



Nexus Market Research, Inc.

**Residential Building  
Energy Standards  
Compliance Analysis  
FINAL REPORT**

**Submitted to:  
Vermont Department of Public Service**

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## Executive Summary

The objective of this report is to assess the compliance of newly-constructed single-family homes with the Vermont Residential Building Energy Standards (RBES). This analysis is part of a broader study of the single-family residential new construction market in Vermont.<sup>1</sup>

Seventy-six of the 106 inspected homes passed RBES via the Home Energy Rating (HERS) compliance path or the VTcheck software, yielding a compliance rate of 72%. Weighting the results by the proportion of new homes located in the targeted regions and the remainder of Vermont<sup>1</sup> yields a weighted compliance rate of 70%. These results show improvement over the 2002 new construction study,<sup>2</sup> in which 58% of 158 homes met RBES via the VTcheck methodology or HERS compliance path. Because compliance is not enforced and there is no penalty for non-compliance in Vermont, achieving 100% compliance is likely not feasible.

In general, the features that appear to contribute to homes failing VTcheck are an excessive percent glazing or high U-value windows and inadequate foundation wall insulation. The 30 homes that did not pass VTcheck had an average glazing percentage of 13.6% and an average window U-value of 0.37, compared to 12.2% and 0.33 for the 46 homes that passed VTcheck. In addition, of the 43 homes that passed VTcheck and had foundations, 95% had foundation wall insulation, compared to 62% of the 24 homes that did not pass VTcheck.

ENERGY STAR homes must comply with all requirements of the HERS compliance path in order to be certified, therefore we do not assess these homes' compliance with the RBES prescriptive tracks or VTcheck software. As stated in the RBES manual, the HERS method credits homes for air tightness, solar gain, efficient hot water systems, and efficient lighting and appliances, which are not accounted for in the other compliance paths. Thus, all thirty ENERGY STAR-qualified homes passed RBES via the HERS compliance path.

**Compliance Paths.** Homes can pass RBES using several different compliance paths – the Fast-Track method, the Tradeoff method, and the VTcheck software. Each of the 76 non-ENERGY STAR homes were tested using each of these methods. Twelve percent of the 76 non-ENERGY STAR homes passed RBES using the Fast-Track method, 20% passed RBES using the Tradeoff method (including all nine homes that previously passed the Fast-Track method), and 61% passed RBES using VTcheck (including all 15 homes that previously passed the Tradeoff method). All of the homes that passed the Fast-Track method passed either the first package or sixth package, and all of the homes that passed the Tradeoff method passed the first package. This indicates that certain prescriptive packages are used much more often than other packages.

**RBES Certificate.** The auditors found an RBES certificate during the on-site inspection in only 12 of the 106 homes (11%). This indicates that few homeowners are provided with or retain the

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<sup>1</sup> Overall Report, Vermont Residential New Construction Study. February 23, 2009. Nexus Market Research, RLW Analytics, Dorothy Conant. Submitted to Vermont Department of Public Service

<sup>2</sup> Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency. Prepared by Westhill Energy and Computing for the Vermont Department of Public Service. January 3, 2003.

RBES certificate. On the positive side, those 12 homes were all found to be correctly labeled as RBES compliant as all 12 met the RBES requirements either by being ENERGY STAR qualified or passing VTcheck.

All together, the results of this study suggest that while compliance with RBES has improved relative to prior years, the current program approach may still have some deficiencies, both in terms of homeowner/builder understanding of the certification process, as well as in terms of the fact that roughly one-fourth of new homes do not meet all RBES requirements.

## Introduction

The objective of this report is to assess the compliance of newly-constructed single-family homes with the Vermont Residential Building Energy Standards (RBES). This analysis is part of a broader study of the single-family residential new construction market in Vermont.<sup>3</sup> The data used to analyze compliance were collected during on-site audits of 106 newly-constructed homes.<sup>4</sup>

The Department of Public Service requested state level information on newly constructed single-family homes located in Vermont plus detailed information for four separate geographic regions. The four geographic regions are three geographically targeted (GT) regions (Northern Chittenden, St. Albans, and Newport/Derby) plus the city of Burlington. Of the 106 homes inspected, 10 were completed in the Northern Chittenden/Burlington region, 15 in the St. Albans region, and 14 in the Newport/Derby region. The remaining 67 homes were located across the state of Vermont.<sup>3</sup>

Volunteers for the on-site audits were recruited from the telephone surveys of 296 owners of newly constructed homes in Vermont. Newly-constructed homes are defined as homes less than two years old, according to the homeowner, at the time of the telephone survey (December 2007 – February 2008).<sup>5</sup> The sample for the telephone surveys was developed from the Grandlist database available from the Vermont Department of Property Valuation. Because the volunteers from the telephone survey did not provide enough homes in some of the targeted regions, lists of new residential electric service requests provided by Efficiency Vermont and Burlington Electric Department were used to supplement the survey respondents; these lists yielded eight additional on-site audits.

