Energy Design update

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NEWS

RESIDENTIAL ENERGY - CONSUMPTION DOWN; COSTS UP; CONSERVATION POTENTIAL STILL GREAT

The average household in the U.S. used 17 percent less energy in 1981 than in 1978 but paid 41 percent more. Based on data from 83 million homes, the newly released Residential Energy Consumption Survey shows that as of March, 1982, the typical home used 114 million Btu's per year.

Oil consumption showed the most significant decrease, 20.2 percent, followed by natural gas at 11.4 percent. Electricity and LPG showed less decline (Figure 1). By region (Figure 2), greatest reductions in average household consumption were in the North Central and Western states (18.3% and 18.1% respectively), followed closely by the Northeast (16.9%). Energy expenditures are still climbing, however, with the average household spending over $1000 per year (Figure 3). Hardest hit was the oil-dependent Northeast with a 61 percent rise in total energy expenditures between 1978 and 1980. Of no surprise was the finding that low-income families suffered the greatest burden, spending up to 22 percent of total income on energy.

Average energy consumption per household is still much above the practical minimum. Even small houses in mild climates (less than 1000 square feet;

TRENDS IN ENERGY CONSUMPTION, 1978-1982.

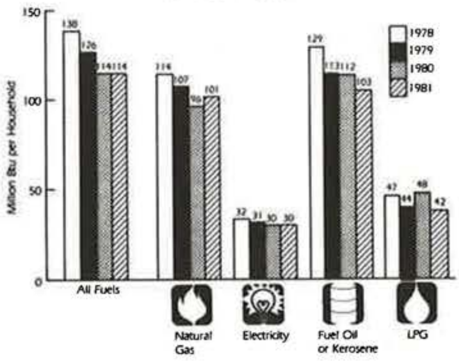

Figure 1
Average Household Total Energy Consumption of All Fuels and of Specific Fuels—1978, 1979, 1980, 1981
(Million Btu per Household)

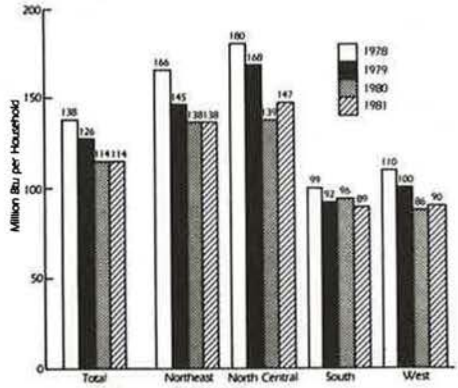

Figure 2
Average Household Total Energy Consumption, by Region—1978, 1979, 1980, 1981
(Million Btu per Household)

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less than 4000 degree days) consumed the equivalent of about 790 gallons of oil per year. Cost-effective methods of energy-efficient construction and retrofit have already demonstrated the practical capability to reduce total consumption far below that level. Unless energy prices show consistent decline, the demand for energy conservation technology is likely to increase, particularly for low- to moderate-income households.

A complete copy of the RECS survey is available free from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; (202)783-3238. The order number is DOE/EIA-0321/1(81).

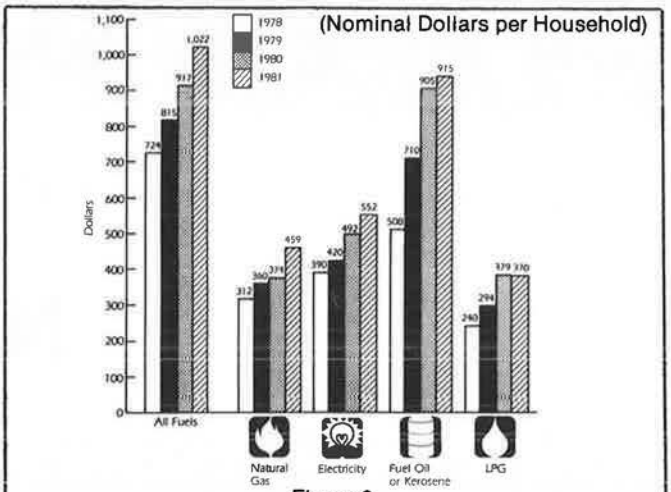


Figure 3
Average Household Expenditures for All Fuels and for Specific Fuels—1978, 1979, 1980 and 1981

FRAUDULENT ADVERTISING BRINGS CIVIL PENALTIES TO TWO INSULATION MANUFACTURERS

According to a Federal Trade Commission (FTC) complaint, Thermtron Products Inc., a manufacturer of cellulose home insulation, knowingly violated the so-called "R-value Rule." FTC charges that Thermtron's products were tested according to procedures other than those specified by the Rule, resulting in inflated coverage-area values. The company and its two principal officers must pay $42,500 in civil penalties. Located in Fort Wayne, Indiana, Thermtron manufactures products under the following names: Atik, Easyway, Oren, and Thermtron Series 500, 501, 600, and 601. Last February, the FTC imposed a similar penalty on Pacific Coast Manufacturing Co. of Bothell, Washington, for overstating the effectiveness of its cellulose insulation product. Considerable controversy exists in the cellulose industry over acceptable methods for testing cellulose for "settled density." Several manufacturers claim that the test required by FTC overstates settled density and underrates their product. Copies of the complaint and consent decree are available from the FTC's Public Reference Branch, Room 130, 6th St. and Penn. Ave. N.W., Washington, DC 20580; (202)523-3598.

PRICES FOR AIR-TO-AIR HEAT EXCHANGERS MAY DROP

Generally considered overpriced, the air-to-air heat exchanger has been a difficult extra cost for many builders to swallow. Still a fledgling industry, heat exchanger manufacturing has not yet reached mass production levels - most units are assembled by hand in small shops. But the industry has been growing and changing. According to Tony Calderone, director of engineering and sales at Des Champs Laboratories Inc. of East Hanover, New Jersey, which manufactures EZ-Duct, the price of heat exchangers will drop 50 percent within the next eight years. Des Champs is about to automate the EZ-Duct production line and may be the first to drop prices. Greatest price drops will occur if and when major appliance producers are drawn into the heat exchanger market. KeepRite of Canada, for example, which supplies hardware to several large appliance manufacturers, is almost ready to market its heat pump ventilation heat-recovery unit for about $800 (see Sept. 1983 EDU).

