A Review of Ten Solar Applications in Iowa

prepared for the
Iowa Solar Operational Results Conference
June 21 & 22, 1979

developed by: Iowa State Solar Office
Iowa Energy Policy Council
Community Action Research Group

THE SOLAR REALITY

A Report to the Iowa Energy Policy Council

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June, 1979

INTRODUCTION

Because of rising energy prices and spot energy shortages, solar energy has been the focus of increased attention in the last several years; but few persons have any real knowledge of what actually is happening in Iowa. It has become especially difficult to develop programs promoting the commercialization of solar resources when legislators and state energy officials have no factual basis around which to build a strong solar program.

The Community Action Research Group (CARG), with financial assistance from the Iowa Energy Policy Council, set out to remedy this situation. A two-month tour took us through some two dozen Iowa communities to visit more than 40 persons. The results were surprising--solar systems indeed work in Iowa, often with remarkable efficiency. Many of these "solar pioneers" have developed some rather ingenious ways to cope with the rising costs of energy. Often they've done it with little or no assistance from government.

Admittedly, there were some problems encountered with the various applications. These, however, stem more from a lack of familiarity with the technology than from inherent design deficiencies. The majority of the solar projects tend to be those undertaken by the "tinkerers" and the "do-it-yourself" crowd. But most of the people believe that with the right combination of governmental financial support and technical assistance, a solid market can develop so that average families and small businesses will be able to take advantage of solar applications.

This report is a series of 10 case studies of representative solar technologies operating in Iowa. It is presented in the belief that the more people can be made aware of these "solar successes", the greater the likelihood that solar energy can become a significant energy resource for Iowa.

The assistance of the Iowa Energy Policy Council is gratefully acknowledged. Any statements or factual errors that may be contained in this report are the responsibility of the Community Action Research Group and not that of the Council.

Skip Laitner
Richard Cool

Ames, Iowa
June 14, 1979

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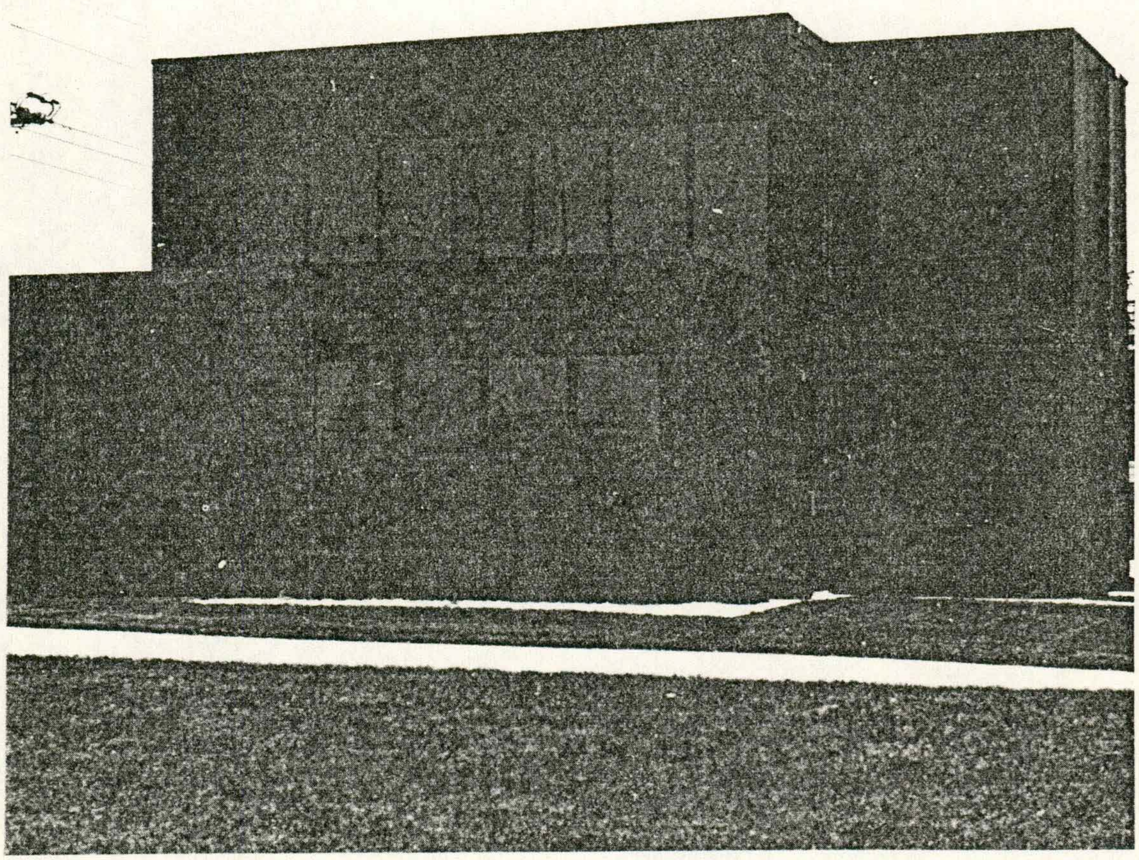
I. FIRST FEDERAL SAVINGS, CHEROKEE

"We need to start looking at alternatives so we decided to use this experience to determine whether we want to loan out money for new solar homes." This was Ken Lewis's explanation of why First Federal Savings of Sioux City chose to install solar panels in its new branch in Cherokee. Lewis is the branch manager.

The 1000 square-foot building uses an electric furnace as its backup. The collector system is the product of "Solar-Aire" of Mead, Nebraska. Although no cost figures have been kept, Lewis estimates that the 12 forced-air vertical panels provide 40-45% of the heating needs. However, he reluctantly points out that "we should be getting a lot more but we got burned."



First Federal Savings of Sioux City utilizes 12 vertical collectors to help provide heat for its branch office in Cherokee.

BUGS TO BE WORKED OUT

Lewis explained that the solar panels, which have been in operation for one full winter, "work beautifully". But using local contractors unfamiliar with solar units resulted in an oversized storage bin, thermostats which may not be properly set, and a design that may not efficiently transfer the solar heat from the collectors to the building.

According to Lewis, the Solar-Aire unit should be providing 60-65% of the building's thermal load. "And the way energy costs are now, bermed houses, domed homes and solar systems are the way to go. But it'll take more experience for people to work out the bugs."

Most solar panels consist of a cover plate using one or more layers of glass or plastic film, a heat transfer passage in combination with an absorber plate (usually with a flat black coating), and an insulated back-plate and enclosure. They are, in essence, black boxes with clear tops which capture solar heat. As air or water is pumped through the box, the temperature rises and the heat is transfered either to the building or to a storage unit.

A SALT STORAGE MEDIUM

The basic 36" x 77" Solar-Aire panel is no different. It is the salt storage unit, however, which sets the system apart from most other collector systems. By placing a compound called glaubers salt in sealed plastic trays (12" x 12" x 7/8"), total storage volume can be reduced significantly compared to water or rock systems.

For example, storage of one million BTU's of heat requires 200 cubic feet of Solar-Aire storage trays. About 1200 cubic feet of rock and 450 cubic feet of water (3400 gallons) are required to store the same number of BTU's. And because salt storage can be maintained at lower temperatures compared to rock or water (90°F compared to 120°F and higher), the Solar-Aire system can function well in an area with a relatively poor sunshine ratio.

The salt stores its heat as it moves from a solid to a liquid. It is this "cycling" from one state to another that raises some questions in people's minds, since there is a tendency for the various elements in the compound to settle out and thereby lower the overall efficiency of the heat storage. Solar-Aire appears to have solved this problem by adding other chemicals which leave the salt in a gelatinous state and prevent the settling. However, while there are several Solar-Aire installations in Iowa, none are known to have been tested for this problem.

Lewis believes his storage unit is designed to hold five days worth of supplemental heat but he's only running three. He's not sure whether it's the oversized bin or the installation. Neither is he able to find an independent, knowledgeable technician to identify the problems and make the necessary corrections. The dealer in Mead, Nebraska, isn't able to break away from his own work to ride herd on the unit. Nor can local contractors help, since they have too little experience with solar systems.

"It's obvious," he says, "that we need more experience and data in this type of work."

Would he do it again? "No question. It's the way to go and we're learning a lot."

II. HEYING ENTERPRISES, WEST UNION

"During the oil embargo of 1974, we kept wondering what we could do to short-circuit the long lead-time required for oil and coal formation. It was such a waste not to use the chicken manure; besides, we work on the premise that all things can be recycled."

Josephine Heying, partner of Heying Enterprises, Inc., was describing the reasons for constructing an agricultural waste digestion system for use on the Heying poultry farms.

