VALUATION OF HOUSEHOLD INVESTMENT IN ENERGY EFFICIENT DESIGN

Joseph Laquatra, Jr.
Cornell University

ABSTRACT

The success of government efforts to promote energy efficiency in the construction of new housing depends on the willingness of buyers to tradeoff higher capital costs for lower operating expenditures and potential capital gains. The rate at which these future benefits are discounted is a crucial parameter to the investment decision. The premise of this paper is that while households are not likely to know the rate at which they discount future energy savings, observations of market transactions for energy efficient homes can yield information on the capitalization process, and an implicit internal rate of return can be derived.

This study is a cross-sectional analysis of houses constructed through the Energy Efficient Housing Demonstration Program of the Minnesota Housing Finance Agency. The questions of whether and to what extent capitalization is occurring in this subsidized market are addressed. The values of investments in energy efficiency in this particular market are derived from a hedonic regression which includes a vector of thermal integrity factors as an independent variable. Internal rates of return implicit to the net present values are calculated under alternative fuel price escalation projections, ownership periods, property value appreciation rates, and resale values. Results of this analysis are discussed with respect to the investment aspects of energy conservation and related policy implications.
VALUATION OF HOUSEHOLD INVESTMENT IN ENERGY EFFICIENT DESIGN¹

Joseph Laquatra, Jr.
Cornell University

INTRODUCTION

Although construction technology is available to greatly reduce space heating energy requirements in the residential sector, the diffusion of energy efficient design necessary to accomplish this is still at an early stage. The fragmented nature of the housing construction industry, combined with uncertainties regarding energy savings and market capitalization of energy saving durable goods investments, are factors which contribute to this situation.

Homebuyer reluctance to invest large sums in energy conservation may be associated with the risk which characterizes this type of investment. The average length of occupancy for homeowners in the U.S. is 6 years (U.S. Department of Agriculture, 1984), a time period much shorter than the economic lifetime of many energy saving durable goods. A general lack of relevant information about whether residential investments in energy efficiency can be recouped through an increase in house resale value can lead households to allocate resources inefficiently in the production of thermal comfort, by substituting more fuel inputs for less capital. From a policy perspective, the end result of this is the continued construction of units in the housing stock with sub-optimal levels of energy efficiency.

To address the uncertainty involved with investing in energy efficiency, government agencies have developed various incentive and demonstration programs, as attempts to compress the diffusion process and speed the rate of adoption of energy conserving technology. One such program is the Energy Efficient Housing Demonstration Program of the State of Minnesota (Hutchinson, et al., 1982). This study will use data available from that program to address the issue of whether capitalization of energy efficiency is occurring in a specific housing market, and if so, to what extent.

The premise of this paper is that households reveal their internal rates of return for investments in energy saving durable goods through market transactions for energy efficient homes. From hedonic price theory (Rosen, 1974), the implicit prices paid for housing characteristics can be derived from a regression of house sale price on those characteristics. Derivation of the price for energy efficiency permits computation of a rate of return on an investment in thermal integrity. Within this context, the specific objectives of this study are: (1) To determine if investments in energy saving durable goods are capitalized into the market value of a house; (2) To identify the

¹ This paper is based on the author's doctoral dissertation, "Housing Market Capitalization of Thermal Integrity," 1984.

F-154
internal rate of return implicit to the market value of an investment in energy efficiency, under different assumptions regarding parameters of the rate of return calculation.

REVIEW OF RELATED LITERATURE

Capitalization is the process through which future income is converted to present value. The determination of the value of specific housing characteristics, as represented by market price, is complicated by certain features of housing that separate it from other goods, including its high cost of supply, durability, heterogeneity, and locational fixity (Quigley, 1979). A bundle of housing attributes is indivisible, further complicating the valuation of a single characteristic, because buyers purchase an entire bundle. The marginal price of a particular item in this bundle, whether it is an additional bathroom or a qualitative aspect, is dependent on features of the bundle itself, and is therefore implicit to the bundle price. Rosen (1974) discussed the identification of this implicit or hedonic price as one that is given by the envelope of the producer's marginal reservation supply price and the buyer's marginal valuation, the bid price. In other words, at market equilibrium, the price for specific housing characteristics can be estimated from information on the entire attribute bundle.