NATIONAL ENERGY PLAN INCLUDES CONSERVATION AS A RESOURCE

Released last month, the new "National Energy Policy Plan" recognizes energy conservation as an important energy resource - "a set of actions that individuals and businesses can take that are cost-effective alternatives to new supply and development." Energy conservation is recognized in the plan as the most important of three areas of energy programs. Second and third are research and development and energy security. Given this official awareness that saving energy is equivalent to producing it, perhaps we will see federal programs which give equal treatment to conservation investments as compared with solar and other renewable energy investments. At present, federal tax credits, for example, give preferential credit to solar energy compared to conservation. Full copies of the plan are available from the U.S. Department of Energy, Washington, DC 20585.

GAS STUDY SAYS BUYERS WANT EFFICIENT PRODUCTS

A study by Hayes/Hill Inc., supported by the Gas Research Institute, shows that purchasers of heating, ventilating and air conditioning equipment are willing to pay more for energy-efficient products provided that the cost can be recovered through reduced operating expense in about three to five years. The study, entitled "Structural Market Analysis of Space Conditioning Equipment for the Residential Sector" (Order No. PB83-195404), is available for $11.50 from the National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161.

NAHB PRESIDENT CITES LACK OF INFORMATION ON ENERGY-EFFICIENT CONSTRUCTION

The reason that passive solar building techniques have not made further progress is because builders don't have sufficient, detailed, reliable data for predicting performance of solar features. So stated Ralph Johnson, President of the National Association of Home Builders (NAHB). Speaking in an interview with ASES News, Johnson said, "If you're going to charge more money for something solar, the buyers naturally want to know: what am I going to get for that extra money?" Current methods for predicting passive solar performance are often too unfamiliar to the average builder to be of much use. The NAHB Building Energy Design Tool Council is now working to develop more practical design tools for builders.

SUPERINSULATION CONFERENCE PROVIDES "MARKET READY" INFO TO BUILDERS

Of the 150 people in attendance at last month's conference on "Superinsulation for the Mid-Atlantic Region," almost all were builders. An excellent presentation by Prof. Howard Faulkner of the University of Southern Maine opened the conference and was followed by a series of practical lectures on vapor and moisture, insulation systems, double wall systems, truss and cathedral ceiling systems, residential air quality, heating systems, air-to-air heat exchangers, and glazing systems. A question-and-answer session during the first evening showed that many of the attending builders were already familiar with energy-efficient construction and are now in need of specific targeted information on how to optimize designs and field practices.

PROFESSIONAL SEMINAR SERIES TO BE OFFERED BY EDU

ENERGY DESIGN UPDATE will produce its third series of seminars on super-energy-efficient construction next spring. Coordinated by EDU editor Ned Nisson, the seminars will be targeted toward the practicing field professional. Cities and dates will be announced in our next issue.

DREXEL TO STUDY MOISTURE PROBLEMS IN BUILDINGS

The Center for Insulation Technology at Drexel University has been awarded a $48,000 grant to study moisture transfer in insulation materials. Headed by Dr. Steve Benner, assistant director of research, the project intent is to generate practical information concerning moisture in building insulation, primarily fiberglass. Another Drexel Center project, funded by Certainteed Corporation, is looking specifically at moisture's effects on the R-value of sprayed-on fiberglass ceiling insulation. Both studies should help fill the partial information void in this important area of building technology. For more information, contact: Dr. Steve Benner, Center for Insulation Technology, Drexel University, Philadelphia, PA 19104; (215)895-2233.

RESEARCH & IDEAS

AND NOW, INDOOR SMOG

Indoor air quality is a relatively new issue for the residential building community, but not for the commercial/industrial sector. Since 1977, there has been a dramatic increase in the number of requests for "health hazard evaluations" initiated by occupants of sealed office buildings who are suffering from illnesses which they believe to be "building related." A recent research study investigating the possible causes of specific health problems hypothesized that some ailments may be due to the formation of photochemical "smog" inside the building. Some of the complaints reported in buildings are the same as those reported for photochemical smog outdoors. Also, many of the vapors associated with the formation of photochemical smog outdoors are also found in the typical office building. Finally, smog formation is accelerated by ultraviolet (UV) light and many fluorescent lamps in buildings have detectable UV emissions. A full copy of the report, entitled "Air Quality in Public Buildings with Health-Related Complaints," by Sterling, Sterling and Dimich-Ward, will be published in the 1983 ASHRAE Transactions, available from ASHRAE, 1791 Tullie Circle N.E., Atlanta, GA 30329.

AERIAL INFRARED THERMOGRAPHY FOUND TO BE OF LIMITED USE

A study by the National Bureau of Standards has found aerial infrared thermography to be of limited use for detecting insulation defects in houses. During the 1970s, several programs were instituted by government and utilities to encourage community energy conservation by displaying aerial infrared photographs that showed some houses with "glowing" roofs, indicating the need for attic insulation. However, according to the NBS study, the aerial thermograms cannot be used to reliably detect insulation defects because many factors besides insulation affect the surface temperature of the roof skin on a house - indoor and outdoor air temperatures, air leakage, wind conditions, roof surface type, and attic ventilation. Even "planned defects," where 36 square feet of insulation were removed from an attic, were not detectable on the thermograms. For more information, contact Doug Burch, National Bureau of Standards, Washington, DC 20234.

DEGREE-DAY TERM GAP by William A. Shurcliff

Don't look now, but there's something missing from the architect's house-heating terminology. What's missing is a term for the general quantity the unit of which is the degree day.

Boston, Massachusetts, is said to be a 5600-degree-day location. The value is 5600. The unit is degree days. But we have no name for the quantity itself!

Contrast this problem to the situation as regards area. I can say: "The area of my new house is 3000 square feet - twice the area of my old house." But suppose the word area had never been invented. Then I would have to use an awkward expression such as: "My new house has a square-foot value of 3000 square feet, twice the square-foot value of my old house."

