Economic Analysis
for
Maine Residential Energy Standard
(Maine RES)

Prepared for:

Maine State Planning Office

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Introduction

This report includes justification for and information about the economic advantages of building an energy-efficient house, specifically a house built to the minimum energy-efficiency level of the voluntary Maine Residential Energy Standard (Maine RES).

In order to justify moving from the energy-efficiency level of the Maine Energy Efficiency Building Performance Standards[1] — the base case — to that of Maine RES, an economic analysis performed on new homes,[2] twenty-four houses were modeled, one-half subject to the climate in Portland and the other half to the climate in Caribou. The guide used for the selection of energy-saving measures was the "Proposed Prescriptive Building Envelope and Heating System Provisions of Maine RES" reproduced in this report as Table 6. This analysis demonstrates that, in the majority of modeled houses, the proposed individual Maine RES measures are cost-effective when examined with savings-to-investment ratio and simple payback tests. When the measures were analyzed as a group or bundle, the resulting cash flow was positive for all the hypothetical models.

It is important to understand that this economic study is only meant to justify progressing to the Maine RES energy levels from those of the current Maine law, it is not intended to justify the Maine RES energy levels compared with houses with no insulation; there is no need to do this for it has been done many times by analysts for ENERGY STAR, the International Energy Conservation Code, and its predecessor, the Model Energy Code.

For many energy-saving measures, such as insulation, as a greater quantity is installed, the benefit from each additional inch decreases. For example, the total incremental benefit of adding an R-value of 15 to an foundation that has no insulation is significantly greater than the incremental benefit of adding an R-value of five to a foundation already insulated with R-10. This is often referred to as diminishing returns. It is likely that diminishing returns is the primary reason that the benefits of some of the individual energy-saving measures modeled for this analysis are close to the margin. However, each bundle of measures does show improvements in cash flow and a present value of savings greater than the bundled cost.

In addition, this report discusses the impact that energy efficient financing can have on the economics of a home purchase. Mortgages available for qualifying houses recognize that energy-efficient features can make a house less expensive to own and, in many cases, allow a borrower to purchase a more expensive home.

The positive relationship between energy efficiency and resale value brings another benefit to the energy-efficient home owner. A number of well-documented studies, referenced in this paper, have established this favorable relationship.

Finally, supporting information for the energy-efficiency levels of Maine RES is included from the Energy Efficiency and Renewable Energy Network (EREN) and from the ENERGY STAR Homes Program.

[1]The Maine Energy Efficiency Building Performance Standards are a Maine law.

[2]In most cases, costs for these energy-saving measures will be higher for existing buildings, while the savings will be the same. As a result, the addition of these measures to existing homes will not be as cost-effective as for new homes.

Description of Economic Analysis

The software used for the economic analysis was REM/*Rate*, version 9.12, by Architectural Energy Corporation. Twenty-four houses were modeled with this software. The base characteristics for each of the modeled houses matched the Maine Energy Efficiency Building Performance Standards (Maine law for speculatively built residential structures) as summarized in Appendix A. The energy efficiency of each house was then increased to comply with the Maine Residential Energy Standard.[3] The measures assigned to each of the modeled houses can be found in Appendix B of this report and the tabulated results of this economic analysis can be found in Appendix C.

A one-story house (960 ft^2) was modeled with Portland weather data using variations of 8, 12, 15, 18, 20, and 25 percent glazing, for a total of six of the twenty-four models. Another six of the twenty-four were modeled as two-story houses (1920 ft^2) with the same glazing percentage variations and using Portland weather data. The same was done for one- and two-story models using Caribou weather data and the same glazing percentage variations (six models for the one-story and six models for the two-story Caribou houses).[4]

The savings-to-investment ratio[5] (SIR) and simple payback[6] (SPB) were calculated for each measure with REM/*Rate.* As expected, the measures generally showed more favorable SIR and SPB values in the colder climate of Caribou than for the Portland area.

The energy-saving measures analyzed were incremental in nature, that is, they were added to a house that already complied with the Maine Energy Efficiency Building Performance Standards. For example, for twenty of the twenty-four models, R-11 fiberglass insulation was added to existing R-38 ceiling. Because insulation is subject to diminishing returns (each inch is less effective than the previous inch), adding R-11 to an already existing R-38 yields less favorable economic results than installing R-49 at the time of initial construction.

The SIR and SPB values for the measures were calculated in two ways; interactively and non-interactively. The *interactive* calculation accounts for the assigned energy-saving measures and ranks them in order of SIR. The assignment of the most cost-effective measure (greatest SIR)[7] for a model reduces the SIR and SPB for the subsequent measures because the annual fuel cost is reduced correspondingly by the previous measure. This method is more useful for analyzing a bundle of energy-saving measures applied to a particular house.

The *non-interactive* calculation method considers each energy-saving measure as if it were the only measure assigned to that house. For some measures, this results in more favorable SIR and SPB values than the measures yield under the interactive method. The non-interactive method is more useful for analyzing measures individually. Table 8 in Appendix C shows the tabulated results of the energy-saving measures added to the twenty-four modeled houses. In most cases, the non-interactive results are not listed because they are very close in value to the

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[3]The proposed Maine Residential Energy Standard is based on the International Energy Conservation Code-2000.

[4]Table 6 in this report shows the "Proposed Prescriptive Building Envelope and Heating System Provisions of Maine RES." These prescriptive standards are for glazing areas of 8, 12, and 15 percent. This economic study also includes modeled houses with glazing areas of 18, 20 and 25 percent. In the case of these three higher percentage glazing areas, the prescriptive standard suggestions for the 15 percent column in Table 6 were used.

[5]An SIR value of 1 or greater is considered acceptable by most analysts. An SIR of 1 can be interpreted as regaining $1 over the useful life of the energy-saving measure for each $1 invested in the measure. If the SIR is 2, this can be interpreted as regaining $2 over the useful life of the energy-saving measure for each $1 invested in the energy-saving measure. An SIR less than one is considered a bad investment.

[6]The simple payback is the additional cost of the energy-saving measure divided by the first-year dollar saving of the measure. For example, if a measure costs $400 and is projected to save $200 the first year, the SPB is 2 years. In other words, the energy-saving measure will pay for itself in two years.

[7]For the twenty-four modeled homes the most cost-effective measure was air-leakage reduction, i.e., the reduction of air changes per hour (ACH) from 0.5 to 0.4.

interactive results. Where there are significant differences, both interactive and non-interactive results are listed.

In addition to the interactive and non-interactive SIR and SPB values, four additional values were calculated based on the interactive bundle of measures. These were 1) the cost of the bundle of improvements ($ Improve), 2) the present value of the savings over the useful life of the measure (PV Savings), 3) the monthly cash flow change as a result of the measure (Monthly Cash Flow), and 4) the Fuel Cost at which Cash Flow Equals Zero.[8]

Analysis of Data[9]

The results of data analysis are dependent on the underlying assumptions of measure costs, fuel costs, mortgage term, and interest rate.[10] These underlying values were selected carefully, but it should be noted that any alteration to these values can significantly influence the results. Table 1 shows a summary of results for the seven energy-saving measures applied in various combinations – bundles – to the twenty-four model houses.