Hedonic theory has comprised an analytical approach for studies covering a broad spectrum of issues related to the dimensionality of housing services. As described in Quigley's (1979) comprehensive review, these issues have included the effect of workplace accessibility on house values; the presence of externalities, such as air pollution and residential blight; taxes and public services; and estimations of income and price elasticities of demand for various housing characteristics. Other issues analyzed from this perspective were described by R. Johnson (1981), and include the value of housing quality, preference rankings of housing attributes, and racial discrimination as observed in black-white price differentials.

Recent applications of hedonic theory have examined the valuation of a structure's thermal integrity. The question of whether investments in residential energy saving durable goods are capitalized by housing markets was investigated by Guntermann (1980), who included in his sample of 900 new homes sold in Lubbock, Texas, both superinsulated houses and houses with levels of thermal integrity as required by building codes. Using a dummy variable for energy efficiency in his regression, he concluded that energy efficient houses sell for a 3.5% premium over conventionally constructed houses.

An examination of the housing market response to rising energy prices was conducted by Zaki and Isakson (1983). They used stepwise regression on a sample of 1,318 houses sold during a three-month period in 1978 through the Multiple Listing Service of the Board of Realtors of Spokane, Washington, and included two explanatory variables for space heating costs: (1) the price of heat, which was defined as the unit cost of heating fuel divided by the thermal efficiency of the heating equipment, and (2) a dummy variable for type of heating fuel. Neither variable was found to be significant, and the authors concluded that the relatively low price of energy in the Spokane area was responsible for these results.
In her sample of 615 gas heated single family dwellings sold in Columbus, Ohio, Longstreth (1981) derived capitalized values for energy efficiency using two approaches. In one model, the value of thermal efficiency was estimated from a regression that included energy conserving features as independent variables. The second model used the quantity of natural gas consumed in a year as the variable for thermal integrity. Results from the two models led the author to conclude that some investments in energy efficiency are capitalized at higher rates than others, and that sale prices of homes in her sample were positively related to their levels of thermal integrity.

In housing markets, the existence of capitalization is evidence of homebuyer willingness to tradeoff higher capital costs in the present for lower operating expenditures in the future. In the investment decision, the valuation of future benefits and costs is a function of the discount rate, the rate which results in an individual being indifferent between x dollars in some future time period i and x(1+r)^{-1} dollars today. For example, if a person has a discount rate of 20%, he or she would be indifferent to receiving $100 now or $120 one year from now.

Closely related to the concept of discounting is the internal rate of return (IRR), the discount rate which equates benefits to costs. In other words, the IRR identifies, for a given investment, the discount rate beyond which net losses are incurred. The IRR is a measure of profitability which depends on timing and magnitude of cash flows. As an evaluation criterion, it can be compared to the opportunity cost of capital, the expected rate of return from other investments of equivalent risk.

With an analytical framework that comprised both hedonics and capital theory, Johnson and Kaserman (1983) estimated capitalized values of energy efficiency from a sample of 1,317 houses sold in Knoxville, Tennessee. Their hedonic equation included an annual utility bill derived as an instrumental variable in a two stage least squares regression. From this estimation of implicit prices, the authors reported that an investment in an energy saving durable good that results in a utility bill decrease of $1000 per year increases the market value of a house by $20.73.

After estimating the marginal value of energy efficiency, Johnson and Kaserman then calculated an implicit rate of return, under different assumptions regarding fuel price escalation and remaining lifetime of the investment. They found that with a remaining lifetime for a house of 50 years and real fuel cost escalation rates ranging between 2 and 4 percent annually, the implicit housing market discount rate, or the internal rate of return, for fuel savings was between 6.3 and 8.4 percent. Comparisons between this range and bond rates on long term U.S. government obligations in 1978 led the authors to conclude that the housing market in their study efficiently capitalized fuel savings from investments in energy conserving durable goods.