Back to the degree-day problem. Because of the lack of any word for the general concept, I am forced to use awkward expressions such as these: "The degree-day value of Boston is 5600 degree days." "Boston has twice as many degree days as central Texas has."

What is at issue, obviously, is how cold the outdoor air is and how long the cold endures. So I propose the word coldurance. "Boston has a coldurance of 5600 degree days." "Boston's coldurance is twice that of central Texas."

The word hotdurance would come in handy too, as the quantity we now express in units as "heating degree days."

FEATURE ARE AIR-TO-AIR HEAT EXCHANGERS COST-EFFECTIVE?

ARE AIR-TO-AIR HEAT EXCHANGERS COST EFFECTIVE?

As concern grows over indoor air quality in tightly sealed houses, designers and builders are confronted with demand for residential ventilation systems. Following the lead of pioneering Canadian builders, initial reaction has been to install air-to-air heat exchangers. But are air-to-air heat exchangers cost-effective? In moderate climates, do the energy savings justify initial investment? Sometimes yes, sometimes no. Before looking at actual numbers, let's first consider the separate requirements of ventilation and heat recovery.

The Need for Ventilation

An airtight house needs intentional ventilation to control humidity and remove indoor air contaminants. ASHRAE residential ventilation standards call for 10 cubic feet per minute (cfm) per room plus 100 cfm intermittent capability for kitchens and 50 cfm intermittent capability for bathrooms. Another generally accepted guideline is simply 0.5 air changes per hour (acph). Actual recommended ventilation will of course vary. For example, ASHRAE recommends a ventilation rate of 20 cfm per person in office environments where people are smoking. On the other hand, an eight-room house with one occupant and no obvious sources of air contaminants should probably have a ventilation rate of 0.25 acph or less.

The reasons for ventilation are health, comfort and moisture control, not energy efficiency. A ventilation system consists of mechanical devices which induce conditioned fresh air and exhaust stale air from a house. It does not necessarily include heat recovery.

The Need for Heat Recovery

Heat recovery is an optional component of a ventilation system. Heat recovery devices such as air-to-air heat exchangers can recover from 50 to 90 percent of the waste heat in exhaust air. The need for heat recovery depends on: 1) energy cost of ventilation; 2) cost savings from heat recovery; and 3) cost of the heat recovery device (air-to-air heat exchanger).

What is the Energy Cost of Ventilation?

Ventilation energy costs depend on four factors: 1) rate of ventilation; 2) how cold it is for how long ("coldurance"); 3) cost of fuel used for space heating; and 4) efficiency of fuel utilization.

Equation 1 can be used to calculate total ventilation energy requirements over a heating season.

$$Q = 0.018 \times acph \times V \times 24 \times DD \qquad \text{(Eq. 1)}$$

where Q is the energy requirement in Btu's, acph is the ventilation rate in air changes per hour, V is the house volume in cubic feet, and DD is the number of degree days. 0.018 is the heat capacity of air - the amount of heat energy, in Btu's, required to raise the temperature of 1 cubic foot of air 1 degree Fahrenheit.

Once the total energy requirements are calculated, one can easily find the total cost using equation 2.

$$C = [Q/(U \times e)] \times P \qquad \text{(Eq. 2)}$$

where C is the annual cost in dollars, U is the number of Btu's per unit of purchased energy, e is the efficiency at which the energy is utilized, and P is the cost per unit of purchased energy. Note that the above cost calculation does not include the cost for power to run fans.

Common units of purchased energy are as follows:

electricity	=	kWh	=	3413 Btu's
natural gas	=	ccf	=	100,000 Btu's
oil	=	gal.	=	138,000 Btu's

Typical fuel utilization efficiencies are:

electric resistance heat	- 1.0
electric heat pump	- 2.0-3.0
gas furnace or boiler	- .65-.95
oil furnace or boiler	- .60-.80

Example 1

What are the ventilation energy requirements, and energy cost (excluding fan power), for a 1500-square-foot house with 8-foot ceilings located in a climate with 5000 degree days, if the ventilation rate is 0.5 acph and the house is heated with electric resistance heat costing $.07 per kWh?

acph = 0.5
V = 1500 x 8 = 12,000 cubic feet
DD = 5000
U = 3413 Btu/kWh
e = 1.00
P = $.07 per kWh

Total Energy Consumption

Q = 0.018 x 0.5 x 12,000 x 24 x 5000
= 12,960,000 Btu per year

Total Cost

C = [12,960,000/(3413 x 1.0)] x 0.07
= $265.81 per year

This house has considerable ventilation cost; heat recovery may look very attractive. But what if instead of electric resistance heat, it was equipped with a condensing gas furnace, such as the Amana, with a seasonal efficiency of 95 percent?

Example 2

What will be the annual ventilation energy cost of the house in example 1 when equipped with a 95-percent-efficient gas furnace? (Gas price is $.60 per ccf.)

Total Cost

C = [12,960,000/(100,000 x 0.95)] x 0.60
= $73.87 per year

In this situation, ventilation costs are fairly low; heat recovery will be less attractive.

How Much Savings Can An Air-To-Air Heat Exchanger Provide?

Most air-to-air heat exchangers have recovery efficiencies between 60 and 90 percent. Subtracted from that is the cost to operate intake and exhaust fans. Equation 3, for calculating savings, assumes that about half of the electricity consumed by the fans is recovered as heat in the heat exchanger. Since that energy theoretically ends up as useful heat, it is not considered a "cost" of operation.

S = (C x eff)-[0.5 x ((p/1000) x t) x $/kWh]
value of recovered energy — heat exchanger cost of operation
(Eq. 3)

where S is the savings in dollars, eff is the recovery efficiency of the heat exchanger, p is the power consumption of the fans (in watts) and t is the number of operating hours.