Potential bias is a concern in any sample based on voluntary participation. However, there is no clear indication of bias in the sample of audited homes.<sup>3</sup> Some homes are very energy efficient and some are not. Some have simple designs and some have complex designs. There are a mix of custom- and spec-built homes; site built and modular homes; large and small homes; ENERGY STAR and non-ENERGY STAR homes; homes that were purchased completed and homes where the owner played a major role in specifying materials and mechanical equipment. Nine percent of the owners of audited homes said they built their own home and 11% of new single family homes completed in 2007 in the Northeast are owner-built homes, according to the U.S. Census Bureau.<sup>6</sup>

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<sup>3</sup> Overall Report, Vermont Residential New Construction Study. February 23, 2009. Nexus Market Research, RLW Analytics, Dorothy Conant. Submitted to Vermont Department of Public Service

<sup>4</sup> Vermont Residential New Construction Baseline Study Analysis of On-site Audits. October 28, 2008. Nexus Market Research, RLW Analytics, Dorothy Conant. Submitted to the Vermont Department of Public Service.

<sup>5</sup> The 106 inspected homes were completed in 2005 or later; 11% were completed in 2005, 63% in 2006, 23% in 2007 and 3% in 2008.

<sup>6</sup> <http://www.census.gov/const/www/charindex.html#singlecomplete> (Northeast includes the following states: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York and Pennsylvania.)

Similarly, the results regarding ENERGY STAR penetration are encouraging. The onsite audits were conducted at 106 newly-constructed homes in Vermont, of which 30 (28%) were verified as being ENERGY STAR-qualified homes. State level data reported by the EPA indicates that 27% of single-family homes built in Vermont in 2007 were ENERGY STAR qualified.<sup>7</sup> This suggests that the sample of inspected homes is not biased with respect to the penetration of ENERGY STAR homes. These ENERGY STAR homes were certified using the HERS compliance method, therefore we do not assess these homes' compliance with the RBES prescriptive tracks or VTcheck software. As stated in the RBES manual, the HERS method credits homes for air tightness, solar gain, efficient hot water systems, and efficient lighting and appliances, which are not accounted for in the other compliance paths.

The remainder of this report is organized as follows. First we present the results of the compliance analysis using the Fast-Track method, a prescriptive approach requiring few calculations. Next, we assess compliance using the Tradeoff method, a prescriptive approach that allows for some design flexibility. Third, we assess compliance using VTcheck, part of the REScheck software package. Lastly, we present information on compliance with RBES basic requirements.

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<sup>7</sup> <http://www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex>

(Northeast includes the following states: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York and Pennsylvania.)

# 1 Fast-Track Analysis

Table 1-1 displays the minimum requirements for the six prescriptive packages under the Fast-Track compliance method.

**Table 1-1: Package Requirements for Fast-Track Compliance Method<sup>8</sup>**

Component	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6
Ceiling Flats & Exposed Floors R-value	R-38	R-38	R-49	R-49	R-38	R-38
Ceiling Slopes R-value	R-30	R-30	R-30	R-30	R-30	R-30
Above-Grade Walls R-value	R-19	R-19	R-19	R-21	R-19	R-19
Floors over Unconditioned Spaces R-value	R-30	R-30	R-30	R-30	R-30	R-30
Basement Walls (full height) R-value	R-10	R-10	R-10	R-10	R-15	R-10
Slab Edge R-value	R-10	R-10	R-10	R-10	R-15	R-10
Unvented Crawlspace Walls R-value	R-10	R-10	R-10	R-10	R-15	R-10
Doors, excluding sliding and patio doors, U-value	0.40	0.40	0.40	0.40	0.40	0.40
Basement Window U-value	0.60	0.60	0.60	0.60	0.60	0.60
Window, skylights, sliding and patio doors, U-value	0.40	0.34	0.50	0.40	0.34	0.34
Heating System AFUE	0.83	0.80	0.87	0.81	0.85	0.84
Glazing Percentage	0.12	0.12	0.12	0.12	0.18	0.15

Table 1-2 displays the results of the Fast-Track compliance analysis for the 76 non-ENERGY STAR homes. Overall, 12% of homes passed at least one of the six prescriptive packages. These homes primarily passed Package One (7%) or Package Six (7%); homes could pass more than one package, thus the sum of the percentages from each package exceeds the 12% listed in the Overall column. Homes failed depending upon which requirement was most stringent in each package, most often because of excessive glazing percentage (46% on average), inadequate ceiling insulation (46%), basement wall insulation (36%), or window U-value (37%). Table cells are shaded if the factor was a reason for failure for at least 50% of homes for a particular package, or at least 33% of homes in the overall/average column. Because not all homes have each feature, particularly exposed floors, sloped ceilings, floors over garage, slabs, and crawlspaces, not all requirements apply to every home. For example, because most homes have flat ceilings, the ceiling flats R-value requirement applies to 88% of homes, while the exposed floor R-value requirement applies to only the 5% of homes with exposed floors. This provides some context with which to interpret the failure rates presented in

<sup>8</sup> Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Table 4-1, Page 24. Note that heating system AFUE requirements were increased, effective June 2007 (<http://www.ncsg.org/Portals/0/GA/VTHB253.pdf>). However, some of the inspected homes were built prior to that date, thus we use the criteria listed in the RBES handbook.

Table 1-2.

