

The High Performance Housing Partnership (HP2) in Texas

FINAL REPORT

The following is an excerpt from the final report of the High Performance Housing Partnership project conducted in Texas from 1994 until 1999. During this project, Habitat for Humanity affiliates and non-profit builders built more than 40 resource-efficient homes in six Texas cities. These new homes were then monitored to measure their performance.

The final report contains data, construction details and color photos from homes built from the detailed hot and humid climate houseplans developed for this project. To order a copy of the 76-page report, send a check or money order for **\$34.95 to NAHN (TX HP2 Final Report), P.O. Box 3706, Butte, MT 59702** or call to order by phone by calling **1-888-732-8145**. You can also order with a purchase order number by sending a fax to **(406) 782-5168**.

Introduction

Low cost housing producers have, for well over a decade, been asking the question: What are the most cost-effective energy measures for our type of construction?

Dozens of organizations have leaped forward over the years to offer their version of the answer to this question. This has caused a Tower of Babel effect, leaving many home builders confused.

The problem is - the true answer to the question is "It Depends." It depends on what the organization is building now, depending on local conditions. It depends on what products are available at an affordable price. It depends on who is building the homes - volunteers, owner-builders or contracted home builders.

These are all dynamic aspects of construction - they change with personnel changes, market changes and many other factors.

In the early 1980s, it was documented that low cost housing could be built that was High Performance housing - it could use under \$200 per year for space heat in our nation's coldest climates while providing improved indoor air quality and health features. And, the best part was that it was very affordable to build this way, because the energy features were designed into the plan from the beginning, rather than as an afterthought. But, it did require some changes in practice, a few new products and a willingness to let go of unnecessary measures that don't pan out in the field studies or that clash with the new approach being taken. As a response to these findings, over time in the Northwest thousands of high performance homes were built, and two states went so far as to change their codes to the new high performance level, a level that exceeds the proposed energy star levels. Yet, most of the United States and the other two Northwest states have not made the transition to this level of performance.

In 1994, the National Affordable Housing Network was founded to represent the consumer's interest in affordable housing production - and work toward bringing the best possible energy efficiency improvements to affordable housing in Texas. NAHN partnered with Habitat affiliates in Texas and began seeking resources to transfer solutions known and explore new solutions appropriate to current markets in Texas.

Habitat for Humanity International is a global organization that partners with low-income families to build simple, decent housing. Habitat cares about the value it is providing the homebuyer, and it also has an abiding concern for keeping first costs at their lowest to spread charitable dollars the farthest. Habitat is a grass-roots organization, a network of independent yet coordinating organizations that make all decisions on the local level. In the United States, San Antonio Texas is the oldest affiliate of Habitat International and consistently one of the nation's top Habitat home producers. Texas has many strong Habitat affiliates.

Dallas City Homes is one of a wave of new non-profit housing producers who work at the local level using federal HOME funds to make housing affordable. Dallas City Homes uses a variety of contracted labor, while Habitat uses volunteer, owner-builder and contractor labor for various elements of the construction process.

The purpose of the partnerships developed was to define affordable energy approaches for Habitat and non-profit housing producers that would provide the best value at the lowest possible first cost. Another purpose was to provide educational opportunities and field information to Habitat home builders.

Given that there are approximately 60,000 independent home builders nationwide, and Habitat and the non-profit sector may represent 5,000 of this number, it is clear that there would be wide divergence between approaches taken by various builders. In 1996, Texas State Energy Conservation Office funded an oil-overcharge project to bring solutions to Habitat homebuilders across the state, who produce as many as 400 volunteer-built homes a year.

The project had three phases - the current practice study, the design and build stage, and the measurement stage. This report is the final deliverable on the Texas SECO contract, and provides an update for participants and an introduction for those who may wish to participate with the High Performance Housing Partnership (Hp2) in the future.

