The Window Market in Texas: Opportunities for Energy Savings and Demand Reduction

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ABSTRACT

The use of high performance windows represents a promising opportunity to reduce energy consumption and summer electrical demand in homes and commercial buildings in Texas and neighboring states. While low-e glass coatings and other energy efficiency features have become standard features in windows in states with building energy codes, their sales in the Texas market remain limited.

This paper presents findings from a pilot energy efficiency program sponsored by American Electric Power Company (AEP). The Texas Window Initiative (TWI) has conducted over 160 on-site training sessions for hardware store sales personnel and builders across the AEP service areas in Texas over the past two years. Companion promotional activities have also been completed.

The past one and a half years have witnessed a very significant increase in the market penetration of energy efficient windows in the AEP service area; from about 2.5% of total window sales in early 2000 to roughly 25% (according to preliminary data) by the end of 2001.[1] Some of this increase is attributable to TWI's activities, although other factors may be responsible for a portion of this increase as well.

The market for windows in Texas is described. TWI's approach to promoting energy efficient windows is reviewed. Initial impact estimates from TWI's activities are presented. The technical potential for energy savings and utility peak demand reduction from the installation of energy efficient windows in Texas is presented. The paper also provides some speculation on how the window market might be impacted by the adoption of building energy codes in Texas.

INTRODUCTION

Window-related energy efficiency measures can result in substantial peak demand reduction and energy conservation in Texas homes. Such savings can be realized through the installation of high performance windows that take advantage of new advances and technologies in glazing materials. These technologies can reduce internal heating during the summer (by reducing the transmission of infrared and ultraviolet rays through the glass), and can also reduce heat loss from inside a home in colder months (though the use of framing materials and glass with superior insulation properties). The more heat gain and loss blocked by the windows, obviously the less air conditioning and heating units will need to operate to maintain comfortable indoor temperatures. The end result is peak demand reduction and energy savings, plus a more comfortable and energy efficient home for the consumer.

Residential windows can affect about 25% of a typical new home's heating energy and up to 60% of a home's cooling costs. Partly as a result of previous utility efforts and general building codes, many Texas homebuilders are already installing adequate levels of wall and ceiling insulation and high efficiency air conditioners. Thus improved windows offer one of the most attractive remaining paths for increased energy savings. Unfortunately, most Texas builders and building suppliers are only beginning to become aware of the benefits of high performance windows. While high performance window products are now available at affordable cost and more could be made available upon demand, limited knowledge among builders and vendors in the past has hampered the adoption of new window technology in Texas.

TWI, a training program sponsored by AEP, is aimed at promoting the installation of high performance windows in the residential new construction and remodeling markets. The focus of the program is to provide education and training to window manufacturers, distributors, retailers, building product sales professionals, homebuilders, replacement contractors, and other upstream and

[1] Measurement and verification of TWI program impacts from the 2000/2001 pilot program is still being conducted and, therefore, may affect the final results.

midstream decision-makers. The TWI pilot program was launched in May 2000 in AEP's three service areas in Texas (Central Power and Light Company, West Texas Utilities Company, and Southwestern Electric Power Company).

PROGRAM DELIVERY APPROACH

TWI has delivered a number of training sessions tailored to the specific needs of various market segments, including window and glass manufacturers, window retailers, and builders who buy and install windows. Enercomp, Inc. of Auburn, California was responsible for conducting most of the training activities. Frontier Associates completed some complementary promotional activities, including the sponsorship of demonstration homes with high performance windows, press releases, some limited advertising, and the development of a brochure for point-of-purchase displays. A web site was jointly developed by Frontier Associates and Enercomp.

A number of impediments to transformation of the market to high performance windows were obvious to AEP and the program implementation team prior to launching the program:

- Many window suppliers in Texas did not stock high performance window products.
- Regional window manufacturers, retail sales personnel, and homebuilders were generally not familiar with the recent advances in window technology and their energy efficiency benefits.
- The national Energy Star® Window program and the National Fenestration Rating Council (NFRC) window rating system were unfamiliar to many consumers and building product sales professionals.
- There is a higher first cost for energy efficient windows. Consumers and sales professionals were often unaware that this initial cost would be offset by lower energy bills within a reasonable payback period.
- Homebuilders often wish to minimize construction costs and have little incentive to minimize long-term energy costs unless they are assured that homebuyers will value energy efficiency features appropriately.

The TWI sought to address these market barriers through a variety of educational and promotional efforts:

- Over the past two years, 177 trainings were delivered to 577 participants in 6 business categories.
- To ensure that high performance window products were widely available, meetings were held with a number of window manufacturers. As a direct result of TWI training, several Texas window manufacturers made major changes to their product lines to incorporate high performance technology.
- To reinforce existing national energy efficiency programs, the TWI training emphasized the benefits of NFRC window ratings/labels and the federal Energy Star® Windows program. Trainees were taught to look for these program labels as a way to identify high performance window products.
- Many window retailers, especially home centers, did not know whether their window suppliers even offered appropriate high performance window products. Sales people were taught how to identify improved products and how to order and recommend the best products for their customers.
- To address consumer concerns about the added cost of efficient windows, the training materials presented several scenarios showing the cost-effectiveness of choosing high performance windows over standard products. In addition, the further benefits of improved comfort, reduced condensation, reduction of fading, and other attributes of better windows were thoroughly explained.
- A number of promotional activities took place during 2001 in cities served by AEP. These included newspaper advertisements promoting high efficient windows, point of purchase TWI brochures for retailers and builders, establishment of an informative web site, and home and garden show displays. TWI also sponsored and coordinated three "demonstration home" projects with builders and suppliers.

