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IOWA ARCHITECT

July/August 1978

ENERGY ISSUE

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IOWA ARCHITECT

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Cover: This thermogram photo is similar to those which will be used to detect heat loss in communities throughout Iowa. In a thermogram photo, heat loss is illustrated in varying shades of grey. The arrow on the left points to a home (dark roof) which is well insulated while the arrow on the right shows a residence (light roof) which is wasting energy.

SOLAR ENERGY ARCHITECTURE FOR IOWA

By David A. Block AIA & Lawrent Hodges Ph.d.

INTRODUCTION

A building designer could pay little attention to energy considerations if energy prices were low and if an ample energy supply were assured. However, the large increases in fuel costs of recent years and the disruptions in the energy distribution system (blackouts, brownouts, natural gas interruptions, etc.) have made energy system design extremely important to the building professional.

The greatest emphasis in the 1970's has, properly, been on energy conservation--designing buildings to decrease the outward thermal flow in winter and the inward heat flow in summer, and using more efficient equipment. Good insulation double or triple grazing, high EER air conditioners, and so forth--these are the best places to put the energy dollar.

No matter how much the building energy load is reduced, however, there remains a need for energy input. Usually this has been in the form of electricity, natural gas, or fuel oil; but there is growing interest in using solar energy for at least part of the thermal input.

To most people a solar energy system for a building means flat-pipe or concentrating collectors, pipes or ducts, valves, pumps or fans, water or rock storage, and so forth--a complicated, sophisticated, capital intensive system. Such "active" systems are becoming more common, more reliable, and more cost-effective, and are often an excellent choice for part of a building's energy dollar.

Another type of solar energy system--the "passive" system--deserves a higher priority than most active systems. A passive system is one in with the thermal energy flow is by natural means. One example is a direct solar gain building in which sunlight is admitted into the interior through large south-facing glazing and stored in massive materials such as adobe, brick, or concrete. Another passive concept is the Trombe wall, a massive wall placed directly behind the south-facing glazing to serve as thermal storage.

Many passive solar energy buildings have been constructed in the past few years, largely in states like New Mexico and California, although a few exist in northern climates. The occupants of passive homes are always enthusiastic about them, because they have low requirements for auxiliary energy, are attractive and comfortable to live in, apparently work well in a variety of climates, can generally be built with standard construction materials at little additional expense, and have little or no maintenance requirements.

To date, passive design has largely been an art based on straightforward principles of physics. The first real scientific information about the performance of passive concepts has been developed in the past years. Most of this work has been carried out at Los Alamos Scientific Laboratory in New Mexico by J. Douglas Balcomb and his colleagues. The federal government began funding passive research only a couple of years ago and the program is now receiving about $4 million a year.

Interest in passive concepts is increasing rapidly. The first national passive conference in Albuquerque in May 1976 was attended by about 600 persons, while the second national conference this past March in Philadelphia drew 1800. As an incentive to use passive concepts, the federal government recently announced a Passive Solar Energy Design Competition and Demonstration.

Can passive principles be used in Iowa? Five passive heating concepts (direct gain, thermal storage wall, sunspace, roof pond, and thermosyphon) and six passive cooling concepts (radiant cooling to the night sky, evaporative cooling, dehumidification, conductive cooling through earth, natural cross ventilation, and natural induced ventilation) have been identified. We believe several of these concepts can be successfully applied in Iowa. In this article, we will concentrate on principles we feel are the most promising for Iowa's climate and environment: the use of direct solar gain, thermal storage walls, and sunspaces for passive heating. We believe there is a virtue to considering active solar systems or active-passive hybrids, and will consider their role. We feel that the use of these concepts and principles offers designers great opportunities to design buildings that are aesthetic and bring their users in closer communion with Iowa's "beautiful land."

PASSIVE SOLAR CONCEPTS

DIRECT SOLAR GAIN

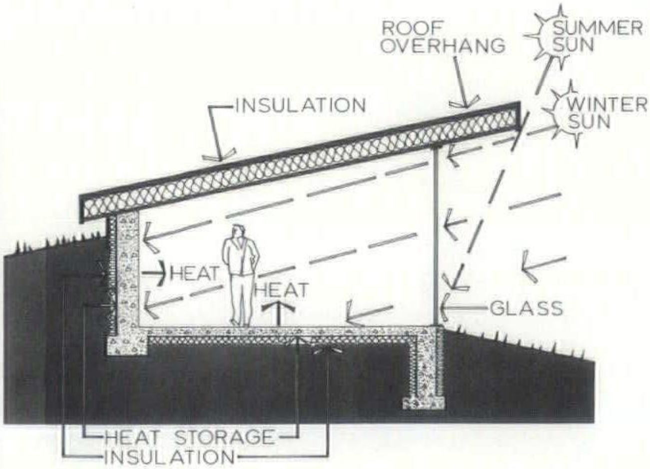
The simplest passive principle is that of direct solar gain: solar energy enters the building through a large expanse of south-facing glass (see diagram). Normally the glass is vertical and can be recessed or shaded by an overhang so that the high summer sun is excluded while the low winter sun can stream into the building.

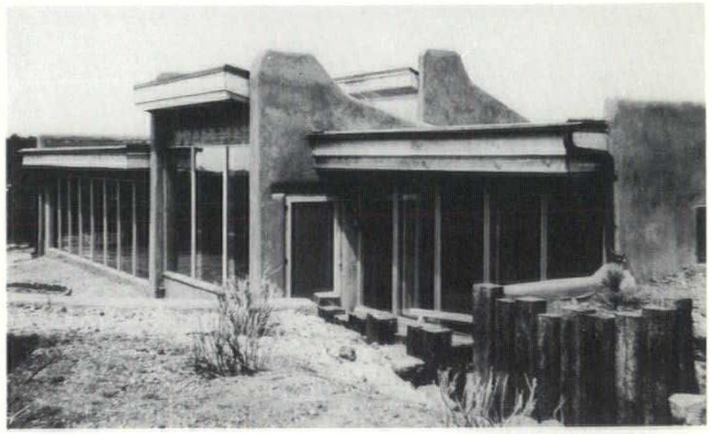
For many buildings, the solar heat gain on a clear winter day can be excessive. It is thus necessary to have materials in the building that can absorb the excess heat. Massive materials such as concrete, masonry, or adobe are suitable for this purpose, as are large containers of water. The minimum amount of mass required has been estimated by Doug Balcomb of Los Alamos Scientific Laboratory to be 150 pounds of masonry or rock or 30 pounds of water per square foot of south-facing glazing if the storage is located in the direct sun, and about four times that amount if it is not in direct sun.

Direct solar gain systems have three possible drawbacks with which the designer should be concerned. The first is that they tend to have significant temperature swings over the course of a day--perhaps 10-15 degrees Fahrenheit or more. Adequate thermal mass will level out the variations since the mass soaks up heat during the day, which decreases the peak temperature, and it releases heat to the building at night, which decreases the drop in temperature. An auxiliary energy system can also smooth out the temperature fluctuations. The other two problems are those of glare from the sunlight streaming into the building and of accelerated fabric degradation due to increased ultraviolet radiation, factors which the designer needs to take into account.

The south-facing glazing can be a major heat loser. Double glazing is recommended even though it will decrease somewhat the radiation passing to the inside; and in Iowa, the use of nighttime insulation behind the window would significantly improve the performance of the solar system.

