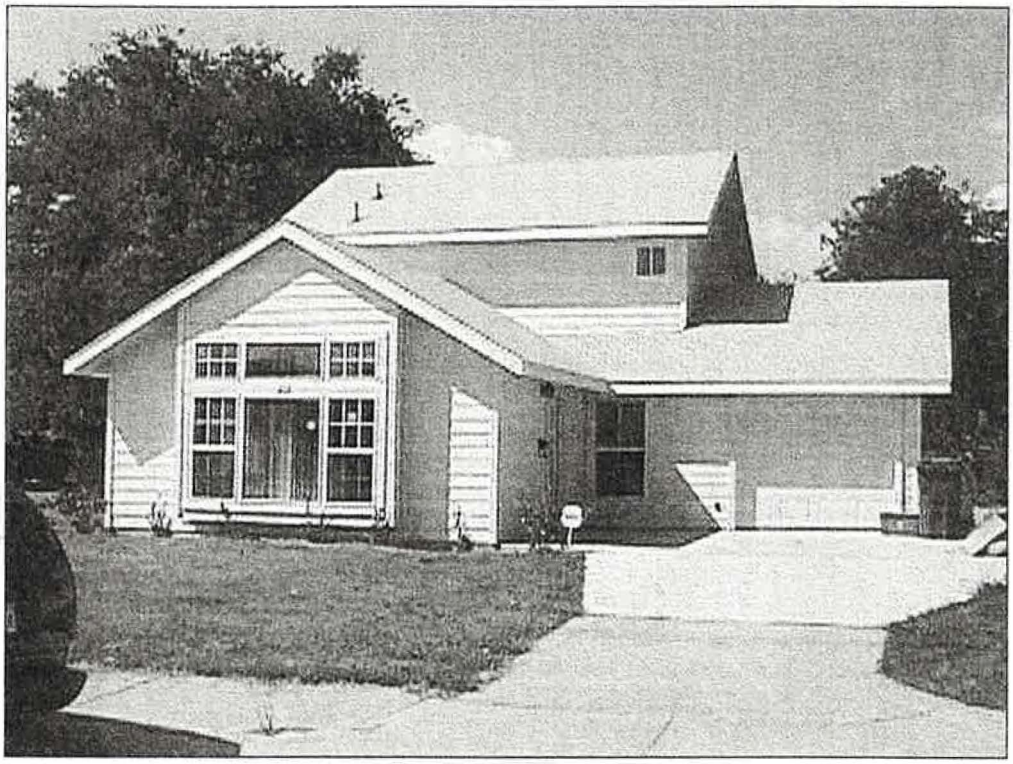
Habitat
Building Lessons

Habitat for Humanity affiliates and other low-cost builders can achieve annual space conditioning costs of less than $250 per year through inexpensive envelope measures and equipment downsizing.



HP2

by Barbara Miller

In 1995, the National Affordable Housing Network (NAHN) began a program called the High Performance Housing Partnership (HP2). This program partners with low-cost housing producers to develop best-practice approaches for low-income consumers. To date, HP2 has developed more than 160 demonstration homes in cold and hot climates.

In Texas, HP2 works with Habitat for Humanity and other low-cost homebuilders, who produce as many as 400 volunteer-built homes a year. One of these, Dallas City Homes, also uses a variety of contract labor, while Habitat uses volunteer, owner-builder, and contract labor for various elements of the construction process.

HP2 Texas

In 1995, HP2 began a project in Texas to identify and demonstrate best-practice space conditioning approaches. The project included a total of more than 40 volunteer-built and contractor-built homes. To begin, HP2 did a current-practice study of more than 100 homes statewide. Most of these homes were developed in 1995, and one year's utility data were available for each home. The purpose of the study was to identify the current construction practices employed by Habitat, and to determine the effects of those practices on energy consumption.