ACKNOWLEDGEMENTS

The High Performance Housing Partnership (Hp2) is a program of the National Affordable Housing Network, a non-profit organization dedicated to representing low-income consumers in the design and development of affordable housing. Staff of NAHN working on this effort included Barbara Miller, project director, and Bob Corbett, chief of design and product evaluation. Simulation, data analysis and collection was performed by Ecotope Inc., under Larry Palmiter, senior scientist and Paul Francisco, with Jack Bartholomew conducting data verification and one-time measurements from the Texas sample. 2000 marks the 22nd year that that Miller, Palmiter and Corbett have worked together on development of high-performance low-cost housing.

Because this report is a milestone in a multi-year effort, we have seen a complete staff change at nearly all the participating building projects in the Hp2 effort. In other words, we have two groups of people to thank and acknowledge for their participation in this work. First, the project would not have been possible without Regina Nobles, of Dallas City Homes (and formerly of Habitat) who shares the mission of wanting to develop the best possible home for the funds available to families who have the support to make the dream of homeownership possible. She sits on the Habitat regional council, and is a frequent support contractor and volunteer to Habitat. Within Habitat, San Antonio Habitat, including Jim Grant, Amy Hartman, and former ED Duane Beechey and Jim Brewer, Paul Blakely at Longview Habitat, Kevin Coleman of Abilene Habitat, Karl Dreher of El Paso Habitat, Gail Ryan of Fort Worth Habitat, NAHN board member and former Habitat International Board Member Carl Umland and Joe Gatlin, regional director for Habitat International. Other former participant staffers at the housing non-profit organizations include Brenda Coleman of Abilene, Wink Dickey of Dallas and Gene Ruckle of Dallas.

Executive Summary

In 1996, Habitat for Humanity in Texas joined with other housing non-profit organizations to study and improve energy practices in their current construction and new building. The National Affordable Housing Network, a non-profit housing research organization, submitted and was approved to conduct an oil-overcharge funded project to pave the way for better understanding of energy practices that represent the best public and consumer value in new affordable housing construction.

The effort included volunteer-constructed homes as well as contractor-built homes. It included a current practice study of more than 100 units statewide. Review of what is currently being done was the basis of the next phase - the study of best-practice - best value elements for three locations in the state, using a variety of fuels and technologies. Then, model plans and guidebooks were developed around three types of space conditioning - natural gas, all-electric, and evaporative cooling. The plans were all under 1,230 SF, with the average home being approximately 1,100 SF, three-bedroom. The project included the construction and performance testing of more than 40 new homes in San Antonio, Longview, Abilene, Dallas and El Paso. The project included the production of approximately 30 educational information pieces and house plans.

The largest sample with the most data collected to date is in San Antonio. The performance of the natural gas homes in first San Antonio sample is to within two percent of the modeling projection for the project. The best performing home had total annual utility cost of under \$490 a year for all uses, with the best group having an average consumption of \$16 for annual space heat and \$191 for annual cooling. This represents a 42 percent savings over the San Antonio current practice (\$849) average in 1996.

Across the other sites, a wide range of performance was seen. The biggest percentage savings were seen in Longview and Dallas/FW, which had the higher 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 best performing of these homes followed the recommended

Hp2 specifications closely. A variety of measurements were taken across the sample, to maximize understanding of the data and report the information in a way that would make it useful to others.

When a home performed differently than expected, reviews were conducted. Consumer behavior had the biggest overall impact on performance, followed by product substitution, changing the specification in a way that affected performance, or workmanship that needed improvement from the energy performance standpoint. Appropriate builder execution of the specification and product selection were key aspects of performance. Occasionally, warranty-covered product failure could be a cause of performance issues. Homes that performed best closely followed all aspects of the specification, were certified to meet the performance benchmarks and had occupants who had appropriate expectations of performance and consumption behaviors within predicted performance levels.

The Design And Build Stage of Hp2 and the Features of the Design with the lowest overall consumption performance

Coming to the Current "Right Answer" for San Antonio's Habitat - Optimization results

Cooling loads are the dominant energy consumption concern, but heating is also an issue. The goal was to identify which cooling solutions had the drawback of increasing heating costs and vice versa. In this regard, the problem to solve for was the proper balance of heating and cooling related measures.