The digestion system, located north of West Union, Iowa, was designed by Sunny Time Foods, Inc., to handle the wastes from 160,000 laying hens. Using an anaerobic digestion process, methane gas is produced which, in turn, is used to power a 100-kilowatt (KW) engine/generator set. An important by-product of the process is a liquid fertilizer, which is used to

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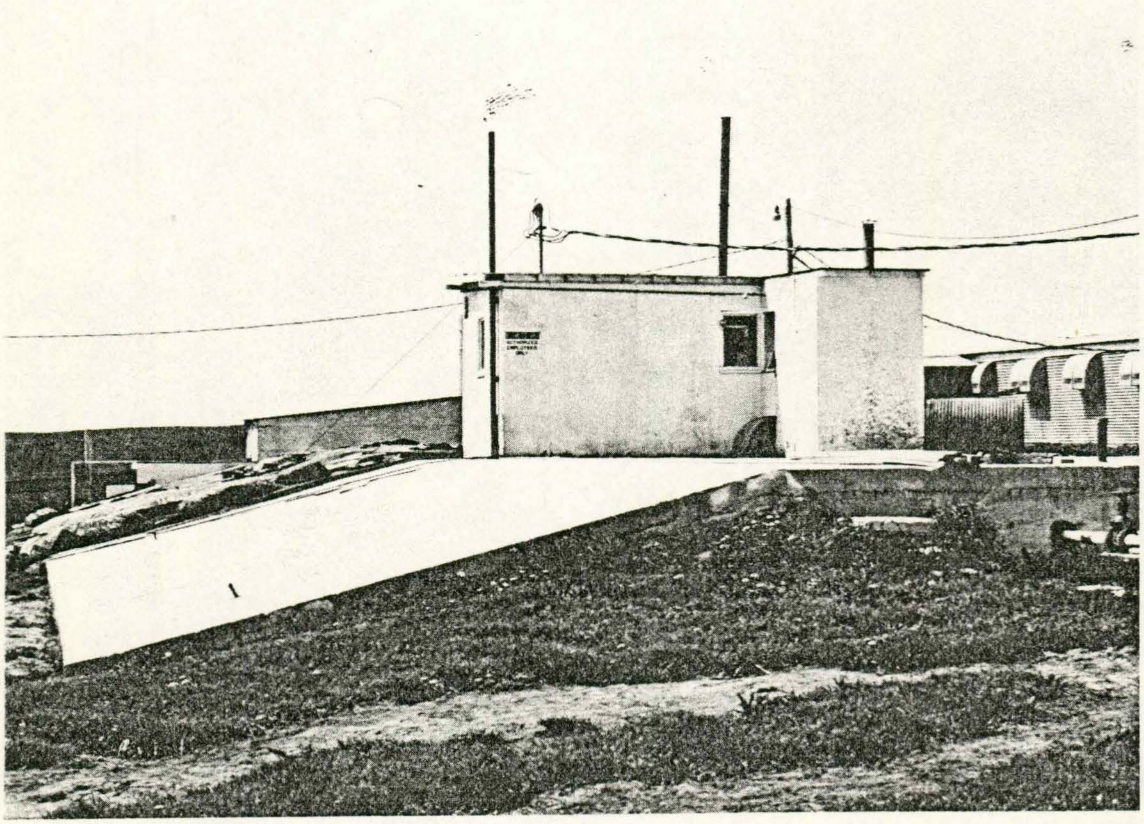


Not only is the Heying's West Union poultry operation developing a process to produce methane gas from manure, it also is able to generate a high-quality fertilizer. As can be seen from the picture, the manure digestion tank and pumping equipment are located underground.

replace commercial fertilizers on nearby farm fields. While there are a number of smaller municipal sewage systems which extract methane gas, and perhaps a dozen farms in the U.S. which use a similar process, the Heying operation is one of the largest of its kind.

PROBLEMS ENCOUNTERED

Although the project has encountered operational problems, Heying remains optimistic. "When starting a new energy source like this one, you always have some problems. It's a learning process and we now think we've got the problems licked."

The digester was designed to handle 10,000 gallons of manure per day, producing about 50,000 cubic feet of methane gas. That amount of gas would be sufficient to operate the 100-KW generator at two-thirds capacity on a 24 hour-per-day schedule. Approximately six kilowatts of capacity is required to operate the Heying farm. The remainder of the electricity generated could be sold to local utilities to offset the costs of operation.

However, since gas production began in August, 1977, the manure production has averaged only 4100 gallons per day. Cutting this feedstock by more than half has had a dramatic effect on gas production. The most gas that could be expected from the 4100 gallon flow is 700 cubic feet of methane per hour. The engine/generator set requires approximately 1250 cubic feet of methane per hour. Consequently, the generator has run for only short periods of time on biogas.

Courtney Allen, president of Sunny Time Foods, Inc., and a principal designer of the Heying system, described the reduced manure feed effect on gas production. "We've designed a symbiotic system that allows the use of all waste products. For example, we dovetailed the waste heat from the engine/generator set to heat the digesting wastes. Without generator operation, the temperature of the digesting waste fell below the optimum for gas production, thereby reducing further the production of biogas." The heating problem was further complicated by the failure to properly insulate the digester's tanks, increasing the system's heat loss.

Allen said that future plans include the digestion of agricultural wastes, such as corn cobs, to increase gas production. "Our theory was logically sound and the sizing problems will be resolved. We're forging ahead because this type of project has the potential to supply almost all of Iowa's average electrical consumption."

SYSTEM OVERVIEW

The digester system consists of several subsystems. The major subsystems are: influent, digestors, heating, electrical generation and effluent. Each subsystem is briefly described below:

A. Influent Handling System--The waste from the two chicken houses is conveyed daily into a mix tank. The operator adjusts the percentage of solids in the raw manure by adding water. The waste is then stirred by a slow-speed paddle mixer. When the mixture has reached the proper consistency, it is pumped into the digester by a centrifugal pump.

B. Digester Vessel--The digester vessel is a two compartment, 500,000 gallon, reinforced concrete tank. Each compartment holds approximately 250,000 gallons. The south compartment is considered the primary digester since it receives the manure-feed first. The north tank acts as a holding tank for the slurry before it goes to the field. The overall width, depth and length is 56 feet by 17 feet by 100 feet.

C. Heating--The waste heat from the engine/generator set or heat from a propane hot water heater provides process heat for the digesting process. The heat exchangers, installed within the digester vessels, consist of large steel cylinders which are ten feet tall and have an I.D. and O.D. of 26 and 30 inches respectively. A combination antifreeze/water solution is circulated through the heat exchangers.

The digesting manure is also mixed to increase heat transfer and gas production. A rotary blower recirculates the gas from the headspace in the digester through pipes under the heat exchangers, increasing flow past the exchangers.

D. Electrical Generation--The engine/generator set is a six-cylinder engine coupled to a 100-KW A.C. generator. The engine is a dual-fuel--propane or digester gas. The engine requires approximately 2000 cubic feet per hour of 600-BTU-per-cubic-foot fuel. The engine cooling water system is connected to the digester heating system and was designed to satisfy all heating demands of the digester.

E. Effluent System--The effluent system simply involves pumping the effluent from the north tank to a liquid manure vehicle. The secondary tank has the capacity to allow manure spreading at the farmer's convenience, rather than every day.

Allen states that when the effluent is spread at a level of 1700 gallons per acre and disked in, corn yields of 160 bushels per acre are possible with no additional commercial fertilizers.

FAVORABLE ECONOMICS

One of the major features of this project is its potential profitability. To build a similar system elsewhere would require a capital investment of over $160,000. Earnings from the production and sale of electricity are estimated to be $21,000 per year. The residual manure from the digester could be sold for $6000 per year. Allen estimates the annual return to be over 30% on the original investment.

Heying concludes, "We are plowing ahead with this project, regardless of the problems we've experienced, because we've got gaith in it. Besides, it will help solve Iowa's energy problems."