RECENT CHANGES IN THE WINDOW MARKET

An initial baseline market characterization study was conducted by Frontier Associates in the Spring of 2000 in order to characterize the window market in the AEP service area prior to any TWI training and promotional activities.

Results from the baseline study indicated that a typical window sold in AEP's three Texas service areas was a double-pane window with clear glass (i.e., no low-E coatings) with an aluminum frame.

The survey also revealed that of all homebuilders, window retailers, and window manufacturers surveyed, only about 8-10% of the windows sold in those service areas had low-E coatings. A smaller share of the windows sold – perhaps 2-3% – met the ENERGY STAR® standards for solar heat gain and insulation properties established by the U.S. EPA and DOE.[2]

Measurement and verification activities were conducted in late 2001 to determine the changes that had occurred in the market for windows since the initial baseline study, and to identify those market changes that appeared to be attributable to TWI. A total of 155 telephone or written surveys were completed in the fall of 2001 with glass and window manufacturers, window retailers and homebuilders in Texas, Louisiana, Arkansas, Oklahoma, and New Mexico. Survey interviews with companies within AEP service areas were considered follow-up surveys to last year's study, and those outside AEP areas were treated as "control groups" to assist in isolating the impacts of TWI from other "naturally-occurring" changes in the market for windows. Although measurement and verification of theTWI program impacts from the 2000/2001 pilot program have for the most part been conducted, a few measurement and verification activities are still ongoing, therefore having the potential to affect the final results. It should also be noted that a discrepancy lies between the timing of when the TWI training sessions and promotional activities were conducted and when the measurement and verification activities began. When the surveys began in November of 2001 training sessions were still being held along with recently published TWI program advertisements, which indicates that the full impact of the TWI program may not be fully represented in the preliminary data.

Survey questions were designed to capture window characteristics of residential primary windows in the AEP service areas and surrounding states. Survey questions included glazing (number of panes, low-E characteristics and specific types of low-E), frame structure and material, types of customers buying windows, market trends, decision factors in choosing windows, awareness of Energy Star, awareness of building energy codes, awareness of utility programs, and other relevant data.

Low Solar Gain Low-E Saturation

In Texas' climate, the presence of low solar gain low-E glass is the most important determinant of a window's energy efficiency. The survey participants were asked what percent of all windows sold have low solar gain low-E glass during the last year.

The low-E data was analyzed by training participant and non-participant within Texas. Figure 1 depicts low-E sales/installations by non-participants of a TWI workshop compared to those who attended a workshop. The non-participant surveys conducted were within the state and mostly in AEP service areas.

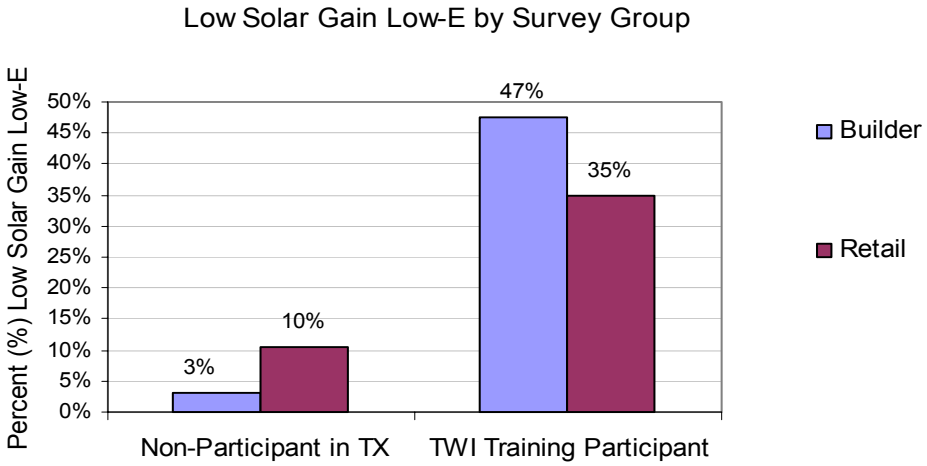

Figure 1. Low Solar Gain Low-E by Survey Group

[2] Energy Star® certified windows require a U-value of 0.75 or less and a solar heat gain coefficient of 0.4 or less for the southern region, which includes all but the most northwestern part of Texas.

Future Low-E Sales

Survey participants were asked two questions regarding future sales of low-E products:

- What percent of your window sales next year do you expect to be low solar gain low-E glass?
- What percent of your window sales in the next 2-5 years do you expect to be low solar gain low-E glass?

Figure 2 represents surveys conducted with Texas companies, the majority of which are in AEP service areas.

The preliminary data in Figure 2 and Figure 3 suggest that TWI training participants reported higher sales of low solar gain low-E glass and a higher anticipated percentage of future low-E window sales than did respondents that did not directly participate in the TWI training activities.

