discussed are likely to produce energy, although efficiency factors are sometimes a concern.)

Of these factors, I believe the most important is the availability of the resource, both short and long term. Since almost any renewable resource type can be converted into energy forms compatible with our needs, heat, electricity, liquid and gaseous fuels, etc., it is crucial that the availability factor be the cornerstone of any renewable energy policy if we are sincerely interested in relying on such energy resources in the future. The four renewable resources I feel are now or can be widely available in Minnesota are:

1. Direct Solar Energy: enough *by itself* to provide 100% of our total energy requirements (if appropriate fuel conversion technologies are applied), even if

only a small portion of the state's land area is used. Of all the potential renewable energy forms, direct solar is the most abundant.

2. Special Energy Crops: enough by itself to provide 100% of the state's energy requirements although with substantially increased land requirements over solar. This energy method requires special low energy production systems on lands not suitable for timber production or farming to be most effective in living up to its potential.

3. Wind Energy: enough to supply 100% of the state's electrical demand with nearly available technology, and perhaps 100% by itself of the state's entire energy supply with as yet undetermined technology.

4. Crop Residues, that portion of agricultural crop material that is not directly used for food, feed, or fiber: enough to supply perhaps 10% of the state's energy supply by itself, although soil erosion control may limit full use of this resource.

I feel that all other renewable resources are relatively limited on a long term basis: wood and wood residue to less than one half of 1% of our total energy supply since demand for paper and lumber is projected to consume our forest production ability by the year 2,000; waste materials (trash) to less than 3% of our total energy supply because of its limited availability and because it appears that recycling this resource, which is basically paper, saves more energy than its combustion produces; human and animal wastes to less than 2% of our total energy supply even if all such wastes were converted; hydropower to less than 1% of our total energy supply even if rivers and streams not currently dammed were used; and conventional food, feed, and fiber agricultural crops to almost zero percent since the production energy required to grow such crops is substantial and the crops have more essential uses for food and other products.

I believe it is possible that with sufficient effort and interest, 25% of Minnesota's energy needs can be met with Minnesota renewable resources by the year 2,000 provided our energy consumption does not significantly grow by then. To reach this goal it is important that all reasonable renewable resources be developed, both large and small. I can only hope however, that appropriate effort and priority is placed on those renewable resources that have the most potential to provide a large share of our energy needs.