Table 1
Summary of Results
Economic Analysis of Energy-Saving Measures

	Savings-to-Investment Ratio/ Simple Payback (Years)	
Energy-Saving Measure	***Portland***	***Caribou***
1. Reduce air leakage from 0.5 to 0.4 ACH, 1 story house	3.3 / 3.4 yrs	4.2 / 2.7 yrs
2. Reduce air leakage from 0.5 to 0.4 ACH, 2 story house	2.4 / 4.7 yrs	3.0 / 3.7 yrs
3. Increase foundation insulation from R-10 to R-15	1.4 / 7.8 yrs	1.9 / 6.1 yrs
4. Upgrade windows from U-0.5 to U-0.35	0.8 /14 yrs	1.1–1.0 / 10.7–11.4 yrs
5. Increase ceiling insulation from R-38 to R-49	0.8–0.7 / 14.7–15.2 yrs	1.0–0.9 / 11.4–12.0 yrs
6. Improve central boiler efficiency from 80% to 84% AFUE	1.2–0.5 / 9.3–20.0 yrs	1.2–0.7 / 9.2–16.0 yrs
7. Improve central boiler efficiency from 80% to 88% AFUE	n/a	1.6–0.6 / 6.8–17.0 yrs

- Savings-to-Investment Ratio (SIR) is the cost of the measure divided by the annual savings, over the life of the measure. Please refer to Appendix D and Table 8 for more information.

- Simple Payback is the time required for annual savings to equal the cost of the measure. Please refer to Appendix D and Table 8 for more information.

A description of the economic analysis results is listed below under each of the seven energy-saving measures used.

[8] These cash flow and other calculated values are based on a thirty-year mortgage at 8.0 percent interest. A positive cash flow value indicates that out-of-pocket expenses (principle, interest, taxes, insurance, and energy) for the house is reduced by the listed amount. A negative cash flow value would indicate out-of-pocket expenses have increased by the listed amount as a result of the bundled energy-saving measures.
[9] The details of the twenty-four modeled houses and the measures used for each may be found in Appendix B of this report. The tabulated results of the economic analysis may be found in Appendix C.
[10] Measure costs can be found in Appendix B, fuel costs are $0.13 per kWh for electricity and $1.20 for fuel oil, mortgage term is 30 years, and mortgage interest rate is 8.0 percent. Also, see Appendix D for calculation methods.

1. **Reduce air leakage from 0.5 ACH to ACH 0.4 for 960 ft^2 house.**[11]
   - The cost of this measure was assumed to be $100.
   - For each of the twenty-four modeled houses, air-leakage reduction demonstrated the most favorable SIR and SPB. For the one-story models (just less than 1000 ft^2), SIR values ranged from 3.3 to 4.2 and SPB values ranged from 3.4 to 2.7 years.
2. **Reduce air leakage from 0.5 ACH to ACH 0.4 for 1920 ft^2 house.**
   - The cost of this measure was assumed to be $250.
   - For each of the twenty-four modeled houses, air-leakage reduction demonstrated the most favorable SIR and SPB. For the two-story models (just less than 2000 ft^2), SIR values ranged from 2.4 to 3 and SPB values ranged from 4.7 to 3.7 years.
3. **Increase foundation wall insulation on exterior surface, foundation top to footing, from R-10 to R-15.**
   - The cost of this measure was assumed to be $0.20 per square foot of foundation area, above and below grade.
   - This measure was used for eight of the modeled houses in the Portland climate and for 10 in the colder Caribou climate. The SIR values were 1.4 and 1.9. The SPB values ranged from 7.8 to 6 years. This measure was cost-effective for all models for which it was applied.
4. **Upgrade windows from U-0.5 to U-0.35.**
   - The cost of this measure was assumed to be $2.50 per square foot of window area.
   - Increasing the insulating value of windows[12] was used in all twenty-four models. This measure was not cost-effective for the twelve Portland models (SIR = 0.8), but was cost-effective for all models in Caribou (SIR = 1.1 to 1.0).
5. **Increase ceiling insulation from R-38 to R-49.**
   - The cost of this measure was assumed to be $0.20 per square foot.
   - Increasing the insulating value of ceiling (attic floor) insulation was used in twenty of the twenty-four models. This measure was not cost-effective for the analysis of the Portland models. This measure proved to be cost-effective for eight of the twelve Caribou models.
6. **Improve central space heating boiler from 80% AFUE to 84% AFUE.**
   - The cost of this measure was assumed to be $250 (distribution system excluded).
   - This measure was used for sixteen of the twenty-four models. For the Portland models, this measure was cost-effective (SIR of 1 or more) for five of the twelve models. For the Caribou models the measure was cost-effective for two of the four models to which it was applied.
7. **Improve central space heating boiler from 80% AFUE to 88% AFUE.**
   - The cost of this measure was assumed to be $450 (distribution system excluded).
   - This measure was used for eight of the twelve Caribou models; it proved cost-effective for all but one of these models. The SIR values were more favorable for the larger two-story models requiring more space heating fuel.

[11] The base case used for this analysis, Maine Energy Efficiency Building Performance Standards, does not have an air leakage requirement. Air changes per hour (ACH), a measurement of air leakage, for the base case is assumed to be 0.5 for this analysis. The IECC-2000, and, therefore Maine RES, do not list a required ACH for the prescriptive or component performance approaches. The IECC-2000 does list ACH requirements for the systems analysis approach on page 65. These requirements range from 0.43 to 0.57 ACH for the climate zones of Maine. For this analysis, and ACH of 0.4 was assumed for the Maine RES levels of energy efficiency. This 0.4 ACH value is based on measured ACH values for the Good Cents Program (Central Maine Power) and the *MaineStar* Program. The only practical method of quantifying air leakage rates in the field is by performing a blower door test on the finished house.

[12] Double-hung windows were assumed for determining the additional cost of the lower U-factor windows.

For each of the twenty-four models, four values were calculated for each interactive bundle of measures: 1) the cost of the bundle of improvements ($ Improve), 2) the present value of the savings over the useful life of the measure (PV Savings), and 3) the monthly cash flow change as a result of the measure (Monthly Cash Flow), and 4) the Fuel Cost at which Cash Flow Equals Zero.

All twenty-four models showed an improvement in cash flow, in other words, the present value of the savings from the bundle of measures was greater than the implemented cost of the bundle. Positive cash flow changes ranged from $3.00 to $84.00 per year.

In all cases, the Fuel Cost at which Cash Flow Equals Zero, is $1.18 or lower for the number 2 fuel oil, the space heating fuel source used for this study. Of course, some of the modeled bundles show a zero cash flow — break even — at a lower fuel price than others, the lowest being $0.81 per gallon.

It is typical for some energy-saving measures to produce better results than others. The important question is: Why do some of the energy-saving measures for the twenty-four models show SIR values of less than one? Possible reasons for these apparently unfavorable numbers are:

1. The analysis is incremental, starting with the energy-efficiency level of Maine Energy Efficiency Building Performance Standards and moving to the level of the proposed Maine RES. As mentioned above, insulation is subject to diminishing returns, making the likelihood of a favorable result unlikely when additional insulation is added to a substantial amount of existing insulation, as done for the hypothetical models of this analysis.
2. Maine Energy Efficiency Building Performance Standards were used as the base efficiency level of this analysis. The requirements of this state energy code do not vary from one climate zone in the state to the next; they are uniform throughout the state. One the other hand, the energy-efficiency levels of Maine RES vary — they become more stringent for the colder northern counties. If the Maine Energy Efficiency Building Performance Standards varied in stringency in proportion to Maine RES, the results of this economic analysis would be more consistent among the Portland models and Caribou models. Assuming that the Maine Energy Efficiency Building Performance Standards are keyed to an average Maine winter climate, by comparison the modeling of Maine RES houses in colder state climates predictably yield more favorable results than those in warmer areas. Conversely, modeled houses in warmer sections of the state — Portland — yield less favorable results.
3. The costs and savings of a number of the measures are constrained by the products available for increasing energy efficiency. For example, adding R-6 to an existing R-38 in an attic might yield more favorable economic results than adding R-11, but R-6 is not readily available, whereas R-11 is common.
4. In some cases, the results are quite sensitive to the underlying assumptions, meaning that a small change in a base value can significantly impact a result. For example, if the cost of fuel oil is increased from $1.20 to $1.50 per gallon (an increase of 25 percent) for the model with the smallest positive cash flow ($3.00), the annual cash flow increases by $35.00 (an increase of more than eleven times).[13] Efforts were made to accurately select the appropriate economic base values for this study, but it must be recognized that this high degree of sensitivity increases the uncertainty of the analysis.

