Developing Energy-Efficiency Packages for New Production Homes

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ABSTRACT

The Environmental Protection Agency's ENERGY STAR® Homes program promotes the construction of new homes that consume at least 30% less energy than the 1993 Model Energy Code specifications for heating, cooling, and water heating end-uses, as determined using the draft National Home Energy Rating System (HERS) Guidelines. We developed packages of energy-efficiency measures to help production home builders in 14 U.S. metropolitan areas meet the guidelines of this program. We evaluated the energy savings and costs of over 70 commercially available measures for the building shell and heating, cooling, and water heating equipment to optimize these packages for broad categories of new homes.

We began by developing building prototypes for energy analysis, based on a survey of construction practices in the 14 cities. We also compiled the best published price data for the more than 70 energy-efficiency measures. We then applied the draft HERS guidelines using the DOE-2 building simulation model, to accurately estimate the energy savings for a wide variety of efficiency measures. To select cost-optimized packages of measures that meet the ENERGY STAR guidelines, we devised an automated economic model that used the building simulation results and measure cost data. This model ordered the measures by cost-effectiveness, accounting for measure interactions to avoid double-counting of energy savings. The resulting packages of measures were modified for certain locations to eliminate measures that builders are reluctant to adopt because of limited product availability, home buyer concerns, and other factors. The packages were also adjusted to ensure greater consistency within each city.

Introduction

The Environmental Protection Agency's (EPA's) ENERGY STAR® Homes program promotes the construction of homes that consume at least 30% less energy than the 1993 Model Energy Code specifications for heating, cooling, and water heating end-uses. We developed packages of energy-efficiency measures to help production home builders in 14 U.S. metropolitan areas meet the guidelines of this program.

Program Overview

EPA's ENERGY STAR Homes program promotes the construction of energy-efficient homes to reduce greenhouse gas emissions. The goal of the program is to completely transform the new home market by increasing the market value of energy-efficient homes. Increased sales prices increase builder profits, while the energy-efficient features of the homes provide positive net cash flow, better comfort, and other advantages for home buyers. EPA hopes that 10% of all new homes will be built to ENERGY STAR guidelines by 2002 and over 95% by 2010. To participate in the program, builders agree to improve the energy-efficiency of their homes and may use the ENERGY STAR logo in marketing these homes. They also receive marketing, sales, and technical support from EPA, and access to preferential mortgage products. To meet the program guidelines, homes must consume at least 30% less energy for heating, cooling and water heating compared to homes meeting the 1993 Model Energy Code guidelines.

This equates to a Home Energy Rating System (HERS) score of 86 using the Draft National HERS Guidelines (HERS Council 1996). These homes must also meet or exceed ASHRAE indoor air quality guidelines (ASHRAE 1989).

Project Goals

Currently, to participate in the program builders must secure third-party analyses to identify the best energy-efficiency upgrades for their homes, followed by a complete HERS rating (requiring site inspections and testing) for each home certified in the program (Hall et al. 1996). To make it easier for builders to participate in the program, and to meet the expected volume of homes built, EPA has developed two alternative, but not exclusive, methods for certifying that homes meet the ENERGY STAR guidelines. The first is a sampling protocol, which allows builders to obtain HERS ratings on a sample of homes in order to certify all the homes of that "batch"[1] (EPA 1997). The second is Regional Builder Option Packages (ReBOPs), which are fixed sets of measures that builders can apply to their homes, along with field inspection and testing, in order to certify program compliance. ReBOPs are expected to have several advantages for the ENERGY STAR Homes program and builders participating in the program. First, ReBOPs make it easier to recruit builders to participate in the program because the ReBOPs provide precise specifications that can be easily understood and judged for practicality. Second, because individual HERS ratings often do not provide meaningful differences between basic plan offerings for a broad range of builders in the same climate region, ReBOPs permit the time and cost of rating individual homes to be reserved for situations that allow the builder to differentiate his product. Finally, ReBOPs provide an alternative to HERS ratings in markets without a strong HERS infrastructure.

