FOCUS ON GREEN BUILDING

Energy Performance in Residential Green Developments: A Florida Case Study

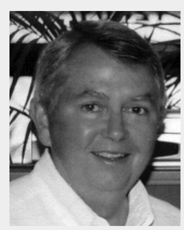
BY PIERCE JONES, PH.D., AND UJJVAL K. VYAS, PH.D., J.D.

THE COMMERCIAL AND RESIDENTIAL SECTORS both have an important role to play in any worthwhile attempt to decrease the overall energy consumption of the United States. Often, the residential sector is too fragmented to provide real, economically sound returns on investment in increased efficiency or overall decreased consumption of energy without direct or indirect subsidization. A good example is the common use of demand side management programs, administered and funded by local and regional utilities, in conjunction with various state-funded subsidies. Until recently, the use of either direct or indirect subsidies was the chief mechanism to push for change in the residential market. This paper addresses the situation in a Florida context, but the issues have national application.

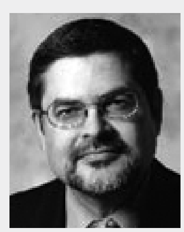
RESIDENTIAL GREEN BUILDING CERTIFICATION PROGRAMS

"Green certification" programs at both the national and local levels are trying to provide an avenue for increasing brand power for premium pricing while attempting to encourage appropriate energy and resource reduction options. In our studies we have concentrated on the ENERGY STAR® certification developed and administered by the U. S. Department of Energy and the U. S. Environmental Protection Agency because of its longer track record and robust building performance concentration. ENERGY STAR has the largest number of residential units certified, with an estimated 12 percent of new homes achieving the certification.[1] This is important because it allows a large enough number of data points to obtain meaningful statistical outcomes. We also selected ENERGY STAR because of its robust third-party verification through the use of Home Energy Raters (HERS) trained and certified by Residential Energy Services Network, a respected industry standard-setting body for residential energy efficiency. The ENERGY STAR system has been in operation since 1992, and a version applying to homes was started in 1995. Other rating product certifications include the National Association of Home Builders Model Green Home Building Guidelines, the U. S. Green Building Council's (USGBC) Leadership in Energy and

About the Authors



Pierce Jones, Ph.D., *earned his graduate degree in mechanical engineering from the University of Florida in 1980, and is a professor there in the Agricultural and Biological Engineering Department in the Institute of Food and Agricultural Sciences. He directs the Program for Resource Efficient Communities, an interdisciplinary, self-funded, entrepreneurial group that promotes the adoption of "best design, construction and management practices" in new, master planned residential developments. Under his direction, the Program for Resource Efficient Communities is directly participating in land development and building projects that adopt and demonstrate "green" practices.*



Ujjval Vyas, Ph.D., J.D., *is the principal of Alberti Group, a Chicago-based interdisciplinary consultancy specializing in emerging issues in the building industry including sustainability and high-performance buildings, building information modeling, and alternative project delivery systems. He has lectured and published extensively on legal and business risks in the sustainable building marketplace, covering large-scale policy, insurance, legal and technical issues. Dr. Vyas holds a Ph.D. from the University of Chicago and a J.D. with honors from Illinois Institute of Technology/Chicago-Kent College of Law.*

Environmental Design (LEED®) Green Building Rating System™ for Homes, and the local Florida Green Building Coalition's own building standards for residential construction, as well as numerous green building programs nationwide.

ENERGY STAR is often referred to as a performance-based program, but in fact it is more accurately a prescriptive path program using the HERS index to model predicted performance. The term "performance-based" could be misleading in that actual energy consumption of homes is not measured post-occupancy or required for ENERGY STAR certification.

The homes that earn the ENERGY STAR designation must meet guidelines for energy efficiency set by the Environmental Protection Agency and the Department of Energy. ENERGY STAR-qualified homes are designed to be at least 15 percent more energy efficient than conventional homes. The ENERGY STAR Qualified New Homes program applies to total energy consumption for heating, cooling, domestic water heating, lighting, appliances and on-site energy production. ENERGY STAR-qualified new homes can include a variety of energy-efficient features such as upgraded insulation, high-performance windows, tight construction and ducts, efficient heating and cooling equipment, and ENERGY STAR lighting and appliances. These features contribute to improved home quality and homeowner comfort, and can lower energy demand and reduce air pollution.

