Creating an Energy Efficient Habitat

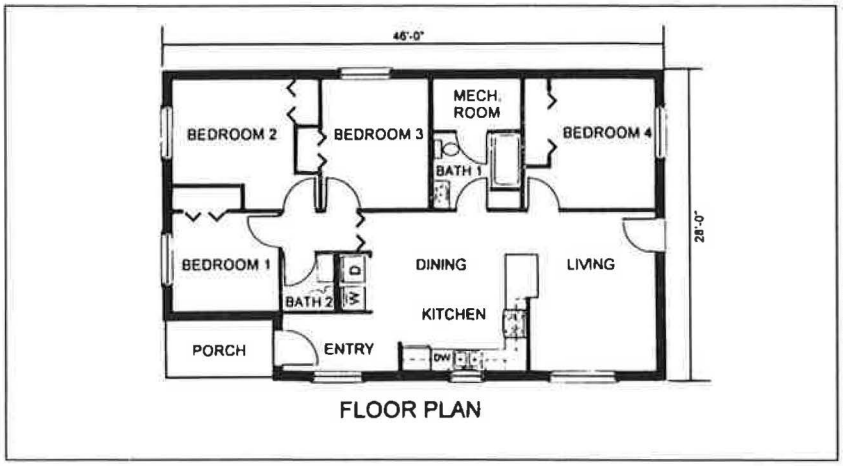
Habitat for Humanity is working to provide housing that is priced within reach of low-income buyers, is safe and durable, and has reasonable energy and maintenance costs. But it takes care and patience to ensure that these and other considerations do not slip through the cracks.

by Linda Wigington

Habitat for Humanity International (HFHI) has helped over 50,000 families obtain affordable housing. Thanks to the commitment and partnership of thousands of volunteers and homeowners, Habitat has become one of the most respected humanitarian organizations and the 20th largest home builder in the United States.

A Habitat for Humanity volunteer caulks around a window opening.

House Plans Maximize Performance per Dollar



The floor plan of a high-performance home developed by the National Affordable Housing Network with Habitat for Humanity in mind.

The National Affordable Housing Network has developed house plans that greatly reduce first costs while providing the greatest possible improvement in energy efficiency and comfort. The houses were designed with Habitat for Humanity in mind; sale prices of finished homes range between $35,000 and $40,000.

The plans feature an R-60 attic, R-40 walls, and an R-19 floor over an uninsulated crawlspace; a poly air-vapor barrier under sheetrock; an 18,750 Btu per hour output wall-mounted, sealed-combustion gas space heater in the living area; and a fully ducted 75% heat recovery ventilation system. The heating load for the 1,238 ft², four-bedroom residence was calculated at 13,640 Btu per hour (–15°F design outdoor temperature).

The plans are the product of more than 15 years of research and development. They are derived from earlier plans designed by Bob Corbett, now NAHN's director of research, and Wally Hansen. During the mid-1980s, five homes (2,400 ft² each), built according to these earlier plans, were monitored for several years as part of the State of Montana's Superinsulation Project. Detailed multichannel hourly measurements showed annual heating costs of approximately $160–$310. During the winter, the measurements showed that heating was needed intermittently during only three months of the year, rather than the five or six months typical for Montana.

Based on these figures, projections for annual gas heating for the NAHN's 1,238 ft² homes are $50–$150. This estimate was calculated using REM energy modeling software and is applicable to locations with over 7,000 annual heating degree-days.

The Montana project also showed that heat recovery ventilation, when designed and installed in conjunction with the right building envelope, can account for more than 22% of space-heating savings. When outdoor temperatures hover below zero for weeks on end, heat recovery provides substantial energy performance improvements. It also has the side benefit of dramatically improving indoor air quality.

Four of five houses tested in the Montana project were tighter than 1.5 ACH at 50 Pascals (Pa) at the first diagnostic test. All were readily tightened to under 1 ACH at 50 Pa. Ventilation was designed to operate at approximately 0.27 ACH continuously, with stale air being exhausted at all times. With ASHRAE's current standard calling for a minimum of 0.35 ACH, continuous mechanical ventilation of 0.27 ACH is very powerful and effective.

NAHN house plans also feature solar orientation and shading and high-performance windows.

