



**Home Innovation**  
RESEARCH LABS™

# **Cost and Stringency Comparison of 2012 National Green Building Standard™ ICC 700-2012, LEED-H 2008, and LEED v4 for Homes Design and Construction**

*Prepared for*

National Association of Home Builders

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## Disclaimer

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The US Green Building Council honored Steve Saunders for leadership to advance LEED in the residential space. "Saunders' employee-owned companies — TexEnergy Solutions, Tempo Mechanical Services, and US-Eco Logic, Inc. — have registered 18,710 LEED homes/multifamily properties, just over 20 percent of all LEED for Homes registrations worldwide."<sup>1</sup>

Home Innovation Research Labs, the leading certification entity for the National Green Building Standard, recognized Steve Saunders as a 2013 NGBS Green Partner of Excellence for his work in program advocacy.<sup>2</sup>

Home Innovation Research Labs staff is grateful for the opportunity to collaborate with this team of professionals with firsthand experience in green building and rating systems in the Dallas, TX market.

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<sup>1</sup> McIver, Terry in *Contracting Business*, 2012. "Texas Energy Solutions' Steve Saunders Honored by USGBC for Leadership in Green Homes"

<sup>2</sup> [www.homeinnovation.com/NGBSGreenPartnersOfExcellence2013](http://www.homeinnovation.com/NGBSGreenPartnersOfExcellence2013)

## Executive Summary

The *ICC 700 National Green Building Standard® (NGBS®)* and *Leadership in Energy and Environmental Design® (LEED®)* are the leading national residential green building protocols in the United States. Both target essentially identical areas of sustainability aimed at preserving natural resources, conserving energy and water, and promoting better indoor air quality and a healthier environment.

This report presents findings from an analysis and comparison of NGBS and LEED and estimates the additional costs for a typical, code-compliant single family house to be certified at each program's various levels. Additionally, the report compares the minimum improvement in energy efficiency that can be expected at each certification level.

NGBS and LEED are similarly structured, with a combination of "mandatory" provisions (NGBS) or "prerequisites" (LEED) and point-valued environmentally preferable techniques and technologies. In each, satisfaction of all applicable mandatory measures plus accrual of sufficient points demonstrates a home's compliance at a chosen level.

In addition to the various compliance levels, three additional variables were considered in the evaluation to maximize its applicability:

1. Three climate zones are considered. Zones 3(A), 5(B) and 6(A) were selected due to the variance of their climates and the presence of major metropolitan areas in each with reasonably strong single family housing markets.
2. Both *LEED-H 2008* and *LEED v4 for Home Design & Construction [2013] (LEED v4 HD&C)* are analyzed and compared since the LEED residential program is presently within a transition period between these two rating systems.
3. Two energy code scenarios are evaluated:
  - The *2009 International Energy Conservation Code* or *IECC* applies (which the majority of states use in some form)
  - The 2012 IECC applies (which is newer and not widely adopted)

In total, the report considers seventy-two distinct variable scenarios. In each, costs associated with meeting the assumed IECC version are not considered as "additional" costs toward certification. However, costs associated with meeting above-code, mandatory provisions prescribed by NGBS and/or LEED are factored in the comparison.

After mandatory/prerequisite costs, the evaluation employs a *Least Incremental Cost* approach to rank point-valued options and make selections that achieve cost-optimized compliance in each scenario. The same selections are then assumed for the energy performance comparison.

### Key Findings

- **The scoring structure of the NGBS forces more balance across sustainability areas than is required in either LEED system.** The NGBS structure establishes more proportional consistency and equality across all sustainability areas and the proportion of discretionary points that come from areas of the user's choosing is much lower in the NGBS (16 – 22% of total points) than in either LEED system (64 – 82% of total points in LEED-H 2008 and 65 – 83% in LEED v4 HD&C).

- **Certification costs vary significantly and cost advantages shift between programs as different compliance levels, climate zone and code scenarios are assumed.** Certification costs encompass any administrative fees combined with any incrementally higher construction costs required to move a project from code compliance to green program compliance. In all three systems, the cost of meeting mandatory/prerequisite items comprises a significant proportion of above-code construction costs at the lower NGBS and LEED compliance levels. The mandatory costs associated with NGBS compliance are significantly lower than the prerequisite costs for either LEED system, so NGBS certification is therefore less costly than LEED at the *Bronze/Certified* and *Silver* levels. This advantage decreases or reverses at the *Gold* and *Emerald/Platinum* levels. For example, in all three climate zones in both code scenarios, the cost of *Emerald* Level NGBS certification is calculated to be higher than LEED-H 2008 *Platinum* certification.
- **Similarly, expected energy efficiency levels are highly sensitive to the variable set, occasionally resulting in significant performance advantages shifts between the programs as different scenarios are considered.** The difference between expected performances is often fairly small (within 5%) but is occasionally considerable (15% or more.) In general, LEED v4 HD&C tends to result in higher energy performance than NGBS, which tends to result in higher performance than LEED-H 2008. However, there are instances where any advantage is negligible and several where advantages reverse.

Other notable energy-related findings:

- All three programs in all climate zones would generate at least a fifteen percent improvement over IECC 2009 at all levels with one exception: LEED-H 2008 would generate under twelve percent improvement in Climate Zone 3(A) at the Certified, Silver or Gold level.
- When IECC 2012 applies, LEED-v4 HD&C in climate zone 3(A) sets the highest mark for efficiency, achieving 44% over IECC 2009 savings at the *Platinum* level.
- The highest efficiency achieved with NGBS was 43% over IECC 2009 savings at the *Emerald* Level in Zone 6(A) (also when IECC 2012 applies.)
- The largest performance disparity between programs at a single level/code scenario was in Climate Zone 3(A) at the *Gold* level when IECC 2009 applies; nearly 31% improvement was achieved with NGBS compared to just under 12% improvement achieved with LEED-H 2008.

The NGBS and the LEED systems share similar structure and purpose. Both are capable of enhancing energy efficiency and other areas of a home's environmental performance. However, neither maintains a clear cost and environmental performance advantage across all possible scenarios.

This evaluation is intended to compare and contrast the implementation of these different programs in a small variety of places. It is important to note, the *Least Incremental Cost* approach to making selections is somewhat limiting; therefore, buyer preference will likely influence selections with some corollary impact on both compliance cost and energy performance.

## Background

Home Innovation Research Labs (Home Innovation) was tasked to compare construction costs, stringency, and minimum energy conservation building code requirements between three residential green building rating standard or systems:

- National Green Building Standard®/ICC 700-2012 (NGBS);
- LEED-H 2008; and
- LEED v4 for Homes Design and Construction [2013] (LEED v4 HD&C)

A reference home for each of three climate zones was specified to the minimum building code requirements of the IECC/IRC 2009 and IECC/IRC 2012.<sup>3</sup> The building codes provide the basis from which the incremental costs of green building standard compliance are measured.

## Introduction

### House Design Selected for the Study

The house selected to represent a “typical” detached single-family home meets the specifications established by a number of 2011 surveys conducted by both the National Association of Home Builders (NAHB) and Home Innovation. The design selected is a two-story, 2,320 square foot structure with four bedrooms, two and one half baths, and an attached two-car garage on a nearly one-half acre lot (21,780 square feet).<sup>4</sup> The home is constructed as a light frame structure with an I-joint floor system and truss component roof on a slab foundation or in-ground poured concrete foundation, dependent upon geographical siting.<sup>5</sup> The building’s footprint measures 40’ by 34’. The base house in Climate Zone 3 was assumed to have been constructed on a slab foundation, whereas those in climate zones 5 & 6 were assumed to have been built on in-ground basement foundations.

The house has a natural gas furnace and electric single zone air conditioner with equipment located in the conditioned, unfinished basement and some return ducting in the attic (approximately 40 percent of the return ducts in the attic under insulation.) The slab house furnace and water heater are located in the attic with supply and return ducting similarly located (approximately 60 percent in attic). In each of the geographical locations selected for this study, the house is served by both natural gas and electric utilities provided at the 2012 national



*Courtesy: Landon Homes*

**Figure 1. Typical Climate Zone 3 Design**



*Courtesy: Richmond American Homes*

**Figure 2. Typical Climate Zone 5 Design**



*Courtesy: New Home Source*

**Figure 3. Typical Climate Zone 6 Design**

<sup>3</sup> International Code Council ([www.iccsafe.org/Pages/default.aspx](http://www.iccsafe.org/Pages/default.aspx))

<sup>4</sup> Taylor, H. for NAHB 2011. *New Construction Cost Breakdown* ([www.nahb.org/fileUpload\\_details.aspx?contentTypeID=3&contentID=169974&subContentID=393214](http://www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=169974&subContentID=393214))

<sup>5</sup> NAHB Research Center, 2011. *Builder Practices Survey*.

average cost of \$1.04/therm<sup>6</sup> and \$.1068/kWh<sup>7</sup>, respectively. The furnace, range, and water heater are fueled with natural gas; all other appliances are electric. Figure 1 through Figure 3 depict typical homes for sale in the metropolitan areas that conform to the design that was modeled for this analysis. Exterior claddings depicted in Figure 1 through Figure 3 vary from those of our “reference” house which is clad with horizontal vinyl siding and has an asphalt composition shingle roof.

Additional features included in the reference house are covered in Appendix D. Several presumed features that allowed the reference design to perform above code minimum (in some climate zones) include:

- .35/.30 (u value/SHGC) windows (typical values found in stock windows at big box suppliers);
- ENERGY STAR dishwasher and refrigerator (can be purchased for costs equal to a non-rated appliance);
- 80 percent AFUE furnace (cost equal to 78 percent unit); and
- Windows accounted for 8 percent of the exterior wall surface area per the architectural design that was used in the analysis (there were no windows on side walls).

The house is constructed on a lot that a builder purchased from a developer as a “finished lot” within a suburban subdivision that does not have a green building certification. The lot follows the national average size for lots of 20,614 square feet, or nearly half an acre.<sup>8</sup>

## Geographical Location of the Design Selected for the Study

The geographical locations of the houses in the study are identified in Table 1. The cities that were selected for the analysis correspond with current data on the top numbers of single-family detached housing permits issued in major metropolitan areas.