**Table 1-2: Results of Fast-Track Compliance Method Analysis  
for Non-ENERGY STAR Homes**

	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6	Overall / Average
Percent Passing	7%	1%	0%	0%	0%	7%	12%
<b>Reasons for Failure*</b>							
Ceiling Flats R-value	28%	28%	82%	82%	28%	28%	46%
Exposed Floors R-value	4%	4%	4%	4%	4%	4%	4%
Ceiling Slopes R-value	13%	13%	13%	13%	13%	13%	13%
Above-Grade Walls R-value	7%	7%	7%	84%	7%	7%	20%
Floors over Garage R-value	13%	13%	13%	13%	13%	13%	13%
Floors over Unconditioned Basement R-value	21%	21%	21%	21%	21%	21%	21%
Basement Walls (full height) R-value	29%	29%	29%	29%	71%	29%	36%
Slab Edge R-value	18%	18%	18%	18%	30%	18%	20%
Unvented Crawlspace Walls R-value	0%	0%	0%	0%	0%	0%	0%
Doors, excluding sliding and patio doors, U-value	18%	18%	18%	18%	18%	18%	18%
Basement Window U-value**	n/a						
Window, skylights, sliding and patio doors, U-value	8%	68%	0%	8%	68%	68%	37%
Heating System AFUE	8%	0%	67%	5%	21%	11%	19%
Glazing Percentage	58%	58%	58%	58%	17%	25%	46%
Number of Homes	76	76	76	76	76	76	76

\*Homes may fail more than one requirement, so percentages may sum to greater than 100%.

\*\*Note that we did not assess basement window U-value due to lack of data. However, this requirement should be relatively easy to achieve because a standard double pane wood/vinyl window has a default U-value of 0.56 or 0.57, according to RBES handbook Table B-1. Thus, we expect that few homes would fail due to this requirement.

Twenty of the 76 non-ENERGY STAR homes failed Package One because of a single requirement; 12 of these homes failed due to excessive glazing percentage. Thirteen homes failed Package Six because of a single requirement; nine of these homes failed due to high window U-values. Eleven homes failed Package Two because of a single requirement; five of these homes failed due to excessive glazing percentage and five due to high window U-values.

## 2 Tradeoff Analysis

Table 2-1 and Table 2-2 display the minimum requirements for the six prescriptive packages under the Tradeoff compliance method.

**Table 2-1: Package Requirements for Tradeoff Compliance Method<sup>9</sup>**

Component	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6
Ceiling Flats & Exposed Floors R-value	R-38	R-38	R-49	R-49	R-38	R-38
Ceiling Slopes R-value	R-30	R-30	R-30	R-30	R-30	R-30
Above-Grade Walls R-value	R-19	R-21	R-19	R-21	R-19	R-21
Floors over Unconditioned Spaces R-value	R-30	R-30	R-30	R-30	R-30	R-30
Basement Walls (full height) R-value	R-10	R-10	R-10	R-10	R-15	R-15
Slab Edge R-value	R-10	R-10	R-10	R-10	R-15	R-15
Unvented Crawlspace Walls R-value	R-10	R-10	R-10	R-10	R-15	R-15
Doors, excluding sliding and patio doors, U-value	0.40	0.40	0.40	0.40	0.40	0.40
Basement Window U-value	0.60	0.60	0.60	0.60	0.60	0.60
Window, skylights, sliding and patio doors, U-value	See Table 2-2					
Heating System AFUE	See Table 2-2					
Glazing Percentage	See Table 2-2					

<sup>9</sup> Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Table 5-1, Page 30.

**Table 2-2: Heating System AFUE Requirements by Glazing Percentage and Window U-value for the Tradeoff Compliance Method<sup>10</sup>**

Glazing %	U-value											
	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52
<b>Package 1</b>												
18%	85	86	88	90	91							
17%	84	85	87	89	90	91	92					
16%	82	84	86	87	88	89	90	92				
15%	81	83	84	85	87	88	89	90	91	92		
14%	80	81	83	84	85	86	87	88	89	90	92	
13%	80	80	81	82	84	85	86	87	88	89	90	92
12%	80	80	80	81	82	83	84	85	86	87	88	89
<b>Package 2 &amp; 3</b>												
18%	84	85	87	89	90	92						
17%	83	84	86	88	89	90	91					
16%	82	83	85	86	87	88	89	91				
15%	80	82	83	84	86	87	88	89	90	91		
14%	80	80	82	83	84	85	86	87	88	89	91	
13%	80	80	80	81	83	84	85	86	87	88	89	91
12%	80	80	80	80	81	82	83	84	85	86	87	88
<b>Package 4</b>												
18%	83	84	86	88	89	91	92					
17%	82	83	85	87	88	89	90	92				
16%	80	82	84	85	86	87	89	90	92			
15%	80	81	82	83	85	86	88	88	89	90	92	
14%	80	80	81	82	83	84	85	86	87	89	90	92
13%	80	80	80	80	82	83	84	85	86	87	89	90
12%	80	80	80	80	80	81	82	83	84	86	86	87
<b>Package 5</b>												
18%	82	83	85	87	89	90	91					
17%	81	82	84	86	87	88	89	91				
16%	80	81	83	84	85	86	87	89	91			
15%	80	80	81	82	84	85	86	87	88	89	91	
14%	80	80	80	81	82	84	84	85	86	87	89	91
13%	80	80	80	80	81	82	83	84	85	86	87	89
12%	80	80	80	80	80	80	81	82	83	84	85	86
<b>Package 6</b>												
18%	81	82	84	86	87	89	91	92				
17%	80	81	83	85	86	87	88	90	92			
16%	80	80	82	83	84	85	86	88	90	92		
15%	80	80	80	81	83	84	85	86	87	88	90	92
14%	80	80	80	80	81	82	83	84	85	86	88	90
13%	80	80	80	80	80	81	82	83	84	85	86	88
12%	80	80	80	80	80	80	80	81	82	83	84	85