Plans can be ordered by e-mailing NAHN@nahn.com.

—Barbara Miller

Barbara Miller is executive director of the National Affordable Housing Network.

Since its inception in 1976, HFHI and its independent affiliates have been making decent shelter a matter of conscience and action. Last year alone, HFHI made 3,000 new or rehabbed houses available to low-income families in the United States. The houses were sold at an average cost of $39,724 with no-interest monthly mortgage payments of about $200–$400.

New Construction or Rehab?

Many of the 1,400 U.S. Habitat affiliates have focused on new construction—overall, 85% of the houses are newly built and 15% are rehab. Rehabs are stickier to deal with than new constructions, must be handled on a case-by-case basis, and can end up having high energy costs. The standardized plans and approach of new construction makes it a more manageable and often more energy-efficient option (see "House Plans Maximize Performance per Dollar").

So why even bother with rehabs? Because rehabs, if done correctly, can save both energy and materials. Dave Ewing, senior advisor for the environment at Habitat's headquarters office, maintains that rehabs are the green way to go. "Rehab can ultimately be the best thing you can do environmentally, rather than build new homes. The energy embodied in the building is captured and the resource efficiency is enhanced." But Ewing acknowledges that a rehabbed home, while more resource efficient, has many potential energy and safety pitfalls and requires a great deal more thought and planning.

Although Habitat affiliates have succeeded in keeping the initial cost of their homes affordable to low-income buyers, energy costs have been more difficult to control. The National Affordable Housing Network (NAHN) analyzed energy use in new and rehabbed Habitat homes in Texas over the past three years. They found that annual costs ranged from $400 to $2,200 per year for a 1,100 ft² residence.

According to Barbara Miller, NAHN's executive director, these findings surprised some Habitat affiliates. Those with higher costs subsequently changed their approach and incorporated new techniques to bring their costs in line with their neighbors.

A New Approach Pays Off

At the Greene County Pennsylvania Habitat affiliate, where I have been involved for 12 years, we closely monitored energy costs for rehabbed homes from 1991 to 1994. We discovered that some of our homes had energy bills as high as $1,800 annually.

The highest energy consumption occurred among rehab houses where we had not given adequate attention to the building envelope and HVAC equipment, and had merely added insulation to walls and attics (we generally used the existing furnaces and ductwork). In 1990, we started using a whole-house building approach. This included maximizing south-facing glass, minimizing windows on the west and north, and paying close attention to thermal and pressure boundaries. Attics were insulated to R-40 or R-50. We also installed new heating and hot water systems—thanks to support from Equitable Gas Company and Columbia Gas of Pennsylvania. These were installed in the living space, typically on the first floor.

The ductwork was usually placed in the living space, most often in the ceiling between the first and second floor. In a few cases, we used a bulkhead to provide space for the ductwork—in two cases, we had 12-ft ceilings, which we dropped 2 ft. Gas cookstoves were prohibited (for the sake of indoor air quality); other combustion appliances were either induced draft or sealed combustion. All houses were tested with a blower door to verify that the air sealing was effective.

LINDA WIGINGTON

Pictured here is the most efficient home built by Greene County Pennsylvania's Habitat for Humanity affiliate. The purchase price was $30,000, which included the in-kind value of the property and donated materials, as well as a $3,000 administration fee. The family contibuted well over the 500 hours of sweat equity required of Habitat homeowners.

From our monitoring data we discovered that monthly gas bills for heat and hot water at four sites where we had installed new high-efficiency furnaces or integrated appliances and followed a whole-house approach ranged from $27 to $34 per month (at $7.50/MCF), or 40 to 54 million Btu annually (see Table 1). Gas bills at rehabbed houses that did not have new heating systems ranged from $60 to $110 per month.