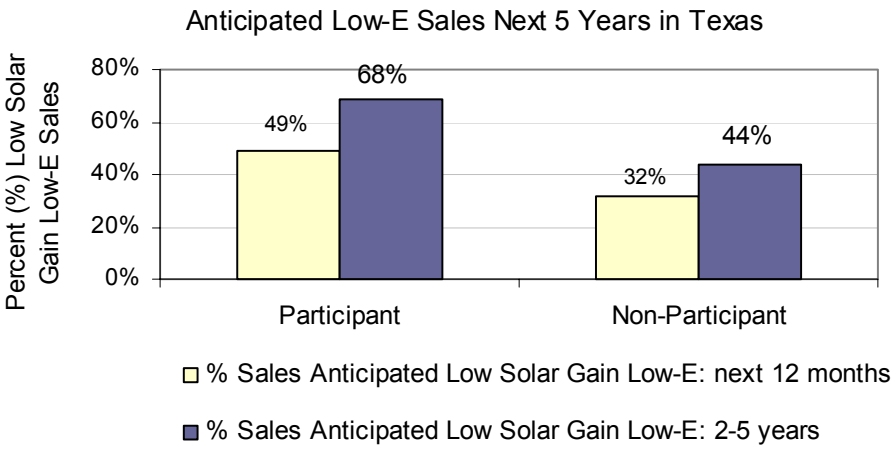

Figure 2. Anticipated Low Solar Gain Low-E Sales Next 5 Years in Texas

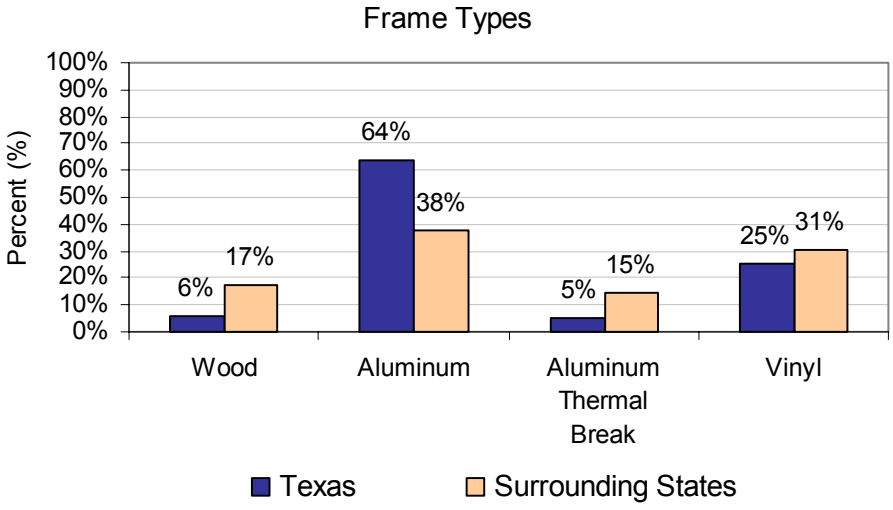

Figure 3. Frame Types in Texas and Surrounding States

Incremental Cost for Low-E Products

The survey included a question asking for an estimate of the incremental cost increase associated with low solar gain low-E relative to standard clear glass. The question was answered in several ways, but most answers fell into two categories - % increase and $ increase. On average the preliminary findings indicate that respondents said low solar gain low-E costs 17.7% more or $20.81 more per window.

The average incremental increase in cost for a low-E window reported by respondents in the 2000 Baseline Survey was 29.2%.

Energy Star Awareness

The results of the 2000 Baseline Survey indicated only thirty-three percent (33%) of manufacturers were aware of Energy Star, retailers were slightly less at thirty percent (30%) and builders had almost no recognition with only one (1) builder out of forty-three (43) or 2% recognizing Energy Star. The preliminary data calculated from the 2001 Survey indicated that Texas has become more aware of the national Energy Star program, with 73% of the respondents stating they are aware of Energy Star.

Frames

The survey participants were asked to estimate the percent of windows sold or installed that have wood, vinyl, or aluminum frames. Aluminum was divided into two groups, with a thermal break and without a thermal break. The overall preliminary statistics from the survey of window frames indicates Texas still predominately uses aluminum frames.

The 2000 baseline results were similar, however, there is an increase in vinyl frames as reported by respondents this year. This was evident in the question regarding frames and also in some of the open questions such as noticeable trends in the window market. Several respondents mentioned the window market moving towards vinyl frames.

Market Trends

When asked what market barriers are found when selling (manufacturing or installing) windows with low solar gain low-E glass in Texas most respondents indicated they felt the new building energy codes will affect the window market and move the market towards more efficient windows. Increased demand for vinyl frames was another common answer. Several comments stated higher utility bills have motivated people to increase their investigation of high performance products.

Types of Customers Purchasing Windows

Survey respondents that are glass or window manufacturers or window retailers were asked to describe the types of customers they serve. Figure 4 shows responses from these groups of participants.

QUANTIFICATION OF ENERGY SAVINGS

Energy conservation and demand reduction estimates related to increased installation of energy efficient windows has been estimated based on estimates of the total size of the window market in the AEP service areas in Texas, changes in sales of energy efficient windows, and deemed savings estimates adopted by the Public Utility Commission of Texas.

The size of the window market in the AEP service area was estimated using two approaches: a "top-down" and a "bottom-up" approach.

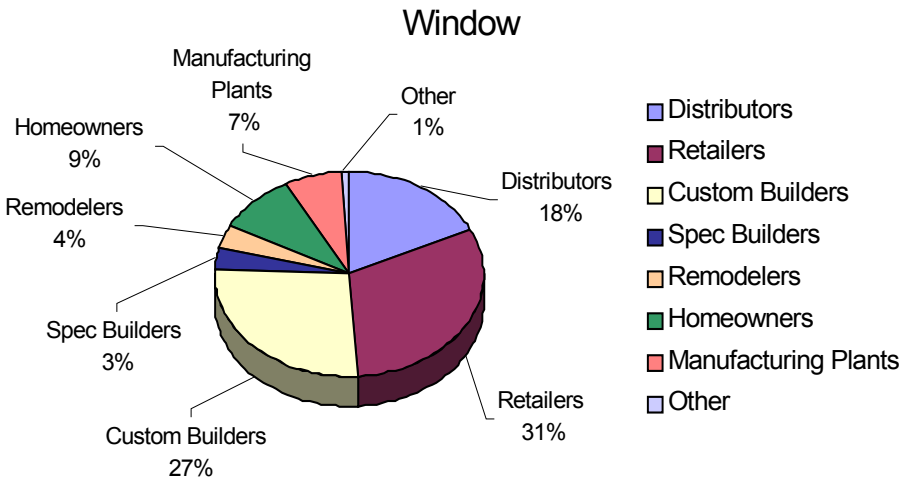

Figure 4. Types of Window Purchasers

Top-Down Approach.