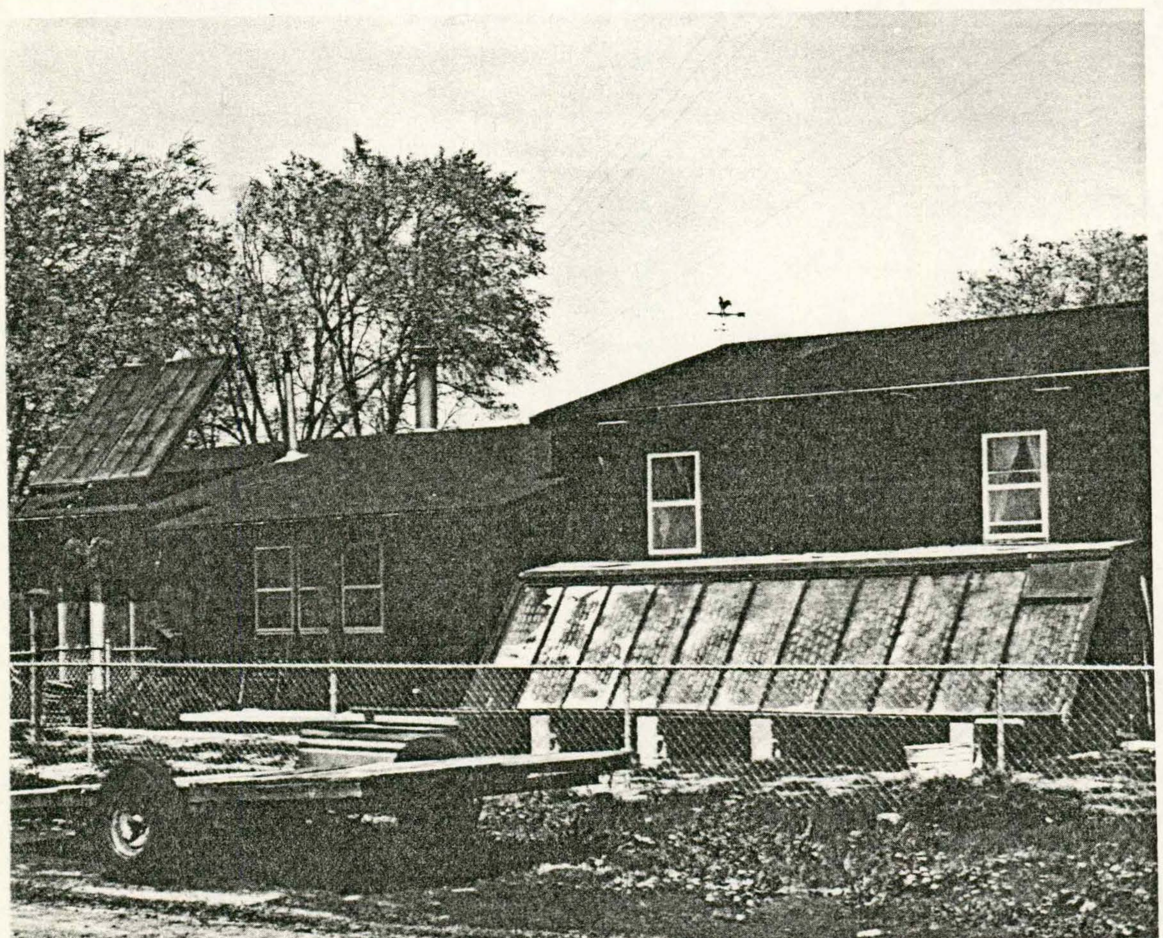
III. BOB & LINDA WILLIAMS, COUNCIL BLUFFS

They haven't used their electric furnace in three years. Their electric water heater hasn't been on for over one year. "They" are Bob and Linda Williams, a Council Bluffs couple who built an integrated solar/wood heating system that has virtually freed them from utility bills.

SPACE HEATING

"We never have been cold!" Bob Williams states. "With the combination Franklin stove and beer can collector, we can keep our house at 72°F right through the winter. Nobody has to be cold if they work at it."

And work at it they did. The 138 square foot air collector required more than 900 aluminum beer cans soldered together into some 60 rows.



Bob and Linda Williams, using a homemade beer can collector and a Franklin stove in their Council Bluffs home, haven't used the electric furnace for three years.

"We don't drink beer but Linda and I'd be out mornings at 6:00 am at the back of the bars and take what we needed," Williams said. "We pretty much scrounge for everything. Never have bought any wood."

Because of the wood stove, the Williams' solar system requires no storage unit. This substantially reduces the cost. "I could probably build a much better outfit next time for $300-$400."

Although it has worked quite effectively, the collector system has had a few problems. Some condensation has formed on the air return side of the unit because, at first, Williams couldn't find a good caulk that would maintain a tight seal as the Kalwall glazing expanded under the heat. In fact, the beer cans tend to over heat, reaching temperatures of 250-260°F.

Now that a better sealant has been applied, Williams plans to reverse the airflow in the collector to allow the hotter outlet temperature to eliminate the condensation. One feature of the collector that he feels people ought to utilize is the cover which prevents the summer sun from overheating the collector. In the winter, however, the cover unfolds to a horizontal position, revealing a bright surface which reflects additional sunshine into the beer cans.

SOLAR HOT WATER

The combination of two roof-mounted collectors (4' x 8') plus a homemade wood firebox located beneath the water tank makes Williams' hot water system "one of the most efficient things I've ever seen. It's well insulated and can consistently give me 150°F water."

Does he have any specific cost saving figures? "If the water's hot, I'm satisfied."

The solar system, also built by Williams, is a more typical liquid collector that pumps about 10 gallons of water through copper tubing serpentined on the panels to a heat exchanger which, either by itself or in combination with the wood assist, can kick the home's hot water temperature up to 150°F. The water in the collector drains at night into a storage tank to prevent winter freezing of the system. This eliminates the need for an antifreeze solution.

As with most of his energy systems, all materials have been scrounged from other units. The water heater consists of a small steel drum converted into a tight, efficient wood stove and welded beneath two used gas water heaters that have been fashioned into a single unit.

WIND GENERATORS

"The highest electrical bill we've ever paid was last January's, which was $12-13, and that was because we had a portable electric heater for some baby chicks. Otherwise, it's about four or five dollars."

Two 1000 watt rebuilt Winchargers made in Sioux City provide the Williams household with a high degree of independence. "We run a 32-volt direct current system and that operates our lights, refrigerator, pumps and deep-freeze. My wife's Christmas present was a 1941 Electrolux vacuum cleaner which also runs on 32 volts." Williams noted that "the only thing we need an inverter for is our TV and stereo."

Again, by scrounging Williams managed to dig up five Winchargers, paying anywhere from $15 to $100 apiece for them. After putting in new bearings and rewiring and cleaning them, they're usually ready to go. His two house units are mounted on 80 and 87 foot towers, which cost $3.50 per foot.

Storage is provided by 16 large 1680 amp-hour lead-acid batteries. Williams estimates that running everything, he has about 5 days worth of storage. Despite their success with wind generators, both Bob and Linda caution that "wind isn't for everybody. They need a lot of work and you have to enjoy taking care of them. Right now it's a do-it-yourself technology--but that's changing."

NEXT?

"We bought 16 acres of land that we're building on. When finished, we'll have a semi-underground, two-bedroom home for $4000 worth of materials. That's because we'll be scrounging."

Williams plans to have a 20' x 10' greenhouse as part of the living room. The house should be completed by the fall. "When we get up there, I'm not going to hook up to the utility at all. We're going to use a passive approach because as long as you've got blowers, you're going to have utility bills."

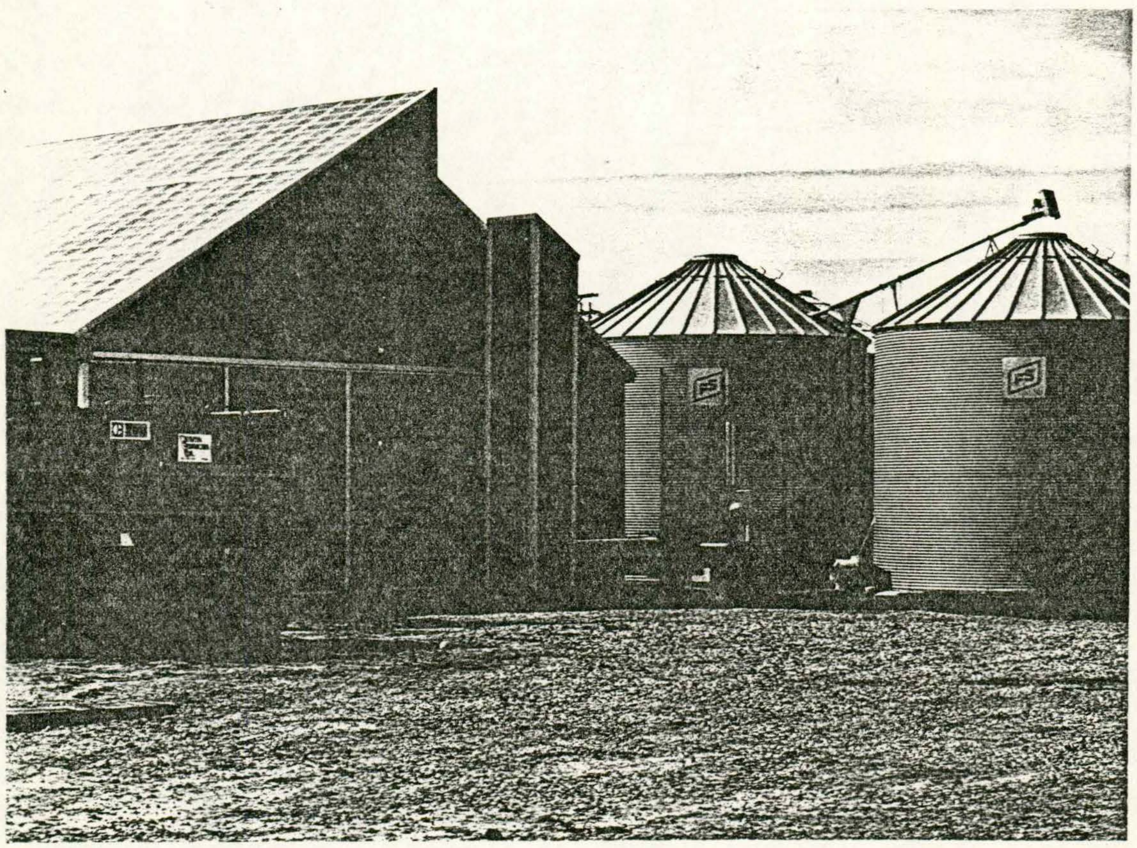
IV. COOPER EVANS, GRUNDY CENTER

"There's no reason in the world why it can't be done," said Cooper Evans, commenting on his use of solar energy to dry corn. "I've always had an interest for solar applications and when the need arose for a new machinery building I thought I would incorporate the two aspects."