Example 3

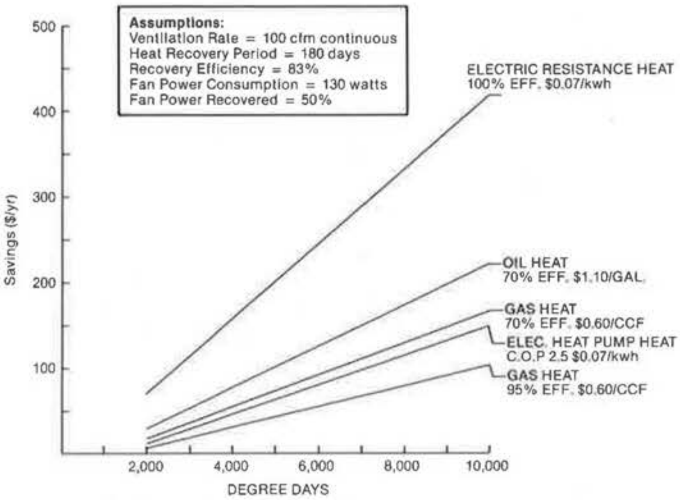
Using the house in Example 1, let's look at the savings attainable from installing an air-to-air heat exchanger. As a realistic example, let's install a Van Ee R200, one of the more popular heat exchangers on the market today. At 100 cfm, the R200 has a measured recovery efficiency of 83 percent and fan power consumption of 130 watts. Using equation 3 and assuming the unit runs continuously during a 180-day heating season, the savings are as follows:

S = ($265.81 x 0.83) - [0.5 x ((130/1000) x 4320 hrs) x 0.07]
= $200.96 per-year savings

Example 4

What are the savings if the house in Example 2 is equipped with the same heat exchanger?

S = ($73.87 x 0.83) - [0.5 x ((130/1000) x 4320 hrs) x 0.07]
  = $41.65 per-year savings



Example Cost Savings with Air-to-Air Heat Exchanger

What Is The Payback?

Simple payback is calculated by dividing the cost of the system by the annual savings. When considering cost, it is important to separate the ventilation component from the heat recovery component. The true cost of heat recovery equals the total cost of an installed system minus the cost of a regular ventilation system, including fans, ductwork, dampers, controls, filters and pre-heaters.

For example, the Van Ee R200 in our example retails for about $800 in the U.S. The extra cost for a complete installed system, above and beyond a regular ventilation system without heat recovery, is about $650. Using the two houses in Examples 1 and 2, a simple payback is as follows:

From Example 1 (electrically heated house):

Total Extra Cost = $650
Annual Savings = $201
Simple Payback = 650/201 = 3.2 years

From Example 2 (gas heat at 95% efficiency)

Total Extra Cost = $650
Annual Savings = $42
Simple Payback = 650/42 = 15.5 years

The above analysis shows the variability of heat exchanger cost effectiveness. If simple payback is used as the decision criterion, the gas-heated house would be a poor candidate for an air-to-air heat exchanger.

Climate is also important - the colder it is, the greater the savings. It's no wonder that in Saskatchewan, with 12,000 degree days, most superinsulated houses have heat exchangers. Figure 1 shows climate-related variations in savings for several types of heating systems. From the savings projections, one can see that the simple payback can vary from less than two years to almost never.

Some Important Qualifications

The above analyses ignored several factors which affect the cost-effectiveness of air-to-air heat exchangers:

1) If "Base-65" degree days are used in equation 1, heat recovery savings will be overestimated. Ventilation energy requirements, as well as other heating energy requirements, are proportional to the number of heating degree days only if the degree days are measured to a base corresponding to the "balance point" of the house. The "balance point," defined as the outdoor temperature below which a house needs auxiliary heat, changes continuously, depending on intrinsic heat

gain (waste heat from lights, appliances and people) and solar heat gain. When using base-65 degree-day data in Equation 1, you are assuming the balance point to be 65 degrees - rarely the case in an energy-efficient house. The calculations produce "worst case" results for ventilation costs and "best case" results for cost savings from heat recovery. Actual ventilation costs and heat recovery savings will be from 10 to 50 percent less than those calculated in Equations 1 and 2, depending on house balance point and climatic patterns.

2) Latent heat recovery adds to heat exchanger effectiveness. If water vapor in the exhaust air condenses in the heat exchanger, part of the latent heat of condensation will be recovered and transferred to the incoming fresh air. Although the actual amount of recovered heat is difficult to calculate, it adds to the energy savings and cost-effectiveness of the heat exchanger.

3) Defrost cycle energy adds to the cost of operation of a heat exchanger. Some heat exchangers use electric defrost which could add significantly to operating costs, particularly in very cold climates.

4) Simple payback is a very limited method of investment analysis. Other methods, such as "life cycle costing," provide a more realistic picture of cost-effectiveness.

An Air-To-Air Heat Exchanger Is The Easiest Way To Install A Residential Ventilation System

In addition to energy savings, an attractive feature of the air-to-air heat exchanger is that it is the only off-the-shelf packaged residential ventilation system you can buy. The alternative - to install a complete ventilation system using component hardware - is a new and unusual task for the average residential heating contractor. Heat exchangers not only provide the complete package, but as the market matures, manufacturers are providing increasingly good design and installation support.

That benefit is reflected in the marketing strategy of one heat exchanger manufacturer, Des Champs Laboratories of New Jersey, makers of EZ-Duct. We asked Tony Calderone, director of engineering and sales at Des Champs, how they justify the use of their units in moderate climates where energy savings are marginal compared to installed cost. "Comfort and health are the only issues we're dealing with," states Calderone. "If you're selling on anything else, you're missing the boat." Des Champs is actually selling the benefits of ventilation, which could be effectively provided by a properly designed ventilation system without an air-to-air heat exchanger. But the air-to-air heat exchanger system provides all the benefits of ventilation plus the obvious added benefit of energy savings through heat recovery.

Summary and Conclusions

1. When dealing with air management in an airtight house, one must not confuse ventilation with heat recovery. Ventilation is necessary to assure indoor air quality and humidity control but does not necessarily include heat recovery.

2. Savings attainable with an air-to-air heat exchanger depend on ventilation rate, climate and energy price. In cold climates (7000 degree days or more), heat exchangers will usually be cost-effective, particularly in houses heated with electric resistance heat. In moderate climates, however, savings will be marginal, especially in houses with high-efficiency gas heating systems.