The "top-down" approach compared data representing AEP's three Texas service regions to regional data that represents the West South Central (WSC) region, including Texas, Louisiana, Oklahoma and Arkansas[3]. The AEP remodeled and replacement window market was determined by calculating a ratio of the number of existing homes in the AEP service areas to the total number of existing homes in the WSC region then combining the ratio with the total number of remodeled and replacement windows sold in the WSC region. The new construction window market was determined by calculating a ratio of the number of new single family home starts in the AEP territories to the total number of new single family home starts in the WSC region then combining the ratio with the total number of windows sold for single family new construction homes in the WSC region.

Bottom-Up Approach.

The second approach used a "bottom-up" framework that combined the number of AEP new home starts with average single family home window statistics[4], and the number of existing homes in the AEP service area with a ratio of remodeled windows per home calculated using the WSC regional data.

Both approaches yielded a similar total window market size of approximately 13 million square feet of window.

Over the past year and a half, the market share of energy efficient windows in AEP's three service areas in Texas has increased significantly. In the initial baseline study, it was concluded that 2-3% of all windows sold in these areas in early 2000 would meet the energy efficiency standards for windows established by the Energy Star® program based on the responses to questions pertaining to low-E coatings and frame materials. As of late 2001, the market share of energy efficient window products has increased to approximately 25%.

Deemed savings estimates have been adopted by the Public Utility Commission of Texas for the purpose of estimating the impact of various energy efficiency measures. For the installation of energy efficient windows in lieu of "baseline" windows, annual deemed savings range from 2.68 to 9.5 kWh per square foot of window glass per household per year, depending on climate zone and the type of heating system. The corresponding demand reduction values range from 0.0024 to 0.0033 kW per square foot of window glass. These deemed savings values were, in turn, based on research conducted by Lawrence Berkeley National Laboratory.

Combining this information yields "gross" lifetime energy savings from recent changes in the window market in the AEP service areas of 162,725 MWh (assuming the 10-year energy efficiency measure life that the Public Utility Commission of Texas typically uses in cost-effectiveness calculations) and annual peak demand reduction of 8 MW per year. Assuming a more-realistic 20-year life for windows, the lifetime savings from first-year impacts would be about 325,451 MWh. If the market were completely transformed in the AEP service areas (i.e., 100% market penetration of energy efficient windows), the savings would be about four times this level.

It is likely that some improvement in the market share of energy efficient windows in the AEP service areas would have occurred even in the absence of the TWI, due to gradual changes in building practices, promotions by window manufacturers, greater awareness of energy efficiency prompted by recent events in California, and other factors. Net savings is that portion of gross savings that can be attributed to program activities, and thus excludes changes resulting from naturally-occurring market changes and building codes. The project team is still seeking to isolate the impacts of TWI from naturally-occurring changes in the window market to derive an estimate of net savings.

We have also estimated the statewide technical potential for energy savings and peak demand reduction from energy efficient windows. A hypothetical increase in the market penetration of energy efficient windows from 0% to 100% of all new construction and remodeled windows would result in statewide savings of 262 GWh per year and 136 MW per year, based on the deemed savings values approved by the Public Utility Commission of Texas, reasonable assumptions regarding the distribution of the housing stock by space conditioning equipment type, and a reasonable estimate of the size of the statewide window market. A hypothetical instantaneous replacement of all existing windows in Texas homes with energy efficient windows would result in a statewide savings

[3]Regional data obtained from Ducker Research Company, Inc., and the US 2000 Census Bureau. Local data obtained from AEP and the Texas Real Estate Research Center.

[4]Provided by the Public Utility Commission of Texas on deemed savings analysis for an average single family home.

of roughly 4,998 GWh per year and 2,589 MW per year. Of course, these are just hypothetical estimates, and a great deal of uncertainty is inherent in estimates of this nature.

TEXAS BUILDING ENERGY CODES

When the Texas Window Initiative began in 2000, there were discussions in the building industry about adopting statewide building energy codes in Texas. Until September 2001, such codes did not exist at the state level. As of September 2001, the International Residential Code (IRC) has been adopted as the energy building code for Texas. The code has requirements that will encourage the use of higher performance fenestration products that are NFRC rated and labeled. For residential, products meeting the code requirements will likely need to use a low solar gain low-E coated glass, and may also need a lower conductance frame depending on the glazing percentage.

In general, survey respondents from Texas stated the new IRC code will have an impact on the windows market. Several survey respondents stated they thought enforcement of the code will play a key factor in how quickly the market is transformed.

SUMMARY

The TWI program has achieved considerable success in educating Texas window manufacturers, window retailers, and builders about the benefits of high performance windows. Considerable progress has been made in transforming the Texas window market. However, significant potential for energy conservation and electrical peak demand savings remains.

REFERENCES

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Lawrence Berkeley National Laboratory (LBNL), 2001, "LBNL Window & Daylighting Software RESFEN".

Public Utility Commission of Texas (PUCT). 2001. *Deemed Savings* [online]. Available from World Wide Web:(http://www.puc.state.tx.us/electric/projects/22241/22241.cfm)

U.S. Census Bureau. *Census 2000 Housing Units* [online]. (accessed: November 2001). Available from World Wide Web:(http://quickfacts.census.gov/hunits/)

Homes produced with airtight duct systems (around 15% savings in Htg and Cooling Energy)

Palm Harbor Homes	22,000
Southern Energy Homes	8,000
Cavalier Homes	1,000
	= = =
Subtotal	31,000

Technical measures incorporated in BAIHP homes include some or many of the following features - better insulated envelopes (including Structural Insulated Panels and Insulated Concrete Forms), unvented attics, “cool” roofs, advanced air distribution systems, interior duct systems, fan integrated positive pressure dehumidified air ventilation in hot humid climates, quiet exhaust fan ventilation in cool climates, solar water heaters, heat pump water heaters, high efficiency right sized heating/cooling equipment, and gas fired combo space/water heating systems.