Table 1. Climate Zones and Metro Areas Covered in the Study

| Climate Zone | Metro Area               | Heating Degree Days (HDD) <sup>A</sup> | Cooling Degree Hours (CDH) <sup>A</sup> |
|--------------|--------------------------|--|---|
| 3A           | TX, Dallas/Ft. Worth     | 2,420                                  | 36,294                                  |
| 5B           | CO, Denver/Aurora        | 6,023                                  | 5,908                                   |
| 6A           | MN, Minneapolis/St. Paul | 8,010                                  | 6,806                                   |

<sup>A</sup> Values utilized in the simulations produced with REMRate software.

## Builder Demographics

For the purposes of this analysis, the builder’s operation was assumed to be sized to deliver 20 homes per year on scattered lots. At an average house price of \$310,619<sup>9</sup>, this represents an annual gross volume of \$6.2 million. Additional small volume builder demographics were attributed to the builder as required by the analysis and so stated.

Builders are assumed to observe standard business practices including contracts and Statements of Work (SOWs). The SOWs are expected to encompass industry best practices within the base bid price.

<sup>6</sup> [www.eia.gov/dnav/ng/ng\\_pri\\_sum\\_dcu\\_nus\\_a.htm](http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm)

<sup>7</sup> [www.eia.gov/dnav/ng/ng\\_pri\\_sum\\_a\\_EPG0\\_PRS\\_DMcf\\_a.htm](http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm)

<sup>8</sup> Taylor, Heather. 2011 *New Construction Cost Breakdown*.

[www.nahb.org/fileUpload\\_details.aspx?contentTypeID=3&contentID=169974&subContentID=393214](http://www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=169974&subContentID=393214)

<sup>9</sup> Taylor, H. for NAHB 2011. *New Construction Cost Breakdown*.

## Comparison Methodology – Least Incremental Cost

### Estimate the Added Cost for each NGBS Practice

Many of the building envelope details that make a home more airtight, water impervious, energy efficient, and, thus, comfortable and durable, require attention to these details in the design and subcontractor Scopes of Work and implementation, and very little added cost. The first such “no cost” practices selected toward the green rating were those that require the execution of broadly recognized industry and building science best practices, only, such as the *Mandatory* items in the NGBS. Practices which are employed to meet the minimum requirements of the building codes were also considered as “no cost” actions in this analysis.

Once the no-cost practices in the green building programs were identified and selected, each practice that would accrue points toward higher levels of certification was selected based on a least incremental cost approach that added the least expensive practices and features that were appropriate for the climate and design. Costs were developed and interpolated at the national level primarily from four sources. These are a Home Innovation database that was originally compiled in 2008 which has been updated and expanded over the ensuing five years, R.S. Means *Residential Cost Data 2013*<sup>10</sup>, and websites for major national manufacturers and retailers. Estimated cost for renewable energy features were derived from U.S. Department of Energy’s National Renewable Energy Laboratory (NREL’s) website, *National Energy Efficiency Measures Database*.<sup>11</sup> Some costs, i.e., the cost of an ENERGY STAR rated ceiling fan, were developed as a range from low to high due to the multitude of features that affect cost for these items. When a cost range was developed, the NGBS and LEED-H practice cost reflects the low end of the range. Costs may be customized for specific regions using the adjustment factor table in Appendix C or by substitution of current bid prices. Costs are shown in the rating spreadsheets contained in Appendix A and Appendix B.

Because of the temporary nature of subsidies, costs were estimated without the factoring of local and federal tax incentives or utility company rebates. However, some of these are substantial enough to warrant investigation and incorporation in specific situations.<sup>12</sup>

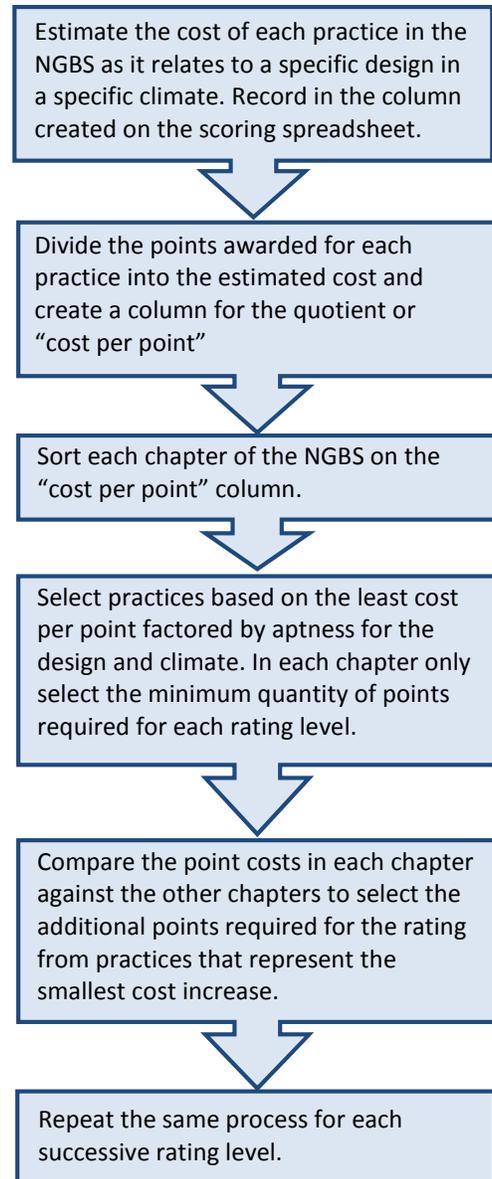


Figure 4. Process for Practice Selection

<sup>10</sup> Published by Reed Construction Data <http://rsmeans.reedconstructiondata.com/default.aspx>

<sup>11</sup> National Renewable Energy Laboratory, National Energy Efficiency Measures Database, [www.nrel.gov/ap/retrofits/](http://www.nrel.gov/ap/retrofits/)

<sup>12</sup> Available subsidies may be researched through [www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=US37F](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F)

After the cost for the practice was estimated, a cost per point was tallied and the practices denoted in each chapter of the NGBS were sorted based on cost per point, by the process shown in Figure 4.

The performance path to energy efficiency in Chapter 7 of the NGBS presented an exception to the methodology. Section 701.1.1 provides the minimum performance path requirements and states that buildings complying with that path “shall exceed the baseline minimum performance required by the ICC IECC by 15 percent and shall include a minimum of two practices from section 704”. Accordingly, any building seeking compliance with the performance path will earn at least 30 points from section 702 by demonstrating this required improvement over IECC. In practice, there are not enough possible points available in the sections allowed by the performance path (704 and 705) to satisfy the Energy Efficiency chapter point requirements at either the Gold or Emerald levels (which require energy point accumulations of 80 and 100 respectively) Therefore, employing the least cost approach, additional points from section 702 beyond those required by the performance path rules are needed to reach these two highest levels. As with all other chapters, cost was used to optimize the selection of the energy conservation measures that were used to meet the requisite points at all levels beyond Bronze within the Performance Path. However, the application of the approach differed slightly since, after achieving the initial 15 percent over 2009 IECC requirement, selections had to be cost optimized based on an additional comparison of the cost-per-points for 702 and 705 selections versus the cost per additional percent of energy performance improvement, each of which earns two points toward certification in Section 702.

REM/Rate v14.2, supported by Architectural Energy Corporation, is the software that was used for the energy simulation models. This software includes output titled “2012 NGBS Energy Performance Path Compliance Report” that compares a house to the reference 2009 IECC.

Other minor exceptions to the outlined process can usually be explained as the incorporation of “standard or best practice” details at the Bronze level. These preferred practices may have a cost attached that doesn’t follow a least cost approach. This exception was made because these practices possibly should have been considered to be no cost practices as they are required by the building inspector or a regional environmental entity, but may not be mandated in the code itself. An example of the practice is the addition of flashing details to the architectural plans, NGBS 602.1.9. Flashing is required in the building code but often absent from the architectural plans, as was the case on the plans used for this analysis. The cost of compiling a standard details page spread over 20 houses is reflected in the Bronze level cost. That cost is also represented as the practice required to meet the LEED-H durability planning prerequisite, LEED 2008 ID 2.1.

To arrive at several ratings, a practice with a higher cost per point was selected because the aggregate cost of the practice was less than an alternate action that produced more points than were required at that level. As an example, in the rating of a Dallas home to the 2012 building code, in Chapter 5 of the NGBS, practices 503.1(3) and 503.1(5) are worth 4 and 3 points each, respectively (see Appendix A1). Cost estimates are \$140 and \$119 which breaks down to a cost per point of \$35 and \$40, respectively. The 3 point \$119 practice was selected for the Silver level and the other at the Gold, because three points were all that were required to complete the Silver rating and the overall cost of the latter practice was less than the alternative.

Overhead and administrative costs required to compile or create documents for certification were estimated as the actual time expenditure divided by the assumed annual production of 20 homes where the benefit of the activity would inure to all (e.g., development of knowledge teams and homeowner manuals). National average salaries were compiled from various internet sites and the salaries were

burdened by 33 percent; a mid-range multiplier used by employers to estimate the additional cost to salary of taxes and benefits.

### **Selection of Universal Practices**

Site-specific practices that were deemed not to be replicable on a large scale or continuing basis were not selected for points toward the ratings. In some cases these practices were attributed an estimated cost based on the parameters described under the *Notes* section of the scoring spreadsheets shown in Appendix A. One such practice example, NGBS 503.2(7), covers the use of on-site or community-generated trimmings and mulch for landscaping. The cost for the practice reflects several hours for trucking and placing the material, however, these programs are not yet commonplace enough to assume that the material would be available nearby at no charge, thus the practice was not selected.

Several practices were deemed impractical for a suburban home in a community setting, such as practices NGBS 801.5(b) and (c), covering the installation of urinals and composting toilets. Despite a cost per point that might merit inclusion, the use of these in traditional homes was considered to be a marketing obstacle.