---

2 This is true as long as an investment's net present value is a smoothly declining function of the discount rate. This condition holds for most residential investments in energy saving durable goods, because benefits gradually accumulate. For more on this issue, see Brealey and Myers (1981).
A different approach to the question of capitalization and discounting of residential energy efficiency was taken by Corum and O'Neal (1982), who combined calculated annual heating loads of a prototype design for a house, under alternative applications of conservation measures, with the costs of these measures, to derive net savings in energy expenditures. Under four sets of assumptions regarding various parameters in the net present value calculation, rates used to discount the conservation applications were computed for ten cities. In each of the cities, savings were calculated for three fuel types: oil, electricity, and gas. A wide range of discount rates was observed among the fuel types, cities compared, and assumptions regarding financial arrangements and fuel price expectations. The authors reported a significant gap between this range and the historical range of real market interest rates, with discount rates defining the higher end of the range.

The studies reviewed indicate that housing market capitalization of energy saving durable goods is occurring, and that rates of return compare favorably with the opportunity cost of capital. To date, however, a general lack of data has prevented an examination of this issue with the use of a precise measurement of thermal integrity. With data from a state demonstration program described below, such a measurement can be used to examine the efficiency of a particular housing market with regard to capitalization of this characteristic.

THE DATA

This study is a cross sectional analysis of houses constructed through the Energy Efficient Housing Demonstration Program (EEHDP), which was implemented in 1980 by the Minnesota Housing Finance Agency (MHFA). Under this $11 million mortgage loan program, 144 units were constructed with a variety of energy efficient designs, throughout the state of Minnesota. Marginal prices for housing characteristics are not constant across markets, a factor which necessitates limiting a hedonic analysis to one area, usually defined by county lines or as a Metropolitan Statistical Area (MSA). 81 of the EEHDP units are located within the Minneapolis-St. Paul MSA, and comprise the sample for this study. Ideally, a much larger number of observations would be used for this type of research, but at this early stage of the diffusion process, a large enough sample of recently sold homes with accurate measurements of thermal integrity is only available at considerable expense, and was beyond the means of this paper.

One of the program objectives of EEHDP is the gathering and analysis of data. For the houses built, this has resulted in descriptive information about their structural characteristics and thermal integrity levels. These data were supplemented with Census tract information for neighborhood variables, and municipal maps and school district data for locational attributes.
THE HEDONIC EQUATION

In the first stage of this analysis, the marginal price for thermal integrity of a house is estimated from a hedonic equation of the general form

\[ \text{SALEPRI} = f(X, \text{DESTIF}) \]  

(1)

where SALEPRI is the sale price of the house, X is a vector of structural, neighborhood, and locational characteristics, and DESTIF is the design thermal integrity factor.

A linear specification of the hedonic equation was indicated from a test for functional form described by Zaki and Isakson (1983). In a test for heteroscedasticity on the Ordinary Least Squares (OLS) model (Breusch and Pagan, 1979), the null hypothesis of homoscedasticity was rejected. Accordingly, a Weighted Least Squares (WLS) regression was selected for the final estimation.

Variable definitions and results from the WLS regression are shown in Table I. \( R^2 \) for this regression indicates that over 67 percent of the variation in SALEPRI is explained by this set of variables. Root Mean Squared Error (RMSE) for the WLS regression of 206 indicates superior predictive ability over the OLS model (RMSE = 3,323). The coefficient for DESTIF, the variable of interest, indicates that a unit decrease in the thermal integrity factor results in an increase in house sale price by $2,510.

IMPLICIT RATES OF RETURN

Results from the WLS regression indicate that in this sample of demonstration houses, investment levels in energy efficiency that resulted in a marginal increase in thermal integrity were capitalized into house sale price. Results from this model are used to calculate the value of thermal integrity for each house in the sample, in a comparison with the highest DESTIF of the group, which is 3.0. This "high" thermal integrity factor is much lower than the average for new construction in Minnesota of between 6.0 and 8.0 (Hutchinson et al., 1982). The calculation used will be useful for observing the effect of investing in levels of energy efficiency that are substantially beyond that which is typical for new construction. The cost of the investment in the \( j \)th unit (\( \text{CST}_j \)) is then calculated as

\[ \text{CST}_j = (3.0 - \text{DESTIF}_j) \times 2,510 \]  