The largest passive building in the world, the Annexe of St. George's School, Wallasey, England (near Liverpool), is a direct gain building designed and constructed in the early 1960's by E.A. Morgan. It is located in a climate more temperate than Iowa's (16° F warmer in mid-winter), but would appear to be in a poor location for solar energy because it is very far north at latitude 53° N (at winter solstice sunrise is at 8:30 a.m. and sunset at 3:30 p.m.), and the weather is very foggy and cloudy much of the time. However, the school has derived about two-thirds of its heat from direct solar gain and the rest form heat generated by lights and students. The auxilary hot-water system was used only once in the first dozen years, during an electrical blackout.





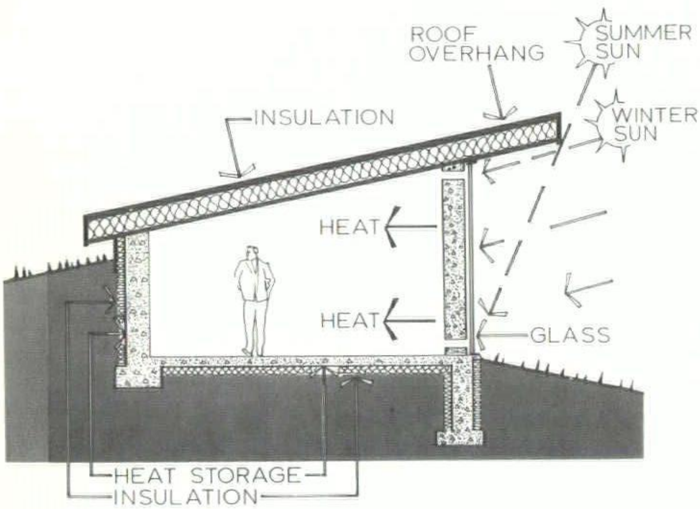
THE NICHOLS HOUSE

Wayne Nichols of Communico, Inc., Santa Fe, N.M., designed and built this passive house. Behind the glazing of each of the wings of the house is a Trombe wall into which two windows have been placed. From the inside of the house, these walls appear to be rather ordinary walls with windows.

THERMAL STORAGE WALL

A thermal storage wall system differs from a direct gain system in the placement of the thermal mass, which is in the form of a wall located directly behind the south-facing glazing (see diagram.) The wall may be poured concrete, concrete block, adobe, or any other masonry construction, or it may consist of large containers filled with water.

The Trombe wall (named after Felix Trombe, who first used it in France in 1967) is a concrete wall about one foot thick, placed between the glazing and the interior of the building. The south side of the wall should be a dark color for good absorption of the solar radiation that falls on it. During the day, the south surface of the wall may heat up to about 150° F. The thermal energy diffuses through the wall and the building interior is heated by radiation and convection from the interior surface of the wall. The wall stores a great deal of heat to permit considerable nightime release. The wall can also be built with ports at the bottom and top to provide a natural convection path during daytime; cold interior air is drawn through the bottom ports into the space between the wall and the glazing and returns, much warmer, through the ports at the top. To prevent nightime heat losses by a reverse air flow, automatic backdraft dampers are needed; these may be as simple as light dampers of plastic film.



Careful tests of Trombe walls in small test buildings have been carried out by Doug Balcomb at Los Alamos. His measurements and computer simulations of the experimental results show that in any climate, a Trombe wall works best if it has a thickness of about 12 to 16 inches. The masonry should have a high density (100 pounds per cubic foot or more). The wall's interior surface will then remain at a fairly uniform temperature of about 85° F and release heat into the room.

Another type of thermal storage wall is the water wall, such as tall fiberglass cylinders filled with water, or 55 gallon drums of water laid on end or on the sides. The performance of a water wall is usually a few percent better than that of a Trombe wall because the convective currents in the water transfer the thermal energy throughout the storage very quickly, reducing heat losses at the south surface. Water has a high heat capacity so only about 30 pounds of water are needed per square foot of south glazing, and the wall need be only eight or nine inches thick for optimum performance.

One major disadvantage of the thermal storage wall is it may block the view to the outside (in some circumstances, of course, that might be an advantage). This has sometimes been remedied by placing windows or other openings in the wall itself (see the Nichols house on the facing page). Another disadvantage is that the wall takes up space, reducing the usable depth of the interior by approximately 1½ feet. However, this type of passive system has excellent durability and freedom from maintenance.

Doug Balcomb has made calculations of the solar heating fraction obtainable from an 18 inch Trombe wall (perhaps a bit thicker than optimal) with vents having dampers to prevent reverse thermocirculation. For a building heating load of 12 Btu per degree-day per square foot glazing, the Trombe wall was calculated to meet about 42 percent of the heating needs in Madison, Wisconsin (7838 degree days, 1961-62 weather data) and 59 percent in Lincoln, Nebraska (5995 degree days, 1958-59 data).

A rough estimate is that a well-designed Trombe wall system in an energy-efficient house in Iowa could satisfy half of the heating needs of the residence.

SUNSPACES

A sunspace is a secondary space, isolated from the living areas of a building, which receives direct gain sunlight and stores it in massive materials (see diagram). It may be regarded as an intermediate concept between the Trombe wall system (in which the storage is adjacent to the south-facing glazing) and a direct gain room (in which the storage is distributed throughout the room).

An example of a sunspace is a greenhouse on the south side of a house. The back wall of the greenhouse separates it from the living space. The thermal storage may be this back wall, the floor of the greenhouse, or other massive materials in the greenhouse (such as rock beds, benches, or containers of water). The amount of storage should follow the rule of thumb given in the discussion of direct gain systems.

The sunspace need not be used as a greenhouse, but may serve as an atrium, a sunporch, a sunroom, or for some other purpose. The sunspace can be allowed to have large temperature fluctuations, particularly if it is unoccupied. If it is used as a greenhouse, the plants may be able to tolerate (or even thrive on) these temperature swings.

Some care must be exercised in the design of a sunspace to ensure that the thermal storage is adequate and that the transfer of heat into the living space occurs at a suitable rate. One solution is to have a massive wall with controllable openings (such as doors or windows) between the sunspace and the living areas.

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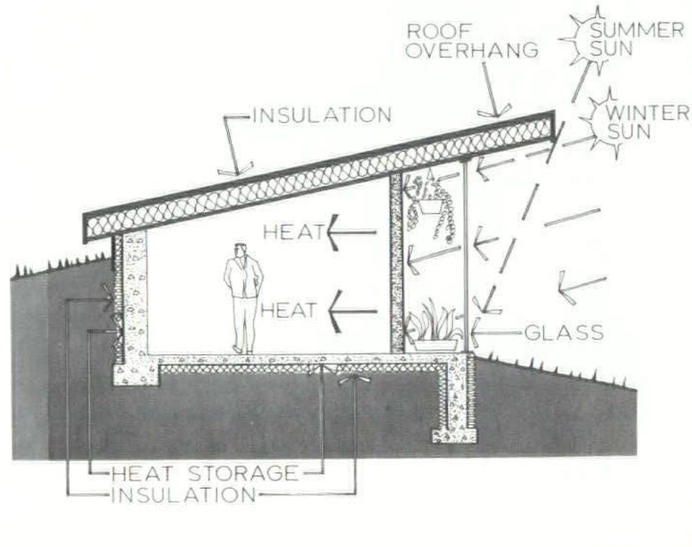