<sup>10</sup> Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Table 5-1a, Page 31. Note that heating system AFUE requirements were increased, effective June 2007 (<http://www.ncsg.org/Portals/0/GA/VTHB253.pdf>). However, some of the inspected homes were built prior to that date, thus we use the criteria listed in the RBES handbook.

Table 2-3 displays the results of the Tradeoff compliance analysis. Overall, 20% of Non-ENERGY STAR homes passed at least one of the six packages, including all of the homes that previously passed the Fast-Track method. All of the homes that complied did so under Package One (20%), however homes could pass more than one package. As with the Fast-Track results, homes failed depending upon which requirement was most stringent in each package, most often due to inadequate ceiling insulation (46% on average), above-grade wall insulation (45%), or basement wall insulation (43%). Table cells are shaded if the value is at least 50% for a particular package or at least 33% in the overall/average column. Again, note that not every home has each feature, particularly exposed floors, sloped ceilings, floors over garage, slabs, and crawlspaces.

**Table 2-3: Results of Tradeoff Compliance Method Analysis  
for Non-ENERGY STAR Homes**

	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6	Overall / Average
Percent Passing	20%	4%	1%	0%	3%	0%	20%
<b>Reasons for Failure*</b>							
Ceiling Flats R-value	28%	28%	82%	82%	28%	28%	46%
Exposed Floors R-value	4%	4%	4%	4%	4%	4%	4%
Ceiling Slopes R-value	13%	13%	13%	13%	13%	13%	13%
Above-Grade Walls R-value	7%	84%	7%	84%	7%	84%	45%
Floors over Garage R-value	13%	13%	13%	13%	13%	13%	13%
Floors over Unconditioned Basement R-value	21%	21%	21%	21%	21%	21%	21%
Basement Walls (full height) R-value	29%	29%	29%	29%	71%	71%	43%
Slab Edge R-value	18%	18%	18%	18%	30%	30%	22%
Unvented Crawlspace Walls R-value	0%	0%	0%	0%	0%	0%	0%
Doors, excluding sliding and patio doors, U-value	18%	18%	18%	18%	18%	18%	18%
Basement Window U-value**	n/a						
Glazing > 18%	17%	17%	17%	17%	17%	17%	17%
Heating System AFUE given Glazing Percentage and Window U-value	14%	13%	13%	12%	9%	7%	11%
Number of Homes	76	76	76	76	76	76	76

\*Homes may fail more than one requirement, so percentages may sum to greater than 100%.

\*\*Note that we did not assess basement window U-value due to lack of data. However, this requirement should be relatively easy to achieve because a standard double pane wood/vinyl window has a default U-value of 0.56 or 0.57, according to RBES handbook Table B-1. Thus, we expect that few homes would fail due to this requirement.

Twenty of the 76 non-ENERGY STAR homes failed Package Three because of a single requirement; 17 of these homes failed due to inadequate flat ceiling insulation. Eighteen homes failed Package Five because of a single requirement; 13 of these homes failed due to inadequate basement wall insulation. Sixteen homes failed Package One because of a single requirement; three homes each failed due to inadequate insulation in a floor over a garage, high door U-values, and inadequate heating system AFUE given the glazing percentage and window U-value. Fifteen homes failed Package Two because of a single requirement; 12 of these homes failed due to inadequate wall insulation.

### 3 VTcheck Analysis

All 76 non-ENERGY STAR homes were run through the REScheck software<sup>11</sup>, using the pre-installed Vermont building codes. In order to run the homes through VTcheck, it was necessary to make several assumptions because some data were not collected during the on-site audits. These assumptions are listed below:

- **Wood-framed Walls.** All wood-framed walls are assumed to have 16” stud spacing (a conservative assumption).
- **Foundation Walls.** Below grade foundation walls (where 50% or more of the wall is below grade) are assumed to have a full height of 7.5 feet with five feet below grade and wall insulation (if present) extends the entire height of the wall. Above grade foundation walls (where 50% or more of the wall is above grade) are assumed to have a full height of 7.5 feet with two feet below grade and wall insulation (if present) extends the entire height of the wall.
- **Slabs.** Slabs are assumed to be square, so the perimeter of the slab is calculated as the square root of the area times four. Mixed-grade slabs occur most often for a walkout basement on the downward slope of a hill, and thus these homes are assumed to have only one side on-grade. Slab insulation is assumed to extend inward four feet from the edge. If the R-value of the slab insulation is unknown, the median R-value value for homes with known slab insulation R-value is assumed.
- **Building Shell.** If both foundation walls and the floor over basement are insulated, we used the situation that produced the higher efficiency design.
- **Doors.** Doors are all assumed to be 21 square feet (seven feet high by three feet wide). Default U-values were estimated from RBES Handbook Table B-2.