LEED for Homes is a green building rating system product released by the USGBC that covers some performance, environmental and social welfare issues. Based on a highly successfully marketed green building rating system for new commercial construction, the hope is to achieve equal success in the residential market. LEED for Homes is aimed at a new home market interested in including sustainable design features.

While there are already a number of local or regional green homebuilding programs, LEED for Homes is attempting to provide national consistency in defining the features of a green home and to enable home buyers anywhere in the country to identify green homes. LEED for Homes was developed and refined by a diverse group of national experts and experienced green builders. The LEED for Homes Green Building Rating System measures the overall performance of a home in eight categories that include location, site, water efficiency, energy, materials, indoor air quality and education.

The National Association of Home Builders (NAHB) has developed voluntary *Model Green Home Building Guidelines* designed to be a tool kit for the individual builder looking to engage in green building practices as well as for home builder associations (HBAs) looking to launch their own local green building programs. This certification addresses the builder and the building process rather than the individual home. The system aims to organize the green design and construction process and help home builders incorporate more green building features into their homes. The *NAHB Green Building Guidelines* address seven primary sections including lot design and development, materials, energy, water, indoor air quality, homeowner education and global impact.

While the LEED for Homes rating system is geared to appeal to the final consumer, the NAHB is interested in embedding the green preferences into the product delivery chain. Given the current residential market, it remains to be seen if consumer price sensitivity will allow any significant uptake for the LEED or NAHB products.

It should be noted that none of these green residential certification programs are structured to measure or verify post-occupancy performance of the home. Thus they remain incapable of contributing to increasing our data pools for analyzing and improving on the real performance attributes of green residential buildings. Surprisingly though, many developers, lawmakers and government officials have become convinced, as a result of active marketing campaigns, that a green rating will serve as a credible proxy for post-occupancy performance. Given the nature of the green certifications at present, only the ENERGY STAR qualification procedure, primarily because it is based on an actual testing and verification of certain crucial attributes of energy performance, provides some initial assurance of subsequent energy performance. It should be noted that ENERGY STAR figures prominently in the energy efficiency sections of the LEED and NAHB rating system as well.

FLORIDA LEGISLATION

On July 13, 2007, Florida Governor Charlie Crist concluded the first Florida Summit on Global Climate Change by signing three executive orders. Many of the ideas in the executive orders are directly and significantly changing Florida's building construction practices. Among other things the governor ordered Florida's Department of Management Services to "adopt the USGBC's Leadership in Energy and Environmental Design for New Construction (LEED-NC) standard for all new buildings," and he precluded all state agencies from leasing "office space that does not meet ENERGY STAR building standards."[2] He also established "greenhouse gas emissions reduction targets;" directed the Florida Department of Environmental Protection (DEP) to achieve "adoption of a maximum allowable emissions level of greenhouse gases for Florida's electric utilities;" and directed the Department of Community Affairs to revise the "Florida Energy Code for Building Construction to increase the energy performance of new construction in Florida by at least 15 percent from the 2007 Energy Code."[3] Finally, he established the Florida Governor's Action Team on Energy and Climate Change with a mandate to recommend legislative policies in specific areas—for example, "market-based regulatory mechanisms, such as cap and trade, for use in efficiently reducing greenhouse gas emissions."[4]

One year later, at the second Florida Summit on Global Climate Change, Governor Crist signed Florida House Bill 7135 into law, enacting new energy and climate change policies. Sections 17 through 22 of the energy bill codify the green construction standards outlined in the governor's executive orders, specifically requiring all design, construction and renovation of state-owned buildings to be certified through the USGBC's LEED rating system, the Green Building Initiative (GBI) Green Globes rating system, the Florida Green Building Coalition's (FGBC) standards, or another nationally recognized rating system. The legislation also authorized the Florida Climate Protection Act, mandating the DEP to develop a greenhouse gas (GHG) cap-and-trade program that could begin operation as soon as Jan. 1, 2010.