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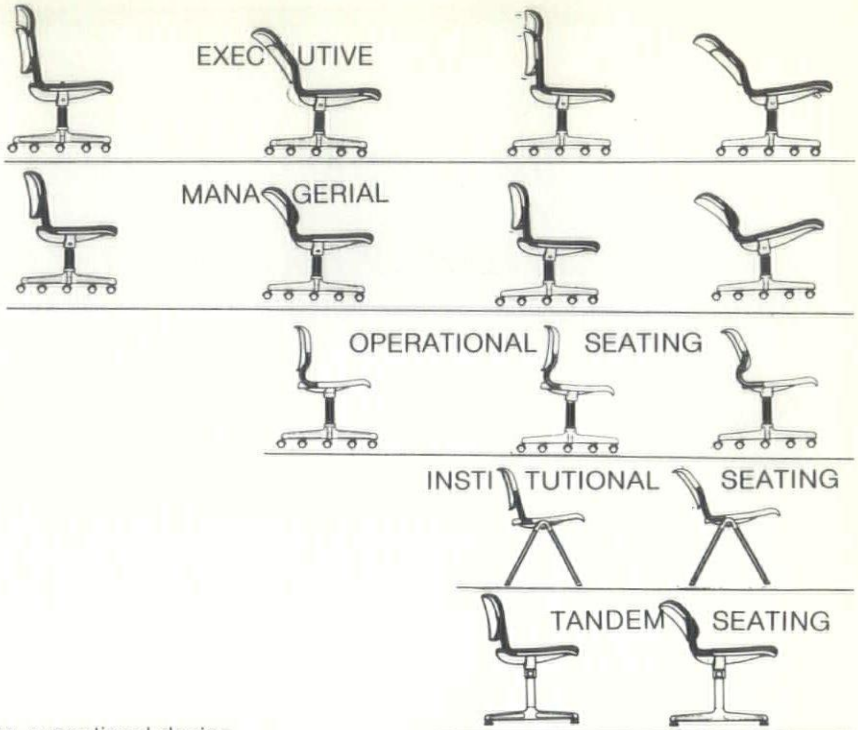

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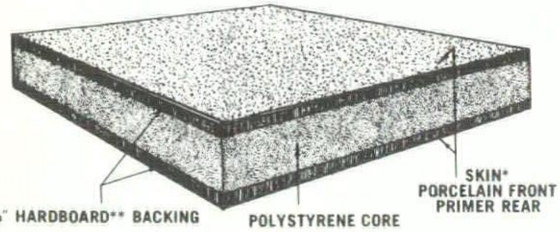

INSULATED PANELS

APPROX. THICKNESS	"U" FACTOR	R-VALUE
1"	.193	5.20
1¼"	.153	6.56
1¾"	.108	9.27
2¼"	.084	11.97
3¼"	.058	17.38

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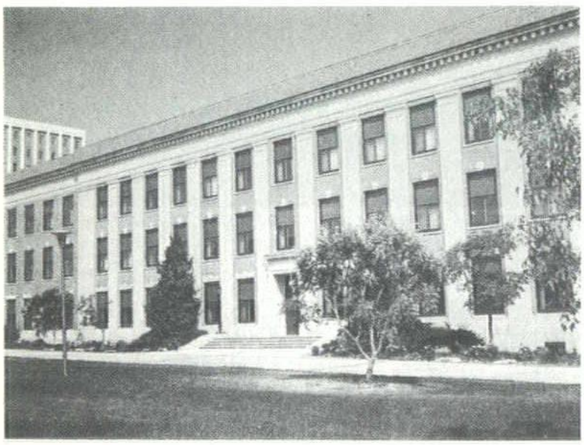

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The U-value of a product is a measurement showing the BTU loss passing through a square foot of material per hour per each degree of temperature difference. The lower the U-value the more effective the material. R-value is another method of measuring insulation. The higher the R-value the more effective the product.

The following are approximate typical U-Values and R-Values for a variety of products.

PRODUCT	U-Value	R-Value
¼" glass	1.10	.91
1" insulated glass	.56 to .62	1.79
4" brick	1.25	.80
6" pre-cast	2.08	.48
8" concrete block	.90	1.11
4" brick and 8" concrete block	.52	1.91
MAPES 1" INSULATED PANELS	.193	5.20
MAPES 1¼" INSULATED PANELS	.153	6.56
MAPES 1¾" INSULATED PANELS	.108	9.27
MAPES 2¼" INSULATED PANELS	.084	11.97
MAPES 3¼" INSULATED PANELS	.058	17.38
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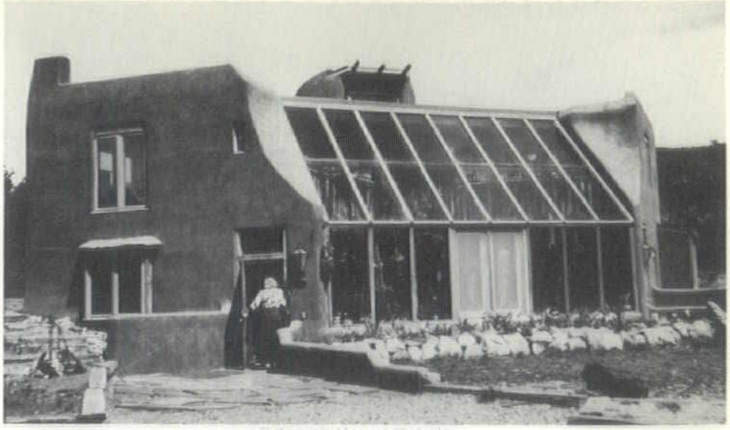
BALCOMB HOUSE

Doug Balcomb's house near Santa Fe, N.M., which was designed by Wayne and Susan Nichols, is an example of a sunspace (or greenhouse) passive system. The two-story 2300 ft adobe building wraps around a south-facing greenhouse. Heat is collected by direct gain into the greenhouse. Warm air rising to the top of the greenhouse is blown to two rock storage beds. The adobe walls also act as thermal storage. Cooling is by ventilation through windows, doors in the greenhouse, and high vents. Auxiliary heating is by electric baseboard heaters in each room. During a recent 6400 degree-day winter, the home used only 857 kilowatt-hours ($38) of auxiliary energy.


Balcomb House Exterior

ACTIVE SOLAR COLLECTION

An active solar collection system uses a heat transfer medium (air or a liquid) to remove heat from the solar collector panels, and may use that heat to heat the building directly, to produce domestic hot water, or to build up thermal storage. The components of an active system are the collector, transfer loop, transfer medium, load (building), and remote storage. The recommended active collectors are flat plate collectors because they are considerably cheaper per Btu collected than alternatives (such as concentrating collectors) and they are better suited to the collection of the low temperature energy required by buildings. Active solar collectors must be used if low tolerances of temperature variance are desired and a high degree of control is required. The systems can be made to perform automatically with as high a level of comfort as a conventional furnace.

Office buildings, commercial installations, and some residences are the primary candidates for this type of solar system.


Balcomb House Interior

BOWLES RESIDENCE

The Bowles residence designed by author Dave Block is nearing completion in Indianola, Iowa. It is primarily an active solar system building although some passive principles are also employed. Incoming solar heat is transferred to a water storage tank. Domestic hot water is constantly preheated by the storage tank (to 140° F in the summer). The main storage tank is then utilized to heat the house. A hot water heating fireplace is also incorporated for additional heat production and back-up potential. The heat pump is primarily for summer cooling but could be used for winter heating during extended cold cloudy periods.