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<sup>11</sup> REScheck version 4.1.0, which was the version available in 2007, towards the end the time when most of the homes were built.

**Results.** Forty-six of the 76 Non-ENERGY STAR homes (61%) passed RBES using the VTcheck software, including all 15 homes that previously passed using the Tradeoff method.

VTcheck assesses RBES compliance by multiplying the U-value of individual building shell components by their area to compute an overall UA value and then comparing it to the maximum allowable UA value for a home with the same dimensions. For example, a home with a UA value greater than the maximum allowable UA value for a similarly-sized home would be “below code;” a home with a UA value less than the maximum allowable UA value for a similarly-sized home would be “above code.”

Using VTcheck, the average and median percent above/below code for all 76 non-ENERGY STAR homes is -9% and 6%, respectively. The non-ENERGY STAR homes that do not meet code tend to be further below code than the homes that meet code exceed code; the average percent above code for the 46 homes that meet code is 13% while the average percent below code for the 30 homes that do not meet code is 42%. However, many homes tend to cluster around the code level, as 42% of homes are within  $\pm 10\%$  of code. The non-ENERGY STAR home with the highest efficiency exceeds code by 41% while the non-ENERGY STAR home with the lowest efficiency is 183% below code.<sup>12</sup>

In general, the features that appear to contribute to a high UA value in homes that fail VTcheck are an excessive percent glazing or high U-value windows and inadequate foundation wall insulation. The 30 homes that did not pass VTcheck had an average glazing percentage of 13.6% and an average window U-value of 0.37, compared to 12.2% and 0.33 for the 46 homes that passed VTcheck. In addition, of the 43 homes that passed VTcheck and had foundations, 95% had foundation wall insulation, compared to 62% of the 24 homes that did not pass VTcheck.

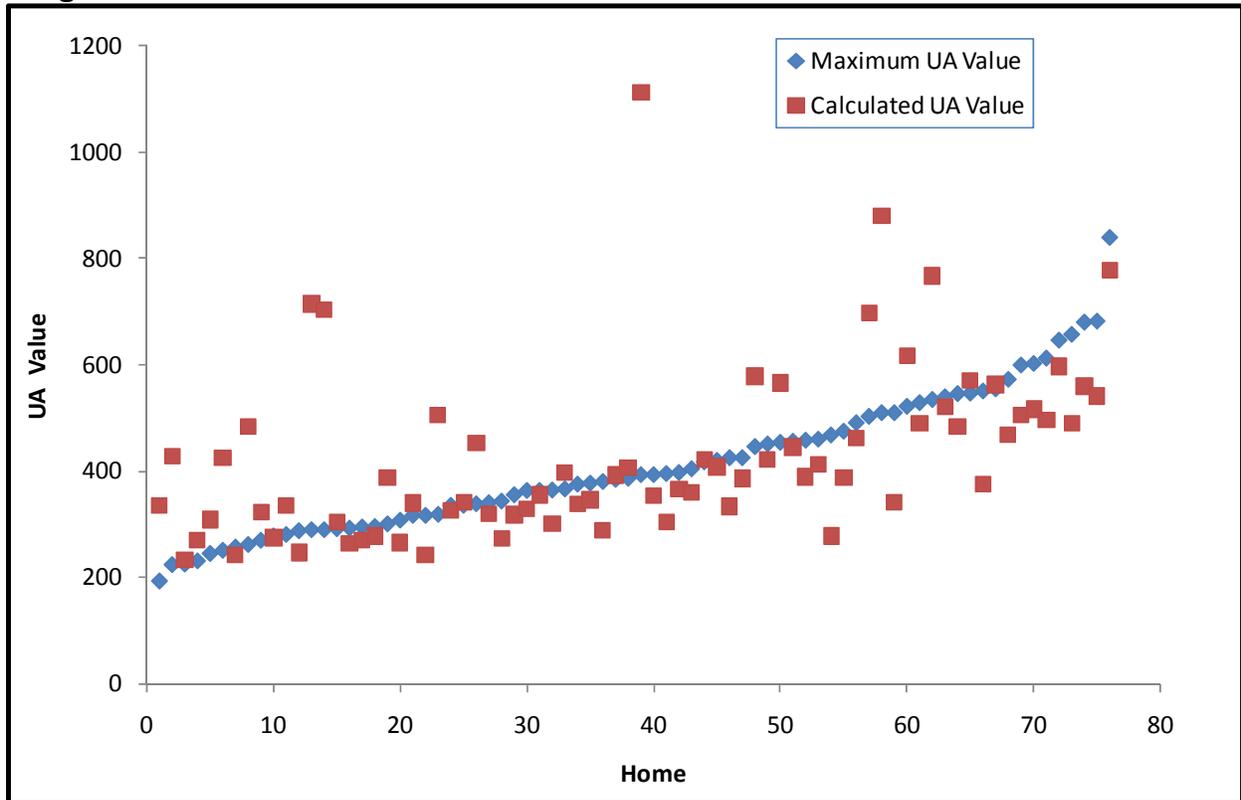
Seventy-four percent of the 38 Non-ENERGY STAR homes that are larger than the median home size (as measured by total heated area) passed VTcheck, compared to 47% of the 38 homes smaller than the median size. A similar result was found in the 2002 study, where 65% of large homes passed compared to 51% of smaller homes. We do not compare compliance rates between custom-built, spec-built, and owner-built homes due to the small number of spec-built homes (4) and owner-built homes (6).