Energy is not a new subject for Evans. His engineering background and energy interests landed him the position of Chairman of the House Energy Committee in the Iowa Legislature. Evans is also a legislative representative to the Iowa Energy Policy Council.

SYSTEM DESCRIPTION

The Evans designed system, located in Reinbeck, incorporates a hot-air collector constructed on the south-facing roof of the machinery building.



By operating a solar grain drying system, Rep. Cooper Evans has reduced the cost of fall drying from 4¢/bushel with propane to 1.5¢/bushel with solar

The roof's peak was extended to create additional collector surface and space for ducts within the building enclosure. Local labor crews were used for the construction of the system.

The system consists of approximately 2500 square feet of collector surface on a 55 degree slope. The collector surface is made of plywood panels painted black and covered with a greenhouse corrugated fiberglass called "filon". The filon comes in 4' x 12' sheets and it is nailed onto 2" x 2" boards. This provides a spacing of approximately one and one-half inches between the plywood and the filon through which the air moves.

A ten horsepower fan draws the air through the collector and ducting, forcing it into the bottom of an 8000-bushel grain bin. The warm air is forced up into the grain through a false floor that is permeated with many small holes. The bin also contains a circu-flow auger system that recirculates the partially dried grain to the top of the bin, allowing the warm air to come in contact with the wet corn at the floor surface.

Evans has been very satisfied with his system's operation. "I had it built in the fall of 1976 and have used it for three harvest seasons with no problems. The solar portion of the project cost me approximately $7000 but it's paying for itself."

The system is able to dry 16,000 bushels each season with the use of two 8000-bushel bins. He has calculated the operating costs of his solar drying system a 1.5 cents per bushel. His natural gas powered drier costs an estimated 4 cents per bushel and similar drying and storage operations at a local elevator would cost 20-25 cents per bushel.

THE DRYING PROCESS

What advice does he have for other farmers interested in solar grain drying? "Start slowly and give it some thought," Evans advises. "You just have to know how to dry grain or you'll create problems. For example, if your air is too warm and it strikes high moisture corn, you'll get condensation and possible spoilage."

The Evans system can raise the ambient air temperatures as much as 40 degrees at low flows. To compensate for these high temperatures, Evans has devised a vent that allows the mixing of outside air with the heated air. When the system is used for cold grain, the air temperatures are kept at 20-25 degrees above the ambient until the grain heats up.

To avoid condensation problems, Evans does not place corn above 24% moisture into the bins. For winter storage, he can dry the corn to 17% moisture and finish drying it during the following March or April. For final storage, the corn is dried to 13% moisture.

A 100,000 BTU gas heater has been added to the system to allow nighttime drying. The heater will create a 10 degree increase in ambient air temperatures.

"At the present time, I only operate the system during October to December and a few weeks in the spring. It's underutilized. If I had it to do over again, I would make the south-facing vertical wall a collector and I would install ducts into the building floor. This would allow me to dry alfalfa for use as dehydrated pellets. It would be an excellent summer use of the collectors."

MORE SOLAR

Evans' satisfaction with his solar drier has whetted his appetite for further solar ventures. "I would like to build a large hot air collector for use on my other grain bins and I anticipate experimenting with plastic tile pipe installed underground, using the earth for storage purposes."

The construction of a solar still and a small-scale alcohol production facility have also caught Evans' interest. Pointing to the local co-op elevator, Evans comments, "There is a lot of spoiled grain at Iowa's elevators each fall that could produce some energy. We should put it to use."

Evans' final advice to any farmer planning to construct a new building: "It's not every day that someone builds a large structure that can double as a solar collector. A person must anticipate the eventual use of solar energy and construct the buildings so that a large southern exposure is available."

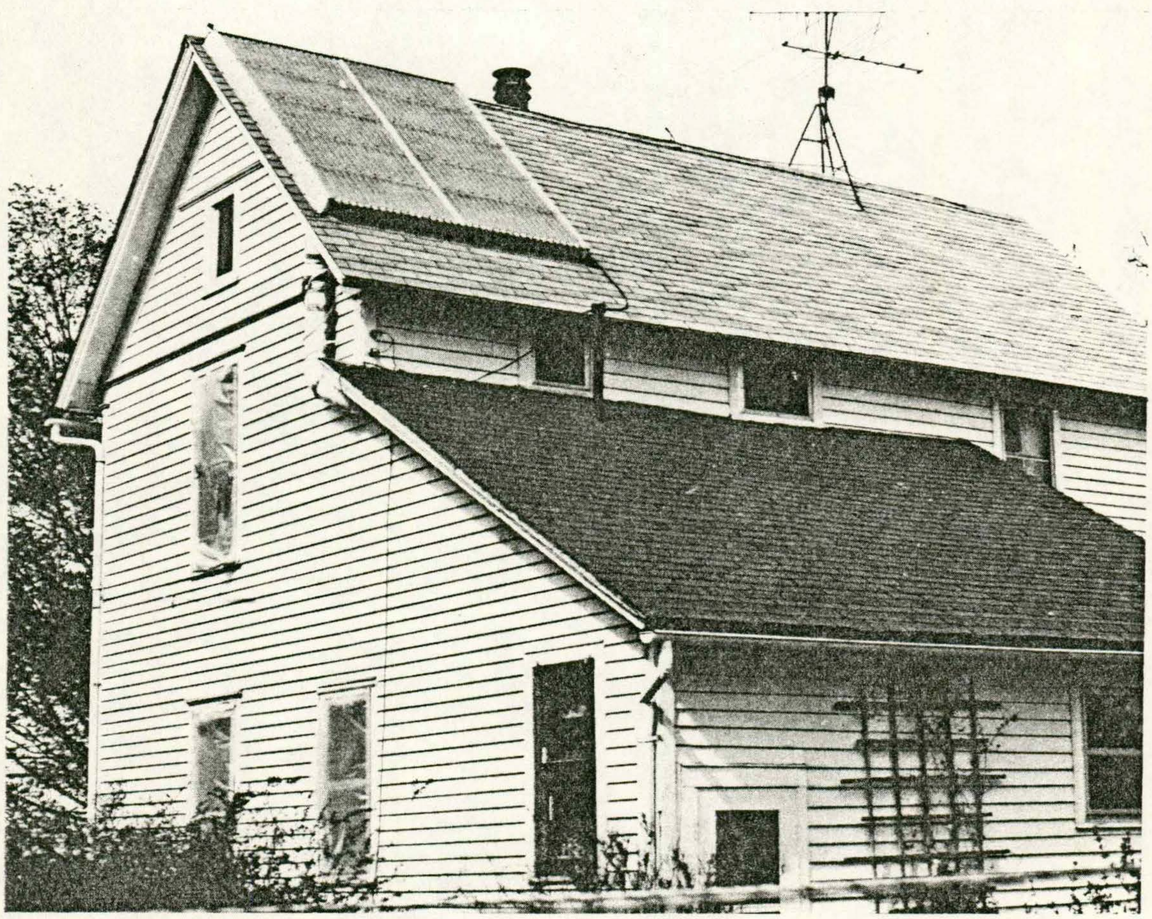
V. KEN & HELEN FAUCETT, WEST BRANCH

Sometimes, just knowing the right people can get you interested in new ideas; that and a high electric or hot water bill.

Ken and Helen Faucett, a West Branch farm couple, through a friendship with Don Laughlin, decided to "go solar" in an effort to further reduce their monthly energy costs. In January, 1977, they installed a "Longwood Dual Fuel Furnace" which burned a wood/fuel-oil mixture in such a way as to lower their winter fuel-oil consumption by 70%. A solar preheater kit seemed to be the best complement to the new furnace.

A NEW COLLECTOR DESIGN

Laughlin, an electrical engineer, had been working with Don Spencer, a University of Iowa mechanical engineer, to produce a new type of solar



This 80 square feet of collector provide Ken and Helen Faucett, a West Branch farm couple, with 70% of their hot water needs.

collector which operates at slightly below atmospheric pressure. The design, conceived of several years ago by Spencer, has several advantages over traditional collectors; a higher thermal efficiency, which means more BTU's captured per square foot, lower costs, faster warm-up, and greater mechanical flexibility.

In this collector, the absorber plate is actually two sheets of stainless steel (each .006 inches thick). The upper flat plate is blackened to absorb the solar heat while the lower plate is corrugated with a series of .015 inch grooves. Water is contained between the two plates, flowing through the grooves at one pound per square inch below atmospheric pressure. The design significantly reduces heat loss from the collector and increases thermal transfer to the heat exchanger located in the basement.

SYSTEM PERFORMANCE

With some assistance from Pleiad Industries, the small firm operated by Laughlin and Spencer, Faucett installed an 80-square-foot preheater kit in September, 1977. These kits are available for about $800 and include the collector, pumps, controls, and a 110 gallon steel storage tank. Heat from the collector is transferred to the basement storage tank by copper tubing.