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[13]Portland, 960 square feet, one-story, 25 percent glazing.

Table 2 lists most of the economic data calculated for this economic report. The values in the body of the table are explained at the bottom of the table. For example, notice that for the two-story house in Caribou with 15 percent glazing, the cost of the energy-saving bundle of options is $1962.00, found in column 2. The items making up the bundle of energy-saving options are found in the Table 7 in Appendix B. These items include air leakage control, foundation insulation from R-10 to R-15, window insulation from U-0.5 to U-0.35, ceiling insulation from R-38 to R-49, and boiler efficiency from 80% AFUE to 88% AFUE. The annual savings from this energy-saving bundle is $248.00 for an annual mortgage payment increase of $174.00 per year (both values in column 3). These yield a positive cash flow of $74 per year (column 4). The present value of the energy savings from the bundle is $2,763.00 (column 5) over the life of the measures. The savings-to-investment ratio (SIR) for the entire energy-saving bundle is 1.4 (column 6). This SIR value can be interpreted as a $1.40 return for each $1.00 invested over the life of the energy-saving measures in the bundle.

Table 2
Selected Results from House Modeling, Portland and Caribou, Maine

1. House Model	*2. Cost of Energy-Saving Bundle*	*3. Annual Savings / Increased Mortgage $ per Year*	*4. Annual Cash Flow Change*	*5. Present Value of Savings*	*6. Savings-to-Investment Ratio of Energy-Saving Bundle*
One Story					
Portland, 8% glazing	$650	$60 / $53	$7	$666	1.1
Caribou, 8% glazing	$797	$94 / $71	$23	$1,039	1.3
Portland, 12% glazing	$735	$70 / $65	$5	$799	1.1
Caribou, 12% glazing	$1,132	$139 / $100	$39	$1,553	1.4
Portland, 15% glazing	$1,227	$116 / $109	$7	$1,289	1.0
Caribou, 15% glazing	$1,427	$163 / $126	$37	$1,812	1.3
Portland, 18% glazing	$1,322	$123 / $118	$5	$1,371	1.0
Caribou, 18% glazing	$1,522	$173 / $135	$38	$1,926	1.3
Portland, 20% glazing	$1,387	$128 / $123	$5	$1,428	1.0
Caribou, 20% glazing	$2,049	$180 / $141	$39	$2,004	1.3
Portland, 25% glazing	$1,547	$140 / $137	$3	$1,566	1.0
Caribou, 25% glazing	$1,747	$197 / $155	$42	$2,196	1.3
Two Story					
Portland, 8% glazing	$960	$106 / $86	$20	$1,175	1.2
Caribou, 8% glazing	$1,152	$151 / $102	$49	$1,688	1.5
Portland, 12% glazing	$1,190	$124 / $106	$18	$1,375	1.2
Caribou, 12% glazing	$1,587	$207 / $141	$66	$2,317	1.4
Portland, 15% glazing	$1,762	$175 / $157	$18	$1,957	1.1
Caribou, 15% glazing	$1,962	$248 / $174	$74	$2,763	1.4
Portland, 18% glazing	$1,934	$188 / $172	$16	$2,107	1.1
Caribou, 18% glazing	$2,134	$266 / $189	$77	$2,971	1.4
Portland, 20% glazing	$2,049	$197 / $182	$15	$2,207	1.1
Caribou, 20% glazing	$2,249	$279 / $200	$79	$3,109	1.4
Portland, 25% glazing	$2,337	$220 / $208	$12	$2,458	1.1
Caribou, 25% glazing	$2,537	$309 / $225	$84	$3,456	1.5

- Column 1: One-story house is 960 square feet. Two-story house is 1920 square feet.
- Column 2: The cost of the energy-saving bundle or improvement. Please refer to Appendix B for the cost of each energy-saving measure and the measures that were applied to each of the twenty-four modeled houses. Also, refer to Appendix C for the tabulated results of this analysis.
- Column 3: Annual savings from the energy-saving measures bundle and the increase in annual mortgage costs as a result of the cost of the energy-saving bundle in Column 2.
- Column 4: The difference between expected annual savings (column 3) and the increased annual mortgage cost (column 3) resulting from the energy-saving measures. Values are based on interactive analysis. - Column 4: Annual savings resulting from the energy-saving measures.
- Column 5: Present value of savings over the life of the energy-saving measures. Values are based on interactive analysis.
- Column 6: The savings-to-investment ratio of the energy-saving bundle applied to the hypothetical model. Please refer to Appendix B for the cost of each energy-saving measure and the measures that were applied to each of the twenty-four modeled houses.

Data for HERS ratings and resale values for each hypothetical model are presented in Table 3. The Home Energy Rating Score (HERS) for the same two-story home in Caribou is 86.6

(column 4), high enough to qualify as an ENERGY STAR home and the possibility of a favorable ENERGY STAR mortgage. A HERS rating of 86 or greater qualifies as an ENERGY STAR home.

The increase in resale value because of the added Maine RES energy-saving bundle is potentially $4,960.00 (column 3). This favorable increase in resale value resulting from energy efficiency is discussed in this document under Energy Efficiency and Resale Value.

Again, this example makes it clear that it is beneficial for a homebuyer to build to the energy levels of Maine RES standard rather than to those of the current Maine law.

Table 3
Selected Results from House Modeling, Portland and Caribou, Maine

1. House Model	***2. Annual Savings***	***3. Increase in Resale Value at Maine RES***	***4. HERS Rating When Improved to Maine RES***
One Story			
Portland, 8% glazing	$60	$1,200	86.5
Caribou, 8% glazing	$94	$1,880	86.1
Portland, 12% glazing	$70	$1,400	86.2
Caribou, 12% glazing	$139	$2,780	86.9
Portland, 15% glazing	$116	$2,320	86.6
Caribou, 15% glazing	$163	$3,260	86.5
Portland, 18% glazing	$123	$2,460	85.9
Caribou, 18% glazing	$173	$3,460	85.9
Portland, 20% glazing	$128	$2,560	85.5
Caribou, 20% glazing	$180	$3,600	85.6
Portland, 25% glazing	$140	$2,800	84.3
Caribou, 25% glazing	$197	$3,940	84.6
Two Story			
Portland, 8% glazing	$106	$2,120	87.6
Caribou, 8% glazing	$151	$3,020	86.7
Portland, 12% glazing	$124	$2,460	86.6
Caribou, 12% glazing	$207	$4,140	86.4
Portland, 15% glazing	$175	$3,500	86.5
Caribou, 15% glazing	$248	$4,960	86.6
Portland, 18% glazing	$188	$3,760	85.7
Caribou, 18% glazing	$266	$5,320	86.0
Portland, 20% glazing	$197	$3,940	85.2
Caribou, 20% glazing	$279	$5,580	85.5
Portland, 25% glazing	$220	$4,380	83.9
Caribou, 25% glazing	$309	$6,180	84.4

- Column 1: One-story house is 960 square feet. Two-story house is 1920 square feet.
- Column 2: Annual savings from the energy-saving measures. Please refer to Appendix B for the cost of each energy-saving measure and the measures that were applied to each of the twenty-four modeled houses.
- Column 3: Values are the product of column 2, Annual Savings, times 20 (see section in this report “Energy Efficiency and Resale Value”). This is the expected increase in resale value resulting from the energy-saving measures added to increase the energy-efficiency level from that of the Maine Energy Efficiency Building Performance Standards to that of Maine RES. Annual savings values are based on interactive analysis.
- Column 4: Home Energy Rating (HERS) value as calculated by REM/Rate. Shaded cells do not qualify as ENERGY STAR homes, i.e., have a HERS score less than 86.

