The Urban Options

Solar Greenhouse Demonstration Project

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FINAL REPORT

MASTER

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I. THE DESIGN PROCESS

The Urban Options Solar Greenhouse Project began in June 1979 with the formation of a committee to finalize the solar greenhouse design. The committee consisted of board and staff members who had experience with solar greenhouse construction, including some of the authors of the original proposal to the U. S. Department of Energy. Peggy Goodrich, an interior design student at Michigan State University, worked on the drawings for the project along with Randy Eveleigh, an Urban Options staff member. Although there was some discussion of constructing a one-story greenhouse, a majority of the committee favored the construction of a two-story greenhouse to maximize solar gain. The design was, however, altered somewhat from the original drawings submitted with the grant proposal. The general appearance of the greenhouse on the front of the house was a primary consideration. Refer to Appendix A for copies of the final greenhouse drawings.

These changes were made during the design process:

1) Dimensions: The greenhouse as constructed is narrower in width than planned in the original proposal. The area of the first floor is 16' x 7', and the second floor, 4'6" x 22'. A permit from the city's zoning appeal board would have been required to make the greenhouse wider, resulting in a delay of one month in beginning construction. Although the variance probably would have been granted, the Urban Options board decided in July to build a narrower greenhouse. This design change increased the heating capacity of the greenhouse, especially of the second story, but decreased the amount of available growing area. The glazing tilt angle was also changed from 65° to 69° from the horizontal.

2) Facade: Glass panels and awning windows replaced approximately one-third of the Kalwall fiberglass front facade to improve the appearance of the greenhouse. This change also allows a view of the outside from the inside of the greenhouse, increasing the feeling of spaciousness inside the greenhouse. Unfortunately, we discovered that awning windows cannot be sealed properly when they are installed on an inclined surface. Despite numerous attempts to flash the exterior, the windows continue to leak through the framing during rainstorms and snow melts. The leaking is particularly severe on the second story. We have considered removing the

awning windows and replacing them with plain thermopane glass panels even though this would reduce vent area. We now advise visitors to the greenhouse not to install these windows on an inclined surface.

3) Entrance: The entrance to the house was changed from a side entrance to a front entrance with a vestibule. The existing two-door entrance (one door to each apartment) was replaced with two openings in sequence: one with a heavily insulated handmade door to the outside, and a second opening to the living room which is closed off by french doors. This vestibule has a peastone and cement floor and contains some small windows and skylights and an antique lighting fixture for illumination.

4) Thermal Storage Materials: The original proposal stated that water would be the primary thermal storage medium. Water thermal storage was used in the first story of the greenhouse, but cannot be used in the second story because of the lack of space. The solar greenhouse design committee decided that the only practical alternative was to use eutectic salts as a thermal storage medium in the second story, where space is at a premium (eutectic salts have a higher thermal storage capacity per volume than water). In July, 1979, the Dow Chemical Company donated some calcium chloride hexahydrate ($CaCl_2 6H_2O$) for use as the storage medium in the greenhouse. Several types of inexpensive plastic containers were tested to see which ones would hold up under the pressure changes generated in a sealed container by the phase-changing material. The primary containers tested were ordinary polyethylene and polyethylene terephthalate bottles. Current results indicate that the one liter polyethylene terephthalate bottles may be the best choice. The bottles will be placed in the wall cavity between the studs of the second story house wall.

Because the eutectic salt thermal storage system was not included in the original proposal to DOE, we found it necessary to obtain other sources of funding for the system, which is considerably more expensive than water in discarded 55 gallon drums. The most expensive component of this system is the containers. Fortunately, the Michigan Solar Office, through MASEC (Mid-America Solar Energy Complex), decided to finance a set of containers. The salts will be packaged and installed this fall.

5) Insulating Curtains: Although both exterior and interior shutters and curtains were considered in discussions of night insulation, only interior

curtains seemed practical and inexpensive. The Urban Options Energy Savers Coop designed and constructed the insulating curtains, which are made mostly of readily available local materials, such as vinyl-backed nylon, upholstery polyester, and aluminized mylar. See Appendix B for a description of the curtain construction. The Coop spent a considerable amount of time searching out sources of materials and testing prototypes. Although insulating curtains are often discussed as an essential component of passive solar structures in the north, very little actual construction and testing of home-made insulating curtains has been done. An exception to this is the excellent work done by the Center for Community Technology in Madison, Wisconsin* They have devised several home-made insulating curtains based on the roman shade concept. Since commercially-made insulating curtains would have cost at least $1500, the Coop decided to adapt these designs to the slanting face of the greenhouse. In the lower story of the greenhouse, a track was put up to hold the curtain up and allow it to be stored under the ceiling. An aluminum track was put up first as a prototype, but the aluminum strips were far too expensive. Acrylic strips were tried next as a retainer, but eventually these strips warped out of shape, making a bumpy track. The Coop is continuing to experiment with different track systems to see if any further improvements can be made. They will be trying some components of commercially-made curtains next to see if smooth operation can be achieved.

Because of these problems and the much more limited working space in the second story, the curtains there are simply a modified roman shade with awning snaps to hold it against the framework of each glazing section. The curtains on the second story are much thinner, since the polyester was eliminated. Although these curtains will take some time to put up or take down, there are no sticky tracks and errant dowels to worry about. Next winter we will be able to see how the two types of curtains differ in their insulating properties and ease of operation. The R-value of the curtains in the lower story is about R-5.0; the upper story curtains have an R-value of about R-3.0.

The DOE grant included funds for the design of an insulating cover for the greenhouse, but did not include funds for materials. We applied for and

* What About Windows? A Report on Thermal Window Coverings; Nancy Korda and Susan Kummer, Center for Community Technology, 1121 University Ave., Madison, Wis. 53715; October 1978.

received funds for curtain materials from the State of Michigan Solar Office.

6) Solar Hot Water Heater: A thermosiphon solar hot water heater was installed above the vestibule on the second story of the greenhouse, between the framing. This eliminated one portion of the glazing in the upper greenhouse. The hot water heater was constructed during a workshop held in May 1980. This project was funded by the Michigan Solar Energy Association.

Although many changes were made in the final design of the greenhouse, the overall structure is the same as originally planned: a two-story greenhouse with a slanting facade. Fortunately, the design changes accomplished our goal of improving the aesthetics of the structure without sacrificing energy efficiency. This summer, the Bailey Neighborhood Community Association presented an award to Urban Options for enhancing the character and appearance of the property and the neighborhood.

II. CONSTRUCTION

A Solar Greenhouse Design Workshop was held on June 30th for the general public. At this time, the Solar Greenhouse Construction Class was announced to the community. The class consisted of a series of lectures on greenhouse design and construction in conjunction with the building of the Urban Options solar greenhouse. (See Appendix C for the workshop schedule). Although the solar greenhouse grant project officially began on June 18th, funds from DOE were not received until August 21st. Credit was arranged and Urban Options funds spent so that the building could proceed as planned.

The eighteen workshop participants demolished the existing porch on July 21st. The greenhouse foundation was put in on August 4th, the framing mostly completed on August 25th, and the glazing installed on September 8th and 15th.

After the middle of September, most of the work on the greenhouse, and associated projects in the house itself, was completed by Urban Options staff members and some volunteers. The work proceeded by month as follows:

October 1979: Vestibule framing completed, greenhouse and vestibule insulated, vapor barrier installed, drywall installed in the interior of the greenhouse first story.

November 1979: Drywall taped and plastered in greenhouse first story, water

storage filled, second glazing installed in first story, vents constructed and installed.

December 1979: Second story drywall installed, interior of first story painted, window to downstairs living room removed and doorway framed, front planting bed constructed.

January 1980: Vestibule completed, doors to living room installed, insulating curtains designed, seedlings started in the first story of the greenhouse.

February 1980: Window upstairs removed and door to greenhouse framed, insulating curtain construction begins, portion of downstairs planting bed filled with soil and planted.

March 1980: Installation and testing of prototype insulating curtain in first story.

May 1980: Remainder of downstairs planting bed filled with soil, solar water heater installed.

June 1980: Tile floor in second story completed, drywall taping and plastering in second story finished, exterior siding completed, curtains for second story constructed.

July 1980: Window and floor trim in second story completed, interior glazing installed, interior of second story painted.

August-September 1980: Eutectic salts packaged and installed.

The greenhouse construction took an estimated 1600 work hours to complete, far more than originally anticipated. Most of the major structural work was finished during the solar greenhouse class, but this is only about half of the work involved in finishing a solar greenhouse. In retrospect, it might have been wise to extend the solar greenhouse workshop beyond the original eight weeks to include insulation and drywall installation, drywall plastering and taping, trimwork, and construction of planting beds. An attempt was made to get participants of subsequent workshops and classes, such as the Home Retrofitting Class and the Solar Greenhouse Class held in the spring, to work on finishing the greenhouse, but the students were generally not interested. Another limiting factor was the small size of the greenhouse. Although twenty people could easily work on framing the exterior, only a few people at a time can work in the narrow interior space (especially in the second story). Finally, our resident carpenter felt that much of the work, such as laying the tile floor, installing trimwork, constructing doors, etc., required a degree of skill that made close supervision of volunteers absolutely necessary if attractive results were to be expected. In the last analysis, if speed was a requirement, a skilled carpenter could do the work faster than volunteers in a workshop, especially when the time

and labor needed to organize a good workshop is included. These are the reasons why another workshop was not organized after the first workshop ended, despite our usual emphasis on hands-on workshops as a learning and organizing tool.

This decision did not result in the rapid completion of the greenhouse, however. As the greenhouse was being slowly finished, the staff was also working on several other related and unrelated renovation projects in the house, including: insulation of the remaining uninsulated area (walls and windows); reconstructing and remodeling the living room; construction of a front ramp to the greenhouse, and remodeling of a bathroom for handicapper accessibility. The need to finish all of these projects simultaneously in order to have a presentable demonstration house slowed down the completion of the greenhouse.

A few members of our staff were trained by the Solar Sustenance Team of New Mexico, a group which emphasizes community workshops as a means of spreading solar technology while reducing its cost. This group has conducted numerous $2\frac{1}{2}$ day workshops and sometimes gives the impression that it is possible to finish a solar greenhouse in this time period. We now believe that this is possible only if the solar greenhouse is very small, designed simply (one-story, standard framing), and only if the workshop is conducted by a very experienced and organized team. Since we returned from our training in New Mexico, several solar greenhouses have been built by non-profit organizations in Michigan, and every one of them has taken much longer than expected to complete. Organizations and individuals building solar greenhouses on their own should be aware that large, complicated greenhouses cannot be completed im a short workshop, and additional labor should be available after the workshop to complete the greenhouse if necessary.

Through the experience of actually conducting workshops we have also learned that the optimum size for a workshop is no more than twenty people. Usually if there are more than twenty people at a workshop, some people end up with nothing to do. This is why we limited participation in our workshop to this number. It can be expected, however, that not all of the registered participants will show up each day, so the actual limit can be set somewhat higher for registration.

The cost of the greenhouse was also much higher than anticipated because of changes in the design and increases in the price of building materials over the two years since the grant was written. Recycled building materials were not extensively used in this greenhouse because of time constraints and the volunteers' lack of carpentry experience. If time and labor are not a problem, then an attractive solar greenhouse can be built very inexpensively by using some recycled materials (such as used concrete blocks, which cannot be seen anyway) and native rough-cut lumber.

The cost of materials for the solar greenhouse and sources of funding are outlined below:

Construction Materials and Related Expenses		
DOE and Urban Options Expenditures	$3128.75	
Donations		
All-Phase Electric	16.00	
Central Michigan Lumber	50.00	
Glaser's Lumber	50.00	
Martin Block (est.)	144.90	
Roary Corporation	111.48	
Robert Eveleigh, Tile Contractor	166.70	
Construction Materials Total		$3657.84
Eutectic Salt Thermal Storage System		
Michigan Solar Office Grant: Containers	250.00	
Donation: Dow Chemical Company - Calcium chloride hexahydrate	50.00	
Thermal Storage Material Total		300.00
Insulating Curtains		
Michigan Solar Office Grant: Materials	415.28*	
Donation: Bert Seyfarth, Architect - Mylar	51.00	
Insulating Curtains Total		466.28
TOTAL COST OF SOLAR GREENHOUSE		$4434.11

* Expenditures to date. This is the approximate cost of the curtains not including materials used for experimentation.

III. THERMAL PERFORMANCE OF THE SOLAR GREENHOUSE

The monitoring program was successful in obtaining some data on conditions inside the greenhouse for six months: from late winter through spring and into the summer. Because of the slow pace of construction, and the existence of two separate stories, it was possible to see how the greenhouse performed at various stages of completion. The first story of the greenhouse was finished first and provided a decent environment for the plants during the winter. The second story was operated during the winter and spring with only one layer of glazing and almost no thermal storage. The results were predictable: the second story often overheated and then dropped below acceptable minimums, while the first story maintained a much more even temperature, although the heat provided to the house was not so obvious on sunny days.

While the monitoring program gave us some information on how the greenhouse performed, it did not provide much information on how much heat was actually being contributed to the house. The lack of precise instrumentation, and the discovery after a few months that the operation of the house gas meter was possibly faulty, precludes any conclusive information on how much gas energy was saved by the operation of the greenhouse until the end of another winter.

The monitoring consisted of the following data collection methods:

1) Greenhouse Interior Air Temperature - Minimum and Maximum: Minimum/maximum thermometers were attached to the east wall of both greenhouse stories and shaded with a reflective cover. These thermometers are marked in $2^{o}F$ intervals. When compared to more accurate thermometers, these minimum/maximum thermometers seem to have a range of $\pm 4^{o}F$. More accurate thermometers are not available for a similar price. All temperatures were adjusted when read to take account of these inaccuracies.

These thermometers are read in the morning, around 10 a.m. The maximum readings then apply to the previous day, and the minimum readings apply to the night which has just passed.

2) Outside Air Temperature - Minimum and Maximum: This minimum/maximum thermometer was installed in a shaded location outside on the wall of the house. It is read in the same way as those inside the greenhouse.

3) Water Thermal Storage Temperature: A simple stem thermometer was inserted into the first 6" of water in a 55 gallon drum. The water at the top of the drum is usually warmer than that in the rest of the drum, so the temperatures obtained do not represent the temperature of the entire water thermal storage. They do tell us something about the growing conditions, however, since plants are often placed on the top of the drums where they get the most heat. This thermometer was read daily in the morning along with the other thermometers.

4) Soil Temperature: A stem thermometer was also placed in the front planting bed in the first story. The thermometer was inserted in the middle of the $1\frac{1}{2}$ foot wide bed because the temperature at different locations in the bed varied widely. This thermometer was also read in the morning along with the other thermometers.

5) Daily Gas Consumption: The gas meter was read daily at the same time as thermometer readings were taken. The consumption is measured in hundred cubic feet, and applies to the past 24 hours. The meter reading began in December, and from the beginning some of the readings seemed strange. After this erratic pattern was repeated over the next few months, we asked the gas company to replace the meter. This was done in April, too late to obtain any usable data on the winter months. The original plan was to compare the gas consumption of the house on sunny days, partly sunny days, and cloudy days to see how much of a difference in gas consumption there was when the greenhouse was adding heat to the house. To eliminate outside air temperature as a factor, the gas consumption could be divided by the degree days for our location. (These degree days should be obtained from the minimum/maximum readings on location, because we discovered that the readings from the U. S. Weather Station five miles away were quite different.)

6) Room Temperature: Thermometers were placed in various rooms of the house. Occasionally these thermometers were read while the greenhouse was operating as a solar collector on sunny days to determine if the greenhouse was raising the temperature of adjoining rooms.

The readings each morning were recorded on data forms which can be found in Appendix D. It was noted on the forms whether or not doors to the house or vents to the outside were open, since this could affect the temperature

inside the greenhouse.

Before setting forth the results of our monitoring program, a description of Lansing's weather is in order. The climate here alternates between continental and semimarine. The Great Lakes cause milder winters and cooler summers here than in locations west of the lakes (such as Wisconsin), but they also create many more cloudy days than in other midwestern states. There is appreciable precipitation more than one day in three, and there are almost twice as many cloudy days as clear days thoughout the year. Much cloudiness prevails during the winter months, but the sun shines fairly often during the summer. These conditions make central Michigan one of the most demanding climates in the nation for solar heating of any kind during the winter. Many other places have colder temperatures during the winter, but the sun can be counted on to shine more often.

The winters of 1976-77 and 1978-79 were much colder and cloudier than usual. The winter of 1979-80 seemed much milder than these last few winters, but in reality it was closer to the average winter in this area. The average number of degree days for the months of October through April is 6407, while the number of degree days for the same period in 1979-80 was 6653. The average percent possible sunshine for October through April is 41.4%, whereas in 1979-80, it was 39.4%. Thus the solar greenhouse performance described did not take place during a winter that was markedly different from the average in this area.

Data collection began on January 28th, when the doors between the solar greenhouse lower story and the house were installed. The installation of the doors allowed us to close off the greenhouse from the house at night and on cloudy days. The greenhouse did, of course, gain some heat through the house wall. However, the house is not used as a residence, and the thermostat was usually turned down to 55°F at night. There was no supplementary heat in the greenhouse, with the exception of the heat generated by an 80 watt flourescent lamp and a 120 watt heating pad used to start seedlings. The greenhouse second story was also closed off from the main part of the house. During the monitoring period, the second story contained no thermal storage and only one layer of glazing. Heat loss from the house to the greenhouse may have been more substantial on the second floor than on the first floor because the outside sheathing of the adjoining wall was

removed. There was only one layer of lathe and plaster between the house and the greenhouse. There is no insulation between the first and second stories - only the drywall, wood joists, and flooring, although there are vent openings between the two stories. These are closed off during the winter with a piece of plywood.

Monitoring of the greenhouse has continued through the latter part of July. Although the most interesting information was obtained during the winter months, we were curious to see how hot the greenhouse would get during the summer. The highest temperatures in both stories of the greenhouse, however, were recorded during the winter. The lower story reached 110°F on February 2nd, and the upper story reached 130°F on both February 3rd and March 20th. The lowest temperatures recorded were 32°F on February 25th in the lower story, and 25°F in the upper story on February 28th. These lows occurred after a series of cloudy days and cold weather. The temperature outside dropped below zero several times during the month of February.

Chart number one shows the greenhouse performance during the most demanding period - the end of January and the entire month of February. It is evident from this chart that the lower story maintained a much more even temperature than the upper story. Our guests were more impressed, though, with the tropical atmosphere in the second story on sunny days. Also note that the low temperatures in the second story follow closely the outside minimum temperature, indicating the tremendous heat loss that was occurring because of the existence of only one layer of glazing and no thermal storage.

We can confidently state that the average greenhouse temperature will be at least 20°F higher than the average outside temperature, and most of the time it will be much higher. This can be seen in chart number two, where the average greenhouse temperature in the lower story is shown for about three months.

Clear days, while rare, were spectacular in their effect on the greenhouse and the house, as shown in these journal entries:

<u>December 10, 1979</u>

Clear day, 45°F outside. Greenhouse upper story at 1 p.m. is 92°F; adjoining office is 77°F. Greenhouse lower story is 80°F, and it is 72°F

CHART NO. 1: Greenhouse Air Temperature

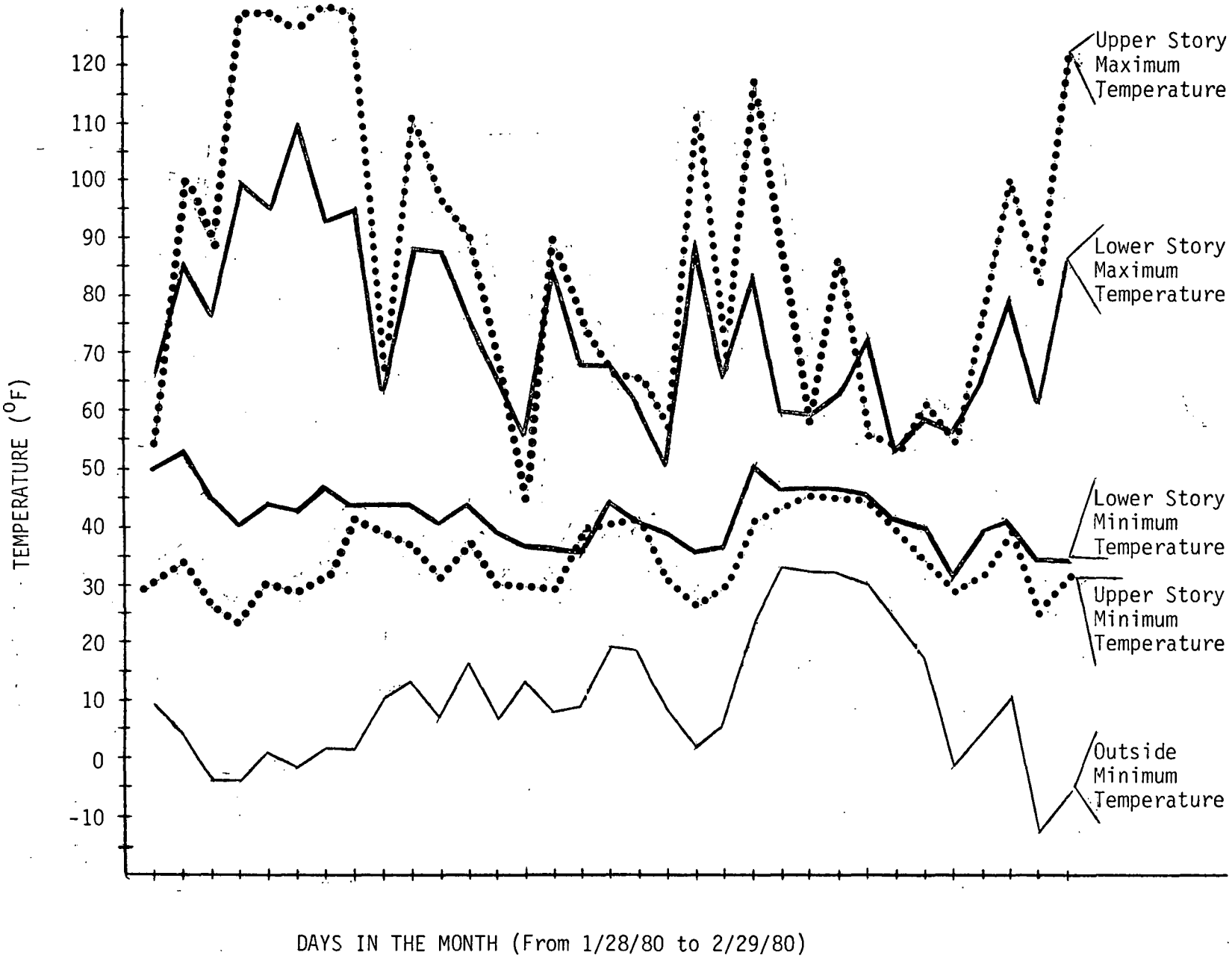
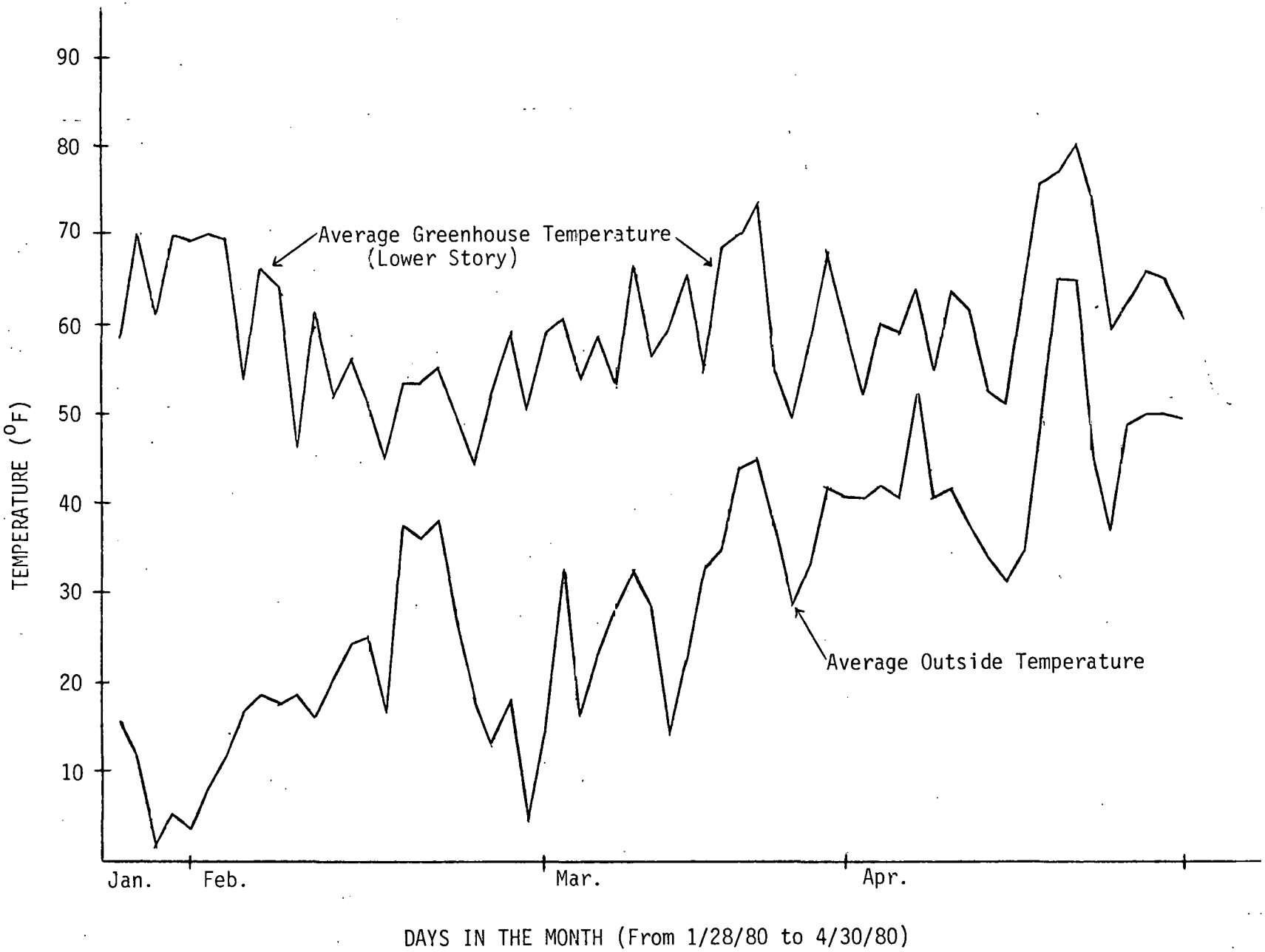


CHART NO. 2: Average Greenhouse and Outside Air Temperature



in the adjoining office and living room. (At this time, there were no doors between the lower greenhouse and the house.) Furnace has been turned off and the thermostat set at 50°F.

February 29, 1980

Clear day after a very cold night. I had to look twice at the minimum/maximum thermometer outside because it registered a low of -13°F last night. The heat in the house was turned on at 8 a.m. By 9:30 a.m., the temperature outside has warmed up to -6°F. It is 40°F in the upper story of the greenhouse, and 43°F in the lower story. The thermal storage temperature reads 48°F. The house is still chilly: 53°F in the upstairs office and 55°F in the downstairs living room. By 11:30 a.m., the house has begun to warm up a little, even though it is -2°F outside. The upper story of the greenhouse has warmed up to 81°F and has helped to heat the adjoining office to 59°F. The greenhouse lower story is 66°F, and the living room has reached 63°F. The furnace was turned off at 10:00 a.m., but the staff is desperate for some heat, so a fire was started in the fireplace. By 2:15 p.m., the fire has died down and the house is comfortable. The greenhouse upper story is 106°F, and the adjoining office is 68°F. The greenhouse lower story is 84°F, and the living room is 64°F. As the sun is beginning to set at 4:00 p.m., it is a balmy 2°F outside. The upstairs offices are 74°F because of the greenhouse upper story, which has reached 110°F. The downstairs living room has maintained 64°F, while the greenhouse lower story is 83°F. The water thermal storage has gained 13°F, going from the morning low of 48°F, to 61°F.

As can be seen from the last journal entry, the biggest problem with the use of the solar greenhouse as a heating device is the need for heat early in the morning, when the greenhouse has not yet warmed up enough to contribute to the house. The lower story of the greenhouse, with its thermal mass, never did warm up enough to contribute a substantial amount of heat to the living room. The upper story of the greenhouse, with its single layer of glazing and minimal thermal storage, did heat up quickly, and helped to warm the second story. The upper story was actually operating as a simple hot air collector. This combination of a hot air collector with no thermal storage and a passive solar greenhouse with thermal storage may be a good one for houses and offices that need heat in the morning. The primary problem with the greenhouse operated as a hot air collector was overheating later on in the day. The heat in the second story offices was also sometimes unbearable during the fall, when the temperatures outside were moderate, so much so that we finally installed a duct and fan to circulate the air from the greenhouse second story to the back rooms of the house, which are always cold.

The minimum thermal storage temperatures were always much higher than the minimum air temperatures. Readings of the dial thermometer taken in the morning probably do not indicate the lowest temperature to which the water storage dropped during the night, but it is probably fairly close. Chart number three shows the gradual increase in the thermal storage temperature as the seasons progress. The lowest temperature recorded was 46°F, which is still above the minimum germination temperature of cold-tolerant plants (35-40°F). Thus it should be possible to start seedlings on top of the water storage barrels. However, it can be expected that the thermal storage temperature could drop drastically during an extended cloudy period, such as that reported by the Weather Bureau during January 1978, when there were 26 cloudy days, 4 partly cloudy days, and 1 clear day during the month. This winter, the sunny and partly sunny days were well distributed, but it is not unusual in this area to have several weeks of unrelieved cloudy weather during December and January.

The soil temperature followed about the same pattern as the thermal storage temperatures, as shown in chart number four. The minimum temperature recorded was again 46°F. These temperatures are somewhat misleading, however, because there is a considerable difference in the temperature taken from the front edge of the bed as opposed to the back of the bed, which is closest to the foundation and the glazing. The thermometer was therefore placed in the middle of the bed. The temperatures in the coldest part of the bed, which is a corner formed by two exposed foundation walls, hovered around 40°F during March. Peas planted in this corner took a long time to germinate, but they eventually did grow. The temperature gradations in the planting bed are caused by the exposure of one side to the outside air (even though the wall is insulated), and the shading of the back of the bed by the sillplate and associated framing in the winter. The sun only reaches the front 10" of the bed nearest the interior of the greenhouse, leaving the back part of the bed perpetually in shadow. This phenomenon drastically affects the growth rate of plants in different parts of the bed. This problem could be partially solved in our greenhouse by raising the soil level above the framing, and by using insulating curtains at night. Where there is thermal storage located under the greenhouse floor, warm air can be vented directly under the

CHART NO. 3: Water Thermal Storage Temperature

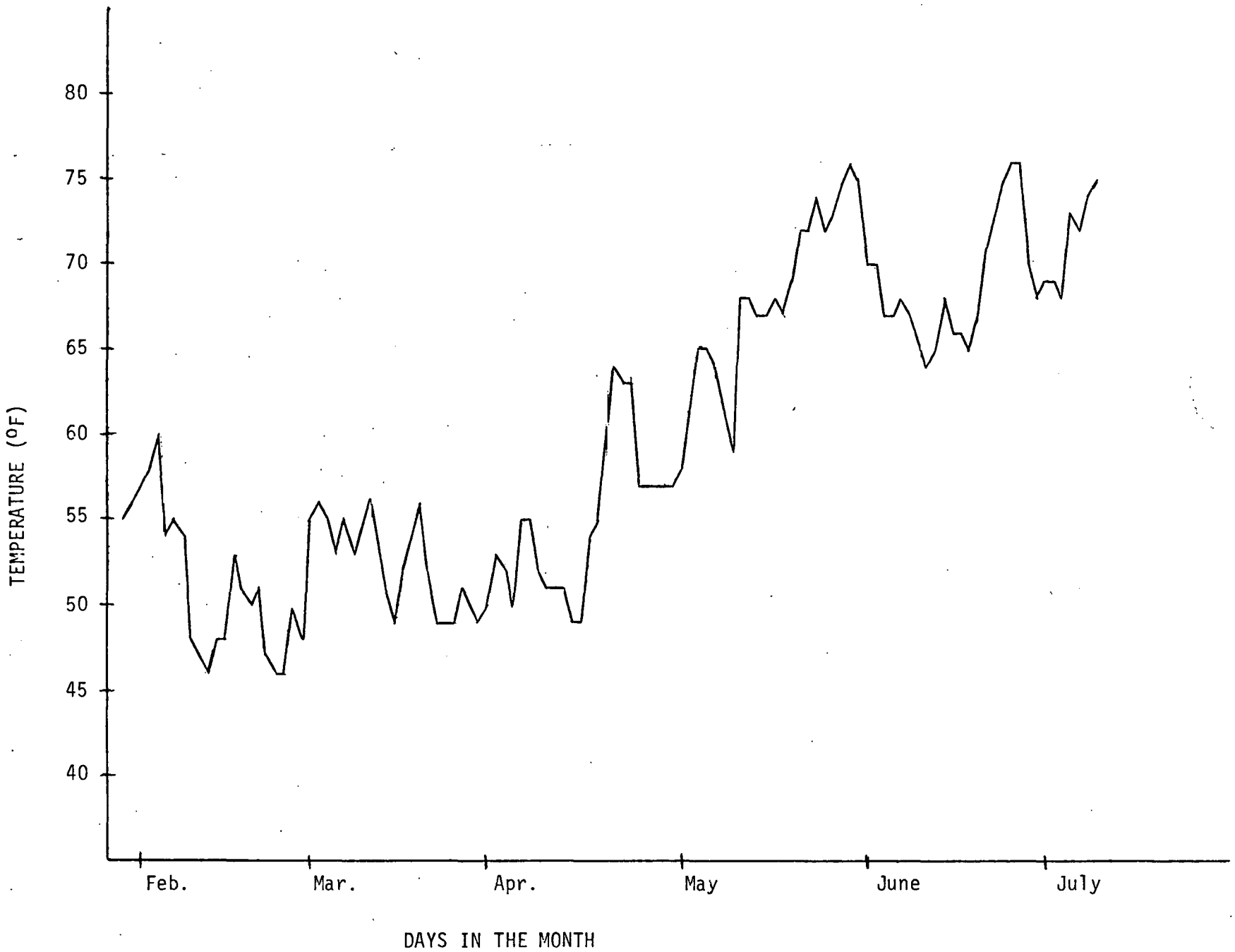
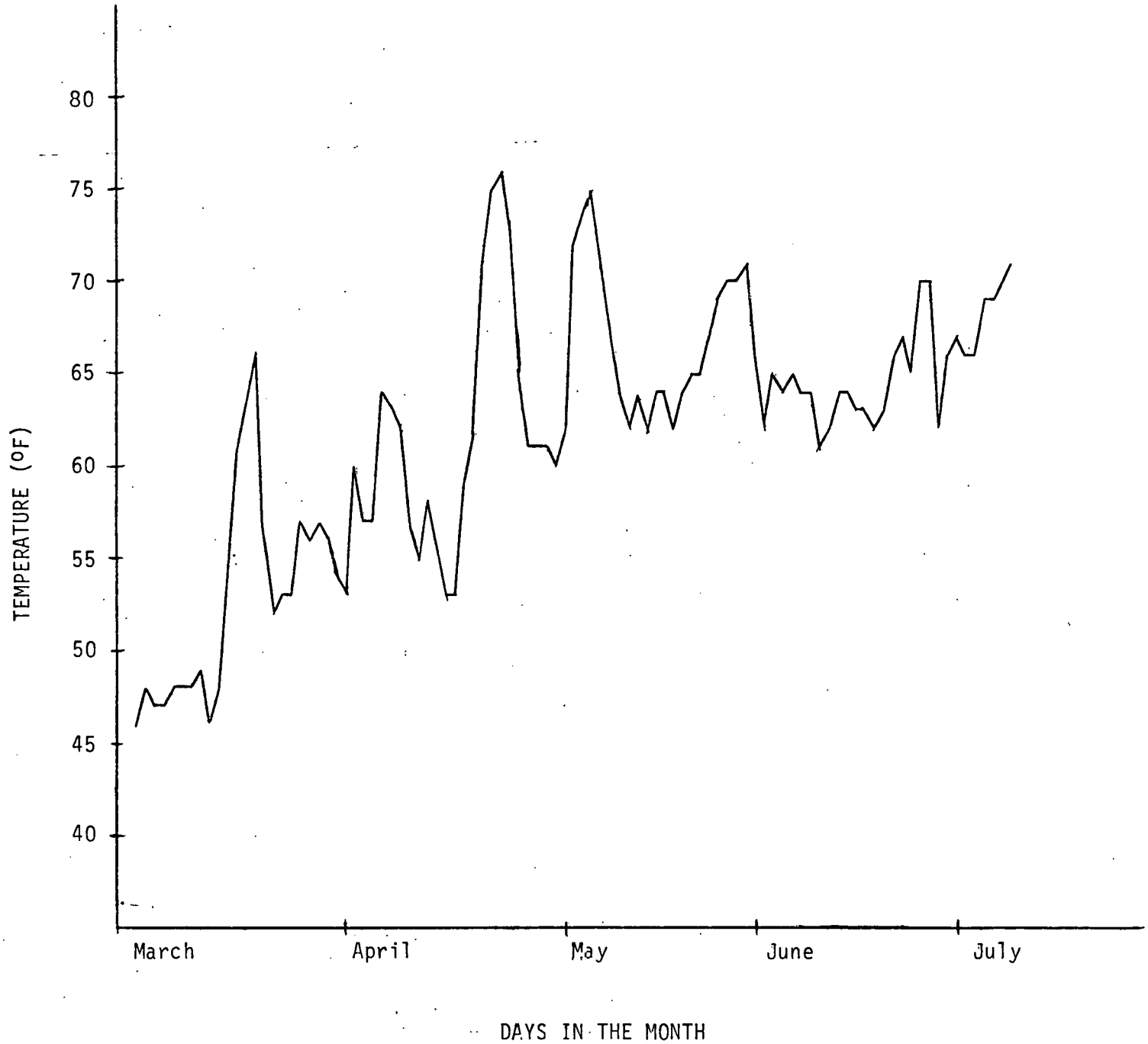


CHART NO. 4: Soil Temperature



glazing, to create a buffer zone between the plants in the bed and the cold glazing.