HYBRID SYSTEMS

Hybrid systems are those using two or more of the solar concepts described in this article. For example, a large expanse of passive glass could be used as the major space heating source, but if too much heat is coming in and the interior is overheating, the additional heat could be transferred to remote storage by fans; this would allow some bridging between sunny days. A common type of hybrid system is one in which both passive glazing and flat-plate collectors are used, perhaps the

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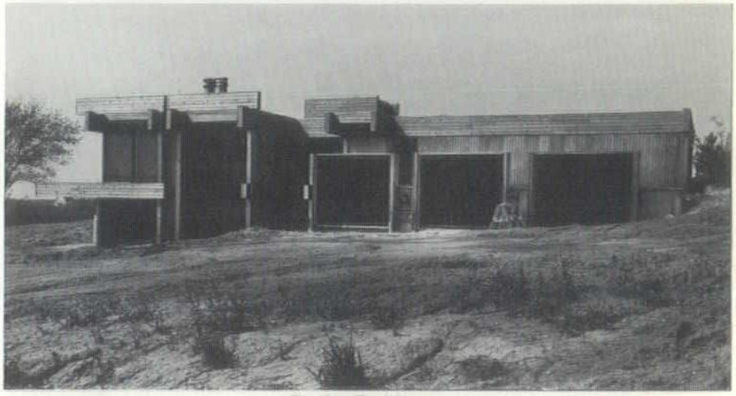
Bowles Residence

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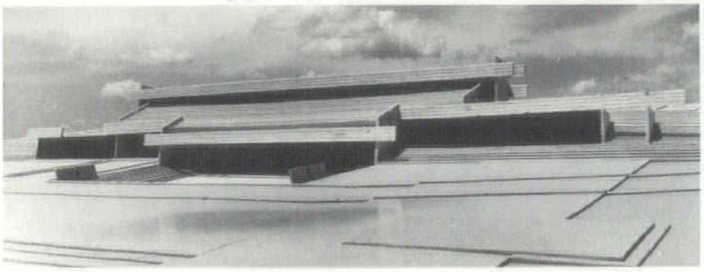
former for space heating and the latter for domestic hot water heating. Owner manipulation and future change is enhanced by the use of hybrid systems, which may become increasingly desirable.



THOMPSON RESIDENCE

The Thompson residence (scheduled for Fall 1978 construction in Garden City) is an example of a hybrid system. The passive concept of direct gain is the major heating principle, with the necessary thermal mass on the interior of the building. Three hundred and twenty square feet of glass is employed for direct gain. On the sides are 100 square feet of active solar collector capable of bridging 1½ cloudy days. A fireplace will be used as back-up. Because of the low heat loss of the residence, additional components are not anticipated. Overhangs are designed for sun control so that no summer sun hits the passive glass to cause interior overheating.

SOLAR COOLING

We are saying little about solar cooling in this article. If the building is properly designed, the cooling loads in our climate can be greatly reduced and conventional cooling equipment (such as a heat pump) is attractive. Active solar cooling systems (such as absorption cooling systems) have high initial cost and short yearly time usage in Iowa, making their payback periods exceedingly long. Passive cooling techniques can be very helpful and should be considered by the designer; these may include windows that open for natural cross ventilation or ventilation induced by the solar heatlng of air near a high vent in the building.

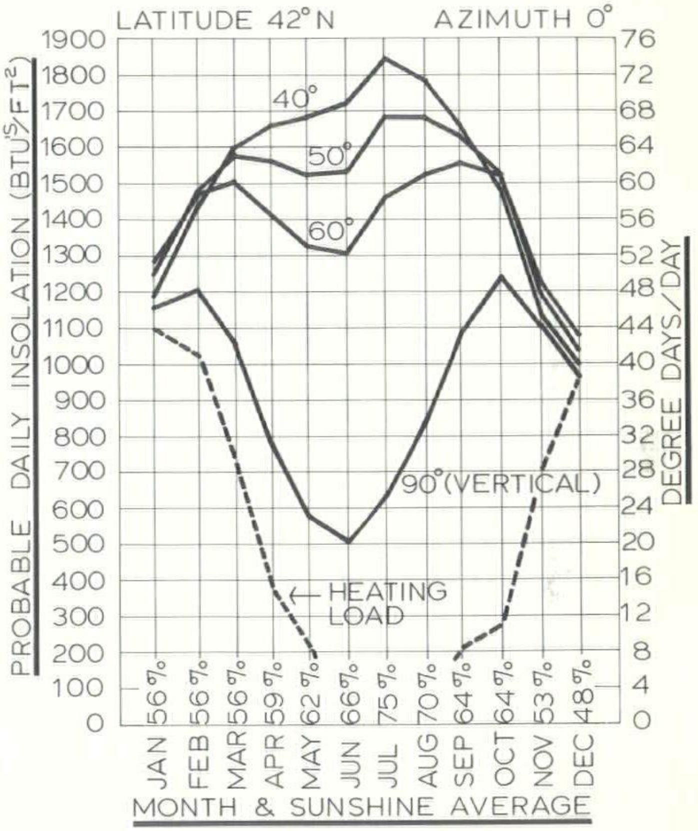
INSULATION DIAGRAM PRINCIPLES

The solid curves on this graph show (For each month of the year) the average probable daily insulation (in BTU per square foot) on surfaces which face due south (zero azimuth) and are tilted at various angles to the horizontal.

The data refer to surfaces located at 42° N latitude (Ames, Iowa) and assume average cloud cover typical of Des Moines for that month. During December, the maximum clear day insulation for a vertical surface (90° tilt) averages 1573 Btu/ft., but the probable daily insulation taking cloud cover into account is only 1000 Btu/ft. as plotted. The actual amount of heat collected will, of course, be a function of the efficiency of the collector used.

What is the best tilt to use? If the solar system is intended to provide space and domestic water heating, as would be the case in Iowa, the usual answer is something like latitude plus 15°, or 55° to 59° in Iowa.

The curves show that tilt angles of 40°, 50° and 60° are all essentially equivalent during the major heating months of December, January and February, with 60° having a slight edge. To determine the tilt that would provide the maximum annual solar. contribution to the heating load of a building, the designer would need to carry out a careful calculation using detailed weather data and tested performance curves for the type of collector used. The similarity of the curves during the heating months suggests, however, that a choice of tilt based on aesthetic considerations would probably have only a minor effect on performance.



Vertical south-facing glazing--often used in passive systems and occasionally encountered in active systems--is an excellent alternative, as shown by the curve labeled 90°. During November, December, and January-- a period including two of the three major heating months--a given expanse of vertical glass receives about as much insulation (90 percent or more as much) as an equal area of glazing tilted 40°-60°. During the summer the insulation on a vertical surface drops sharply--a very desirable situation that can be further improved by using an overhang for shading. (By contrast, collectors tilted 40°-60° are difficult to shade.)

During the months of February and March, which have substancial heating requirements, a vertical collector receives significantly less insulation than a 40°-60° collector. However, the average heating requirement, shown by the dashed line and expressed in degree-days per day for Des Moines, follows a curve remarkably

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THE ENERGY SITUATION

by Maurie Van Nostrand
Chairman Iowa Energy Policy Council

INTRODUCTION

Each day now, the United States is taking 150,000 barrels of imported crude oil and dumping it back into pumped-out wells in our country. This is to be retained as a reserve to provide some protection should one or more foreign producers shut off the flow of oil to the United States.

But let me put this bit of good energy news in perspective. At that rate of flow into reserve--150,000 barrels each and every day--in a 30 day period we can accumulate enough oil to provide for this nation's needs for just **six hours.**

In 1977, 46 percent of all the oil we used was imported. That is a staggering fact--and an indisputable fact. But Americans seem to refuse to accept it and therefor certainly cannot be expected to accept its perilous implications.

Nothing demonstrates that better than a poll conducted recently. CBS and the New York Times asked people whether they thought the United States imported any oil. The results were depressing--but they make it easier to understand why our political system has not been able to respond to this incomparably serious problem.

That poll showed that 48 percent of those interviewed thought the United States did import **some** oil, 33 percent said no, we did not import **any** oil, and the balance--that good old 19 percent that is always "out of it"--didn't know or care.