Likewise, where a reworking of the architectural plans might have indicated a lower cost per point than an alternate practice, these options were not selected. A builder embarking on a comprehensive plan to build a green home would be well-advised to develop the architectural plans with compliance to a green building standard or system in mind.

### **Performance Approach to Energy Efficiency**

The NGBS and both versions of LEED-H allow two paths to certification in the *Energy Efficiency* section – Prescriptive and Performance. The Performance Path approach was used for the practices and point selection in this analysis.

### **Rate to the NGBS Initially Then Apply Practices to LEED Ratings**

This analysis started with the compilation of the NGBS ratings for a reference house built to both the 2009 and the 2012 IECC. The 2012 IECC base NGBS ratings were shared with U.S. Eco Logic<sup>13</sup>, an independent employee-owned company of whole house building science, energy, environmental, comfort and indoor air quality professionals accredited as NGBS Green verifiers and LEED-H raters. U.S. Eco Logic staff developed the LEED-H ratings using costs attributed to similar practices in the NGBS and assisted in the NGBS rating refinement for regional application, costs, and review and comment for this report.

### **Confidence Level & Caveats**

The approach taken in this analysis rests principally on the accuracy of the practice costs that have been developed based on national data. Across the country, costs will vary based on the skill sets of the available labor force, regional practice, and proximity to components' manufacture/extraction locations. This analysis presents one approach to estimation that can be easily modeled by builders in development of their own green building effort. Costs used in this analysis were developed from reputable sources and applied evenly to similar practices within each rating program.

To accommodate the aggregation of costs, overhead costs associated with program compliance were estimated, applied across the annual volume of 20 houses and included in the estimated cost per house. These included costs to develop a *Homeowner's Manual*, owner education, team training and

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<sup>13</sup> [www.usecologic.com/](http://www.usecologic.com/)

certification, and the interest carrying cost of the inventory (used in development of the cost for LEED v4 EQ 3, 48-hour pre-occupancy flush).

Both of the LEED-H systems require extensive pre-planning and attestation paperwork submission to support the integrative processes of design and construction for the specific site. Some of the associated costs may have been understated as some of the pre-construction interaction is the business of building, and was not regarded as an additional time or cost constraint.

The LEED v4 HD&C rating system was passed by ballot vote of USGBC membership on July 3, 2013 and the full program was unveiled in November 2013. Voluntary beta test sites are currently being solicited. Several new practices were incorporated in the new rating system that have yet to be defined and were included in this analysis at no cost in the *Regional Priority* and with a \$1,000 per point allowance in *Innovation*. These points were selected for the *Gold* and *Platinum* levels only, and represent place holders rather than specific practices, which are as yet unknown. The LEED v4 BD&C program will develop with a series of clarifications and performance rulings that may change assumptions that were made in this analysis.

## Rating Systems

### Threshold Points for Rating Systems

The NGBS rating system requires mandatory and minimum practices in five areas of sustainability at each level in the standard’s rating format. In addition to these minimums, successively higher level ratings allow 50-100 of the point accumulation practices to be selected from any of the areas within the NGBS. The rating system and relationship of the points per section to the total is shown in Table 2.

**Table 2. Point Thresholds in the National Green Building Standard, ICC 700-2012**

| National Green Building Standard™                  |           | Bronze     |                                  | Silver     |                                  | Gold       |                                  | Emerald    |                                  |
|--|-----------|------------|----------------------------------|------------|----------------------------------|------------|----------------------------------|------------|----------------------------------|
| Areas of Environmental Impact                      | Mandatory | Points     | % Points Required at Rated Level | Points     | % Points Required at Rated Level | Points     | % Points Required at Rated Level | Points     | % Points Required at Rated Level |
| Lot Design Prep & Development                      | 0         | 50         | 22%                              | 64         | 18%                              | 93         | 18%                              | 121        | 19%                              |
| Resource Efficiency                                | 11        | 43         | 19%                              | 59         | 17%                              | 89         | 17%                              | 119        | 19%                              |
| Energy Efficiency                                  | 11        | 30         | 13%                              | 60         | 17%                              | 80         | 16%                              | 100        | 16%                              |
| Water Efficiency                                   | 0         | 25         | 11%                              | 39         | 11%                              | 67         | 13%                              | 92         | 14%                              |
| Indoor Environmental Quality                       | 10        | 25         | 11%                              | 42         | 12%                              | 69         | 14%                              | 97         | 15%                              |
| Operation, Maintenance, & Building Owner Education | 9         | 8          | 3%                               | 10         | 3%                               | 11         | 2%                               | 12         | 2%                               |
| Additional   |           | 50         | 22%                              | 75         | 21%                              | 100        | 20%                              | 100        | 16%                              |
| <b>Minimum Threshold</b>                           | <b>41</b> | <b>231</b> | <b>100%</b>                      | <b>349</b> | <b>100%</b>                      | <b>509</b> | <b>100%</b>                      | <b>641</b> | <b>100%</b>                      |

LEED-H 2008 similarly requires prerequisite practices and allows points for other preferred practices, as shown in Table 3. LEED-H 2008 allows an increasing proportion of the practices per areas of environmental impact to the user’s discretion at each successive level. Consequently, in a LEED-H 2008 *Platinum* level home, as much as 82 percent of practices can be in environmental impact areas of the user’s choosing. This is in contrast to the NGBS where about 20 percent of the points are at the rater’s option regarding area of environmental impact at any rating level (ranging from 16-22 percent). Consequently NGBS compliance requires a more balanced spread of points across environmental impact areas, as four of the LEED-H 2008 areas require no minimum points other than the prerequisites, including the *Energy & Atmosphere* section which covers energy efficiency.

Table 3. LEED-H 2008 Point Thresholds

| LEED-H 2008 (modified 4/1/13)        |               | Certified |                                  | Silver |                                  | Gold   |                                  | Platinum |                                  |
|--------------------------------------|---------------|-----------|----------------------------------|--------|----------------------------------|--------|----------------------------------|----------|----------------------------------|
| Areas of Environmental Impact        | Prerequisites |           | % Points Required at Rated Level |        | % Points Required at Rated Level |        | % Points Required at Rated Level |          | % Points Required at Rated Level |
|                                      |               | Points    |                                  | Points |                                  | Points |                                  | Points   |                                  |
| Innovation & Design                  | 3             | 0         | 0%                               | 0      | 0%                               | 0      | 0%                               | 0        | 0%                               |
| Location & Linkages & Sustainability | 2             | 5         | 11%                              | 5      | 8%                               | 5      | 7%                               | 5        | 6%                               |
| Materials & Resources                | 3             | 2         | 4%                               | 2      | 3%                               | 2      | 3%                               | 2        | 2%                               |
| Energy & Atmosphere                  | 2             | 0         | 0%                               | 0      | 0%                               | 0      | 0%                               | 0        | 0%                               |
| Water Efficiency                     | 0             | 3         | 7%                               | 3      | 5%                               | 3      | 4%                               | 3        | 3%                               |
| Indoor Environmental Quality         | 7             | 6         | 13%                              | 6      | 10%                              | 6      | 8%                               | 6        | 7%                               |
| Innovation in Operations (A&E)       | 1             | 0         | 0%                               | 0      | 0%                               | 0      | 0%                               | 0        | 0%                               |
| Additional                           |               | 29        | 64%                              | 44     | 73%                              | 59     | 79%                              | 74       | 82%                              |
| Minimum Threshold                    | 18            | 45        | 100%                             | 60     | 100%                             | 75     | 100%                             | 90       | 100%                             |

LEED-H 2008 has two prerequisites in the *Energy & Atmosphere* area—ENERGY STAR compliance and refrigerant management. Initially, this was interpreted to correlate to an alternative compliance method in the *Energy Efficiency* section of the NGBS that recognizes compliance at the Bronze level when a building has an ENERGY STAR certification; however, as of this writing, the USGBC continues to accept ENERGY STAR version 2 in satisfaction of this prerequisite in the LEED-H 2008 system<sup>14</sup> whereas the 2012 NGBS cites the current version, 3, of ENERGY STAR. Compliance to Energy Star version 3 requires stricter insulation installation standards, a tighter building envelope tolerance, four additional quality control and performance testing checklists, sealed combustion equipment in cold climates, and tighter ducts than version 2, among other practical differences. Accordingly, the LEED-H 2008 *Certified* level minimum requirements and the *Bronze* level energy efficiency requirements in the NGBS are not deemed to be equivalent. LEED v4 HD&C maintains the prerequisite for ENERGY STAR compliance, citing version 3. The U.S. Environmental Protection Agency, the ENERGY STAR program’s administrator, maintains that “each ENERGY STAR certified new home is independently verified to be at least 15 percent more energy efficient than a home built to the 2009 International Energy Conservation Code (IECC).”<sup>15</sup> Fifteen percent is also the minimum performance level required to reach the *Bronze* rating level in the NGBS, thus the newer LEED v4 HD&C is deemed to be of equal energy efficiency stringency at the entry level.

The recently approved LEED v4 HD&C will continue the previous version’s prerequisites, with the exception of a requirement for construction waste diversion documentation that was dropped in the new version and the total points that are awarded at each level of merit. The threshold point scheme in the revised LEED v4 HD&C has been amended for a lower point threshold requirement than the original version, as shown in Table 4.

