The Value of Energy Efficiency

A close look at nailing down the added value of efficiency leads to some concrete suggestions.

by Joseph Laquatra

If you sell an energy-efficient home, is it worth more than its conventional counterpart? And if it is, how much more? If you upgrade the energy efficiency of a house, will that increase its resale value? If it does increase in value, by how much does it increase? (See "Show Me the Money," p. 11.) Although these questions may initially seem simple, they have been at the core of a debate among statisticians, economists, and other academics for the past 20 years. A recent project that was a joint effort of the EPA, Cornell University, the National Association of Home Builders (NAHB), and the NAHB Research Center took a close look at this issue by analyzing published studies about the value of energy efficiency in housing.

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The process through which the value of a housing attribute, such as square feet of living space or a fireplace, is reflected in the house's price is referred to as capitalization. The capitalization process for energy efficiency is particularly important to home builders, home buyers, appraisers, and policymakers. Knowing precisely how the value of energy efficiency affects the value of a home would give builders a clear incentive to invest in levels of energy efficiency beyond that which is specified by building codes. Home buyers would be less concerned with payback times for investments in energy efficiency, because they could recoup them when they sold the house (see "Do Paybacks Really Matter?"). Appraisers, before they could confidently include the value of residential energy efficiency in their home appraisals, would need a generally accepted method of calculating this value. This issue is also important to policymakers who set criteria for energy efficiency on the basis of costs and benefits to consumers.

For several reasons, putting a value on a home's level of energy efficiency is much more complicated than valuing the number of bathrooms in a house. We invest in an efficient furnace, high-performance windows, and insulation with the expectation of energy savings over time. To put a value on savings in utility bills over the lifetime of a house requires any of several calculations, such as lifecycle cost analysis, net present value, or cost-benefit analysis. Financial analysts typically prefer net present value, which calculates the value of savings that occur in the future and expresses them in today's dollar, because it is straightforward. But another technique—the hedonic regression statistical procedure—captures more of the variables that affect the value of energy efficiency (see "Calculating Energy Efficiency's Value").

Do Paybacks Really Matter?

Typically, when someone is evaluating the feasibility of investing in residential energy efficiency—whether that involves installing low-e windows, an efficient space conditioning system, or additional insulation—the length of the payback period is considered. While this calculation can easily convey the concept of returns on an investment, long payback periods often result in a decision not to invest in energy efficiency. There are some serious limitations to using the payback time analysis. The first is that, usually, the simple payback is used. That means that energy savings in the future are not discounted to their present values; nor are other variables, such as the fuel cost growth rate, considered. In addition, benefits that accrue beyond the payback period are not taken into account, including future savings and—as discussed in this article—capitalization effects. Nor are nonmonetary benefits, such as increased comfort, considered. If we can determine how the value of energy efficiency should be reflected in a house's price, we may be fortunate enough to see the use of payback times for investments in residential energy efficiency discontinued.

Most of the studies that we reviewed used the hedonic regression statistical procedure. Each took a different approach by including in the regression model various measures of energy efficiency: inches of insulation in walls and ceilings, annual utility bills, results from aerial infrared photographs, engineering calculations of projected energy use, and compliance with energy conservation construction codes (see Table 1). Sample sizes in these studies ranged from 67 to 46,000 houses.

Readers of *Home Energy* are well aware that none of these measures of energy efficiency is perfect. But in fairness to the researchers, it should be noted that most of these studies were undertaken before quantifiable measures of residential energy efficiency, such as HERS, existed. We know now that having 6 inches of fiberglass insulation in an exterior wall cavity matters, but how well it is installed matters too.

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A common theme ran through all of the studies: energy efficiency is recognized in the sale price of a house.

These studies analyzed data from sales of existing and newly constructed homes in housing markets across the United States. Notice that the term "housing markets" is plural. There is no such thing as the U.S. housing market. We have local housing markets that are defined by city or county boundaries or Bureau of Census-defined Metropolitan Statistical Areas.

Though they differ in their approaches and specific findings, a theme common to all of these studies is that because home buyers place value on future energy savings, energy efficiency is recognized in the sale price of a house. This is consistent with economic theory. But because of the local and fragmented nature of housing markets, it is possible that the magnitude of capitalization of energy efficiency changes from one place to another and over time.

We recommend that a database be developed that contains homes with varying levels of energy efficiency, as