3. An added benefit of air-to-air heat exchangers is that they provide a complete ventilation system in one package.

PRODUCTS

THE MOST EFFICIENT WATER HEATER

As rated by the Gas Appliance Manufacturers Association, the Therma-Stor Heat Pump Water Heater is more energy-efficient than any other water heater on the market. Manufactured by DEC International, Inc., Madison, Wis., the Therma-Stor includes a heat pump mounted on top of a water tank. The heat pump extracts sensible and latent heat from room air and transfers it to water in the tank at temperatures up to 140°F. It not only supplies hot water at a high efficiency, but also cools and dehumidifies the room in which it sits. (There is no danger of cooling the room too far because the unit is programmable to cut off the heat pump and resort to backup heat at a preset temperature.)

The 80-gallon Therma-Stor has an "energy factor" (EF) of 3.5. "Energy factor" is a measure of overall performance of a water heater based on recovery efficiency, standby loss and energy input. An EF of 1.0 is equivalent to an efficiency of 100 percent. Like any heat pump, the Therma-Stor has an efficiency greater than 100 percent because the useful energy output is greater than the purchased energy input. Typical gas-fired water heaters have EFs ranging from .50 to .60. (The most efficient gas water heater available, the "Hot Water Maker" by Amtrol, has an EF of .64.) Electric-resistance water heaters typically have EFs ranging from .75 to .90.

Is The Therma-Stor Cost-Effective?

The 80-gallon Therma-Stor retails for $1395, about $1000 to $1200 more than most gas or electric water heaters. Its cost-effectiveness, compared to gas or electric resistance heaters, depends on water consumption rate and utility prices. Let's look at an average situation for a family of four:

Hot water consumption	- 65 gallons per day
Degrees heated	- 80°F
Electric rates	- $.08 per kWh
Gas rates	- $.60 per ccf

	Annual Energy Consumption:	
Heater Type	Amount	Cost
Therma-Stor	1325 kWh	$106
Gas(.52 EF)	304 ccf	$182
Electric(.85 EF)	5456 kWh	$436

Savings from using Therma-Stor:	
Compared to gas	- $76/year
Compared to elec. resistance	- $330/year

Water consumption affects savings considerably. The following table compares the savings attainable at three levels of hot water use - 20, 65, and 100 gallons per day (assuming the same gas and electric rates as above).

Hot water use (gal/day)	20	65	100
Savings with Therma-Stor:			
--compared to gas	$25	$76	$174
--compared to electric	$101	$330	$565

Unless water usage is extremely low, the Therma-Stor will almost always be cost-effective compared to electric-resistance water heating. When the alternative is gas heating, the cost-effectiveness of the Therma-Stor depends on the relative costs of gas and electricity. For example, if, in the above example, electric rates were only $0.04 per kWh, the savings using Therma-Stor would be double those listed.

Another factor, often overlooked in water heater efficiency analyses, is durability of efficiency. Scaling on the heating element or heat exchanger can cause the efficiency of water heaters to degrade over time, particularly in areas with hard water. Gas and electric water heaters are more prone to scaling because the heating elements operate at high temperatures. The Therma-Stor should be less prone to scaling because the heat exchanger surrounds the entire water tank and operates at a lower temperature (about 145°F). Thus it is likely to better maintain its high efficiency.

The Cooling Advantage (Disadvantage)

Heat pump water heaters don't work by magic. The reason they put out more energy than they consume is because they draw sensible and latent heat from their surroundings. During the cooling season, the Therma-Stor provides the benefit of 8000 Btu per hour of "free" cooling.

On the other hand, during the heating season, a heat pump water heater can be a liability when located in a space heated with purchased fuel. The manufacturer recommends locating the appliance in an area which is not intentionally heated, such as a boiler room, where the heat pump can draw on what would otherwise be waste heat. But what if there is no such space - such as in an electrically heated home with no basement? During the heating season, the Therma-Stor will have little or no advantage over a conventional electric water heater; its apparent extra efficiency will be derived from expensive electric space heat. In those cases, the overall advantage of a heat pump water heater depends on the relative lengths of the heating and cooling seasons.

For more information about Therma-Stor, contact: Ken Gehring, DEC International Inc., Therma-Stor Products Group, Box 8050, Madison, WI 53708; (608)222-3484.

RADIANT CEILING HEATING SYSTEM FROM NORWAY

Radiant heating is always more energy-efficient than baseboard electric. Working in its most efficient mode, ceiling radiant heat warms room occupants by the direct transfer of long-wave infrared radiation from the ceiling (at about 100°F) to the room occupants (93-95°F skin temperature), making them feel comfortable even when room air temperature is cooler than normal. Thus, by operating at a cooler indoor temperature, a house with radiant heat can theoretically use less energy than one with convective heating.

Radiant Heater From Norway

The ESWA electric radiant heating system is an inexpensive and easy-to-use product imported from Norway. Distributed by Heat Saver Systems Inc., Chalfont, Pa., the ESWA system is similar in structure to the Flexel radiant heating system (see March/April 1983 EDU), consisting of conductive foil strips laminated between plastic sheeting. The system is simply rolled out and stapled to the ceiling joists after the insulation is installed (see Figure). Each roll comes with the wiring already attached to one end. After installation, the wires are ganged together at a junction box and connected to a line voltage thermostat.

Electric radiant heat is safe; ESWA has UL approval. Driving a nail through the element won't damage it, but if the heat is on and the person holding the nail is grounded, he/she will of course become part of the circuit and get shocked.

An attractive feature of this and other radiant heating systems is the way the thermostat is calibrated - no temperature settings, just comfort settings. If the thermostat had degrees, most people would adjust it to their usual 68 or 70 degree setting - we are conditioned to feel cold if we know that the temperature is below 68. But radiant heat is different; ceiling-surface temperature controls thermal comfort as much as air temperature. Air temperature may be only 63 or 65 degrees, but if the ceiling is at 100 degrees, occupants will feel comfortable anyway. (This feature should be extended to controls for other types of heating systems in very energy-efficient houses because even without radiant ceiling heat, the warm surfaces and absence of drafts often allows cooler room temperatures with no sacrifice of thermal comfort.)