Energy-Efficient Financing

Any home built to the Maine RES guidelines will qualify for energy-efficient financing. This preferential financing makes the energy-efficient home easier to own, giving an economic advantage to a borrower buying a new home or improving an existing one.

Energy-efficient financing includes a number of products: Energy Efficient Mortgages (EEM), ENERGY STAR mortgages, and Energy Improvement Mortgages (EIM). EEMs and ENERGY STAR mortgages are products that ease qualifying requirements and/or offer some sort of interest rate or closing cost incentive for already-efficient (new) homes.[14] EIMs are financial products that allow the upgrading of energy features of an existing house as part of the mortgage.[15] In order to qualify for energy-efficient financing, the borrower must have a Home Energy Rating System (HERS) analysis done on the house.

The basic feature of energy-efficient financing is the ability of the borrower to finance into the mortgage 100 percent of the cost of eligible energy efficient improvements, subject to certain dollar limitations, without an appraisal of the energy improvements and without further credit qualification of the borrower. To be eligible for inclusion into the mortgage, the energy-efficient improvements must be cost effective, meaning the total cost of the improvements, including maintenance costs, must be less than the total present value of the energy saved during the useful life of the improvements.

Generic EEMs can be offered by lenders selling their loans to Fannie Mae and Freddie Mac. Fannie Mae allows a 2 percent stretch of the front-end and back-end ratio[16] for homes built to the 1992 Model Energy Code (MEC) or better. As an alternative to the 2 percent stretch, Freddie Mac allows lenders to increase the maximum principal, interest, taxes and insurance amount by a dollar amount equal to the estimated energy savings. Most lenders offer generic EEMs.

FHA EEMs allow lenders to add 100 percent of the additional cost of energy-efficienct improvements to an already approved mortgage. No additional down payment is required and the FHA loan limits do not interfere with the process of obtaining the EEM.

ENERGY STAR mortgages are offered by only a handful of ENERGY STAR Mortgage Partners. These mortgages offer the 2 percent stretch plus an additional feature that might be cash back at closing, discounted interest rates, or interest rate locks. Many Maine RES homes will qualify under ENERGY STAR standards.[17]

It is impossible to determine a general economic advantage of energy-efficient financing; each case varies. However, any home built to the Maine RES level will qualify for this preferential treatment, giving an advantage to the buyer of a new home or the owner of an existing home.

> The effort to ensure the energy efficiency of new homes through improved building energy codes has raised concerns with the housing industry that improved energy codes will cause higher construction costs, which in turn, will reduce housing affordability. Home energy ratings coupled with energy efficient mortgages can provide an opportunity to turn this perception around. In reality,

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[14] Richard Faesy, "Understanding and Overcoming the Energy Mortgage Barrier: Financing Energy Improvements in Existing Homes," *2000 ACEEE Summer Study on Energy Efficiency in Buildings*, footnote number 1 on page 1.
[15] *ibid.*
[16] The front-end ratio is monthly housing expenses (principal, interest, taxes, and insurance) divided by gross monthly income. The back-end ratio is total monthly obligations (including auto loans, for example) divided by gross monthly income. Standard underwriting criteria for a 30-year, fixed-rate mortgage is a 28 percent constraint on the front-end ratio and a 36 percent constraint on the back-end ratio.
[17] Of the twenty-four homes modeled for this study, thirteen qualify as ENERGY STAR homes (HERS score of 86 or greater).

> the value of energy efficiency actually greatly exceeds the added cost and thereby increases the number of qualified home buyers. It also increases consumers' "buying power" for higher quality, more comfortable and more affordable energy efficient homes. Through the market force of home energy ratings and the energy mortgages investing in making homes energy efficient will have the positive effect of making housing ***more*** affordable, not less affordable.[18]

An issue related to energy efficient financing is buyer disqualification resulting from increased housing costs:

> In the Northeast, there is a perception by builders that improved energy codes cause higher housing costs which, in turn, reduce housing affordability. The concern is that higher costs will lead to the financial disqualification of home buyers from mortgage products based upon standard lending debt-to-income ratios.[19]

As mentioned above, there are a number of financing options that now mitigate the problem of mortgage disqualification, however, the *perception* that energy-efficient houses cost more to own remains a market barrier.

> The message that needs to be demonstrated and communicated to builders, the real estate community, and lenders, as well as to consumers, is that the value of energy efficiency greatly exceeds the costs and thereby increases the number of qualified buyers and increases consumers' buying power for better, more energy efficient and expensive homes. Energy efficiency investments make housing more affordable, not less affordable.[20]

Energy Efficiency and Resale Value

Energy-efficient construction not only has the potential of creating a positive cash flow for the homeowner (lower monthly out-of-pocket expenses), but it can also increase the resale value of a house.

The ten studies summarized in Table 4 examined the resale value as a function of energy efficiency. In all the studies a positive relationship was found between energy efficiency and resale value.

Study numbers five through ten examined the relationship between the increase in resale value as a function of a one-dollar decrease in annual energy costs. The most significant of these studies, Nevin and Watson, found that the home resale value increase by about $20.00 for every one-dollar decrease in annual fuel costs.[21] *This increase in home value is an addition to the expected benefits of preferential financing and positive cash flow.*

In Table 3, column 3 lists the increased resale value of the twenty-four modeled houses when increased from the level of energy efficiency of the Maine Energy Efficiency Building Performance Standards (Maine law) to that of Maine RES. These values vary from $1,200.00 to $6180.00.

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[18]Steve Baden, "A Winning Combination: Linking Codes with Home Energy Ratings," Handout for presentation at the 1999 National Workshop on Building Energy Codes.
[19]Jeffrey Pratt and Gary Smith, *Energy Efficient Residential New Construction, Improved Energy Codes, and Housing Affordability in the Northeast*, draft prospectus, May 7, 1998, Northeast Energy Efficiency Partnerships, Inc.
[20]ibid., page 1.
[21] The most recent of these studies (number 10 in Table 4) found an even stronger relationship between lower energy costs and higher resale value — for every dollar decrease in annual energy costs, a twenty-five dollar increase in resale value.

> The implication for homebuyers is that they can profit by investing in energy-efficient homes even if they do not know how long they might stay in their homes. If their reduction in monthly fuel bills exceeds the after-tax mortgage interest paid to finance energy efficiency investments, then they will enjoy positive case flow for as long as they live in their homes and can also expect to recover their investment in energy efficiency when they sell their homes.[22]

This increased resale value also yields an advantage to real estate agents. If a house built to Maine RES sells for an additional $4000.00 because of energy-efficient features, the realtor receiving a 6 percent commission for selling the house will benefit from an additional $240.00.