Many people are concerned about how hot a solar greenhouse will get during the summer. In our case this was not a problem; in fact, it has been too shady in the greenhouse to grow the hot weather crops as quickly as we anticipated. The extreme angle of the glazing, and the design of the first and second story roofs, prevent the sun from reaching very far into the greenhouse and heating the thermal storage. The vent area is adequate to provide considerable air movement. Finally, the large walnut tree near the east corner of the greenhouse spreads its branches across the entire front of the greenhouse, shading it completely until late afternoon in the summertime. The most severe overheating problems occurred during the spring and fall, when there were no leaves on the tree, and the sun angle was low enough to penetrate the glazing and hit part of the thermal storage.

A rough idea of the impact of the solar greenhouse on the house's energy consumption can be obtained from the gas utility bills. Although many individual monthly bills from the past several years have been estimated, it is possible to determine the actual consumption for the entire winter by looking at the actual meter readings taken at the beginning and end of each winter. During the winter of 1977-78, the gas consumption rate was 0.326 Ccf per degree day. At this time, the house was occupied by renters and essentially uninsulated. Urban Options moved into the house in October 1978, and immediately began weatherization projects, including weatherstripping windows and doors, adding storm windows and insulating shutters, insulating the roof of the addition, and a few walls. The following winter (1978-79), the gas consumption rate was 0.228 Ccf per degree day, or 30% less than the previous winter. Some of this reduced consumption was also due to a change in the use of the building from 24 hour occupation (at 65-70°F) to occupation only 8 to 12 hours per day. The solar greenhouse began to add heat to the house from September 1979 on. The consumption during the past winter (September to February only, as March and April billings are adjusted and cannot be used), has dropped to 0.116 Ccf per degree day, or 50% less than that of 1978-79. However, after the solar greenhouse was constructed, additional weatherization projects were completed on the house, such as the insulation of the

walls on one side of the house, the addition of more attic insulation, and the construction of more insulating shutters. Thus it is impossible to say exactly how much heat the greenhouse was contributing to the house, although if we accept these figures, it is probably a substantial contribution. Unfortunately, these figures may not be accurate because of the possibility that the gas meter was faulty. Monitoring over at least one more winter is required before we can say for certain that this is the actual consumption rate.

Despite these uncertainties, there is some evidence that the greenhouse will provide a substantial amount of heat to the house. Using dimensions and U-values of the house and the greenhouse as they are new, and local insolation data for East Lansing, I have calculated that 35.5% of the house's heating load will be provided by the solar greenhouse in an average year. A summary of the calculations and methodology is presented in Appendix E.

Using the results obtained from the calculations, I have estimated the payback period for the solar greenhouse (materials cost only) using standard discounting economic analysis which takes into account the inflation rate, the return on alternative investments, and other variables listed in Appendix E. This analysis shows that the solar greenhouse will pay for itself in approximately 15 years if natural gas is the home heating fuel, $3\frac{1}{2}$ years if oil is used, and $4\frac{1}{2}$ years if electricity is used. The value of food grown in the greenhouse is not included. Since about 75% of the homes in this area are heated with natural gas, the 15 year payback period may be discouraging to many people. Compared to conventional house additions and greenhouses, however, which have no "payback period", even a 15-year return on investment is favorable. In some cases, the cost of the greenhouse can be substantially reduced by substituting other materials and by judicious use of the greenhouse to grow food for the table or plants for sale. For the home heated with electricity or oil, the addition of a solar greenhouse appears to be a very wise choice.

IV. HORTICULTURE IN THE SOLAR GREENHOUSE

Our experience with horticulture during the grant period was limited by the priority of finishing the greenhouse structure, time constraints, and planting times that were less than optimal. At least a full four seasons is needed to really see how plants respond to the environment of a solar greenhouse. We have enough experience, however, to make the following comments about growing plants in our solar greenhouse:

Although many non-edible plants can be grown in a solar greenhouse, our goal during this project was to use the greenhouse for food production. Greenhouse horticulture has become very energy-intensive over the years, as scientists have found that certain amounts of heat, light, and carbon dioxide can speed up plant growth and reduce the time and labor needed to grow plants for sale. Since the goal of the solar greenhouse project is to reduce energy consumption, we chose to try and grow these plants with a minimum of energy use in the form of heat, light, fertilizers, and pesticides. We emphasize the use of organic materials for fertilizers instead of petroleum-based fertilizers, and try to use a minimum of toxic pesticides, since the use of toxic chemicals in a home greenhouse may pose a health threat to those families that have greenhouses. Despite these good intentions, some compromises were made along the way which increased the energy input into the greenhouse environment.

The solar greenhouse was operated without any additional heat from the house, so the vegetables grown during the winter months had to be the cold-resistant varieties. There are a large number of vegetables that are cold-resistant, and some that are even freeze-resistant, but many of them are not well-known to Americans. A considerable amount of time was spent researching these varieties and working out a planting sequence. In a small greenhouse, space can be utilized most efficiently by starting plants that can stand transplanting in seedling flats. Accordingly, on January 16, 1980, the following vegetables were planted in flats: mustard greens, kolrahbi, swiss chard, spinach, kale, corn salad, onions, four varieties of leaf lettuce, Chinese kale, Chinese cabbage (Siew Choy), Chinese india mustard, and Bok Choy.

By starting these plants in January, we were violating the first principle of horticulture in solar greenhouses: a solar greenhouse user

must learn to work with the seasons, and not against them. These plants should have been started in the fall and grown to maturity during the winter. Unfortunately, the greenhouse was not ready for operation until January, so if there were to be any plants at all in the greenhouse, they had to be started in the worst month of the year. To guarantee some success in this enterprise, a propogation tent was built out of recycled 2 x 4s and set up on two of the 55 gallon drums. A two-tube flourescent lamp was suspended from the top of the tent, and the whole framework was covered with plastic, so that heat could be captured inside the tent when it was closed off from the rest of the greenhouse. A heating mat was placed in the bottom of the tent to provide bottom heat to the seedlings. The flourescent lamp and the heating mat were both hooked up to timers so that they ran only when necessary.

A pervasive killer of seedlings is damping-off disease, which is promoted by unsterilized planting medium, overwatering, and lack of proper heat and light. The propogation tent and the use of a special commercial potting mix helped us to avoid this problem. The potting mix was another compromise of the low-energy growing techniques, since it is made up of peat moss, vermiculite, and various commercial fertilizers and trace elements. This mix is expensive, but it is convenient and works very well. In the future, if the labor is available, we may try using a pasteurized mixture of garden soil and compost. No compost, however, was available in January.

The propogation tent worked very well. Everything germinated except the spinach, which apparently strongly prefers cold soil temperatures for germination. Selected seedlings were transplanted to six packs on January 30th and continued their growth in the tent. The propogation tent had only one serious drawback, which we discovered on those few clear sunny days. If the sun came out on a day when the tent was closed, with the heating pad on, the plants inside began to cook from the heat. The tent then had to be vented manually.

Seedlings in the tent also tend to get long and leggy because of the predominance of light from one direction. This phototropism was reduced by the addition of a sheet of thermoply (which has a reflective, foil-covered surface) to the back of the tent. Phototropism also affected the adult plants in the greenhouse, and the plants in pots were turned

occasionally to correct the condition.

The biggest problem in getting greenhouse operations started was deciding which planting medium to use in the beds, and whether or not it should be pasteurized. It was impossible to get good topsoil and compost in January and pasteurize a large amount of it. In the fall, an Urban Options member donated some clay loam topsoil, sand, and pig manure, as well as the use of a wood-fired soil pasteurizer. The pasteurizer was used to steam about one 20 gallon can full of a soil/sand mixture, although the process was discontinued when it proved to be too tedious in the below-freezing temperatures of February. This soil mixture was added to equal portions of regular commercial potting soil and VSP Mix (which is peat based). The front planting bed in the lower story of the greenhouse is divided into two sections by a center support. This soil mix was put into the smaller of the two sections. We would have liked to fill the entire bed, but the commercial mediums were so costly that it was much more reasonable to wait until the weather warmed up so that the donated soil could be used.

Into this section of the bed, which measured 5'8" x 1'8" x 1'6", were transplanted kale, kolrahbi, corn salad, Chinese cabbage (Siew Choy), and three types of leaf lettuce. At the same time, the root crops, such as radishes, turnips, carrots, and peas were planted. This was done on February 29th. All of the vegetables were spaced according to the French-intensive method of planting, where most vegetables are spaced at about three quarters of the distance recommended on seed packets. Vegetable varieties having a beneficial effect on each other are also interplanted. We had mixed success with this experiment, because the transplanted seedlings tended to shade the newly-emerging root crops as soon as they started rapid growth. The radishes and turnips did make it, but the carrots never passed the seedling stage, and the peas suffered greatly by being shaded by the huge chinese cabbages.

The original plan was to transplant all of the seedlings into the beds, but after we gave up the attempt to fill the beds with soil in the winter, some of these seedlings were transplanted into clay pots. The Bok Choy and india mustard had gone to seed and were discarded. This happened either because of too much supplemental light and heat (they

like short days), or because after they reached a certain stage, the heating pad was turned off. Some members of the cabbage family (such as Bok Choy and cauliflower), will bolt if subjected to temperatures less than 55°F for two weeks or more at the seedling stage. This is one reason why a propogation tent is a necessity in an unheated greenhouse during the winter.

Of the winter crops planted in the bed, the most outstanding crop in terms of the amount of edible material produced was the Siew Choy Chinese cabbage. The two cabbages grew very quickly to the height of about 18" and took over one end of the bed. The B. S. Simpson and Paris Island Cos lettuce also grew very well, along with the corn salad, kolrahbi, Chinese kale, and radishes. As spring approached and the greenhouse began to warm up, though, the aphid population began to get out of control. On May 9th, the remainder of the corn salad, kolrahbi, turnips, and radishes were harvested before any serious damage was done. Only the turnips were immature at harvest, and these were used as greens. The peas alone were left in the bed to grow, and they never did produce very much because of their early stunting by the Chinese cabbages.

Of the plants in the clay pots, the lettuce and chard did the best. Everything else was somewhat stunted, probably because the pots were too small for the root systems. Container gardening is a relatively new horticultural method, and not much information is available on the size of containers used for different vegetable varieties. Plants in clay pots must also be watered much more often than plants in beds, and this can be a time-consuming chore if there are a lot of pots.

The harvest dates of the winter crops are listed in Appendix F. Most of the vegetables took much longer to mature in the greenhouse than they normally do during the summer season. The vegetables that were not started in the propogation tent took the longest time to grow. Also, as mentioned in the section on the thermal performance of the greenhouse, there was a big difference in the soil temperatures and light levels in various parts of the bed. This affected the growth rates of the vegetables. The plants closest to the outside glazing grew very slowly and were more susceptible to pests and diseases.

One of the most important reasons for building a greenhouse is to have

a place to start seedlings for outside gardens in the spring. On March 25th, lettuce, oregano, celery, cauliflower, and broccoli were planted in flats. The propogation tent was used again, with the heating mat on from sunset to sunrise. The flourescent lamp was not used. After a few weeks, when the greenhouse began to warm up, these plants were moved out of the tent and into the greenhouse and tomatoes, marjorum, basil, sage, nasturtiums, peppers, and eggplant were started. Finally, on May 8th, melons, squash, and cucumbers were planted in peat pots. These seedlings were transplanted into the garden in May and June. A visit to the local Frank's Nursery during this time verified that the quality of these seedlings was excellent compared to what was commercially available. The peppers and eggplants were left in the greenhouse a little too long, however, and were attacked by spider mites and aphids. With some trepidation, these seedlings were transplanted after the pests were killed by hand (no pesticides used). The insects have not reappeared and these plants have produced very well.

By the end of May, most of the winter crops had been harvested out of the greenhouse. The remainder of the planting bed was filled with an unpasteurized mixture of 1/3 clay loam, 1/3 horse manure, and 1/3 sand. Tomatoes, eggplant, peppers, cucumbers, and basil were transplanted into the beds. Some bush beans were also grown in the small section of the bed, having been planted on May 8th. Unfortunately, the plants in the newly-filled bed suffered a setback, because the manure began to heat up once inside the greenhouse, using up the available nitrogen. This problem was corrected with the liberal use of fish emulsion and the addition of cottonseed meal, colloidal phosphate, and greensand to the soil. The plants began to grow again, but they still remain far behind their counterparts outside in the garden. The lower story of the greenhouse is much cooler and shadier than expected, not an ideal environment for the sun-loving eggplants, peppers, cucumbers, and tomatoes. Since many of the root and leaf crops can better tolerate shady conditions, beets, lettuce, collards, turnips, radishes, mint, parsley, and basil were planted in the bed on June 30th.

The use of the clay loam mixture in the rest of the bed has not worked out, and hopefully this planting medium will be replaced with a better mixture before winter. Despite the liberal addition of sand and manure, the clay particles stick together and tend to form a crust on the

top. A greenhouse soil must be light, rich, and loose for good results. Probably a good black sandy loam with some very old manure or peat would be the best mix. We may have to hunt around for this type of soil, because the clay loam is the predominant soil in this area.

The unpasteurized soil was used in the main bed as an experiment, to see if pasteurizing was necessary. During the spring, when there was only pasteurized soil in the greenhouse, a population of aphids and spider mites was present. Most of these were destroyed when the winter crop was harvested, but a few remained and these have begun to build up a population again. The unpasteurized soil has brought in some pillbugs and thrips. Recently the staff reported seeing huge numbers of tiny black flies, probably fungus gnats, in the greenhouse. This population explosion has died out and does not appear to have hurt the plants. Some other larger flies have appeared that do not seem to be causing any visible harm. Many of these larger flies have been caught by spiders, which also seem to have increased during the summer. It is too early to say whether the additional pests brought in by the unpasteurized soil will prove to be a serious problem. It appears, however, that those who choose to use unpasteurized soil are trading the time saved in pasteurizing soil for the time spent in combating pests. This may make it well worth the time and money for the greenhouse owner. In any case, pasteurizing the soil will not guarantee a pest-free greenhouse, since many pests enter the greenhouse on potted plants.

A variety of methods have been used to control the pest population in the greenhouse. One of the easiest is to simply crush the insect. Many aphids and pillbugs have been destroyed in this way, but it can be very time-consuming, especially when the insect tends to spread all over the greenhouse. Some repellant sprays have been used with mixed results - the insects disappear for a while, but eventually they come back. A milk paste solution can be effective in killing (not just repelling) spider mites, but this only seems to work on certain plants. Since spider mites do not travel very far very fast, infested leaves can be cut off and destroyed to control the population. Ladybugs were imported this summer to keep the aphid population in check. Out of a large number of ladybugs, only a few settle down and eat aphids. The rest seem to become totally disoriented and gather on the glazing, where they are often captured by spiders. Despite these

disappointing results, we are continuing to experiment with the ladybugs to see how they can be induced to eat more.

While each of these methods alone is not completely effective, all of them together seem to keep the pest population within reasonable boundaries. Most plants will survive and produce if given the proper growing conditions and if the pests are kept away when they are young. Where greenhouse yields or the appearance of the plants are very important, the greenhouse owner will be tempted to use pesticides from the start. From our experience it is evident that it takes a great deal of knowledge and experience to use organic pest control methods successfully in a greenhouse. There has been very little research done on organic horticulture at major agricultural universities, so greenhouse owners are forced to do their own experimentation.

We estimate that growing plants in an attached greenhouse takes a minimum of ten hours per week on the average. More time is required to start seedlings and transplant them, and less time can be spent in the greenhouse when the plants are past the seedling stage.

The Urban Options solar greenhouse produced about $11\frac{1}{2}$ pounds of vegetables in its first three months of operation, using only about one-third of the available growing area in the lower greenhouse. Because of the exotic nature of some of these vegetables, it is difficult to estimate the worth of this produce. About four flats of seedlings were grown in the spring, with an estimated worth of about $30. The yield from this summer's plantings in the greenhouse will probably be about the same as the winter planting. No real conclusions can be drawn on greenhouse yields until we are able to utilize the entire greenhouse for at least one year. In Michigan's cloudy climate, it is unlikely that the greenhouse will produce an outstanding yield, especially during the winter months. It should produce more than enough, however, to pay for the cost of supplies. The design of the greenhouse, its location, and the horticultural skill of its owner can vary the yield of a solar greenhouse so much, that it is very difficult to accurately estimate the savings from growing vegetables in a solar greenhouse. Therefore, no estimate of the value of produce is included in the economic analysis of the solar greenhouse. It is wise for most potential greenhouse owners not to rely too much on the monetary savings from growing food in a solar greenhouse. Research done on green-

houses in much more favorable climates has shown very little savings.* For many people, the value of having fresh, organically grown vegetables available year-round through the hobby of horticulture is the most important reason why they build a solar greenhouse.

* "Food Production in Small Solar Greenhouses" Dr. John H. White
<u>Solar Greenhouse Digest</u>, No. 7, Oct./Nov. 1979, p. 30

V. EDUCATIONAL ACTIVITIES

The number of visitors to the Energy House increased substantially during and after the construction of the solar greenhouse. We estimate that the number of walk-in visitors averages about four per day. In addition, one to three classes per month tour the house during the school year. Many of these visitors are primarily interested in the solar greenhouse. During December 1979 and January 1980, we conducted a survey of information requests by the general public. Of the 78 walk-in and phone requests recorded, the top six interest areas were as follows:

Greenhouse	15.45%
Weatherization	13.8%
Insulation	10.8%
Solar/Passive	10.0%
Recycling	7.7%
Insulated Shutters	6.2%

A total of one-quarter of our visitors are interested in passive solar design and solar greenhouses.

Since it was printed by Michigan State University in December 1979, about 800 copies of the article "Attached Solar Greenhouses in Michigan" have been distributed from the Energy House. This article is a good basic introduction to solar greenhouses, and was obtained by one of the authors for distribution until the pamphlets required under this grant could be written. Although the grant application narrative indicated that one pamphlet would be written at the beginning of the project, the decision was made to write both pamphlets at the end of the project, when more data was available on the greenhouse. The first pamphlet was written in May for the Solar Greenhouse Workshop segment on horticulture. The second pamphlet explains the operation of the Urban Options solar greenhouse to our numerous visitors. Certain questions were asked again and again in the nine months since the greenhouse was constructed, and this pamphlet was designed to answer most of these questions. Since not all of our staff members and volunteer tour leaders are equally knowledgable about solar greenhouses, these pamphlets will help us to provide complete information to the general public. Samples of the literature described above are included in Appendix G.

Although the Urban Options Energy House is open to the public during business hours, occasionally we have special open houses on Saturdays or

Sundays that are widely advertised. Three open houses were held this year, each attracting between 30 and 100 people. On June 3rd, 1980, the City of East Lansing sponsored a tour of solar homes. The Energy House was included in the tour, and on that day, about 250 people visited the Energy House, despite the rainy weather. This tour indicates the interest in solar energy that exists in the community.

The construction of the wheelchair ramp and remodelling of the first story of the house made it possible for handicapped persons to visit the Energy House and see the solar greenhouse. Residents of the Moore Living Center, a home for the retarded, were particularly delighted to tour the solar greenhouse. Urban Options and the Capital Area Community Services Agency will be assisting this home in the construction of its own solar greenhouse.

Another important aspect of our educational program is our workshops and classes. The classes cover a topic in depth and last several weeks. The Solar Greenhouse Construction Class was described in the section of this report on the construction of the solar greenhouse. This was our most successful class during the year, as the hands-on aspect of this workshop was intriguing to many people. It was also relatively low-cost. During the winter, a class on home weatherization and retrofitting was conducted. Solar greenhouses and other solar projects were covered during this class. In the spring, a class was organized again on solar greenhouses. The aim of this class was to not only help the participants understand the principles of solar greenhouse design, but also to help them design and draw their own greenhouse. Because we are trying to make these classes self-supporting, the fee for this class was higher than other classes, but participants received not only instruction but also consulting time to help them design their greenhouse. The brochures describing these classes can be found in Appendix C.

Altough the nature of our project requires that visitors come to us, we also occasionally go into the community to present information on our project. We have to be very selective about giving presentations, however, or we could easily be overwhelmed with requests. Many of the presentations and exhibits done in the past year have related specifically to the solar greenhouse project. In September, 1979, we were invited by the Governor's Energy Awareness Advisory Committee to submit a proposal to construct a

portable solar greenhouse that would be transported to four energy fairs sponsored by them throughout the state. The exhibit was built by our staff and set up at these fairs, exposing a large number of people to information on solar greenhouses. An estimated 150,000 people attended these energy fairs. Of course, the experience gained in constructing the DOE-funded solar greenhouse was shared with people who were particularly interested in building a solar greenhouse.

The portable greenhouse has been set up at other events in the Lansing and mid-Michigan area since the energy fairs, including a visit to a local elementary school and a teacher's energy conference. Slides of the Urban Options solar greenhouse were shown to an audience of 35 people at Fenner Arboretum, and to solar greenhouse workshop participants in Muskegon. The Urban Options staff is assisting a group of senior citizens to build a free-standing solar greenhouse at a senior citizen's apartment complex. The pictures of the construction process and the greenhouse itself, and the experiences that we could share, were important in getting this project started. At this time, we are the only group in this area that can provide assistance on solar projects of this sort.

This project has also been advertised through the news media. Television and radio coverage of the greenhouse construction was extensive. This was the only planned media event on the solar greenhouse project, but other stories have been written by reporters throughout the year as they learn about the solar greenhouse project and the Energy House. News stories can be found in Appendix H. We originally planned to have a formal news conference in the spring, but this was postponed until the greenhouse was completely finished and all of the important data on the greenhouse performance was analyzed.

VI. FUTURE PLANS

If additional grant funding is not found to continue this project, we will have to rely more on volunteers to carry on some aspects of the project. Since the skill level, time, and interest of volunteers is always uncertain, it may not be possible to do all that we would like to do with the solar greenhouse.

Probably the most important volunteer that must be found is someone who would like to grow plants in the greenhouse. There is nothing more depressing than an empty greenhouse. Hopefully, we can find one or more volunteers with enough time to fill the entire greenhouse with plants, and continue the monitoring of vegetable production. If we find that vegetable production is too labor-intensive for the amount of volunteer time available, we may have to fill the greenhouse with perennial herbs, flowers, and house-plants instead of vegetables.

The recording of greenhouse temperatures will be continued by a new staff of CETA trainees, to be hired in October. Although we cannot afford more accurate monitoring devices, it should be possible to determine more precisely the accuracy of the data by testing the thermometers against more accurate models, and by changing their location in the greenhouse to see if microclimates are affecting the readings. With a new gas meter installed, it should be possible to obtain more accurate information on fuel consumption during the next winter. Finally, the installation of the insulating curtains will make it possible to compare the fuel usage of the house during a period when the greenhouse is not operating (i.e. when the insulating curtains are left closed all the time), and a period when the greenhouse is operating normally.

Analyzing data on the greenhouse should be much easier when we obtain a programmable calculator and program it to calculate heat loss and solar gain. We have obtained a small grant to purchase a calculator and will be working on the programming this fall. With this calculator, we will be able to expand our solar site surveys to include calculations of fuel savings from adding on a solar greenhouse. The answer to the big question "How much heat will it provide?" can then be obtained in about one-half hour, rather than after days of tedious calculations.

One of the new CETA staff members will be assigned to creating and maintaining exhibits in the Energy House. This should include more

explanatory posters, drawings, etc., in the greenhouse to explain its operation to visitors. This should substantially increase the value of the Energy House as a working demonstration. Our outreach program will also be expanded and streamlined with the completion of the slide show on solar greenhouses. This slide presentation was funded by the State of Michigan Solar Office, through MASEC, and will concentrate on solar greenhouse construction and design in mid-Michigan. This slide show should make it much easier to give presentations, since no time is required to sort slides and put together a decent slide show, as well as prepare a speech. The slides can also be borrowed with the tapes by a group who needs to give a presentation when a speaker is unavailable.

At the very least, the solar greenhouse will continue to be accessible to the public at all times. For most people, seeing is believing, and the Urban Options solar greenhouse is the first example they have seen of the practical use of the sun's energy.

APPENDIX A

GREENHOUSE BLUEPRINTS

(See left-hand pocket in front of report.)

APPENDIX B

INSULATING CURTAIN DETAILS

August 29, 1980

To: Ruelaine Stokes

From: Jane Wilcox

Re: Report on Insulating Shades - Michigan Energy Administration Grant

Two shade designs are completed and ready to hang in the upstairs and downstairs sections of the greenhouse.

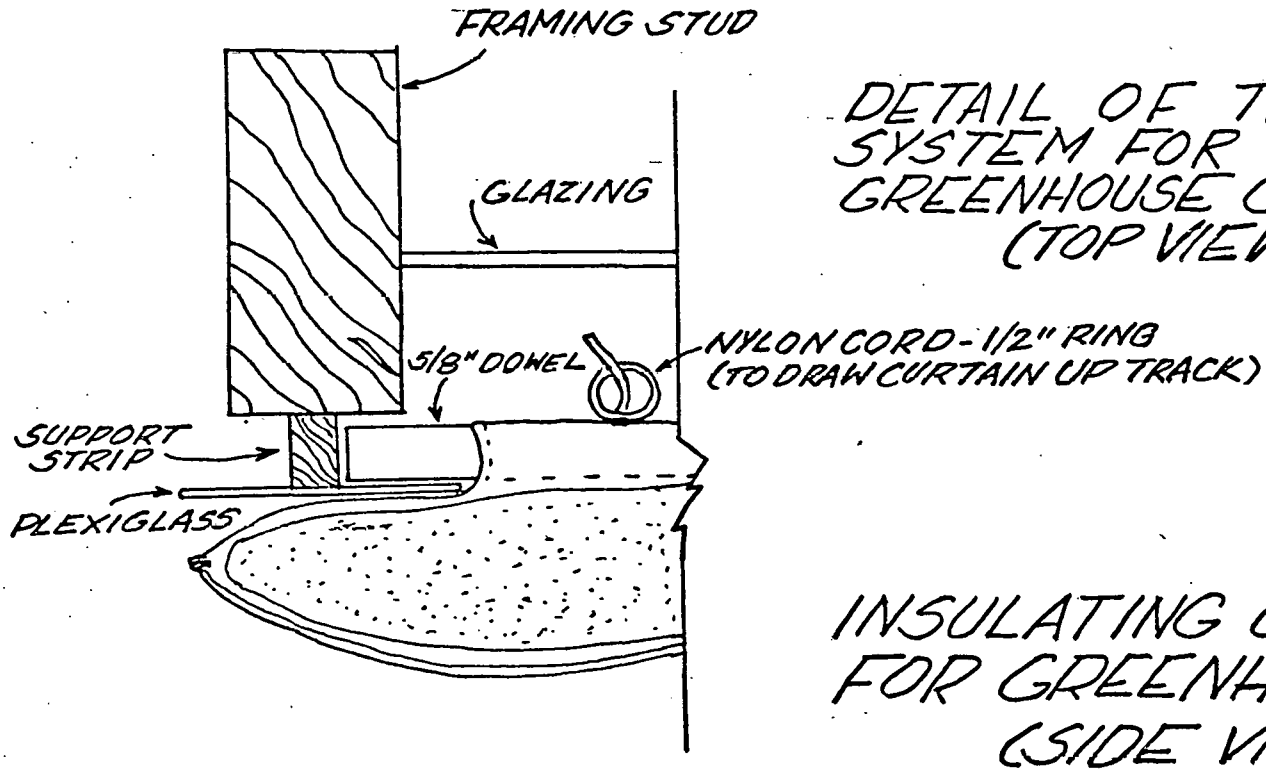
The upper level shades are triple-layered, with vinyl-backed ripstop nylon outer layers and an inner layer of reinforced mylar emergency blanket. Attached to an upper mounting strip, the shades are pulled up by a series of nylon cords. Turnbuckles at the midpoint and bottom hold the shades against the sloping surface for a tight seal. These will be stored until the interior finishing of the upper level is complete.

The lower level shades are thicker, since more ceiling storage space is available. In addition to two layers of vinyl-backed nylon and emergency blanket, these shades contain an inch of polyester fiberfill. A track system is being improved to raise and lower the shades. Dowels sewn into batten pockets hold the quilt in place in the track, carrying it up to the ceiling. Although the shades are complete, more work is needed on the track for smooth operation and durability.

August 20, 1980

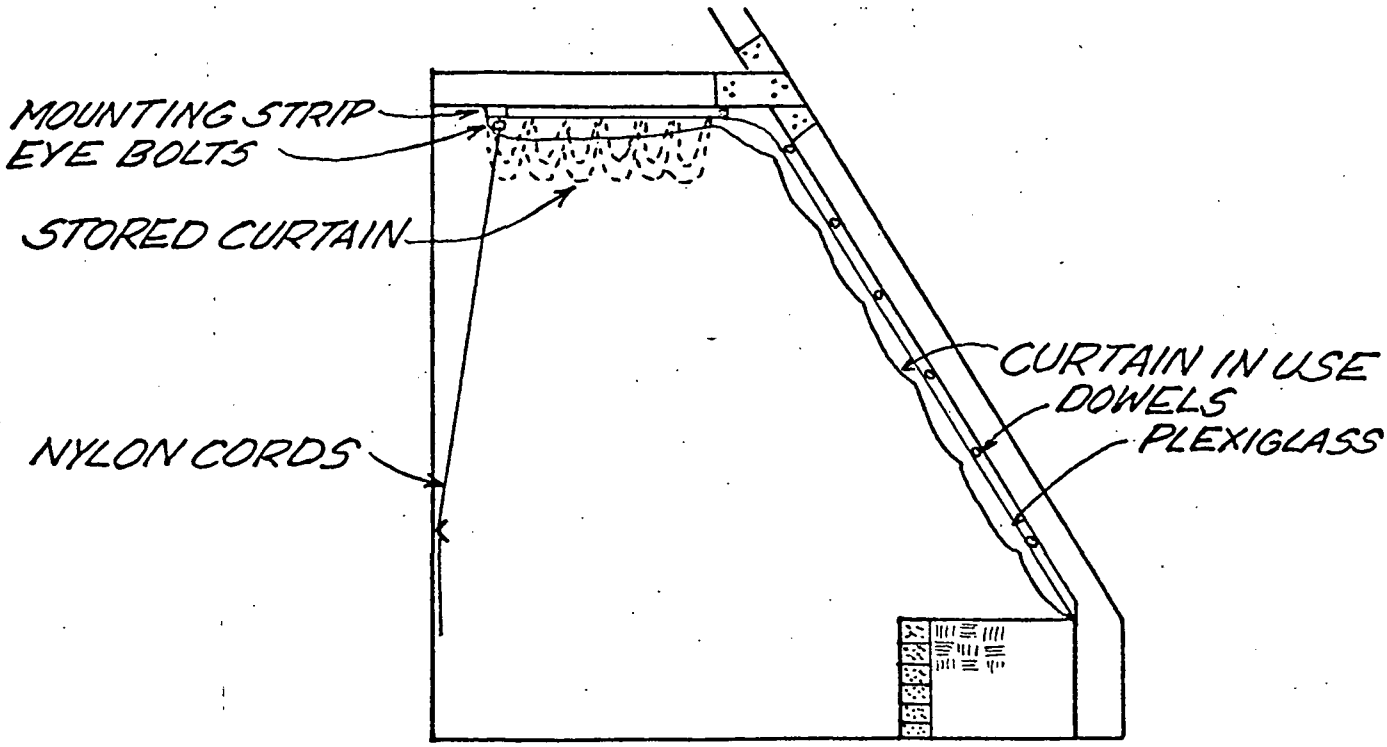
An improved track system is under development. Narrow PVC tubing, slit on the side, will serve as the track. Small beads or buttons, sewn to the curtain edges, will fit inside the tube track and carry the curtain up and down. This system makes the battens less important and prevents the curtain from slipping out.