Some bad news about energy savings. For superinsulated houses, the energy savings from radiant heat will be less than in conventional houses and may even be insignificant. Why? Because the ceiling only makes people feel warm when the electric element is on; the electric element is only on when the house needs auxiliary heat; superinsulated houses rarely need auxiliary heat; and thus the radiant heating effect on people, and the resultant energy savings, are only active a small part of the time. The rest of the time, room temperature may have to be raised to normal temperature to maintain comfort. Of course, there will still be benefit and savings whenever the system is operating. Also, thermal lag of the ceiling surface will provide some "carryover" of the radiant heat even after the system is off. But claims of savings up to 30 percent are probably exaggerated and should not be counted on in super-energy-efficient houses.

ESWA is available in widths ranging from 12 to 48 inches and lengths up to about 22 feet. Heat output ranges from 11 to 20 watts per square foot depending on model purchased and voltage in the house. According to Ron Greene, President of Heat Saver Systems, an ESWA system for a house with a design heat load of 17,000 Btu per hour (about 5000 watts) costs about $325 for materials. Installation can usually be done in less than one day.

For more information, contact: Ron Greene, Heat Saver Systems Inc., 1397 Upper State Road, Chalfont, PA 18914; (215)345-5177.

DEHUMIDISTAT FOR CONTROLLING INDOOR HUMIDITY

The word "dehumidistat" always sounds like a misnomer. After all, a "thermostat" controls both heating and cooling; shouldn't a "dehumidistat" therefore control both humidification and dehumidification? Etymology aside, the Ranco J10-809 Dehumidistat is the best buy we've seen for controlling dehumidifying and/or ventilating equipment. With a setting range between 20 percent and 80 percent relative humidity and a maximum 8 percent differential, the Ranco unit can be used to operate air-to-air heat exchangers or simple exhaust ventilation. The price is hard to beat - $23! For information, contact: Ranco, Controls Division, 8115 U.S. Route 42 North, Plain City, OH 43064; (614)873-4611.

Ranco Dehumidistat

HOUSES AND PLANS

EER-2 - A DEMONSTRATION OF RESIDENTIAL ENERGY EFFICIENCY

The Energy Efficiency Residence (EER-2) research and demonstration program was conducted by the NAHB Research Foundation Inc. under contract to the U.S. Department of Housing and Urban Development (HUD). The objective was to develop information and data for designing and building cost-effective energy-efficient homes in the future.

The 2600-square-foot house pictured above was built on a site in Damascus, Maryland, approximately 40 miles north of Washington, D.C. Design and construction of the EER-2 house included a well-thought-out blend of passive solar features, superinsulated construction, and energy-efficient heating system and appliances. It was rented to a typical family starting October 1, 1981, and closely monitored for a full year thereafter to evaluate the effectiveness of the special energy-conserving features.

Although the EER-2 house is not as energy-efficient as some of the ultra-superinsulated houses in North America, its performance is impressive. During the 5518-degree-day heating season from October through May, a total of 2,117 kWh was consumed for all heating functions, equivalent to only $115 at the prevailing electric rate of $0.053/kWh. Cooling performance was equally impressive with only 1,038 kWh used for mechanical cooling during the four-month season from June through September. The largest

EER-2-A

energy expenditure was for domestic water heating - a total 3,871 kWh, costing $205 at prevailing rates.

The most valuable aspect of the EER-2 project is that careful cost and performance monitoring allowed the project team to isolate and separately evaluate each of the individual energy-conserving components. The following is a description of the most significant features and a summary evaluation of their cost-effectiveness.

1. Heavily insulated, airtight thermal envelope. This house should be considered "superinsulated," not only because of high R-values in walls and ceilings, but also because the framing was carefully designed to reduce thermal bridging and because extra care was taken to insure proper installation of the insulation system. According to Donald Luebs, manager of the project, quality construction is one of the most important ingredients of EER-2's energy-efficient construction.

Walls were built with 6-inch studs, 24" o.c., with R-19 fiberglass batts and R-8 foam sheathing on the outside. Framing design included single top plates, two-stud corners, and plywood box headers over windows and doors. Ceilings were insulated with R-49 fiberglass; the wood foundation walls were insulated with R-26 fiberglass batts; and 1-inch extruded polystyrene was installed under the concrete slab, thickened to 2 inches at the perimeter. Band joists were insulated with R-16 plastic foam insulation.

The walls were wrapped on the inside with a 6-mil polyethylene vapor barrier. No vapor barrier was installed in the ceiling. No special attempt was made to seal the vapor barrier around electrical boxes or outlets, nor was the vapor barrier caulked at the seams. Plastic foam sealant was used to seal around all door and window openings, construction joints, and penetrations of the building skin. The measured infiltration, based on several measurements, was approximately 0.2 air changes per hour.

Costs for Extra Insulation	
Walls	$1530
Ceiling	610
Overhangs	140
Slab	930
Foam sealant	180
TOTAL	$3390

Savings Attributed to Extra Insulation
$541 (elec. rates - $0.053/kWh)

2. Earth-Coupled Heat Pump. The primary heating system in EER-2 is an earth-coupled water-source heat pump which also provides summer cooling. The heat pump draws heat from a nontoxic antifreeze solution that circulates through a closed loop of pipe that is inserted in a well. The closed loop acts as a heat exchanger to extract heat from groundwater without actually drawing water from the ground. The cycle is reversed for summer cooling, with the circulating solution discharging heat to groundwater.

The closed-loop system is more ecologically sound than systems that remove water from the ground and pump it directly through the heat pump. It is also more efficient because the small circulator pump in the closed-loop system uses only a fraction of the power that a standard well pump requires.

The heat pump was the most effective energy-saving feature in the EER-2 house.

Extra Cost For Heat Pump System - $1560
Yearly Savings Compared to
Electric Resistant Heat - $580

3. Passive Solar Heating. A two-story solarium, isolated rock-bin thermal storage, and a special distribution system accounted for over 43 percent of the total extra cost for energy-saving features. Although the house was sited for optimum exposure, solar heating, including direct gain through south-facing windows, proved to be minimally effective.

Total Cost of Solar Features - $16,840
Yearly Savings - $93

4. Thermal Shutters. A variety of types

of thermal shutters, all R-14, were installed on all doors and windows. Their cost-effectiveness was poor.

