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More Evidence of Rational Market Values for Home Energy Efficiency

Rick Nevin, Christopher Bender, and Heather Gazan

The article, "Evidence of Rational Market Values for Home Energy Efficiency," which appeared in the October 1998 issue of *The Appraisal Journal,* presented the results of research indicating that market values for energy-efficient homes reflect a rational tradeoff between homebuyers' fuel savings and their after-tax mortgage interest costs. This research estimated implicit values for the number of rooms in a house, the square footage of living space, lot size, location, and other home characteristics, including the annual utility bill. We performed separate regression analyses for attached and detached homes based on the 1991, 1993, and 1995 American Housing Survey (AHS) national data and AHS metropolitan statistical area (MSA) data for 1992 through 1996. Table 1 shows that the results of these separate regression analyses were remarkably consistent, indicating that home value increases by about $20 for every $1 reduction in annual utility bills, reflecting after-tax mortgage interest rates of about 5% from 1991 through 1996.

To demonstrate the "real world" validity of this research, the regression results have been compared with the collective judgment of real estate agents participating in "cost versus value" surveys conducted by *Remodeling Magazine* (RM). Each year, the RM survey asks agents throughout the United States to estimate the amount that popular remodeling projects would add to the value of a home in their area if the home were sold within a year of project completion. This sur-

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TABLE 1 Reduction in Home Value per One-Dollar Increase in Annual Utility Bill

	National AHS		MSA AHS	
	1995	1993	1991	1992–1996
Detached homes	$24	$20	$21	$18
Attached homes	$20	$12	$19	$23

vey reflects estimates from about 300 agents familiar with diverse neighborhoods in 60 metropolitan areas. (Between three and seven agents are surveyed in each area.) The remodeled home for which these estimates are made is a "mid-priced house in an established neighborhood in each city." These value estimates are then compared with cost estimates for each MSA (derived from estimating manuals and from experts in unit cost analysis).

As will be explained, the RM survey value estimates for home additions are consistent with the overall ICF regression model for home value. A window replacement project in the 1993 RM survey[1] also supports the estimate for the value of energy efficiency, and further analysis of the RM cost and value estimates suggests that increased home value can fully recover the cost of window replacement in many existing homes. Detailed calculations of home additions, the assumptions on which the window replacement analysis was based, and the results obtained for individual cities are available from the authors.

RM Home Additions Survey

Table 2 compares value estimates for four home additions from the 1992 through 1996 RM survey with the regression model estimates. In particular, the regression values from the MSA detached home sample were used in the comparison because this regression was taken of the largest AHS sample and showed the highest measures of statistical significance in our study. The value estimates in table 2 reflect changes in the following regression variables:

- The number of rooms and square footage of living space (as specified in the RM survey);
- The estimated change in utility bills (based on the project's addition to living space relative to the average size and utility bills for detached homes in the MSA sample); and
- The living space and utility interaction measures in the ICF regression model (utility bill multiplied by number of rooms, and utility bill multiplied by square footage of living space).

Other variables in the model (lot size, age of unit, and location) are not reflected in table 2 because these variables would not be affected by an addition to an existing home.

The average RM survey value estimates for all four home additions are within 7.4% of the model estimates. The similarity of these estimates is especially striking in light

TABLE 2 Comparison of *Remodeling Magazine* Survey and ICF Model Estimates for Resale Value for Home Additions

	Family Room	Master Suite	Two-Story Addition	Attic Bedroom
Remodeling Magazine Survey				
1993	$24,681	NA	NA	$18,001
1994	$24,019	$24,744	$42,438	$18,199
1995	$26,451	$29,252	$43,004	$17,933
1996	$26,483	$30,530	$46,236	$20,624
RM survey, 1993–1996 average	$25,408	$28,175	$43,893	$18,689
ICF model estimates	$23,655	$26,104	$46,582	$18,715
Difference in dollars	$1,754	$2,071	-$2,689	-$26
Percentage difference	6.9%	7.4%	-6.1%	-0.1%

1. "Cost vs. Value," *Remodeling Magazine* (October 1993): 90.

of the detail provided in the RM survey questions that could not be reflected in the model estimates. For example, the master suite described in the 1994 RM survey is "a 24-foot-by-16-foot master bedroom with walk-in closet, dressing area, master bath, whirlpool tub, separate ceramic tile shower and double-bowl vanity." The model estimate, by contrast, reflects only the value of adding any 382-square-foot room, and the associated change in the home's annual utility bill. In spite of the generic nature of the model, there is actually more variation between the annual RM survey estimates than there is between the average RM estimates and the model estimates.