The upper level of the greenhouse is now painted and prepared for the mounting of the shades.



DETAIL OF TRACK SYSTEM FOR GREENHOUSE CURTAINS (TOP VIEW)

INSULATING CURTAINS FOR GREENHOUSES (SIDE VIEW)



APPENDIX C

WORKSHOP SCHEDULES

SOLAR GREENHOUSE CONSTRUCTION CLASS

Designed to complement the Urban Options Energy House Solar Greenhouse Workshops, this class will cover the basics of passive solar design, including collection, retention and distribution of solar heat. We will also discuss basic construction techniques relative to attached solar greenhouses: structural loading, heat storage, glazing, shuttering and insulation. We will conclude with information on how to use your greenhouse growing space effectively.

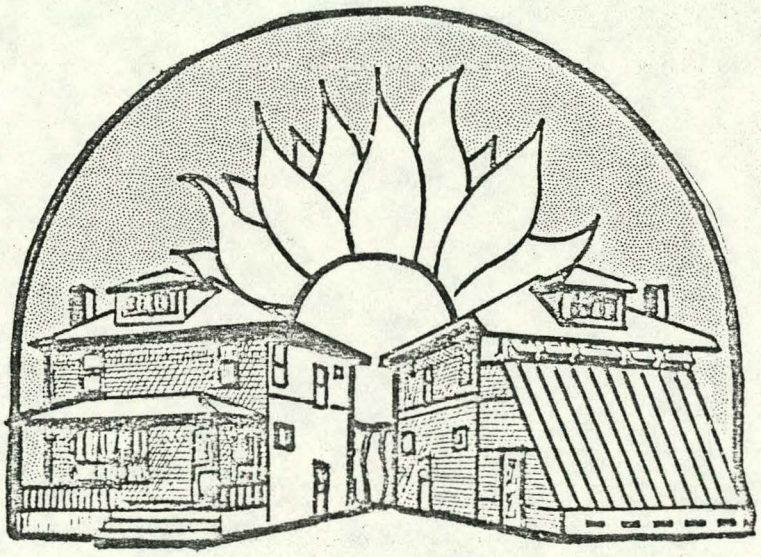
Instructors for the 8 week course are: Randy Eveleigh, Energy House Coordinator, Thom Peterson, solar housing Instructor at Lansing Community College and Tom Young, Instructor in Human Environment and Design at Michigan State University.

Class will meet Tuesday nights from 7:30 - 9:30 for lectures and five Saturdays from 9 - 5 p.m. for "hands on" construction of the solar greenhouse.

Tuition for the non-credit course is $35.00 and includes membership in Urban Options. Current members are entitled to a $5.00 discount.

CLASS SIZE IS LIMITED. REGISTER SOON BY CALLING 351-3757.

LAST DAY FOR REGISTRATION IS JULY 21.



urban options
energy house
135 linden
east lansing

SOLAR GREENHOUSE CONSTRUCTION

COURSE OUTLINE

DATE	TUESDAY CLASSES (7:30 - 9:30 p.m.)	*SATURDAY WORKSHOPS (9 - 5 p.m.)
7/21		PORCH DEMOLITION
7/24	Introduction; Passive Solar Design and the Energy Efficient Shelter	
7/28		FOOTINGS
7/31	Basic Construction, Part I: tying-in, footings, foundation	
8/4		FOUNDATION
8/7	Thermal Storage and Distribution	
/14	Basic Construction, Part II: structural loads, framing	
8/21	Nighttime shutters, glazing and insulation	
8/25		FRAMING
8/28	Horticulture in the Northern solar greenhouse	
9/4	Heat loss and Solar input calculations	
9/8		GLAZING
-/11	Conclusions/Celebration!	

Classes and Workshops meet at the Energy House, 135 Linden St, East Lansing
*Saturday Workshops - Bring a bag lunch.

INSTRUCTORS FOR 1980 SOLAR DESIGN CLASS

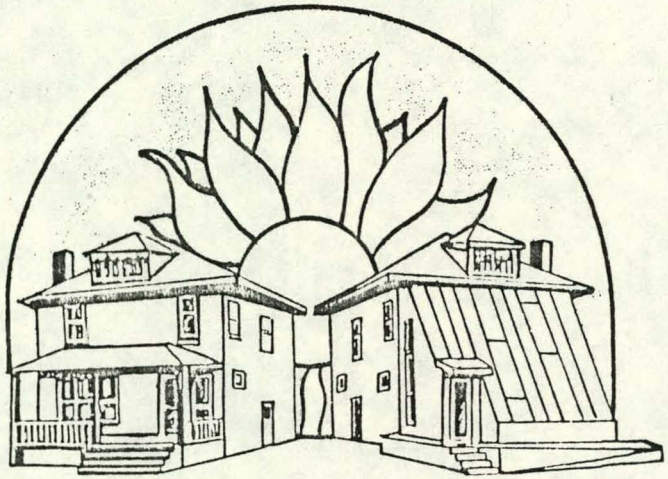
LORI CIPPARONE - Urban Options Horticulturist and Greenhouse Manager. Solar Greenhouse Training by New Mexico "Solar Sustenance Team" - 1978. Workshop Leader for Solar Greenhouse Construction Workshop. Former Ingham County Energy Office Energy Auditor. Instructor in Urban Options "Solar Greenhouse Construction Class" (Fall 1979) and Urban Options "Retrofit Class" (Winter 1980).

RANDY EVELEIGH - Urban Options Energy House Coordinator. Workshop Leader for Urban Options Weatherization and Solar Energy Workshops. Instructor in Urban Options "Solar Greenhouse Construction" and "Retrofit" Classes. Training by New Mexico "Solar Sustenance Team". Design Assistant on two working solar greenhouses. Design Committee Member for energy efficient retrofit of Energy House. Licensed Builder.

JOHN MELCHER - Carpenter. Urban Options Board Member. Organizer and Instructor for Solar Energy Program for Vocational Education teachers.

THOM PETERSON - L.C.C. Solar Energy Program Instructor. Classes taught: Solar Greenhouses, Solar Housing, Solar Hot Water Lab, Solar Collector Lab. Design Assistant on Urban Options Greenhouse.

TOM YOUNG - Builder and Sculptor. Former M.S.U. Housing Construction Instructor. Designer of several solar heated buildings. Landscaping and Drafting.



ABOUT URBAN OPTIONS

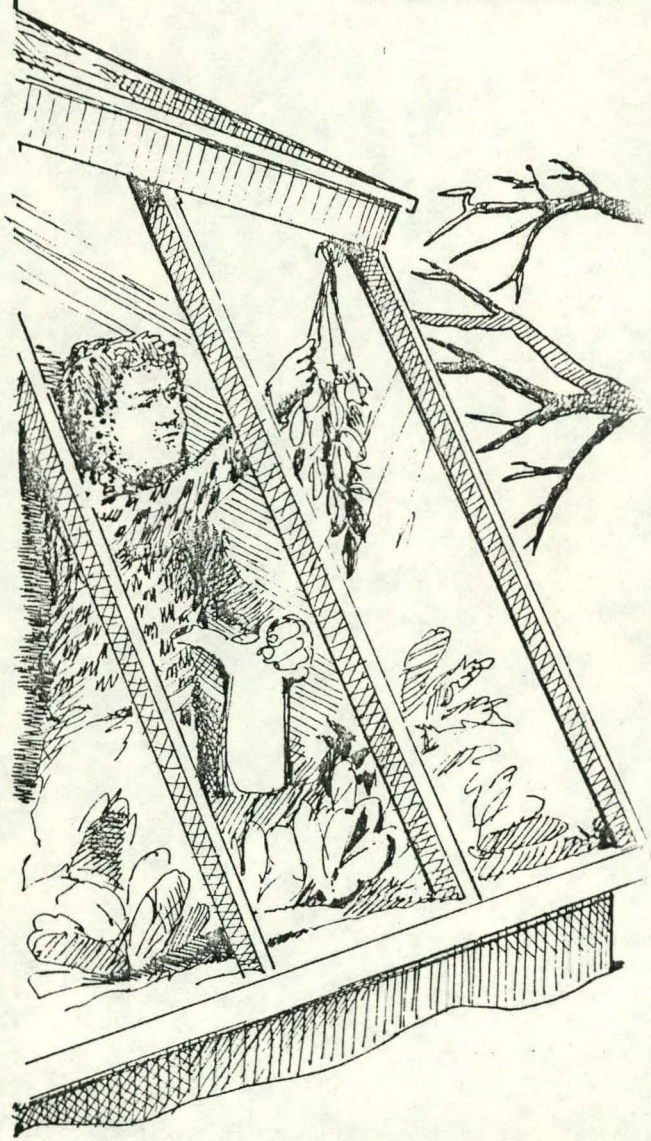
Urban Options is a non-profit group formed to provide information, intensive research and "hands on" experience in energy saving techniques. The City of East Lansing has donated the Energy House to Urban Options for use as a demonstration project.

Urban Options aims to bring energy conservation information to local residents in a form that is immediately understandable and will encourage people to implement what they learn in their own homes. "Hands on" workshops fulfill this function. In a typical workshop, participants take part in a lecture/discussion about home energy conservation. The "hands on" part of the workshops enables people to practice specific weatherization techniques on the Energy House.

If you would like to become involved in Urban Options, become a member. Members receive the most up to date information on Energy House programs via the monthly "Energy House Newsletter". Members are also entitled to attend all Energy House workshops free. Membership dues are $10.00/year ($5.00 for students).

The Energy House is open to the public, 9 am - 5 pm weekdays and 10 am - 2 pm Saturdays. Stop by or call us 1-3757.

SOLAR GREENHOUSE DESIGN for the OWNER BUILDER



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A NINE WEEK COURSE FOR PEOPLE PLANNING TO CONSTRUCT THEIR OWN SOLAR GREENHOUSE

APRIL 9TH - JUNE 4, 1980
WED. EVES. 7:30 - 9:30

DESIGN YOUR OWN SOLAR GREENHOUSE WITH HELP FROM URBAN OPTIONS

Subjects include: An Introductory Solar Lecture and Slide Show of area solar homes, Heat Loss in your house and Heat Gain from your greenhouse, Analysis of your site for Solar Applications, Energy Efficient Design for Solar Greenhouses, Construction Fundamentals for Greenhouses, Assistance with Basic Drafting for Your Greenhouse Design, Glazing Materials and Night Shuttering Devices, Thermal Storage, Planting Bed Design and Layout, and Horticulture in Solar Greenhouses.

INDIVIDUAL DESIGN CONSULTATION

Five hours of individual help will be provided each student to insure completion of final designs and "construction-ready" working drawings for participants own greenhouses. Consultations are in addition to the 18 hours of lecture and will be arranged by appointment.

SOLAR TAX CREDITS

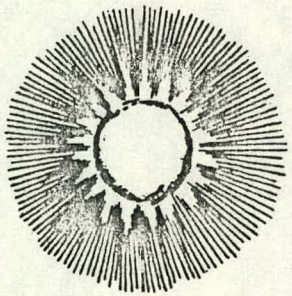
All solar greenhouse designs completed in this course will be evaluated to insure compliance with both State and Federal Income Tax Credit guidelines for Solar Heating Systems.

ENROLLMENT LIMITED

Register early. Class size will be limited to allow direct assistance to each student.

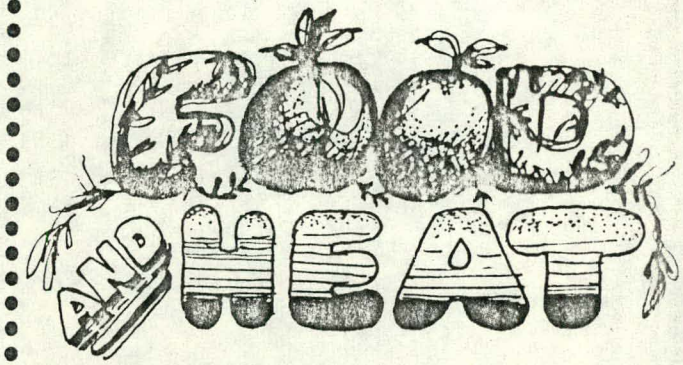
COST

$90.00 covers all instruction and consultation time and includes membership in Urban Options. (Members receive monthly newsletters and can attend Urban Options workshops free for one year.) *Class fee is per project, so family members working on the same design pay only one registration fee.*



Passive Solar Greenhouses are an economic and efficient use of solar energy, providing not only heat to your home but fresh produce in the winter and a pleasant "sun room" for dining or relaxation.

A



PROVIDER

REGISTRATION FORM FOR SOLAR GREENHOUSE DESIGN CLASS

Enclosed $90.00 Class Fee (Includes 1 year membership in Urban Options.)

NAME _____

ADDRESS _____

ADDRESS _____ ZIP _____

PHONE _____ DATE _____

Make Check or Money Order Payable to: URBAN OPTIONS, 135 Linden Street, East Lansing, MI 48823

urban options

energy house

135 linden street · east lansing · michigan 48823 (517) 351-3757

SOLAR GREENHOUSE DESIGN FOR THE OWNER/BUILDER

classes meet Wednesday nights 7:30 - 9:30 at the Energy House

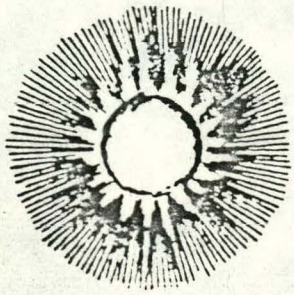
INSTRUCTORS: Lori Cipparone, Randy Eveleigh, John Melcher, Thom Peterson, Tom Young

TEXT: "The Solar Greenhouse Book" edited by James C. McCullagh
available at: Jocundry's Books, Paramount Newscenter

COURSE SCHEDULE:

April 9	Introductory Solar Lecture & Slide Show
April 16	Site analysis & Sun Angles (read Chpts. 1,2,Appendix V)
April 23	Construction Fundamentals & Types of Greenhouses (read Chpts. 8,9,10)
April 30	Heat Loss/Gain - Energy Audits (read Chpt. 3,Appendix III&IV)
May 7	Energy Efficient Design (read Chpts. 6,7)
May 14	Glazings & Insulated Shutters (read Chpts. 4,Appendix VI)
May 21	Thermal Storage & Planting Beds (read Chpt. 5)
May 28	Horticulture in the Greenhouse (read Chpts. 12,13,14,App.VIII)
June 4	Materials & Cost Estimating, Final Critique

Individual Consultations for each project will be arranged by appointment.



3 basic elements of Solar Greenhouses:

*efficient collection of solar energy
*storage of solar energy
*prevention of heat loss

APPENDIX D

SAMPLE DATA FORMS

DAILY TEMPERATURE CHART FOR SOLAR GREENHOUSE

Date	Time	Outside Temp.		1st Floor Temp.		1st Floor Doors		2nd Floor Temp.		2nd Floor Doors		Weather Conditions
		Hi	Low	Hi	Low	Op	Clos	Hi	Low	Op	Clos	

MISCELLANEOUS TEMPERATURES - SOLAR GREENHOUSE

ROOM THERMOMETERS: 1_____ 2_____ 3_____ 4_____

OTHER THERMOMETERS: 5_____ 6_____

7_____ 8_____

Date	Time	Outside Temp.	Room Thermometers				Other Thermometers				Comments
			1	2	3	4	5	6	7	8	

DAILY GAS CONSUMPTION RECORD

SCHOOL _____ MONTH _____

METER NO. _____ METER LOCATION IN BLDG. _____

CURRENT YEAR			PREVIOUS YEAR
DATE	METER READING	CONSUMPTION SINCE LAST READING	CONSUMPTION LAST YEAR
1			
31			
30			
29			
28			
27			
26			
25			
24			
23			
22			
21			
20			
19			
18			
17			
16			
15			
14			
13			
12			
11			
10			
9			
8			
7			
6			
5			
4			
3			
2			
1			
30/31			

APPENDIX E

SUMMARY OF PERFORMANCE CALCULATIONS ON THE URBAN OPTIONS SOLAR GREENHOUSE

Month	1 Average Daily Radiation at 70° 0° alt.	2 Average Deg. Days/ Month	3 E/Month Total	4 Cloudi-ness Factor %	5 Effic. Factor	6 % Non-Shaded	7 Actual E/Month	8 BTU/ Month Total	9 % Solar
September	1386.8	133	8,058,628	70	.9	77	3,909,240	1,398,958	100
October	1279.6	422	7,682,270	67	.9	91	4,215,492	4,287,062	98
November	784.8	798	4,323,044	54	.9	89	1,869,889	8,109,368	23
December	705.0	1175	4,232,686	53	.9	84	1,695,953	11,941,159	14
January	753.3	1314	4,414,494	56	.9	90	2,002,414	13,316,572	15
February	1115.3	1148	6,263,996	62	.9	93	3,033,929	11,685,004	26
March	1262.8	995	7,581,332	64	.9	92	4,017,499	10,353,250	39
April	1088.9	555	6,326,372	68	.9	92	3,562,000	5,978,628	60
May	1216.3	280	7,302,132	73	.9	77	3,694,076	3,118,188	100

$$\frac{\text{Total Solar Gain in BTUs - Sept. through May}}{\text{Total Heat Loss in BTUs - Sept. through May}} \quad \frac{24,914,322}{70,188,189} = 35.5\%$$ of Total Heating Load Provided by Solar Greenhouse

See NOTES on the next page for an explanation of the figures in each column of the chart above.

NOTES

1) Average Daily Radiation on a Tilted Surface (BTU/Day/Square Foot) for East Lansing, Michigan. From a computer printout provided by the Michigan Energy Administration.

2) Average Degree Days per Month. From the U. S. Weather Bureau figures for Lansing, Michigan.

3) E/Month = Average Daily Radiation/Month at 70° Tilted Surface (Column 1)
   x Light Transmission (%)
   x Dirt Factor (0.98)
   x Number of Days in the Month
   x Area of Glazing

   This was calculated for both the thermopane and Kalwall-plus-polyethylene glazing:

   Thermopane: Light transmission - 0.79; Area - 88.5 ft^2
   Kalwall/Polyethylene: Light transmission - 0.75; Area - 165.0 ft^2

4) This was figured using a formula from Other Homes and Garbage, J. Leckie, G. Masters, H. Whitehouse, L. Young; Sierra Club Books, 1975, p. 120.

$$\text{Cloudiness Factor} = 0.35 + 0.61 \frac{\%\ \text{Sunshine/month}}{100}$$

5) Efficiency of Collector = Effective Utilization Factor: The efficiency of solar greenhouses varies considerably. A factor of 0.90 was used in these equations. The actual efficiency could, however, be as low as 59%. In this case, the solar heating fraction of the house and greenhouse drops to 25% for the entire heating season. More research is needed to determine exactly what this efficiency factor should be for various solar greenhouses. Some of the references on solar greenhouses do not include this factor in solar gain calculations for greenhouses.

6) This was calculated for each month using a sun path chart with the hourly fractions of daily total sunshine for each area of the horizon.

7) Actual E/Month = Column 3 x Col. 4 x Col. 5 x Col. 6

8) BTU/Month Total: This is the heat loss per month for the house and greenhouse, based on these totals:

	BTU/Hr./°F
House	
Above Ground	200.2
Below Ground	36.2
Infiltration	64.9
Greenhouse	
Above Ground	96.3
Below Ground	1.9
Infiltration	33.9

If 60°F is used as the temperature difference for above-ground areas, and

26°F for below-ground areas, the BTU/hour heat loss is 16,849 BTUs/hour for the house and 7,862 BTU/hour for the greenhouse, for a total of 24,711 BTU/hour. This is assuming that the insulating curtains are used in the greenhouse at night.

Of course, degree days are used to obtain the BTU/month total instead of temperature difference. Since degree days are based on an inside temperature of 65°F, the heat loss from greenhouse may be slightly overstated. The BTU/Hour/°F figures for the below-ground foundation areas were multiplied separately by a different set of degree days modified to reflect the different temperatures of the soil. Degree days for Lansing can be found in column 2.

9) Solar Fraction: Solar gain (Actual E/Month) divided by the BTU/Month. From May to September, the solar greenhouse should provide about 35.5% of the heat needed by the house.

ECONOMIC ANALYSIS

The payback period for the solar greenhouse was calculated on a programmable calculator using a program for the economic analysis of solar hot water heating. This program is based on the f-chart method, which can be applied to solar devices other than solar hot water heaters. The program was taken from "Solar Water Heating Analysis Using a Programmable Calculator" by Steve Waslowski, Claudia Myers, and Bill Stout, Agricultural Engineering Information Series No. 414, File No. 18.8, January, 1980. Below is a list of the factors used in the calculations:

Factor	Nat. Gas	Oil	Electricity
Annual Loan Interest Rate	11%	11%	11%
Term of Loan, Years	10	10	10
Total Cost of System	$4434	$4434	$4434
Down Payment	$1000	$1000	$1000
General Inflation Rate per Year	13%	13%	13%
Fuel Escalation Rate per Year	15%	15%	15%
Discount Rate (after tax return on best alternative investment)	9%	9%	9%
Daily Heating Load, BTU	193,443	193,443	193,443
Yearly Fraction of Heating Needs Met by Solar	35.5%	35.5%	35.5%
Present Cost of Conventional System Fuel per Million BTU, Dollars	$2.95	$7.17	$15.00
Efficiency of Conventional System Furnace	65%	55%	100%
Federal Income Tax Bracket[1]	0.237	0.237	0.237
Direct Tax Credits (Dollars)[2]	$2051	$2051	$2051
Payback Period (Years)	15	4.5	3.5

1) A middle-income tax bracket was chosen for this figure in our hypothetical example.

2) Tax credits include both federal and state solar tax credits. Future IRS rules may completely and explicitly exclude solar greenhouses from eligibility for federal solar tax credits. Currently, although "greenhouses" are excluded, "hot air collectors" are included.

APPENDIX F

DATA ON VEGETABLE PRODUCTION

Plant	Variety	Date Planted	Earliest Date Harvested	Days to Maturity-Projected	Days to Maturity-Actual	Amount Produced (Ounces)	Quality	Notes
WINTER CROPS								
Chinese Cabbage	Bok Choy	1/16/80	--	50	--	--	--	Bolted to seed
Chinese Cabbage	Siew Choy	1/16/80	4/29/80	80	104	67 1/2 oz.	Excellent	
Chinese Kale	Gai Lohn	1/16/80	4/12/80	70	87	10	Excellent	
Corn Salad		1/16/80	4/12/80	45	87	5 1/3	Excellent	
India Mustard	Gai Choy	1/16/80	--	45	--	--	--	Bolted to seed
Kale	Green Curled Scotch	1/16/80	5/26/80	55	131	2	Fair	
Kolrahbi	Grand Duke	1/16/80	5/5/80	45	110	9 1/2	Good	
Lettuce	Black Seeded Simpson	1/16/80	4/12/80	41	87	17 1/3	Excellent	
	Parris Island Cos	1/16/80	4/12/80	75	87	24	Excellent	
	Grand Rapids	1/16/80	--	45	--	--	--	Not used - seedlings good
	Buttercrunch	1/16/80	4/12/80	60	87	7 1/2	Good	
Mustard	Green Wave	1/16/80	4/24/80	45	99	5 1/3	Fair	
Onion	White Lisbon	1/16/80	5/26/80	60	131	5	Fair	
Peas	Little Sweetie	2/29/80	5/28/80	60	89	1	Poor	Shaded too much
Radishes	Cherry Belle	2/29/80	4/24/80	24	55	4 1/2	Good	
Spinach	Cold Resistant Savoy	1/16/80	--	45	--	--	Poor	Poor germination Slow growth rate
Swiss Chard	Rhubarb	1/16/80	5/26/80	60	131	9 3/4	Good	
Turnips	Tokyo Cross Hybrid	2/29/80	5/9/80	30	71	7 7/8	Fair	Only greens harvested
SPRING/SUMMER CROPS								
Basil		4/12/80	--	85	--	--	Excellent	Greenhouse & garden crop
Beans	Tendercrop/ Gold Crop	5/8/80		46		5 7/8	Poor	Attacked by thrips Greenhouse crop
Broccoli	Green Sprouting	3/25/80	--	85	--	--	Good	Transplant to garden
Cauliflower	Extra Early Snowball	3/25/80	--	50	--	--	Poor	Transplant to garden Small heads

Plant	Variety	Date Planted	Earliest Date Harvested	Days to Maturity-Usual	Days to Maturity-Actual	Amount Produced (Ounces)	Quality	Notes
SPRING/SUMMER CROPS, cont.								
Celery	Florimart	3/25/80	--	105	--	--	Good	Transplant to garden
Cucumbers	Patio Pik	5/8/80	--	48	--	--	Poor	Greenhouse crop
Eggplant	Black Beauty	4/13/80	--	80	--	--	Excellent	Greenhouse & garden crop
Marjorum		4/12/80	--	70	--	--	Fair	Greenhouse crop
Muskmelon	Harper Hybrid	5/8/80	--	74	--	--	Good	Transplant to garden
Nasturtiums	Cherry Rose	4/12/80	--	50	--	--	Excellent	Greenhouse & garden crop
Pepper	Sweet Hungarian	4/13/80	--	75	--	--	Excellent	Greenhouse & garden crop
	Keystone Resistant	4/13/80	--	80	--	--	Excellent	Greenhouse & garden crop
Sage		4/12/80	--	75	--	--	Excellent	Transplant to garden
Spearmint		3/25/80	--	80	--	--	Good	Transplant to garden
Squash	Golden Nugget	5/8/80	--	95	--	--	Good	Transplant to garden
	Zucchini Select	5/8/80	--	47	--	--	Excellent	Transplant to garden
Tomato	Early Cascade	4/12/80	--	52	--	--	Fair	Greenhouse & garden crop
	Patio	4/12/80	--	60	--	--	Fair	
	Veemore	4/12/80	--	70	--	--	Fair	Garden transplant

APPENDIX G

PUBLICATIONS

(See right-hand pocket in back of report.)

APPENDIX H

NEWS ARTICLES ON THE SOLAR GREENHOUSE PROJECT

NOTEBOOK

Solar greenhouse construction class offered

If you want to learn Solar Greenhouse construction from the ground up, Urban Options is offering an eight-week Greenhouse Construction course beginning this Saturday)July 21) at 9 am. The course will be conducted at the Energy House, 135 Linden Street, East Lansing.

This non-credit class will give participants a working knowledge of passive solar design principles including collection, retention and distribution of solar heat. The class will also cover basic construction techniques related to attached solar greenhouse: structural loads, heat storage, glazing, shuttering and insulation. Also included will be information on how to use your greenhouse growing space effectively. By the end of the course, class members will know how to design, construct and operate their own greenhouses.

The class will be taught by Randy Eveleigh, Energy House coordinator, Thom Peterson, Solar Course Instructor at LCC, Tom Young, Instructor in Human Environment and Design at MSU and other local experts.

The class will meet Tuesdays from 7:30 to 9:30 pm for lectures and on five Saturday from 9 am to 4 pm for "hands on" construction of the Energy House soalr greenhouse.

Tuition is 35 dollars which includes membership in Urban Options. To register, call or stop by Urban Options Energy House, 351-3757. The deadline is July 21.

Individual greenhouse construction workshops will be open to the public. There is a five dollar workshop fee, adjusted to the ability to pay.

The Energy House Solar Greenhouse Porject is funded by a grant from the Department of Energy's Midwest Appropriate Technology Program.

Urban Options slates workshop

Urban Options will conduct a solar greenhouse design workshop at the Energy House, 135 Linden St., Saturday at 9 a.m.

Principles of passive solar design will be taught, with special emphasis on how solar greenhouses can be effective heat producers in Michigan's northern climate.

Urban Options plans to construct a solar greenhouse on the Energy House with a $10,000 federal grant received from the Department of Energy.

The greenhouse will be built in July during public workshops designed to give participants experience they can use in building their own greenhouses.

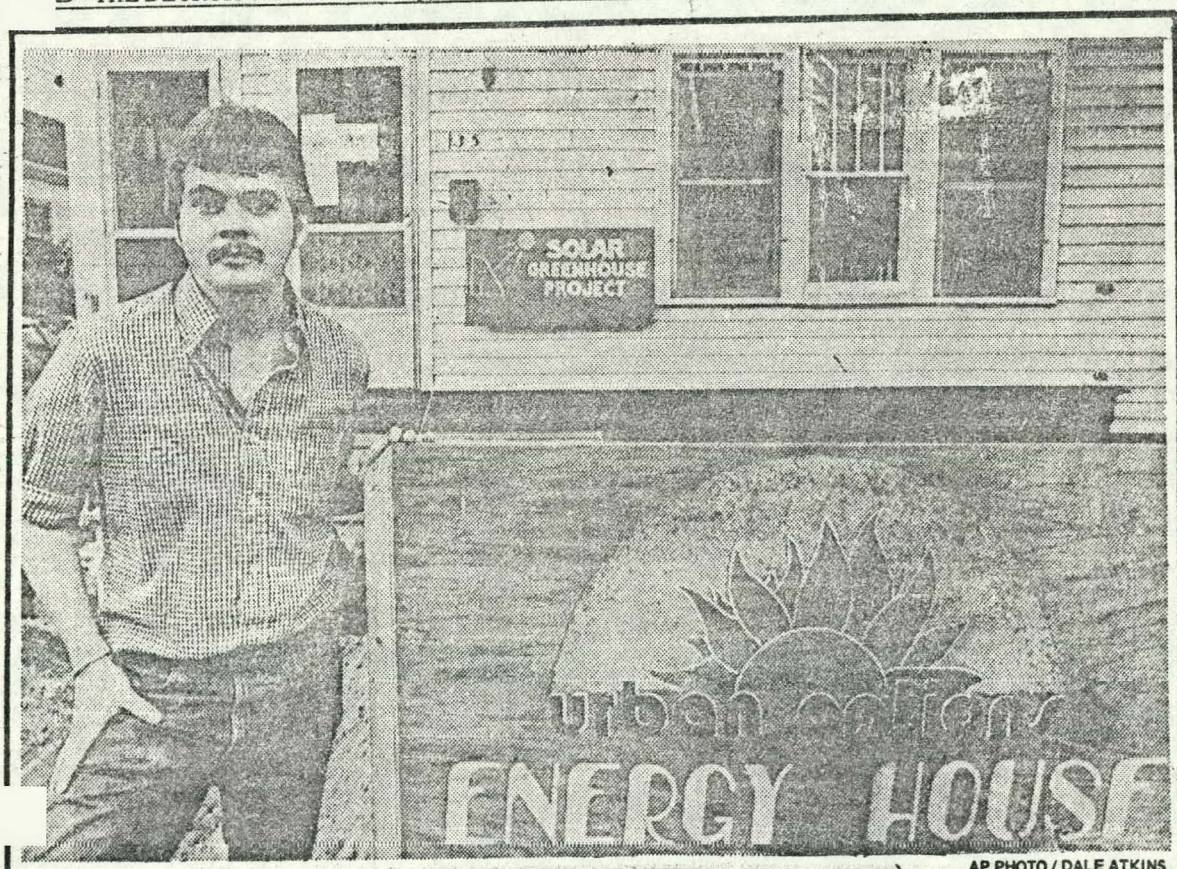
The grant money was part of $1.3 million awarded to 63 individuals and groups through the 1978 Midwest Appropriate Technology Program.

The design for the energy house greenhouse will be used as a model for the discussion.

The film "Build Your Greenhouse Solar Style" will also be shown.

There is a $5 workshop fee for nonmembers

STATE NEWS 6-29-79



AP PHOTO / DALE ATKINS

SUN SPOT — Mike Ryan poses outside the East Lansing solar-energy house he and three other persons are working on. The project is one of 10 which has been awarded federal funds as a means of encouraging the use of local material and talent to solve energy problems.

Dual purpose for sun catcher

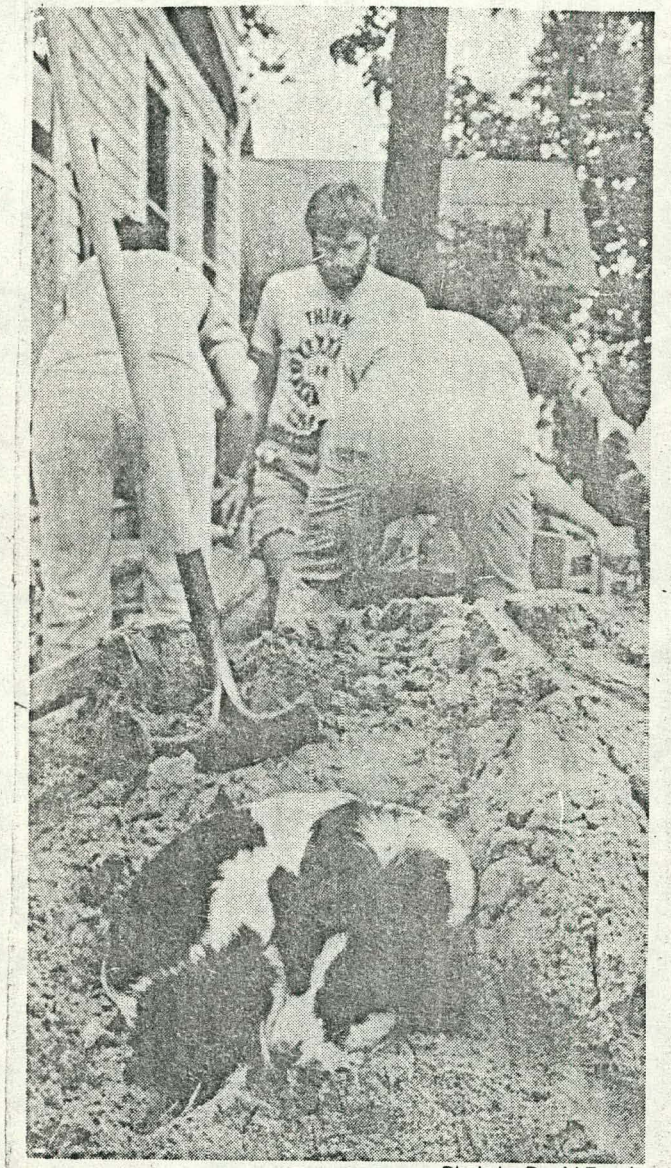


Photo by David Frank

Only the dog got a break at Saturday's solar greenhouse workshop

By DEBRA FURR

The term "solar greenhouse" may seem redundant. After all, most greenhouses use the sun to grow the greenery.