<sup>14</sup> [www.usgbc.org/Docs/Archive/General/Docs3638.pdf](http://www.usgbc.org/Docs/Archive/General/Docs3638.pdf)

<sup>15</sup> [www.energystar.gov/index.cfm?c=bldrs\\_lenders\\_raters.pt\\_bldr](http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.pt_bldr)

Table 4. LEED v4 HD&C Minimum Point Thresholds

| LEED v4 for HD&C  |               | Certified                        |                                  | Silver                           |                                  | Gold                             |                                  | Platinum                         |                                  |
|---|---------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Areas of Environmental Impact                               | Prerequisites | % Points Required at Rated Level |                                  |
|   |               | Points                           | % Points Required at Rated Level | Points                           | % Points Required at Rated Level | Points                           | % Points Required at Rated Level | Points                           | % Points Required at Rated Level |
| Integrative Process   | 0             | 0                                | 0%                               | 0                                | 0%                               | 0                                | 0%                               | 0                                | 0%                               |
| Location & Linkages & Sustainable Sites & Regional Priority | 3             | 4                                | 10%                              | 4                                | 8%                               | 4                                | 7%                               | 4                                | 5%                               |
| Materials & Resources                                       | 2             | 0                                | 0%                               | 0                                | 0%                               | 0                                | 0%                               | 0                                | 0%                               |
| Energy & Atmosphere   | 3             | 4                                | 10%                              | 4                                | 8%                               | 4                                | 7%                               | 4                                | 5%                               |
| Water Efficiency  | 1             | 3                                | 8%                               | 3                                | 6%                               | 3                                | 5%                               | 3                                | 4%                               |
| Indoor Environmental Quality                                | 7             | 3                                | 8%                               | 3                                | 6%                               | 3                                | 5%                               | 3                                | 4%                               |
| Innovation  | 1             | 0                                | 0%                               | 0                                | 0%                               | 0                                | 0%                               | 0                                | 0%                               |
| Additional  |               | 26                               | 65%                              | 36                               | 72%                              | 46                               | 77%                              | 66                               | 83%                              |
| Minimum Threshold   | 17            | 40                               | 100%                             | 50                               | 100%                             | 60                               | 100%                             | 80                               | 100%                             |

As previously stated, following the performance path, an initial rating (*Bronze/Certified*) in the NGBS and LEED v4 HD&C should result in at least a 15 percent energy efficiency (EE) over the 2009 IECC. That 15 percent of energy savings satisfies EE requirements at any rating level in LEED v4 HD&C. Compliance with ENERGY STAR version 2 satisfies the requisite EE to rate at any level in LEED-H 2008, but does not result in a 15 percent energy savings above the 2009 IECC in the Climate Zone 3 house at the *Certified* rating level, as per Table 5. The minimum point requirement by environmental impact area at each level makes the selection of additional *Energy Efficiency* practices compulsory in the NGBS system.

Table 5. Percentage of Energy Efficiency Improvement (over 2009 IECC) at Each System Rating Level

| Program & Rating |             | Dallas TX - Climate Zone 3 |             |           |                       | Denver CO - Climate Zone 5 |             |           |                       | Minneapolis MN - Climate Zone 6 |             |           |                       |
|------------------|-------------|----------------------------|-------------|-----------|-----------------------|----------------------------|-------------|-----------|-----------------------|---------------------------------|-------------|-----------|-----------------------|
|                  |             | Bronze/Certified % EE      | Silver % EE | Gold % EE | Emerald/Platinum % EE | Bronze/Certified % EE      | Silver % EE | Gold % EE | Emerald/Platinum % EE | Bronze/Certified % EE           | Silver % EE | Gold % EE | Emerald/Platinum % EE |
| 2009 IECC        | NGBS        | 15.00%                     | 15.00%      | 30.84%    | 30.84%                | 15.14%                     | 15.14%      | 31.01%    | 32.45%                | 16.27%                          | 22.52%      | 34.15%    | 34.15%                |
|                  | LEED-H 2008 | 11.90%                     | 11.90%      | 11.90%    | 21.81%                | 15.77%                     | 25.53%      | 25.53%    | 35.70%                | 15.51%                          | 15.51%      | 25.03%    | 32.40%                |
|                  | LEED-H v4   | 17.47%                     | 18.74%      | 18.74%    | 38.94%                | 24.43%                     | 24.43%      | 34.45%    | 35.27%                | 28.80%                          | 28.80%      | 28.80%    | 35.83%                |

LEED-H 2008 and LEED v4 HD&C have very similar minimum point thresholds per environmental impact area and no additional minimum point requirements at successively higher rating levels – only the aggregate point requirement increases for each rating level. However, because of the minimalist point structure inherent in LEED versions, each practice that earns one point typically encompasses several practices in the NGBS. For example, in LEED v4 HD&C's *Water Efficiency* area one point is awarded for a 10 percent reduction in water use (indoors and out) over standard practice. This could be deemed to equate to the NGBS' practices 801.2(1), an Energy Star dishwasher (2 points), 801.3(1), showerhead flow rates of 2.25 gpm or less (5 points), and 801.6.5(1) an evapotranspiration irrigation control (8 points).

LEED v4 HD&C allows a minimum shared point threshold between *Location & Linkages* and *Energy & Atmosphere*, for which the minimum threshold has been split between the two in this analysis. The LEED philosophy is that buildings allow the occupants to save energy in transportation (by siting closer to city centers and public transportation) or building energy usage. The NGBS, on the other hand, requires the building to meet strict energy savings thresholds while rewarding some of the transportation-related energy savings practices, as well, in the *Lot Design, Preparation & Development* area of environmental impact (Chapter 5).

LEED-H 2008's and LEED v4 HD&C's absence of increased minimum point thresholds in every environmental impact area at higher rating system levels allows more flexibility in selection of practice areas to focus on than is permitted by the NGBS. However, the absence of LEED system minimum point thresholds across all areas in either version provides little indication as to the environmental impact areas targeted by a project without seeing the project's scorecard. This is especially true at the higher LEED ratings.

## Results: Selected Practices

The typical practices that comprise the ratings in this analysis and the levels at which the practices are adopted within the programs are covered in Appendix A1-A3 (NGBS), Appendix B (LEED-H 2008), and Appendix C (LEED v4 HD&C), which are under separate covers.

To accommodate the difference in point structure between the programs, the LEED-H practices selected at successive rating levels may include higher level NGBS practices or practices that were not selected to satisfy the requirements of the NGBS rating. Here are two examples of this:

- Energy or Heat Recovery Ventilation (ERV or HRV) equipment was not selected for any of the NGBS ratings when the 2009 IECC was the base. The equipment was included in the houses in Climate Zones 5 and 6 Gold and Platinum ratings for LEED-H 2008 because the points were required to offset the five point adjustment for home size.
- The selected efficiency for a component covered by selected practices may differ between NGBS and LEED-H houses at rating levels to meet the point threshold requirements for each. For example, a 14.5 SEER air conditioner might meet the HERS score required for LEED-H 2008 additional points whereas a 16.0 SEER unit is required to meet the NGBS EE increase to achieve all of the points required to reach the next rating level.

## Results: Costs of Rating Systems

### Minimum Cost of Certification

The Table 6 through Table 8 indicate the costs of *Bronze/Certified* level certification to the NGBS, LEED-H 2008, and LEED v4 HD&C when the house is in compliance with the 2009 IECC in Climate Zone 5. These costs have been extracted from NGBS and LEED spreadsheets that are contained in Appendix A1-A3, Appendix B, Appendix C and the comprehensive list of mandatory practices in each of the rating systems found in Appendix G. *Verification & Inspection* costs are an estimate of the fees paid to rating system Verifiers and/or Raters. These are the independent third party licensed professionals who inspect the home and lot for compliance with the areas of environmental impact and perform the building/equipment testing that demonstrate rating system compliance.

Table 6. Administrative & Certification Cost for Bronze/Certified Rating – Climate Zone 5, 2009 IECC

| Administrative Costs, Climate Zone 5, 2009 IECC, Bronze/Certified Rating Level   | National Green Building Standard | LEED-H 2008 <sup>1</sup> | LEED v4 HD&C <sup>1</sup> |
|--|----------------------------------|--------------------------|---------------------------|
| Verification & Inspection Services   | \$430                            | \$430                    | \$430                     |
| Project Registration   | \$0                              | \$0                      | \$0                       |
| Project Certification  | \$200                            | \$0                      | \$0                       |
| <b>Total Bronze/Certified Costs</b>  | <b>\$630</b>                     | <b>\$430</b>             | <b>\$430</b>              |
| <sup>1</sup> Based on USGBC's <i>LEED for Homes Verification &amp; Submittal Guidelines For Project Teams</i> , August 2009. |                                  |                          |                           |
| <sup>1</sup> Add \$375 for registration and certification fees above Certified rating level for all LEED.                    |                                  |                          |                           |

The NGBS shows the highest cost for administration and certification at the *Bronze/Certified* rating level because the U.S. Green Building Council (USGBC), LEED's certification entity, waives certification and registration fees totaling \$375 at that level. The USGBC fees apply to certifications at the *Silver*, *Gold*, and *Platinum* rating levels, thus the estimated cost for NGBS, LEED-H 2008, and LEED v4 HD&C certifications at all levels above *Bronze/Certified* are \$630, \$805, and \$805, respectively.

Table 7 and Table 8 indicate how *Mandatory/Prerequisite Costs* contribute to significant initial costs in the LEED-H 2008 and LEED v4 HD&C systems compared to that of the NGBS in which costs for mandatory practices are less than LEED-H 2008 by a factor of two and less than LEED v4 HD&C by a factor of four (at the *Bronze* and *Silver* rating levels).