Table 4
Research Findings on the Market Value of Energy-Efficient Homes

Study Authors	Time Period	Key Findings
1. Halvorsen and Pollakowski	1970-1975	The 1974 spike in relative cost of fuel oil raised price differential between gas- and oil-heated houses to $761 in 1974, and up to $4,597 in the first half of 1975.
2. Corgel, Geobel, and Wade	1978-1979	Value of energy-efficient homes (with lower structural heat loss) was $3,248 higher than inefficient homes.
3. Laquatra	1980	Home value increased by $2,510 for each one-point decrease in thermal integrity factor (Btu/ft^2, heating degree day)
4. Longstreth	1971-1978	A one-inch increase in wall insulation increased home value by $1.90 per square foot; a one-inch increase in ceiling insulation increased home value by $3.37 per square foot; high-quality (energy-efficient) windows increased home value by $1.63 per square foot.
5. Johnson and Kaserman	1978	Home value increased by about $20.73 for every $1 decrease in annual fuel bills.
6. Dinan and Miranowski	1982	Home value increased by $11.63 per $1 decrease in fuel expenditures needed to maintain house at 65^{O}F in average heating season.
7. Horowitz and Haeri	1983-1985	Home value increased by about $12.52 per $1 decrease in electric bills, consistent with home buyers discounting savings at after-tax mortgage interest rate.
8. Nevin and Watson	1991-1996	Home value increased by about $20.00 for every $1 decrease in annual fuel bills.
9. Nevin, Bender, and Gazon	1993	Home value increased by about $20.00 for every $1 decrease in annual fuel bills. Also, replacement of wood-frame single-pane windows with high performance low-e windows increased the value of the house enough to offset the cost of the replacement windows.
10. ICF Consulting/EPA	1998	Home market values increase $25.00 for every $1 decrease in annual energy costs.

1. Robert Halvorsen and Henry O. Pallakowski, "The Effects of Fuel Prices on House Prices, " *Urban Studies*, v.18, no.2 (1981): 205-211.

2. John B. Corgel, Paul R. Geobel, and Charles E. Wade, "Measuring Energy Efficiency for Selection and Adjustment of Comparable Sales," *The Appraisal Journal* (January 1982): 71-78.

3. Joseph Laquatra, "Housing Market Capitalization of Thermal Integrity," *Energy Economics* (July 1986): 134-138.

4. Molly Longstreth, "Impact of Consumers' Personal Characteristics on Hedonic Prices of Energy-Conserving Durable Good Investments," *Energy*, v.11, no. 9 (1986): 893-905.

5. Ruth C. Johnson and David L. Kaserman, "Housing Market Capitalization of Energy-Saving Durable Good Invenstments," *Economic Inquiry* (July 1983): 374-386.

6. Terry M. Dinan and John A Miranowski, " Estimating the Implicit Price of Energy Efficiency Improvements in the Residential Housing Market: A Hedonic Approach," *Journal of Urban Economics*, v. 25, no. 1 (1989): 52-67.

7. Marvin J. Horowitz and Hossein Haeri, "Economic Efficiency v. Energy Efficiency," *Energy Economics* (April 1990): 122-131.

8. Rick Nevin and Gregory Watson, "Evidence of Rational Market Valuations of Home Energy Efficiency," *The Appraisal Journal* (October 1998): 401-409.

9. Rick Nevin, Christopher Bender, and Heather Gazan, "More Evidence of Rational Market Valuations of Home Energy Efficiency," *The Appraisal Journal* (October 1999): 454-460.

10. ICF Consulting, *Evidence of Rational Market Values for Home Energy Efficiency*, March 1998, under contract with EPA.

Table based on Nevin and Watson, page 403.

[22] Rick Nevin and Gregory Watson, "Evidence of Rational Market Valuations of Home Energy Efficiency," *The Appraisal Journal* (October 1998), page 409.

Supporting EREN Information

The Energy Efficiency and Renewable Energy Network (EREN), a division of the US Department of Energy, has published residential energy economics information on their Internet site. This information, included in its original form in Appendix E, is listed in truncated form in Table 5.

At this EREN web site it is stated: "These recommendations are *cost-effective* levels of insulation based on the best available information on local fuel and materials costs and weather conditions. Consequently, the levels may differ from current local building codes. In addition, the apparent fragmentation of the recommendations is an artifact of these data and should not be considered absolute minimum requirements." [Emphasis added by author].

Table 5
US Department of Energy Recommended Total R-Values for New Construction in Maine

	Insulation R-value							
	Ceiling						Basement	
Fuel	Attic	Cathedral	Wall	Floor	Crawl Space	Slab Edge	Interior	Exterior
Gas, Fuel Oil, Heat Pump	49	38	18	25	19	8	11	10
Electric Furnace	49	60	28	25	19	8	19	15

Source: www.eren.doe.gov/consumerinfo/energy_savers/rvalue_map.pdf

This information developed by EREN includes the states of Maine, New Hampshire, Vermont, and New York.[23] Of these four states, Maine has the coldest winter climate. Generally, the colder the winter climate, the more favorable the energy economics results. Therefore, it is probably safe to conclude that these values in Table 5 are conservative for the Maine climate, especially northern Maine. Because the recommended prescriptive standards for the proposed Maine RES are close to, or in some cases, less than these "cost-effective" EREN prescriptive recommendations, they support the cost-effectiveness of the proposed Maine RES prescriptive standards.

Supporting ENERGY STAR Information

The ENERGY STAR program was created by the US Department of Energy and the Environmental Protection Agency to help consumers quickly and easily identify appliances and other products, such as houses, that save energy. The ENERGY STAR label is broadly recognized by the American public.

All ENERGY STAR homes must be certified as complying with ENERGY STAR standards by a HERS analysis.

A home built to the ENERGY STAR standards uses 30% less energy than if it were built to the 1993 Model Energy Code (MEC-1993). Maine RES is based on the International Energy

[23]There is no support analysis listed with this EREN information, only the analysis results.

Conservation Code for 2000 (IECC-2000), a newer and more stringent version of MEC-1993. As a result, houses that are built to comply with Maine RES will often meet the ENERGY STAR standard. A HERS value of 86 or higher qualifies a home for ENERGY STAR standard. Of the twenty-four houses modeled for this study, 13 scored 86 or higher.[24] Those that did not qualify all had a high percentage of glazing.

In Appendix F, Supporting ENERGY STAR Information: Example of Savings from an ENERGY STAR Home, clearly shows that an ENERGY STAR home costs less to own, even though it costs more to build. The savings in energy costs more than offset the additional building costs. Of the houses modeled for this report, thirteen of the twenty-four improved to the Maine RES qualify as ENERGY STAR homes.[25] This means that this brief analysis in Appendix F is appropriate for most of the modeled homes and for the majority of homes built to the Maine RES level of energy efficiency.

[24]The HERS value of each of the improved models used for this study is noted in Table 3, column 4.
[25]Refer to Table 3, column 4 for the HERS values for each of the improved model houses.

Appendices

Appendix A. Summary of Maine's Energy Efficiency Building Performance Standards, Residential Sections Only

Maine's Energy Efficiency Building Performance Standards Act became law in 1979 (10 MRSA, Chapter 214, § 1411 - § 1420) and was updated and amended in 1983, 1985, 1987, 1989, 1991, and 1993. A summary of the requirements is provided below as a point of reference.

Major features of the Energy Efficiency Building Performance Standards include:

Residential buildings[26]

Prescriptive Approach

This is the easiest compliance method for builders and designers. If their design adheres to the following requirements, their building complies. This is a simple, easy to understand compliance method requiring no calculations. However, it is an inflexible method allowing no tradeoffs.