Next, HP2 conducted a study of best-practice–best-value options for three locations in the state, using a variety of fuels and technologies. The design-research team then modeled these options in order to identify the lowest first-cost items and to determine how low-income builders might use this information. The modeling was performed for four locations. Model plans and guidebooks were developed around three types of space conditioning, and a package was developed for the lowest-cost option (see "Space Conditioning", p. 39).

Most of a Texas consumer's bill goes to A/C, but heating is also an issue. The goal was to identify which cooling solutions had the drawback of increasing heating costs and vice versa. The challenge was to get the proper balance of heating- and cooling-related measures.

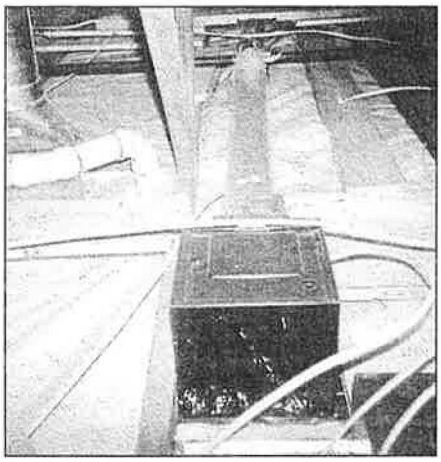
Then followed the construction of more than 40 new homes in San Antonio, Longview, Abilene, Dallas/Fort Worth, and El Paso. All of these homes incorporated the new space conditioning package. The plans for these homes were all less than 1,230 ft², with the average being approximately 1,100 ft².

Performance testing was then conducted on all the homes. For each location, measured data were compared to current-practice data. The largest sample, consisting of more than 30 homes, was in San Antonio. The performance of these homes was found to be within 2% of the modeling projection for the project. The best-performing home had total annual utility costs of less than $490 for all uses. This represents a 42% sav-

ings over the San Antonio current-practice ($849) average in 1996. The San Antonio sample served as one part of the baseline controls.

Findings for homes in other cities varied. The biggest savings measured as a percentage of current practice were seen in Longview and Dallas/Fort Worth, which had the highest energy bills in the 1996 sample. Contractor-built homes tended to have the greatest absolute consumption. The Habitat-built homes employed a wide range of technologies and approaches.

The monitoring staff took a variety of measurements across the sample, to maximize understanding of the data and to report the information in a way that would make it useful to others. When a home performed differently than expected, the monitoring staff conducted a review in order to find out why. They found that consumer behavior had the biggest overall effect on performance. Other factors that affected performance were using substitute products, changing the specification, and poor workmanship. The homes that performed best followed the specifications closely, were certified to meet the performance benchmarks, and had occupants with appropriate expectations and predictable behavior. (See "Features of the Best-Performing Homes," p. 40.)



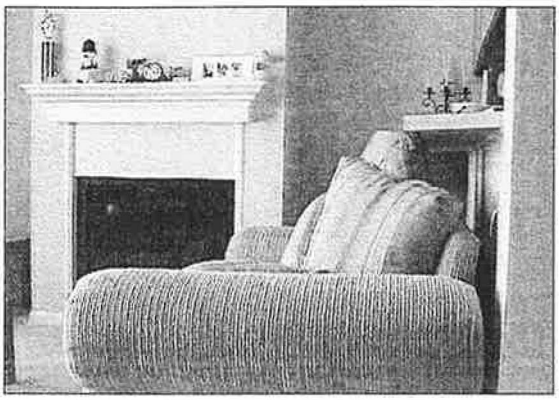
HP2 PROJECT TEAM MEMBERS

All-electric HP2 homes use unitary heat pumps.

Results in San Antonio

The homes built in San Antonio were used as a baseline for the study. The San Antonio plan is 1,045 ft², with three bedrooms and a slab-on-grade foundation. The home uses natural gas for hot water and space heat and has an electric through-the-wall air conditioner, gas cooking, and an electric or gas clothes dryer.