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<sup>12</sup> The maximum allowable UA value for this home was 393, and the calculated UA value was 1,113.

Below is a chart of the maximum allowable UA value and calculated UA value for the 76 Non-ENERGY STAR homes that were run through VTcheck (Figure 3-1). The homes are sorted ascending, on the horizontal axis, using their maximum UA value; the vertical axis displays the maximum UA value and calculated UA value. The calculated UA values above the maximum UA value line signify homes that are below code and the calculated UA values at or below the maximum UA value line signify homes that meet code.

**Figure 3-1: Maximum and Calculated UA Values for non-ENERGY STAR Homes**



## 4 Basic Requirements

RBES includes additional requirements beyond insulation levels, window U-values, glazing, and heating system efficiency. However, because the on-site audits focused on collecting information on thermal shell characteristics, auditors did not always have time to gather data regarding some of the basic requirements. In addition, the auditors were unable to collect information for some characteristics due to the inaccessibility of certain spaces and equipment. Because there is not sufficient information to reasonably assess compliance of all homes with all the basic requirements, the results presented in this section simply provide information on the level of compliance of homes with the individual requirements.

Auditors defined conditioned space as intentionally heated space, which is the same definition used in the 2002 baseline study, but different from the definition in the Vermont Residential Building Energy Code Handbook. The handbook definition of conditioned space is:

A space is “**conditioned**” if heating and/or cooling is deliberately supplied to it or is indirectly supplied through uninsulated surfaces of water or heating equipment, through uninsulated ducts, or through adjacent uninsulated building surfaces. Basements and crawl spaces without ceiling insulation are considered conditioned space.

Our definition of unconditioned space is broader than the RBES definition, therefore more spaces are considered unconditioned than RBES would define as unconditioned. Thus, our analysis overstates the number of homes where RBES requirements for unconditioned spaces, such as duct sealing/insulation and pipe insulation, apply. However, these homes may or may not comply with the requirements, thus we are unable to assess how this situation may affect the compliance rate.

Table 4-1 displays a summary of the analysis of RBES basic requirements.<sup>13</sup> The table lists the individual requirements and the compliance results if it was feasible to collect the necessary data during the on-site audit.

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<sup>13</sup> Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Appendix C, page 70.

**Table 4-1: Summary of Basic Requirements Compliance  
for Non-ENERGY STAR Homes**

Basic Requirements Summary	Compliance Notes
<p><b>Air Leakage:</b> Seal all joints, access holes and other such openings in the building envelope, as well as connections between building assemblies. In insulated ceilings, recessed lights must be either (1) Insulation Contact (IC) rated and designed as airtight or (2) installed inside an airtight assembly, with a 0.5-inch clearance from combustible materials and a 3-inch clearance from insulation.</p>	<p>This would require an extensive inspection (possibly before drywall installation) of the entire building shell and removal of recessed light fixtures. However, the average air infiltration for the 58 homes that received blower door tests was 0.29 ACHnat; 67% of these homes met the Vermont ENERGY STAR homes program requirement of 0.35 ACHnat.</p>
<p><b>Vapor Retarder:</b> For non-vented framed ceilings, wall and floors, install a vapor retarder (i.e., 6 mil. plastic or vapor-barrier paint) on the warm-in-winter side of the insulation.</p>	<p>Of the 67 homes with data on flat ceilings, 28% were found to have vapor barriers.</p>
<p><b>Duct Insulation:</b> In unconditioned basements, crawlspaces and attics, insulate supply and return ducts for heating and cooling systems to R-5. Insulate ducts outside the building to R-8.</p>	<p>Of the 12 homes with data on ducts in unconditioned spaces, six met the insulation requirement.</p>
<p><b>Duct Sealing:</b> In unconditioned spaces, seal ducts using mastic with fibrous backing tape. (Pressure sensitive tape maybe used only for duct-board systems, in accordance with NAIMA standards.) Duct tape is not permitted.</p>	<p>Of the 12 homes with data on ducts in unconditioned spaces, eight met the sealing requirement.</p>
<p><b>HVAC Systems: Efficiency &amp; Balancing:</b> HVAC heating and cooling systems must comply with minimum federal efficiency standards 80% AFUE for residential boilers; 78% AFUE for furnaces). All HVAC systems must provide a means of balancing, such as air dampers, adjustable registers or balancing valves.</p>	<ul style="list-style-type: none"> <li>• All homes had a furnace or boiler of at least 80% AFUE. Note that AFUE requirements were increased, effective June 2007 (<a href="http://www.ncsg.org/Portals/0/GA/VTHB253.pdf">http://www.ncsg.org/Portals/0/GA/VTHB253.pdf</a>). Because some of the inspected homes were built prior to that date, we use the criteria listed in the RBES handbook. However, 66 of 74 homes met the new AFUE requirement.</li> <li>• Dampers located inside registers are not visible.</li> </ul>
<p><b>Temperature Controls:</b> Each separate HVAC zone must have its own thermostat.</p>	<p>Each home with more than one heating system had at least one thermostat per system. Homes with hydronic systems have one thermostat per hydronic zone.</p>
<p><b>HVAC Piping Insulation:</b> In unconditioned crawlspaces, basements or attics, insulate HVAC piping to R-4 (i.e., with a 1” thickness of foam or compressed fiberglass.) Insulate HVAC piping outside the building to R-6.</p>	<p>None of the 30 homes with boilers located in unconditioned space had pipe insulation.</p>
<p><b>Swimming Pools:</b> All swimming pools must have a time clock to control the pump. Heated swimming pools must have both a heater on/off switch in an accessible location and a pool cover.</p>	<p>Only one home had a pool, which was not heated and the pump was not accessible</p>