Although the events described above are unique in the Southeast, many other states nationwide are moving to adopt energy efficiency standards and reduce greenhouse gas emissions (most notably California). As Stephen Del Percio reports in another of the articles in this issue, "24 states and 90 local governments had adopted the U.S. Green Building Council's LEED green building standards, while 12 states had included the Green Building Initiative's Green Globes system in legislation" as of August 2007. These green certification programs are being adopted as standards of performance, in spite of the fact that there is very little information about how buildings designed and constructed in compliance with these programs actually perform.

PROJECT BACKGROUND

The building science aspect of energy-efficient construction is well understood while the most variable component of residential energy efficiency lies in occupant behavior and building maintenance. While the HERS rating system takes into account many of the factors that affect home energy use, it serves only as an indicator of actual energy use. This is a crucial and often overlooked point in many of the current discussions about green rating system products and/or certifications: they are not structured to actually measure the real energy consumption rates of the homes or developments that are given the certification. It is our hope that the current research work at the University of Florida, which significantly updates and expands detailed earlier work in the Gainesville area, will provide the necessary data and protocols for analysis in a fully transparent manner to aid the real development of the energy-efficient residential market. This paper provides only some of the initial indications of the data analysis, but they are of import for policymakers and developers. Fully detailed papers are being prepared for publication and should be available shortly.

Consumers (and developers) lack basic information with which to properly monetize residential energy efficiency attributes. Aside from anecdotal information, homeowners have very little idea of how their household energy consumption compares to community average consumption patterns. Further, they often have only a general idea of how energy efficiency upgrades and behavioral changes could affect their utility bills. Acquisition of the proper utility information, provided in a manner that would enable open comparison, would be a first step toward creating an adequate information pool for residential product differentiation in the market and for developers to clearly understand the proper pricing the market will bear. If a consumer cannot easily acquire the information that "X" house uses a significantly lesser amount of energy than "Y" house (putting aside behavioral considerations for the moment), a buyer cannot properly account for these attributes in willingness to pay any premium pricing.

2003 PUBLISHED STUDY

The University of Florida began a research project to analyze the actual metered performance of ENERGY STAR homes in Gainesville, with the goal of determining if, and to what degree, energy-efficient residential developments provided real economic benefits for the homeowners. Three major issues were examined: 1) whether ENERGY STAR developments really perform better in terms of energy consumption relative to other comparable homes; 2) if so, whether this was of any statistical significance in providing reduced homeownership costs; and 3) what policy implications could be gleaned from the results.[5] Single-family detached homes in four conventional developments were compared with those in an ENERGY STAR development. Two local utilities that supplied the gas and electricity for the ENERGY STAR and control homes provided data so that we could independently ascertain the real energy consumption data pool. The data were scrubbed and appropriately normalized prior to statistical analysis (in this case an analysis of variance methodology) to prevent skewing.[6]

The results of the 2003 study show that there was a statistically significant energy savings and the units sold in the chosen ENERGY STAR development fared well against non-ENERGY STAR units for the years 2000 and 2001. In fact, "energy savings resulted in annual utility cost savings for the average ENERGY STAR household of $180 per year, which was capitalized to indicate a value increase of the average housing unit of $4,500 and the ability to afford a mortgage of $2,255 more than in the absence of the energy savings."[7]

In an effort to expand on this work, a research agenda was established to acquire the data for the same set of developments but to compare the data set from 2000 with the data set of metered information provided by Gainesville Regional Utility and Clay Electric Cooperative

Figure 1a

Gainesville Developments

Development	n-value	Avg. home size	Built dates
Broadmoor	114	2018 sq ft	1996-1999
Capri	106	1863 sq ft	1996-1999
Eagle Point	114	1788 sq ft	1996-1999
Mentone	92	1708 sq ft	1996-1999
Stillwind	46	1828 sq ft	1997-1999

All homes in the 2003 and 2007 studies for residential developments in Gainesville, Florida, have full electric and natural gas use data for 2000 and 2006, and were market rate with comparable pricing.