But growing plants is only half the purpose of one solar greenhouse being built in East Lansing. Its will also collect and store the heat energy of the sun.

The greenhouse will take shape over the next few weeks at the Urban Options "energy house" at 135 Linden. The project's construction crew is made up of the members of an eight-week workshop.

Urban Options moved into the city-owned house last fall. City council agreed to let the non-profit group use the house to offer energy conservation workshops to local residents.

Basic weatherization workshops started in November, giving "hands-on" experience in caulking, weatherstripping and insulation. "We've caulked and weatherstripped about two-thirds of the house. And we have about two-thirds of the building insulated too," said Randy Eveleigh, energy house coordinator.

With completion of the greenhouse in September, the group hopes to cut this winter's energy consumption to half of last year's total, Eveleigh said. They hope to get about 30 percent of their heat from the greenhouse.

The greenhouse's glass panels will cover the front of the house, which faces south. The enclosed space will act as a solar energy collector Sunlight will warm the air inside the greenhouse. Containers of water and the concrete floor will store the heat.

As the air cools at night, the stored heat will radiate from the greenhouse can be drawn into the house by fans or vents. In the summer, the greenhouse can help cool the house. Vents can be opened to pull air out of the building through the "chimney effect" of warm air rising.

The greenhouse is being funded through a $10,000 U.S. Energy Department grant Urban Options recently received. Materials donated by local businesses will also be used, Eveleigh said.

The group was a little surprised by the response to the greenhouse workshops, he said. The workshop class has 20 members now, five more than the planned maximum. "We could have filled the course two or three times with the response we got," Eveleigh said.

Class members attend lecture sessions on Tuesday evenings to learn the principles of passive solar design. At Saturday work sessions, the members will learn how to apply these principles, from pouring the foundation to glazing the windows in place.

The house is open to visitors from 9 a.m. to 5 p.m. on weekdays. "We used to average about four people a week. Now it's about four people a day," Eveleigh said.

Visitors can see displays of improvements already made on the house. Next to each display is a sign listing the R-value (its resistance to heat conduction), the materials used and their approximate cost.

Another display shows three different kinds of insulation behind a plastic see-through panel. The effects of time and gravity on the insulation can be observed. Insulated shutters in two styles are on display.

Urban Options is working to make the house accessible to handicappers. A ramp to the front door is planned as part of the greenhouse construction.

The group will continue to offer weatherization and solar retrofitting workshops this fall and winter. Members will also be teaching free workshops in certain neighborhoods through federal community development funds. "We want to do more outreach work than last year," Eveleigh said.

Urban Options has also begun a glass recycling program. "We're doing really well on the recycling. We take the glass to Charlotte every couple of weeks," Eveleigh said. One and one-half tons of glass were recycled in May and June.

TOWNE COURIER

Aug. 13, 1979

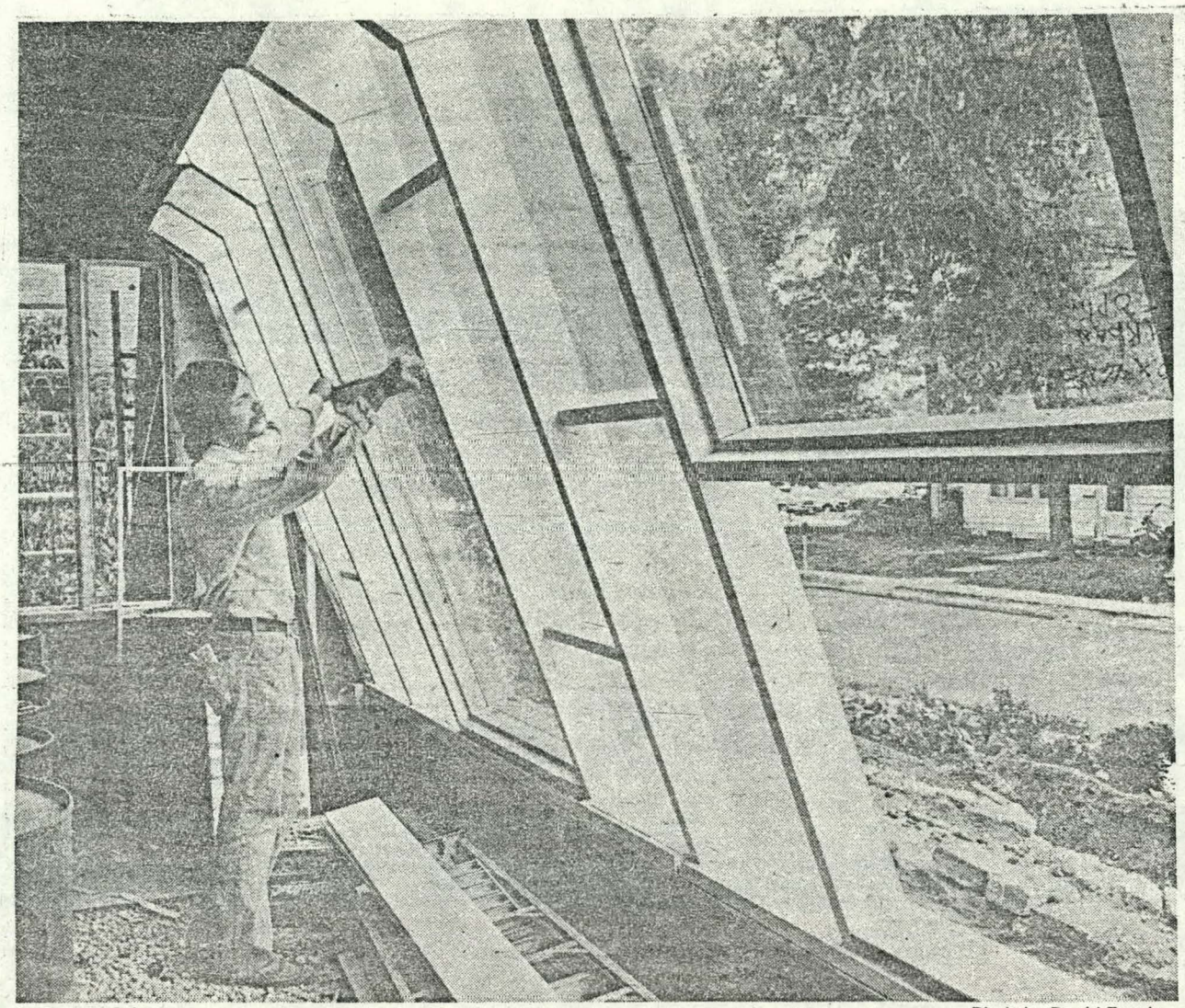


Photo by David Frank

The Urban Options "solar greenhouse" has been steadily taking shape for months at the Energy House at 135 Linden St. in East Lansing. The greenhouse will serve two purposes – providing space for plants and trapping solar energy for heating. Above, Randy Eveleigh, the energy house coordinator, installs greenhouse windows. The greenhouse workshop class – whose members provided much of the labor – celebrated the structure's near-completion at a party last week.

Towne Courier 9-26-79

Editorial

TOWNE COURIER Aug. 1979

Group aids energy waste war

A productive war on energy waste is being waged in East Lansing at Urban Options which occupies an old wooden house at 135 Linden.

Urban Options has been showing residents how to win the energy conservation battle through basic home weatherization workshops. The group is to be commended for its efforts.

Classes are filled to capacity as neighbors study ways to preserve the environment while saving money on next winter's heating bills. "Hands on" experience in caulking and weatherstripping are the focus of some of the popular classes.

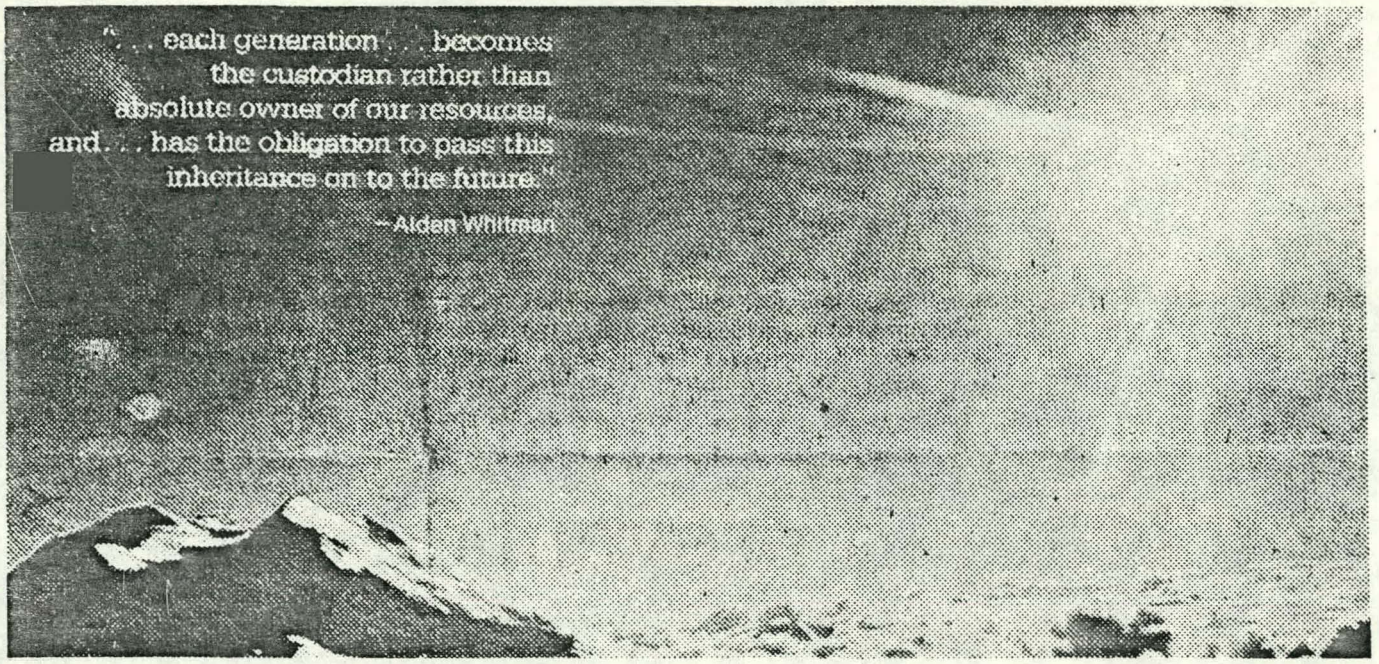
Urban Options will also offer free workshops this fall and winter in certain neighborhoods through federal community development funds.

The current project at Urban Options is construction of a solar greenhouse. In addition to functioning as a greenhouse, the structure will store heat energy from the sun. The group hopes to cut the Linden Street house's energy consumption to half of last year's total. The green house construction is being done by the members of an eight-week workshop on solar greenhouses.

The greenhouse is being funded with a $10,000 federal energy department grant. Local businesses are helping be donating materials.

Urban Options also runs a glass recycling program. It recycled 1.5 tons of glass in May and June.

A dedication to reducing energy consumption is the only way citizens will win this battle. Urban Options offers an example the rest of us may follow.



Exposition sheds more light on the many uses of energy

By JUDY CELMER
News Lifestyle Editor

MARQUETTE — Energy. The buzz word of the 70s. How to it, how not to use it. Ways to conserve. How to ıufacture it, control it, store it.

And on it went, booth after booth at Sunday's Energy Expostiion at Lakeview Arena here, sponsored by the Governor's Energy Awareness Advisory Committee.

Expo-goers were treated to new developments in the world of energy ranging from solar greenhouses to how to build your own sauna -- from more effective window insulation to dome houses.

"The whole idea of having an energy exposition was to make the public more generally aware," said Sandy Yonker, systems manager of the State Energy Exposition.

Energy awareness is taking its toll: "A lot has been happening in large cities —naturally, because they're population centers. But we wanted to get the word out in regional areas, so we're having a series of (more local) expositions. This is the first," she said.

Use of the sun to heat, store heat and light homes is gaining momentum as solar energy is cheaper and in some ways, more practical than electricity or gas.

Bob Dean of Marquette is setting out to utilize solar enegry to its fullest by building his own dome house which is expected to be completed by Christmas.

His insulation value, "about double what a normal house would be," combined with his unique placement of solar heat collectors ("...they are all on the roof, oriented from east to west instead of facing south like standard solar collectors,") will make his home 80 percent solar heated when completed.

His method requires a basement swimming pool. When the heat collectors on the roof reach a certain temperature, the ter from the pool is circulated through them. Then when temperature drops, the water goes back to the pool.

"Now the basement surface water is 80 degrees, for example," Dean said. The heat from the water rises into the air, which creates a vapor barrier. The heat rises above this vapor barrier and then circulates through the house.

"On a sunny cold day — say it's zero out — your solar collectorts still could easily heat up to 200 degrees.

"The problem is not with the temperature (outside) but with how much sun you get (in terms of hours)," he said.

SOLAR ENERGY IS also being tapped by a group of innovative builders in East Lansing who have constructed a Solar Greenhouse in the heart of that college town.

The greenhouse, attached to the front of the house, totals 210 square feet of floor area and 300 square feet of glass area. With windows facing south, it is designed to catch as much of the sun as possible, all year round.

"And it works!" said Randy Eveleigh, one of the builders and its representative at Sunday's exposition.

The advantages of a solar greenhouse? According to Eveleigh, food can be grown all year round in it, the greenhouse can help to heat the house (if attached), and if not attached, it acts as a self-heating unit.

Greenhouse collectors are large oil drums, painted flat black (to absorb more heat), and filled with water. The sun hits the drums in short wave radiation, is converted into long waves, and is stored in the drums. On cold or cloudy days the collectors release the heat and Voila! -heat for all!

Winter might pose a problem to the greenhouse if there are as number of cloudy days in succession. In this case, the heat will run out, "but if the plants start to freeze, we just open the vents to the house and let the house heat the plants," Eveleigh said.

People's homes can be made more heat-efficient by utulizing storm windows, or "replacing windows with insulated glass," said Dick Giebner of Gwinn. But he cautioned that, in the window case, two are better than one.

"Windows with regular glass and a storm window are beter than one pane of insulaed glass," he said. This is because "you have another seal, and you have a buffer zone (of air). Dead air space is your best insulator," he said.

NEXT ENERGY EXPOSITION will be the weekend of Oct. 5-7 to be held in Traverse City's Skate World Arena; the following weekend, Oct. 12-14, an Energy Expo will take place in Read Field House in Kalamazoo. Capping "Energy Awareness Week," Nov. 5-11, will be the finale of Energy Expos to be held in Detroit's Cobo Hall, Nov. 8-11.

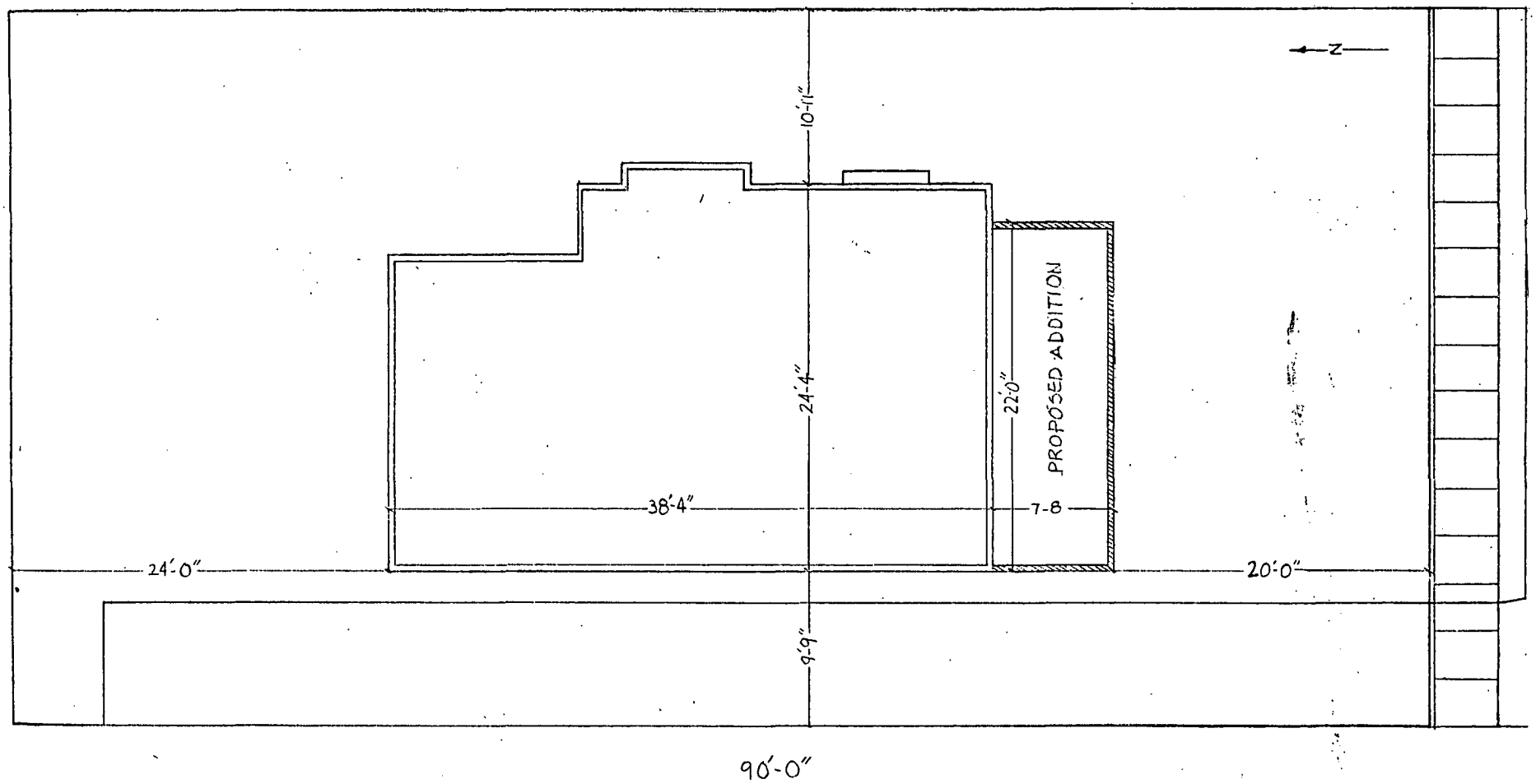
APPENDIX I

FINANCIAL STATEMENT

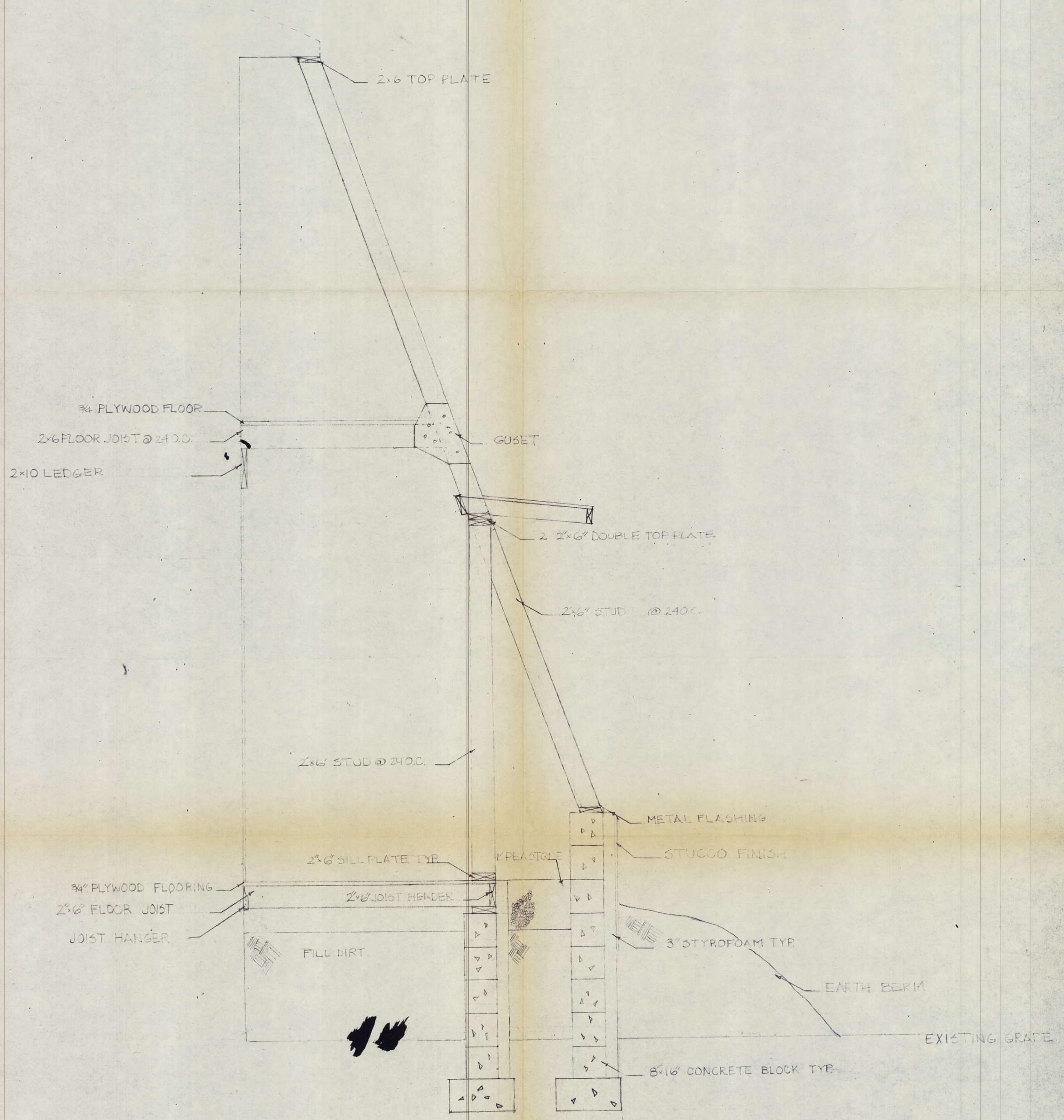
COST CATEGORY	DOE Share		Urban Options Match		TOTAL	
	Budget	Actual	Budget	Actual	Budget	Actual
RECEIPTS	$9,945.00	$8,950.00				
DISBURSEMENTS						
A. Personnel						
1. Horticulturalist (20 hrs./week)	5,000.00	5,000.00			5,000.00	5,000.00
2. Agricultural Task Force Coordinator (400 hrs. at $5.51/hr.)			2,500.00	2,060.00	2,500.00	2,060.00
3. Energy House Coordinator (660 hrs. at $5.51/hr.)			2,500.00	3,399.00	2,500.00	3,399.00
Total Personnel	$5,000.00	$5,000.00	$5,000.00	$5,459.00	$10,000.00	$10,459.00
B. Fringes						
1. FICA	327.00	-0-	305.00	-0-	632.00	-0-
2. Health Insurance	480.00	215.04	240.00	240.00	720.00	455.04
3. Workers Compensation	27.00	16.00	25.00	25.00	52.00	41.00
4. Liability Insurance	54.00	-0-	51.00	-0-	105.00	-0-
5. Life Insurance	41.00	12.00	20.00	20.00	61.00	32.00
Total Fringes	$929.00	$243.04	$641.00	$285.00	$1570.00	$528.04
C. Equipment						
1. Office	170.00	76.36			170.00	76.36
2. Greenhouse Monitoring/Supplies	194.00	379.18			194.00	379.18
Total Equipment	$364.00	$455.54			$364.00	$455.54
D. Consultant	$860.00	$860.00			$860.00	$860.00
E. Other Direct Costs						
1. Travel	90.00	50.40	90.00	90.00	180.00	140.40
2. Office Supplies	60.00	67.16	30.00	10.00	90.00	77.16
3. Postage	60.00	27.62	30.00	-0-	90.00	27.62
4. Telephone	60.00	33.63	30.00	30.00	90.00	63.63
5. Printing/Photocopying	325.00	332.90	-0-	-0-	325.00	332.90
6. Reference Library	150.00	118.70	-0-	-0-	150.00	118.70
7. Construction Materials	1,797.00	2,506.01	-0-	-0-	1,797.00	2,506.01
Total Other Direct Costs	$2,542.00	$3,136.42	$180.00	$130.00	$2,722.00	$3,266.42
F. Total Direct Costs	$9,695.00	$9,695.00	$5,821.00	$5,874.00	$15,516.00	$15,569.00
G. Indirect Costs: Bookkeeping	$250.00	$250.00			$250.00	$250.00
TOTAL DISBURSEMENTS	$9,945.00	$9,945.00	$5,821.00	$5,874.00	$15,766.00	$15,819.00

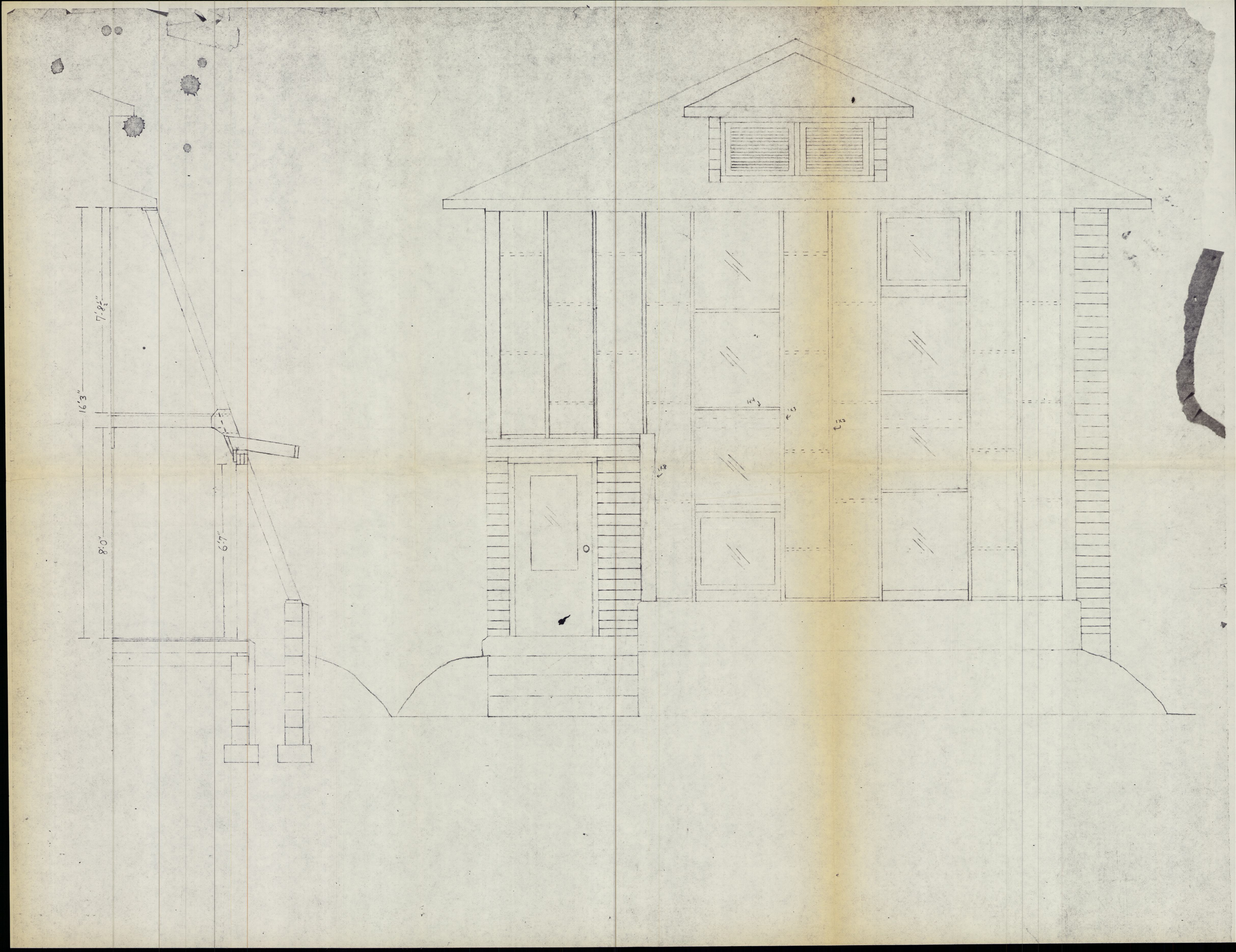
APPENDIX A

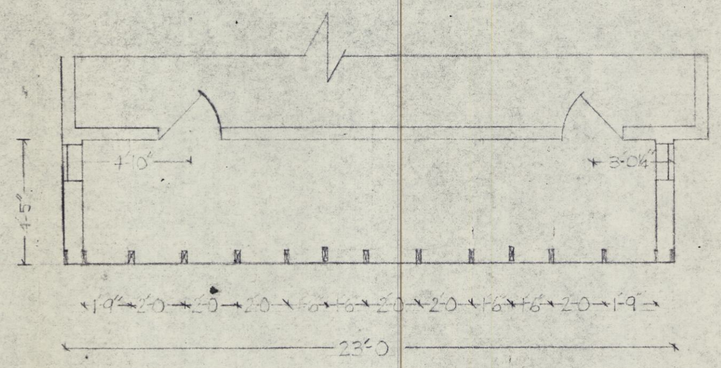
GREENHOUSE BLUEPRINTS



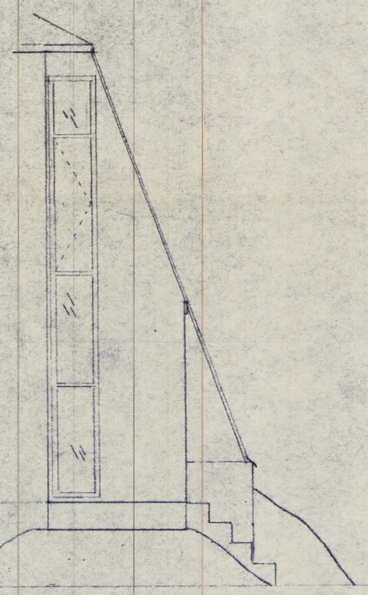
URBAN OPTIONS	6-28-79	PLOT PLAN
135 LINDEN ST.	1 OF 1	SCALE: 1"=10"
E. LANSING	DRAWN BY:	PEGGY GOODRICH


2x6 TOP PLATE
3/4 PLYWOOD FLOOR
2x6 FLOOR JOIST @ 24 O.C.
2x10 LEDGER
GUSET
2 2"x6" DOUBLE TOP PLATE
2"x6" STUD @ 24 O.C.
2x6" STUD @ 24 O.C.
METAL FLASHING
STUCCO FINISH
2"x6" SILL PLATE TYP.
1" PEASTONE
3/4" PLYWOOD FLOORING
2"x6" JOIST HEADER
2"x6" FLOOR JOIST
JOIST HANGER
FILL DIRT
3" STYROFOAM TYP.
EARTH BERM
EXISTING GRADE
8"x16" CONCRETE BLOCK TYP.

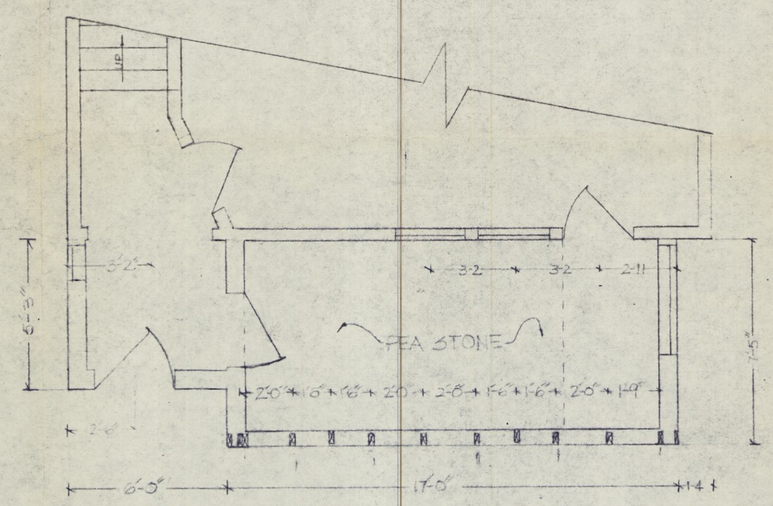

7'-8½"
16'3"
8'-0"
6'7"



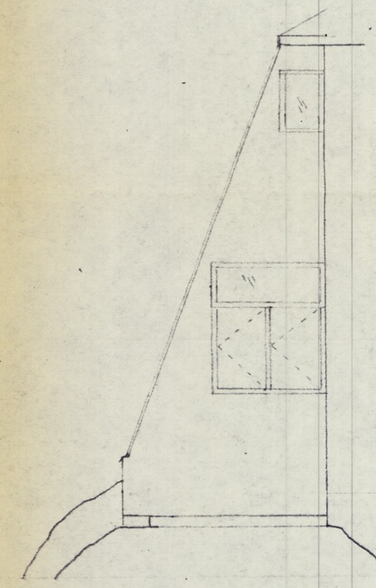
SECOND LEVEL FLOOR PLAN



WEST ELEVATION



FIRST LEVEL FLOOR PLAN



EAST ELEVATION

¼=1' SCALE

URBAN OPTIONS

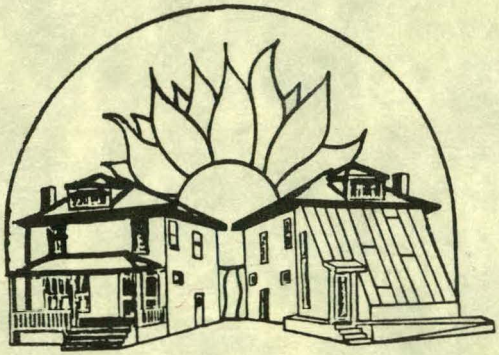
135 LINDEN ST.