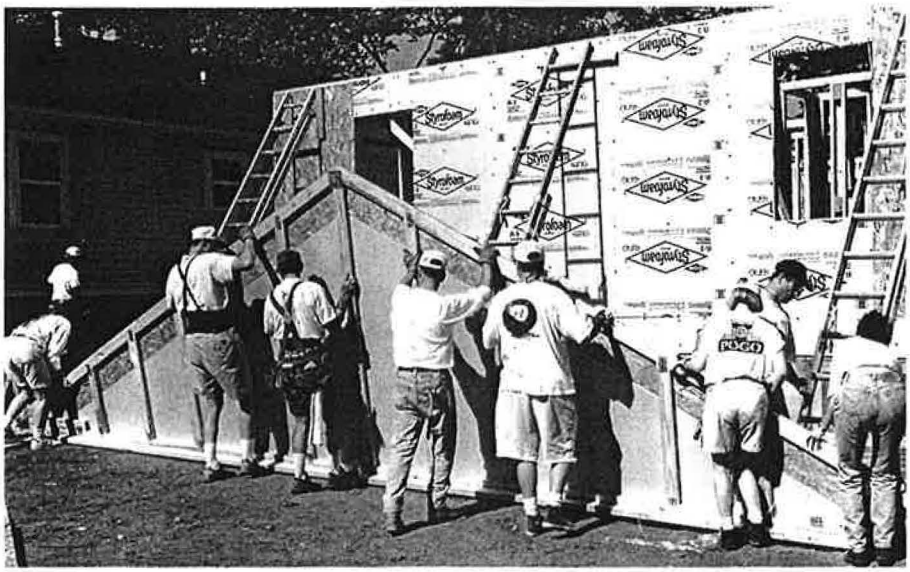
Baseload electric costs were consistently higher than heat and hot-water costs (electricity averaged approximately $55 per month at 5¢/kWh). Some of this cost (approximately $5–$10 per month) was due to the electric stove. The remainder was due largely to inefficient electric dryers and refrigerators; we discovered a few refrigerator energy hogs that were consuming as much as 6 kWh per day, or 16% of the average bill.

In some cases, individual homeowner behavior had a dramatic impact on

Table 1. Comparison of Annual Heating Energy Consumption (Greene County Habitat for Humanity)

	House Number	Hot Water Btu/yr Size (ft^2)	Heat Btu/yr (in millions)	Heat (in millions)	Btu/ft^2/DD
Rehabbed Houses	1	1,300	NA	75	11
(Wall and Attic Insulation only)	2	1,800	NA	95	10
Rehabbed or Gutted Houses	3 (gut)	1,250	18	25	4
(Whole-House Approach: Improved	4 (gut)	1,304	16	27	4
Ductwork, HVAC Sizing, Thermal	5 (rehab)	1,428	12	28	4
Boundaries, Insulation, and Tightness)	6 (rehab)	1,341	9	45	6
New Construction	7	1,248	16	14	2
	8	960	Electric	25	5
	9	1,120	13	33	5

Note: In rehabbed homes the original plaster was left intact. In gutted homes, walls were stripped to the studs. All homes used gas for heat and hot water, except as otherwise indicated. Heat and hot-water energy use was calculated based on a comparison of summer and winter loads. The Btu/ft^2/DD estimates were based on 5,500 degree days and a 65°F fixed base.



Volunteers in Atlanta, Georgia, prepare to attach a roof truss to a building under construction by Habitat for Humanity.

electric baseload. In one case, a homeowner was spending $20 per month to dry 60 loads of wash in an electric dryer. In another case, an antique electric streetlight had been salvaged to light a play area. A 500W bulb in the fixture burned for 24 hours per day, costing the homeowner $23 per month.

Table 1 shows that our most efficient home (2 Btu/ft²/DD) was newly constructed. This home was built on an insulated slab, and the walls were insulated with R-19 batts and 1-inch high-R sheathing (except at the corners, where ½-inch plywood was used with ½-inch sheathing). We installed a high-efficiency furnace and a power-vented gas water heater in the utility room. Ductwork was located between the first and second floor, and an energy-efficient exhaust fan was installed in the bathroom. The homeowner also installed a room air conditioner in the house, which the family uses extensively during the summer (the highest electric bill during the summer was $86). The entire cost for this house was $30,000.

While this house was our most energy efficient, a few of our rehabbed houses trailed close behind at 4 Btu/ft²/DD. This shows that it is possible to achieve nearly the same level of energy efficiency in rehabbed homes as in newly constructed homes.

Water and Sewer Costs

Recently we have begun to examine water and sewage costs among the homes within our affiliate. As Table 2 shows, these rates varied considerably.