EPA asked Lawrence Berkeley National Laboratory (LBNL) to develop a consistent set of ReBOPs for several cities across the country. We designed the analysis to meet the following goals: 1) provide packages tailored to the climate and typical construction practices in the cities EPA is targeting with its program, 2) provide packages that "reasonably assure" meeting the program energy savings guidelines, 3) account for space conditioning equipment downsizing due to improved thermal envelopes, and 4) estimate energy savings based on hourly simulations. Table 1 presents the target cities for which ReBOPs were developed.

Table 1. Target Cities for Analysis

Phoenix, AZ	Gainesville, FL	Detroit, MI	Houston, TX
Sacramento, CA	Orlando, FL	Las Vegas, NV	Salt Lake City, UT
Denver, CO	Chicago, IL	Columbus, OH	
Washington, DC	Boston, MA	Dallas, TX	

Project Design

To develop the ReBOPs, we first conducted a survey of building practices in the target cities to develop prototype homes for analysis. We then compiled measure price data for over 70 energy-efficiency measures applicable to new homes. We estimated energy savings for these measures using the DOE-2 building simulation model. We then developed an economic model that combined measure prices and energy savings to rank the measures by cost-effectiveness. In essence, this project required developing a HERS rating process that could accurately model a wide range of efficiency measures and automatically order these measures by cost-effectiveness to develop optimal packages. The resulting packages of measures were modified in certain locations to eliminate measures that builders are reluctant to adopt because of limited product availability, home buyer concerns, or other reasons. The final packages were also adjusted to ensure greater consistency within each city, especially between gas- and electric-heated homes.

[1] A "batch" of homes typically consists of all the homes of a particular model built in one phase of a given subdivision. The sampling protocol is currently in a pilot phase with a small number of builders.

Residential Building Practices Survey

We surveyed building practices for new production homes in the target cities to develop prototype homes for analysis. The survey was conducted in twelve of the target cities[2]. We conducted in-depth telephone interviews with building code officials, builders, heating and cooling contractors, utilities, state energy offices, EPA's cooperative partners (grantees), and building industry consultants. Not all these types of institutions were contacted in all cities. In most cities, we interviewed two to five individuals to develop a general overview of new home characteristics in that city. The data collected were limited to those needed to model energy consumption, such as building configuration (floor area, window area, stories, foundation type), thermal integrity (insulation levels, window type), heating and cooling equipment (equipment type and fuel, efficiency levels), and exterior finishes. Certain characteristics that are not generally known for production homes in the field, such as duct leakage, were based on best estimates informed by previous research studies where possible. Thermal integrity levels were based on the higher of either survey responses or local code requirements. Table 2 illustrates the resulting prototype characteristics for Dallas.

Table 2. New Home Prototype Characteristics for Dallas

Common Characteristics	
Component	**Value**
house type	detached
foundation type	slab
foundation insulation	none
exterior wall finish	brick
wall type	2 x 4 wood frame @ 16" o.c.
exterior wall R-value	R-13
ceiling R-value	R-19
roof pitch (inches run per 12 inches rise)	8
roof overhang - horizontal (feet)	1.5
roof finish material	composite shingle
window frame material	aluminum
window glazing type	double pane clear
heating equipment efficiency	gas: 78 AFUE; elec: 6.8 HSPF
duct location (supply and return)	
1-story house	attic
2-story house	50% attic, 50% exterior wall
duct insulation (supply and return)	R-4.2
cooling efficiency	10 SEER
water heating efficiency	gas: 0.54 EF; elec: 0.86 EF
water heater insulation (tank wrap)	none

[2]Building practices in Orlando, FL were assumed to apply to Gainesville, FL; and Dallas, TX results were applied to Houston, TX.