The prescribed requirements are:

- Ceilings must be insulated to at least R-38.
- Walls must be insulated to at least R-19.
- Floors over unheated spaced must be insulated to at least R-19.
- Slab-on-grade floors must be insulated to at least R-10.
- Foundation walls must be insulated from the top of the foundation to the frost line to at least R-10.
- All windows must have a minimum insulating value of R-2.

Performance Approach

Unlike the prescriptive approach, this method allows flexibility and tradeoffs. If a builder wishes to construct a house with a flat roof that will be insulated only to R-19 rather than the prescriptive value of R-38, the builder may compensate for the additional heat loss through the roof by reducing the heat loss through other surfaces. The disadvantage of this method is its complexity compared with the prescriptive approach.

The performance approach requirement is:

"A house may comply with the Standards by the performance compliance alternative if the energy usage of the proposed building design is not greater than that of a standard building design. In other words, if it is properly demonstrated that the proposed building will not use any more energy than it would if [it] were a standard building (built to the prescriptive standards), it is deemed to be in compliance."[27]

Compliance with and Enforcement of the Residential Energy Code

"Except as stated below, any single-family and multifamily residential structure designed for year-round or winter seasonal use must comply with the prescriptive or performance standards."[28] The exemptions are:

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[26]For specific details please see the *Manual of Accepted Practices*, 1997.
[27]*Maine Guide to Energy Efficient Residential Construction: A Manual of Accepted Practices*, 2nd ed., 1992, page 83. Please refer to this document for more details.
[28]*Maine Guide to Energy Efficient Residential Construction: A Manual of Accepted Practices*, 2nd ed., 1992, page 5.

- Single-family residences built by an individual for his or her personal residence.
- Single-family residences built by a contractor hired by an individual to build that individual's personal residence.
- Log homes built by anyone.
- Summer camps (heating the structure is not intended) built by anyone.

Waivers to mandatory compliance are available for a number of building classifications, including renovations of historic buildings.

Enforcement of the mandatory sections of the residential code is limited; a small number of code enforcement officers occasionally inspect residential buildings for compliance. Periodically the DECD receives questions about the code from builders and code enforcement officers.[29]

[29]Telephone conversation with Chris Carroll, DECD, February 9, 2000.

Appendix B: Definition of Incremental Measures and Costs for Modeled Houses

The incremental measures for this economic study where selected to make the modeled houses more efficient by increasing their energy efficiency from that of the Maine Energy Efficiency Building Performance Standards — the base case — to the proposed Maine Residential Energy Standard (Maine RES).

Each of the seven incremental measures is listed below, followed by the used estimated cost of each measure for new construction. The selection of these measures was dictated by Table 6 below, making sure that each of the twenty-four house models was brought up to the Maine RES level. Table 7 lists the particular bundle of the seven measures assigned to each of the twenty-four models.

1. Air leakage reduced from 0.5 ACH to ACH 0.4 for 1000 ft^2 house — $100.00.
2. Air leakage reduced from 0.5 ACH to ACH 0.4 for 2000 ft^2 house — $250.00.
3. Foundation wall insulation on exterior surface, foundation top to footing, from R-10 to R-15 — $0.20 per ft^2.
4. Windows from U-0.5 to U-0.35 — $2.50 per ft^2.
5. Ceiling from R-38 to R-49 — $0.20 per ft^2.
6. Central space heating boiler from 80% to 84% AFUE — $250.00 (distribution system excluded).
7. Central space heating boiler from 80% to 88% AFUE — $450.00 (distribution system excluded).

Table 6
Proposed Prescriptive Building Envelope and Heating System Provisions of Maine RES

	Percentage Window Area to Gross Exterior Wall Area		
Building Element	**8%**	**12%**	**15%**
Glazing U-factor			
All Zones	0.35	0.35	0.35
Ceiling R-value			
Zone 1	38	38	49
Zone 2	38	49	49
Zone 3	49	49	49
Exterior Wall R-value			
All Zones	19	19	19
Floor over basement/crawl R-value			
All Zones	19	19	19
Basement wall R-value			
Zone 1	10	10	15
Zones 2 and 3	10	15	15
Central Boiler AFUE			
Zone 1	82%	84%	84%
Zones 2 and 3	84%	84%	87.5%
Central Furnace AFUE			
Zone 1	80%	82%	82%
Zone 2	81%	83%	85%
Zone 3	81%	84%	87%

- These prescriptive values were determined with MEC*check*-2000. Percentages are of gross exterior above-grade wall area.
- For glazing areas greater than 15%, use component performance approach for compliance.
- The R-values for basement walls assume the floor above the basement is not insulated.
- The R-values for floors over basement/crawl spaces assume basement and crawl space walls below are not insulated.
- Zone 1 includes counties of Androscoggin, Cumberland, Hancock, Kennebec, Knox, Lincoln, Penobscot, Sagadahoc, Waldo, Washington, and York.
- Zone 2 includes counties of Franklin and Oxford.
- Zone 3 includes counties of Aroostook, Piscataquis, and Sumerset. County groupings based on *International Energy Conservation Code* 2000, page 31.

Installed costs for the selected measures were derived from *Contractor's Pricing Guide: Residential Detailed Costs - 2000*, by R.S. Means Company, Inc., by querying local building material suppliers, and from price estimates from Wes Riley and Bruce Berube of York County Community Action in Stanford, Maine.

The cost of fuel oil used for this study was $1.20 per gallon. This cost is higher than the 1999-2000 winter, but significantly lower than the apparent average for the 2000-2001 winter. Although more homes in Maine will be heated with natural gas in the future, oil was used here because it is the predominant space heating fuel in Maine today.

The cost of electricity was set at $0.13 per kWh. This cost had little impact on the results of this study because the energy-saving measures did not alter the use of electricity in any significant way. All space heating was supplied by fuel oil, water heating energy was not altered, and cooling costs were not examined.

Table 7
Energy-Saving Measures Used for Various Modeled Houses in Economic Analysis

	Incremental Measure Number (if checked, measure used for analysis of house type)						
Modeled House Location and Glazing Percentage*	1	2	3	4	5	6	7
Portland, one story							
8% glazing	√			√		√	
12% glazing	√			√		√	
15% glazing	√		√	√	√	√	
18% glazing	√		√	√	√	√	
20% glazing	√		√	√	√	√	
25% glazing	√		√	√	√	√	
Portland, two story							
8% glazing		√		√		√	
12% glazing		√		√		√	
15% glazing		√	√	√	√	√	
18% glazing		√	√	√	√	√	
20% glazing		√	√	√	√	√	
25% glazing		√	√	√	√	√	
Caribou, one story							
8% glazing	√			√	√	√	
12% glazing	√		√	√	√	√	
15% glazing	√		√	√	√		√
18% glazing	√		√	√	√		√
20% glazing	√		√	√	√		√
25% glazing	√		√	√	√		√
Caribou, two story							
8% glazing		√		√	√	√	
12% glazing		√	√	√	√	√	
15% glazing		√	√	√	√		√
18% glazing		√	√	√	√		√
20% glazing		√	√	√	√		√
25% glazing		√	√	√	√		√

* Percentage glazing of gross exterior wall area. Exterior wall is defined as "An above-grade wall enclosing conditioned space. Includes between floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof, and basement walls with and average below grade-wall area which is less than 50 percent of the total opaque and non-opaque area of that enclosing side." Source: IECC-2000, page 6.