Prior to entering the hot water heater, cold water passes in parallel through two 80' coiled copper tubes (3/8") located in the storage tank. There it is preheated and moves to the electric hot water heater. Both the heater and the tank are well-insulated. To prevent freezing, the Pleiad system drains at night.

In December, 1977, the system reduced the electric heating bill by 50% over the previous year. Comparison of bills for years prior and subsequent to installation show an overall reduction in costs of 70%.

In a paper prepared for the Iowa Energy Policy Council, Spencer and the Faucetts attribute the cost-effectiveness to a combination of factors:

> First, the roof of the home is pitched at an appropriate angle (about 45°) and is not shaded by near-by buildings nor trees. (A space frame or a surface oriented in the appropriate direction upon which to mount a collector, will always be a major cost of any collector system if not available free as part of an existing structure or included in the design of a new structure.) Secondly, the roof was due for reshingling. This was done after the collector had been installed, again illustrating a common sense approach. Thirdly, a collector was selected which adds no more load to a roof than ordinary asphalt shingles. Thus no additional roof support was required.

EARLY PROBLEMS

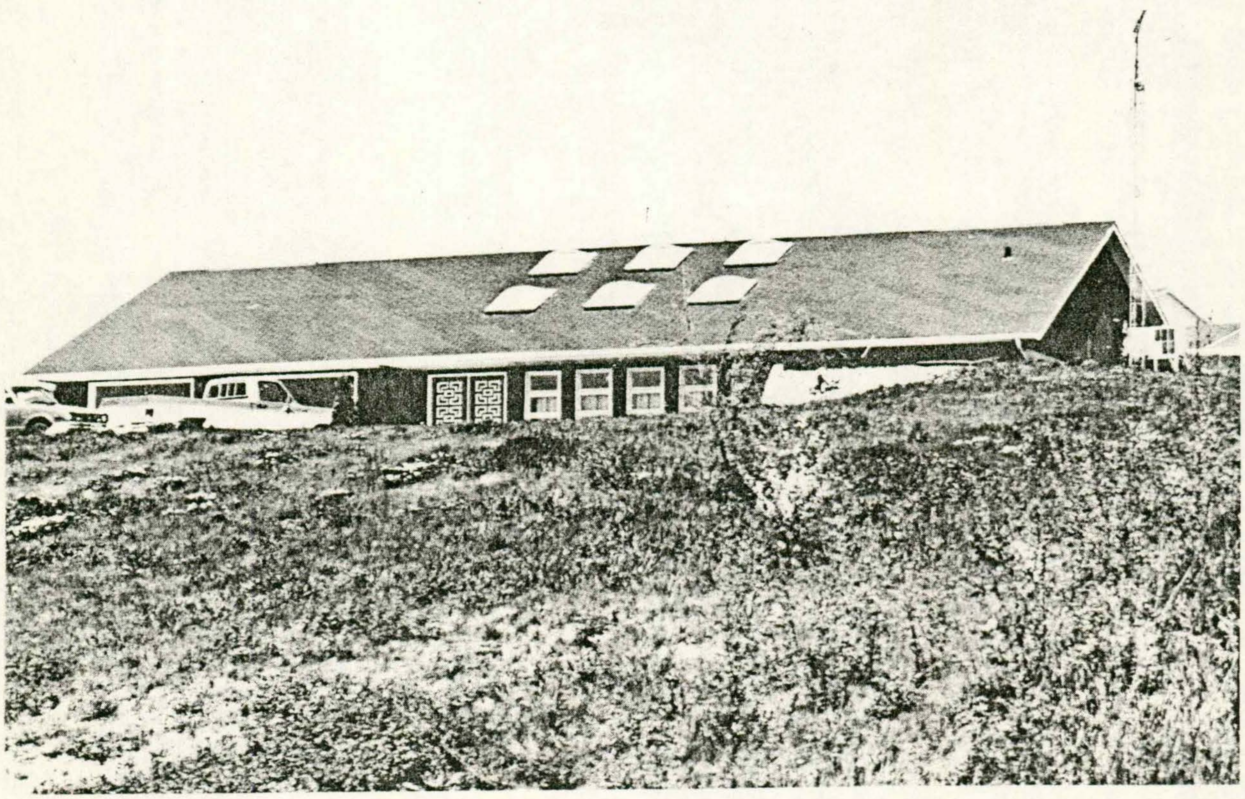
In the original installation, about 17 feet of the lines leading to and from the collector were exterior to the house. Despite an effort to insulate them, the system experienced some freeze-up difficulties. To eliminate this problem, the tubes were removed and taken down through the house. In another instance, a broken electrical lead resulted in unpredictable controls operation, requiring manual operation until the lead was located and repaired.

VI. PAUL & LOIS KURT, MONTICELLO

"If underground homes are going to be accepted, we have got to get rid of the myths such as the cave-like syndrome. In fact, it would be more appropriate to call them 'subterranean homes'", said Paur Kurt, commenting on the public's attitudes concerning underground housing.

"Half of the people in Jones County said we would go stir-crazy or suffer from cabin-fever. They thought we would catch ricketts or TB. After three years, I still consider myself to be a normal person and I'm not suffering any of those ailments."

The Paul and Lois Kurt family has occupied their subterranean home, located one mile northwest of Monticello, since December, 1975. Their decision to go underground was encourage by an article in Popular Science on underground homes in New England. The Kurts decided, "If it works there, it should work here."



Designing a subterranean home has enabled Lois and Paul Kurt to significantly reduce winter bills.

"Besides, solar energy is Mom's pet project," explained Chip, the son of Paul and Lois.

HOME LAYOUT

Indeed, the Kurt's home dispels any misconceptions that one has about underground homes. As you pass through the front door, you enter a spacious, sun-bathed atrium. The sun enters the atrium through nine large domed skylights located in the roof and through the south-facing windows.

The 28' x 30' atrium, outfitted with a massive stone fireplace, serves as a family room. The large quantities of available sunlight have allowed the Kurts to plant a large flower garden that is sunk into the atrium floor. The combination of sunlight and decorative plants makes one forget that the house is completely bermed on three sides, having no visual contact with the outdoor environment.

The other living spaces, such as the bedrooms, study, and dining room, are located on the atrium's perimeter. Each room has a set of glass walk-out doors opening onto the atrium and allowing illumination by natural light. This feature further reduces the potential "boxed-in" feeling that many people associate with subterranean homes.

TYPICAL CONSTRUCTION

According to Paul, this home was no more difficult to construct than the typical above-ground house. The footings were increased in width to 24 inches and the poured concrete walls are 8 inches thick. A tar sealant was applied to the exterior surfaces to prevent leakage.

The interior wall is a standard 2" x 4" construction on 16 inch centers. This allows for insulation with 4 inch fiberglass batts. Only the southern wall is of the typical frame construction.

The ceiling was peaked to a height of 16 feet. The Kurts are presently constructing a loft in the atrium area that will increase the living area by 400 square feet. As Paul states, "The high ceiling created a lot of wasted space and increased the amount of wasted heat."

The skylights are a double-paned device with a curved, acrylic dome over a single flat pane. Six lights are located in the south-facing roof with the remaining three lights on the north-facing slope. Paul enjoys the skylights because there are fewer windows to wash and storms to change.

Although the Kurts have not kept an accurate account, contractors estimated the home cost $75,000 three years ago.

INEXPENSIVE ACCOMODATIONS

The Kurts have combined the conservation aspects of subterranean living with an alternative energy source, wood heating. The atrium fireplace is equiped with a forced-air tubular grate.

"My friend went to his blacksmith shop and threw the grate together for less than $5 in materials. A small squirrel-cage fan, no larger than a hand held hair drier, does an excellent job of heating the atrium."

The heating bills are clear evidence of the energy-saving aspects of the Kurt's 3000 square foot home. During the winter of 1977-78, the Kurts used $230 worth of LP gas. A neighbor with a similar size house had a one-month heating bill of $175 for gas.

"The house will maintain a steady 60° during winter days when no one is around. When we get home, the heater doesn't run any time at all before it's up to 68° and then the fireplace helps us out too," stated Paul. The house also creates less demand for air conditioning.

One problem encountered by the Kurts is that of humidity. The house does require the operation of a couple of dehumidifiers. This situation is aggravated by the presence of the large number of plants in the atrium garden. However, the plants are worth the added problem. Paul quips, "During the long winters, especially around February, I can look out into the atrium garden and all those thriving green plants give me a new outlook, a real lift in spirits."

According to Chip, the humidity problem could have been a lot worse. "Mom wanted a swimming pool in the atrium but we voted her motion down 3 to 1. I'm glad we talked her out of it and as it is now, she has acquired quite the green thumb."

LOCAL INTEREST

The Kurts have not been without company. Many interested people have stopped to view the house or to inquire about the domed "solar collectors", the skylights. It is an educational experience for the public, as Chip says: "People are really surprised to see we are not 30 feet underground in a cave."