DRAWN BY: PEGGY GOODRICH

URBAN OPTIONS

ANNUAL REPORT

FEBRUARY 1979 - MARCH 1980



Urban Options Logo

The Urban Options logo was designed by local artist and solar home owner, Tom Price. The logo features two houses, both the Energy House at 135 Linden.

The House on the left is the Energy House before being leased to Urban Options for use as an Energy Demonstration House. The House on the right is the Energy House transformed after a year - completely energy efficient with an attached solar greenhouse and handicapper ramp. Both these houses are under a prominent sun suggesting solar power now and for our future.

URBAN OPTIONS ANNUAL REPORT

FEBRUARY 1979 - MARCH 1980

Editor: Rosa Arenas
Design and Layout: Rosa Arenas
Photography: Randy Eveleigh, Ruelaine Stokes

Information in this report may be reproduced.

URBAN OPTIONS

ANNUAL REPORT

FEBRUARY 1979 - MARCH 1980

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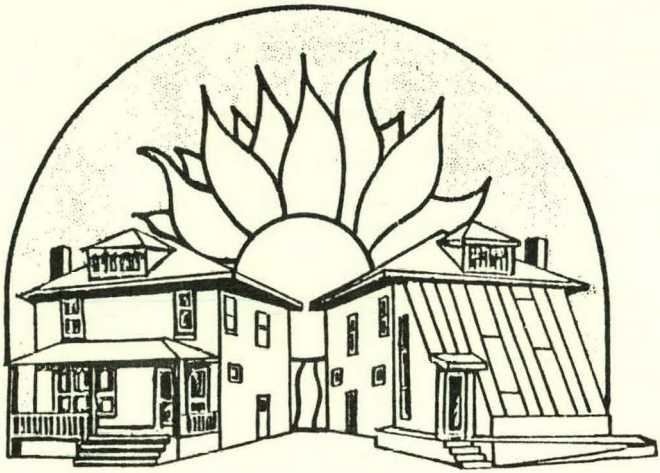


ABOUT URBAN OPTIONS

Urban Options is a non-profit group formed to provide information, intensive research and "hands on" experience in energy saving techniques. From our beginning in November, 1978 we have concentrated on demonstrating weatherization and solar technology to Ingham County residents in workshops based at the Energy House, 135 Linden Street, East Lansing. The City of East Lansing has leased the Energy House to Urban Options for use as a demonstration project.

Urban Options aims to bring energy conservation information to local residents in a form that is immediately understandable and will encourage people to implement what they learn in their own homes. "Hands on" workshops fulfill this function. In a typical workshop, participants take part in a lecture/discussion that gives a basic overview of the "hows and whys" of home energy conservation. Participants and workshop leaders then determine a general home weatherization "strategy". The "hands on" part of the workshops give participants a chance to practice specific weatherization techniques on the Energy House.

Workshops are also offered outside of the Energy House environment. Urban Options Community Development Program holds workshops in which people weatherize homes, apartment buildings and co-ops of East Lansing residents.

Urban Options six staff members are funded through the Ingham County CETA Program, the U.S. Department of Energy and the City of East Lansing Community Development Block Grants Program.

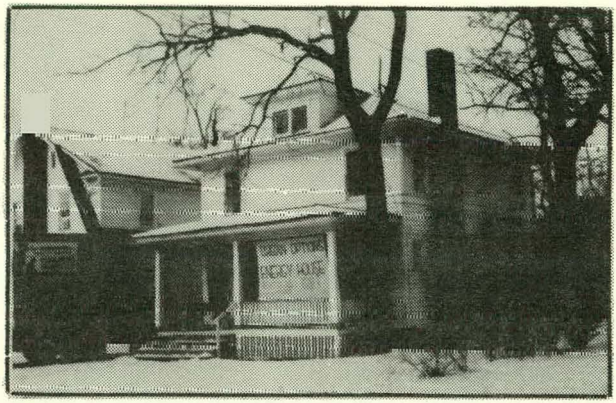
The Urban Options Board of Directors meets every other week to supervise on-going programs and devise new projects. A fund-raising committee is seeking money from grants and foundations for next year's programming.

The Urban Options Task Forces have been working on several different areas of research related to energy conservation and the appropriate use of technology on a city wide scale. Members of the community have been involved in research gathering at regular Task Force meetings held at the Energy House. Our goals are to use this research on Housing, Transportation, Water and Waste Management and Urban Agriculture to further community awareness and to present suggestions and recommendations to City Council and other governmental units.

The odd-looking structure attached to the front of the Energy House is a "Passive solar greenhouse". A passive solar structure stores heat from the sun with no mechanical assistance. We have estimated that the greenhouse will provide 30 percent of our winter heating needs as well as a fresh supply of vegetables. The greenhouse project is funded by a grant from the Department of Energy "Midwest Appropriate Technology" Program.

If you would like to become involved in Urban Options, become a member. Members receive the most "up to date" information on Energy House activities via the monthly "Energy House Newsletter". Members are also entitled to attend all Energy House workshops free of charge. Membership dues are $10.00/year ($5.00 for students).

The Energy House is open to the public, 9 a.m. - 5 p.m. weekdays and 10 a.m. to 2 p.m. Saturdays. For "energy information" phone, 351-3757.



THE ENERGY HOUSE DEMONSTRATION PROJECT

What is now the Urban Options Energy House on 135 Linden Street, was in 1978, a deteriorating City-owned house. Because of its wood-frame construction, typical of many houses in the area and its convenient central location and unobstructed southern exposure, the Urban Options Board asked the City for its use as an "Energy Demonstration House".

The Urban Options Board envisioned the Energy House as a place that could be used to involve the people of the Lansing area in learning practical energy saving and energy producing techniques that are effective in southern Michigan. At the Energy House people would be able to learn first hand weatherization and solar techniques by installing or constructing them in this model house environment. Urban Options Board members reasoned that people are more inclined to incorporate energy saving measures in their own houses once they become familiar with various techniques, have experimented and have seen how well they actually work.

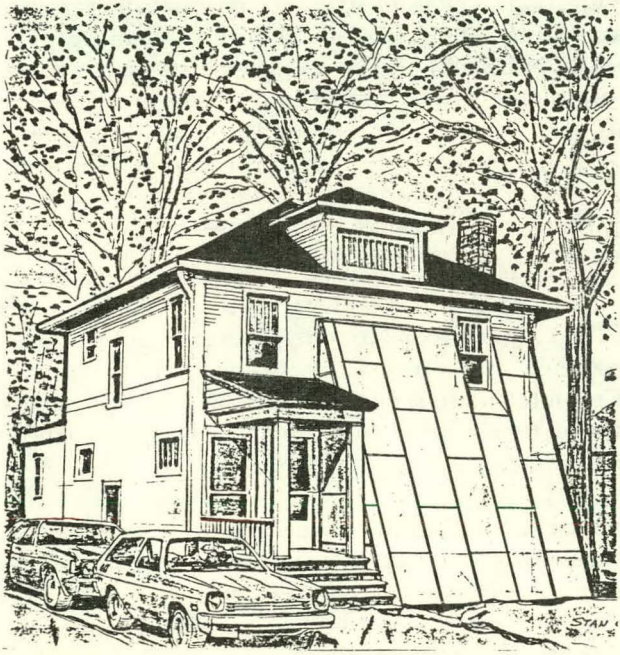
The Energy House retrofit process began in November 1978 after Urban Options received access from the City to the house on Linden Street. Workshops on basic weatherization, general insulation, window treatments and specific workshops on attic, wall, basement and water heater insulation were conducted from November 1978 - February 1979 with volunteers from the Board of Directors acting as Instructors.

Since February 1979, when Urban Options received CETA funding, Randy Eveleigh, the Energy House Coordinator, has conducted Energy House weatherization workshops and much of the actual retrofit work on the house.

From February 1979 - March 1980, sixteen workshops were held at the Energy House on topics ranging from basic weatherization and insulation to solar greenhouse design and construction, solar window box heaters, urban agriculture and handicapper accessibility. (See Participation Profile Chart, Appendix.)

Over $2,000 worth of materials for Energy House workshops and improvements to the house have been donated by area business people with an additional $800 purchased out of memberships, donations and workshop fees (See attached Financial Report, Appendix.)

In addition to "hands on" workshops, Urban Options has sponsored several comprehensive courses. The first was a "Solar Greenhouse Design and Construction" class conducted for eight weeks from July - September 1979. The course included lectures on passive solar design and solar greenhouse horticulture as well as construction workshops in which participants built the Urban Options Solar Greenhouse that is attached to the front of the Energy House. Funds for the solar greenhouse project were received from the Department of Energy Midwest Appropriate Technology Grants Program.



Artists conception of the Urban Options Energy House. Drawing by Stan Olejczak © 1978.

A five week "Retrofit" class held at the Energy House from January to February 1980 covered construction principles, weatherization and solar and wood heating.

A nine week course on "Solar Greenhouse Design" is now in process at the Energy House (April - June 1980). Participants are designing greenhouses for their own homes. At the end of the course, each participant will have produced a set of working drawings and will be ready to begin construction.

Urban Options Staff and Board members have also organized a series of special events at the Energy House including public lectures, films and slide shows. In January 1980, a lecture/slide show on Arcosanti, a solar community in Arizona, drew 60 people into the Energy House. 45 people came to see a Slide Show of Area Solar Homes that was shown in April 1980, and another fifteen people went on a Bicycle Tour of Solar Homes in the East Lansing area in celebration of Earth Day '80 (April 22). Several more special events are planned for the next few months including a film on "earth sheltered homes" and a lecture on New Alchemy projects. (New Alchemy is a Massachusetts appropriate technology group.) Local musicians, poets and dancers have donated their time at three Benefit Performances for Urban Options during the past year. The Benefits have raised spirits and generated much response and support from the Lansing community. The Energy House has been open three Sundays during the past year for Open House. Over 400 people have toured the Energy House during Open House, viewing the weatherization displays, the recyling center, outdoor gardens and the solar greenhouse.

The workshops, classes and special events have provided the Urban Options Staff and Board members with knowledge and experience unique to the Lansing area. Not only does this group of people possess well researched and tested knowledge of practical solar and weatherization techniques but they also have considerable experience in transmitting that information to people who come to the workshops, classes and events.

One colorful office wall of the Energy House attests to this accumulation of experience. A collage of posters advertizing workshops and events greets the visitor. The posters are designed by Rosa Arenas, Communications Director for the Energy House. Rosa also designs, edits and distributes the Energy House Newsletter and other publications.

Randy Eveleigh, Energy House Coordinator, compares caulking materials in a typical weatherization workshop at the Energy House.

The Energy House has generated much local interest, particularly after the addition of the Solar Greenhouse. The Staff and volunteers on duty at the Energy House receive at least ten phone calls a day requesting information. (See Survey of Information Requests, Appendix.) Since completion of the greenhouse, there is on the average 30 walk-in visitors per week. The staff also receives requests to visit individual homes and advise people on specific energy conservation measures and ways to use solar energy.

Groups touring the Energy House range from nursery schools through college and adult education classes. Students from Michigan State University and Lansing Community College have put in many volunteer hours working on the house, some of them for college credit. Student volunteers come from a wide range of fields including engineering, building and construction, landscape architecture, cartography and sociology.

Board and Staff members have delivered twenty lectures to groups outside the Energy House on topics including energy conservation, solar heating, appropriate technologies in cities and the Urban Options Project. These presentations have been to business and consumer groups, neighborhood organizations, university classes, public forums and professional conferences. Board members have travelled from Kentucky to Detroit and Alpena for such information sharing and outreach.

These various Energy House programs have reached several hundred people and based on workshop questionaires and follow ups, the programs have provided the kinds of sound and useful advise people want. Implementation of energy saving ideas offered has not yet been monitored but most participants indicate that they plan to use at least some of the suggestions soon after attending a program. Information on weatherization financing is an integral part of all presentations and one essential for implementation.

The performance of the Energy Demonstration House has been gratifying. Various conservation measures such as insulation, window shutters, and caulking were calculated to cut fuel consumption by 60%. The Solar Greenhouse was designed to provide 25-30% of the remaining heating needs. Based on rough data for energy consumption from the two years prior to the Urban Options Project and the monitoring system implemented in December 1979, average fuel consumption is down 65% from January to April 1980.

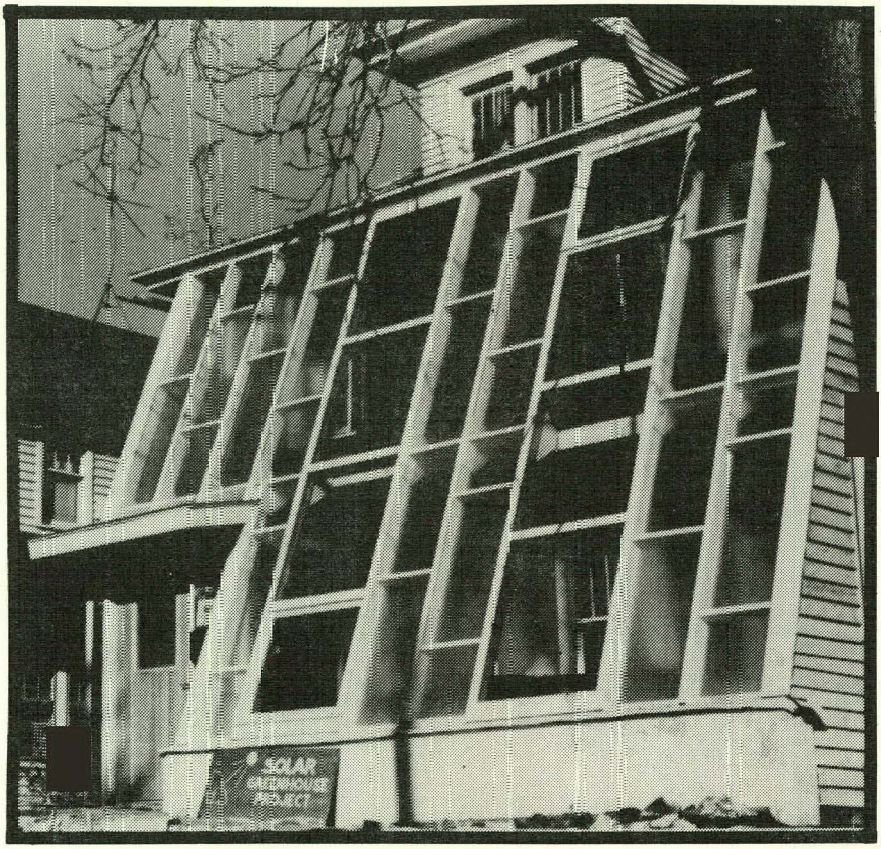
Sunny day fuel consumption is down approximately 78%. The "thermal flywheel effect" of heat retention from sunny through cloudy days is noticeable in collected data. More detailed data collection is a goal for the coming year.

Much of the basic weatherization work has been completed or will be in the next few months. Further projects to retrofit the Energy House will reconstruct the waste and water systems of the house to integrate the house with the city lot.

Another project planned for the coming year will improve the displays and educational opportunities available in the Energy House. Individuals and groups will be able to tour the Energy House and receive a pleasing and accurate synthesis of energy conservation and solar techniques. In addition, students and interests residents will be encouraged to use the extensive library on conservation and appropriate technology compiled at the Energy House.

The Urban Options Board and Staff hope the Energy House will be used as a basic training site for audit, weatherization and solar teams and as a center for specific referrals to local weatherization and solar products and services.

The Energy House is a very different place from what it was one and a half years ago. Much work has been accomplished and the education received during the retrofitting process places the Urban Options group in a qualified position to assist in local solutions to the energy crisis.



THE URBAN OPTIONS SOLAR GREENHOUSE

A part of the Urban Options vision was realized in the summer of 1979, when the U.S. Department of Energy announced approval for funding of a solar greenhouse grant proposal submitted in the fall of 1978. A two storey solar greenhouse soon rose in the place of the old front porch.

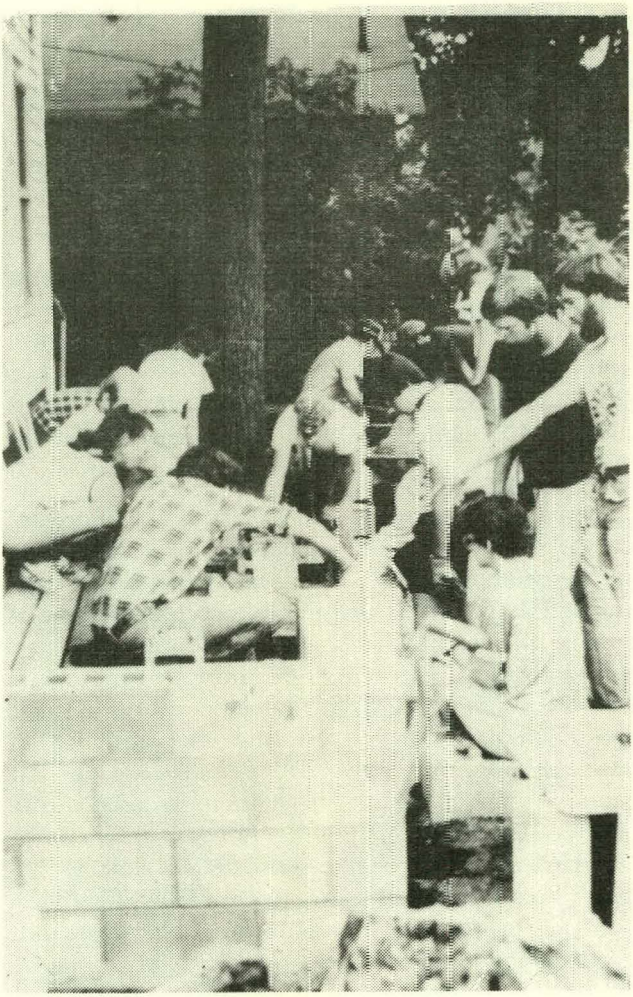
A design committee determined the final shape and structure of the greenhouse. The final drawings were completed by an interior design student intern and Urban Options staff. The solar greenhouse was built in workshops comprising an entire course on solar greenhouse construction at the Energy House. Twenty enthusiastic students demolished the porch, laid the footings and foundation, put up the framing and installed glazing while they learned the basics of solar greenhouse design, construction and operation. The interior finish work was completed by staff and board members and building construction, horticulture and engineering student volunteers from Michigan State University.

What is it like to have a solar greenhouse? Lori Cipparone, who plants and monitors the solar greenhouse under the D.O.E. grant, describes its operation:

> "The first storey of the greenhouse has been completed, and insulating curtains are being constructed by the Energy Saver's Co-op. A variety of cold-tolerant vegetables planted in February provided excellent salads and greens. Vegetables planted and harvested this winter included 10.8 pounds or 4933 grams per month of lettuce, kale, corn salad, mustard greens, Swiss chard and onions.
>
> There are flowering plants in the greenhouse also. Chrysanthymums grown from cuttings, tulips and hyacinths grown from bulbs and sweet violets, parsley, thyme and sage have all thrived in the greenhouse this spring. Among the vegetables are celery, cauliflower, squash, peppers, eggplants, cucumbers and four types of lettuce. From February to April, the air temperature in the greenhouse ranged between 32°F and 90°F and the soil and water temperatures never dropped below 45°F. This was a mild winter so insulating curtains were not essential. The second storey of the greenhouse is very narrow and performs well as a collector, a little too well for my comfort. The eutectic salt system is not fully installed. Peter Guins is continuing to research problems encountered with the installation. On sunny days, with the storage system not yet in working order, the temperature rises to a high of 125°F. The heat pours into my office, which reaches a tropical 80°F by early afternoon. This happens even when the temperatures outside dips below zero, which it did this winter."

The solar greenhouse has had a dramatic impact on the number of

visitors to the Energy House. People in the community are intrigued by this unusual structure, and many of them stop by just to look. Others come with specific questions on how to build their own greenhouses. For a great number of people, the Urban Options Solar Greenhouse Project is their first opportunity to experience solar energy at work.



Solar Greenhouse Construction Class.
Above: Foundation Workshop, August 1979.

Next page: Framing Workshop, August 1979.

THE PORTABLE GREENHOUSE AND FOUR ENERGY FAIRS

The opportunity to reach 147,000 people with information on solar greenhouses was provided in the fall of 1979 by the Governor's Energy Awareness Advisory Committee. The Committee offered to fund a Portable Solar Greenhouse Exhibit to be taken to four energy fairs held in different parts of Michigan. Although Urban Options was in the midst of working on its own greenhouse, the vision of the traveling greenhouse exhibit was compelling.

Lori Cipparone found volunteers to help with the construction of the Portable Greenhouse and staffing at the four fairs, which were held in Marquette, Traverse City, Kalamazoo and Detroit from September through November.

The Portable Greenhouse, which is modelled after an exhibit constructed by the Solar Sustenance Team in New Mexico, is actually a full-sized greenhouse that can be dismantled into five flat panels for transport in a pickup truck. Even more people will hear abut solar greenhouses this spring when the Portable Greenhouse will be exhibited at local energy programs and outdoor fairs.

Interior view of nearly completed Urban Options Greenhouse, 135 Linden Street, East Lansing. November 1979.

URBAN OPTIONS
TASK FORCES

BUILDINGS TASK FORCE

The Buildings Task Force, coordinated by Steve Ferns, working with other interested groups and individuals, has presented extensive testimony on energy and housing problems to the City of East Lansing in connection with the City's Comprehensive Plan revision process. The Task Force in continuing to work with various city committees to develop energy conscious Building, Housing and Zoning codes.

The Buildings Task Force has received a small grant from M.E.C.O.G. (Michigan Energy Conservation Group) to initiate and develop an Energy Information Service (E.I.S.). The E.I.S. would provide information on low cost energy conservation and alternatives to the public. The Service will include: general and "how to" instruction, information on standard prices and cost effectiveness of building materials, and referrals to area businesses offering energy related services. The E.I.S. will be staffed by volunteers and a back-up technical staff. Services will be provided to people by phone or on a walk-in basis.

Another job of the Buildings Task Force has been to review Michigan's Proposed Utility Residential Audit Program. Both general and technical testimony has been presented this spring to the Michigan Public Service Commission.

SOLID WASTE TASK FORCE

The Solid Waste Task Force, coordinated by Steve Ferns, has focused on solid waste issues surrounding recycling. In response to a decline in local recycling efforts, glass and newspaper recycling stations have been established at Urban Options Energy House and Hannah Middle School, respectively. Records have been kept indicating the types, amount and prices of recycled materials. In the small recycling centers beside the Energy House, one and a quarter tons of glass is recycled per month.

A survey of recycling center users is being designed by the Task Force. Results will help in determining area recycling attitudes and practices, and also provide a data base for demonstrating the practicality of recycling for small groups or local governments.

Testimony on recycling has been presented to Lansing and East Lansing City Councils and the East Lansing Comprehensive Plan Commission. Citizens groups such as the East Lansing Peace Center and Citizens for a Liveable Community have worked with the Solid Waste Task Force in planning and realization of recycling efforts.

A study of solid waste problems and prospects in Ingham County has also been initiated. This study is expected to provide insight on area needs and assist citizen input on solid waste planning in the State mandated planning process.

Issues surrounding a proposed "Solid Waste Authority" for the Lansing/East Lansing area have been researched. Educational materials and position statements on this issue have also been proposed. The Solid Waste Task Force is actively monitoring this issue as it develops.

TRANSPORTATION TASK FORCE

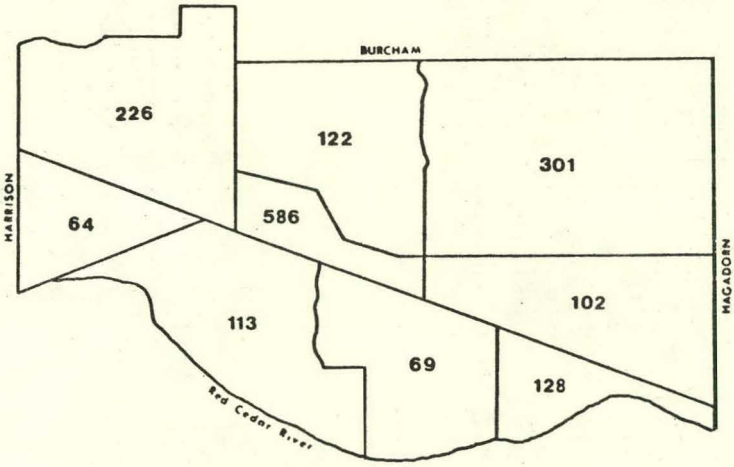
The Transportation Task Force, coordinated by Peter Guins, chose to concentrate its efforts on examining the East Lansing transportation system, recommending changes in the direction of improved energy efficiency.

The Task Force has worked to refine the transportation planning process so that the kinds of trips people need to take can be matched to the most appropriate ways of taking them. In view of the decreasing availability and increasing cost of fossil fuels, the Task Force feels that a model shift from automobiles to more energy efficient forms of transportation, primarily mass transit, bicycles and walking, is necessary.

The Task Force then decided to undertake a dual purpose study, which would expand the existing data base, and serve to demonstrate that such studies need not be costly or complex. In order to accomplish these goals they designed a survey consisting of only two questions which could be asked of drivers while they were stopped at traffic lights.

DAILY CAR TRIPS

WITHIN ZONES IN EAST LANSING



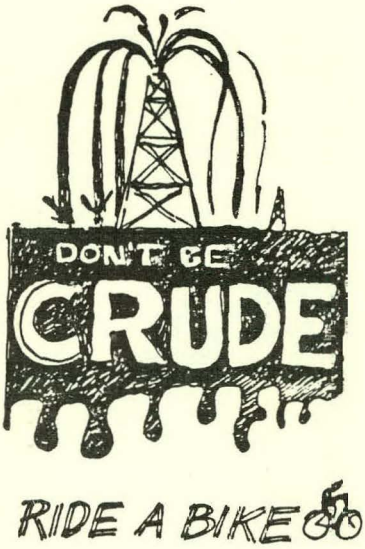
The questions were simply: "Where are you going?" and "Where are you coming from?". Answers to these questions are sufficient to determine the use pattern of a specific section of road.

The survey was carried out on Grand River in the Central Business District of East Lansing. The sample was broken down by trip length and compared to existing traffic volume data to determine the destination and number of trips taken daily. It was found that 33.3% or approximately 11,322 trips/day were made in the downtown East Lansing area that could have been more appropriately taken by bicycling or walking.

The survey results indicated that private auto use has been over emphasized in the area and that a shift to more energy efficient modes such as walking and bicycling would be both possible and practical.

The Task Force submitted a report detailing its findings and recommending specific additional research to the East Lansing Planning Commission and City Council in October, 1979.

In January 1980, the Transportation Task Force began development of a "Bicycle Use Promotion Program" and is currently seeking funds to implement the proposal. The Bicycle Use Promotion Program is designed to convince area residents that bicycling is a safe and convenient form of regular travel in East Lansing.



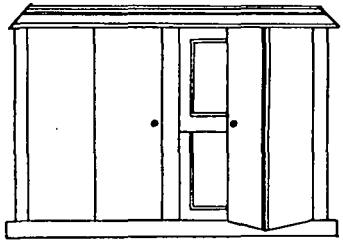
Poster sketches for "Bicycle Use Promotion Program". Designs by Tom Price © 1980.

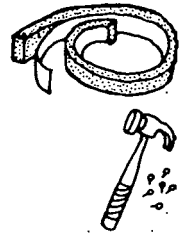
URBAN AGRICULTURE TASK FORCE

The Urban Agriculture Task Force, coordinated by Peter Guins, has concentrated on encouraging gardening in the city. The Task Force has become a coalition of community garden groups, community service agencies and interested residents.

The Task Force activities for the past year include: a survey of local community garden groups to determine problems encountered in establishing community gardens, the formation of a new "Food and Nutrition Program" at Capitol Area Community Services (CSA) and plans for two new solar greenhouses to serve the Greater Lansing Community.

During several workshops, the Urban Agriculture Task Force has begun transforming the Energy House lot on Linden Street into a model city lot where food production and recycling are encouraged. The front lawn is planted using French Intensive raised vegetable and flower beds. A compost and more vegetable beds are in the backyard. Further lot development and integration with the greenhouse and waste and water systems is part of a project proposal for next year.





COMMUNITY DEVELOPMENT WEATHERIZATION PROGRAM

In addition to the Energy House Workshops, Urban Options offers free weatherization workshops for low and moderate income residents. Urban Options Community Development Program is funded through the City of East Lansing's Community Development Block Grant Program. (H.U.D.) The C.D. Weatherization Program, coordinated by Ruelaine Stokes,provides instruction in home weatherization, energy conservation and practical applications of solar technology through a combination of lectures and "hands on" workshops in which participants weatherize homes in the community. Several members of Urban Options Board of Directors have taken active roles assisting with the program as part-time workshop instructors.

To date, twelve programs (which include a two hour class and construction workshop) have been conducted in the East Lansing area. Topics have included: weatherstripping and caulking, window repair, insulation, insulating shutters, water heater efficiency, furnace efficiency, and solar food dryer construction.

APPENDIX

FINANCIAL REPORT

URBAN OPTIONS
FINANCIAL SUMMARY
FEBRUARY 1, 1979 THROUGH MARCH 31, 1980

CASH IN BANK - START	-0-
RECEIPTS	
Grants	
CETA	50,507.00
D.O.E.	8,950.50
C.D.	7,881.66
Governor's Grant	1,767.60
MECOG	520.67
Total Grants	69,627.43
Other	
Loans	7,700.00
Memberships	770.00
Donations	733.57
Class Fees	700.00
Fundraising	605.75
Workshop Fees	212.00
Glass Recycling	98.47
Leaflet Sales	72.00
Honorariums	70.00
Energy audits & Solar Site	55.00
Total Other	11,016.79
TOTAL RECEIPTS	80,644.22

DISBURSEMENTS

Payroll	51,620.38
Construction Materials	2,788.68
Health Insurance	2,514.83
Travel	1,761.84
Instructors	1,761.44
Copying & Printing	1,476.60
Training	1,196.28
Equipment Rental	909.79
Matching FICA Tax	899.60
Loan Repayment	850.00
Worker Compensation	825.00
Office Supplies	765.97
House Remodeling	729.93
Weatherization Supplies	671.84
Office Equipment	655.70
Postage	606.01
Telephone	516.81
Bookkeeping	478.75
Workshop Supplies	374.75
Loan Interest	327.79
Greenhouse Equipment	294.53
Tools	250.60
Insulating Curtains	233.92
Loans	220.00
Fundraising	216.59
Life Insurance	173.90
Liability Insurance	172.00
Advertising	161.79
Artwork	120.00
Reference Library	118.70
Maintenance & Cleaning	113.56
Refreshments	105.20
Photography	73.27
Bonding	65.00
Publications & Subscriptions	34.49
Donations	25.00
Bank Fees	21.93
Sales Tax	20.35
Filing Fees	15.00
State Withholding Tax	(169.86)
Federal Withholding Tax	(570.10)
TOTAL DISBURSEMENTS	73,427.86
CASH IN BANK - END	7,216.36

URBAN OPTIONS
CETA
FINANCIAL SUMMARY
FEBRUARY 1, 1979 THROUGH MARCH 31, 1980

CASH IN BANK - START	-0-
RECEIPTS	
CETA	50,507.00
Loans	7,050.00
TOTAL RECEIPTS	57,557.00
DISBURSEMENTS	
Payroll	44,301.88
Advertising	136.80
Bank Fees	21.93
Copying	600.11
Equipment Rental	909.79
Equipment Purchase	579.34
Handtools	200.00
Health Insurance	2,261.68
Liability Insurance	172.00
Life Insurance	166.40
Office Supplies	347.13
Photography	73.27
Postage	497.43
Printing	385.76
Telephone	387.74
Training	1,018.78
Travel	726.97
Workers Compensation	805.75
Bookkeeping	478.75
Loan Repayment	850.00
Federal Withholding Tax	(455.60)
State Withholding Tax	(129.67)
Matching FICA Tax	899.60
Sales Tax	1.00
Bonding	65.00
TOTAL DISBURSEMENTS	55,301.84
CASH IN BANK - END	2,255.16

URBAN OPTIONS
NON-CETA
FINANCIAL SUMMARY
FEBRUARY 1, 1979 THROUGH MARCH 31, 1980

CASH IN BANK-START		-0-
RECEIPTS		
MECOG grant		520.67
Donations		733.57
Energy Audits & Solar Site		55.00
Fundraising		605.75
Governor's Grant		1,767.60
Honorariums		70.00
Leaflet Sales		72.00
Memberships		770.00
Glass Recycling		98.47
Workshop Fees		212.00
Class Fees		700.00
D.O.E. Reimbursement		634.02
TOTAL RECEIPTS		6,239.08
DISBURSEMENTS		
Loans To CETA Acct.		220.00
Class Instruction		265.00
Donations		25.00
Fundraising		216.59
House Remodeling		729.93
Loan Interest		327.79
Maintenance & Cleaning		113.56
Office supplies		171.51
Postage		13.70
Publications & Subscriptions		34.49
Printing		68.52
Refreshments		45.98
Sales Tax		19.35
Telephone		117.96
Tools		50.60
Workshop supplies		374.75
Governor's Grant:		1,785.97
Construction	489.79	
Office Supplies	31.09	
Postage	5.00	
Printing	83.76	
Travel	1,034.87	
Artwork	120.00	
Instructors	21.46	
Filing Fees		15.00
Advertising		24.99
D.O.E. Grant		821.17
TOTAL DISBURSEMENTS		5,441.86
CASH IN BANK - END		797.22

URBAN OPTIONS
DEPARTMENT OF ENERGY
FINANCIAL SUMMARY
AUGUST 1, 1979 THROUGH MARCH 31, 1980

CASH IN BANK - START	-0-
RECEIPTS	
Grant	8,950.50
Loans	650.00
TOTAL RECEIPTS	9,600.50
DISBURSEMENTS	
Payroll	3,193.84
Federal Withholding Tax	(47.60)
State Withholding Tax	(18.72)
Matching FICA Tax	-0-
Health Insurance	83.68
Worker Compensation	8.50
Office Equipment	76.36
Greenhouse Equipment	294.53
Telephone	11.11
Office Supplies	61.51
Postage	22.38
Printing	90.07
Reference Library	118.70
Construction Materials	2,111.74
Training	177.50
Insulating Curtains	233.92
TOTAL DISBURSEMENTS	6,417.52
CASH IN BANK - END	3,182.98