Table 7. Mandatory Practices for Bronze/Certified Rating – Climate Zone 5, 2009 IECC

| Prerequisite Practices  |   | NGBS 2012 | LEED-H 2008 <sup>1</sup> | LEED v4 HD&C <sup>1</sup> |
|---|---|-----------|--------------------------|---------------------------|
| SS 1.1  | Construction Activity Pollution Prevention  |           | \$500                    | \$500                     |
| ID 2.1  | Durability Planning   | \$246     | \$354                    | \$246                     |
| ID 2.2  | Durability Mgmt. Meet checklist requirements and have <u>Quality Assurance program</u> in place. <sup>2</sup> |           | not calculated           |                           |
| EA 1  | ENERGY STAR v2  |           | \$552                    |                           |
| EA P1   | ENERGY STAR Version 3   |           |                          | \$3,538                   |
| 701.3   | Third Party Building Leakage Testing  | \$215     |                          |                           |
| MR P1   | Certified Tropical Wood   |           |                          | \$645                     |
| MR 3.1  | Construction Waste Mgmt Planning & Documented diversion rate for waste ( 1 hr. /wk. for 12 weeks)             |           | \$896                    |                           |
| EQ 2.1 & EQ P2  | Combustion Venting - Power or direct vent equipment <sup>1</sup>  |           | \$610                    | \$305                     |
| EQ. 9 & EQ P4, 902.3(a)   | Radon Protection <sup>3</sup>   | \$617     | \$617                    | \$617                     |
| EQ. P1  | Ventilation   |           |                          | \$349                     |
| EQ. P2  | Combustion Venting / CO monitor per floor   |           |                          | \$99                      |
| EQ. P3  | Garage Pollutant Protection   |           |                          | \$144                     |
| AE P1   | Ops & Training Manual   | \$225     | \$341                    | \$341                     |
| Prerequisites - Bronze & Silver Levels  |   | \$1,303   | \$3,870                  | \$6,783                   |
| Prerequisites at Gold & Emerald Levels  |   | \$2,053   | \$3,870                  | \$6,783                   |
| <sup>1</sup> For LEED v4 HD&C in climate zones 5 and 6 this cost is reduced to \$305 because only the water heater requires power venting. (The furnaces are upgraded to direct vent by ENERGY STAR 3.0 compliance) |   |           |                          |                           |
| <sup>2</sup> This can be satisfied with a series of checklists, per the Rating System.  |   |           |                          |                           |
| <sup>3</sup> Not all Climate Zone 5 locations are in a Radon Zone 1, however, the houses in this study are.   |   |           |                          |                           |

Table 8. Compliance Costs for Bronze/Certified Rating – Climate Zone 5, 2009 IECC

| Total Bronze/Certified Compliance Cost, Zone 5, 2009 IECC |                                  |                          |                           |
|---|----------------------------------|--------------------------|---------------------------|
| Cost Category   | National Green Building Standard | LEED-H 2008 <sup>1</sup> | LEED v4 HD&C <sup>1</sup> |
| Verification & Inspection Services                        | \$630                            | \$430                    | \$430                     |
| Mandatory/Prerequisite Costs <sup>2</sup>                 | \$1,303                          | \$3,870                  | \$6,783                   |
| Bronze Compliance Costs (Selected Features/Points)        | \$668                            | \$865                    | \$565                     |
| <b>Total Bronze/Certified Costs of Compliance</b>         | <b>\$2,601</b>                   | <b>\$5,165</b>           | <b>\$7,778</b>            |

<sup>1</sup>Based on USGBC's *LEED for Homes Verification & Submittal Guidelines For Project Teams*, August 2009. Add \$375 for registration and certification fees above Certified rating level for all LEED.

<sup>2</sup>Add \$750 to NGBS mandatory costs at the Gold & Emerald levels for dual flush toilets.

Includes \$617 for radon remediation for this project which is located in Radon zone 1 - all rating systems.

### Incremental Cost to Construct – 2009 IECC Compliant

Based on the costs estimated for the practices described in the rating system worksheets (Appendices A-C), Figure 5 represents the estimated cost of compliance at each of the rating levels of the three green building rating systems for the design as if it had been constructed in Dallas, TX to the 2009 IECC. Figure 6 and Figure 7 follow this same reporting format for Denver, CO and Minneapolis, MN.

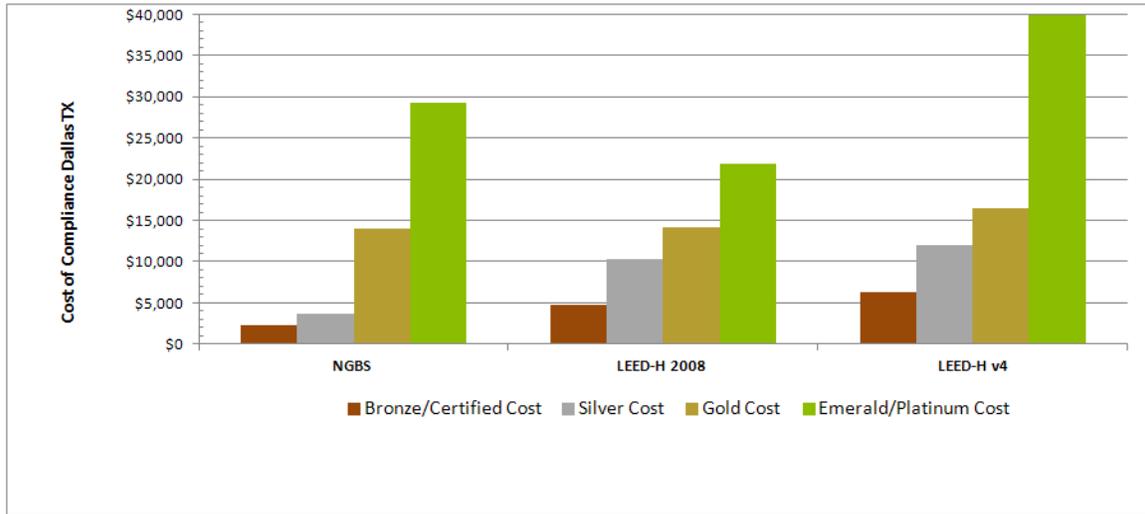


Figure 5. Cost of Rating System Compliance – Dallas, TX, Climate Zone 3, 2009 IECC Compliant

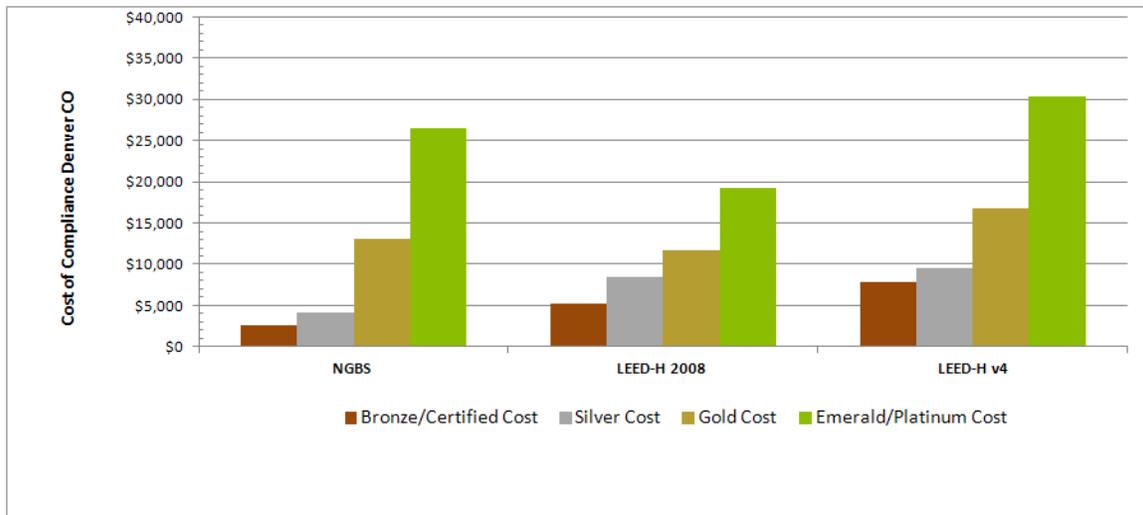


Figure 6. Cost of Rating System Compliance – Denver, CO, Climate Zone 5, 2009 IECC Compliant



Figure 7. Cost of Programs – Minneapolis, MN, Climate Zone 6, 2009 IECC Compliant

Table 9 contains the numbers that support these graphs which indicate the following:

For 2009 IECC code-compliant houses:

- NGBS cost of compliance at the *Bronze* level ranges from \$2,300 - \$3,000
- LEED-H 2008 cost of compliance at the *Certified* level ranges from \$4,600 - \$5,200
- LEED-H v4 HD&C cost of compliance at the *Certified* level ranges from \$6,400 - \$8,100
- NGBS cost of compliance at the *Silver* level ranges from \$3,700 - \$4,200
- LEED-H 2008 cost of compliance at the *Silver* level ranges from \$7,100 - \$10,300
- LEED v4 HD&C cost of compliance at the *Silver* level ranges from \$9,600-\$12,000

The cost of rating level compliance for LEED – H 2008 is roughly twice that of the NGBS at the lower rating levels, approximately equal to the cost of the NGBS at *Gold*, and less than NGBS at the

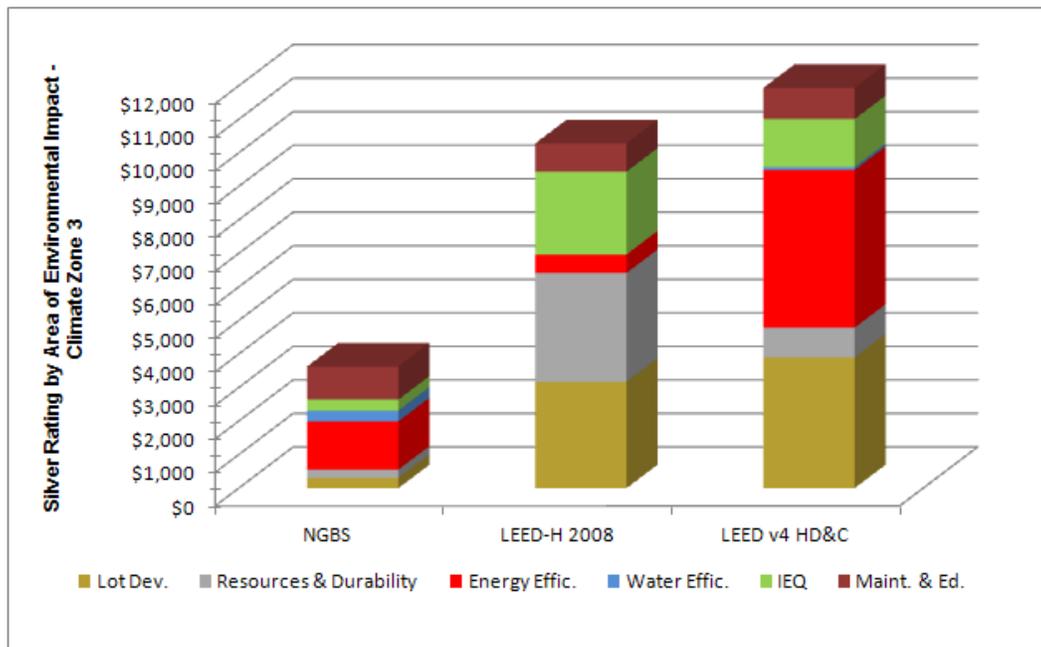
*Emerald/Platinum* level. The trend for NGBS compliance to cost less than LEED v4 HD&C continues at the *Gold* and *Emerald/Platinum* levels in climate zones 3 and 5; however, the range of the cost difference narrows considerably in climate zone 6 where LEED v4 HD&C shows a \$1,000 cost advantage over the NGBS at the highest rating level.