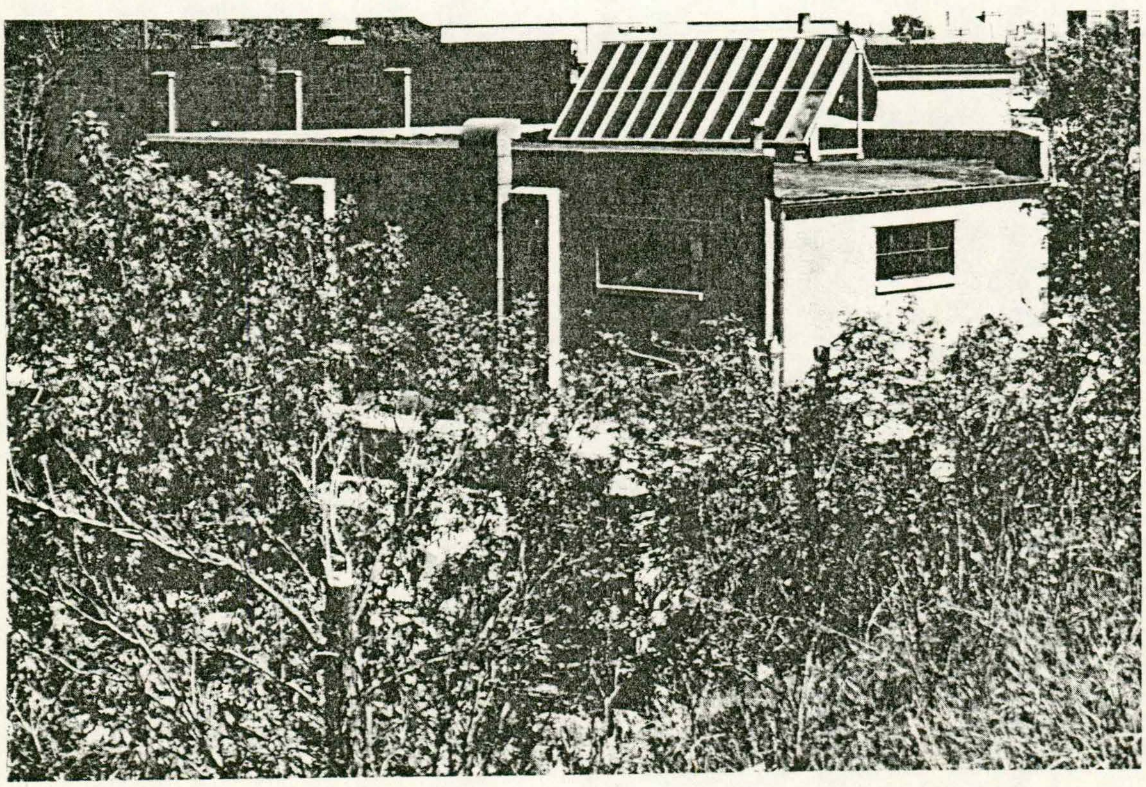
Perhaps Paul is right--the term should be subterranean!

VII. RUNDE'S CUSTOM UPHOLSTERY, INC., DUBUQUE

The heating bills continued to rise; there was no relief in sight. He began to experiment by installing six solar collectors. It worked and he was convinced "it's the coming thing!"

For Bill Runde of Dubuque, solar energy is working. Runde operates an upholstery shop located in a converted dairy building. The rooms are extremely large, with sixteen-foot ceilings and large uninsulated garage door entryways. The constant opening and closing of these doors has proven to be very costly in wasted energy. Runde needed a solution to this problem.

In February, 1978, Runde installed six liquid solar collectors on the shop roof. He scrounged through the junked dairy equipment and discovered two usable heat exchangers with attached fans. The exchangers were connected in series with the collectors and put into operation.



These collectors, manufactured and used in Dubuque, provide Tom Runde with a cost-effective supplemental heat source for his upholstery shop.

During the spring, Runde installed an additional four collectors to increase the heat output.

SYSTEM OPERATION

The collector system is designed and manufactured by Engineers Ltd. of Dubuque. This system contains ten panels (12.5 square feet of collecting surface per panel) connected in series. No heat storage is included because the heat is used as it is collected.

A one-third horsepower pump circulates an anti-freeze/water solution through the collectors at a rate of 20-25 gallons per minute. Runde has discovered that the heat transfer solution will leave the collectors at 140°F on the coldest winter day. There is a temperature drop of approximately 65°F across the heat exchangers, allowing the solution to return to the collectors at 75°F.

Runde can use his system for approximately 6 hours per day during the winter: "I could probably get another hour of heat but there's a large hill that shades the afternoon sun." The collector system is utilized from October to April. Runde estimates the system cost at approximately $2100, self-installed. Installation charges could amount to an additional 20%.

"It's really easy to install," said Runde. "I just built a stand, bolted it to the roof, and connected the piping. I only needed an electrician for wiring the fans."

Runde has experienced few problems with his system and he anticipates adding an additional 6 collectors this year. This would raise his solution temperature and allow him to add another heat exchanger.

His advice to those people considering a solar collector system: "Don't let the initial cost scare you because they are not costly to operate. The fuel is free! However, do place your collectors in an easily accessible area so that you can remove any snow that may accumulate."

INTEREST GENERATED

"People are always stopping to ask what kind of contraption I have on the roof. They are interested but they're still laying back and waiting until the facts are in."

No accurate estimates have been made of the energy savings. But, says Runde, "If I had that hard data, I'm sure people would be convinced that solar energy can work for them too." Using a conservative estimate of 40% collector efficiency, a simple pay-back period of less than six years is expected for the unit.

Concerning his interest in pursuing other solar projects, Runde said: "I would install a set of hot water heating collectors for my swimming pool but the pool already takes up all my yard. And I am thinking about experimenting with a hot air collector on the shop roof."

Engineering Ltd. manufactures a hot water heating collector system consisting of two collectors, a pump, heat exchangers, storage container, and controls. This system is designed to provide all the hot water for a family of two except during extended (3-4 days) cloudy periods. The installed cost averages $1200-$1500.

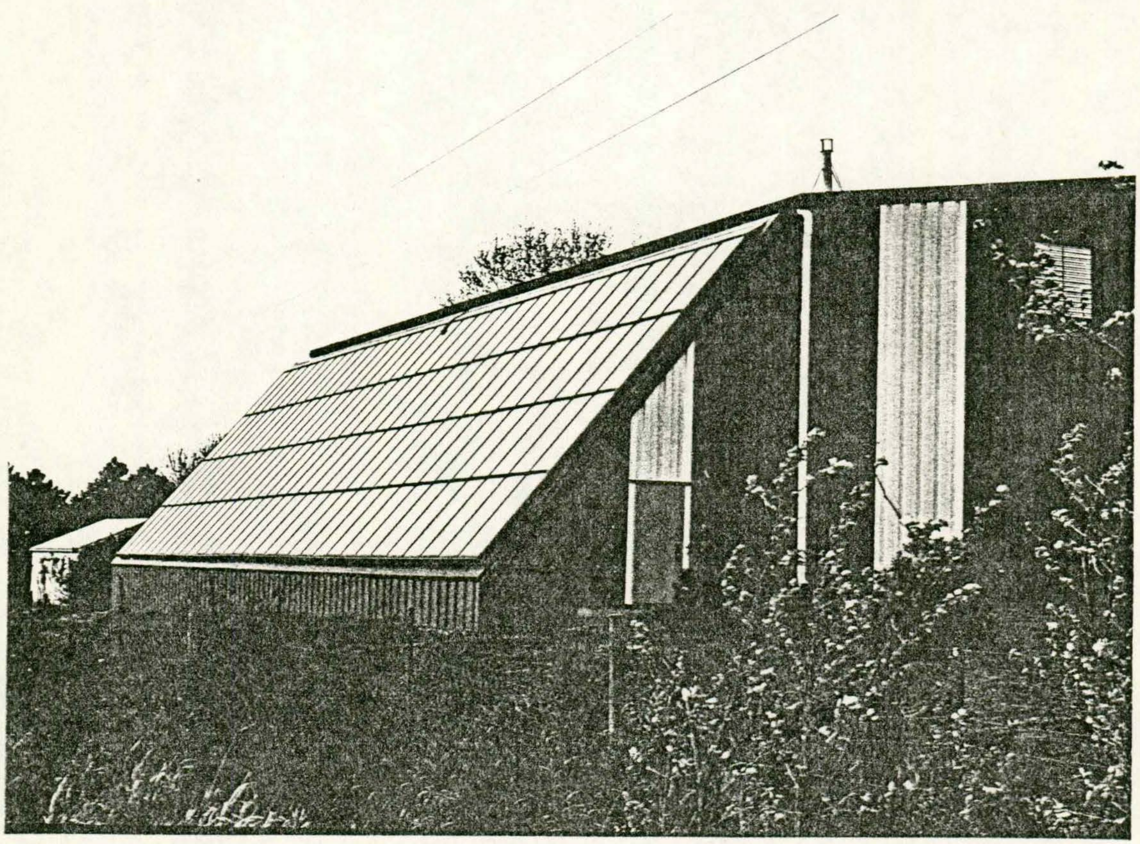
Bill Runde knows that his application of renewable energy is economical and he concludes: "Solar energy is going to save the people a lot of money."