HOMES BY THE FLORIDA HOME ENERGY AND RESOURCES ORGANIZATION (FL.H.E.R.O.)

Over 400 single and multifamily homes have been constructed in the Gainesville, FL area with technical assistance from FL H.E.R.O. These homes were constructed by over a dozen different builders. In this paper data from 310 of these homes is presented. These homes have featured better envelopes and windows, interior and/or duct systems with adequate returns, fan integrated positive pressure dehumidified air ventilation, high efficiency right sized heating/cooling equipment, and gas fired combo space/water heating systems. The innovative outside air (OA) system is described below.

The OA duct is located in the back porch (Figure 1) or in the soffit (Figure 2). The OA is filtered through a 12"x12" filter (which is readily available) located in a grill (Figure 3) which is attached to the OA duct box. The flex OA duct size varies depending on the system size - 4" for up to 2.5 tons, 5" for 3 to 4 ton and 6" for a 5 ton system. The OA duct terminates in the return air plenum after a manually adjustable butterfly damper (Figure 4).

Figure 1 OA Intake Duct in Back Porch

Figure 2 OA Intake Duct in Soffit

Figure 3 Filter Backed Grill Covering the OA Intake

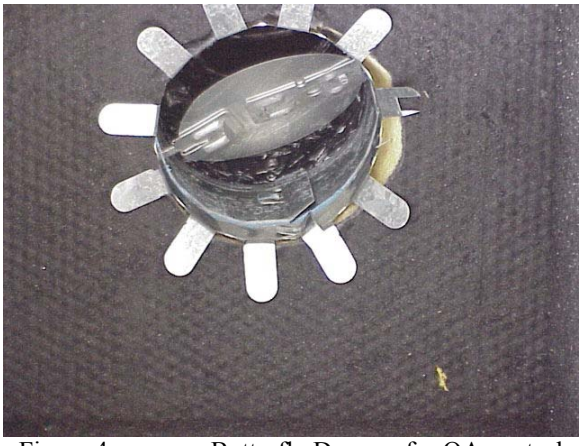


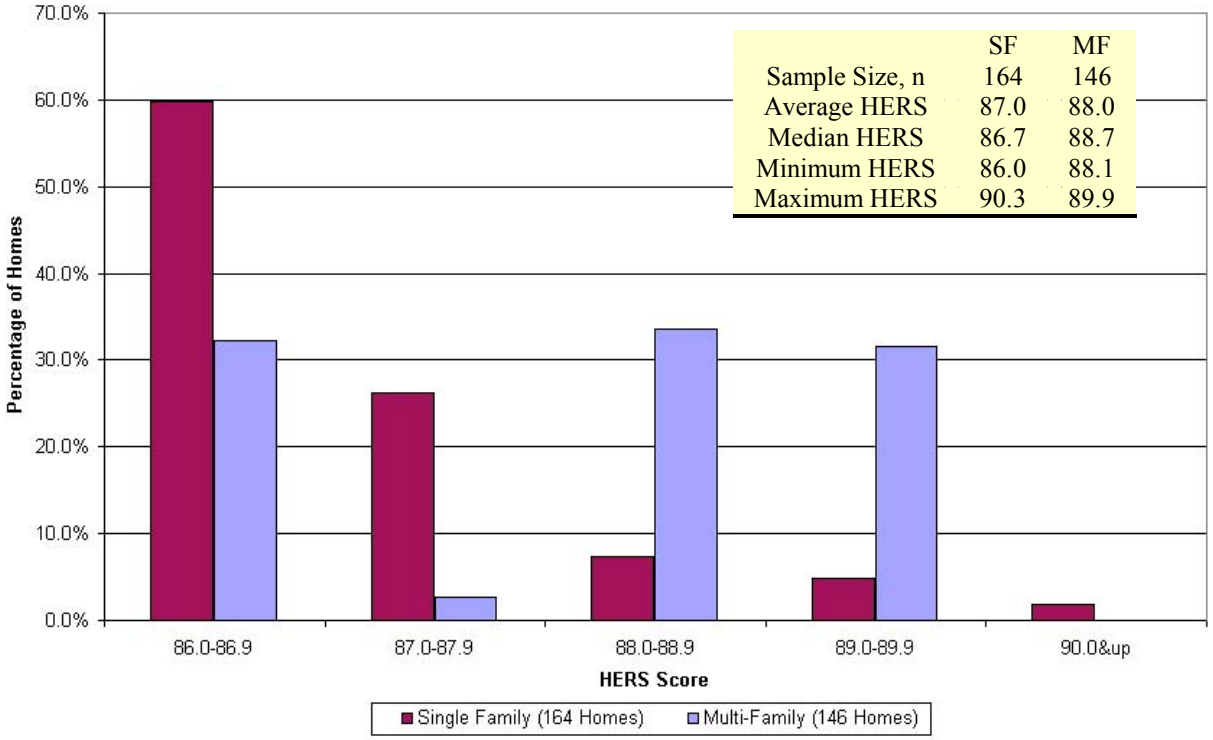
Figure 4 Butterfly Damper for OA control

The damper can be set during commissioning and closed by the homeowner in case the OA quality is poor (e.g. forest fire). This system introduces filtered and conditioned ventilation air only when the cooling or heating system is operational. The ventilation air also positively pressurizes the house. Data on the amount of ventilation air or positive pressurization is not available from a large sample of homes. A few measurements indicate that about 25 to 45 cfm of ventilation air is provided which pressurizes the house in the range of +0.2 to +0.4 pascals.