Generally, HP2 Texas avoided ducted systems, relying instead on a combination of tight construction with separate heating and cooling stations to provide the small amount of space conditioning required in these homes. This was the approach that was used in San Antonio. Using this approach combined with leaky construction can make for comfort callbacks. However, these small houses are built tightly and are well enough insulated that wind has virtually no impact on them, and indoor air temperatures remain stable throughout the house.



HP2 PROJECT TEAM MEMBERS

A fireplace heater adds style to the Dallas City Homes house.

Builders in some cities did opt for centrally ducted heat and air, because their customers preferred it. HP2 accepted this option, provided that the builders would allow follow-up testing for duct leakage, and if necessary, would make corrections.

An alternative is to install the smallest available forced-air system with as little ductwork as possible, located totally within the conditioned space. Any ductwork installed outside the conditioned space must be as highly insulated as possible, and it must be checked for air leakage at the connections and for proof of performance. It is important not to use products or installations that have combustion transfer to the conditioned space. Generally these systems cost more to install and may cost more to operate over time.

Ventilation

Because of the need to control indoor moisture year-round, the HP2 project team chose a 13.2W Panasonic Fv05vq high-performance fan that would run continuously at a cost of less than $10 a year. The fan is so quiet and efficient that it is virtually silent. This quantum advance in fan technology allows a 50 CFM–70 CFM exhaust fan to run continuously in the bathroom, so that, with tight construction, the air from the entire home is slowly removed and replaced with outside air drawn through the envelope. A second low-energy fan can be employed elsewhere for a boost or can be installed in a second bathroom when additional whole-house ventilation is required. Very few other models could duplicate the specific performance of this Panasonic fan, which was used in all the homes built in San Antonio.

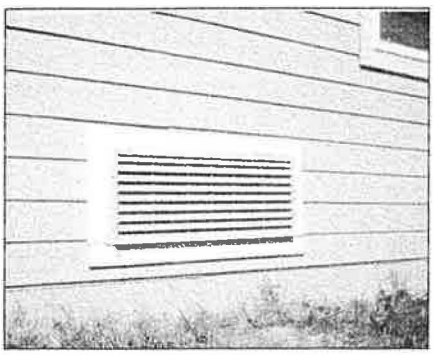
Cooling Strategy

The cooling loads were cut so much that a single central room conditioner could readily handle the load for the whole house. Measured cooling consumption in San Antonio had a mean cost of $160 per household per year, and an average cost of $191. The average cost is dominated by one high-energy user, while the mean cost is closer to the average cost without this user. Most of the homes in the San Antonio sample had a cooling cost of less than $140. A combination of small factors—including humidity control, heat rejection, and improved insulation—led to this reduction in cooling load.

Heat rejection was achieved by installing high-performance windows and building larger roof overhangs to reduce solar heat gan through the windows. Insulation was improved by raising R-values to R-18 in the walls and R-30 in the attic, and by ensuring uniform, right construction. Exterior wall insulation was also used to achieve airtightness and moisture control under the

Space Conditioning

A package was developed for the lowest-cost space conditioning option. The preferred fuel statewide for heating and water heating was natural gas, and this package was thought to be the most widely applicable for that reason. The package included a point source natural gas sealed-combustion wall furnace or fireplace, a point source through-the-wall air conditioner for cooling and dehumidification, continuous air exhaust through the bathroom exhaust fan, and overhead fans. Only in El Paso was evaporative cooling chosen; this option required a large ductwork system, a natural gas furnace, an exhaust fan, and overhead fans.



HP2 PROJECT TEAM MEMBERS

In HP2 Texas homes, the hard-ducted exhaust fan is vented out the soffit. The fan runs continually.