**Table 9. Cost of Rating System Compliance at Levels, 2009 IECC Compliant**

| Program & Rating |             | Dallas TX - Climate Zone 3        |                     |                   |                                   | Denver CO - Climate Zone 5        |                     |                   |                                   | Minneapolis MN - Climate Zone 6   |                     |                   |                                   |
|------------------|-------------|-----------------------------------|---------------------|-------------------|-----------------------------------|-----------------------------------|---------------------|-------------------|-----------------------------------|-----------------------------------|---------------------|-------------------|-----------------------------------|
|                  |             | Bronze/<br>Certified<br>Cost (\$) | Silver<br>Cost (\$) | Gold<br>Cost (\$) | Emerald/<br>Platinum<br>Cost (\$) | Bronze/<br>Certified<br>Cost (\$) | Silver<br>Cost (\$) | Gold<br>Cost (\$) | Emerald/<br>Platinum<br>Cost (\$) | Bronze/<br>Certified<br>Cost (\$) | Silver<br>Cost (\$) | Gold<br>Cost (\$) | Emerald/<br>Platinum<br>Cost (\$) |
| 2009 IECC        | NGBS        | 2,325                             | 3,631               | 14,041            | 29,298                            | 2,601                             | 4,091               | 13,044            | 26,442                            | 2,744                             | 4,259               | 13,992            | 28,801                            |
|                  | LEED-H 2008 | 4,719                             | 10,282              | 14,156            | 21,825                            | 5,164                             | 8,402               | 11,712            | 19,193                            | 4,522                             | 7,038               | 10,762            | 20,999                            |
|                  | LEED-H v4   | 6,357                             | 11,939              | 16,492            | 39,849                            | 7,777                             | 9,532               | 16,712            | 30,291                            | 8,010                             | 10,033              | 12,725            | 27,945                            |

### Costs by Area of Environmental Impact

Incongruous parallels exist between the NGBS and LEED v4 HD&C program areas of sustainability. The point trade-off that LEED v4 HD&C allows between *Location & Linkages* and *Energy & Atmosphere* indicates the program’s equal treatment of transportation energy savings and building energy savings, whereas the NGBS is more focused on building energy savings. The owner education and maintenance component in LEED v4 HD&C has been tallied in the related environmental impact area. The environmental impact area supported by *Innovation* and *Regional Priority* practices will likely be situational. To tally these—*Sustainable Sites, Location & Linkages, Integrative Process, and Regional Priority*—are included in *Lot Development* and *Innovation* is included in the *Maintenance & Education* area. Because of this, no correlation has been made between the costs associated with compliance based on the sustainability area; however, a sample graph of each system’s costs per environmental impact area is shown in Figure 8, Figure 9, and Figure 10 for a *Silver* rated house built in compliance with 2009 IECC in the three climate zones.



**Figure 8. Compliance Cost by Environmental Impact Area, Climate Zone 2, Silver Rating, 2009 IECC Compliant**

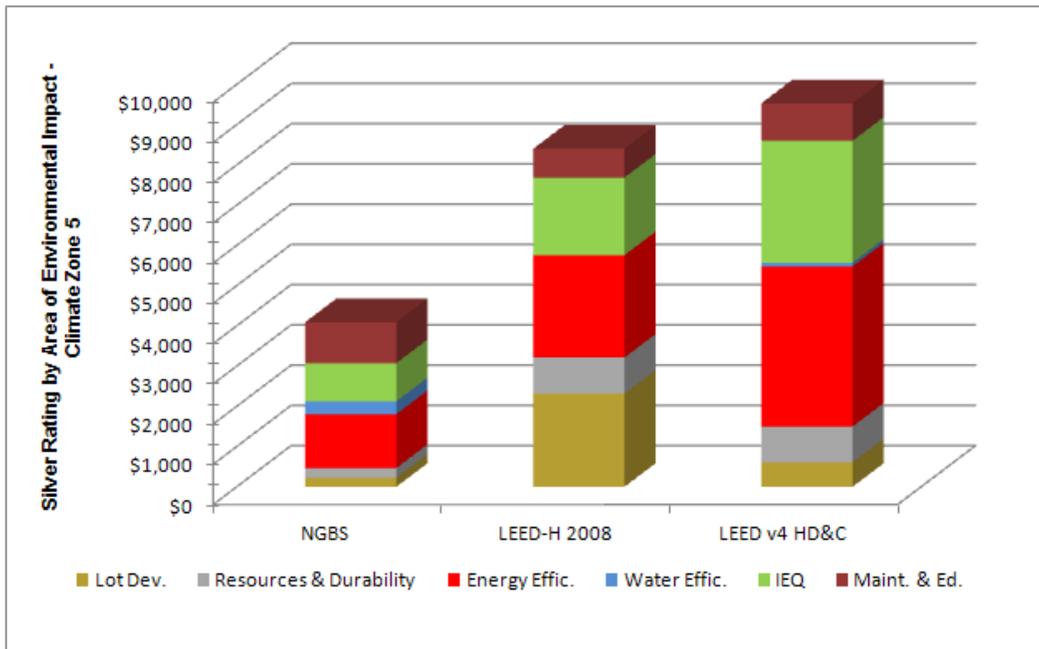


Figure 9. Compliance Cost by Environmental Impact Area, Climate Zone 5, Silver Rating, 2009 IECC Compliant

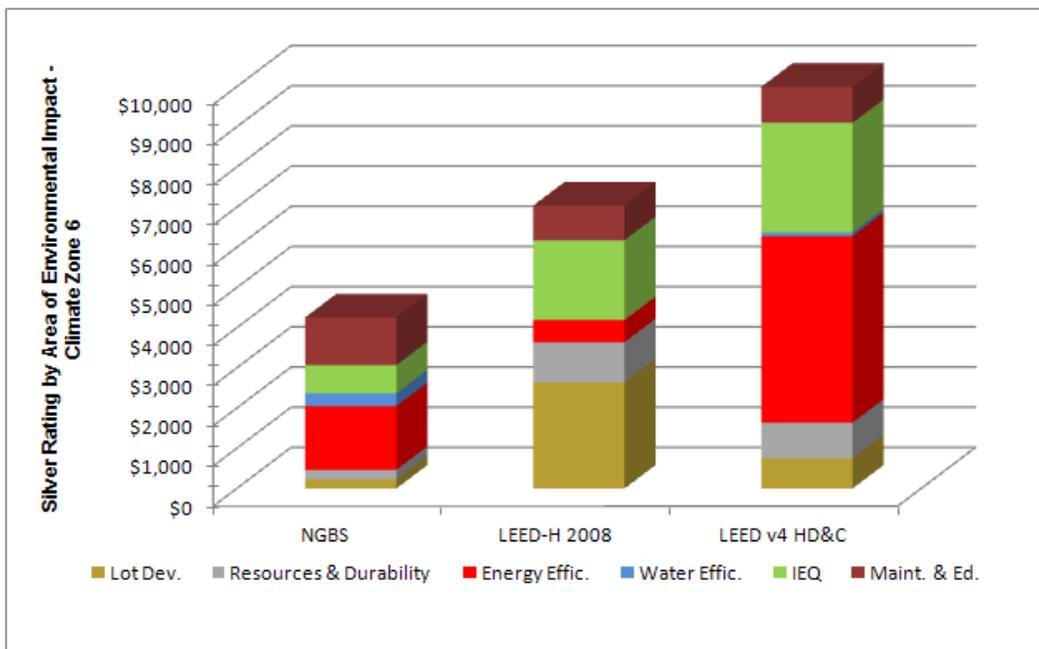


Figure 10. Compliance Cost by Environmental Impact Area, Climate Zone 6, Silver Rating, 2009 IECC Compliant

## Illustration of Minimum Energy Efficiency Requirements

LEED-H 2008 energy savings at the *Certified* level is lower than the NGBS *Bronze* level in climate zone 3, although the rating cost is double that of the NGBS. Approximately \$1,000 of the \$2,400 difference is due largely to a prerequisite requirement to document construction waste diversion from landfills (MR3.1). The prerequisite is optional and awarded up to 3 points in the new LEED-H v4 HD&C version.

A 2009 IECC compliant house rated using LEED v4 HD&C shows higher energy efficiency at the *Certified* and *Silver* levels than the same house rated to the NGBS *Bronze* and *Silver* levels due to the differences in the base metrics of each system – Energy Star version 3 and 2009 IECC, respectively. Energy Star version 3 requires more stringent energy performance for windows and HVAC equipment and greater building envelope tightness than is required by the 2009 IECC in all climate zones. At higher rating levels the simulated energy efficiency is generally comparable between the two systems (assuming the LEED professional selects similar *Energy & Atmosphere* features). LEED v4 HD&C’s estimated cost at the *Certified (Bronze)* or *Silver* level exceeds the NGBS by a factor of at least two.

Table 5 contains the energy efficiency percentages simulated for the subject house in the stated climate zone locations built to be compliant with the 2009 IECC. The same information is depicted graphically in Figure 11, Figure 12, and Figure 13. The NGBS and LEED v4 HD&C systems indicate more comparable energy efficiency at rated level than does LEED-H 2008.