Think about that for a moment. Less than half of our people think we import any oil. And I think you will agree it is likely that only a small percentage of our people is ready to acknowledge a widely published fact--that 8.7 million barrels of oil are brought into the United States from countries around the world everyday.

Okay, so we import a lot of oil everyday. What does that mean? It means, for example, that our foreign oil bill of 1977 was approximately $45 billion. The national economic implications of that bring a unanimous response from a professional group whose members seldom agree on anything. American economists--all the way from Walter Heller on the left to Milton Friedman on the right--agree that unemployment cannot be reduced to satisfactory levels as long as that volume of dollars--dollars that ought to be used in building productive and job-creating facilities--is being spent annually buying something that is consumed--figuratively, in a puff of smoke--almost immediately.

Let's compare America's 1977 foreign oil bill with something so we can better understand it. In 1970, just seven years ago, that foreign oil bill was $3 billion. We had a devastating 1400 percent increase in the outflow of dollars for oil since 1970. I believe it would be virtually impossible to find a measure of economic or social activity in America that has shown this kind of castrophic deterioration since 1970.

An interesting exercise is to compare oil imports with agricultural exports. In 1970, when we spent $3 billion for foreign oil, we sold to foreign countries $7 billion worth of farm products. Our agricultural exports were more than twice our oil imports. But in 1977, our farm exports were slightly more than half our oil bill--about $24 billion.

It is obvious the U.S. cannot develop an independent foreign policy with the present dependence on other nations for oil. But making the situation more frightening is this nation's enormous and growing dependence on **dictatorships** for its oil.

Over 40 percent of the oil we import now comes from nations with little or no human rights, where elections are not held, where there is no judicial system, where there is no free press, where there are no checks and balances to provide political stability and protect the citizens against executive abuses.

The current danger is not that the members of OPEC (Organization of Petroleum Exporting Countries) will cut off oil shipment to the United States solely to see us in misery. The big danger is the Arab nations in OPEC will do as they have done four times before--cut off oil shipments to the United States to try to influence our stance regarding Israel. Let there be no doubt how closely the economic welfare of each American is tied to peace in the Middle East.

Today OPEC is setting the price, around the world, for liquid and gaseous energy. OPEC oil landed in the United States today costs about $14.20 per 42-gallon barrel. Regular gasoline refined from that oil alone, with state and federal taxes and local distribution costs added, would cost between 75 and 80 cents per gallon at the pumps in this city. But Oklahoma and Texas oil, under present federal regulations, sells for only $9 per barrel. Why, for heaven's sake, should 100,000 Btu's of energy brought in from abroad be worth more than 100,00 Btu's of energy produced here? Even in ordinary times that doesn't make much sense. But now, with balance of payments deficits about to inundate us, and with the Arab nations in control of our foreign policy, anyone ought to see the wisdom of the principle that American produced energy is worth as least as much as energy brought from beyond our borders.

Prices paid by American consumers for energy **must** reflect cost or replacement cost. An energy policy built on that foundation will put us on the road quickly toward solution of this devastating problem.

Everytime a unit of energy is consumed, enough money must change hands so another unit of energy can be produced--from a reliable, secure source in a manner that will not wreck our nation. Continued deviation from that principle robs our children, deprives the poor of an opportunity for advancement, and guarantees our decline as an economic power.

I think the record is now clear that Americans will not conserve energy for energys conservation's sake. They will conserve energy for one or both of two reasons--that the price of energy becomes a major item in their budgets and thereby causes them to look at possible options to huge and wasteful use--and that there is a visible enemy that can be beat back only by their dedicated action.

Moving prices of energy to their replacement cost--with a simultaneous plea by Congress for citizen help to loosen the Arab stranglehold on our nation, will, I'm confident, bring about energy conservation. And it will result in more domestic energy production. I disagree with the public statements of energy company officials that at some price all the oil and natural gas we want can be produced in and off-shore of these United States. I doubt sincerely, for example, that we could produce in the U.S., regardless of price, the 19 million barrels of oil we are consuming daily.

But we can make an oil-like substance from many things. And by providing American ingenuity an opportunity to work, by giving the American system an opportunity to function, I'm convinced we can move away from the current terrible dependence on other nations for one of our more important commodities.

Please help the folks in Congress. They say the people do not perceive energy to be a problem and that, therefore, any action taken to correct that problem will be unpopular. Tell them you think the energy problem is very serious and you want it given the attention it deserves.

Tell them you're more afraid of the foreign dictators than you are of the Americans who own our energy companies. Tell them you worry about sending $45 billion a year overseas for oil. And ask them who they'll blame for the certain disaster that will result if the Arabs cut off our oil again.

You can help--only if you understand that the Congress of the United States has both the authority and the duty to prevent or correct situations like the current energy problem. The American people are conducting themselves exactly as I'd expect them to do under these circumstances. It is the abysmal performance of the Congress I cannot understand.

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ENERGY CONSUMPTION IN HOMES

By Duke Fulton and David Weiss, Iowa Power

We hear a lot these days about the energy crisis. Some, perhaps too many, believe there is some kind of magic solution to our energy problems just around the corner.

What we must keep in mind is that there is a serious energy problem in this country and in the world. Political sniping of the oil companies for "rip-offs" does not change the basic fact that we are using up our energy resources at an alarming rate.

And still the demand continues to rise. The consumer is not yet totally convinced that certain resources are in short supply. However, he is learning very quickly that the continued heavy use of any of these resources has become costly. (See Chart A) Gone forever are the days of cheap fuels.

One utility industry expert has described the next 40 to 50 years as a transition period between fuel epochs." During this time our energy sources will shift overwhelming dependency from fossil and nuclear fission fuels to the inexhaustible energy from nuclear fusion and the sun itself.

These are the years during which we must buy time by making the best use of energy sources in comparatively abundant supply, as developing the technologies of every alternate source of energy.

Everyone can help. The most important thing we can do as individuals is to practice energy conservation in our homes. Iowa Power has long been committed to promoting insulation and the wise use of energy. This (1978) is the seventh year we have emphasized adequate home insulation through mass media advertising and work with insulation dealers and suppliers. The Company was one of the first utilities in the nation to recognize the advantages of energy conservation through insulation.

Dealers sales figures indicate that as many as 30,000 homeowners in the central and southwest Iowa area served by Iowa Power have reinsulated. In 1975 the Company introduced an insulation financing program which makes it possible for customers to finance up to $500 worth of insulation on their utility bill over a three year period at nine percent simple interest. Close to 2,500 customers have participated to the tune of more than $650,000.

The Operation Sky Scan program conducted throughout our service territory this year also brought forth some interesting results. In addition to bearing out our estimate of the number (30,000) of homeowners who have reinsulated, the aerial heat loss survey also supported our contention that the public is at last becoming interested in conservation.

In 1974 Iowa Power initiated a wise energy use program independent of the general insulation activity. It began with the Dr. Wise Use Energy Diet, a booklet outlining energy costs of appliances and challenging consumers to control their own energy use. The Energy Diet gained wide acceptance and was soon augmented by an energy efficient homes program featuring stringent guidelines for the energy conscious homeowner. To further these efforts, the Company has joined with utilities nationwide in support of the National Energy Watch (NEW). The first nationally organized consumer energy conservation program, NEW recognizes homeowners who conserve energy by improving the thermal integrity of their homes by installing energy efficient systems and appliances and by adopting better use habits.