Measured Home Energy Ratings (HERS) and airtightness on these FL. H.E.R.O. homes is presented next in figures 5 through 8. Data is presented for both single family detached (SF) and multifamily homes (MF). See Table 2 below.

Table 2. Summary statistics on FL.H.E.R.O. Homes
n = sample size

	SF	MF
Median cond area	1,909	970
% constructed with 2x4 frame or frame and block	94%	100%
Avg. Conditioned Area, ft^2	1,993 (n=164)	1,184 (n=146)
Avg. HERS score	87.0 (n=164)	88.0 (n=146)
Avg. ACH50	4.5 (n=164)	5.2 (n=146)
Avg. Qtot (CFM25 as %of floor area)	6.9% (n=25)	5.0% (n=72)
Avg. Qout (CFM25 as %of floor area)	3.0% (n=15)	1.4% (n=4)



	SF	MF
Sample Size, n	164	146
Average HERS	87.0	88.0
Median HERS	86.7	88.7
Minimum HERS	86.0	88.1
Maximum HERS	90.3	89.9

Figure 5 HERS Scores for FL H.E.R.O. Homes

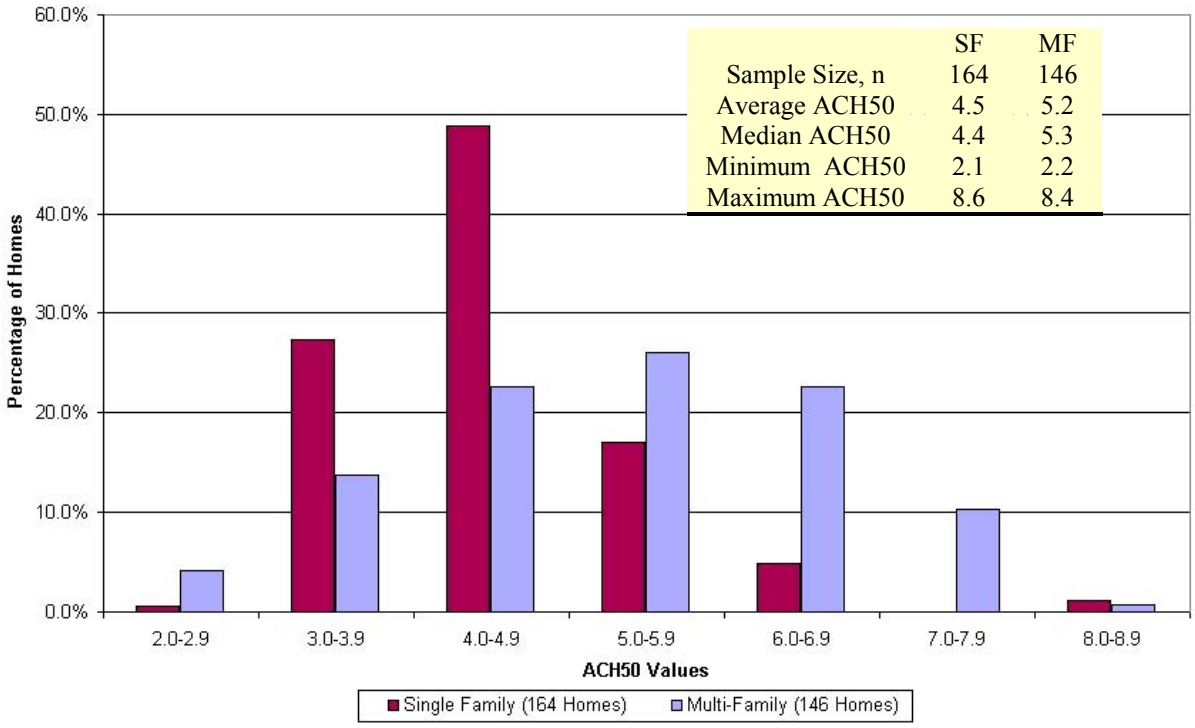


Figure 6 ACH50 Values for FL H.E.R.O. Homes

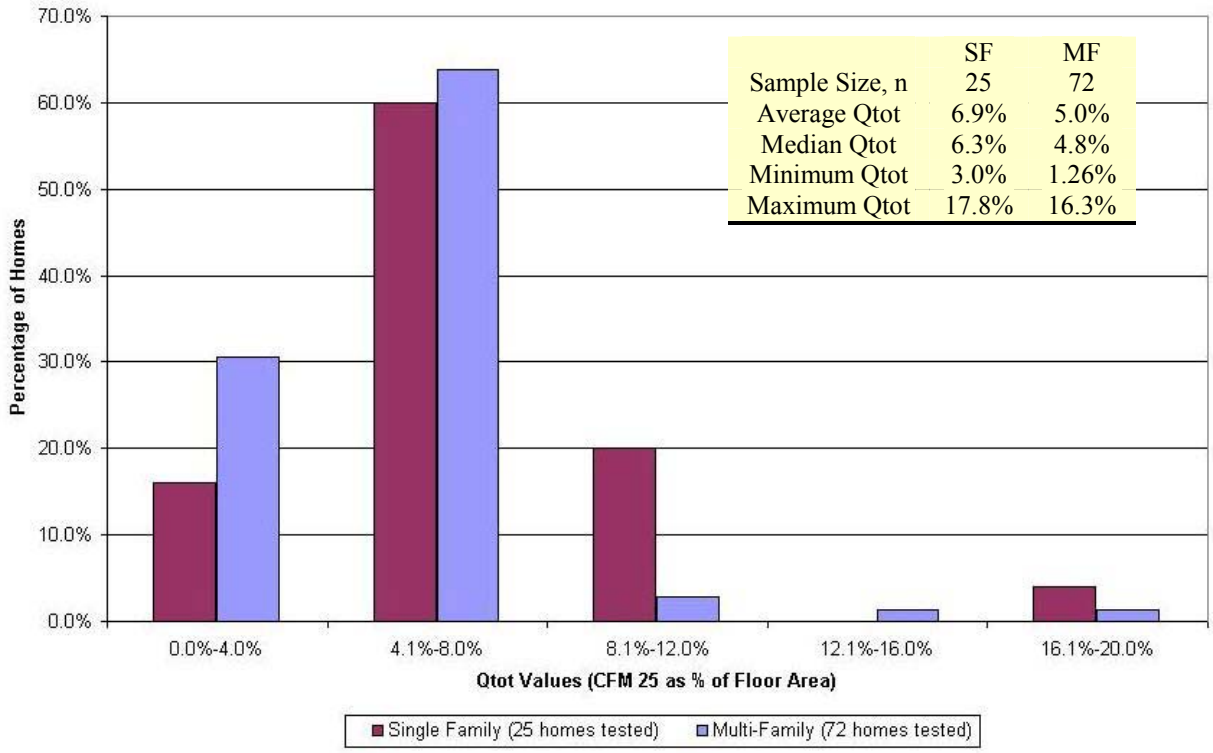


Figure 7 Qtot Values for FL H.E.R.O. Homes

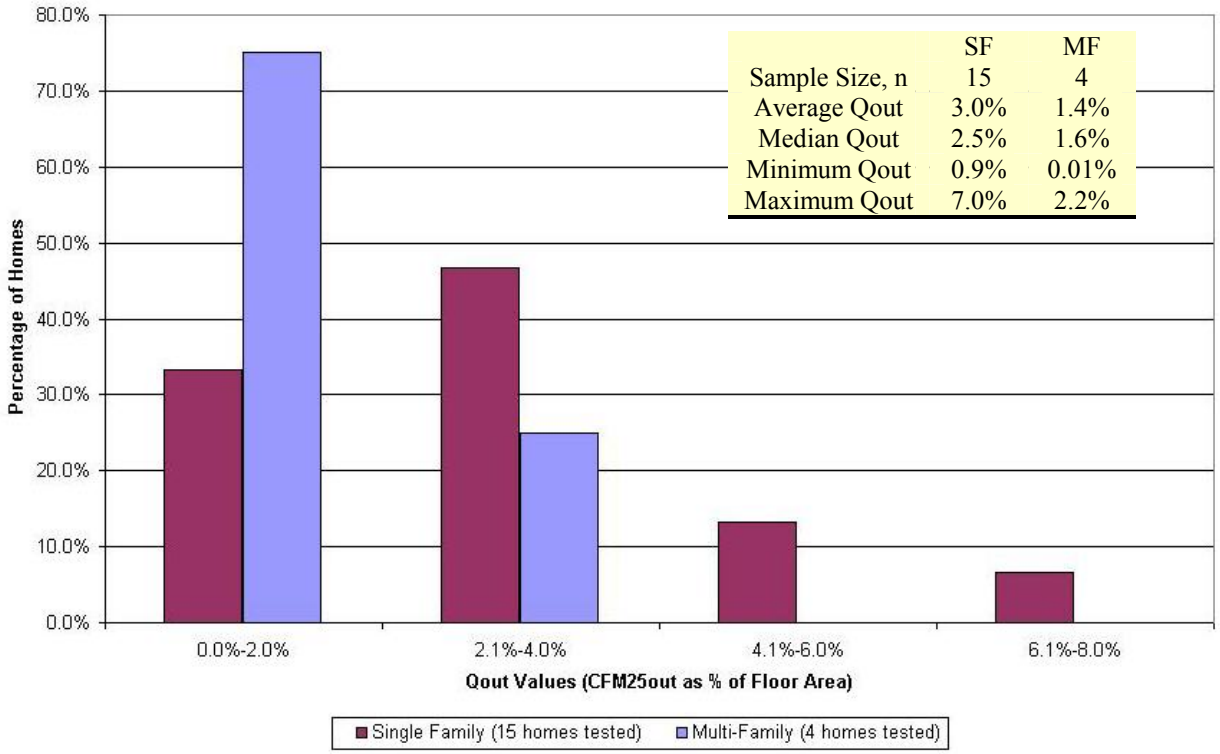


Figure 8 Qout Values for FL H.E.R.O. Homes

Data is available for other typical non BAIHP, new Florida homes (FPL , 1995 and Cummings et al, 2001). The FPL study had a sample size of over 300 single family homes and the median Qout was 7.5% , three times that of the FL. H.E.R.O. homes. In the Cummings study of 11 homes the measured average values were : ACH50= 5.7, Qtot=9.4% and Qout=4.7%. Although the sample sizes are small the FL. H.E.R.O. homes appear to have significantly more airtight duct systems than typical homes.

The remainder of the paper presents status of other tasks of the BAIHP project.

OTHER BAIHP TASKS

Moisture Problems in HUD code homes

The BAIHP team expends considerable effort working to solve moisture problems in existing manufactured homes in the hot, humid Southeast.

Some manufactured homes in Florida and the Gulfcoast have experienced soft walls, buckled floors, mold, water in light fixtures and related problems. According to the Manufactured Housing Research Alliance (MHRA), who we collaborate with, moisture problems are the highest priority research project for the industry.