Source: Pierce Jones 2008

Figure 1b

Methodology for Comparing Neighborhoods

Five subdivisions were evaluated to compare energy consumption in ENERGY STAR® versus conventionally constructed homes in the Gainesville, Florida, market. One subdivision, Mentone, began building ENERGY STAR qualified homes in 1998 and averaged approximately 50 houses per year. The four other subdivisions (Capri, Stillwind, Broadmoor and Eagle Point) were built to comply with the Florida/local building code. All homes are frame construction with fiber cement plank siding. They are all air-conditioned and use natural gas (NG) for domestic water and space heating (NG furnace). The houses are all single-story and are mainly 3-bedroom/2-bathroom split plans.

Population Selection and Data Cleaning:

- Homes were selected based on parcel number to identify neighborhoods
- Data were cleaned to include only 2000 and 2006 utility use data
- Homes without a full set of use data for both 2000 and 2006 were excluded from the study
- ENERGY STAR status was determined using the Florida Solar Energy Center's database of HERS-rated ENERGY STAR homes

Data Compilation and Analysis:

- Electric and natural gas data were compiled by month for each home (e.g., if a home had two readings in one month, the data were proportionately combined to represent the full month)
- Monthly data were corrected –data were broken into average daily use by dividing monthly use by metered days –daily use values were multiplied by 30.5 to correctly represent an average month
- Total energy was calculated using the following equation:
  - o Total = Electric + (NG x 29.3kWh/therm)
- Individual household data were compiled by subdivision to represent neighborhood averages

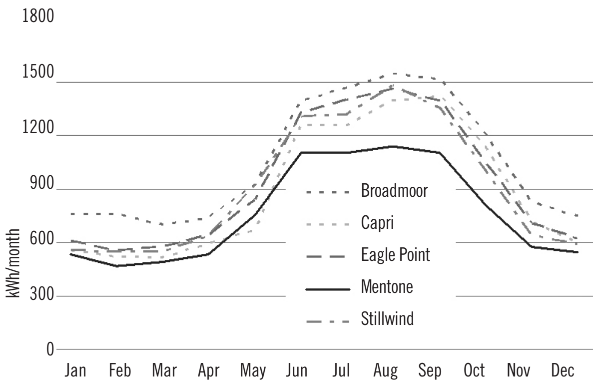
Methodology for comparing ENERGY STAR development to non-ENERGY STAR developments used for both 2000 and 2006 data.

Source: Pierce Jones 2008

for 2006. By updating the data (in 2007), we expected to see the energy savings gain momentum at the ENERGY STAR development previously studied. A more detailed description of the methodology used can be found in Figures 1a and 1b below.

Figure 2a

2000 Electric Energy Consumption

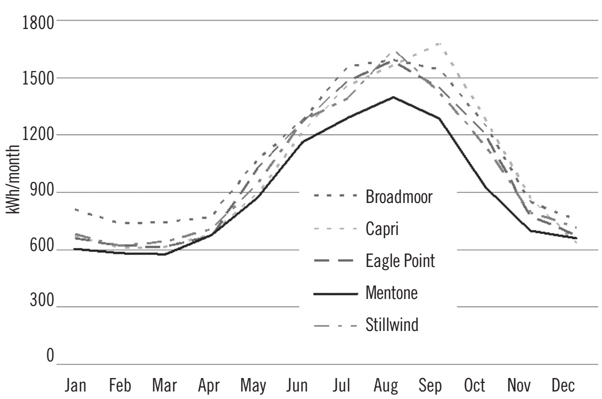


Monthly average household electric energy use for Mentone, an ENERGY STAR® development, and four non-ENERGY STAR developments for calendar year 2000.