The guidelines of the National Energy Watch have been set for maximum cost-effectiveness in this climate. If implemented, these standards will repay the individual homeowner for his investment in terms of added comfort, lower operating costs and increased property value. NEW also marks the home as an energy efficient structure, thereby increasing its marketabiltiy. The principles measures of these guidelines include:

INSULATION

The following R-values are recommended as minimum standards for all new homes:

Ceilings	R-30
Walls (frame)	R-19
Floors over vented crawl spaces	R-19
Floors over unheated basements	R-11
Walls between heated and unheated rooms	R-11
Basement walls	R-4

SLAB CONSTRUCTION

The edges of concrete slabs on grade should be insulated 24 inches vertically and 24 inches horizontally. Thermal resistance values should be no less than R-6.

DUCTWORK

All ductwork should be located in conditioned space, or insulated to a minimum value of R-4.

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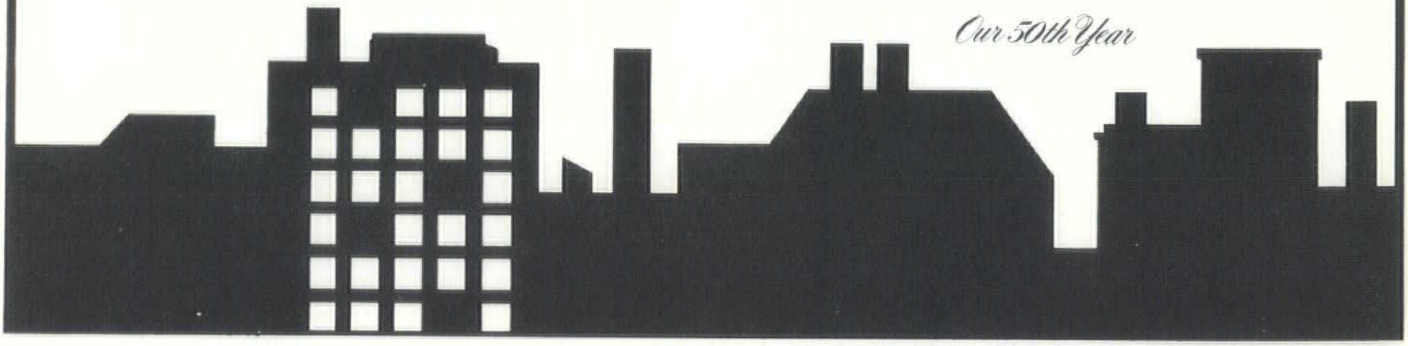

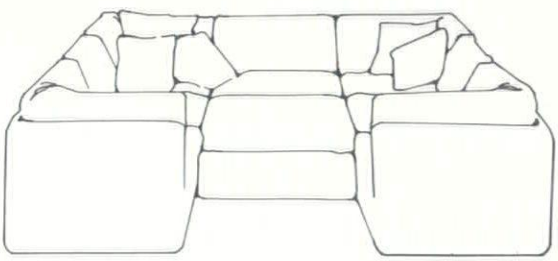

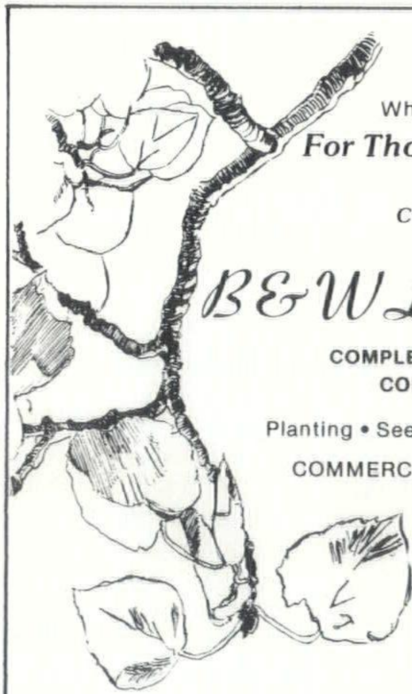

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WINDOWS AND DOORS

Double glazed windows and insulated doors with R-values of three, or storm doors should be incorporated in all buildings. Triple glazing is recommended for additional thermal efficiency.

Air infiltration should be minimized by the effective use of weather stripping, caulking and sill sealing.

COMFORT CONDITIONING

Heat pumps with COP of 1.6 or greater should be carefully considered for all homes. When a gas-fueled system is chosen, the furnace should feature electronic ignition. In addition, installation of an automatic flue damper is suggested.

Central systems incorporating air conditioning should have a minimum energy efficient ratio of 7.5.

Solar assist equipment should be incorporated wherever economically feasible.

Appropriate controls, including set-back thermostats, should be installed to minimize energy consumption.

Non-centralizing heating or cooling systems should incorporate room to room controls.

(Guidelines for certain other areas and for some major appliances are also spelled out in the NEW program.)

These guidelines have been designed to promote optimum energy efficiency. Short of building a home underground, today's technology has probably brought us to the saturation point in terms of reducing heat loss. Energy efficient standards of the 1950's probably reduced heat loss to about 105 Btu/square foot. By 1960 this figure had been lowered to approximately 72 Btu/square foot and as 1970 rolled around heat loss had fallen to approximately 56 Btu/square foot. Today's energy efficient standards have lowered heat loss still further, to less than 40 Btu/square foot.

Energy consumption figures for our residential customers point out an interesting paradox. While annual use of natural gas declines, continuing a trend which began in 1973, the annual consumption of electricity has climbed significantly during the past 10 years.

In 1972 the annual consumption for the average residential natural gas customer was 1,804 Ccf. During 1977 this figure had slipped to 1,484 Ccf. (See Chart B). Obviously the heating season customer has begun to take energy conservation seriously.

But what about electric use? Ten years ago the annual consumption of electricity by the average residential customer totalled 5,285 Kwh. Since then this figure has climbed at a steady rate, peaking in 1977 at 7,400 Kwh yearly. (See Chart B)

Thus, with the increasing demand for more electricity we are compelled to provide additional generation. The

Chart A

IOWA POWER HEATING FUEL COST COMPARISON (January 1978)

COST/MILLION BTU OUTPUT

#2 Fuel Oil

$$\frac{(10^6\ \text{BTU's})\ (\$.43/\text{gal.})}{(140{,}000\ \text{BTU/GAL})\ (.55\ \text{eff})} = \$5.58/10\ \text{BTU's}$$

Propane

$$\frac{(10^6\ \text{BTU's})\ (\$.42/\text{Ccf})}{(92{,}000\ \text{BTU/GAL})\ (.60\ \text{eff})} = \$7.61/10\ \text{BTU's}$$

Natural Gas

$$\frac{(10^6\ \text{BTU's})\ (\$.21/\text{Ccf})}{(100{,}000\ \text{BTU/Ccf})\ (.60\ \text{eff})} = \$3.50/10\ \text{BTU's}$$

Electric Heat Pump

$$\frac{(10^6\ \text{BTU's})\ (\$.0214/\text{kwh})}{(3413\ \text{BTU/KWH})\ (1.5\ \text{SPF})} = \$4.18/10\ \text{BTU's}$$

Electric Resistance Heat

$$\frac{(10^6\ \text{BTU's})\ (\$.0214/\text{kwh})}{(3413\ \text{BTU/KWH})\ (1.0\ \text{eff})} = \$6.27/10\ \text{BTU's}$$

Electric Furnace

$$\frac{(10^6\ \text{BTU's})\ (\$.0214/\text{kwh})}{(3413\ \text{BTU/KWH})\ (.8\ \text{eff})} = \$7.84/10\ \text{BTU's}$$

1. Based on cost per million BTU's output.
2. #2 Fuel Oil at $.43/gal; 140,000 BTU/GAL.
3. Propane at $.42/gal; 92,000 BTU/GAL
4. Electricity at $.0214/kwh; 3,413 B/KWH.
5. Natural Gas at $.21/Ccf; 100,000 BTU/Ccf
6. Natural Gas and Propane seasonal efficiency at 60%
7. Fuel Oil seasonal efficiency at 55%.
8. Electric Heat pump seasonal performance factor at 1.5