(2)
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Definition and Units</th>
<th>Parameter Estimate</th>
<th>t Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>SALEPRI</td>
<td>House sale price ($)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>LTSIZ</td>
<td>Size of lot (sq.ft.)</td>
<td>0.05</td>
<td>0.54</td>
</tr>
<tr>
<td>DUPLX</td>
<td>Dummy variable for duplex unit</td>
<td>2.81</td>
<td>0.90</td>
</tr>
<tr>
<td>ATCHD</td>
<td>Dummy variable for attached unit</td>
<td>-8,641</td>
<td>-5.16</td>
</tr>
<tr>
<td>DESTIF</td>
<td>Design Thermal Integrity Factor (BTU/sq.ft./DD)</td>
<td>-2,510</td>
<td>-2.44</td>
</tr>
<tr>
<td>MEDVAL</td>
<td>Median house value in census tract ($)</td>
<td>0.81</td>
<td>10.93</td>
</tr>
<tr>
<td>PUPEXP</td>
<td>School district expenditures/pupil ($)</td>
<td>12.90</td>
<td>8.27</td>
</tr>
<tr>
<td>WORKJOUR</td>
<td>Mean journey-to-work time for census tract (minutes)</td>
<td>-944</td>
<td>-4.20</td>
</tr>
<tr>
<td>INTDIST</td>
<td>Distance from interstate ramp (miles)</td>
<td>1,645</td>
<td>5.99</td>
</tr>
</tbody>
</table>

\[ R^2 = .6722 \]

\[ \text{RMSE} = 206 \]
The net present value of the investment in energy efficiency is equal to the net savings in heating expenditures, less initial and amortized incremental costs, plus the resale value of the investment and associated tax credits and net tax savings. In a rate of return framework, this relationship can be expressed as

\[
0 = \left[ (3.0 \times FLRAREA_j \times 8195) \times FUELPRI_0 \right] \sum_{n=1}^{N} \frac{(1+f/1+r)^n}{(1+f/1+r)^N} - \left[ (DESTIF_j \times FLRAREA_j \times 8195) \times FUELPRI_0 \right] \sum_{n=1}^{N} \frac{(1+f/1+r)^n}{(1+f/1+r)^N}
\]

\[
- \frac{.25(CST_j)}{1/(1+r)^{N}} + \frac{.75(CST_j) i(1+i)^{N}/(1+i)^N-1}{1/(1+r)^{N}} + \frac{[1/(1+r)^N] + CST_j N/(1+r)^N - \sum_{n=1}^{N} CST_j (1+ q)^n}{1/(1+r)^{N}}
\]

\[
\text{where}
\]

\[
FUELPRI_0 = \text{Price of fuel in $/BTU at time 0}
\]

\[
N = \text{Length of mortgage (30 years)}
\]

\[
8195 = \text{Minneapolis heating degree days}
\]

\[
f = \text{Fuel cost escalation rate}
\]

\[
r = \text{Internal rate of return}
\]

\[
q = \text{the rate of annual property value appreciation.}
\]

\[
TC_j = \text{State tax credit: 20% of CST, limited to first $10,000.}
\]

\[
T_{jn} = \text{Tax savings for the}
\]

\[
j^{th} \text{ household in year}
\]

\[
n, \text{calculated as in Equation 4.}
\]

The deductability of mortgage interest and property tax payments favorably affects the household's valuation of an investment in real property. For the \(n^{th}\) year, tax savings are

\[
T_{jn} = t_{jn}[I_{jn} + \tau CST_j (1+ \eta)^n]
\]
where

\[ t = \text{marginal tax rate} \]

\[ I = \text{interest payment, calculated from a mortgage program, using} \]
\[ (.75)\text{CST}_j \text{ as the principal} \]

\[ \tau = \text{property tax rate}. \]