URBAN OPTIONS
COMMUNITY DEVELOPMENT
FINANCIAL SUMMARY
AUGUST 1, 1979 THROUGH MARCH 31, 1980

CASH IN BANK- START	-0-
RECEIPTS	
Grant	7,881.66
TOTAL RECEIPTS	7,881.66
DISBURSEMENTS	
Payroll	4,124.66
Health Insurance	169.47
Life Insurance	7.50
Worker Compensation	10.75
Instructors	1,474.98
Printing & Copying	248.38
Weatherization Supplies	671.84
Postage	67.50
Office Supplies	154.73
Refreshments	59.22
Federal Withholding Tax	(66.90)
State Withholding Tax	(21.47)
TOTAL DISBURSEMENTS	6,900.66
CASH IN BANK - END	981.00

DONATED MATERIALS as of February, 1980

Company	Value		Materials used on Greenhouse
Aaro Rentals	61.46		
All-Phase Electric (est.)	16.00		16.00
Applegate	259.84		
Bollerts	19.98		
Calkins Paint (est.)	18.00		
Capitol City Lumber	99.96		
Central Mich. Lumber	150.00		50.00
Clawson Floors (est.)	18.00		
Glaser's Lumber	50.00		50.00
Hager Fox	534.54		
Haslett Lumber	55.00		
Hazen Lumber	53.15		
Insulation Specialists (est.)	5.85		
Lansing Lumber	3.95		
Martin Block (est.)	144.90		144.90
Meijer Inc.	10.00		
Roary Corp.	250.00	(cash donation to Non-CETA acct.)	
Robert Eveleigh (est.)	166.70		166.70
Robert's Wallpaper & Paint	42.10		
Silver Lead Paint	24.20		
Sunfire Shop (book)	8.95		
Westphalia Builder's Supply	42.96		
Wickes Lumber	78.67		
TOTALS	2114.27		427.60

GREENHOUSE COST:

donated materials	427.60
NON-CETA Urb-Op money	141.00
D.O.E. grant	2106.01
TOTAL	2674.61
total Square Footage	÷262.5
Cost per square foot	10.19

DONORS

Company	City
Aaro	Lansing
All-Phase Electric	Lansing
Applegate	Okemos
Bollerts	Lansing
Calkins Paint	Lansing
Capitol City Lumber	Lansing
Central Mich. Lumber	St. Johns
Clawson Floors	Lansing
Glaser's Lumber	Lansing
Hagar Fox	Lansing
Haslett	Haslett
Hazen	Lansing
Insulation Specialists	Lansing
Lansing Lumber	Holt
Martin Block	Lansing
Meijer, Inc.	Lansing
Roary Corp.	Lansing
Robert Eveleigh	Lansing
Robert's Wallpaper & Paint	Lansing
Silver Lead Paint	Lansing
Sunfire Shop	Mason
Westphalia Builder's Supply	Lansing
Wickes Lumber	Mason

URBAN OPTIONS STAFF

CETA (full time):

Rosa Arenas	**Communications Coordinator** - Publications, Publicity
Randy Eveleigh	**Energy House Coordinator** - Design of Energy House "Retrofit", Class and Workshop Leader
Steve Ferns	**Task Force Coordinator** - Leader of Waste and Water Management, Buildings Task Forces
Peter Guins	**Task Force Coordinator** - Leader of Transportation and Urban Agriculture Task Forces

DOE (half time)

Lori Cipparone	**Horticulturalist and Greenhouse Manager** - Planting and Monitoring Greenhouse Performance

CD (half time):

Ruelaine Stokes	**Community Development Workshop Coordinator** - Plans and Conducts Workshops in CD target areas

URBAN OPTIONS OFFICERS

PRESIDENT:	Anabel Dwyer
TREASURER:	Charles Ipcar
SECRETARY:	Jane Wilcox

URBAN OPTIONS BOARD OF DIRECTORS

Board Member	**Resource Areas**
Rosa Arenas	Communications Coordinator, Editor, Graphic Design, Public Relations
Steve Brede	Carpentry and Solar Design
Lori Cipparone	Solar Greenhouse Horticulturalist
Anabel Dwyer	Urban Planning and Community Organization
David Dwyer	MSU Assistant Professor, Anthropology and African Studies
Tom Edens	MSU Faculty Member in Resource Development and Agicultural Economics, Coordinator of Energy Impact Grant with the State of MI

Board of Directors (continued)

Randy Eveleigh	Energy House Coordinator, Carpentry & Insulation
Steve Ferns	Buildings and Solid Waste Task Force Coordinator
Marian Frane	Bookkeeper, Community Organizer
Cynthia Fridgen	Community Development
Joe Fridgen	Energy & Recreation Research
Peter Guins	Carpenter & Urban Argiculture Task Force Coordinator
Craig Harris	PHD Sociology, co-director, Project Conserve.
Charles Ipcar	Mortgage Redlining, NSF Research Resident, Housing Co-op Member
Guy Kerr	Licensed Builder, Owner-Builder of Solar House, Solar Design & Arcosanti* Volunteer Coordinator
John Melcher	Carpentry & Workshop Instructor
Thom Peterson	LCC Faculty Member in Applied Arts & Sciences, Instructor in Energy Related Courses, Insulation Specialist
Tom Price	Carpentry, Owner/Retrofitter of Solar Heated Home, Volunteer Coordinator for Arcosanti*, Community Designer, Freelance Artist
Dave Roitman	Program design and evaluation, PHD Candidate, Ecological Psychology
Susan Roitman	Energy Audits, Communications, Graphics
Bert Seyfarth	Registered Architect, Designer & Builder of Solar Heated Houses
Ruelaine Stokes	East Lansing CD Weatherization Workshop Coordinator
Michael Thomas	Building Construction, MSU undergraduate
Jane Wilcox	Adult Education Teacher, Laborer & Communications, Energy Savers Co-op
Thomas E. Young	Sculptor, Solar home builder, Landscape Architect

* Arcosanti refers to a solar designed urban environment being created in Arizona

SURVEY OF INFORMATION REQUESTS

Information requests made by the general public to Urban Options Energy House were monitored for the months of December 1979 and January 1980. Requests were categorized by subject, intent, and mode of contact. Additional information on how the person had heard of Urban Options, and their name and address, was requested as well.

Of the 78 inquiries that were recorded, the top six interest areas were as follows:

Greenhouse	15.45%
Weatherization	13.8%
Insulation	10.8%
Solar/Passive	10.0%
Recycling	7.7%
Insulated Shutters	6.2%

From the discussion with the inquirer, the staff member filled out for each interest area the "intent" or reason that each person called. Catagories of intent, together with the percentage of response in each catagory follow.

How-to info	36.8%
Why do it info	11.7%
Where to get it	16.45%
How much does it cost	6.4%
When or where does it happen	8.8%
What is happening	11.1%
Other	8.8%

The mode of contact was evenly divided between walk and phone-in requests. People heard about Urban Options primarily through word of mouth (41.7%) and referrals from other agencies (20.7%). Newspaper stories and advertisements (10.4%) were also significant sources of contact.

PARTICIPATION PROFILE CHART

GEOGRAPHIC DISTRIBUTION				
activity & numbers	percentages			
	Lansing	E. Lansing	Local Area	Out State
Workshop Participants 120	42%	36%	20%	2%
CD Workshop Participants 115	7%	90%	3%	—
1st Greenhouse Workshop 33	33.3%	33.3%	30.3%	3%
Greenhouse Class 18	50%	33%	17%	—
Retrofit Class 8	37%	63%	—	—
Members 121	28%	45%	20%	7%
Board of Directors 23	34.8%	56.5%	8.7%	—
Open Houses approx. 200	addresses not filed			

URBAN OPTIONS PUBLICATIONS AVAILABLE

Energy House Newsletter, Published monthly. Free with membership. Write for subscription information.

Hot Water From the Sun by Ruth Weitzel. A guide to solar hot water heaters. Published with the assistance of the Michigan Solar Energy Association (MSEA). 75¢

Solar Greenhouse Horticulture by Lori Cipparone. Everything you need to know from essential plant requirements to soil pasteurization to pest control. 50¢

Solar Greenhouses in Michigan by Robbi Austen and Lori Cipparone. An introduction to solar greenhouse design considerations with a comprehensive bibliography of solar books. Printed by Department of Agricultural Engineering, M.S.U. Distributed free of charge by Urban Options. Send S.A.S.E.

Transportation Task Force Report by Peter Guins. 50¢

Urban Options Annual Report, Feb. 1979 - March 1980. 50¢

Urban Options Brochure Send S.A.S.E.

Water and Waste Task Force Report by Mike Ryan 50¢

OTHER MATERIALS

Urban Options Slide Show Documentary on Urban Options, includes Energy House displays, workshops, solar greenhouse construction and a solar hot water heater workshop sponsored by MSEA (May 1980). $5.00 Rental $10.00 Purchase

Urban Options T-Shirt, Three color, silk-screened with Urban Options logo. $5.00 plus 50¢ handling

Send S.A.S.E.

Urban Options presents plan for public EL 'energy house'

By EDITH STARZYK

A house now owned by the city of East Lansing would become an "energy house," under a proposal submitted to City Council by Urban Options, a non-profit corporation.

If council approves the proposal, the house will be made energy efficient and opened to the public as a demonstration center. Remodeling would include installation of insulation, storm windows and doors, and

'HANDS-ON' WORKSHOPS

Weatherization taught

By ANNA BROWNE
State News Staff Writer

repair and refurbish anything that has deteriorated or been damaged."

Model insulation project viewed

5-B THE STATE JOURNAL Thurs., May 3, 1979

This house displays frugal use of energy at hand

East Lansing's Urban Options group shows way to live midst crisis

Urban Options Energy House is open for public tours Sunday

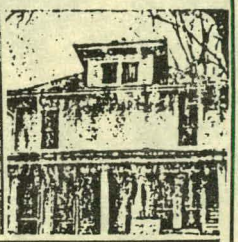
Urban Options will hold an informational open house from 1 to 5 p.m. Sunday at the Energy Demonstration House, 135 Linden St.

Tours of the Energy House will be conducted by Urban Options staff.

Past workshop projects on

NOTEBOOK

Solar greenhouse construction class offered



Editorial

Group aids energy waste war

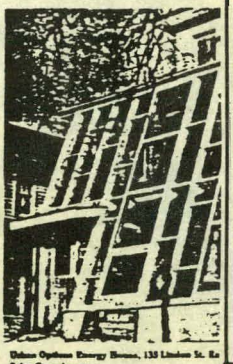
Other Voices:

East Lansing Organization Takes on Energy Issues

By Ron Arcuna
Urban Options

Urban Options is a non-profit group formed to provide information, innovative research and "hands on" experience in energy saving techniques. From our beginning in November, 1978 we have concentrated on demonstrating weatherization and solar technology to Ingham County residents in workshops based at the Energy House, 135 Linden Street, East Lansing. The Energy House is city-owned and donated to Urban Options for use as an energy demonstration project.

Urban Options aims to bring energy conservation information to local residents in a form that is immediately understandable and will encourage people to



Urban Options Energy House, 135 Linden St. Its Solar Greenhouse.

Solar energy seminar tonight

By DAVE VARGA
State News Staff Writer

Urban Options, a community energy conservation group, is sponsoring a free solar hot water seminar at 7 tonight in the East Lansing Public Library, in cooperation with its "hands on" workshops Saturday and Sunday.

The free seminar will present design considerations and an overview of solar hot water systems along with state and federal regulations for tax credits.

The workshops will be in the Energy House, 136 Linden St. beginning at 9 a.m. Saturday and 11 a.m. Sunday. These workshops will be free fee to a grant from the Michigan Solar Energy Association.

Workshops will give people a chance to build a thermosphoning solar hot water system at the Energy House. Covered in the workshop will be collector plate assembly, piping installation and system operation.

PEOPLE INTERESTED IN attending the workshops should register early as space is limited to about 10 persons each day.

The solar hot water system will be constructed on the second floor of the house, said Randy Brodnigh of Urban Options.

Urban Options moved into the city-owned Energy House about one and one-half years ago.

Displays have been set up at the house to show the usefulness of such energy conservation items as insulated shutters, solar curtains and wall insulation. These conservation options have been subjects of past workshops.

Energy House is distinguished by solar panels which adorn its front.

A SOLAR GREENHOUSE was built about a year ago for growing plants and space heating of the house during a series of workshops.

A Department of Energy grant of $10,000 paid for materials and a full-time staff employee during construction of the greenhouse on page 10

For a complete Press Packet, write: Urban Options, 135 Linden St., East Lansing, MI 48823 or phone (517) 351-3757.

Agricultural Engineering
Michigan State University

INFORMATION SERIES

aeis no. 408
file no. 18.8
date 1/80

ATTACHED SOLAR GREENHOUSES IN MICHIGAN

A well-designed solar greenhouse can save on the fuel cost for a conventional greenhouse, depending upon the flowers and vegetables grown, the amount of supplemental heat and light needed, and the months operated.

Although solar greenhouses function well in many climates, efficiency varies at each site. In Michigan, solar greenhouses can provide supplemental home heating in spring and fall and on sunny winter days. The growing season for fresh vegetables and flowers can be extended by several months even if the greenhouse receives no additional heat.

Specific features distinguish the solar greenhouse, designed with the local climate in mind, from a conventional greenhouse. First, the solar greenhouse is always oriented along the southern exposure to maximize energy collection from the sun. Second, thermal storage is incorporated into the design of the north wall. Dark-colored containers filled with water or massive masonry walls store excess heat.

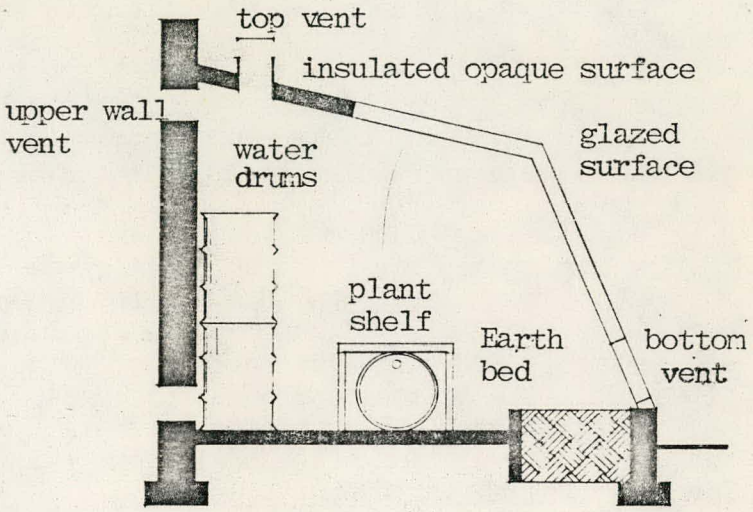


Figure 1. Components of an attached solar greenhouse.

In Michigan, insulating the north wall and parts of the east and west walls helps minimize heat loss during cold months. The rest of the greenhouse is covered with two layers of transparent or translucent glazing (glass, plastic, or fiberglass), and insulated with movable curtains or shutters. During summer, to prevent overheating, high and low vents pull cool air through the greenhouse, while part of the roof is thermal storage units from the sun overhead (Figure 1). Finally, some plants can be grown in beds at ground level, reducing fluctuations in soil temperature and moisture. However, pots or other containers make soil and container sterilization easier for the home owner.

By Robbi Austin and Lori Cipparone, Ingham County Energy Office and Greg Heilman, Claudia Myers and Bill Stout, Agricultural Engineering Department, Michigan State University, January, 1980.

All diagrams used with permission of the Solar Sustenance Team, Santa Fe, New Mexico.

Types of Solar Greenhouses

Solar greenhouse designs can be altered to fit a particular site. Solar greenhouses can be attached to the dwelling or community building or built separately. Attaching the greenhouse to the building's south side is preferred because: 1) it costs less to build; 2) no heat escapes through the north wall of the greenhouse; and 3) it supplies heat to the house and reduces heat loss through the south wall of the house. When a porch is attached to the south side of the house, an inexpensive greenhouse can be built simply by enclosing the porch and adding heat storage. Skylights may be needed in the front part of the ceiling so that light can penetrate the porch rear in the winter.

Where there is land available but no building with a convenient southern exposure, a freestanding greenhouse is the next best choice. This is usually more expensive to build, because the north wall of the greenhouse must be heavily insulated to prevent heat loss. During colonial times in New England a freestanding pit greenhouse was popular. A pit is dug into the ground or hillside and the glass or other glazing material installed facing south. A proper drainage system is important. A pit greenhouse retains heat well, especially in areas where the frostline is not excessively deep, because ground temperatures below the frostline are fairly constant, warmer than the outside air in the winter and much cooler in the summer.

Solar greenhouses can be built with or without night insulation, that is, shutters or curtains that can be pulled over the glazed area at night or heavily overcast days to prevent heat loss (Figure 2). A greenhouse without night insulation is simpler to design, costs less, and requires less attention on the owner's part. However, in Michigan, the greenhouse will not be usable for growing plants during the winter without supplementary heat and/or insulating curtains.

Devoted greenhouse gardeners who want to see green year-round should include shutters or curtains in the design from the beginning, especially if automatic controls are desired. Night insulation is most effective if it is sealed around the edges, so that air currents cannot circulate between the insulation and the glazing. The most challenging aspect of solar greenhouse design is devising some type of night insulation. Some systems have insulating panels that are locked into place in the evening, or curtains made of several layers of insulating material. Others utilize more complicated mechanical devices such as the bead wall where a small fan blows styrofoam beads between panes of glass.

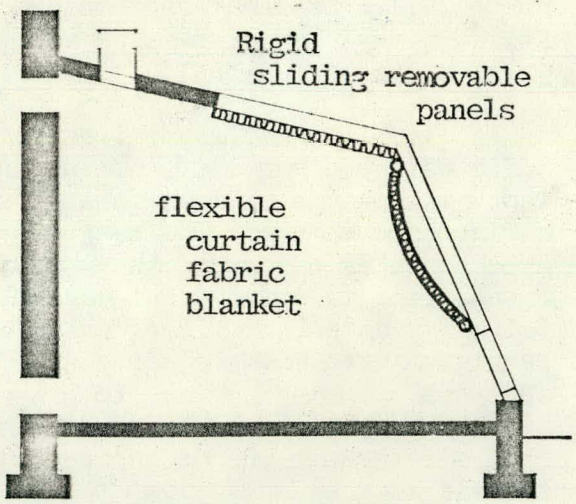


Figure 2. Moveable insulation should be used at night and on overcast days.

Choosing the Site

Choose the greenhouse site carefully to achieve maximum performance. The greenhouse glazing should face due south, although, with some loss in the amount of solar energy collected, it can face up to 30° to the southeast or southwest (Figure 3). Note all obstructions that will shade the greenhouse, such as trees, neighboring houses, or a wing or second story of the attached house. It is best to watch shading patterns on the site in all seasons before designing the greenhouse. Trees which lose their leaves in the winter may appear to be a serious problem is the site is examined in the summer, but once the tree limbs are bare, the shadow cast on the site may not be substantial. Greenhouse shading is actually an advantage in the summer because greenhouses tend to overheat then. Planting tall summer plants on the south side or using curtains could help prevent this. However, for the site to be acceptable, sunlight must be able to enter the greenhouse from at least 11 a.m. to 2 p.m. every day during spring, fall and winter.

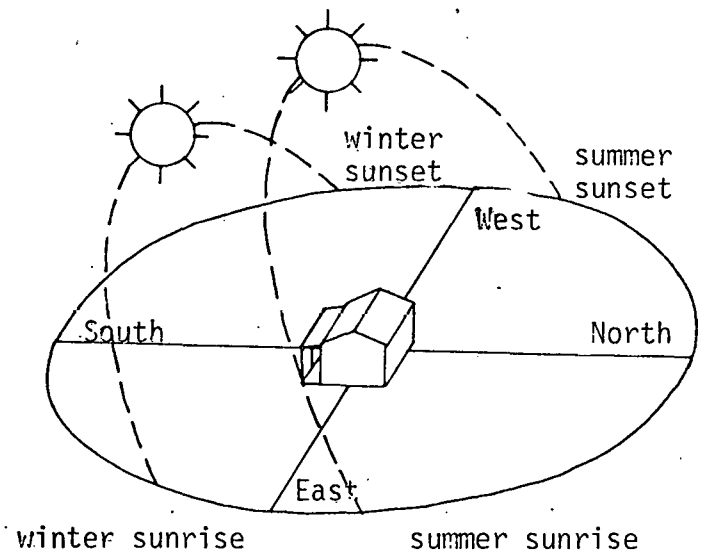


Figure 3. The sun is lower in the sky in the winter than in the summer.

In urban areas, it may be impossible to build a solar greenhouse on a south wall of a house because the property line is too close. Zoning laws often have setback requirements prohibiting additions to the front of the house. The owner or builder may have to obtain a variance from the city's zoning commission to build an attached greenhouse. Emphasize that it will not be used for commercial purposes as these greenhouses are usually regulated under different zoning laws and building codes.

A prime consideration when choosing a greenhouse site is convenience to the user. Building an attached greenhouse over an existing window and door

provides a ventilation system (when the window is opened to the house), ready access to the greenhouse for the user, and reduced heat loss from that outside door and window.

Designing the Greenhouse Structure

Design the solar greenhouse to maximize light penetration and collection and storage of heat. The angle from the horizontal of the glazing should be based on rules that apply to all solar collectors. If the greenhouse will be used in the winter, the angle should equal the latitude plus 20°. Since latitudes range from 40° to 48° in Michigan, this means glazing angles of 60° to 68°. If the greenhouse will be closed down in the winter, and used simply as as a season extender, the angle should approach the latitude plus 10° (50° to 58°).

If non-breakable glazing such as fiberglass is used, these angles are possible. However for a glass greenhouse, it is safer and easier to install a vertical rather than angled front face (Figure 4.). Some roof portions will need glazing so that light can reach the rear of the greenhouse.

The important factor in determining how much of the roof to glaze is based on the sun's position in the sky at various times of the year. On December 21st at noon the sun is 20° to 26° above the horizon in Michigan, but on June 21st at noon, the sun is 70° to 76° overhead (Figure 5). Therefore, the roof should be glazed so that the sun will reach the back wall and storage medium in winter but stop at least 2 ft. from the wall, to shade the storage medium, in summer. For a greenhouse the size of the one in Appendix II the shingled roof will need to extend 4 ft. to 4 1/2 ft. from the back wall.

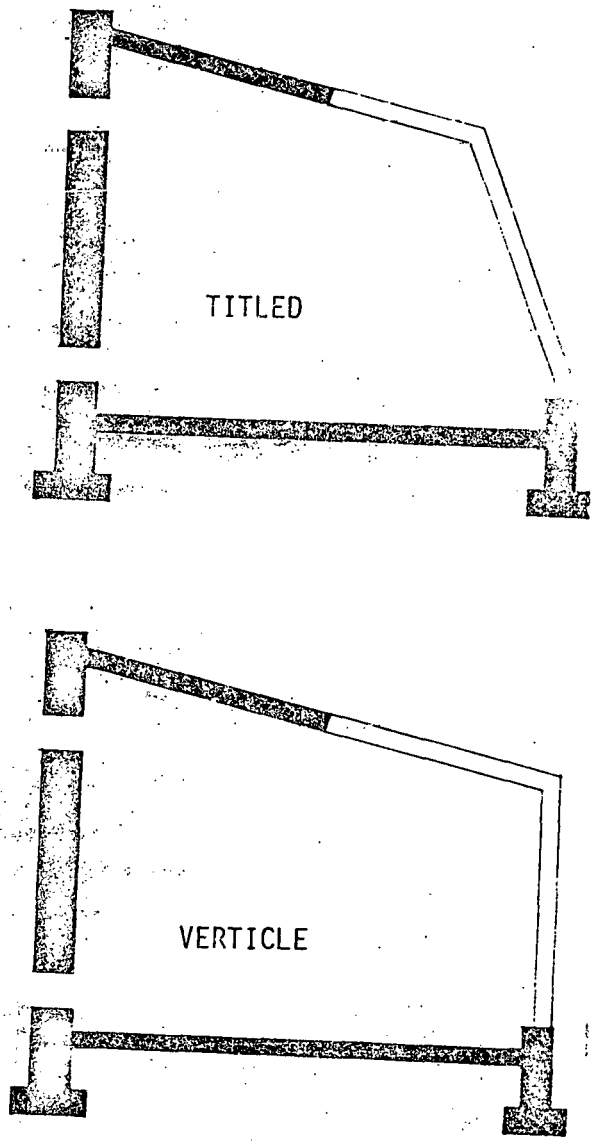


Figure 4. The front face of the solar greenhouse can be oriented vertically however an angle of 55° to 65° is better for the collection of solar energy.

Also consider the azimuth angle to determine how much light should reach the inside of the greenhouse from the side walls. The sun travels in a wide arc during summer, rising in the east and setting in the west; in winter it moves a fewer degrees to the east and west (Fig. 3). Therefore, if the greenhouse is used only in winter (and if it faces due south) do not glaze the east and west walls. But if the greenhouse will be used extensively during the spring and fall, glaze the front portion of the east and west walls so light can enter the greenhouse when the sun is further to the east or west.

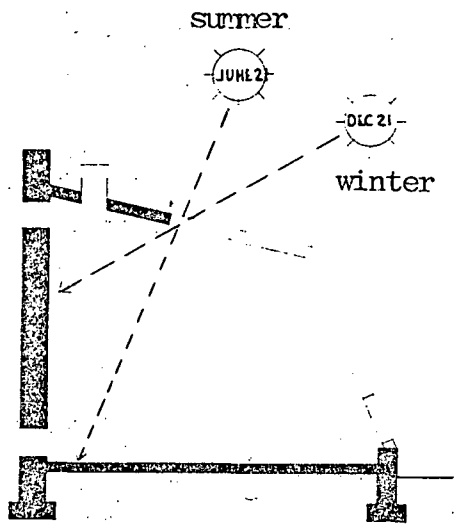


Figure 5. The roof should be designed to optimize shade in the summer and light in the winter.

The greater the glazed area on the greenhouse, the less heat the greenhouse will retain, unless efficient insulation covers the glazing at night and on cloudy, snowy days. Balance the need for light against potential heat loss. Clear areas need at least two layers of glazing.

To maximize light within the greenhouse, paint structures not used for heat storage white. Foil can be used to increase reflection in the greenhouse, but too intense of a reflection will burn the plants.

Insulate all solid areas of the greenhouse to minimize heat loss. The insulating value of a material is usually expressed in terms of its R-value. The greater the R-value, the better the insulating value of the material. Typical insulation levels for a solar greenhouse in Michigan are: R-19 for the walls (for example, 6 in. of fiberglass), R-19 to R-38 for the ceiling (6 in. to 12 in. of fiberglass), R-15 for the foundation wall down to the bottom of the footing (3 in. of extruded polystyrene), and R-10 for night insulation.

Adequate weatherstripping and caulking are also important to prevent air infiltration in the structure. Putting the outside entrance door on the wall opposite the prevailing winds will reduce heat loss because air cannot blow in when it is opened. In general in Michigan, the prevailing winds are out of the southwest. Therefore, locate the door on the east wall.

Many people are surprised to learn that vents in a greenhouse sometimes must be opened on sunny winter days to prevent overheating. This heat can be directed from an attached solar greenhouse into the home by means of vents in the house wall (Fig. 6 Install a high and low vent to provide adequate air circulation. To moderate sudden air temperature changes in a solar greenhouse, a storage medium is provided to absorb and hold heat that would otherwise be vented to the attached home or the outside. Common storage materials are brick and stone (for the back wall of the greenhouse), pea gravel or concrete (for the floor), water in metal or plastic containers, and soil. Other materials used as storage include eutectic salts, wet sand, and fish ponds.

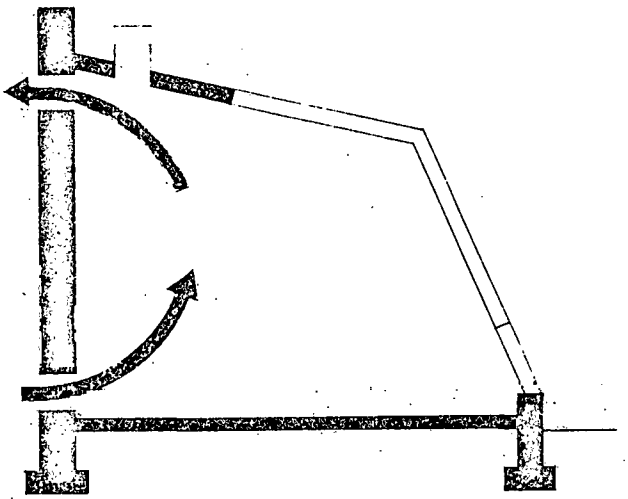


Figure 6. Winter ventilation.

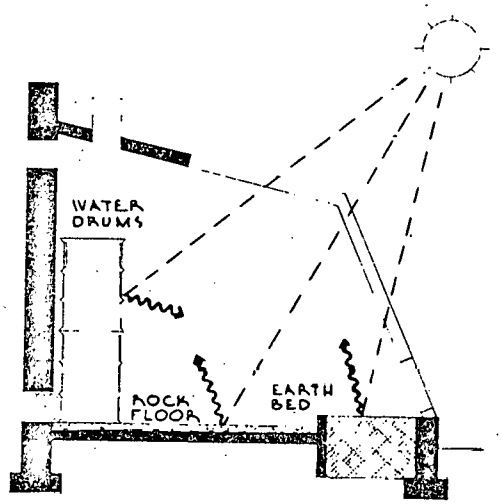


Figure 7. Heat storage.

Storage materials vary in their ability to hold heat. For example, a given volume of rock will store about one-third to one-half as much heat as the same volume of water for the same temperature increase. This is why water in containers is often used as a storage medium in solar greenhouses where space is at a premium.(Figure 7). In Michigan, a minimum of 3 gallons of water storage is needed for every square foot of greenhouse floor area. Do not let water freeze in the containers. Incorporate as much rock and earth material as possible into the greenhouse structure to supplement water storage. The storage medium will absorb more heat if placed in direct sunlight, but even shaded areas will absorb heat from the air. Paint all storage mass surfaces flat black or another dark flat color to maximize absorption.

Adequate outside ventilation can prevent overheating in the summer (Fig. 8). Install one high and one low vent on opposite sides of the greenhouse. Usually the low vent is installed on the side of the greenhouse which receives the summer prevailing winds. Night insulation can also provide shading when used to cover portions of the greenhouse on very hot days. Growing tall spreading vines and plants inside or on the outside of the glazed areas is another way to achieve shading. A fan with automatic controls can be installed so that vents need not be manually operated.

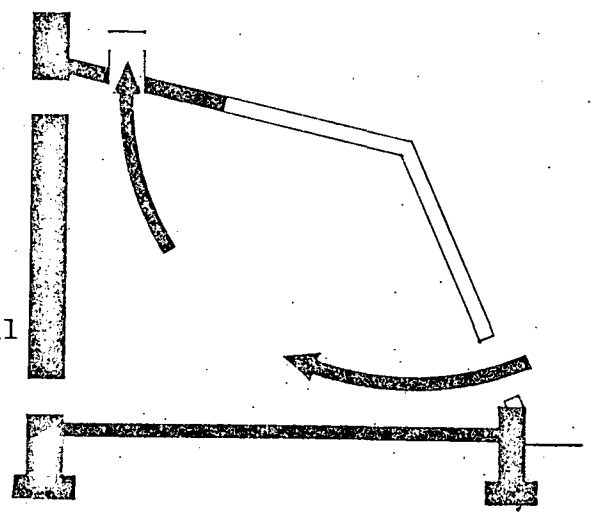


Figure 8. Summer ventilation.

The inside floor plan for the greenhouse should allow for adequate work space, whether the planting beds are built-in or elevated. Often, seed flats are placed on top of water storage barrels to provide direct heat to the plants. Be sure to allow for floor drainage if the greenhouse has a slab concrete floor. Also, a source of water and electricity inside the greenhouse is desirable for convenience.

In most areas of Michigan, building codes govern the type of structure that can be built. Find out what the requirements are in your area before building to ensure that the greenhouse can withstand snow loads and ground shifting.

Materials Used in Greenhouse Construction

Avoid unnecessary material waste when designing a greenhouse by using standard material dimensions -- 4-foot units are usually used because fiberglass comes in 4-foot sheets (Figure 9). The front framing of the greenhouse can, therefore, be 2 or 4 feet on center. Unless expensive and scarce redwood is used, the wood must be treated to prevent moisture damage. Do not use pentachlorophenol or creosote, since fumes from these preservatives will kill greenhouse plants. The recommended wood preservatives for greenhouses are copper napthenate or a water-borne salt-type preservative.

The most important decision in choosing materials is the type of glazing to use. Glass was commonly used in the past in greenhouses, but it is hard to handle for a do-it-yourself builder, expensive and must be installed to allow for expansion to prevent breakage. Glass will, however, last a long time.

Many synthetics are available which can be used instead of glass, although scarce petrochemicals are used in their manufacture. Some synthetics, such as fiberglass, are not clear like glass but allow diffuse light into the greenhouse. Fiberglass will gradually lose its ability to transmit light unless it is coated with Tedlar[1/] or acrylic. These coatings should extend the life of the fiberglass to 10 years. Unfortunately Tedlar coated fiberglass is not readily available.

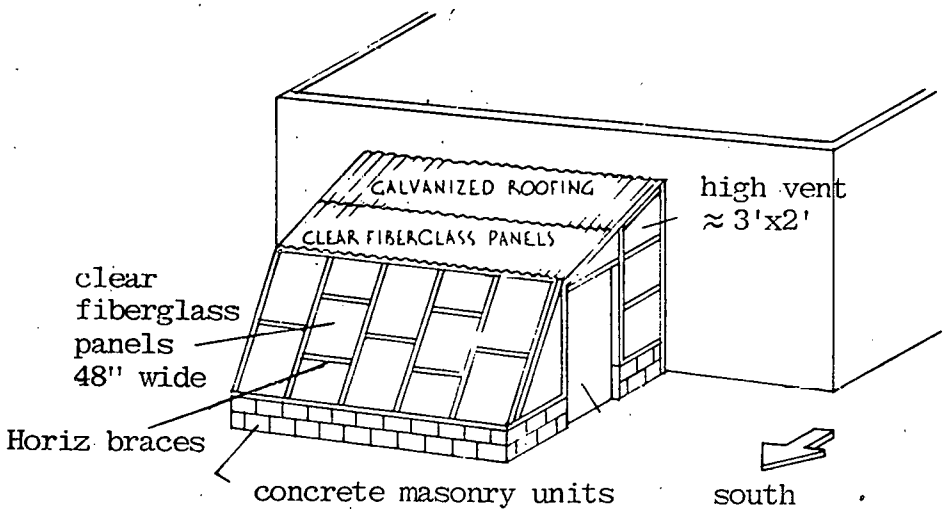


Figure 9. Basic attached solar greenhouse design.