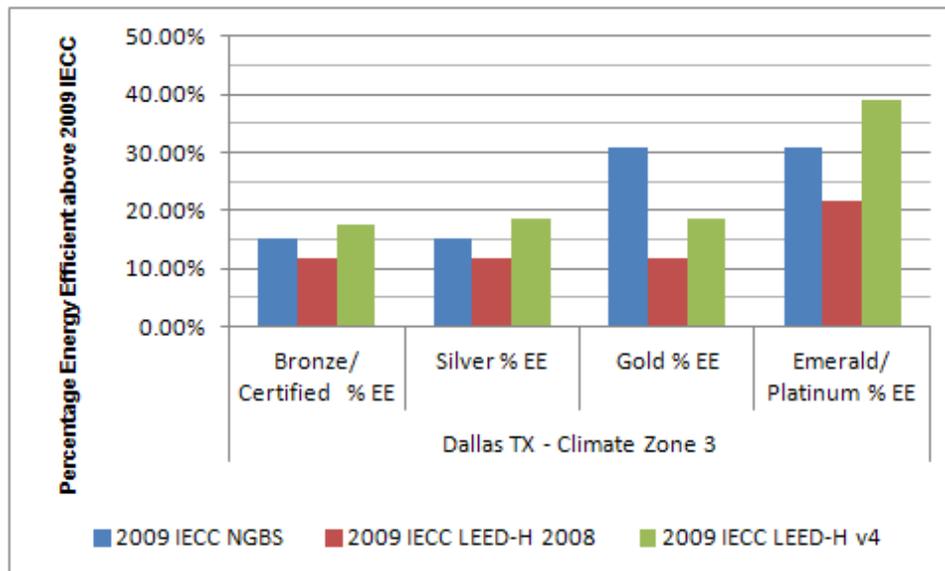


Figure 11. Simulated Energy Efficiency at Rated Level for Each System

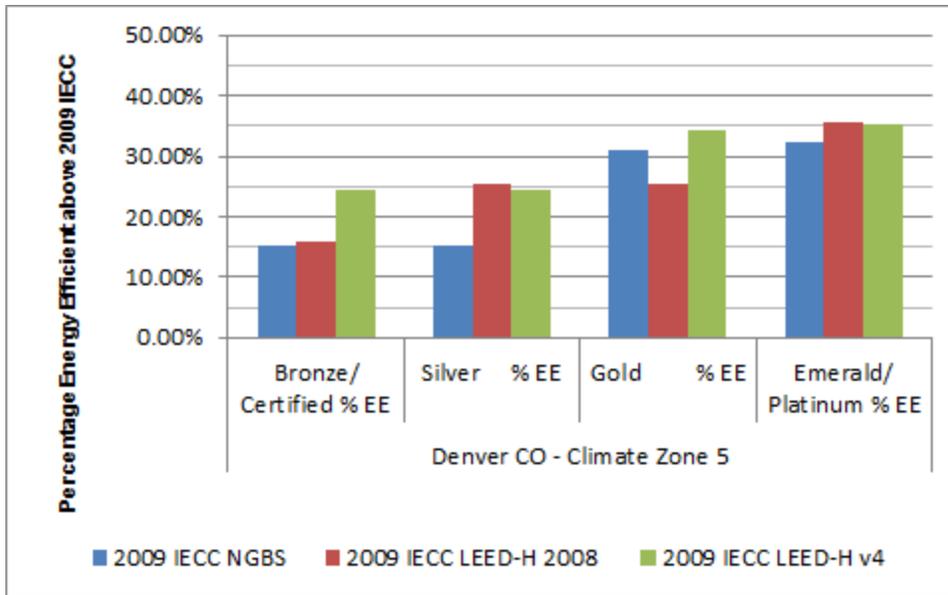


Figure 12. Simulated Energy Efficiency at Rated Level for Each System

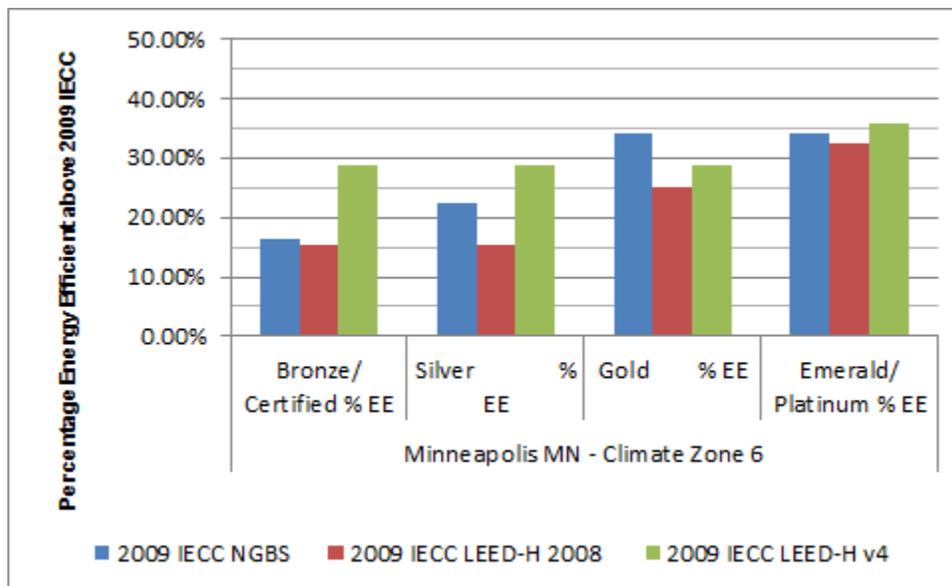


Figure 13. Simulated Energy Efficiency at Rated Level for Each System

## Incremental Cost to Construct – 2012 IECC Compliant

### About the 2012 IECC

The adoption of the 2012 IECC increases the “baseline house cost” metric of this study by \$4,000 - \$7,000 dependent on climate zone. Table 10 identifies these added costs as they are largely responsible for NGBS program compliance in the *Energy Efficiency* section at the *Bronze* level in cases where

compliance to the 2012 IECC applies. Houses compliant with the 2012 IECC and rated to both LEED-H 2008 and LEED v4 HD&C systems would also incur these added costs and energy efficiency benefits.

**Table 10. Estimated Additional Cost of 2012 IECC Compliance over the 2009 IECC**

| Location   | Texas   | Denver  | Minneapolis |
|--|---------|---------|-------------|
| Practice/Component   |         |         |             |
| R-5 sheathing  |         |         | \$3,117     |
| R-20 walls   | \$3,144 |         |             |
| R-19 bsmt walls  |         | \$477   |             |
| R-38 ceiling   | \$635   |         |             |
| R-49 ceiling   |         | \$952   |             |
| Duct Sealing (8% out vs. 4%)   | \$220   | \$220   | \$220       |
| Building leakage testing <sup>A</sup>  | \$150   | \$150   | \$150       |
| Bath fan controllers for exhaust ventilation   | \$266   | \$266   | \$266       |
| 3 ACH 50   | \$1,224 | \$1,224 | \$1,224     |
| .35/.25 wdws   | \$1,145 |         |             |
| .32/.40 wdws   |         | \$641   | \$641       |
| 2012 Base Cost Increase  | \$6,783 | \$3,930 | \$5,618     |
| <sup>A</sup> Some ductwork in attic. Approximate cost of \$150 for duct leakage testing not included as it was required under IECC 2009 403.2.2 Sealing Mandatory. |         |         |             |

The adoption of the energy efficient practices in the 2012 IECC is more than sufficient to satisfy the 15 percent minimum certification level for *Energy Efficiency* in the NGBS. The added cost to comply with the 2012 IECC is partially recouped by lower costs to comply with the rating systems, Table 11. When compared with Table 9, the cost of rating compliance within the systems decreases between approximately 0 - \$5,000 for each of the three rating systems with the highest savings for rating compliance seen in climate zones 5 and 6. In addition, both LEED-H versions indicate similar energy efficiency performance expectations as the NGBS – ranging from less than 1 percent worse (LEED-H 2008) to four percent better (LEED v4 HD&C) than the NGBS, but at costs greater by a factor between two and three Table 9 and Table 11.

The 2012 IECC has not been widely adopted by the states at the date of this report. Several states that have adopted the code have adopted it with exceptions that change the baseline metrics used in energy efficiency calculations which will reduce the expected energy efficiency of the ratings at the lowest levels in all of the systems.

**Table 11. Cost of Rating System Compliance at Levels, 2012 IECC Compliant**

| Program & Rating |             | Dallas TX - Climate Zone 3        |                     |                   |                                   | Denver CO - Climate Zone 5        |                     |                   |                                   | Minneapolis MN - Climate Zone 6   |                     |                   |                                   |
|------------------|-------------|-----------------------------------|---------------------|-------------------|-----------------------------------|-----------------------------------|---------------------|-------------------|-----------------------------------|-----------------------------------|---------------------|-------------------|-----------------------------------|
|                  |             | Bronze/<br>Certified<br>Cost (\$) | Silver<br>Cost (\$) | Gold<br>Cost (\$) | Emerald/<br>Platinum<br>Cost (\$) | Bronze/<br>Certified<br>Cost (\$) | Silver<br>Cost (\$) | Gold<br>Cost (\$) | Emerald/<br>Platinum<br>Cost (\$) | Bronze/<br>Certified<br>Cost (\$) | Silver<br>Cost (\$) | Gold<br>Cost (\$) | Emerald/<br>Platinum<br>Cost (\$) |
| 2012 IECC        | NGBS        | 1,372                             | 2,433               | 14,569            | 29,556                            | 2,088                             | 2,702               | 10,730            | 22,385                            | 2,426                             | 2,881               | 9,225             | 23,903                            |
|                  | LEED-H 2008 | 4,370                             | 5,762               | 11,962            | 19,840                            | 4,593                             | 6,878               | 11,721            | 20,985                            | 4,510                             | 6,612               | 10,456            | 20,578                            |
|                  | LEED-H v4   | 6,378                             | 8,927               | 13,784            | 36,160                            | 6,366                             | 8,263               | 11,442            | 25,503                            | 6,535                             | 7,536               | 11,195            | 24,401                            |