VIII. SCATTERGOOD SCHOOL, WEST BRANCH

What better owner of an alternative energy system than an alternative high school! It's not only an opportunity to demonstrate the use of solar energy but a chance as well to involve and familiarize growing adults with an important technology.

A DEMONSTRATION PROJECT

Scattergood is a co-educational high school near West Branch, Iowa. Operated by the Friends Church, the school has a resident population of some 60 students. Many of the faculty also reside on campus. In 1975, the school applied for and received a grant from the Department of Energy to install a 2500 square foot flatplate air collector solar system. It was originally designed to provide 75% of the heat requirements for a new



Scattergood School utilizes these 2500 square feet of collectors to heat the school's gymnasium, preheat water for showers and dry 5000 bushels of grain.

gymnasium and hot water for showers. Later, it was modified to siphon hot air for grain drying purposes.

Mark Patton, the faculty member responsible for the solar unit, notes that while it is performing as expected, the unit is primarily a demonstration model and likely would not be economical for personal or small commercial use. "It's clearly the cadillac of solar systems," he notes, "and with all the monitoring equipment, the costs are quite high."

The school gym, a rather small building by most standards, cost $110,000 to construct. The addition of the 128 double-panel collectors, ductwork, storage bin, and controls added another $90,000--clearly too expensive to install commercially. Despite the cost of this specific design and system, however, Patton believes that its successes clearly show that solar technology can provide significant energy if given the opportunity.

The collectors were built by Solaron, a manufacturer based in Denver. The installation was carried out by local contractors and completed in September, 1977. Since that time, the solar operation has required only a few modifications, primarily in the hot water subsystem which failed during the advent of a severe cold spell. A power relay failure shut the system down for about 3 weeks in the spring of 1978. Patton stressed that these problems were not inherent in the solar phase of the system but were primarily the kind of problems one might expect with any large heating unit.

SYSTEM SAVINGS

"During the dead of winter," Patton commented, "you can get 55-60% of the gym's heating requirements. Year-round it's about 75%."

The collectors face south at a 50 degree angle. Energy is stored in a 64 ton pebble bed and in two 120 gallon preheating tanks. Auxiliary heating for hot water is provided by electric immersion heaters and, for the gym and locker room, by propane heaters.

In February, 1979, DOE data indicated that the Scattergood system furnished 21.6 million (73%) of the BTU's required to meet the combined space heating and hot water demand. Because of the 60% combustion efficiencies of the propane heaters, the total savings of the solar operation was 3.6 million BTU's (21.6 divided by .6), equal to about 390 gallons of propane. The solar system required .35 million BTU's (103 KWH) of electricity to operate. In February the collectors absorbed 40% of the total incident radiation striking the plates. Patton believes this is a typical level of performance for the school's system. Occasionally, the students have to brush off some accumulated snow but otherwise the unit offers no real operational problems.

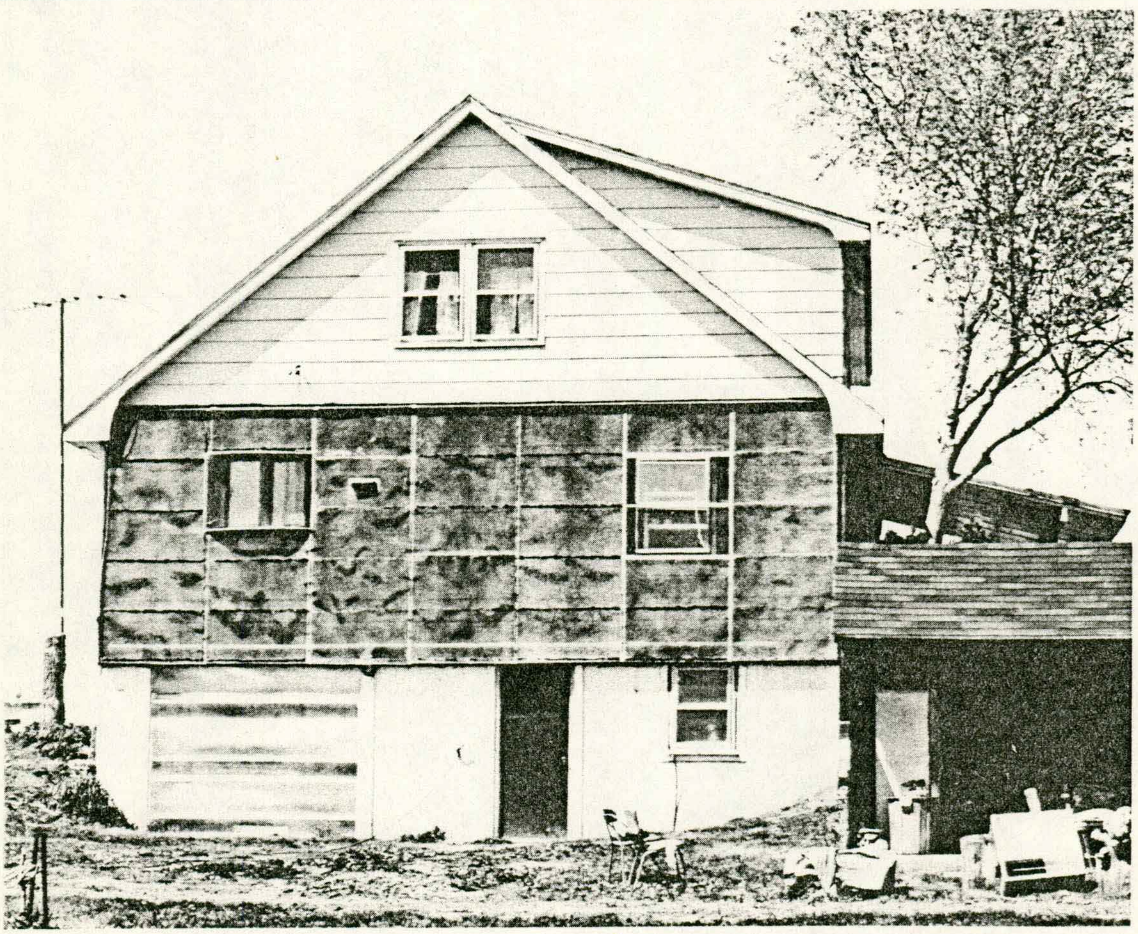
The innovative aspect of this project is the grain drying facility. Each fall the school produces about 5000 bushels of grain from farmland it leases. By installing a series of manually operated dampers in the collector ductworks, Patton is able to divert the flow of warm air to a drying bin located only 50 feet away. "It's quite easy to work with," he says, "taking only two to 2 1/2 weeks a year to take the grain from 23% moisture down to less than 16%. Iowa State people estimated that we saved about $300 in propane costs each year," he added.

IX. EUGENE & GENEVIEVE BASSLER, MAQUOKETA

"It made me very nervous every time the Arabs sat down for a meeting. You didn't know what to expect so I had to do something to calm myself," commented Eugene Bassler on the reasons he went solar. "Besides, I've always been conservation-minded and solar energy does save those nonrenewable fuels."

Eugene and Genevieve Bassler operate a dairy farm located eight miles north of Maquoketa. These "do-it-yourselfers" have incorporated several types of solar devices into their home and milk parlor. The results are impressive.

"During the winter, we would fill our 1000 gallon LP gas tank every three weeks; with the combination of solar collectors and a wood furnace, we now fill it once every months."



Gene Bassler used to fill his 1000 gallon propane tank every three weeks for his Maquoketa farm. With a solar wall and collectors, assisted by a wood stove, he now fills it only every three months.

HOMEMADE TECHNOLOGY

One of Bassler's devices is the "sun-wall" on the south face of his home. It consists of 2" x 6" vertical supports and 2" x 2" crosspieces made of wood and covered with reinforced fiberglass panels. The 280 square foot wall has been painted a flat black to absorb the sun's rays.

The heated air flows by natural convection through an open window or a duct that has been inserted in the wall. Air temperatures as high as 120° are achieved on sunny winter days. During the summer, the top and bottom boards are removed to allow natural convection cooling.

Bassler quips, "It may not be a thing of beauty but for $200 and 8 man-days, it's a bargain."

Three concentrating collectors are also located in the south wall. Each collector has 16 square feet of glazing area and a curved absorbing plate. This plate concentrates the solar radiation onto a duct through which the air is passed. The collectors, connected in parallel, can heat 465 cubic feet of air per minute to 114°F on a bright winter day. The heated air is ducted into the Bassler basement.

For the last three years, the Basslers have also used wood heat. Gene scrounged until he found an old cast iron upright furnace, for which he paid $15. With a few simple modifications, it was incorporated into the existing gas furnace. A double-chamber cast iron heat exchanger 4" in diameter by 28" long was also installed in the furnace and it is used to preheat domestic hot water.

The wood furnace is required only during the evenings or extended cloudy periods. To supplement the wood fuel, the Bassler uses a trash compacter to make "logs" out of burnable refuse and feed sacks. Ash removal is only required every two weeks. Bassler's combined systems heat approximately 2800 square feet of floor space.