Chart B

Energy Consumption Per Iowa Power Residential Customer

ANNUAL AVERAGE

Gas (Ccf)	Year	Electric (Kwh)
1772	1968	5285
1816	1969	5263
1790	1970	6224
1750	1971	6452
1804	1972	6598
1589	1973	6820
1557	1974	6710
1581	1975	7326
1550	1976	7137
1484	1977	7400

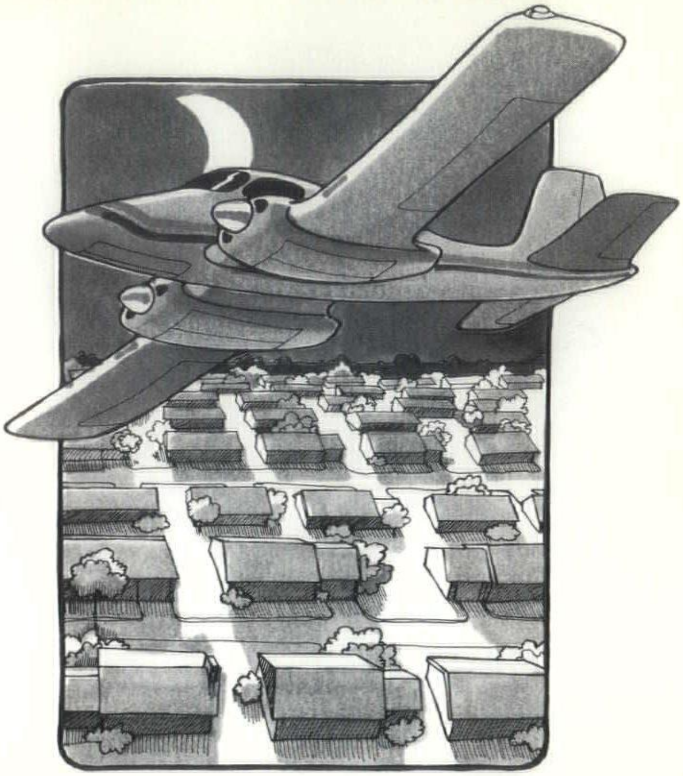
trend (of increasing demand) which has established itself through the years is expected to continue. Energy experts predict electric demand to continue to rise at the historical figure of five to six percent annually.

Will we be able to keep up with this demand? Starting as early as next year, sections of our country may begin experiencing severe power shortages—brownouts as well as blackouts, according to the National Electric Reliability Council (NERC). Here in the Midwest, NERC warns of potential shortages by 1983. Such impending shortages may not last for only a few hours; they could go on for days, weeks, even months.

Can we avoid these shortages? We can if we are able to build sufficient generating and transmission facilities to supply the increasing demand for energy. This is the goal of Iowa Power and utilities throughout the nation.

We're working to avoid energy shortages. But we can't do it without your support. We need to implement all of the guidelines and proven technologies available to reduce energy waste, and we must build new generating plants and transmission facilities, utilizing the best available sources of energy, including coal and nuclear fuel.

With your continued support, there won't be brownouts in your future.



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similar to the insulation on a vertical collector. A vertical collector would produce a solar heating fraction that is very high in the fall (note the ratio of the solid to the dashed curve), drops to a minimum in December (when, it should be noted, it does nearly as well as a 40°-60°collector), and increases through the rest of the heating season.

In summary, a vertical collector is a good choice for Iowa, and has several significant advantages over collectors tilted at conventional angles. This fact is extremely relevant in passive design.

SOLAR ENERGY PRINCIPLES

Many factors influence the decision to incorporate sloar concepts and equipment in buildings. These features include the designer's opinion concerning the future of energy prices and supply; and the availability, cost, and long term reliability of solar equipment.

Solar energy is appealing to many people because they want to be as energy self-sufficient as possible, because they want to reduce the depletion of non-renewable natural resources, and because they favor en vironmentally benign technologies. Nevertheless, we believe most people are interested in solar energy as an economic alternative to other forms of energy, whose prices are rising and whose availability is often uncertain.

Since it is our intent to make solar energy economical as well as functional and attractive, we believe that solar equipment payback, solar building type usage, and solar opportunities for aesthetic architecture should be stressed.

The following ten principles summarize our views on solar energy usage.

PRINCIPLE 1. THE DECISION TO USE SOLAR CON CEPTS REQUIRES A COMPREHENSIVE DESIGN APPROACH TO THE BUILDING AND A THOROUGH ANALYSIS OF THE OCCUPANT'S ENERGY REQUIREMENTS. For example, a house is occupied 24 hours a day whereas a commercial building may be used only 8 hours a day, and sizeable downward temperature swings at night may be better tolerated in the latter. Seasonal building usage is also important. Thus the type and amount of solar equipment and the control mechanisms employed may vary greatly.

PRINCIPLE 2. SOLAR ENERGY BUILDINGS USUAL—LY COST MORE INITIALLY THAN NON-SOLAR BUILDINGS, BUT SHOULD COST MUCH LESS OVER THE LONG TERM. OWNERS MUST BE WILLING TO MAKE AN INVESTMENT IN THE FUTURE. For example, the amount of glass needed for both passive and active solar buildings normally costs more than the wall or roof it replaces. But the utility bill savings over the first few years can recoup this initial investment plus interest costs, ands substantial utility bill savings continue thereafter. In many cases, the extra mortgage payments resulting from the solar investment are more than offset by the lower utility bills. This is particularily true of housing and lower cost structures, but may not be true for office and commercial buildings.

PRINCIPLE 3. ON A PRIORITY BASIS, THE FIRST DOLLAR IN ENERGY MANAGEMENT SHOULD BE PLACED IN ENERGY CONSERVATION. Studies at Iowa State University, Argonne National Laboratory, and some done for private clients indicate that heat loss in winter can be reduced as much as 60 percent through employment of a combination of earth berming, low-aspect ratio (length/width), increased insulation, wind diverters, and glass placement. A slightly lower decrease in heat gain reduction occurs in the summer. Placing first priority on energy conservation is suggested by the very short payback period, the relative ease of inclusion, and the actual decrease in maintenence.

PRINCIPLE 4. THE SECOND DOLLAR IN ENERGY MANAGEMENT SHOULD BE PLACED IN A LIQUID COLLECTOR TO PRODUCE DOMESTIC HOT WATER. The large advantage of solar hot water heaters stem from the fact that this equipment is utilized year round. For example, a small collector can produce 100 percent of the hot water required for a residence for nine of the twelve months and up to 60 percent for the remaining three months. Because hot water usage normally increases in summer as does solar availability, the mating of solar to this demand is most fortunate. Payback periods as short as five years can be expected on some domestic solar applications with substantial savings anticipated from that point on.

PRINCIPLE 5. THE THIRD DOLLAR IN ENERGY MANAGEMENT SHOULD BE PLACED IN SPACE HEATING. IN MOST INSTANCES, ECONOMIC ANALYSIS WILL INDICATE THE USE OF PASSIVE SOLAR CONCEPTS. The primary advantage of passive solar concepts is lower initial cost than active systems. Also, there is no anticipated increase in maintenence because there are no moving parts. Disadvantages are a reduction in interior temperature control relative to a conventional furnace and the absence of heated storage beyond approximately 12-16 hours. Payback periods of 7-10 years are anticipated with these concepts.