Total Cost of Thermal Shutters - $3600
Yearly Savings - $70

5. Airlock Vestibule. That airlock entries are not cost-effective has been "discovered" over and over again in the energy design community. Gene Leger, one of the pioneers of superinsulation, realized it several years ago after using it in several houses. Although it may provide ancillary benefits such as "mud room" space or protection from uncomfortable wind gusts, the airlock vestibule can never be justified on energy savings alone. Furthermore, according to Luebs at NAHB Research Foundation, the EER-2 vestibule suffered moisture problems: Warm air leaking around the inner door condensed in the vestibule, causing mildew and other problems. We have seen similar problems in entryways in superinsulated houses in Minnesota.

Total Cost of Vestibule - $1810
Yearly Savings - Insignificant

6. Air-to-Air Heat Exchanger. Little emphasis was placed on the air-to-air heat exchanger. It was initially "hard-ducted" into the return plenum of the warm-air distribution system, but they noticed that when the furnace fan went on, excessive outdoor air was drawn in through the fresh-air intake, even though it was dampered. (Most heat exchanger manufacturers warn against ducting directly to a warm air system for that very reason.) It was subsequently disconnected from the return plenum, allowing the intake air to feed into the mechanical room. Connected to the clothes dryer, it did extract some useful heat, but was not run extensively and was not considered a cost-effective measure. According to Luebs, there were no apparent problems with indoor air quality.

Total Cost for Heat Exchanger System - $1160
Yearly Savings - Marginal

7. Rock-Bin Thermal Storage. An isolated rock-bin thermal storage was included to store excess heat from the solarium. Monitoring showed that it did not contribute effectively to space heating in conjunction with the relatively low-grade heat produced by the solarium. In addition, it appears to have produced a net loss during colder months due to the thermo-syphoning of cold air through ducts from the solarium. It was concluded that a higher temperature heat source would be required to make effective use of rock storage.

Total Cost for Rock Bin - $3380
Yearly Savings - Marginal

Other Energy-Conserving Features

Item	Extra Cost	Savings
High-Effic. Water Heater	$ 50	$50
Greywater Heat Recovery	660	49
High-Effic. Refrigerator	200	28
Ceiling Fans	350	marginal
Window Bay Shading	820	insignif.
Passive Roof Vent	2720	insignif.

Summary and Conclusions

The total extra cost of all special energy-saving features incorporated in EER-2 was $38,870. For the year, savings in energy were equivalent to $1411 compared to a conventional house of similar construction. The savings produced by the two most effective features - the earth-coupled heat pump and the extra insulation package - totaled $1121 at a total extra cost of only $4950. Although it is not possible to precisely determine the net contribution of some of the lesser features, it appears that the savings produced by all other features acting together totaled approximately $300.

This project demonstrates some important facts and raises some pertinent questions about superinsulation in moderate climates. First, how much focus on airtightness is necessary? While the NAHB team certainly paid more than average attention to sealing the house tight, they did not go to the extremes typical of many superinsulation projects in Canada and the U.S.: No vapor barrier was installed in the ceiling; the wall vapor barrier was simply lapped at the seams, not sealed with caulk; no special techniques or materials were used to seal the vapor barrier to electrical boxes in walls; there were even a few electric fixtures in the ceiling (which had no vapor barrier); the vapor barrier was not wrapped around the band joists as is common in superinsulated construction. What was the perceived difference in performance between this house and "super" airtight houses? The natural infiltration rate was two or three times as high as many superinsulated homes but the total heating bill was still reduced by 90 percent (compared to a conventional house of the same size). Even if more extreme airtightness would have reduced total energy costs another 50 percent, the additional savings would only be about $55. For the Maryland climate, the construction techniques used in EER-2 may be optimum. One must be careful, however, in extending this observation to other climatic areas because natural infiltration is induced by temperature differential (through the stack effect) and wind. In colder, windier climates, the construction methods used in EER-2 could result in significantly higher infiltration rates.

Another question raised by this project is whether or not to install a ceiling vapor barrier. It was left out of the EER-2 house to allow excess indoor humidity to passively diffuse out of the house through the ceiling. Luebs stated that this technique was effective in EER-2 but cautioned that it may not be advisable in colder climates. We agree with him. Attic ventilation is not controllable; in cold climates, moisture diffusing through the ceiling could condense and even freeze before it can be vented out of the attic. More important than a vapor barrier is a tight air barrier to prevent air leakage into the attic from the living space.

Finally, EER-2 demonstrates that effective energy-conserving design may preclude any added benefit from passive solar heating. Although the solarium and direct-gain solar windows admitted a lot of solar heat, it came at times when it wasn't needed, and not much of it was utilizable. The rock-bin thermal storage didn't help much. Though the solarium adds a very pleasant living space, it is probably never a cost-effective energy-producing element.

The information from this articles is partially excerpted from a yet-unpublished report from the NAHB research foundation. For more information about EER-2, contact Donald F. Luebs, NAHB Research Foundation Inc., Box 1627, Rockville, MD 20850; (301)762-4200; or Orville Lee, Architectural Division, Department of Housing and Urban Development, 451 7th St. S.W., Washington, DC 20410; (202)755-0640.

CALENDAR

NORTHEAST

Window Treatments '84. January 24-26, 1984, New York City, NY. Contact: Window Energy Systems, 345 Cedar Building, Ste. 450, St. Paul, MN 55101. (612)222-2508.

Infra-Red Scanning Course. February 7-10, May 15-18, 1984, Econolodge Conference Center, Burlington, VT. Contact: Paul Grover, Infraspection Institute, Hullcrest Drive, Shelburne, VT 05482.

Superinsulation: Buildings for the Future. February 16-17, Boston, MA. Contact: Rogal Conference Planners, 72 Langley Road, Newton Centre, MA 02159. (617)965-1000.

Commercial Applications of Solar for the Mid-Atlantic Region: Conference & Exhibit. March 12-13, 1984, Bellevue Stratford Hotel, Philadelphia, PA. Contact: Nancy Weissman, MASEA, 2233 Gray's Ferry Ave., Philadelphia, PA 19146. (215)545-2150.

Energy & Home Improvement Expo. March 15-18, 1984, Nassau Coliseum, Uniondale, NY. Contact: Energy Expo, Inc., 33 Bell St., W. Babylon, NY 11704. (516)293-5533.