Window Replacement Comparison

In 1993 *Remodeling Magazine* did a survey on the value of window replacement. The RM window replacement project would "replace 16 existing 3-foot-by-5-foot windows with energy-efficient vinyl or vinyl-clad aluminum double-pane windows." To determine whether the RM value estimates for this project were largely attributable to the energy savings, we performed an analysis that included the following four steps:

1. Specifying model home energy use characteristics consistent with the RM survey question for windows
2. Estimating pre-project utility bills using the (Department of Energy's) DOE2 energy analysis program, and validating these estimates against actual bills reported in the AHS
3. Estimating post-project utility bills and calculating utility bill savings for different types of windows
4. Multiplying annual utility savings times the model value for utility bill, and comparing these window replacement value estimates with RM survey value estimates

These four steps were repeated for every MSA included in both the RM survey and in the AHS MSA sample. In all, 25 MSAs were included, providing a range of geographic and climate scenarios to test the regression estimate for the value of energy efficiency. The MSAs were:

- *East:* Boston, Providence, Pittsburgh, Baltimore / Washington, D.C., and Hartford
- *South:* New Orleans, Dallas, Birmingham, Charlotte, and Atlanta
- *Midwest:* Columbus, Kansas City, Milwaukee, St. Louis, Minneapolis, Detroit, Cleveland, and Indianapolis
- *West:* San Diego, Denver, Salt Lake City, Phoenix, Seattle, San Francisco, and Portland

Model home specifications for this analysis were designed to approximate historical construction practices and reflect the description of remodeled homes in the RM survey. The model home in each city was assumed to have floor space equal to the AHS median square footage for single-family detached homes in that MSA, reflecting the RM survey description of a "mid-priced house." The analysis also specifies 240 square feet of windows, based on the RM description of replacing sixteen 3-foot-by 5-foot windows. The model home is assumed to have relatively little wall insulation because the RM survey describes a home in an "established neighborhood" and agents responding to the survey are likely to think about older homes when asked about window replacement. Older homes and especially those built before the oil shocks of 1973 and 1979 are likely to have less insulation than newer homes. Ceilings are assumed to have somewhat more insulation because ceiling insulation has been added to many older homes since the 1973 and 1979 spikes in fuel prices.

To reflect somewhat different regional construction practices, homes in the South and West were assumed to have a 28% duct loss, whereas homes in the East and Midwest were assumed to have a 20% duct loss. Energy efficiency assumptions for heating and cooling were based on estimates from the Home Energy Rating Systems Council. The DOE2 energy analysis program was used to estimate model home energy demand with and without air conditioning, and with each of four heating system types (electric resistance, heat pump, natural gas furnace, and oil furnace). Weighted average energy demand for each city was calculated based on AHS data showing the percentage of pre-1980 single-family detached homes in each MSA with air conditioning and each type of heating system. Data from the 1993 Residential Energy Consumption Survey (RECS), presented in table 3, show that pre-1980 homes account for practically all of the homes that reported replacement of all original windows. Therefore, real estate agents responding to the 1993 RM Survey must have made value estimates for window replacements

TABLE 3 Age Distribution of Homes with All Original Windows Replaced

Year of Home Construction	Northeast	Midwest	South	West
Pre-1940	38%	45%	22%	15%
1940–1949	8%	14%	13%	20%
1950–1959	32%	17%	35%	43%
1960–1969	15%	21%	11%	13%
1970–1979	5%	3%	10%	6%
Post-1980	2%	0%	9%	3%
	100%	100%	100%	100%
Percentage of all homes with all windows replaced	22%	12%	7%	7%

Source: Residential Energy Consumption Survey, 1993.

based on their experience with pre-1980 homes.

Energy consumption associated with hot water was estimated to reflect typical units in the AHS MSA data for single-family detached homes built before 1980. Energy consumption for other uses of electricity was based on estimates from the Home Energy Ratings Systems Council.

Table 4 presents the model home specifications that would change as a result of the window replacement project. Separate DOE2 model estimates for homes before window replacement were developed to illustrate the significant difference in energy use for homes with wood-frame windows versus homes with metal-frame windows. The pre-project specifications reflect RECS data indicating that most pre-1980 homes in the East and Midwest have storm windows, but most homes in the West and South do not. The RECS data also show that single-pane windows are the norm for pre-1980 homes in all regions. The infiltration rate in homes before window replacement was assumed to be one air change per hour, and the window replacement project was expected to reduce the infiltration rate to 0.7 air changes per hour.

Post-project double-pane windows with clear glass were expected to be the basis for value estimates in the RM survey because high-performance low-emissivity (low-e) windows were not widely used before the 1990s. RECS data show that low-e windows account for less than 5% of all replacement windows installed before 1993. Therefore, this analysis examines whether the energy savings with clear-glass, double-pane windows can substantially explain the RM survey value estimates. The additional energy savings with low-e windows are then calculated to show how additional home value can be realized with the choice of high-performance windows. Two different high-performance windows were examined to yield the best performance in warm or cold climates.