Heating systems for units in this sample are forced air natural gas. Fuel prices are expressed on a per BTU basis (prices were obtained from the Minnesota Department of Energy, Planning, and Development). 100% efficiency was assumed for electric heat and 61% for gas. Property tax rates for the school districts represented in the sample were adjusted for Minnesota's Homestead Exemption. State confidentiality regulations prohibited the release of all but summary income statistics for the households in the sample. The sample was divided into 12 groups according to house type, and the mean income for each group was calculated. The income figure used for each household is the mean for its respective group. This figure, household size, and 1980 federal income tax tables were used to derive a marginal tax rate for each household. These rates increased each year as \((1+\alpha)\text{t}_i(n-1)\). Based on a 10 percent annual per capita income increase calculated from Minnesota historical data (Economic Development Administration, 1977; Bureau of the Census, 1983), \(\alpha\) was set at .10. Three alternative scenarios projected by the U.S. Department of Energy (1983) were used to calculate fuel cost escalation rates. In these projections, the price of fuel changes every five years. The lowest escalation occurs in A, with an average increase of .10 every 5 years; in B, the average increase is .15; and in C, it is .22.

Using the results of the hedonic regression to calculate CST; as in Equation 2, an iterative computational procedure was used to solve for r in Equation 3, under the 3 energy price escalation scenarios. The use of mean incomes for groups defined according to house type resulted in rates of return that differed within groups according to the household marginal tax bracket. Accordingly, representative observations from the groups were chosen for inclusion in Table II, where results of the iteration are summarized, and assumptions for the different cases are listed. Characteristics of the units represented are shown in Table III.
Table II. Implicit internal rates of return

<table>
<thead>
<tr>
<th>UNIT IDENTIFIER</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>.17</td>
<td>.27</td>
<td>.40</td>
<td>.17</td>
<td>.27</td>
</tr>
<tr>
<td>5</td>
<td>.17</td>
<td>.26</td>
<td>.39</td>
<td>.17</td>
<td>.27</td>
</tr>
<tr>
<td>10</td>
<td>.20</td>
<td>.31</td>
<td>.44</td>
<td>.20</td>
<td>.31</td>
</tr>
<tr>
<td>11</td>
<td>.19</td>
<td>.29</td>
<td>.42</td>
<td>.19</td>
<td>.29</td>
</tr>
<tr>
<td>12</td>
<td>.19</td>
<td>.29</td>
<td>.42</td>
<td>.19</td>
<td>.29</td>
</tr>
<tr>
<td>13</td>
<td>.20</td>
<td>.30</td>
<td>.43</td>
<td>.20</td>
<td>.30</td>
</tr>
<tr>
<td>14</td>
<td>.18</td>
<td>.29</td>
<td>.42</td>
<td>.18</td>
<td>.29</td>
</tr>
<tr>
<td>15</td>
<td>.19</td>
<td>.30</td>
<td>.43</td>
<td>.19</td>
<td>.30</td>
</tr>
</tbody>
</table>

I: N = 30, w = .10

II: N = 30, w = 0

III: N = 30, w = .10, Resale Value = 0

IV: N = 6, w = .10

V: N = 6, w = 0
Table III. Constants in the calculation.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>IDENTIFIER</th>
<th>DESTIF</th>
<th>CST</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.24</td>
<td>$4,418</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.30</td>
<td>4,267</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.43</td>
<td>3,941</td>
<td>.20</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.55</td>
<td>3,640</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.55</td>
<td>3,640</td>
<td>.20</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.60</td>
<td>3,514</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1.60</td>
<td>3,514</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1.80</td>
<td>3,012</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1.85</td>
<td>2,886</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1.95</td>
<td>2,636</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2.01</td>
<td>2,485</td>
<td>.20</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>2.19</td>
<td>2,033</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>2.19</td>
<td>2,033</td>
<td>.21</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>2.48</td>
<td>1,305</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2.48</td>
<td>1,305</td>
<td>.20</td>
<td></td>
</tr>
</tbody>
</table>

Following M. Johnson (1981), $ was set at .10 in Cases I, III, and IV, as a basis for comparison against a zero rate of property value appreciation in Cases II and V. The full 30-year mortgage period is compared with 6 years of ownership in Cases IV and V. The effect of a zero resale value of the investment in thermal integrity is observed for the 30-year ownership period in Case III. A case not included in the table, which will be discussed, is a zero resale value in the 6-year time horizon.