Table 2, con't. New Home Prototype Characteristics for Dallas

Variable Characteristics	
Component	**Value**
conditioned floor area (sq. ft.)	2000, 3000
# of stories above grade	1, 2
window area (as % of floor)	20%, 25%
heating equipment/cooling equipment	gas furnace/CAC, electric heat pump
water heating fuel	gas, electric
Number of Prototypes Modeled:	**16**

Note: Common home characteristics apply to all prototypes in a given city. Variable characteristics are varied (in combination) to produce the alternative prototypes within that city. Space and water heating are always assumed to use the same fuel. R-values are for insulation only, not including framing and finish materials.

Where the survey showed a large variation in building characteristics within a city, we created home prototypes spanning the range of variation. Because the survey was not based on a representative sample of new homes, we could not draw conclusions about the frequency of occurrence of particular combinations of features, so we simply modeled all combinations of the important building features (including heating fuel). For example, we developed 16 prototypes for Dallas, based on the data in Table 2 (two values each for: floor area x stories x window area x heating fuel). In general, we analyzed eight to sixteen prototypes per city.

Measure Price Compilation

We included a wide range of energy-efficiency measures for this analysis. Because the National HERS Guidelines are limited to the heating, cooling, and water heating end-uses, we only considered measures that apply to these end-uses (i.e., no appliance or lighting measures). Moreover, we only considered "proven" technologies that are widely available to production home builders. The final analysis included over 70 measures, summarized in Table 3. In any given prototype, approximately 40 of these measures were modeled due to the climate- and construction-specific nature of some measures. Due to the difficulty of compiling representative price data specific to each city, we used the best national price data sources where possible and adjusted prices for each city using the R.S. Means location multipliers (R.S. MEANS Co. 1995) to account for general regional differences in construction labor and materials prices[3]. Where published price data were unavailable, we called retailers and/or contractors for price quotes. Prices used in the analysis represent retail prices paid by the home buyer, including a builder markup of 10%, and are in 1996 dollars. We inflated price data from years prior to 1996 using the U.S. Census Bureau's published price indices for durable goods (US Bureau of the Census 1996). We compiled price data from many different sources, as there is no one source that provides price data for the range of measures we analyzed (Brown et al. 1998). Because measure prices affect the ordering of measures (and the eventual recommendation of one product type over another), we tried to ensure consistency in price data across all the measures.

Measure Evaluation and HERS ratings

The needs of this project led us to develop a customized HERS rating process employing energy savings estimates from the DOE-2 building simulation program. We needed to meet the following objectives: 1) implement the Draft National HERS Guidelines, 2) accurately model a range of house characteristics in a variety of climates, 3) allow non-directionality in all shell characteristics (to model

[3] If the published price source was a local or regional survey, we first adjusted the local prices to national prices by using an average of the R.S. MEANS location multipliers for the cities in that region.

average conditions), 4) accurately model many energy-efficiency measures, including measures such as white roofs and duct sealing, and 5) automate the analysis process to allow analyzing a large number of measures in many prototypes.

Table 3. Efficiency Measures Analyzed

Exterior Wall Insulation
- Wood frame walls: R-11, R-13, R-15 (2x4); R-19, R-21 (2x4 with insulative sheathing); R-19, R-21 (2x6)
- Concrete block walls: R-3, R-6

Attic Insulation: R-19, R-30, R-38, R-49, R-60

Basement Insulation
- Conditioned Basements: R-11 (interior wall insulation)
- Unconditioned Basements: R-19, R-25, R-30 (floor above basement)

Under-Slab Insulation
- Warmer Climates: R-5, R-10 (to 2 ft)
- Colder Climates: R-5, R-10 (to 4 ft)

Insulated Door and Window Headers

Envelope Air Sealing to 0.35 ACH

Light-colored Roof
Radiant Barrier

Windows
17 window combinations:
- Panes: single or double
- Frames: aluminum, aluminum with thermal break, wood or vinyl
- Glazings: clear, tinted, pyrolytic low-E, solar-control low-e
- Gas fill: none, argon
- Superwindow: (triple glazing, 2 low-E coatings, argon gas fill, non-metallic spacer, vinyl frame)