Table 1. How the Studies Compare

Study	Sample Size	Key Finding	Strengths	Weaknesses
Halversen and Pollakowski (1981)	269	Oil-heated homes less marketable than gas-heated in period after Arab oil embargo.	Shows some evidence of buyer sensitivity to utility costs.	Fuel-type variable does not capture energy efficiency.
Corgel, Goebel, and Wade (1982)	100	Energy efficiency increases house price by $3,416.	Aerial photography to measure energy efficiency was a viable option in early '80s.	Critical variables missing from hedonic equation; crude measure of energy efficiency by today's standards.
Johnson and Kaserman (1983)	1,317	Every $1 annual decrease in utility bills from investing in energy efficiency results in house price increase of $20.73.	Adequate explanation for using two-stage estimating procedure.	Results from first stage missing from paper.
Dinan and Miranowski (1989)	234	Every $1 annual decrease in utility bills results in house price increase of $11.63.	Authors adjusted their procedure to correct for differences in utility bills across households.	Results from first stage of their two-stage procedure missing from paper.
Longstreth, Coveney, and Bowers (1984) and Longstreth (1986)	615 505	1 inch of insulation adds $528 to value of house; each additional inch adds $508. Storm windows and/or thermopane glass adds $407.	Addition of specific energy-saving features to the hedonic regression was a step forward in this research area.	Quality of installation of energy-saving features not considered. Problematic interpretation of some regression results.
Laquatra (1986)	81	Every unit decrease in thermal integrity factor results in house price increase of $2,510.	Use of a continuous measure of energy efficiency was a step forward in this research area.	Small sample size; market for homes in the sample distorted by government subsidies.
Horowitz and Haeri (1990)	67	Increase in house price of $1,315 for homes built to Model Conservation standards.	Authors recognized that larger homes command larger prices and added a term to hedonic equation to control for this.	When viewed individually, hedonic coefficients were confusing to interpret.
Nevin and Watson (1998)	3,000–46,000	House values increase by $20 for every $1 reduction in annual utility bills.	Authors recognized that utility bills are larger for larger homes and attempted to control for this.	No neighborhood vector in hedonic equation; self-reported house values from American Housing Survey have been shown to be biased.

Calculating Energy Efficiency's Value

Calculating the net present value of future utility savings requires a number of assumptions, including a fuel cost growth rate, inflation rate, and—most vexingly—the discount rate. The discount rate is the number that brings a future dollar amount to its present value, and what is vexing about it is that it varies by individual. To illustrate this, think of how much money, under $500, you would be willing to accept today to forgo the promise of receiving $500 five years from now. One person might accept $440, while another might insist that only $460 now would make the trade worthwhile. If you said $440, you recognize the time value of money, and your discount rate is 2.67%. Mathematically stated, the discount rate is the rate r that results in an individual being indifferent between x dollars in some future time period i, and $x(1+r)^{-i}$ dollars today.

Economists have been using the technique described above to calculate a person's implicit discount rate—the rate you unknowingly apply when asked such a question or when purchasing something that saves or makes you money. If everyone discounts energy savings differently, how can we determine the value of a home's level of energy efficiency? One way is to observe market transactions and calculate an average rate. This is the basis of the hedonic price index.

The hedonic price index is an application of a statistical procedure— multiple regression analysis—that in this case calculates the value of individual housing characteristics. Hedonics—from the philosophy of hedonism—is a branch of both psychology and ethics that deals with pleasure. The word was adopted by economists to refer to value as a function of satisfied wants and needs. The technique is used to determine the contribution of individual traits to the price of goods that come as bundles of traits, such as houses and cars. No one, for example, can say about an existing home, "I'll buy this house, but don't include that third bathroom."

The statement often attributed to real estate brokers that "location, location, location" determines the value of a house is only partly true. The value of a house is determined by its location in a community, by neighborhood characteristics, and by the physical characteristics of the house itself. A hedonic price index includes numerous features, or variables, of each of those categories, or vectors.

For example, the locational vector typically includes dollars spent per pupil in the school district, or test scores, to capture school quality. The neighborhood vector usually includes median house price in the neighborhood. For this study, the vector of interest is the physical characteristics vector. Our research team looked at studies that added measures of energy efficiency to this vector, along with number of bedrooms, square feet of living space, and so on.

As an application of multiple regression analysis, the hedonic price index calculates the value of individual housing characteristics as

$$SP = \alpha + \beta_p P + \beta_n N + \beta_l L + \varepsilon$$

where

SP = house selling price

α = constant value

β_x = individually calculated coefficient for each vector

P = vector of house physical characteristics

N = vector of neighborhood characteristics

L = vector of locational characteristics

ε = error term

Alpha (α) is calculated as the starting point. No house price will be lower than this. Because no regression model can capture all the influences of home selling prices in a housing market, the error term (ε) captures what the model does not. Sometimes a hedonic model is additive, as in the above equation. However, there are many other forms it can take.

In the years since the studies reported in this article were conducted, much research has been undertaken on the effectiveness of hedonic models. Specific factors—including whether a sample of houses for sale in a market represents a random sample (a necessity to prevent a biased sample and skewed results); the fact that houses located near each other influence each other's selling price; and the influence of a home's age on the error term—require the use of alternative regression applications. Statistical software packages allow the technique to be refined to address these concerns.

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measured through HERS programs or the EPA's Energy Star Homes program. In addition, such a database should include information about a large number of home, neighborhood, and locational characteristics, so that a statistical model can isolate the impact of energy efficiency on house price. Data sets are actually being assembled now; and it may be possible to construct a standard model and apply it to local markets that have large enough samples of Energy Star homes. The importance of this capitalization issue to so many different interest groups underscores the need for continuing work in this area.

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Laquatra, J., et al. "Housing Market Capitalization of Energy Efficiency Revisited." In *Teaming for Efficiency: Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington: American Council for an Energy Efficient Economy, 2002.