While water and sewage generally amounted to less than half the total utility costs, in some cases they were as high as $71 per month (the highest bills had a flat sewer rate of $33 per month). The variation between the highest and lowest monthly water and sewer rates across homes was $45. Although $45 may not be that significant for a middle-income homeowner, for a low-income homeowner living at the margin, an extra $45 per month can make a huge difference.

The houses in Table 2 have low-flow toilets, faucets, and shower heads. Additional water conservation measures are thus not likely to bring down these costs significantly. Another option for increasing potential savings is to shop around for the lowest sewer and water rates before siting a building. An excellent resource for any affiliate would be a survey of utility and tax rates to help guide property acquisitions.

Table 2. Average Monthly Utility Costs for Greene County Habitat for Humanity Homeowners

Project Type	Number of Occupants	First Cost	Gas Cost per Month	Electricity Cost per Month	Water Cost per Month	Sewage Cost per Month	Total Cost per month	Twenty-Year Utility Cost
Gut	2	$20,000	$32	$54	$22	$14	$122	$29,000
Gut	3	$27,000	$43	$41	$23	$33*	$130	$31,000
Gut	4	$26,000	N/A	$82	$17	$15	$114	$27,000
Gut	4	$30,000	$52	$41	$14	$14	$121	$29,000
Gut	4	$24,000	$53	$39	$20	$19	$131	$31,000
Gut	5	$19,000	$44	$72	$26	$33	$175	$42,000
New	2	$35,000	$47	$29	$14	$33*	$123	$29,000
New	4	$25,000	N/A	$99	$15	$33*	$147	$35,000
New	4	$30,000	$25	$60	$15	$11	$111	$27,000
Rehab	5	$22,600	$49	$69	$20	$14	$152	$36,000
Rehab	5	$27,000	$49	$45	$32	$33*	$159	$38,000
Rehab	5	$18,300	$114	$35	$23	$25	$197	$47,000
Rehab	5	$21,500	$42	$86	$38	$33*	$199	$48,000
Rehab	6	$26,000	$49	$35	$15	$14	$113	$27,000

First costs include land, materials, in-kind value, and up to $4,000 in administration fees. Gas rates ranged between $9 and $10.50 per MCF (including monthly service). Electric rate was .065¢/kWh.
*Flat rate

Clearly, any opportunity for savings should not be overlooked. Table 2 shows that when utility costs are summed over a 20-year period (the average life of a mortgage) they often exceed the first cost of a home.

Tight or Not Too Tight?

The monitoring of our affiliate's houses demonstrated the success of our program in controlling heating energy costs. However, as I learned later, this was not the end of the story.

I took a one-year leave from Habitat in September 1995. When I returned, I found that the building approach I had helped to establish was coming undone. For example, when I offered to lead a team of workers to insulate a house, the new construction leadership told me they didn't want air sealing. They believed that some houses we had built in the past were too tight. At another house, I found that a volunteer heating contractor had installed a conventionally vented furnace and water heater, and flex ducting in the unconditioned attic. In addition, this house had a northern orientation with few south-facing windows.

I wondered what had happened in my absence. I learned that the changes had arisen from the new construction leadership team's approach, the heating contractor's recommendations, and the board's desire to lower construction costs and address concerns about indoor air quality. These latter concerns stemmed in part from ventilation problems that occurred in several homes. Although fans were in place to provide the necessary ventilation, they had not been operated properly.

The new team considered our earlier efforts in tightening and insulating homes to be overzealous and not sensitive enough to homeowner health. They knew that utility costs had been impressively low, but they felt that it was appropriate to trade off some savings for a lower-cost house, particularly if by doing so we could also avoid indoor air quality problems.

I did not agree with the decision to reduce the tightness of our homes, but I certainly understood the concerns. I am now trying to improve the operation of the exhaust fans and controls we use in our affiliate, and am testing Tamarack's Airetrak control system. This device can be set to run a fan for a fraction of each hour of the day.