Water Heaters
- Gas-Fired: 0.62, 0.63, 0.66, 0.86 Energy Factor
- Oil-Fired: 0.66, 0.68 Energy Factor
- Electric: R-12 tank wrap, desuperheater

Electric Heat Pump: 11, 12, 13, 14 SEER
Central Air Conditioner: 11, 12, 13, 14 SEER
Gas Furnace: 80, 90, 93 AFUE
Gas Boiler: 85, 87.5, 90.6 AFUE
Oil Boiler: 83, 85 AFUE

Forced-Air Ducts
- seal to 6% total leakage
- insulate to R-8

Estimating Energy Savings

We used the DOE-2.1E building energy simulation program (Birdsall et al. 1990) to estimate the heating, cooling, and water heating energy consumption and equipment sizes for the prototypical homes identified in the builder survey. The prototypes varied in number of stories, floor area, window area, foundation type, and other attributes, but all were non-directional (i.e., they had the same dimensions and characteristics on each building facade). The four facades always faced in the cardinal directions. For each prototype, we performed one annual DOE-2 simulation run for: 1) an idealized Energy-Efficient Reference Home (EERH) case conforming to the *HERS Guidelines* (for the purposes of calculating a HERS score), 2) a base case with similar characteristics, and 3) up to 40 variations of the base case incorporating one applicable energy-efficiency measure at a time. The measure energy savings were calculated by subtracting the consumptions in 3) from the base case consumption in 2). We used the ASHRAE 152P duct model (ASHRAE 1997) to pre-calculate annual average duct efficiencies for each prototype (both the baseline and duct measures), which were then used as inputs to the DOE-2 model. Air conditioner desuperheater (heat recovery unit) savings were based on a previous analysis performed by LBNL (Atkinson et al. 1997). Details of the energy modeling are provided in Brown et al. (1998).

Economic Evaluation

Once we estimated the energy savings from each measure, we used a spreadsheet model to evaluate measure cost-effectiveness and calculate HERS ratings. The cost-effectiveness analysis used the "supply curves of conserved energy" methodology (Koomey et al. 1991; Meier et al. 1983), in which the measures are sequentially added to the baseline prototype in order of cost-effectiveness. This method avoids double-counting energy savings from multiple measures, because the energy savings for the yet-to-be-included measures are recalculated after each measure is added to the package. This was accomplished using the percentage energy savings for each measure (compared to the baseline), which remain relatively constant despite changes to other parts of the thermal shell and equipment. We found that based solely on the initial energy consumption estimates for each measure from DOE-2, we could use a spreadsheet model to estimate the cumulative savings from several measures to within 0% to 3% of what DOE-2 would estimate (Brown et al. 1998). This accuracy allowed use of a spreadsheet model for measure ordering, and avoided iterative DOE-2 runs to re-estimate energy consumption as each measure was added to the package.

We used the benefit-cost ratio (annual energy bill savings ÷ annualized measure price) as the criterion for ordering the measures (Thuesen et al. 1977). Measure prices were annualized using a 7.875% nominal discount rate, to represent a typical 30-year fixed mortgage rate in 1997. Electricity and natural gas prices were based on 1995 utility block rate data from national data providers (AGA 1996; UDI 1995).

Rather than including all measures with positive cost-effectiveness in the package, as is typically done in a supply curve study, we added measures to the package until the ENERGY STAR guidelines (86 HERS) were met. We calculated HERS ratings using the draft National HERS Guidelines, with one significant modification. For gas-heated homes we calculated HERS scores based on source energy, rather than site energy as prescribed in the National Guidelines. We did this because the ENERGY STAR Homes program recognizes that the Department of Energy was not able to rule out source-based HERS scores for setting "final" guidelines, and many gas utilities around the country are promoting source-based HERS ratings for new construction. For all the sunbelt cities, we modeled both a gas-heated and heat pump-heated version of every prototype. If the thermal shell or cooling equipment measures in the final packages differed between these two versions, we applied the more stringent set of measures to both homes to ensure greater consistency.