The BAIHP team has conducted diagnostic tests (blower door, duct blaster, pressure mapping, moisture meter readings) on about 40 such problem homes from five manufacturers in the past two years and shared the results with MHRA. These homes were newly built (generally less than 3 years old) and in some cases just a few months old when the problems appeared. The most frequent causes were:

- Leaky supply ducts and/or inadequate return air pathways resulting in long term negative pressures.
- Inadequate moisture removal from oversized a/c systems and/or clogged condensate drain, and/or continuous running of the air handler fan.
- Presence of vinyl covered wallboard or flooring on which moist air condenses creating mold, buckling, soft walls etc.
- Low cooling thermostat set point (68-75F), below the ambient dew point.
- Tears in the belly board and/or poor site drainage and/or poor crawlspace ventilation creating high rates of moisture diffusion to the floor.

Note that these homes typically experience very high

cooling bills as the homeowners try to compensate for the moisture problems by lowering the thermostat setpoints. These findings have been reported in a peer reviewed paper presented at the ASHRAE IAQ 2001. conference (Moyer et al)

The Good News:

As a result of our recommendations and hands-on training, BAIHP partner Palm Harbor Homes (PHH) has transformed duct design and construction practices in all of its 15 factories nationwide producing about 11,000 homes/yr. All Palm Harbor Home duct systems are now constructed with mastic to nearly eliminate air leakage and produced with return air pathways for a total cost of <$10/home!! The PHH factory in AL which had a high number of homes with moisture problems has not had a single problem home the past year!

Field Monitoring

Several houses and portable classrooms are being monitored and the data displayed on the web. (Visit http://www.infomonitors.com/). Of special interest is the side-by-side monitoring of two manufactured homes on the campus of the North Carolina A & T U. where the advanced home is saving about 70% in heating energy and nearly 40% in cooling energy, proving that the Building America goal can be met in manufactured housing. Other monitored sites include the Washington State U. Energy House in Olympia, WA; the Hoak residence in Orlando, FL; two portable classrooms in Marysville, WA; a classroom each in Boise, ID and Portland, OR. See other papers being presented at this symposium for details on two recently completed projects giving results from duct repairs in manufactured homes (Withers et al) and side by side monitoring of insulated concrete form and base case homes (Chasar et al).

"Cool" Roofs and Unvented Attics

Seven side-by-side Habitat homes in Ft. Myers, FL. were tested under unoccupied conditions to examine the effects of alternative roofing strategies. After normalizing the data to account for occupancy and minor differences in thermostat set points and equipment efficiencies, the sealed attic saved 9% and the white roofs saved about 20% cooling energy compared to the base case house with a dark shingle roof for the summer season in South Florida. Visit http://www.fsec.ucf.edu/%7Ebdac/pubs/coolroof/exsum.htm for more information.

Habitat for Humanity

Habitat for Humanity affiliates work in the local community to raise capital and recruit volunteers. The volunteers build affordable housing for and with buyers who can't qualify for conventional loans but do meet certain income guidelines. For some affiliates, reducing utility costs has become part of the affordability definition.

To help affiliates make decisions about what will be cost effective for their climate, BAIHP researchers have developed examples of Energy Star homes for more than a dozen different locations. These are available on the web at http://www.fsec.ucf.edu/bldg/baihp/casestud/hfh_estar/index.htm . The characteristics of the homes were developed in conjunction with Habitat for Humanity International (HFHI), as well as Executive Directors and Construction Managers from many affiliates. Work is continuing with HFHI to respond to affiliates requesting a home energy rating through an Energy and Environmental Practices Survey. 36 affiliates have been contacted and home energy ratings are being arranged using combinations of local raters, Building America staff, and HFHI staff.

HFHI has posted the examples of Energy Star Habitat homes on the internal web site PartnerNet which is available to affiliates nationwide.

"Green" Housing

A point based standard for constructing green homes in Florida has been developed and may be viewed at http://www.floridagreenbuildings.org/. The first community of 270 homes incorporating these principles is now under construction in Gainesville, FL. The first home constructed and certified according to these standards has won an NAHB energy award.

BAIHP researchers are participating as building science - sustainable products advisor to the HUD Hope VI project in Miami, redeveloping an inner city area with over 500 units of new affordable and energy efficient housing.

Healthy Housing

BAIHP researchers are participating in the development of national technical and program standards for healthy housing being developed by the American Lung Association.

A 50-year-old house in Orlando is being remodeled to include energy efficient and healthy features as a demonstration project.

EnergyGauge USA®

This FSEC developed software uses the hourly DOE 2.1E engine with FSEC enhancements and a user-friendly front end to accurately calculate home

energy ratings and energy performance. This software is now available. Please visit http://energygauge.com/ for more information.

Industrial Engineering Applications

The UCF Industrial Engineering (UCFIE) team supported the development and ongoing research of the Quality Modular Building Task Force organized by the Hickory consortium, which includes thirteen of the nation's largest modular homebuilders. UCFIE led in research efforts involving factory design, quality systems and set & finish processes. UCFIE used research findings to assist in the analysis and design of two new modular housing factories – Excel homes, Liverpool, PA and Cardinal Homes - Wyliesburg, VA.

CONCLUSIONS

The entire BAIHP team of over 20 researchers and students are involved in a wide variety of activities to enhance the energy efficiency, indoor air quality and durability of new housing and portable classrooms.

In addition to energy efficiency, durability, health, comfort and safety BAIHP builders typically consider resource and water efficiency. For example, in Gainesville, FL BAIHP builders have incorporated the following features in developments:

- Better planned communities
- More attention given to preserving the natural environment
- Use of reclaimed sewage water for landscaping
- Use of native plants that require less water
- Storm water percolating basins to recharge the ground water
- Designated recreational areas
- Better designed and built infrastructure
- Energy efficient direct vented gas fireplaces (not smoke producing wood)

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