Habitat's Environmental Initiative

In 1994, HFHI launched an environmental initiative centered on the idea of sustainable construction—an idea that embraces resource- and energy-efficient and environmentally sensitive building techniques. The initiative is designed to reduce the environmental impact of HFHI affiliates' building programs by providing education and training, fund-raising assistance, and when possible, financial support to accommodate environmental objectives. HFHI is committed to developing and implementing this initiative without diverting funds from building homes. Over $4.5 million has been raised for environmental and resource efficiency projects—much of it coming from affiliates at the local level.

HFHI's environmental initiative has helped to spur dozens of projects. One such project is the construction of a five-star Energy Star model home by the Houston, Texas, Habitat for Humanity affiliate, in cooperation with the Alliance to Save Energy in Washington, D.C. The frame-wall house was built for less than $32,000, excluding land and fees, and includes these energy-efficient design features:

- Increased insulation levels (R-30 ceilings, R-16 walls, and R-6 ducts)
- High-efficiency equipment (12.0 SEER,1.5 ton air conditioning unit and 80% AFUE gas central furnace)
- Building ventilation and infiltration controls (ceiling fans for increased air circulation, sealing of exterior envelope to 0.4 ACH and duct system to 90% efficiency)
- Solar shading with solar screens and increased overhangs

The design looked good in theory, but the Houston Habitat wanted it tested. The affiliate and the Texas State Energy Office had Texas A&M's Energy System lab perform continuous monitoring of the house. Remote monitoring of HVAC run time, indoor-outdoor temperatures, and humidity showed 25% greater energy efficiency, at peak kWh demand, of the 12.0 SEER air conditioning over the 10.0 SEER unit next door.

Unfortunately, the homeowners set the setback thermostat to an indoor summer temperature level of less than 70°F, 24 hours per day. This initially negated the offsets gained by the design. Habitat quickly intervened to correct this problem; the homeowner was informed of the need to adjust the settings.

Experience on this project clearly demonstrates that, while energy efficiency improvements are important, careful monitoring and homeowner education are also key to ensuring success.

For more information on this project, contact Malcom Verdict, Director of Research, the Alliance to Save Energy, Washington, D.C. Tel:(202)857-0666; E-mail: mverdict@ase.org.

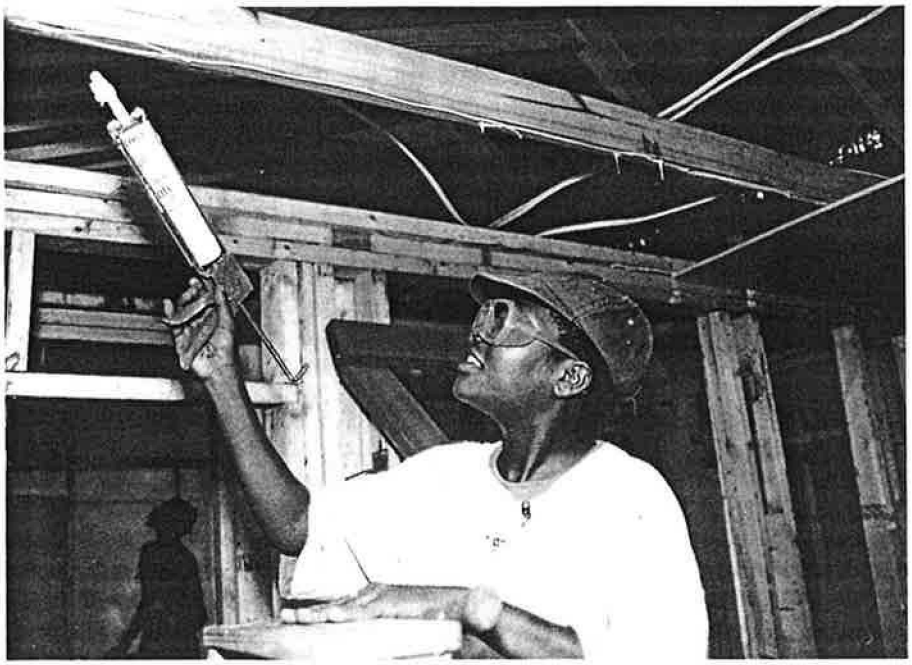
—Malcom Verdict

Malcom Verdict is director of research at the Alliance to Save Energy in Washington, D.C.