For each prototype we also calculated the reduction in heating and cooling equipment capacity permitted by the application of the ReBOP measures. We used the price data described previously to calculate the reduction in equipment price due to reduced capacity. This price reduction ("downsizing credit") was subtracted from the total cost of the package. Note that the downsizing credit was applied once at the end of the measure ordering, not sequentially as each measure was selected for the package.

Whenever possible, we developed two packages for each prototype: one requiring diagnostic testing of ducts and air sealing, and one for which it was optional. Builders selecting the latter option are required to locate ducts entirely within conditioned space, and cannot take credit for sealing the building envelope beyond the default infiltration level specified in the National HERS Guidelines (approximately 0.50 to 0.70 ACH, depending on the location). For many prototypes in the northern cities, it was not possible to reach 86 HERS without airsealing, thus the option of no diagnostic testing is not available.

The resulting packages of measures were modified for certain locations to eliminate measures that builders are reluctant to adopt because of limited product availability, home buyer concerns, and other factors. Additionally, the final measures were adjusted in some cases to provide greater consistency among the prototypes within a city. Tables 4 through 6 summarize the types of measures that are included in the ReBOPs, in each of three distinct climates – hot, mixed, and cold. For the purposes of this paper, we selected one city to represent each of these climates. Note that these are preliminary results and are subject to change before being published for ENERGY STAR Homes program compliance. Typically the net package cost, accounting for heating and cooling equipment downsizing, is $1,500 to $2,000, and in all cases provides significant positive net cash flow to home buyers and investment returns of 14% to 28%. The higher package costs in Detroit are primarily due to baseline house characteristics that are significantly less energy efficient than the Model Energy Code, thus requiring more measures to reach a HERS score of 86; however, even in this case, the returns on investment exceed 20%.

Lessons Learned

Several findings from this study significantly affect the final results. First, the most important factors influencing the final measures in a package (within a given climate) are: 1) window area, 2) foundation type, and 3) presence of central cooling. This last factor has a large effect on the HERS score because the National HERS Guidelines effectively reduce the HERS score of a home without cooling equipment, compared to the same home configuration with cooling. This aspect of the HERS Guidelines has less effect on new homes, since the vast majority of homes built today have central cooling or will have it installed soon after sale. Nevertheless, we believe this situation should be addressed in future revisions of the National HERS Guidelines so that houses without cooling are not penalized. The floor area of homes and the number of stories are less important drivers in the final measures selected (the number of stories is more important in affecting the duct location and configuration rather than direct thermal shell losses).

Second, we found that gas-heated homes often require more shell measures and higher cooling equipment efficiencies, compared to homes with electric heat pumps, in order to meet the ENERGY STAR guidelines. This seems to be the result of lower attainable efficiency levels for gas space heating and water heating equipment (again, compared to electric equipment). This difference is not reflected in the final packages because we only used the most stringent set of measures from the two heating fuel types, in order to reduce the amount of variation in the packages.

Finally, developing packages of measures for a large population of homes requires a tradeoff between assurance that all homes using the packages will achieve an 86 HERS score, versus the simplicity and usability of the packages for builders. The broader the range of house characteristics to which a package will be applied (i.e., the fewer the number of separate packages), the more stringent the package's efficiency requirements must be to assure that a very high percentage of the houses in that range will in fact achieve an 86 HERS score using that package. There are several possible strategies to increase the probability that homes applying the ReBOPs will actually achieve an 86 HERS score: 1) set narrow applicability limits for house features such as window area, foundation type, etc., 2) use a higher HERS threshold score (87 or 88 HERS) to develop the ReBOPs, or 3) use a worst-case home configuration (orientation, shading, window area, etc.) to develop the ReBOPs. In this analysis, we have employed the first strategy above, and we have recently decided to adopt a worst-case home configuration to develop the final ReBOPs for publication.