The model home specifications just described were used to estimate annual energy consumption for homes before window replacement in each MSA, and these estimates were multiplied by 1993 energy prices to estimate utility bills before window replacement. MSA energy prices were approximated with available data on 1993 statewide averages for residential prices from the Energy Information Administration. Table 5 shows AHS average utility bills and the estimated utility bills for two pre-project model homes in each region, with wood- and metal-frame windows.

The regional average for DOE2 model utility bills in homes with wood-frame windows are within 14% of the average utility bills reported in the AHS MSA data. The RECS

TABLE 4 Model Home Specifications for Window Replacement

Region	Pre-Project Specification	Post-Project Specification
East and Midwest windows (DOE2 glass values)	Single-pane with storm (U-0.57, SC-0.96, SHGC-0.83)	Clear glass, double-pane (U-0.49, SC-0.89, SHGC-0.76) *or* High Performance Low-e (U-0.29, SC-0.33, SHGC-0.29 *or* U-0.24, SC-0.5, SHGC-0.44
South and West windows	Single-pane, without storm U-1.09, SC-0.95, SHGC-0.81	
Infiltration rate	1.0 air change per hour	0.7 air change per hour

TABLE 5 DOE2 Estimated Utility Bill for Pre-Project Model Home Versus Actual AHS Average Utility Bills

	DOE2 Estimated Annual Utility Bill		AHS Average Annual Utility Bill	Percentage Difference	
	Metal frame	Wood frame		Metal frame	Wood frame
East	$2,057	$1,922	$1,774	-16%	-8%
South	$1,575	$1,471	$1,598	1%	8%
Midwest	$1,742	$1,626	$1,428	-22%	-14%
West	$1,429	$1,337	$1,200	-19%	-11%
25-MSA average	$1,684	$1,573	$1,467	-15%	-7%

Source: American Housing Survey data and DOE2.

data in table 6 show that non-metal frames are most common in older homes, and are therefore more likely to be the basis for the RM survey estimates. The DOE2 model bills should be somewhat higher than the AHS average because the model home bills reflect the average for pre-1980 homes with single-pane windows. Although RECS data indicate that about 70% of pre-1980 homes have single-pane glass in most windows, the 30% that report double-pane glass in most windows would tend to reduce the average utility bills in the AHS data. The DOE2 model bills in the South are somewhat lower than the actual AHS bills, indicating that the DOE2 model home specifications for this analysis may slightly overstate the energy efficiency of average homes in the South.

Table 7 presents the DOE2 estimated annual utility bill savings from the window replacement project described in the 1993 RM survey. Four estimates were calculated for each region, showing the annual savings associated with replacing wood- or metal-frame, single-pane windows with clear-glass, double-pane windows or high-performance low-e windows.

The 25 MSA average shows that the energy savings from replacing wood-frame, single-pane windows with clear-glass, double-pane windows is $200 per year, and the energy savings from replacing metal-frame, single-pane windows is $310 per year. Using high-performance low-e replacement windows increases annual savings by an additional $114 per year.

Table 8 compares the RM survey estimates for window replacement value with the ICF model estimates for clear-glass, double-pane replacement windows. The ICF estimates reflect the savings in the annual utility bill resulting from clear-glass, double-pane windows (from table 7) multiplied by $20 (based on the ICF conclusion that home

TABLE 6 Percent of Homes with Non-Metal Frames in Most Windows

Year of Construction	Northeast	Midwest	South	West
Pre-1940	84%	87%	78%	65%
1940–1949	68%	82%	68%	50%
1950–1959	75%	72%	45%	44%
1960–1969	71%	62%	36%	15%
1970–1979	71%	72%	31%	13%

Source: Residential Energy Consumption Survey.

TABLE 7 DOE2 Estimated Annual Utility Bill Savings from Window Replacement

Post-Project Window:	Clear-Glass Double-Pane		High-Performance Low-e	
Pre-Project Window:	Metal frame	Wood frame	Metal frame	Wood frame
East	$337	$202	$419	$284
South	$312	$208	$503	$399
Midwest	$302	$186	$396	$280
West	$299	$207	$404	$312
25-MSA average	$310	$200	$424	$314

Source: *Remodeling Magazine*.

value increases by $20 for every dollar reduction in annual utility bills).

The 25 MSA average shows that the energy savings from replacing wood-frame, single-pane windows with clear-glass, double-pane windows explains 73% of the RM survey value estimates for this project. The energy savings from replacing metal-frame, single-pane windows with clear-glass, double-pane windows could increase home value by 113% of the RM survey value estimates. As noted before, the RM survey primarily should reflect the experience of real estate agents with the value of replacing wood-frame windows because older homes account for most of the homes that have replaced all original windows, and older homes are more likely to have wood-frame windows.