The following items had cost and performance characteristics that appear to have the lowest first cost and lowest operation cost, compared to other packages.

The San Antonio plan has 1,045 square feet, slab on grade. This house plan has three bedrooms. The home uses natural gas for hot water and space heat. The following listing shows the features of the home that had the lowest consumption data in our sample:

1) 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 (1/2 inch to 3/4-inch); slab edge is insulated; Roofing is the lightest acceptable color. In Dallas, structural insulated panels (SIP) were used for walls. Energy trusses were used to allow maximum insulation values in the attic.

2) WINDOW UPGRADE - HEAT REJECTION AND GLAZING UPGRADE - All windows meet the tightness specification. All windows have heat rejection glazing, double glazed, vinyl frames.

3) MOISTURE CONTROL PACKAGE - Because of the impact of humidity on cooling loads and comfort levels, controlling indoor relative humidity levels can save cooling costs. Moisture transmission through slab is reduced through an under slab moisture barrier, and the building is tightly constructed to avoid moisture transmission through ambient infiltration. A continuous vapor barrier is installed above the ceiling sheetrock to stop air leakage and control moisture.

4) VENTILATION - INDOOR AIR QUALITY PACKAGE - Controlled continuous ventilation is performed with high-performance fan, located in the bathroom, wired directly to the panel. which does triple duty of spot moisture control, on-going moisture discharge and meeting ventilation recommendations. Is automatic and extremely affordable.

5) "PERFORMANCE TESTED COMFORT SYSTEM" HVAC (system downsizing and verification, including duct testing). Due to the low consumption predictions, the HVAC system was downsized to a point source, with air mixing through controlled exhaust ventilation. Air tightness level was verified to match HVAC system. Ductwork (if any) is checked for air leakage as part of verification activities. All combustion heating equipment is sealed combustion, to insure air quality and safety. Heating systems included sealed combustion gas fireplaces, small gas wall furnaces sealed combustion, and heat pumps. Cooling systems included small through-the-wall air conditioners, central heat pumps and central room heat pumps. Hp2 emphasized the lowest cost approaches to equipment selection for heating-cooling equipment. Only sealed combustion was recommended.

Measures that were not included for cost or performance reasons

It is very much a sifting process to determine what the consumer's best value is, at a given point in time. Value is also relative to what the consumer's preferences are. In housing, there are several choices that consumers and appraisers feel are improvements versus those that are thought to be "downgrades" or economy models. Many times the economy model will work just fine, and if it doesn't have other problems, it can be quite acceptable. For this reason, in San Antonio it was considered an upgrade to switch to sealed combustion gas heaters, from the prior product, which was a centrally located gas furnace with no ductwork. In other locations, the need for central heat and air was dominant, and less cost effective approaches were employed due to consumer preference. People have strong tastes and preferences when it comes to space conditioning choices, and Hp2 was flexible with those builders who would allow follow-up testing and correction, if previous standards were employed.

Generally, Hp2 avoided ducted systems and relying instead on a combination of tight construction with a point source of space conditioning to achieve comfort at the lowest first and on-going cost. In this system, these small houses are built tightly enough that wind has virtually no impact on them. (See Appendix 1: Data from Abilene) Thus, air temperatures were similar throughout the house without ducted air handling. This is possible when better levels of insulation, air tightening, heat rejection and other envelope features are employed.

Low-income housing long has been associated with inadequate heating and cooling systems, and some people still see a point source of heating or cooling in this negative light. Indeed, point sources of space conditioning combined with leaky construction can make for comfort call-backs. An alternate system is the smallest available forced air system with all ductwork within the conditioned space and kept to a minimum. If outside the conditioned space, they must be insulated to the maximum degree possible and checked for air leakage and proof of performance. Also, this approach must avoid products or installations that have combustion transfer to the conditioned space. These systems cost more, and may cost more to operate over time.

Where's the "whole house fan?"