Appendix C. Tabulated Results of Economic Analysis

Table 8 Tabulated Results of Economic Analysis, Fuel Oil cost of $1.20 per gallon

Portland, One Story, 960 Ft^2

	SIR interactive (SPB interactive) / SIR non-interactive (SPB non-interactive)						Based on Interactive Measures			Fuel Cost at which Cash Flow Equals Zero
% Glazing	1. Air Leakage	3. Found. R-10 to R-15	4. Win to 0.35	5. R-38 to R-49	6. Boiler to 84%	7. Boiler to 88%	$ Improve	PV Savings	Cash Flow	
8	3.3 (3.4) /	n/a	0.8 (14) /	n/a	0.5 (20) / 0.6 (17.8)	n/a	$605	$666	$7	$1.07
12	3.3 (3.4) /	n/a	0.8 (14) /	n/a	0.6(19) / 0.6 (16.6)	n/a	$735	$779	$5	$1.12
15	3.3 (3.4) /	1.4 (7.8) /	0.8 (14) /	0.8 (14.7) /	0.5 (20) / 0.7 (15.9)	n/a	$1,227	$1,289	$7	$1.14
18	3.3 (3.4) /	1.4 (7.8) /	0.8 (14) /	0.8 (14.7) /	0.6 (19.3) / 0.7 (15.2)	n/a	$1,322	$1,371	$5	$1.15
20	3.3 (3.4) /	1.4 (7.8) /	0.8 (14) /	0.8 (14.7) /	0.6 (18.8) / 0.7 (14.7)	n/a	$1,387	$1,428	$5	$1.14
25	3.3 (3.4) /	1.4 (7.8) /	0.8 (14) /	0.8 (14.8) /	0.6 (17.6) / 8 (14.8)	n/a	$1,547	$1,566	$3	$1.18

Portland, Two Story, 1920 Ft^2

	SIR interactive (SPB interactive) / SIR non-interactive (SPB non-interactive)						Based on Interactive Measures			
% Glazing	2. Air Leakage	3. Found. R-10 to R-15	4. Win to 0.35	5. R-38 to R-49	6. Boiler to 84%	7. Boiler to 88%	$ Improve	PV Savings	Cash Flow	
8	2.4 (4.7) /	n/a	0.8 (14.4) /	n/a	0.9 (12.34) / 0.9 (11.4)	n/a	$960	$1,175	$20	$0.97
12	2.4 (4.7) /	n/a	0.8 (14.4) /	n/a	0.9 (11.4) / 1.0 (10.6)	n/a	$1,190	$1,375	$18	$1.03
15	2.4 (4.7) /	1.4 (7.8) /	0.8 (14.4) /	0.7 (15.1) /	1.0 (11.1) / 1.1 (10)	n/a	$1,762	$1,957	$18	$1.07
18	2.4 (4.7) /	1.4 (7.8) /	0.8 (14.4) /	0.7 (15.1) /	1.0 (10.5) /1.1 (9.5)	n/a	$1,934	$2,107	$16	$1.10
20	2.4 (4.7) /	1.4 (7.8) /	0.8 (14.4) /	0.7 (15.1) /	1.1 (10.1) / 1.2 (9.2)	n/a	$2,049	$2,207	$15	$1.11
25	2.4 (4.7) /	1.4 (7.8) /	0.8 (14.4) /	0.7 (15.2) /	1.2 (9.3) / 1.3 (8.5)	n/a	$2,337	$2,458	$12	$1.14

Caribou, One Story, 960 Ft^2

	SIR interactive (SPB interactive) / SIR non-interactive (SPB non-interactive)						Based on Interactive Measures			
% Glazing	1. Air Leakage	3. Found. R-10 to R-15	4. Win to 0.35	5. R-38 to R-49	6. Boiler to 84%	7. Boiler to 88%	$ Improve	PV Savings	Cash Flow	
8	4.2 (2.7) /	n/a	1.1 (10.7) /	1.0 (11.4) /	0.7 (16) / 0.8 (13.8)	n/a	$797	$1,039	$23	$0.91
12	4.2 (2.7) /	1.9 (6.1) /	1.1 (10.7) /	1.0 (11.4) /	0.7 (16.1) / 0.8 (12.9)	n/a	$1,132	$1,553	$39	$0.87
15	4.2 (2.7) /	1.9 (6.1) /	1.1 (10.7) /	1.0 (11.4) /	n/a	0.6 (17) / 0.8 (13)	$1,427	$1,812	$37	$0.93
18	4.2 (2.7) /	1.9 (6.1) /	1.1 (10.7) /	1.0 (11.4) /	n/a	0.8 (14.1) / 1.0 (11.2)	$1,522	$1,926	$38	$0.93
20	4.2 (2.7) /	1.9 (6.1) /	1.1 (10.7) /	1.0 (11.4) /	n/a	0.8 (13.8) / 1.0 (11.5)	$1,587	$2,004	$39	$0.94
25	4.2 (2.7) /	1.9 (6.1) /	1.1 (10.7) /	1.0 (11.4) /	n/a	0.8 (12.9) / I.0 (11.5)	$1,747	$2,196	$42	$0.94

Caribou, Two Story, 1920 Ft^2

	SIR interactive (SPB interactive) / SIR non-interactive (SPB non-interactive)						Based on Interactive Measures			
% Glazing	2. Air Leakage	3. Found. R-10 to R-15	4. Win to 0.35	5. R-38 to R-49	6. Boiler to 84%	7. Boiler to 88%	$ Improve	PV Savings	Cash Flow	
8	3.0 (3.7) /	n/a	1.0 (11.4) /	1.0 (11.7) /	1.1 (9.6) / 1.2 (8.9)	n/a	$1,152	$1,688	$49	$0.81
12	3.0 (3.7) /	1.9 (6) /	1.0 (11.4) /	1.0 (11.7) /	1.2 (9.2) / 1.3 (8.2)	n/a	$1,587	$2,317	$66	$0.82
15	3.0 (3.7) /	1.9 (6) /	1.0 (11.4) /	0.9 (12) /	n/a	1.3 (8.2) / 1.4 (7.4)	$1,962	$2,763	$74	$0.84
18	3.0 (3.7) /	1.9 (6) /	1.0 (11.4) /	0.9 (12) /	n/a	1.4 (7.7) / 1.5 (7)	$2,134	$2,971	$77	$0.86
20	3.0 (3.7) /	1.9 (6) /	1.0 (11.4) /	0.9 (12) /	n/a	1.4 (7.5) / 1.6 (6.8)	$2,249	$3,109	$79	$0.86
25	3.0 (3.7) /	1.9 (6) /	1.0 (11.4) /	0.9 (12) /	n/a	1.6 (6.8) / 1.7 (6.3)	$2,537	$3,456	$84	$0.87

SIR = Savings-to-Investment ratio
SPB = Simple Payback in years
Fuel Oil Price $1.20 per gallon

Appendix D: REM/*Rate* Improvement Analysis Definitions and Calculations

Financial Information

Installed Cost of Improvements

Installed cost of energy-saving measures.

Cost Weighted Life of Measures (Years)

Average life of all accepted measures as weighted by their costs.

Sum(MeasLife * MeasCost) / TotalMeasCost

Mortgage Term (Years)

For the twenty-four modeled homes, the mortgage term was 30 years.

Discount/Mortgage Rate (%)

For the twenty-four modeled homes, the mortgage rate was 8.0 percent.