The results in table 9 indicate that the RM survey value estimates for window replacement can be substantially explained by the market value of energy efficiency estimated by ICF. The 25 MSA average values indicate that about $4,000 of the RM survey window replacement value may be due to energy efficiency, and about $1,500 to the value ascribed to the ease of use and the appearance of new windows.

The difference between the model value (for wood frame) and the RM survey value is only $435 in the South, but this may reflect limitations of the RM survey data. RECS data indicate that only 7% of homes in the South report that all their original windows have been replaced so that real estate agents responding to the RM survey in this region may have relatively little experience with the market value of window replacement. Further, AHS data show that the percentage of pre-1980, single-family detached homes in the South with central air conditioning increased from 49% in 1985 to 66% in 1995. Therefore, the response of real estate agents in the South who estimate the value of window replacement based on their career experience may reflect the lesser value of energy-efficient homes associated with years when fewer homes had central air conditioning.

The 1993 RM survey concludes that window replacement only recovers about 70% of project costs, on average, but the data in table 8 suggest that RM value estimates may represent only the value of replacing wood-frame windows with clear-glass, double-pane windows. Significantly greater energy-efficiency value could be realized by replacing metal-frame windows, and even greater energy savings would be realized with high-performance low-e windows. Therefore, the RM survey may accurately reflect the historical cost recovery percentage for window replacement but may understate the potential cost recovery with more efficient windows.

Table 9 compares the RM estimates for window replacement *cost* with our energy value estimates for high-performance windows (based on annual utility savings with high-efficiency windows multiplied by $20). The 25-MSA average shows that the value associated with energy savings from high-efficiency windows could recover more than 85% of the cost of replacing wood-frame, single-pane windows and 115% of the cost of replacing metal-frame windows.

Although older homes with wood-frame windows account for most of the homes that have already replaced all original windows, RECS data indicate that about half of all existing homes have metal-frame windows. Table 9 suggests that replacing metal-frame windows with high-performance windows could result in an energy-efficient home value that exceeds the cost of window replacement.

In the case of wood-frame windows, table 9 indicates that the average cost of window replacement is about $1,100 more than the ICF model value for high-performance windows. RM cost estimates in table 9 may also under-

TABLE 8 ICF Estimated Energy Value for Clear-Glass Double-Pane Windows Versus *Remodeling Magazine* Survey Value Estimates for Window Replacement

	ICF Model Values for Clear-Glass Double-Pane		RM Survey Value Estimates	ICF Model Percentage of RM Survey Value	
	Metal frame	Wood frame		Metal frame	Wood frame
East	$6,744	$4,048	$6,372	106%	64%
South	$6,248	$4,160	$4,595	136%	91%
Midwest	$6,035	$3,718	$5,757	105%	65%
West	$5,989	$4,149	$5,118	117%	81%
25-MSA average	$6,206	$3,993	$5,469	113%	73%

Source: *Remodeling Magazine.*

TABLE 9 ICF Estimated Energy Value of High-Performance Low-e Windows Versus RM Survey Cost Estimates for Window Replacement

	ICF Model Values for Clear-Glass Double-Pane		RM Survey Cost Estimates	ICF Model Percentage of RM Survey Cost	
	Metal frame	Wood frame		Metal frame	Wood frame
East	$8,376	$5,680	$7,764	108%	73%
South	$10,064	$7,976	$6,455	156%	124%
Midwest	$7,920	$5,603	$7,571	105%	74%
West	$8,083	$6,243	$7,642	106%	82%
25-MSA average	$8,486	$6,272	$7,406	115%	85%

Source: *Remodeling Magazine.*

state the higher cost of low-e windows by about $240 (an additional dollar per square foot of window area). On the other hand, the ICF model values in table 9 reflect only the value of energy efficiency, and the analysis of table 8 concluded that the appearance value of new windows makes up about $1,500 of the value of energy efficiency. The net effect of these factors suggests that the total value of new high-performance low-e windows may also fully recover the cost of window replacement in homes with wood-frame windows.

CONCLUSION

The validity of the overall model for home value is substantiated by the comparison with value estimates of home additions provided by real estate agents participating in the "cost versus value" survey by *Remodeling Magazine.* Detailed analysis of the RM survey on a window replacement project also indicates that the value estimates from window replacement can be substantially explained by the market value of energy efficiency, as estimated in the regression analysis. This analysis also indicates that the RM survey appears to reflect the historical recovery of window replacement cost, but may understate the potential cost recovery with more efficient windows. In fact, this analysis shows that the value associated with high-performance low-e windows could fully recover the cost of replacing wood-frame, single-pane windows and may well exceed the cost of replacing metal-frame windows.