Whole house fans employ cooler night air to reduce indoor temperatures. They tend to be located in the center of the house plan, and field tests have shown them to leak air year-round, giving them an energy penalty in this regard. They can work well when used, but most require occupant action, and any system that requires occupant action is likely to not be used much or at all. In the end, the savings from not using the air conditioner would not justify the measure, particularly when the air leakage is considered.

High-Performance ventilation instead

Because of the need year round to control indoor moisture and remove indoor-generated pollutants, a high performance fan was identified that would run continuously and use under approximately \$10 a year in energy to operate. Moreover, the fan is so quiet and efficient, that it cannot be heard when operated and is virtually silent. This quantum advance in fan technology has been coming for a long time. Thus, a small fan can run continuously in the bathroom, and with tight construction, the air from the entire home is slowly ventilated out the bathroom fan exhaust. A second low-energy fan can be employed elsewhere for a "boost" or for a second bathroom when additional whole house ventilation is required or occupancy in the home increases. Because of the specific performance of this piece of equipment, very few substitutes would work.

Cooling Strategy

The cooling loads were cut to such a low level that a single central room conditioner could readily handle the small cooling load for the whole house. Measured cooling consumption in San Antonio had a mean cost of \$160 per household per YEAR. (\$191 average). A combination of small steps leads to this performance. This was accomplished through the combination of humidity control and heat rejection, with improved insulation.

The cooling strategy included reducing heat gains through windows, larger roof overhangs for shading, along with uniform, tightly constructed, well-insulated walls and roof. Exterior wall insulation is employed for air tightness and moisture control under the siding. The slab on grade construction has a moisture barrier underneath the concrete. This reduces water vapor from migrating into the building through the concrete. This allows the concrete to become a large cooling component that doesn't add to cooling

loads because of unwanted moisture transmission. Supplemental cooling, including compression-driven dehumidification, is accomplished by a central-room through the wall cooler, needed only during the hotter hours. The ground-coupled high-mass floor staves off the cooling demand, reducing the amount of compression-driven cooling that is required. Overhead fans are installed in most rooms to provide additional comfort. Passive cooling measures are joined with moisture removal through the on-going ventilation by the low-energy fan system.

Special products in this situation include long-life plastics under the floor slab, and heat rejection glazing and tight window construction. The wall air conditioner should have a SEER of 10 EER or greater to meet the Model Energy Code.

Evaporative Cooling has lowest consumption, but limited applicability

El Paso Habitat was alone in its use of evaporative cooling, a move that further reduces simulated energy consumption by approximately \$100 a year under the San Antonio consumption. Data from El Paso had shown this performance level in the current practice study. Humidity levels in most of the rest of Texas do not readily allow for this approach. Thus, while homes using evaporative cooling in El Paso using the Hp2 specification can expect to use under \$400 a year for all uses, based on the consumption seen in San Antonio. The San Antonio model has the wider applicability, being possible anywhere gas is available to the development, with possible annual costs of \$500 for all end uses. The all-electric model has reduced its consumption to under \$600-700 a year for all end uses, down from a high average of \$1,500 a year in Longview in the current practice review in 1996.

MARGINAL COST INFORMATION

Marginal cost depends on where the particular builder is starting from. In several cases, it was clear that the HP2 specification combined in the plan form or guidebook as recommended was likely less expensive than what the builder was currently building. On the other hand, the better windows and other features can add to cost if the builder is already building at the tightest possible margin. Because of the HVAC downsizing, it is possible to reduce the marginal cost of better insulation, windows, doors, and moisture control features in most cases. Each builder in Hp2 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.

Two of the project builders chose to spend significantly more than the baseline (San Antonio) house by adding much more glazing area or adding a large central ducted HVAC system. Habitat and independent builders are working with local markets, and they may wish to take a certain approach with full knowledge that the costs may be greater based on occupant preferences.

Hp2 aimed at demonstrating a benchmark of the lowest first cost combined with the best overall performance possible. It is always possible to "solve" energy issues with money - similar performance can be purchased for approximately \$7,000 in the form of a geothermal heat pump system. But, Habitat cannot afford this route on a routine basis, so Hp2 focused on getting similar performance from a system of low-cost changes.

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