Table 4. ReBOP Summary Results for Orlando, FL

House Type **Heating/Cooling equipment**	detached heat pump or gas furnace/CAC
ReBOP Recommendations	
Wall and rim joist insulation	wood frame: R-11; concrete block: R-6
Door and window header insulation	wood frame: insulate all air spaces
Ceiling insulation	R-19
Slab edge insulation	R-0
Windows	
# panes	2
glazing	solar control low-E
gas fill	air
frame	aluminum
Envelope airtightness (max)	-
Heating efficiency	gas furnace: 78 AFUE; heat pump: 6.8 HSPF
Cooling efficiency	10 SEER, 12 SEER[1]
Electric water heater efficiency	0.92 EF
Gas water heater efficiency	0.54 EF, 0.63 EF[1]
Duct insulation	R-6
Duct leakage (% of fan flow)	6%
Economic Analysis Results (averaged over all packages)	
Package Cost	$2,058
HVAC downsizing credit	($722)
Net Cost	$1,336
Annual Bill Savings	$380
Annual After-tax Net Cash Flow[2]	$292
Return on Investment (Case 1)[3]	28%
Return on Investment (Case 2)[4]	167%
HERS rating	86.4

Notes to Table 4:

[1] Specific efficiency level depends on the window area of the house.

[2] Based on net cost of package, assuming 30-year mortgage at 7.875% interest rate and deduction of mortgage interest at a marginal income tax rate of 28%.

3 Assumes all-cash home purchase; incremental cost of energy efficiency measures is not reflected in home resale value.

4 Assumes mortgage financing with 5% downpayment, 30-year fixed mortgage, sale of home after 8 years, and recovery of incremental purchase price at time of home sale.

These are interim results and are subject to change. They may not be used for compliance with the ENERGY STAR Homes guidelines.

All characteristics in the table pertain to ReBOPs that require diagnostic field testing.

Table 5. ReBOP Summary Results for Washington, DC

House Type **Foundation type** **Heating/Cooling equipment**	detached conditioned basement electric heat pump or gas furnace/CAC	attached any electric heat pump or gas furnace/CAC
ReBOP Recommendations		
Wall and rim joist insulation	R-13	R-13
Door and window header insulation	insulate all air spaces	insulate all air spaces
Ceiling insulation	R-30, R-38[1]	R-30, R-38[1]
Basement walls (if conditioned basement)	R-11	R-11
Floor above basement (if unconditioned basement)	-	R-19
Slab-on-grade perimeter	-	R-5
Windows		
# panes	2	2
glazing	solar control low-E	solar control low-E
gas fill	air, argon[1]	argon
frame	vinyl or wood	vinyl or wood
Envelope airtightness (max)	0.35 ACH	0.35 ACH
Heating efficiency (AFUE or HSPF)	Gas furnace: 78, 90; Heat pump: 6.8, 7.8[1]	Gas furnace: 78, 80; Heat pump: 6.8, 7.0[1]
Cooling efficiency (SEER)	12	12
Water heater efficiency (Energy Factor)	Gas: 0.63; Electric: 0.92	Gas: 0.63; Electric: 0.92
Duct insulation	R-8	R-4
Duct leakage (% of fan flow)	6%	6%
Economic Analysis Results (averaged over all packages)		
Package Cost	$2,328	$1,680
HVAC downsizing credit	($558)	($430)
Net Cost	$1,770	$1,250
Annual Bill Savings	$294	$199
Annual After-tax Net Cash Flow[2]	$177	$117
Return on Investment (Case 1)[3]	14%	14%
Return on Investment (Case 2)[4]	63%	40%
HERS rating	86.4	86.4

Notes to Table 5:

[1]Specific efficiency level depends on home characteristics such as window area, floor area, or foundation type.

[2] Based on net cost of package, assuming 30-year mortgage at 7.875% interest rate and deduction of mortgage interest at a marginal income tax rate of 28%.

3Assumes all-cash home purchase; incremental cost of energy efficiency measures is not reflected in home resale value.

4 Assumes mortgage financing with 5% downpayment, 30-year fixed mortgage, sale of home after 8 years, and recovery of incremental purchase price at time of home sale.