The fuel price escalation rates change every five years in the Department of Energy projections, making the sixth year the first year with a price change. One year of different fuel prices did not produce savings substantial enough to affect the discount rate across the 3 scenarios, in the 6-year time horizon. Changes may have occurred at or beyond the third decimal place, but the computational precision of the iterative program used was to 2 decimal places. For this reason, in the 6-year ownership period, only the results from Scenario B are presented.

DISCUSSION OF RESULTS

As seen in Cases I, II, and III, the rates of return are generally insensitive to the changes made in assumptions regarding property value appreciation ( % ) and resale value. Valuation changes affect both net property tax payments and resale value. With an effective assessment rate of .26 used in this analysis, changes in net tax payments resulting from a change in were negligible, although slight increases in the rates of return are seen for observations 5 and 8. A slight decrease in the rate of return, resulting from a zero resale value, is seen for observations 6, 12, and 15.
Other noticeable features of the implicit rates of return in the 30-year projections are that they rise with increases in both fuel prices and the thermal integrity factor. By referring to Table III, the effect of a change in the marginal tax rate can be observed. Pairs of observations that are identical except for this rate are 4 and 5, 6 and 7, 12 and 13, and 14 and 15. Generally, an increase in the marginal tax rate results in an increase in the rate of return.

Rates of return derived under the 6-year time horizon are much lower than those calculated for the 30-year ownership period. Sensitivity to a change in the marginal tax rate can be observed from pairs of observations that are identical except for this rate are 4 and 5; 6 and 7; 12 and 13; and 14 and 15. Generally, an increase in the marginal tax rate results in an increase in the rate of return.

Available measures of the opportunity cost of capital, for comparison with the results of the 30-year analysis, are the interest rate on long-term U.S. Government bonds, which was 14.52 in July, 1981 (the midpoint of the mortgage closing dates for this sample), and the market rate of interest on conventional mortgages, which was 17.50 at that time (Board of Governors of the Federal Reserve System, 1981). The results under Scenario A compare closely with these measures, and exceed them in Scenarios B and C, indicating that the subsidized market within which these transactions took place has capitalized the future value of net benefits associated with these investments in thermal integrity.

The lower rates of return derived under the 6-year time horizon result from a truncation of net benefit streams. When the rate of property value appreciation is set at .10, all derived rates are higher than the mortgage interest rate. This is not the case when the value of this parameter is set at zero, indicating a higher sensitivity of the results to this parameter in the shorter ownership period. The fact that EEHDP occupants are first-time buyers highlights the significance of this result. As first-time buyers, they are likely to move within the 6-year period, meaning that the 30-year time frame may not be appropriate for this sample. Of course, this implies that the below market mortgage interest rate will not affect patterns of residential mobility. Further research on these buyers would be necessary to analyze this issue.

CONCLUSIONS AND IMPLICATIONS

One observation from this study is that, for the houses in this sample, rates of return and DESTIF are positively related to each other. In other words, the higher the thermal integrity factor (or the lower the level of energy efficiency), the higher the rate of return. An implication of this result is that incentives for investing in energy efficiency may be more effective if they are tailored to the size of the investment. Equity concerns could also justify a sliding scale based on individual marginal tax brackets, as changes in net present values resulting from tax credits vary directly with the income tax rate, so that the higher one's income, the higher the value of the tax credit.
The sensitivity of the rates of return to parameters affecting resale value in the 6-year ownership period highlights the need for further research on this aspect of energy saving durables. Given that this variable has a substantial effect on the rate of return, homeowner interest in quick payback times for conservation investments is justified. In the aggregate, uncertainty about resale values of these investments results in unrealized savings in expenditures for fossil fuels.

The issue of uncertainty poses a major obstacle to routine inclusion of energy efficient design in new construction. The process of change in the housing industry is slow. As observed by Farhar-Pilgrim and Unsed (1982), potential buyers need to see working examples of energy efficient homes. Demonstration programs such as EEHDP are important for the documentation of technological and economic feasibility. Builders and buyers alike become educated about conservation technology, not only through direct participation in the program, but also through the diffusion process.

REFERENCES