**Table 4-1: Summary of Basic Requirements Compliance  
for Non-ENERGY STAR Homes (continued)**

Basic Requirements Summary	Compliance Notes																					
<p><b>Domestic Hot Water:</b> Domestic hot water tanks must meet minimum federal efficiency standards that apply to all equipment manufactured after 1992. Except when the warranty would be voided by installing a tank wrap, tanks must have a minimum total R-value of 14. Stand-alone domestic water heaters must incorporate at least one of the following: (a) internal heat traps; (b) external heat traps; or (c) pipe insulation for the first accessible 6 feet on non-circulating hot and cold water pipes. For circulating systems, refer to Section C4c.</p>	<ul style="list-style-type: none"> <li>• None of the 67 homes with a stand-alone tank had a tank wrap.</li> <li>• Three homes were recorded with pipe insulation, though no information was available on the length of insulation.</li> <li>• Internal heat traps are installed by the manufacturer and thus are not visible.</li> </ul>																					
<p><b>Fireplaces:</b> Fireplaces must incorporate tight-fitting doors and either a tight-fitting chimney damper or a chimney cap damper (preferably both).</p>	<p>All fireplaces were observed to have doors. Fourteen of 22 homes with fireplaces drew outside combustion air.</p>																					
<p><b>Exhaust Fans:</b> Exhaust dampers are required for kitchen, bath and dryer fans.</p>	<p>Dampers are generally installed inside the fan and thus are not visible.</p>																					
<p><b>Ventilation &amp; Combustion Air:</b> All homes must have an automatically controlled ventilation system. Chimney-vented combustion devices must have combustion air.</p> <ul style="list-style-type: none"> <li>• Whole house ventilation fans must be rated for (1) continuous duty, (2) <math>\leq 50</math> watts power, (3) <math>\leq 2</math> sones. Energy Star labeled fans meet these criteria</li> <li>• Whole house ventilation systems have an automatic control or are capable of being set remotely for continuous operation</li> </ul> <table border="1" data-bbox="329 1077 784 1329"> <thead> <tr> <th># Bedrooms</th> <th>Min # fans</th> <th>Min CFM</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>50</td> </tr> <tr> <td>2</td> <td>1</td> <td>75</td> </tr> <tr> <td>3</td> <td>1</td> <td>100</td> </tr> <tr> <td>4</td> <td>2</td> <td>125</td> </tr> <tr> <td>5</td> <td>2</td> <td>150</td> </tr> <tr> <td>&gt;3,000 s.f.</td> <td>2</td> <td>0.05 x s.f</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>• Sealing of fan housing and inlet grilles to ceiling or wall</li> <li>• Fan duct runs &gt;8 ft. are smooth wall ducts</li> <li>• Fan ducts in unconditioned space sealed and insulated per HVAC duct requirements</li> <li>• Clothes dryers vented to outside</li> <li>• Combustion air and dilution air drawn from outside for chimney-vented oil and gas appliances</li> </ul>	# Bedrooms	Min # fans	Min CFM	1	1	50	2	1	75	3	1	100	4	2	125	5	2	150	>3,000 s.f.	2	0.05 x s.f	<p>Unable to consistently collect model information for installed fans.</p> <p>Nine homes had an ERV installed and another eight homes had at least one fan timer control.</p> <p>92% of 65 homes with fan data had an ERV installed or met the requirement for the minimum number of fans and total CFM given the number of bedrooms.</p> <p>Unable to collect because it would require removal of fan housings. Fan ducts are generally inaccessible. Fan ducts are generally inaccessible.</p> <p>In 97% of 66 homes with clothes dryers, the dryers were vented to the outside. One of nine homes with chimney-vented heating units or water heaters drew outside combustion air.</p>
# Bedrooms	Min # fans	Min CFM																				
1	1	50																				
2	1	75																				
3	1	100																				
4	2	125																				
5	2	150																				
>3,000 s.f.	2	0.05 x s.f																				
<ul style="list-style-type: none"> <li>• Solid-fuel appliances have tight-fitting metal, glass, or ceramic doors and ducted combustion air from outdoors</li> </ul>	<p>All wood stoves were observed to have doors. Five of the 20 homes with wood stoves drew outside combustion air.</p>																					

## 5 Summary

Seventy-six of the 106 inspected homes passed RBES, yielding an overall compliance rate of 72%. This figure includes 46 of the 76 non-ENERGY STAR homes that passed RBES using the VTcheck software plus the thirty ENERGY STAR homes that passed HERS testing<sup>14</sup> in order to garner ENERGY STAR certification.