Data provided by Clay Electric Cooperative

Figure 2b

2006 Electric Energy Consumption

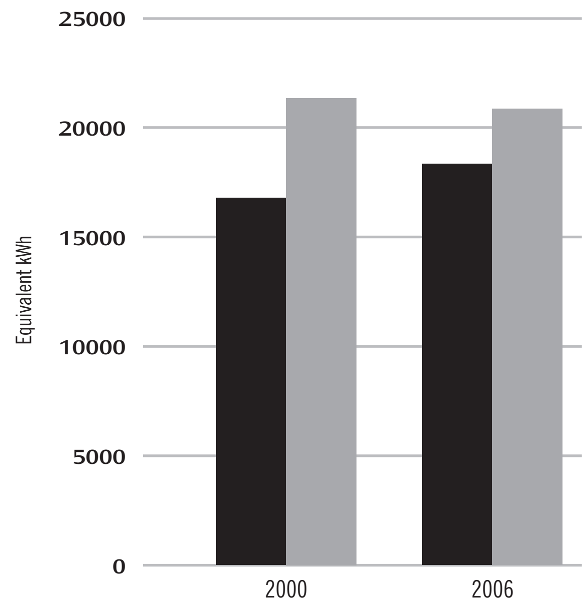


Monthly average household electric energy use for Mentone, an ENERGY STAR® development, and four non-ENERGY STAR developments for calendar year 2000.

Data provided by Clay Electric Cooperative.

Figure 3

Change in ENERGY STAR®



	2000	2006
Mentone	16727	17956
Non-Energy Star Avg.	20911	20718

Total average household energy use (gas and electric) for Mentone, an ENERGY STAR development, and four non-ENERGY STAR developments for calendar years 2000 and 2006. Natural gas consumption has been converted to equivalent kWh for comparison.

Electrical consumption data provided by Clay Electric Cooperative. Natural gas consumption data provided by Gainesville Regional Utilities.

Several preliminary indications can be drawn from the analysis so far. As we can see in Figures 2a, 2b and 3, some changes worth noting have taken place between 2000 and 2006.

DISCUSSION AND OUTCOMES

An examination of the graphs shows three things. First, the general performance of the different developments has remained similar relative to each other. This suggests that the change in energy use performance over time has remained generally consistent among the developments, indicating that the root bases for energy use have not changed appreciably. To put it another way, none of the developments has radically changed its performance profile relative to the others.

Because Florida is a cooling-dominated climate, natural gas usage is minor compared with the electricity required for summer air conditioning needs. We include only the electrical consumption graphs (Figures 2a and 2b) for this reason. The gas data for 2000 and 2006 continue to show the same general relative contours between the various home developments as the electric consumption in both 2000 and 2006. It should be noted that the lower boundary for electrical energy use has increased for all the developments in 2006 (and shows similar kWh equivalent increases in the natural gas consumption). This indicates that all the developments, including the ENERGY STAR-qualified development, are at a higher minimum energy usage requirement. This is not unexpected given the continuing rise of energy use by both the residential and commercial sectors, even with the rapid increase and deployment of energy-efficient products. Whereas in 2000 the occupants might have had one or two telephones and one or two computers, chances are that in 2006, every member of the family had his/her own cell phone and computer. All of these devices are consuming more energy and also creating a larger load based on the use of many miscellaneous appliances.

Second, both the statistical comparison of ENERGY STAR and conventionally built homes constructed in Gainesville and the 2003 study found ENERGY STAR homes to be more energy efficient in both calendar years 2000 and 2006. However—and this has some important implications—average energy consumption in the ENERGY STAR homes appears to have increased measurably more from 2000 to 2006, while holding nearly constant in the conventionally built homes (Figure 3). The total energy use of the Mentone development has, in fact, risen relative to the averages of the non-ENERGY STAR developments, and at present, our study does not have a useful explanation for this decrease in efficiency. The average total energy use of the non-ENERGY STAR homes has actually decreased by 200 equivalent kWh, but the Mentone usage has risen by almost 1200 equivalent kWh.

Although these studies did not engage the human behavioral element in the energy conservation outcomes, it is certainly worth further careful analysis to determine what role, if any, is played by self-selection and energy-consiousness fatigue in understanding ultimate performance. In addition, there is some variance in the average home size included in the studies, but the authors believe that the differences were relatively minor, and have no data to suggest that per capita or per household occupancy was significantly different in the various developments. Even so, future studies should look at size and average number of persons per household to address normalization issues. Such studies may need to elaborate on these behavioral and household occupancy issues.

Putting aside for now any human behavioral factors, let's proceed with the question: does initial higher performance in ENERGY STAR homes hold up over time? If the performance degrades over time, then any attempts to understand the additional value provided by the energy savings must take this into account. At the very least, assumptions that the ENERGY STAR home will provide consistently improved energy performance over the full life cycle of the home need to be explored in more detail. This should not diminish the fact that the Mentone homes did perform better than non-ENERGY STAR homes.