1/ Tedlar is a trademark of Dupont Co., Wilmington, Delaware

Look for a synthetic with a long life (especially for the outside glazing layer), good solar transmissivity, high R-value, and reasonable cost. Many clear acrylics are more expensive than glass and do not have as long a life. Poor grade panels will darken rapidly with age and reduce the light too much for Michigan winters.

How much does a solar greenhouse cost? The cost of an attached solar greenhouse can be as low as $5 per square foot when recycled building materials are used. The total cost will be about $6 to $15 per square foot if new materials are used and the greenhouse is constructed by the owner. This is comparable to the charge for a double-glazed prefabricated greenhouse of conventional design, excluding the required foundation. A solar greenhouse designed and built by a construction firm will cost about $15 to $35 per square foot. In this case, at least half of the cost will be for labor alone.

Horticulture in the Greenhouse

In each season of the year the solar greenhouse has different microclimates. These changing climates affect the types of vegetables which can be grown and where the vegetables will grow in the greenhouse.

From late fall until early spring, the front of the greenhouse receives the most light but is the coolest since heat loss is greatest against the double-glazed south face (Figure 10.) Cool weather vegetables such as peas, greens and members of the cabbage family grow best in this area. The back or north wall of the greenhouse receives a lot of light from the low-lying sun. With thermal storage against this wall, temperatures are warmer. Warm weather vegetables such as beans, peppers and tomatoes could be grown here especially in the spring and fall. Light levels during winter in Michigan may be too low to successfully grow warm weather vegetables. The warmest spot is the area near the greenhouse roof. Hanging baskets of flowers and herbs will grow here. Under the opaque portion of the roof grow shade-loving flowers.

A. LIGHTEST-COLDEST
Leafy greens, radishes, peas, broccoli, roots, tubers, carry over fruiters

B. LIGHT COOL
Herbs, greens, flowers, transplant seedlings

C. LIGHT WARM
Hanging pots, herbs, flowers

D. LIGHT WARM
Winter tomatoes, peppers, climbers

E. LOW LIGHT, WARMEST
Start seeds, sprouts

F. SHADY COOL
Berries

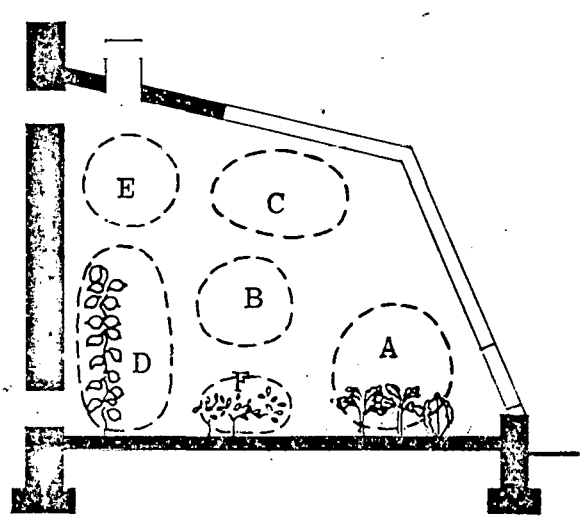


Figure 10. Winter planting profile.

A. SHADING PLANTS

B. FRUITERS, TOMATOES, CLIMBING CUCUMBERS, SQUASH, MELONS

C. SEEDLINGS, HERBS FRUITERS, HYDROPONICS

D. LOW LIGHT: GREENS (IN LATE SUMMER) Climbers, flowers

E. FLOWERS, SHADE LOVERS

F. BERRIES, SHADE LOVERS

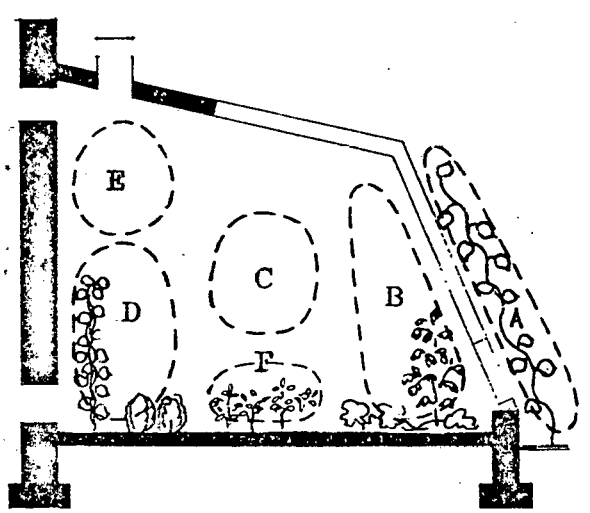


Figure 11. Summer planting profile.

The front of the greenhouse becomes a warm, sunny place from late spring through summer (Figure 11). But with the sun high in the sky, the opaque portion of the roof shades the back wall. Warm weather vegetables grow best when moved to the front of the greenhouse. Low-light vegetables such as leafy greens will do well along the back wall. Seedlings for the garden or greenhouse can be started on raised beds in the center of the greenhouse. This works especially well if seedling trays are placed on thermal storage water barrels. Bottom heat from the barrels gets seedlings off to a good start.

Space in the greenhouse for plant growth is restricted as compared to a vegetable garden. Grow vegetables appropriate in size for a greenhouse. Many space-saving varieties are available through seed catalogs. Look for fall varieties having short growing seasons. The vegetables will mature before the cold, low-light days of winter arrive.

Pest problems can multiply rapidly in a greenhouse. The greenhouse provides a favorable climate for all sorts of insects and diseases. Maintain good air flow to prevent disease establishment. Use screens over outside vents to keep insects out. Do not bring bug or disease-infested plants into the greenhouse. Use sterile soil for plant beds. Also, opening all doors and vents in winter, and allowing the soil to freeze will help but not completely rid the greenhouse of insects.

The solar greenhouse can be used to grow vegetables in harmony with the seasons and to extend gardening enjoyment and bring fresh produce over more months of the year.

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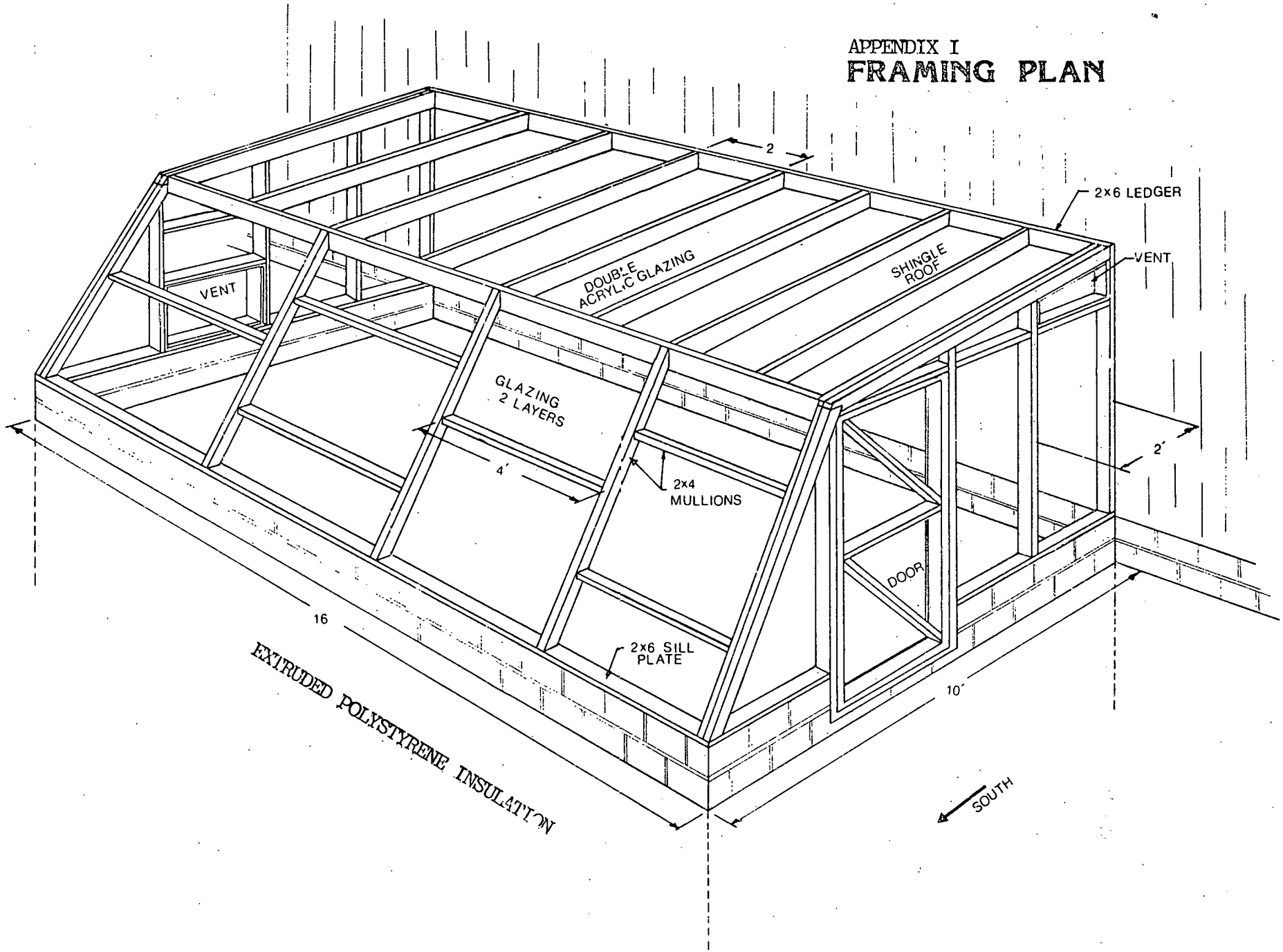
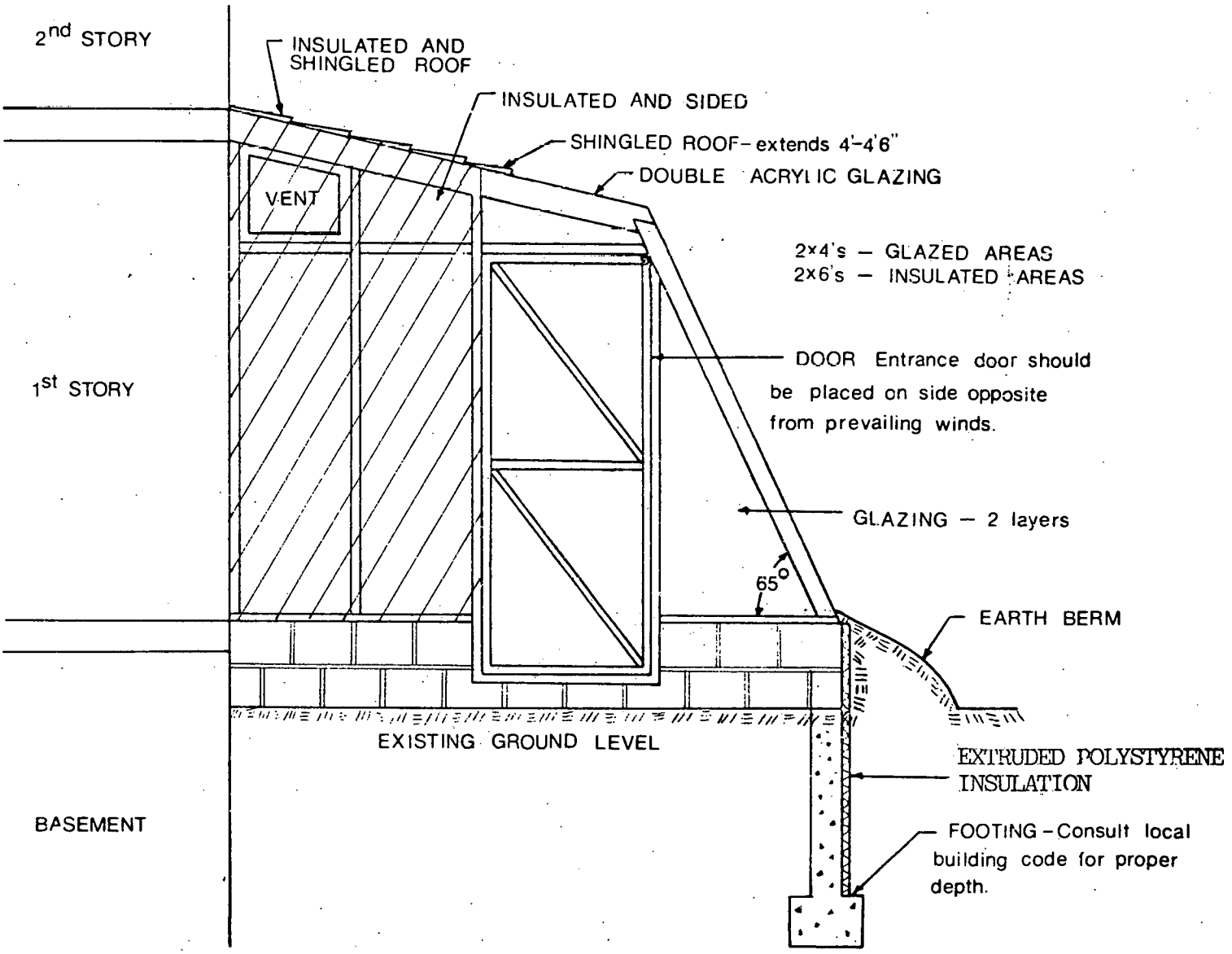
APPENDIX I

FRAMING PLAN

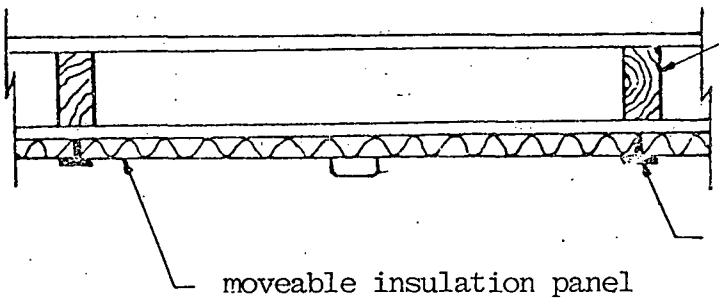


APPENDIX II

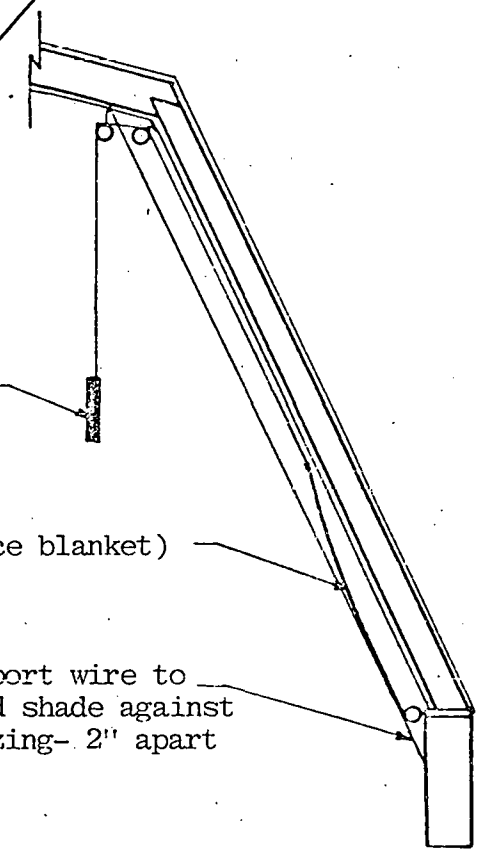

2nd STORY
INSULATED AND SHINGLED ROOF
INSULATED AND SIDED
SHINGLED ROOF- extends 4'-4'6"
DOUBLE ACRYLIC GLAZING
VENT
2x4's — GLAZED AREAS
2x6's — INSULATED AREAS
1st STORY
DOOR Entrance door should be placed on side opposite from prevailing winds.
GLAZING — 2 layers
65°
EARTH BERM
EXISTING GROUND LEVEL
EXTRUDED POLYSTYRENE INSULATION
BASEMENT
FOOTING - Consult local building code for proper depth.

APPENDIX III

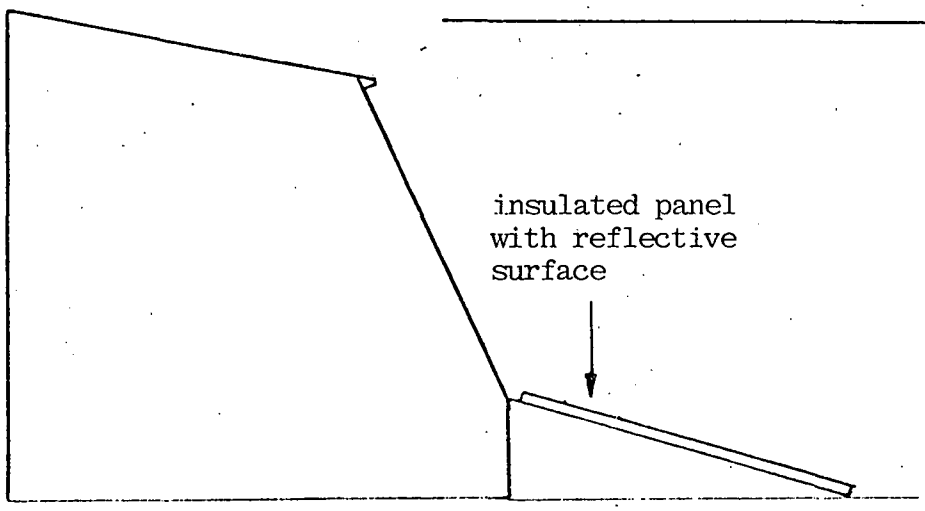
NIGHT INSULATION



Insulation panels can be stored under the roof during the day and pulled down to cover glazed portions of the roof at night.



Moveable curtain on a roll can cover front glazing.



Insulation panels can be made of thermoply with an inside filling of insulation. Edges should be weatherstripped for tight fit.

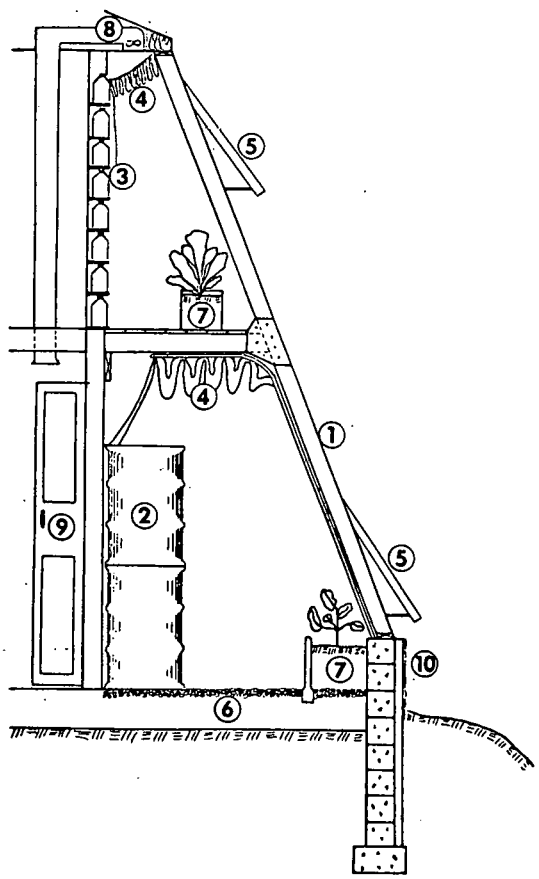
The Urban Options

SOLAR GREENHOUSE

An Urban Options Energy Paper June 1980 Lori Cipparone

ELEMENTS

The Urban Options Solar Greenhouse is a type of solar collector. It was designed and built by Urban Options staff and volunteers during 1979 and 1980 to demonstrate the practical use of solar energy for heating and indoor horticulture. The greenhouse contains the basic elements of all solar systems as well as several unique features. Below is a diagram showing the major components of the greenhouse. These components are described on the following pages.



① *Glazing*
② *Water Thermal Storage*
③ *Eutectic Salt Thermal Storage*
④ *Insulating Curtains*
⑤ *Vents to the Exterior*
⑥ *Gravel or Tile Floor*
⑦ *Planting Beds*
⑧ *Fan and Duct System*
⑨ *Vents to the House*
⑩ *Insulation*

1) *Glazing:* Glazing is the material that lets the sun in. The clear sections in this greenhouse are thermopane (double-pane) glass. The translucent sections are composed of fiberglass (Kalwall) on the exterior and greenhouse-quality polyethylene on the interior. These materials were used in some areas instead of glass to reduce the cost of the greenhouse. Solar greenhouses always have two layers of glazing to reduce heat loss from the structure. Almost all of the glazing faces south because the sun in the winter shines mostly on the south side of buildings. The south glazing is tilted to increase solar gain in the winter. The best angle for solar collection in the winter is about 63° from the horizontal. The glazing on this greenhouse is tilted at 69°. Some portions of the east and west walls can be glazed to let sunshine in from these directions during the spring and fall, when the sun rises more to the east and sets more to the west.

2) *Water Thermal Storage:* Water in 55 gallon drums is the thermal storage mass in the lower story of the greenhouse. The thermal storage mass collects the excess solar energy during the day, and releases the heat back into the greenhouse at night. Without thermal storage, the greenhouse gets much hotter during the day, and colder at night. Water is one of the cheapest thermal storage materials available.

3) *Eutectic Salt Thermal Storage:* A chemical called calcium chloride hexahydrate can be used as a thermal storage material. This chemical is a "eutectic" or "phase-changing" salt because it has the property of changing from a solid to a liquid and vice versa at 81°F, which is within the range of normal greenhouse air temperatures. As heat is absorbed by the material on bright days, it changes from a solid to a liquid. This heat is released as the greenhouse air temperature drops and the material solidifies, keeping the greenhouse warm at night. Eutectic salts are often used as a thermal storage material where space is limited because they can store more heat per volume than water or rock. However, proper packaging of the chemical in sealed containers is critical. We are experimenting with an inexpensive container to see if the use of this material is practical.

4) *Insulating Curtains:* The greenhouse will stay warmer if the glazing is covered by an insulating curtain at night. Insulating curtains are not like the foam-backed draperies commonly found in the stores. Unlike ordinary draperies, the curtain material is sealed to the edges of the window frame as tightly as possible to prevent air currents behind the curtain. Some commercially-made insulating curtains and shutters are available. To reduce the cost, we have designed our own curtains out of upholstery polyester filler covered by one layer of aluminized mylar (spaceblanket) and an exterior covering of vinyl-backed nylon.

5) *Vents to the Exterior:* Ventilation must be provided to the outside during the summertime. Although the diagram shows vents on the front face of the greenhouse, we recommend installing them in the vertical sides of the greenhouse to prevent water leakage problems. Vents can also be installed in the roof of the greenhouse.

6) *Gravel or Tile Floor:* The gravel floor in the lower story of the greenhouse is about 12" deep, and provides some additional thermal storage mass. Gravel floors are much cheaper than concrete, and drainage of water is not a problem. In the upper story, there is a tile floor, an attractive alternative where rock cannot be used.

7) *Planting Beds:* The large amount of soil in beds also contributes to the thermal storage mass in the greenhouse. Because they absorb heat, the beds protect plant roots from colder air temperatures. They also hold water longer than pots, reducing the need for daily watering of plants.

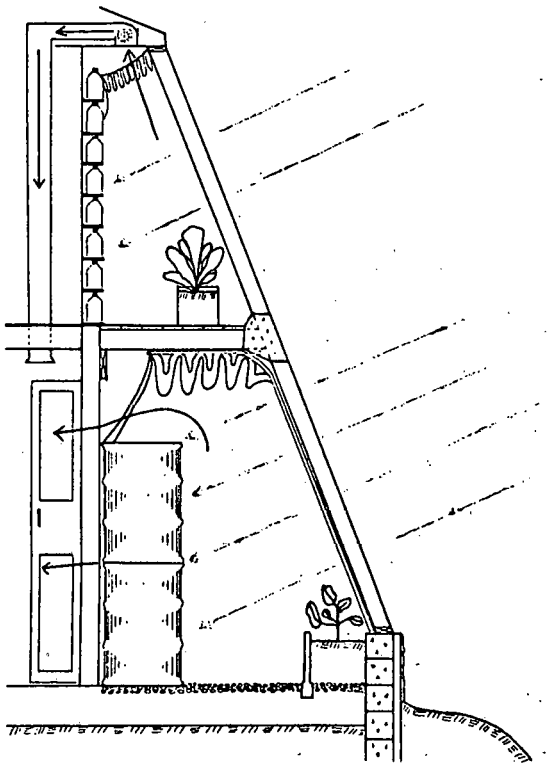
8) *Fan and Duct System:* The fan pulls hot air from the top of the greenhouse and distributes this air to the back rooms of the house. The amount of thermal storage in the upper story is not adequate to prevent temperatures over 90°F on sunny days. The excess heat is very welcome in the cold back rooms of the house.

9) *Vents to the House:* Heat also escapes into the house through natural convection if the windows and doors between the house and greenhouse are opened. These windows and doors can be closed during extremely cloudy days and at night, unless the greenhouse is to be heated like the rest of the house.

10) *Insulation:* The greenhouse should be very well insulated to prevent unnecessary heat loss. The foundation is insulated with 3" of polystyrene. The framing of the greenhouse was done with 6" studs, which allows the installation of 5½" of fiberglass insulation in the walls and ceiling. Even the solid vents have a fiberglass or urethane core.

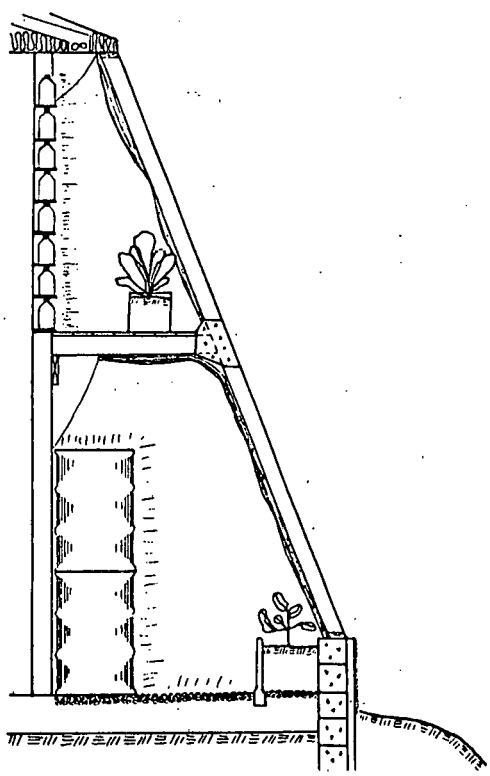
SOLAR GREENHOUSE DATA

	Upper Story	Lower Story	Total
Inside Measurements	4.7' x 22.2'	6.7' x 16.0'	--
Floor Area	104.4 ft^2	107.2 ft^2	212 ft^2
South Glazing	138.0 ft^2	112.0 ft^2	250 ft^2
East Glazing	--	5.7 ft^2	5.7 ft^2
West Glazing	2.3 ft^2	3.0 ft^2	5.3 ft^2
Vent Area	18.9 ft^2	19.7 ft^2	38.6 ft^2
Thermal Mass - Water	--	440 gal.	--
Rock	--	80 cu. ft.	--
Soil	--	40 cu. ft.	--
Eutectic Salts ($CaCl_2 6H_2O$)	1447 lbs.	--	--
Insulating Curtain - R-Value	R-3	R-8.5	
Glazing Angle: 69°			



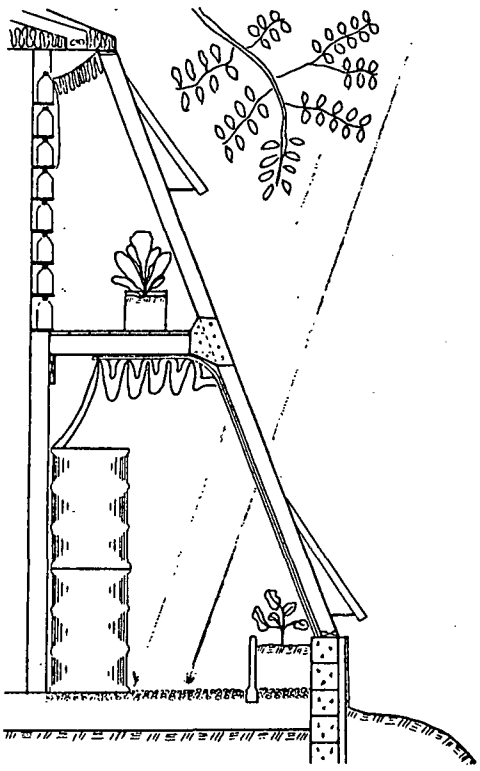
Day — Winter

In the winter, the sun's rays strike the back of the greenhouse, where the water thermal storage is located. On a sunny, partly sunny, or bright hazy day, when the greenhouse temperature rises above 65°F, the doors and windows to the house are opened to let the heat in. If the temperature in the upper story rises above 90°F, the fan is turned on. This fan draws air from the greenhouse to the back rooms of the house.



Night — Winter

At night, the doors between the house and the greenhouse are closed. The insulating curtains are pulled down to conserve heat. The thermal storage mass in the greenhouse slowly releases its heat, keeping the greenhouse well above freezing. On extremely cloudy, snowy days, the greenhouse can be operated as if it were night, since little solar gain can be expected.

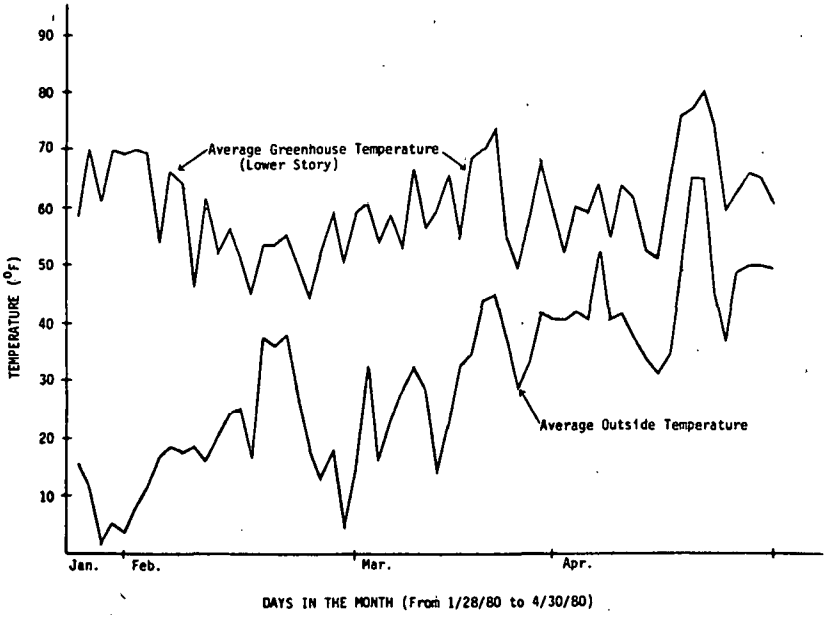


Day — Summer

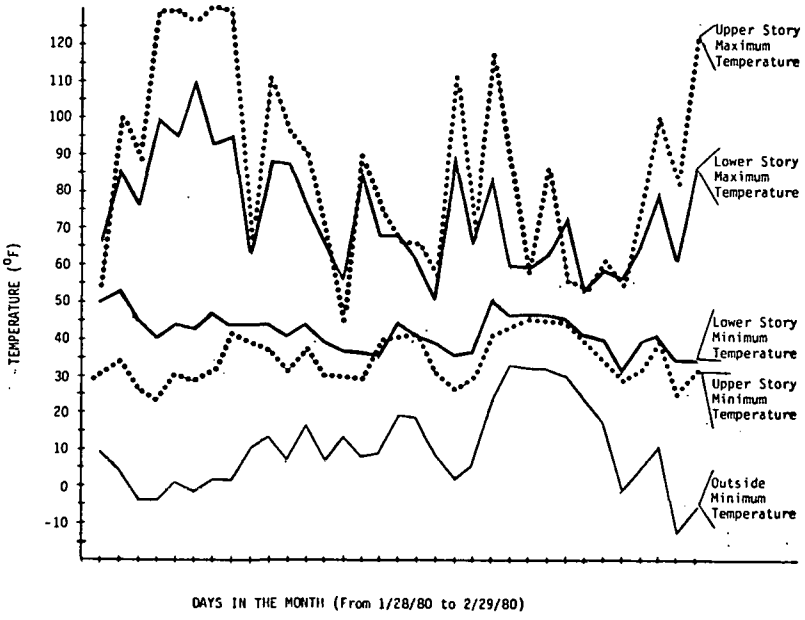
In the summer, the sun is high in the sky. The roof of the greenhouse and the floor of the second story shade the thermal storage materials in the back of the greenhouse. The sun's rays are also partially reflected from the front glazing. The insulating curtain can be used to shade the greenhouse. In the Urban Options greenhouse, the curtains are not used because the branches of the nearby walnut tree fill out with leaves and adequately shade both stories. Vents are opened to the outside in the summer to promote air circulation.

PERFORMANCE

The fuel consumption of the Urban Options house (adjusted for weather) was 50% lower in 1979-80, compared to 1978-79, before the greenhouse was built. It is difficult to determine, however, exactly how much the house's fuel consumption was reduced by the addition of the solar greenhouse, because parts of the house were insulated at the same time. *Careful calculations show that in an average year, the solar greenhouse should provide at least one-third of the heat needed by the Urban Options house.* We assumed that the greenhouse was added on to a well-insulated Energy House, operated as if it were a normal family residence.



The chart at the left shows the performance of the lower story of the Urban Options greenhouse during its first three months of operation. During the winter months, the average air temperature in the greenhouse was at least 20°F higher than the average outside temperature. The greenhouse was shut off from the house at night and no insulating curtains were used.



The minimum and maximum temperatures in the upper and lower stories of the greenhouse are shown here for the month of February 1980. The air temperature of the lower story ranged from 32°F to 110°F. The upper story, which was not completed at the time, was usually warmer on sunny days and colder at night because it had only one layer of glazing and no thermal storage. The temperature in the upper story ranged from 25°F to 129°F.