ASTM Meeting, Committee E-6 on Performance of Building Constructions. April 2-5, 1984, Philadelphia Centre Hotel, Philadelphia, PA. Contact: Ken Pearson, ASTM, (215)299-5520.

SOUTHEAST

Roofing Industry Educational Institute (RIEI) Four-Day Basic Course: January 10-13, Dunfey Atlanta Hotel, Atlanta, GA. Contact: RIEI, 6851 S. Holly Circle, Suite 250, Englewood, CO. (303)770-0613

Solar Inspection Short Course. January 11, 1984, Florida Solar Energy Center, Cape Canaveral, FL. Contact: Ken Sheinkopf, Director of Continuing Education, Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 32920. (305)783-0300.

Build With The Sun: Two Day Course. January 17-18, 1984, Atlanta, GA. Contact: Georgia Solar Coalition, 1083 Austin Ave., N.E., Box 5560, Atlanta, GA 30307.

ASHRAE 1984 Winter Meeting. January 29-February 1, 1984, Atlanta Hilton, Atlanta, GA. Contact: Ralph Burkowsky, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329. (404)636-8400.

Southeastern Air Conditioning, Heating, Refrigerating Exposition. January 30-February 1, 1984, Georgia World Congress Center, Atlanta, GA. Contact: Vince McDonnell, International Exposition Co., 200 Park Ave., New York, NY 10016.

Eighth Annual Conference on Energy From Biomass and Wastes. January 30-February 3, 1984, Lake Buena Vista, FL. Contact: Donald Klass, Institute of Gas Technology, 3424 South State St., Chicago, IL 60616. (312)567-3650.

Solar Installation Short Course. January 31-February 1, 1984. Florida Solar Energy Center, Cape Canaveral, FL. (see January 11 listing for contact address).

Energy Conservation in Housing Rehabilitation. February 1-3, 1984, Chevy Chase, MD. Contact: Community Revitalization Training Center, 5530 Wisconsin Ave., Suite 1600, Chevy Chase, MD 20815. (800)638-8090 or (301)654-8338.

Earth Sheltered Housing: Two Day Course. February 9-10, Atlanta, GA. Contact: Georgia Solar Coalition, 1083 Austin Ave., N.E., Box 5506, Atlanta, GA 30307.

Wood Heating Alliance International Trade Show and Seminars. March 4-6, 1984, Commonwealth Convention Center, Louisville, KY. Contact: WHA Trade Show Office, 111 E. Wacker Dr., Chicago, IL 60601. (312)644-6610.

11th Annual Energy Technology Conference and Exposition (ET '84). March 19-21, 1984, Sheraton Washington Hotel, Washington, DC. Contact: Government Institutes, Inc., 966 Hungerford Dr. #24, Rockville, MD 20850. (301)251-9250.

MIDWEST

Residential Energy Auditing. January 9-13, 1984, University of Wisconsin, Madison, WI. Contact: Dept. of Engineering and Applied Science, 432 N. Lake St., Madison, WI 53707. (608)262-2061.

Kansas City Energy Exposition. March 16-18, 1984, Bartle Hall, Kansas City, MO. Contact: Mary Jo Doheny, 4210 Johnson Dr., Suite 306A, Shawnee Mission, KS 66205. (913)384-3976.

42nd Annual Convention and Exposition of the National Association of the Remodeling Industry, Inc. (NARI). March 29-31, 1984, Expo Center, Chicago, IL. Contact: NARI, 11 East 44th St., New York, NY 10017. (212)867-0121.

Ground Water Heat Pump Conference. April 9-11, 1984, Fawcett Center for Tomorrow, Ohio State University, Columbus, OH. Contact: National Water Well Association, GWHP 1984, Dept. B, 500 Wilson Bridge Road, Worthington, OH 43085.

Superinsulation in Housing, Second National Conference and Exposition. April 17-18, 1984, Kahler Hotel, Rochester, MN. Contact: Jeanne Brownback, AVTI, 1926 Second St. SE, Rochester, MN 55904

WEST

Winter Meeting, National Society of Professional Engineers. January 15-21, San Francisco, CA. Contact: NSPE, 2029 K St. N.W., Washington, DC 20006.

National Association of Home Builders Convention and Exposition. January 21-24, Astrodome, Houston, TX. Contact: NAHB, 15th and M Sts., NW, Washington, DC 20005. (202)822-0254.

1984 Energy Expo. January 21-22, 1984, Centralia, WA. Contact: Ginny Brockman, CURE, 160 Cousins Rd., Chehalis, WA 98532. (206)748-3118.

Solar Trends: Tapping the Infinite Resource. January 24-27, 1984, Phoenix, AZ. Contact: Carolyn Burby, Interstate Solar Coordination Council (ISCC), 300 State Road 401, Cape Canaveral, FL 32920. (305)783-0300.

Winter National Hardware & Home Center Show. February 11-13, 1984, Las Vegas Convention Center, Las Vegas, NV. Contact: Pat Dolson, Box 3933, Stamford, CT 06905.

Fifth Alaska Alternative Energy Conference. February 11-13, 1984, University of Alaska, Fairbanks, AK. Contact: Alaska Alternative Energy Conference. SRA 4007-A, Anchorage, AK 99502.

Urethane Foam Contractors Association (UFCA) Annual Exposition, UFEX-9. February 26-March 1, 1984, San Antonio Convention Center, San Antonio, TX. Contact: UFCA, 300 Arcade Square, Box 1288, Dayton, OH 45402. (513)223-5435.

Insulation Contractors Association, Seventh Annual Convention. March 22-25, MGM Grand Hotel, Las Vegas, NV. Contact: Terry Mason, ICA Convention Headquarters, 15910 Ventura Boulevard, Suite 719, Encino, CA 91436. (213)986-0622.

INTERNATIONAL

Energy Management in Buildings Conference. March 22-23, 1984, University of Nottingham, Nottingham, England. Contact: Construction Industry Conference Centre Ltd., P.O. Box 2, West PDO Nottingham, NG8 2TZ United Kingdom.

Note: Listings for West & Southwest have been combined in this issue.

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