PRINCIPLE 6. THE FOURTH DOLLAR IN ENERGY MANAGEMENT SHOULD BE PLACED IN AN ACTIVE SOLAR COLLECTION SYSTEM FOR SPACE HEATING. The major advantages of an active solar system are its temperature control capabilities and its potential for longer-term storage (2-3 days). It can also be incorporated with a domestic solar hot water heating system. Thus cloudy days can be bridged, something passive systems may not do as well. The disadvantages lie in higher initial costs and higher anticipated maintenance in the future. Payback periods of 10-15 years are anticipated on some active systems recently installed in Iowa. These are good quality but inexpensive systems. Extremely sophisticated active solar systems may never pay back and their use should be discouraged.

PRINCIPLE 7. THE USE OF HYBRID SYSTEMS (COMBINATIONS OF ENERGY CONSERVATION, SOLAR HOT WATER HEATING, AND PASSIVE AND ACTIVE CONCEPTS) OFFER THE GREATEST OPPORTUNITIES

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FOR IOWA AND THE MIDDLE WEST. The hybrid systems offer a balance of intial cost control, temperature control, and maintenence, allowing a good fit between solar equipment and occupant demands. In addition, owner manipulation of controls and equipment used can result in an infinite number of options.

PRINCIPLE 8. SOLAR CONCEPTUAL DESIGN AND EQUIPMENT DETAILING SHOULD BE DONE BY A COMPETENT ARCHITECT AND/OR ENGINEER. Although solar concepts are relatively easy to master, the technical pitfalls are numerous and must be solved in total on the drawing board. The national success rate of this approach is nearly perfect, while the failure rate of the do-it yourselfer is very high, with a corresponding level of frustration.

PRINCIPLE 9. THE PAYBACK PERIOD OF SOLAR EQUIPMENT IS DEPENDENT ON MANY FACTORS AND SHOULD BE INCLUDED IN ALL SOLAR CONSIDERATIONS. Payback occurs when initial capital investment of the solar equipment equals the cumulative utility bill savings (properly discounted). Government tax incentives and owner income tax rates also enter into the decision to utilize solar concepts.

PRINCIPLE 10. SOLAR DESIGN OFFERS OPPORTUNITIES FOR AESTHETIC ARCHITECTURE AND FORMS THAT MAKE BUILDINGS MORE RESPONSIVE TO THE OCCUPANTS NEEDS AND MORE IN HARMONY WITH THE CLIMATE AND THE ENVIRONMENT, THESE PRINCIPLES SHOULD BE AN EXPRESSED AND INTEGRAL PART OF THE BUILDING FORM. Some opportunities for exterior as well as interior forms have been discussed in the accompanying explanations and illustrations. We anticipate that solar architecture will increase rather than decrease the quality of life style, and that in the near future, every new building will incorporate a significant contribution from solar energy.

SOLAR DESIGN COMPETITION AND DEMONSTRATION NATIONAL

The U.S. Department of Housing and Urban Development (HUD), in cooperation with the U.S. Department of Energy (DOE), recently announced a Passive Solar Residential Competition and Demonstration open to architects, engineers, builders, and other single family project designers.

Both new and existing homes are eligible. New home projects can be for private owners or for builders who plan to sell the homes on the open market, and must be planned for construction (conceptual designs for imaginary projects are not eligible). Existing home projects must be based on an existing house but may be planned for construction or may be conceptual. Project construction cannot have begun before March 17, 1978.

Design awards will be $5000 for new passive solar homes and $2000 for existing homes.

Winning new home designs for homes to be sold on the open market are eligible for an additional construction award, which will be $7000 for the first home and $2000 each for the second through fifth homes built from a design at the same time.

HUD'S award budget is $2 million, at least 10 percent of which will be allocated for designs applicable to existing homes.

Applications are due in early August and awards will be made by late October or early November. The grant application is available from: RFGA/Passive Competition, Solar Demonstration Program, Room 8158 Department of HUD, Washington, D.C. 20410.

STATE

The State of Iowa, through the Iowa Energy Policy Council, is also sponsoring a solar residential demonstration program for active, passive, or hybrid systems. Grants of up to $3500, not to exceed 50 percent of the cost of the solar system, will be made to award winners. All Iowa residents are eligible. Applications are available from the Iowa Energy Policy Council, 215 East Seventh St., Des Moines, Iowa 50319. Applications are due August 31, 1978.

AUTHORS

Dave Block (left) is an architect-planner from Ames. He is Assistant Professor of Architecture at Iowa State University and is solar energy researcher with the Engineering Research Institute. He has designed and constructed several residences and commercial buildings incorporating active and passive principles.

Laurent Hodges (right) is Professor of Physics at Iowa State University and a solar energy researcher with the Ames Laboratory (DOE(. He has served as Research Director of the Iowa Energy Policy Council and as an energy consultant to the U.S. House of Representatives and to Rep. Tom Harkin. He is the author of the textbook, Environmental Pollution.

Both authors are currently designing their own solar homes incorporating both passive and active systems.

REFERENCE MATERIALS

A. Available From the National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, MD 20850 (or call toll-free 1-800-523-2929):

1 . Passive Design Ideas for the Energy Conscious Architect
2 . Regional Guidelines for Passive Energy Conserving Architecture
3 . Bibliography on Passive Solar Energy Designs and Systems
4 . Bibliography on Underground Houses
5 . Solar Greenhouse Bibliography and List of Plans
6 . Passive Design Tools
7 . Architects and Designers Familiar With Passive Solar Design (list)

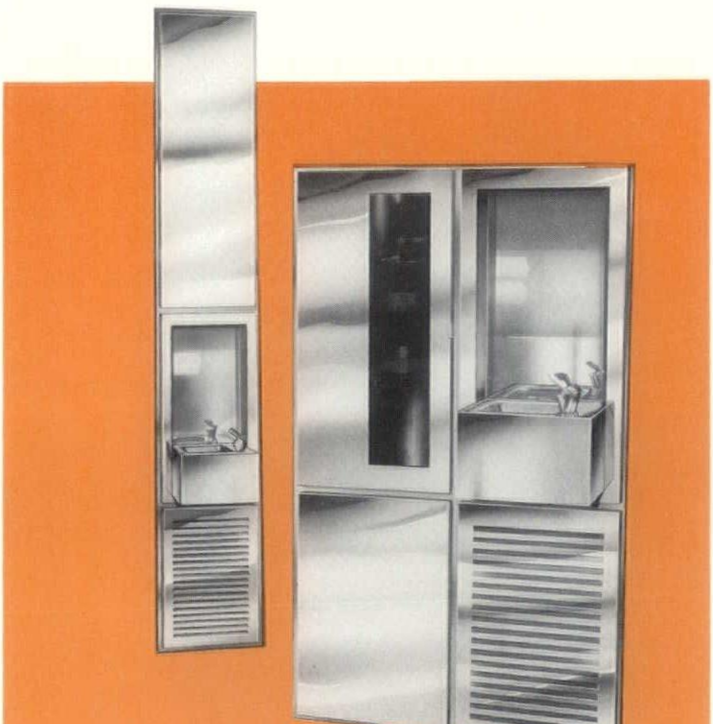
B. Available from DOE Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830:

1 . Passive Solar Bibliography
2 . Survey of Instrumented Passive Solar Systems

C. Available from Superintendent of Documents, U.S. Government Printing Office, Wshington, D.C. 20402:

1 . A Survey of Passive Solar Buildings. $3.75. Stock No. 023-000-00437-2.
2 . Solar Dwelling Design Concepts. $2.30. Stock No. 023-000-00334-1.
3 . Window Design Strategies to Conserve Energy. $3.75. Stock No. 003-003-01794-9.

D. Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161: Passive Solar Buildings: A Compilation of Data and Results. $5.25. SAND 77-1204.



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