These are interim results and are subject to change. They may not be used for compliance with the ENERGY STAR Homes guidelines.

All characteristics in the table pertain to ReBOPs that require diagnostic field testing.

Table 6. ReBOP Summary Results for Detroit, MI

House Type / **Heating/Cooling equipment**	detached / gas furnace/CAC	detached / gas furnace/none	attached / gas furnace/CAC	attached / gas furnace/none
ReBOP Recommendations				
Wall and rim joist insulation	R-19	R-19	R-13	R-13
Door and window header ins.	insulate all air spaces	insulate all air spaces	standard practice OK	standard practice OK
Ceiling insulation	R-38	R-30, R-49[1]	R-30	R-30
Basement walls	R-11	R-11	R-11	R-11
Windows				
# panes	2	2	2	2
glazing	pyrolytic low-E	pyrolytic low-E	clear; pyrolytic low-E	clear
gas fill	argon	argon	air; argon[1]	air
frame	vinyl or wood	vinyl or wood	vinyl or wood	vinyl or wood
Envelope airtightness (max)	0.35 ACH	0.35 ACH	0.35 ACH	0.35 ACH
Gas furnace (AFUE)	90	90	78	78, 80[1]
Central air conditioner (SEER)	10	-	10	-
Gas water heater (Energy Factor)	0.63	0.63	0.63	0.62, 0.63[1]
Duct insulation	R-8	R-8	R-0	R-0
Duct leakage (% of fan flow)	6%	6%	6%	6%
Economic Analysis Results (averaged over all packages)				
Package Cost	$4,905	$4,944	$1,611	$1,430
HVAC downsizing credit	($896)	($383)	($252)	($97)
Net Cost	$4,008	$4,562	$1,360	$1,333
Annual Bill Savings	$1,026	$1,004	$332	$320
Annual After-tax Net Cash Flow[2]	$763	$704	$242	$232
Return on Investment (Case 1)[3]	25%	21%	23%	23%
Return on Investment (Case 2)[4]	216%	204%	210%	245%
HERS rating	86.3	86.2	86.1	86.2

Notes to Table 6:

1 Specific efficiency level depends on home characteristics such as floor area or number of stories.

2 Based on net cost of package, assuming 30-year mortgage at 7.875% interest rate and deduction of mortgage interest at 28% marginal income tax rate.

3 Assumes all-cash purchase; incremental cost of energy efficiency measures is not reflected in home resale value.

4 Assumes mortgage financing with 5% downpayment, 30-year fixed mortgage, sale of home after 8 years, and recovery of incremental purchase price at time of home sale.

These are interim results and are subject to change. They may not be used for compliance with the ENERGY STAR Homes guidelines.

All characteristics in the table pertain to ReBOPs that require diagnostic field testing.

Implementation

Several activities are planned to assure that the packages are useful to builders while still achieving the expected energy savings. First, we are developing a ReBOP users guide to help builders interpret and apply the guidelines. An important part of the users guide is a field verification and testing protocol to be performed by HERS raters to verify compliance with the package recommendations. Second, the packages will be published in both hard copy and interactive database versions to make them as widely available as possible. The interactive database will be both disk-based and World Wide Web-based. Third, we plan to initially make the ReBOPs available on a pilot basis in two states – one with an active HERS industry and one in which the HERS industry is still forming. This will help us gauge the role of the HERS raters in implementing the ReBOPs, and also help identify implementation problems before the widespread release of ReBOPs. As part of this pilot program, we plan to solicit feedback from builders and modify and extend the ReBOPs based on this feedback. Finally, we will quantify the actual energy savings due to the ReBOPs as part of the overall ENERGY STAR Homes program evaluation study, in order to verify that the ReBOPs are achieving the expected energy savings.

Summary

We developed packages of energy-efficiency measures to help production home builders meet the guidelines of the ENERGY STAR Homes program in several cities across the U.S. These packages are intended to be an alternative method of participating in the program. The packages are specific to local climate and building practices, and are intended to maximize net cash flow for new-home buyers.

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