Because of potential inaccuracies in the process of measuring and recording on-site data and estimating default values for unknown data, it is possible that some homes may have erroneously passed or failed VTcheck in our analysis. Thirteen non-ENERGY STAR homes are within  $\pm 5\%$  of code, according to VTcheck; these homes may pass or fail code if one or two characteristics are altered. There are six non-ENERGY STAR homes that are between 0% and 5% above code according to VTcheck; assuming these six homes fail VTcheck results in 66% of all 106 homes passing VTcheck or being ENERGY STAR qualified, down from 72%. There are seven non-ENERGY STAR homes that are between 0% and 5% below code; assuming these seven homes pass VTcheck results in 78% of all 106 homes passing VTcheck or being ENERGY STAR qualified, up from 72%.

The 72% compliance rate shows improvement over the 2002 new construction study,<sup>15</sup> in which 58% of 158 homes met RBES via the VTcheck methodology or the HERS compliance path through Vermont ENERGY STAR Home program certification. Both the 2002 study and the current study utilized a similar nested approach for the on-site inspections; a sample of newly constructed homes was developed from recent Grandlist databases, then homeowners completed a telephone survey which was used to recruit homes for the on-site inspections. Both samples included ENERGY STAR Homes; 19 of the 158 homes in the 2002 study were ENERGY STAR qualified, compared to 30 of the 106 homes in the current study. One difference between the two studies is that the 2002 study sample was a random sample of the entire state, whereas the current study targeted several regions as well as the entire state (see Section 0). Weighting the current results by the proportion of new homes located in the targeted regions and the remainder of Vermont<sup>16</sup> yields a weighted compliance rate of 70%. Because compliance is not enforced

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<sup>14</sup> The RBES handbook (Edition 2.0, effective January 1, 2005) requires a HERS score of 82 or above for single-family homes. However, the HERS score was replaced by the HERS index in 2006, which rates homes from zero (for a net-zero energy home) to 100 (for the 2006 IECC model home). Old HERS scores are converted to the new HERS index using the following equation:  $\text{HERS index} = 5 * (100 - \text{HERS score})$ . Thus, the RBES minimum HERS score of 82 yields a RBES maximum HERS index of 90. HERS index ratings were available for 28 of the 30 ENERGY STAR homes. The average HERS index was 60, the median was 63, the minimum was 41 and the maximum was 71. For more information, visit the following websites:

[http://www.energystar.gov/index.cfm?c=bldrs\\_lenders\\_raters.nh\\_HERS](http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS)  
and <http://www.resnet.us/standards/mortgage/amendments/2005/tech-09.htm>

<sup>15</sup> Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency. Prepared by Westhill Energy and Computing for the Vermont Department of Public Service. January 3, 2003.

<sup>16</sup> Overall Report, Vermont Residential New Construction Study. February 23, 2009. Nexus Market Research, RLW Analytics, Dorothy Conant. Submitted to Vermont Department of Public Service

and there is no penalty for non-compliance in Vermont, achieving 100% compliance is likely not feasible.

**Compliance Paths.** Homes can pass RBES using several different compliance paths – the Fast-Track method, the Tradeoff method, and the VTcheck software. Each of the 76 non-ENERGY STAR homes were tested using each of these methods. Twelve percent of the 76 non-ENERGY STAR homes passed RBES using the Fast-Track method, 20% passed RBES using the Tradeoff method (including all nine homes that previously passed the Fast-Track method), and 61% passed RBES using VTcheck (including all 15 homes that previously passed the Tradeoff method). All of the homes that passed the Fast-Track method passed either the first package or sixth package, and all of the homes that passed the Tradeoff method passed the first package. This indicates that certain prescriptive packages are used much more often than other packages.

**RBES Certificate.** The auditors found an RBES certificate during the on-site inspection in only 12 of the 106 homes (11%); either the certificate was posted somewhere in the home or the auditor asked the homeowner for the certificate. Although these 12 homes were at least found to be correctly labeled as RBES compliant, this is a very low incidence of obtaining, retaining and/or displaying RBES compliance certificates.

In addition, of the 43 owners who reported during the homeowner telephone survey that their home met RBES requirements, only 72% of their homes passed VTcheck or were ENERGY STAR qualified.

All together, the results of this study suggest that while compliance with RBES has improved relative to prior years, the current program approach may still have some deficiencies, both in terms of homeowner/builder understanding of the certification process, as well as in terms of the fact that roughly one-fourth of new homes do not meet all RBES requirements.