HP2 PROJECT TEAM MEMBERS

Abilene HP2 homes had the lowest overall sample energy use in the project.

siding. The slab-on-grade construction has a moisture barrier underneath the concrete to prevent water vapor from migrating into the building through the concrete. The ground-coupled high-mass floor also lessens the cooling load, further reducing the amount of compression-driven cooling that is required.

Supplemental cooling, including compression-driven dehumidification, is accomplished by means of a through-the-wall room A/C unit, which is needed only during the hotter hours. Overhead fans are installed in most rooms to provide additional comfort. Moisture is further controlled through the ongoing ventilation by the low-energy fan system, as described above.

Special products used in the San Antonio homes include long-life plastics under the floor slab, heat rejection glazing, and tight window construction. HP2 specified that the wall air conditioner should have a SEER of 10 or greater to meet the Model Energy Code.

Lessons Learned

Each builder in the Texas project was compensated $2,000 per unit for participation costs, including energy measures. Other programs currently set a limit of $1,500 per unit for marginal costs for energy measures. Such a low limit may not encourage conservation.

Two of the builders chose to spend significantly more than was spent in the baseline (San Antonio) homes by adding much more glazing area or adding a large central ducted HVAC system. Habitat and independent builders work with local markets, and they may choose to depart from the baseline to comply with their customers' preferences, even though this may increase the cost of a home.

HP2 Texas was designed to demonstrate a benchmark of the lowest first cost combined with the best possible overall performance. It is always possible to "solve" energy issues with money. For example, performance similar to that of the San Antonio homes can be purchased for approximately $7,000 in the form of a geothermal heat pump system. But low-cost builders cannot afford to spend that kind of money. In the Texas project, HP2 focused on developing a space conditioning system that offers the best lifetime performance at the lowest first cost.

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

Features of the Best-Performing Homes

Here are the features of the homes that had the lowest consumption data in our sample:

Envelope insulation upgrade. Minimum insulation levels are R-30 in the attic and R-18 in the walls (R-13 batt, with R-3 or R-4 tongue-in-groove exterior foam insulation); insulated slab edge (except where there is termite risk); and roofing that is the lightest acceptable color. In Dallas, 6-inch structural insulated panels (SIPs) were used for walls. Energy trusses (raised heel trusses) were used to allow maximum insulation values in the attic.

Window upgrade, heat rejection and glazing upgrade. All the windows meet the tightness specification of 0.16 ft per minute/156 lb/ft² (single hung). All the windows have heat rejection glazing (which has a shading coefficient of 0.51 compared to 0.91 for a standard double-glazed window at 0.91—UV block of 82%—compared to 42% for a standard double glazed window, and low-e film. All the windows are double glazed and have vinyl frames.

Moisture control package. Moisture transmission through the slab is reduced by an underslab moisture barrier, and the building is tightly constructed to prevent moisture transmission through ambient infiltration. A continuous vapor barrier is installed above the ceiling drywall to stop air leakage and to control moisture.

Ventilation/indoor air quality package. Controlled continuous ventilation is achieved with a high-performance fan located in the bathroom and wired directly to the circuit breaker panel. This fan is used for spot moisture control, ongoing moisture discharge, and ventilation. It is automatic and extremely affordable.

Performance-tested comfort system. The HVAC system is downsized using a comfort station approach, with separate heating and cooling stations located in the main living-dining area. Air mixing is achieved through slow air movement toward the bathroom, where the exhaust fan operates continuously. Airtightness is verified to match the HVAC system, and ductwork is tested for leaks. The heating systems include sealed-combustion gas fireplaces, small sealed-combustion gas wall furnaces, and heat pumps. Only sealed combustion was recommended, to ensure air quality and safety. The cooling systems include small through-the-wall air conditioners, central heat pumps, and unitary heat pumps, forming a single comfort station.

Contact:

National Affordable Housing Network
P.O. Box 3706
Butte, MT 59702
Tel: (406) 782-8145; Fax: (406) 782-5168
E-mail: nahn@nahn.com
Web site: www.nahn.com.