Present Value Factor:

= [(1+ i)^n - 1] / [i * (1 + i)^n]

Where:

i = Discount/Mortgage Rate

n = Cost Weighted Life of Measures

Expected Annual Energy Cost Savings

Total energy cost savings of all of the measures. This includes interactive affects.

= TotalCostAsIsBuilding - TotalCostImprovedBuiliding

Expected Annual Maintenance Costs

The sum of all of the measures $/year specifiers.

Expected Annual Cost Savings

= [Expected Annual Energy Cost Savings] - [Expected Annual Maintenance Costs]

Increased Annual Mortgage Costs

= TotalCosts * [i * (1 + i)^m] / [(1 + i)^m - 1]

Where:

i = Discount/Mortgage Rate

m = Mortgage Term

Present Value of Energy Savings

= TotalAnnualEnergySavings * [(1 + i)^n - 1] / [i * (1 + i)^n]

Where:

i = Discount/Mortgage Rate

n = Cost Weighted Life of Measures

Recommended Energy Measures Information

Life

The reasonable mean service life of the energy-saving measure.

Cost

Installed costs for the selected measures were derived from *Contractor's Pricing Guide: Residential Detailed Costs - 2000*, by R.S. Means Company, Inc., by querying local building material suppliers, and from price estimates from Wes Riley and Bruce Berube of York County Community Action in Stanford, Maine.

Annual Savings (Yr Savings)

The savings generated by the measure.

= TotalCostOfBldgWithoutMeasure - TotalCostOfBldgWithMeasure

SIR (Savings to Investment Ratio)

= {[Yr Savings] * [(1+ i)^n - 1] / [i *(1 + i)^n] } / [Cost]

Where:

i = Discount/Mortgage Rate

n = Life of Measure

PV (Present Value)

= {[Yr Savings] * [(1+ i)^n - 1] / [i *(1 + i)^n] } - [Cost]

Where:

i = Discount/Mortgage Rate

n = Life of Measure

SPB (Simple Payback)

= [Cost] / [Yr Savings]

Appendix E. Supporting EREN Information[30]

FIGURE 1: COST EFFECTIVE INSULATION R-VALUES[a]

If you live in a climate that is...	and your heating system[b] is a...	then insulate to these levels in the... ceiling	wood frame walls[c]	floor	basement/ crawl space walls[d]
Warm with cooling and minimal heating requirements (i.e., FL & HI;coastal CA; southeast TX;southern LA, AR, MS, AL & GA).	gas/oil or heat pump	R-22 to R-38	R-11 to R-15	R-11 to R-13	R-11 to R-19
	electric resistance	R-38 to R-49	R-11 to R-22	R-13 to R-25	R-11 to R-19
Mixed with moderate heating and cooling requirements (i.e.,VA, WV, KY, MO, NE, OK, OR, WA & ID; southern IN, KS, NM & AZ;northern LA, AR, MS, AL & GA; inland CA & western NV).	gas/oil or heat pump	R-38	R-11 to R-22	R-13 to R-25	R-11 to R-19
	electric resistance	R-49	R-11 to R-28	R-25	R-11 to R-19
Cold (i.e., PA, NY, New England, northern Midwest, Great Lakes area, mountainous areas (e.g., CO, WY, UT, etc.)).	gas/oil	R-38 to R-49	R-11 to R-22	R-25	R-11 to R-19
	heat pump or electric	R-49	R-11 to R-28	R-25	R-11 to R-19

a. Adapted from the U.S. Department of Energy 1997 Insulation Fact Sheet.

b. Insulation is also effective at reducing cooling bills. These levels assume that you have electric air-conditioning.

c. R-Values are for insulation only (not whole wall) and may be achieved through a combination of cavity (batt, loose fill or spray) and rigid board materials.

d. Do not insulate crawl space walls if crawl space is wet or ventilated with outdoor air.

[30] Source: The ENERGY STAR Homes marketing Toolkit CD-ROM, version 1.1.

Appendix F. Supporting ENERGY STAR Information: Example of Savings from an ENERGY STAR Home[31]

Example of Savings from an ENERGY STAR Home

If the list price of an ENERGY STAR Home is $3,000 more than a comparable less-efficient home, and the mortgage interest rate is seven percent, the increase in the mortgage payment would be $19.96. As long as the energy savings exceed $19.96, the homeowner will pay less per month to own the ENERGY STAR Home.

	Standard Home	ENERGY STAR Home
Cost	$170,000	$173,000
Monthly Mortgage	$1,435	$1,454.96
Monthly Utility Bill	$135	$95
Monthly Costs	$1,570	$1549.96
Monthly Savings		$20.04

See the table below to figure the increase in your monthly mortgage payments when purchasing an ENERGY STAR Home, then compare this increase to the energy savings you expect from your energy-efficient home to determine your monthly savings.

Monthly Incremental ENERGY STAR Home Cost with Conventional Mortgage Financing

Interest Rate	Total Incremental Cost for ENERGY STAR Home Upgrades									
	$500	$1,000	$1,500	$2,000	$2,500	$3,000	$3,500	$4,000	$4,500	$5,000
6.50%	$3.16	$6.32	$9.48	$12.64	$15.80	$18.96	$22.12	$25.28	$28.44	$31.60
6.75%	$3.24	$6.49	$9.73	$12.97	$16.21	$19.46	$22.70	$25.94	$29.19	$32.43
7.00%	$3.33	$6.65	$9.98	$13.31	$16.63	$19.96	$23.29	$26.61	$29.94	$33.27
7.25%	$3.41	$6.82	$10.23	$13.64	$17.05	$20.47	$23.88	$27.29	$30.70	$34.11
7.50%	$3.50	$6.99	$10.49	$13.98	$17.48	$20.98	$24.47	$27.97	$31.46	$34.96
7.75%	$3.58	$7.16	$10.75	$14.33	$17.91	$21.49	$25.07	$28.66	$32.24	$35.82
8.00%	$3.67	$7.34	$11.01	$14.68	$18.34	$22.01	$25.68	$29.35	$33.02	$36.69
8.25%	$3.76	$7.51	$11.27	$15.03	$18.78	$22.54	$26.29	$30.05	$33.81	$37.56
8.50%	$3.84	$7.69	$11.53	$15.38	$19.22	$23.07	$26.91	$30.76	$34.60	$38.45
8.75%	$3.93	$7.87	$11.80	$15.73	$19.67	$23.60	$27.53	$31.47	$35.40	$39.34
9.00%	$4.02	$8.05	$12.07	$16.09	$20.12	$24.14	$28.16	$32.18	$36.21	$40.23
9.25%	$4.11	$8.23	$12.34	$16.45	$20.57	$24.68	$28.79	$32.91	$37.02	$41.13
9.50%	$4.20	$8.41	$12.61	$16.82	$21.02	$25.23	$29.43	$33.63	$37.84	$42.04
9.75%	$4.30	$8.59	$12.89	$17.18	$21.48	$25.77	$30.07	$34.37	$38.66	$42.96
10.00%	$4.39	$8.78	$13.16	$17.55	$21.94	$26.33	$30.72	$35.10	$39.49	$43.88

Instructions for the table:

1) Find the amount across the top of the table closest to the additional mortgage required for the ENERGY STAR Home.
2) Drop down the table until you find the interest rate closest to current mortgage interest rates.
3) The number in the cell is the amount added to the monthly mortgage payment. As long as the monthly energy savings exceed the amount in this cell, the homebuyer will experience a positive cash flow by purchasing the ENERGY STAR Home.

[31] Source: The ENERGY STAR Homes marketing Toolkit CD-ROM, version 1.1.