COST - EFFECTIVENESS

The cost of the Urban Options greenhouse is as follows:

Construction Materials	*$3668*
Accessories	
Insulating Curtains	*466*
Eutectic Salts	*50*
Eutectic Salt Containers	*250*
	$4434

The cost of the greenhouse is $20.92 per square foot of floor area, or $17.74 per square foot of collector area. Solar greenhouses have been built for as little as $6 per square foot of floor area when recycled materials are used. A contractor-built solar greenhouse can cost between $25 and $50 per square foot of floor area depending on the materials used and the time involved.

A solar greenhouse is an economical choice when compared to an ordinary greenhouse or a non-solar house addition. These structures cost the same or more than a solar greenhouse to build, and additional money must be spent every year to heat them. For example, an unassembled hobby greenhouse meant to be a permanent addition to the house usually costs at least $20 per square foot, not including the foundation and accessories, and may cost up to $300 per year more to heat. A properly designed solar greenhouse heats itself and also provides part of the home heating load.

How long will it take for the cost of the Urban Options greenhouse to be recovered in fuel saving? The payback period varies considerably depending on which conventional fuel is currently heating the house, the financial situation of the greenhouse owner, and how fast you think fuel prices will increase. If we assume that the Urban Options greenhouse was built by a middle income family who borrowed all but $1000 of the cost of the

greenhouse at 11% interest, claimed both federal and state solar tax credits, and assumed that all fuel prices would increase at a rate of 15% per year, we obtain these payback periods:

Conventional Fuel:	*Natural Gas*	*15 years*
	Fuel Oil	*4½ years*
	Electricity	*3½ years*

If the value of plants grown in the greenhouse is included, the payback period would be even more favorable.

HORTICULTURE

In our project, we have emphasized vegetable production in the greenhouse, although there are many flowering plants and herbs that can be grown in a cool greenhouse. The following plants were grown in the greenhouse from January to April of 1980:

Lettuce	*Kolrahbi*	*Swiss Chard*	*Thyme*
Kale	*Chinese Cabbage*	*Parsley*	*Sage*
Corn Salad	*Radishes*	*Onions*	*Chrysanthemums*
Mustard	*Turnips*	*Peas*	*Sweet Violets*
Begonias			

The following vegetables were started in the spring in flats for transplanting into the outside gardens:

Tomatoes	*Squash*	*Cauliflower*	*Sage*
Eggplant	*Melon*	*Broccoli*	*Basil*
Peppers	*Cucumbers*	*Nasturtiums*	*Oregano*

These crops are being grown during the summer in the greenhouse:

Collards	*Basil*	*Beans*	*Tomatoes*
Turnips	*Nasturtiums*	*Cucumbers*	*Eggplant*
Radishes	*Beets*	*Begonias*	*Peppers*
Parsley	*Lettuce*		

For more information on growing plants in solar greenhouses, see the Urban Options Energy Paper "*Solar Greenhouse Horticulture*".

BIBLIOGRAPHY

These books are recommended for further exploration:

The Food and Heat Producing Solar Greenhouse, Bill Yanda and Rick Fisher, John Muir Publications, P. O. Box 613, Santa Fe, NM 87501, 1980. $8.00

The Solar Greenhouse Book, Edited by James C. McCullough, Rodale Press, Emmaus, PA 18049, 1976. $8.95

The Complete Greenhouse Book, Peter Clegg and Derry Watkins, Garden Way Publishing, Charlotte, VT 05445, 1978. $9.95

Solar Greenhouse Digest, Twila DeVries, Ed., P. O. Box 2626, Flagstaff, Ariz. 86003. Subscription price $10.00 per year (6 issues).

ACKNOWLEDGEMENTS

Thank you to all workshop participants and volunteers who helped construct the Urban Options Solar Greenhouse.

The following businesses and agencies have assisted the solar greenhouse project through donations, in-kind contributions, and grants:

All-Phase Electric
710 E. Kalamazoo
Lansing, Mich.

Central Michigan Lumber
407 N. Clinton
St. Johns, Mich.

Glaser's Lumber
2300 Spike
Lansing, Mich.

Bert Seyfarth, Architect
340 Northlawn
East Lansing, Mich.

Dow Chemical Company
Midland, Mich.

Martin Block Corporation
1520 E. Main
Lansing, Mich.

Robert Eveleigh, Tile Contractor
1220 Hazel
Lansing, Mich.

Michigan Solar Office
Michigan Energy Administration
Department of Commerce

U. S. Department of Energy
Midwest Appropriate Technology Program

City of East Lansing
East Lansing, Mich.

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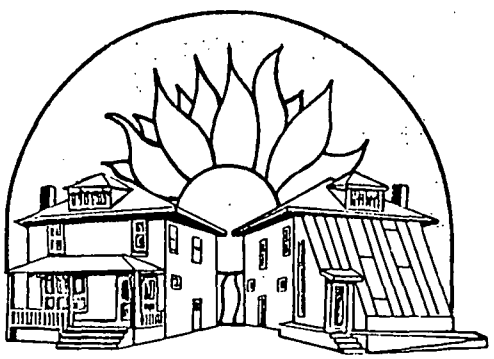
ABOUT URBAN OPTIONS

Urban Options is a non-profit group formed to provide information, intensive research and "hands on" experience in energy saving techniques. The City of East Lansing has donated the Energy House to Urban Options for use as a demonstration project.

Urban Options aims to bring energy conservation information to local residents in a form that is immediately understandable and will encourage people to implement what they learn in their own homes. "Hands on" workshops fulfill this function. In a typical workshop, participants take part in a lecture/discussion about home energy conservation. The "hands on" part of the workshops enables people to practice specific weatherization techniques on the Energy House.

If you would like to become involved in Urban Options, become a member. Members receive the most up to date information on Energy House programs via the monthly "Energy House Newsletter". Members are also entitled to attend all Energy House workshops free. Membership dues are $10.00/year ($5.00 for students).



The Energy House is open to the public, 9 am - 5 pm weekdays and 10 am - 2 pm Saturdays. Stop by or call us at 351-3757.

urban options energy paper ·· lori cipparone ·· june 1980

Solar Greenhouse Horticulture

Growing plants in a solar greenhouse is not a matter of having a "green thumb". It's simply the result of learning what your favorite plants need to survive, and giving them what they need. This article presents some suggestions based on my experience at Urban Options. Add or subtract as you wish - most of your knowledge of horticulture will be gained through trial and error.

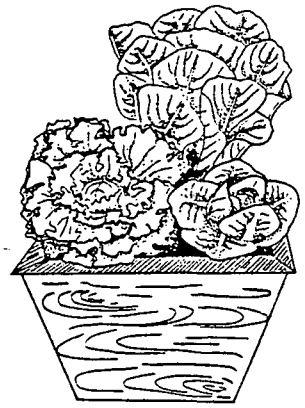
Essential Plant Requirements

All plants require adequate light, water, carbon dioxide, nutrients, and the proper growing temperatures to flourish. *Light* in a solar greenhouse can be maximized by painting all surfaces in the greenhouse that are not thermal storage materials white. Foil-covered cardboard, thermoply, or other reflective materials can be placed along the back wall of the greenhouse to increase light reflection and prevent plants from growing toward the south-facing glazing. *Watering* is easier if there is a source of water and a large tub in the greenhouse. Plants in containers, especially seed flats, should be watered from the bottom up, by immersing the container in a tub of warm water. The water should come within and inch of the top of the container. Overwatering should be avioded in the wintertime, especially if the temperature in the greenhouse at night is approaching the freezing point. Cold-hardy plants will often survive frost if their tissues are not filled with water.

Carbon dioxide is usually provided through adequate ventilation to the house in the wintertime, and to the outside in the summertime. Composting inside the greenhouse can increase carbon dioxide levels. Growth rates in the winter can be increased by adding carbon dioxide to the greenhouse environment. *The proper growing temperature* is different for each plant variety. Solar greenhouse temperatures should be maintained at an absolute minimum of 30°F and an absolute maximum of 105°F if any plants at all are to be grown. Most plants thrive in a temperature range between 40°F and 90°F. Seed germination and seedling growth, however, is maximized for most plants in a protected environment with more constant temperatures. *Nutrients* are provided to plants by increasing the soil fertility through the addition of organic matter and fertilizers. This subject is covered in more detail below.

Containers and Beds

Many different types of containers can be used to grow plants. Adequate drainage of water from the container is essential. Be sure to choose a



container large enough for the plant to be grown. Of the commercially available containers, plastic pots are easier to clean and sterilize than the clay pots (plastic pots can be washed with soapy water, whereas clay posts must be soaked in a mixture of bleach and water). They also don't dry out as quickly as clay pots. However, the plastic pots do not "breathe" like the clay pots. Clay pots should always be soaked in water before potting plants in them. The clay robs the water from the plant roots if this is not done.

Large planting beds are initially more work because they must be filled with a large amount of soil. They offer the advantage, however, of providing an additional thermal storage mass in the greenhouse. This large mass of soil does not cool down as quickly as the individual plant containers do, protecting the plant roots from frost. A bed has to be watered much less frequently than containers do. All planting beds or continuous planters should be at least 12" deep to provide enough room for roots.

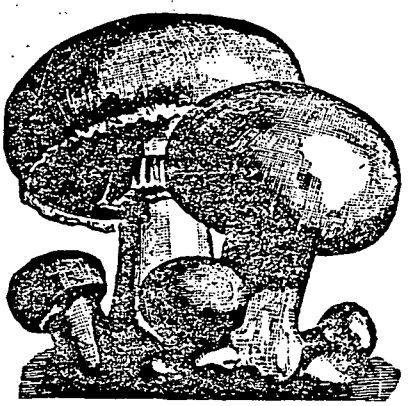
Planting Medium or Soil

Plants can be grown in regular soil mixes or hydroponically in plain sand, vermiculite, or perlite. Where the weight of soil is a problem (i.e. in rooftop greenhouses) hydroponics is the preferred growing technique. Providing the proper nutrients to the plants on a regular basis can be more difficult than it seems at first, however, and generally, beginners should start with soil mixes as a planting medium. This does not mean that you simply go out to your yard, scoop up some soil, and use it in the greenhouse. Greenhouse soil must contain more organic matter and provide better drainage than ordinary garden soil. Some common soil mixes are:

1/3 topsoil	1/3 topsoil
1/3 peat	1/3 compost
1/3 sand, vermiculite, or perlite	1/3 sand, vermiculite, or perlite

Try this recipe which was recommended by an organic solar greenhouse horticulturalist with many years experience:

1/3 black topsoil
1/3 7 to 8 year old rotted horse manure
1/3 sand



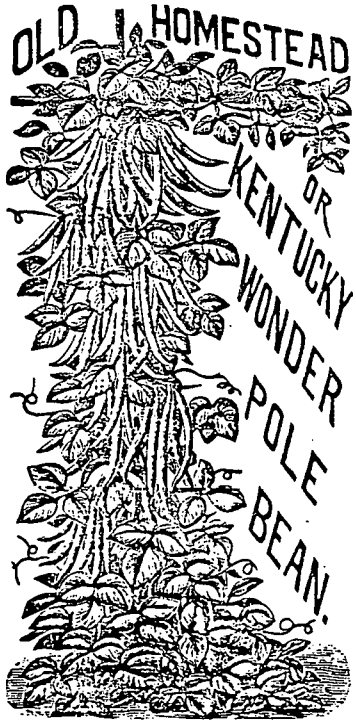
The amount of organic matter and sand can be varied depending on the structure of the topsoil. If it is clay loam, add more sand and organic matter. If you have a sandy loam, add less sand or vermiculite and more organic matter. If you obtain topsoil from a stranger's land, be sure that the area has not been sprayed with herbicides.

If you have money to spend but not much time, you might want to purchase potting mixes from a garden store. These are often pre-pasteurized as well as

pre-mixed. Commercialized potting mixes are especially useful when starting seedlings.

Soil Pasteurization

Pasteurization of the soil destroys any fungus, diseases, insect eggs, and weed seeds that may be present. Topsoil should be pasteurized if it will be used to grow seedlings because seedlings are more likely to die from any of the above. The importance of pasteurizing other greenhouse soils is debatable. In the Urban Options greenhouse, both pasteurized and unpasteurized soils have been used in different beds to see if there is a difference in the number of harmful insects and other problems. If you want to be absolutely safe, pasteurize the soil.



Soil can be pasteurized in these ways:

1) Bake the soil in a foil-covered pan in the oven for 30 minutes on low heat, until a meat thermometer inserted in the soil reads 180°F.

2) Mix acetic acid in water at the rate of ½ gallon of acetic acid crystals to 50 gallons of water. Pour ½ gallon of the liquid over each square foot of soil. This will destroy fungi, but not nematodes.

3) A steam pasteurizer can be constructed out of metal containers such as 55 gallon drums cut in half the long way. Ten inches of soil can be held in a rack over a boiling water. A fire is built under the homemade boiler to heat the water.

Soil Fertility

Plants need the major nutrients, nitrogen, phosphorus, and ~~potassium,~~ as well as several micronutrients to grow properly. Nitrogen promotes leafy growth and greener coloration. Phosphorus creates strong root systems and proper flowering and fruiting. Potassium or potash strengthens stems and reduces disease resistance. The soil pH, or relative acidity or alkalinity, must be neutral (pH-6.0) to slightly acid (pH-7.5) for most plants.

The best way to find out what nutrients your greenhouse soil needs is to have a soil test done. One pint of soil can be taken to the county Cooperative Extension Service office or the MSU Soil Testing Lab in the Soil Science Building. For $4.00, a computer printout will be sent to you showing the level of major nutrients and the soil pH. Instructions are included on how to calculate the amount of fertilizer your soil needs. Soil test kits are also available for home use.

Inorganic fertilizers are often cheaper per pound of nutrient than organic fertilizers, despite the large amount of energy required in their manufacture. This situation may change as the price of fossil fuels increases. At Urban

Options we prefer to use organic fertilizers. The use of inorganic fertilizers can lead to the build-up of salts in the soil, the white crusty matter that you often see on the outside of old clay pots. Organic fertilizers release their nutrients more slowly than the inorganic types, and also contain many micro-nutrients important to plant growth. Below is a list of the most common organic fertilizers available and their nitrogen (N)/ phosphorus (P)/ potassium (K) content. Keep in mind that the actual nutrient content of organic fertilizers varies*

Nitrogen Sources

Cottonseed Meal: 3-7% N, 2% P, 1% K. Lasts 4-6 months. Acidifies soil.
Blood Meal: 12.5% N, 1.3% P, 0.7% K. Lasts 3-4 months.
Hoof & Horn Meal: 14% N, 2% P, 0% K. Lasts 12 months. Slow releasing.
Fish Meal: 10.5% N, 6% P, 0% K. Lasts 6-8 months.
Fish Emulsion: 5.0% N, 1.0% P, 1.0% K Can be mixed with water for a liquid fertilizer.

Phosphorus Sources

Bone Meal: 3% N, 20% P, 0% K. Lasts 6 months to 1 year.
Phosphate Rock: 33% P. Lasts 3-5 years.
Soft or Colloidal Phosphate: 18% P. Lasts 2-3 years. Available to plants more quickly than phosphate rock.

Potassium Sources

Wood Ashes: 1-10% K. Lasts 6 months. Increases alkalinity of soil.
Greensand: 0% N, 1.5% P, 6.7% K Lasts up to 10 years.
Crushed Granite: 3-5% K. Lasts up to 10 years.
Kelp Meal: 1% N, 0% P, 12% K. Lasts 6 months to 1 year.

The Ph of the soil can be lowered by the addition of compost or manure, and raised by the addition of dolomitic lime.

The best and cheapest form of soil conditioner and fertilizer available is compost. Compost can be made by layering leaves, grass, household vegetable garbage, and soil in a pile about three cubic feet in volume. Other materials can be used when available. This pile is watered and turned over every few days, and should heat up to a pathogen-killing 180°F if properly constructed. In several weeks you will have a dark, crumbly material to use in the greenhouse.

Worms can also be added to greenhouse beds to improve the soil quality. Earthworms aerate the soil and also create worms castings, which are high in nutrients.

Soil fertility can be preserved by rotating plants based on their nutrient requirements. Among the vegetables, the legumes (peas, beans, etc.) are "heavy givers", which means that they actually increase the level of nitrogen in the

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* This information taken from How to Grow More Vegetables, by John Jeavons, Ecology Action of the Midpeninsula, Ten Speed Press, 1979. Length of fertilizer effectiveness is probably based on a six month growing season.

soil. Fruiting vegetables and greens (tomatoes, lettuce, etc.) are "heavy feeders", or heavy users of nitrogen. "Light feeders" are generally the root crops (carrots, beets, etc.). Heavy feeders should be followed by heavy givers and then light feeders, to give the soil a rest. After this sequence, heavy feeders can be planted again.

Pest Control

Plants are susceptible to a variety of harmful bacteria, fungi, viruses, and insects. These can be controlled by the use of pesticides, or by using organic methods. Because of the harmful effects of pesticides on human health and the survival of beneficial insects, organic methods are used at Urban Options and will be emphasized in this paper.

Since an ounce of prevention is worth a pound of cure, the following prevention techniques will save you a lot of problems in your greenhouse:

1) Maintain a clean greenhouse. Remove dead leaves and debris. Do not reuse old pots without washing and sanitizing. Remove plants that are heavily infested.
2) Keep plants healthy by avoiding temperature extremes in the greenhouse and over fertilizing as well as underfertilizing (some insects attack plants taking up excess nitrogen). Plants under stress are more likely to become sick (like people).
3) Do not destroy beneficial insects such as spiders, centipedes, and ladybugs.
4) Practice crop rotation. Don't plant the same crop in the same place from season to season - the bugs may be there waiting to attack.
5) Practice companion planting. Some plants are known to have a beneficial effect on other plants. Other plants deter insect pests. The organic gardening books in the bibliography can be consulted for specific companions.
6) Put screens on vents, doorways, etc. to prevent pests from entering.
7) Plant resistant varieties. Many plants are available which have been bred to be resistant to a particular disease.
8) Check plants every day for insect infestation or disease.

Once the insects attack, organic pest control involves a variety of methods:

--Insects can be destroyed by crushing them or dropping them in kerosene. This is an effective control method for insects that can be found easily.

--Traps can be set up for some insects. For example, white fly can be controlled controlled by hanging yellow cardboard coated with a sticky substance such as Tanglefoot near infested plants. White flies are attracted by anything yellow.

--Homemade sprays can be used as repellants. Onion-garlic-pepper mixtures and tobacco juice sprays are the most commonly used. A flour-buttermilk mixture can actually kill spider mites by sticking them to the leaf surface.

--Beneficial insects and animals can keep harmful insects under control, and

can be especially useful when there is a large infestation. Ladybugs, for example, eat aphids and spider mites. They can be ordered at the beginning of the summer and kept in the refrigerator, to be released into the garden and greenhouse when necessary. Like most beneficial insects, they will disappear when their food is gone.

--The "organic" pesticides can be used as a last resort to control pests. These are the chemicals such as pyrethrum, rotenone, and sabadilla which are derived from plants. These pesticides are toxic and should not be applied without proper protection from contact with skin, lungs, etc.

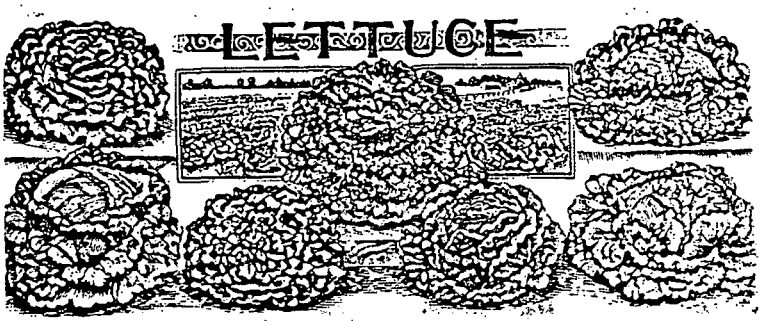
--Sometimes plants can be saved by cutting off the infested parts and starting new shoots. If all else fails, harvest the crop early, clear the greenhouse of plants, and start over when the pest population has died down. These are drastic measures, but they may be preferable to fighting a serious infestation with poisons.

Consult the books listed in the bibliography for specific remedies for a particular pest or disease. These books are available at Urban Options for use by the public.

Plant Propogation

In an unheated greenhouse, starting seedlings or rooting cuttings will be most successful in the winter if it is done in a small enclosed area where heat and light can be provided until the seedlings are large enough to withstand the colder temperatures. At Urban Options, we have set up a bench made of scrap lumber, with a flourescent lamp suspended from a 2 x 4 frame at an adjustable height. In the bottom of the bench, we have an electric heating pad to provide bottom heat. This whole structure, lamp and all, is enclosed in polyethylene. Both the light and the heating pad are plugged into a timer to make sure that they are on only when necessary. This tent works very well for starting plants that require higher temperatures, while eliminating the need to heat the whole greenhouse. On sunny days in the winter, however, it is important to open up the tent when the temperature in the greenhouse reaches 80°F or more.

Now you are as much of an expert as I am. Go and try out your "green thumb". Please come back and share your experiences with us at Urban Options.



TEMPERATURE REQUIREMENTS OF GREENHOUSE PLANTS

Below is a list of some of the plants that can be grown in a greenhouse at different air temperatures. The minimum germination temperature range given indicates the minimum soil temperature required for germination:

VEGETABLES

Hardy (35-70°F) Minimum germination temperature range: 35-40°F

Beet	Spinach	Chives	Fennel
Cabbage	Turnip	Garlic	Potato
Carrot	Escarole	Leeks	Parsnip
Cauliflower	Cress	Asparagus	Rutabaga
Chard	Mustard	Rhubarb	Sorrel
Lettuce	Scallions	Salsify	Artichokes
Onion	Kale	Shallots	Celeraic
Parsley	Corn Salad	Broad Bean	Endive
Pea	Broccoli	Collard	
Radish	Chicory	Horseradish	

Chinese and Japanese Vegetables (these vegetables seem to grow faster in solar greenhouses during the winter than many standard Western greens):

Siew Choy (Celery Cabbage)	Komatsuma
Gai Lohn (Broccoli-like Kale)	Kyo Mizuna
Bok Choy (White Cabbage)	Shungiku
Choy Sum (Flowering White Cabbage)	Seppaku Taina
Dai Gai Choy (Mustard Cabbage)	
Gai Choy (Mustard Green)	

Semi-Hardy (50-90°F) Minimum germination temperature range: 50-60°F

Bean, Pole and Bush	Cucumber	Cowpea
Lima Bean	Celery	Mushrooms
Corn	Melon	
Squash	New Zealand Spinach	

Tender (65-95°F) Minimum germination temperature range: 50-60°F

Pepper	Eggplant	Sweet Potato
Tomato	Okra	Watermelon

FLOWERS

Hardy (40-55°F night temperature)

Alyssum	Azalea (Rhodedendron)	Lavender
Anemone	Larkspur	Honeysuckle
Begonia	Marguerite	Star of Bethlehem
Daisy	Marigold	Dwarf Pomegranate
Calendula	Nasturtium	Oxalis
Carnation	Pansy	Cymbidiums (Orchids)
Chrysanthemum	Primula	All bulb plants (tulips, crocuses, etc.) - rooting phase
Dutch Iris	Snapdragon	
Forget-me-not	Stock	
Freesia	Sweet Pea	
Geranium	Violets	
Camellia	Rosemary	

Semi-Hardy (55-70°F night temperature)

Asparagus Fern	Philodendron	Impatiens
Christmas Cactus	Pionsettia	Nicotiana
Coleus	Zinnia	Petunia
Fuchsia	Orange & Lemon Pot Plants	Amaryllis
Gardenia	Heliotrope	Gladiolus
Gloxinia		Cypripediums (Orchids)
All bulb plants - flowering phase		

Sources of Organic Fertilizers and Pest Control Products

Many hardware stores and garden stores in the Lansing area sell small quantities of blood meal, bone meal, etc. It is much harder to find 50-100 pound bags of organic fertilizers. This store carries large bags of cottonseed meal and bone meal:

Millett Elevator
5607 Millet
Lansing
322-0244

The following companies stock a large variety of organic fertilizers and pest control products. Nature's Way Farm and Karma Acres carry on an extensive mail order business:

Allen's Lawn and Garden Supply
2925 Francis St.
Jackson, Mich. 49203
1-789-8927

Karma Acres
7983 1st Ave.
Gobles, Mich. 49055
616-628-4874

Nature's Way Farm, Ltd.
Philip A. Wheeler
8401 Bollinger N.E.
Vestaburg, Mich. 48891
1-268-5541

Beneficial Insect Sources

Bio-Control Company
13451 Highway 174
P. O. Box 247
Cedar Ridge, Cal. 95924
916-272-1997
Ladybugs, praying mantis, trichogramma wasps

Rincon-Vitova Insectaries, Inc.
P. O. Box 95
Oak View, Cal. 93022
Lacewings, ladybugs, trichogramma wasps, fly parasites, predators for spider mites, mealy bugs, white fly

Biotactics, Inc.
22142 Pico St.
Colton, Cal. 92324
Spider mite predators

Better Yield Insects
13310 Riverside Dr.
Tecumseh, Ontario, Canada N8N 1B2
Source of Encarsia Formosa, a small wasp which parasitizes white fly

Seed Sources - Special Varieties

Sources of midget vegetable varieties are listed on the next page, a handy reprint from Organic Gardening Magazine. Chinese and Japanese vegetables can be obtained from the following companies:

Tsang and Ma International
1556 Laurel St.
San Carlos, Cal. 94070

Kitizawa Seed Company
356 West Taylor St.
San Jose, Cal. 95110

BIBLIOGRAPHY

The most useful books and magazines, in my opinion:

Abraham, George and Katy Organic Gardening Under Glass Rodale Press, Emmaus, Pa. 1975.
Best all-around book on organic gardening in greenhouses. Covers all the basics. Includes a good chapter on growing vegetables.

Jeavons, John How to Grow More Vegetables Than You Ever Thought Possible on Less Land Than You Can Imagine Ecology Action of the Midpeninsula Ten Speed Press, P.O. Box 7123, Berkeley, Cal. 94707, 1979
Excellent introduction to the biodynamic/French intensive method of horticulture. Excellent reference for companion planting and spacing of vegetables in beds.

Taylor, Kathryn S. and Gregg, Edith W. Winter Flowers in the Greenhouse and Sun-Heated Pit Chas. Schribner's Sons, N. Y., 1941, 1969
Great book for flower lovers, by two women who have been using their solar greenhouse since 1940. Unfortunately, this book is out of print again. By some miracle, however, the East Lansing Library has a copy.

Solar Greenhouse Digest, Twila de Vries, Ed., P. O. Box 2626, Flagstaff, Ariz. 86003. Subscription price $10.00 per year (6 issues).
Lots of interesting articles for the enthusiast.

Organic Gardening Magazine, Rodale Press, Emmaus, Pa. 18049; Subscription: $10 per year.
This magazine occasionally has good articles on horticulture in solar greenhouses, based on experiments in the solar greenhouse at the Rodale Farm.

Bug Books:

Yepsen, Roger B., Jr., Ed. Organic Pest Protection Rodale Press Inc., Emmaus, Pa. 1976
Encyclopedia of plant pests and diseases, organized by the type of plant.

Philbrick, Helen and John The Bug Book: Harmless Insect Controls Garden Way Publishing, Charlotte, Vt. 1974
Has a good list of spray recipes, although the ingredients of some of the sprays are rather exotic.

Fichter, George S. Insect Pests Golden Press, N. Y. 1966
Color pictures of harmful insects.

Other References:

Pierce, John H. Greenhouse Grow How Plants Alive Books, Seattle, Wash., 1977
May be useful to those who are interested in greenhouse accessories and nonorganic horticulture.

Abraham, George and Katy Raise Vegetables Without a Garden Countryside Books, Barrington, Ill. 1974
About container gardening.

These solar greenhouse books include information on horticulture:

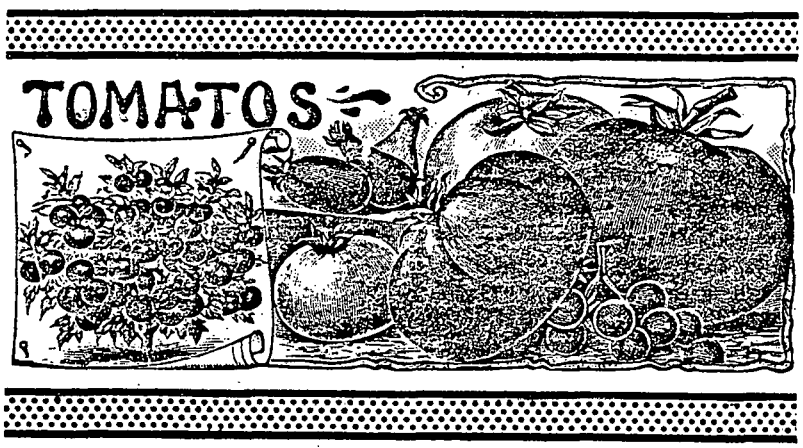
Yanda, Bill and Fisher, Rick The Food and Heat Producing Solar Greenhouse John Muir Publications, Santa Fe, N.M. 1980

McCullough, James C., Ed. The Solar Greenhouse Book Rodale Press, Emmaus, Pa. 1978

Nearing, Helen and Scott Building and Using Our Sun-Heated Greenhouse Garden Way Publishing, Charlotte, Vt. 1977
Information on overwintering vegetables in a very inexpensive solar greenhouse.

DeKorne, James The Survival Greenhouse Peace Press Culver, Cal. 1978
Describes aquaculture and hydroponics in a pit greenhouse.

The books and magazines listed above are available for use by the general public at the Urban Options Energy House.



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WHERE TO GET CONTAINER VARIETIES

SEVERAL OF THE vegetable and fruit varieties recommended for container gardens, especially the All-America winners, are available from many of the reliable mail-order seed firms seen regularly in O.G. Sources for varieties discussed in this article include the following:

VEGETABLE	VARIETY	SOURCES
Bush Beans	TOP CROP	1,2,3,4,5,7,9,11,12,16
	HONEYGOLD	13
Cabbage	DWARF MORDEN	3,12
	BABY HEAD	4,5,9,13
Cantaloupe	MINNESOTA MIDGET	1,3,5,9,11,14
Carrots	BABY FINGER NANTES	13
	SHORT 'N SWEET	1,14
	GOLDINHART	1
	LITTLE FINGER	1,16
	TINYSWEET	2,3,12,16
Casaba Melon	GOLDEN BEAUTY	1
Cucumber	SPACEMASTER	1,13,14
	PATIO PIK	3,4,7,9,10,11,13
	BUSH WHOPPER	11
	POT LUCK	2,4,5,7,9,10
	BURPLESS	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16
Eggplant	DUSKY	1,2,3,6,11,13,15
Endive	BATAVIAN	1,8,10,13,16
Kale	BLUE CURLED SCOTCH	1,4,6,7,9,11,16
Lettuce	GRAND RAPIDS	1,3,4,6,9,12,13,16
	RUBY	1,4,5,6,9,10,11,13
	TOM THUMB	1,3,4,10,12,14,15,16
	BUTTERCRUNCH	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16
	SALAD BOWL	1,3,4,5,6,7,8,9,10,11,14,15,16
	DARK GREEN BOSTON	1,13
Mustard	TENDERGREEN	1,3,4,10,11,12,16
Onions	BELTSVILLE BUNCHING	13
	ISHIKUSO	14
Peas	DWARF GREY SUGAR	1,2,3,4,5,9,10,11,12
	SUGAR SNAP	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16
Peppers	PARK'S POT	11
	CANAPE	6,10,13
	LADY BELL	6
	NOSEGAY	3
	PINOCCHIO	3
	HOLIDAY TIME	3, 11,12,14
Radish	CHERRY BELLE	1,2,3,4,5,6,7,9,10,11,12,13,14,15
	SCARLET GLOBE	1,2,3,4,8,9,12,13,15,16
	WHITE ICICLE	1,2,3,4,5,6,7,8,9,11,12,13
Spinach	MELODY	1,2,3,6,7,9,11,13
	AMERICA	1,5,9,11,13
	LONG STANDING BLOOMSDALE	1,3,6,7,8,9,10,12,13,16
Strawberry	PYRAMID GARDEN	1,2,3,4,5,9,12
Swiss Chard	PERPETUAL	1
Tomatoes	PATIO	7,9,11,13
	PIXIE	1,13,14,16
	TINY TIM	1,2,3,4,8,9,10,11,12,13
	PRESTO	6
	SWEET 100	1,3,4,6,9,11,13,14,15
	YELLOW PEAR	1,2,5,6,9,10,16
Watermelon	SUGAR BABY	1,2,4,5,6,8,9,11,13,15
	GOLDEN MIDGET	3,5,9,11,12

SOURCES

1–W. ATLEE BURPEE, *300 Park Ave., Warminster, Pa. 18974.*
2–BURGESS SEED & PLANT CO., *905 Four Season Rd., Bloomington, Ill. 61701.*
3–FARMER SEED & NURSERY CO., *Faribault, Minn. 55021.*
4–HENRY FIELD SEED & NURSERY CO., *407 Sycamore St., Shenandoah, Iowa 51601.*
5–GURNEY SEED & NURSERY CO., *2nd & Capital, Yankton, S.D. 57078.*
6–JOSEPH HARRIS CO., INC., *Moreton Farm, Rochester, N.Y. 14624.*
7–JACKSON & PERKINS CO., *S. Pacific Hwy., Medford, Ore. 97501.*
8–JOHNNY'S SELECTED SEEDS, *Albion, Maine 04910.*
9–EARL MAY SEED & NURSERY CO., *Shenandoah, Iowa 51603.*
10–NICHOLS GARDEN NURSERY, *1190 N. Pacific Hwy., Albany, Ore. 97321.*
11–GEO. W. PARK SEED CO., *P.O. Box 31, Greenwood, S.C. 29647.*
12–R. H. SHUMWAY SEEDSMAN, *Rockford, Ill. 61101.*
13–STOKES SEEDS, INC., *737 Main St., Buffalo, N.Y. 14240.*
14–THOMPSON & MORGAN, *P.O. Box 100, Farmingdale, N.J. 07727.*
15–W. J. UNWIN LTD., *P.O. Box 9, Farmingdale, N.J. 07727.*
16–MELLINGERS, *2310 W. South Range Rd., N. Lima, Ohio 44452.*