"Affordable" versus "Efficient"

The changes that had occurred at the Greene County Habitat illustrate how easily an affiliate can modify its policies in response to new leadership or ideas. It also reflects the fact that affiliates are composed of a diverse group of volunteers who bring many different perspectives to bear on the process of building affordable homes. The very concepts of what is "affordable" or "energy efficient" are thus often subject to multiple, and sometimes conflicting, interpretations.

Habitat for Humanity International provides its affiliates with basic design criteria; it does not dictate construction methods or techniques. Individual affiliates, which operate as independent nonprofit organizations, decide for themselves how to go about building homes. According to Dave Ewing, "Habitat International only advises; we



ROBERT BAKER

A Habitat for Humanity volunteer in Americus, Georgia glues gypsum board to a ceiling.

do not command. The principle of the relationship is to engender independence." The message to affiliates is to build simple, basic housing. Practices thus reflect the unique skills, leadership, and traditions of the individual affiliates.

While this approach gives affiliates autonomy, it also poses challenges from the standpoint of efficiency. For example, some builders do not consider energy efficiency to be a priority for low-income homes. As NAHN's Barbara Miller—who has helped provide technical assistance to nearly 200 affiliates across the nation and who organized a seven-county Habitat affiliate in Montana—puts it, "Some hard-bitten housing developers feel that high levels of performance in Habitat housing are icing on the cake. [They believe] simple housing that meets minimum property standards should be good enough for desperate low-income families. As leadership volunteers, they tend to work against [energy] efficiency as an unnecessary frill or as something too expensive."

Those builders may be outliers in the group, but even volunteers who are dedicated to building energy-efficient affordable homes do not always agree on how to go about it. Some simply defer to the local building code. Other more zealous members demand superinsulated homes, while still others focus solely on green technology and products.

Habitat affiliates, of course, are not alone in wrestling with the problem of building more energy- and resource-efficient homes. Even building performance and energy efficiency experts do not always agree on how to approach and solve such problems. Until recently, Habitat affiliates have had few good models, backed by measured performance data, to follow. While HFHI is working to provide more energy-efficient low-income housing models (see "Habitat's Environmental Initiative"), institutionalizing energy and resource efficiency is still a way off.

A Role for the Residential Energy Professional

Building diagnostics and consumption analysis are vital to ensuring energy efficiency in homes. Habitat affiliates often do not have the skills or resources to collect the needed information. Building professionals can thus make a key contribution to a Habitat affiliate by offering services in these areas.

From my own experience with a Habitat affiliate, I have found that not only is diagnostic information useful, but the use of the diagnostic equipment itself is an effective teaching tool. Demonstrations, especially in "problem" houses, can help raise awareness among homeowners and volunteers to the complexities of building performance and the need for quality control.

Tracking energy and other utility costs is key to establishing a performance feedback loop, and to educating homeowners about consumption. To help simplify the logistics involved in collecting consumption data, homeowners should be asked to sign a release allowing access to their gas, electric, water, and sewage consumption history. Basic information about the floor area, construction, mechanical systems, appliances, and number of occupants in their homes should also be collected.

One objective of HFHI's environmental initiative is to create a Green Team. This team will have a contact person at each Habitat affiliate who is responsible for coordinating activities under the initiative. Dedicated, qualified volunteers committed to these tasks can make a world of difference in helping to make Habitat's low-income housing affordable and energy-efficient. This is another area where residential energy professionals can have a tremendous impact.

In general, energy professionals can offer valuable skills and help raise the energy consciousness of a Habitat affiliate. At the same time, they need to tread carefully and understand that each affiliate has its own culture. Dennis Creech, executive director of the Southface Institute in Atlanta, who has worked closely with several Habitat affiliates says, "You just can't parachute in. It takes time to understand how the local affiliate functions, and time to help them understand the opportunity that exists.... Solutions aren't turnkey; they need to be customized and appropriate to the affiliate's volunteer base, climate, materials, energy costs, and building style. What we are talking about here is a partnership."

For more information or to find out about a Habitat affiliate in your area, contact Habitat for Humanity International at 1-800-HABITAT.

Linda Wigington is the founder of the Affordable Comfort Conference and continues to serve as its program coordinator.