One implication of this outcome may be that the advantages of an ENERGY STAR home are limited in terms of economic value to a lesser number of years than the commonly used twenty- or thirty-year life cycle assumption linked to mortgage expectations. Another implication of this may be that the decreased number of years will have a real impact on the resale value of ENERGY STAR homes. Buying an ENERGY STAR home one year after the initial sale could have a very different pricing premium than a purchase at resale 10 years later.

Third, we can tentatively suggest some policy outcomes. The 2000 study provided evidence that building construction and home fit-out using energy efficiency as an important consideration—through the use of the ENERGY STAR residential system—could generate a net benefit of economic significance. The increased economic value or decreased hard costs resulting from energy savings could play an important role in policy for the affordable housing market.

A preliminary examination of the 2006 study suggests that the benefit is real—the net energy usage for both 2000 and 2006 was significantly lower in the ENERGY STAR homes. Yet this optimism must be tempered until we have adequate data regarding the decay rate of energy savings performance exhibited by the Mentone homes.

It is very important to recognize that this is a small study, and though it is one of the first to deal explicitly with housing development performance data, it is still only the beginning. This limited analysis covers only one ENERGY STAR builder and does not include more recently constructed ENERGY STAR homes. However, at least one other recent study[8] suggests that recently built ENERGY STAR homes in Gainesville are performing no better than conventionally built homes. All in all, a much more comprehensive analysis is needed to account for climate, regulatory context, and local production cost factors if any worthwhile policy recommendations are to be devised for Florida and national application.[9] The most important policy outcome of this study, and of much of the work done by the University of Florida's Program for Resource Efficient Communities, is the indication that there is a dearth of available, credible data on energy consumption building performance at the residential level. Without this information it is difficult to begin the process of weaving together the economic, regulatory, insurance, financing and urban planning variables in anything but a speculative manner. The 2006 study suggests that there are some grounds for optimism, but optimism alone cannot be the basis of practical policies to effectuate change. ■

ENDNOTES

1. See *www.energystar.gov/ia/news/downloads/annual_report_2006.pdf*, p. 24. Last accessed Sept. 1, 2008. See generally, *www.energystar.gov/ia/partners/downloads/energy_star_report_aug_2003.pdf*. Last accessed Sept. 1, 2008.

2. Executive Order 07-126, Leadership by Example: Immediate Actions to Reduce Greenhouse Gas Emissions from Florida State Government.

3. Executive Order 07-127, Immediate Actions to Reduce Greenhouse Gas Emissions within Florida.

4. Executive Order 07-128, Florida Governor's Action Team on Energy and Climate Change.

5. "The Impact of Energy Efficient House Construction on Homeownership Costs: A Comparative Study in Gainesville, Florida," Marc T. Smith and Pierce Jones, *Family and Consumer Sciences Research Journal*, 2003; vol. 32, 76-98.

6. Ibid., 80-83. Please consult the article for a full and detailed explication of the methodology for data collection and data analysis. Transparent access to data sources and a properly substantive statistical analysis have been sorely lacking in the arena to determine whether green building rating systems can meaningfully provide economic benefits. But see an earlier robust example, Nevin, R. and Watson, G.,"Evidence of Rational Market Valuation for Home Energy Efficiency," *The Appraisal Journal*, 1998; vol. 66, 401-408.

7. Ibid., 96. For the assumption of a 4 percent cap rate for homes, see Nevin and Watson, 404 referenced in note 6 above.

8. Dustin Adam Bass, "Carbon Trading: A Catalyst for Energy Efficient Residential Construction", (unpublished M.Sc. in Building Construction thesis, University of Florida, 2007, on file with M.E. Rinker, Sr. School of Construction Management, University of Florida, Gainesville), 43.

9. The University of Florida Program for Efficient Resource Management and The Real Estate Center at DePaul University are currently teaming up to expand this research to other areas of the country, with the support of a research grant from the Green Building Initiative. Part of the 2006 study analysis was funded in part by the same Green Building Initiative research grant.