SUN ON THE FARM

Bassler is also using two concentrating collectors on his milk parlor. The vertical collectors, connected in series, provide 120°F air to the 14' x 20' building. The 8" concrete, insulated walls act as the storage medium. "If there is sunshine every other day, the gas heater never kicks on and the temperature never falls below 58°F."

Bassler has devised a system to utilize the heat from cows' milk for space and water heating. Everyday, approximately 1000 pounds of milk at 98°F is cooled to 36°F. A heat exchanger is used which heats 2000 pounds (240 gallons) of well water to approximately 80°F. The water is then stored in a 275 gallon tank, to conduct heat to the parlor and for use as preheated wash water for milking equipment and parlor floors.

FUTURE SOLAR PRODUCTION

Bassler's belief that solar energy is one of the best answers to America's energy shortages has led him to initiate new projects. He is currently designing a liquid solar collecting system that could be used for small-farm alcohol production. The Basslers have also utilized a solar-assisted heat pump for their retirement home.

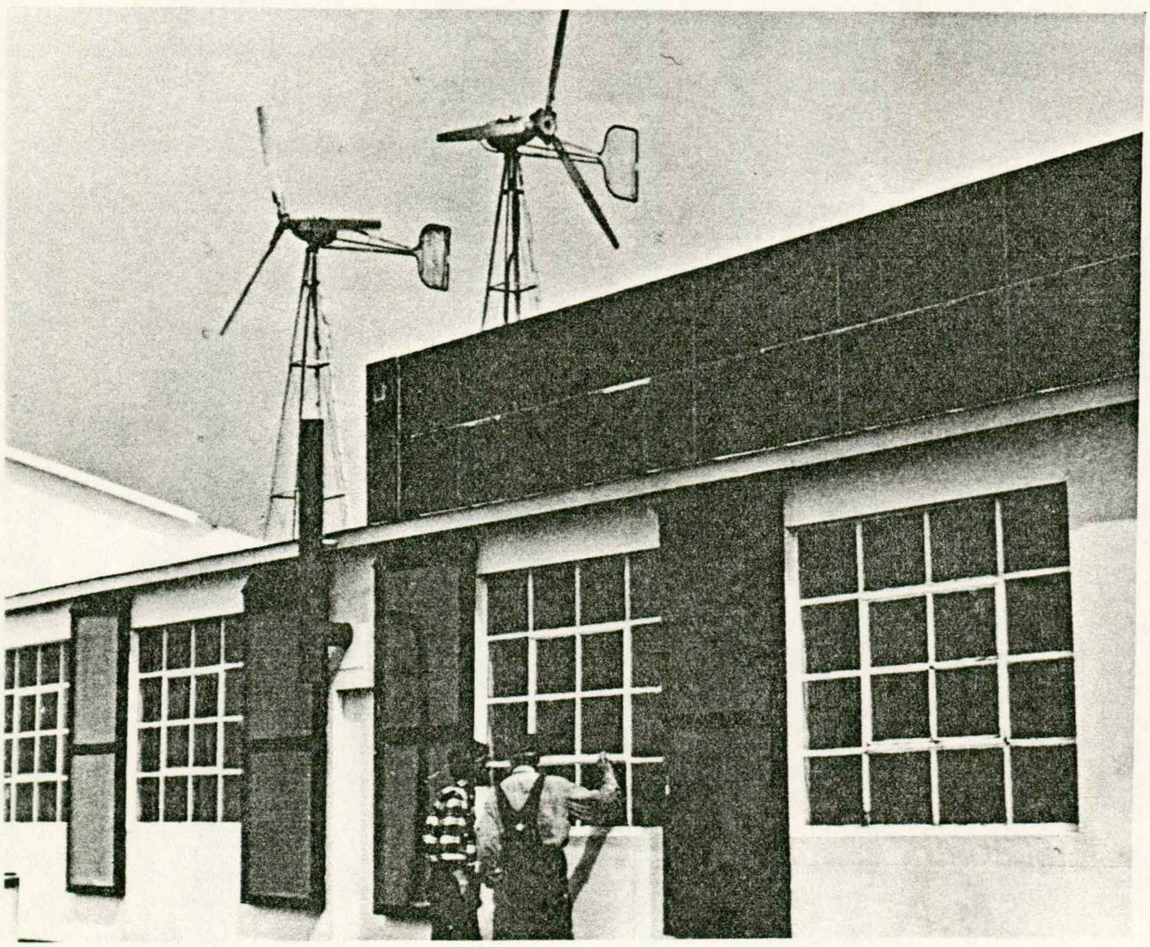
Bassler advises: "There is a lot of interest in solar energy but people should get started by doing solar on their own; you know, the 'hands-on' technology."

X. JON LORENZEN, WOODWARD

After fifty-four years, Jon Lorenzen has yet to pay a dime to a utility for electricity. For all those years he's been doing it with windpower. In the last couple of years, he has been learning how to obtain hydrogen by using his surplus wind energy to electrolize water.

Lorenzen got his start when the Rural Electrification Administration spread cheap electricity across the Midwest. When he was asked if he wanted to be hooked up to the new power line for a minimum of three dollars per month, he said no. "Three dollars a month was a lot of money back then."

As more farms bought into the REA systems, he began to buy up some of the larger generators, paying perhaps $20 apiece. At one point, he could have picked up 800 in Nebraska if he'd had the money then. "Nowadays



For fifty-four years Jon Lorenzen, a Woodward farmer, has generated almost all of his required electricity by windpower. He has yet to pay as much as a nickel to the local electrical utility.

the commercial boys got them pretty well picked up and they're a little scarce," he says. "If I'd gotten those 800 then, today I'd have a goldmine." With prices of generators now running as high as $3000, he's right.

A BIG ELECTRICAL USER

Lorenzen utilizes two Jacobs wind generators mounted on 40 foot towers to provide his electricity. The generators will kick in at windspeeds as low as three miles per hour. At 15 mph they operate at their full output of 2500 watts. "I don't have any idea how much I use but it's a lot," he chuckles. A quick tour through his machine shop supports this. Not only does he have the usual array of small power tools (most of them homemade), but he also uses bigger equipment such as an electric arc welder, lathes, an air-compressor, and an electric forge.

For storage Lorenzen has three banks of alkaline nickel-iron batteries made over 75 years ago. These 170 cells can give him 4-5 days of electricity when the wind is down. The lack of August breezes are not a particular problem, he says. "You have to make sure that your batteries are full up when you come to August. Then I just turn on my second unit. Most of the time, though, I don't need it. And I plan to do my welding when the wind is blowing. That helps."

There are a few times when he cranks over a 200 ampere gas-operated generator. "I only have to start it up three or four times in the summer, about ten minutes each time. Then maybe the wind'll come up overnight and poke alone the rest of the day."

The 32-volt direct current generated by the wind machines poses no real problems for Lorenzen. "I can run most anything I want with it. If I need 110 AC current for higher speeds or for a special tool, I convert it," he says, pointing to another homemade device. "Honeywell came out to see my place and saw my inverter system and made one of their own to sell. They sent me the information on it," he noted, "but they never sent me the price. Maybe they're ashamed of it."

One of the big advantages of the 32-volt system is that "you can't get hurt by it. The current isn't strong enough to shock you." He demonstrated by sticking his finger into a light socket.

NOTHING WASTED

Always the innovator, Lorenzen has managed to create some ingenious equipment out of scrap materials. For example, he's taken the generator out of an old Model A Ford, slapped a chuck and trigger on it, switched a few wires and produced a durable hand drill powered by his windchargers. "I've got an electric stove made out of junk and I never buy a spark plug.

I just clean 'em, sand blast 'em, and reset the gap [using all homemade equipment] and they're as good as new. I find most of my stuff at the city dump. A lot of things go to waste that could be used."

Lorenzen's curiosity has taken him to other areas of solar applications. Using discarded aluminum press plates and old glass windows, he put up four passive solar collectors (each 4' x 8') on the south side of his 2500 square foot machine shop. Cold air enters a one-inch opening across the collector bottom and is heated. It then rises to the top, passing out to the shop's interior through another opening. Even in zero degree weather, the four panels help maintain the room temperature at 70-75°F. From there, Lorenzen added a series of 15 collectors to his roof. Each panel measures 3' x 6.5'. A 1/4 horsepower pump moves cold air through the collectors, where its temperature reaches as much as 210°F.

Lorenzen's work with hydrogen may be the most interesting aspect of his tinkering. "Some people tell me it won't work but I keep trying," he smiles. "The problem is that nobody knows anything; you have to figure it out for yourself." In his home-built electrolysis tank, Lorenzen passes a current through a series of stainless steel plates sitting in water. These plates split the water into hydrogen and oxygen gases, which are siphoned off into different parts of his tank. The hydrogen is then stored in an old propane bottle while the oxygen is simply vented into the atmosphere.

Creating the hydrogen is the easiest part of the process. Adapting stoves and automotive engines may be the most difficult because the gas jets must be so much smaller than those for LP gas. Despite this problem, Lorenzen has already hooked up a demonstration engine. After a propane start-up, he switches over to hydrogen with no apparent loss of efficiency or power. When he can finally adapt a car engine for hydrogen use, he believes he can get up to 100 miles per gallon. Anybody interested?