**Table 12. Percentage of Energy Efficiency Improvement (over 2009 IECC) at Each System Rating Level for a 2012 IECC Compliant House**

| Program & Rating |             | Dallas TX - Climate Zone 3   |                |              |                              | Denver CO - Climate Zone 5   |                |              |                              | Minneapolis MN - Climate Zone 6 |                |              |                              |
|------------------|-------------|------------------------------|----------------|--------------|------------------------------|------------------------------|----------------|--------------|------------------------------|---------------------------------|----------------|--------------|------------------------------|
|                  |             | Bronze/<br>Certified<br>% EE | Silver %<br>EE | Gold %<br>EE | Emerald/<br>Platinum<br>% EE | Bronze/<br>Certified<br>% EE | Silver<br>% EE | Gold<br>% EE | Emerald/<br>Platinum<br>% EE | Bronze/<br>Certified<br>% EE    | Silver<br>% EE | Gold<br>% EE | Emerald/<br>Platinum<br>% EE |
| 2012 IECC        | NGBS        | 21.70%                       | 21.70%         | 30.99%       | 30.99%                       | 25.54%                       | 25.54%         | 37.70%       | 37.70%                       | 29.57%                          | 29.57%         | 29.57%       | 43.07%                       |
|                  | LEED-H 2008 | 22.10%                       | 22.10%         | 22.10%       | 29.69%                       | 24.80%                       | 24.80%         | 24.80%       | 33.25%                       | 27.00%                          | 27.00%         | 36.21%       | 36.21%                       |
|                  | LEED-H v4   | 23.31%                       | 23.31%         | 23.31%       | 44.38%                       | 28.11%                       | 28.11%         | 34.33%       | 36.74%                       | 30.98%                          | 30.98%         | 38.59%       | 38.59%                       |

The 2012 building code requires R-5 continuous insulation on exterior walls with R-20 cavity insulation and a maximum of three air changes per hour at 50 pascals (3 ACH50) with 4 percent maximum duct leakage, which combines with the other stated house features and the cold climate to rank the Minneapolis house, built to that code, at nearly 15 percent more efficient than its 2009 counterpart. The energy savings created by adoption of the more stringent code earns 58 points at the *Bronze* level rating in the NGBS. In a similar outcome, the HERS rating of a house compliant with the 2012 IECC house earns 18 of the 40 total points required for a *Certified* rating in LEED v4 HD&C.

For 2012 IECC code-built houses:

- NGBS cost of compliance at the *Bronze* level ranges from \$1,400 - \$2,600
- LEED-H 2008 cost of compliance at the *Certified* level ranges from \$4,300 - \$4,600
- LEED-H v4 HD&C cost of compliance at the *Certified* level ranges from \$6,300 - \$6,500
- NGBS cost of compliance at the *Silver* level is approximately \$2,700 (\$1,000 to \$1,500 less than a 2009 IECC compliant house)
- LEED-H 2008 cost of compliance at the *Silver* level ranges from \$5,800 - \$6,900 (\$1,500 - \$3,000 less than a 2009 IECC compliant house)
- LEED v4 HD&C cost of compliance at the *Silver* level ranges from \$7,600 - \$9,000 (\$2,000 - \$3,000 less than a 2009 IECC compliant house)

The cost comparison of compliance in each of the rating systems at each level which is represented in Table 11 have been graphed for each of the three climate zones in this analysis in Figure 14, Figure 15, and Figure 16.

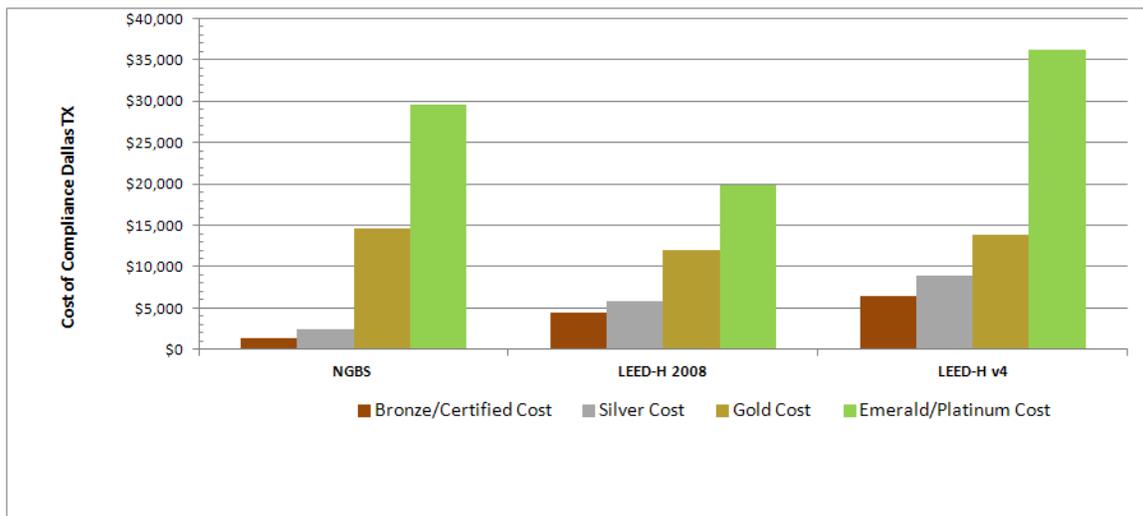


Figure 14. Cost of Rating System Compliance – Dallas, TX, Climate Zone 3, 2012 IECC Compliant

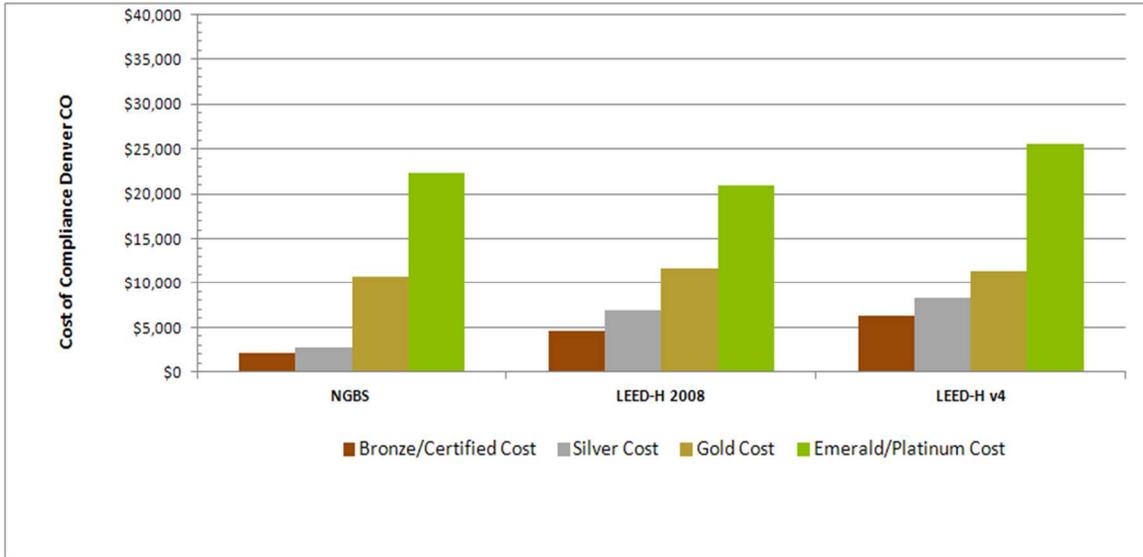


Figure 15. Cost of Rating System Compliance – Denver CO, Climate Zone 5, 2012 IECC Compliant

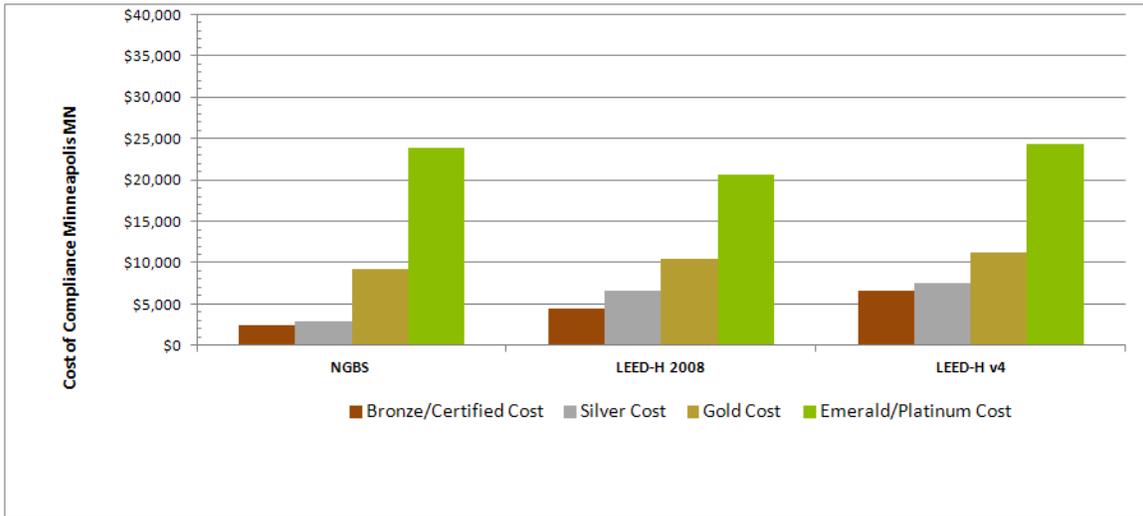


Figure 16. Cost of Rating System Compliance – Minneapolis MN, Climate Zone 6, 2012 IECC Compliant

### Costs by Area of Environmental Impact

Comparison of the rating systems by costs associated with each area of environmental impact for a house built in compliance with the 2012 IECC highlights the balanced approach inherent to the NGBS rating method. (The bar graph indicates cost and the colored bands in the bar graph indicate area of environmental impact. In each of the climate zones shown, all of the environmental impact areas are represented and each area has similar weight in the bar graphs that represent the NGBS silver ratings.

The bar graphs also contain an axis on the right hand side of the graphic that includes the percentage of energy efficiency that is associated with the costs at the *Silver* rating level in each of the systems. The energy efficiency data is shown numerically in Table 11.

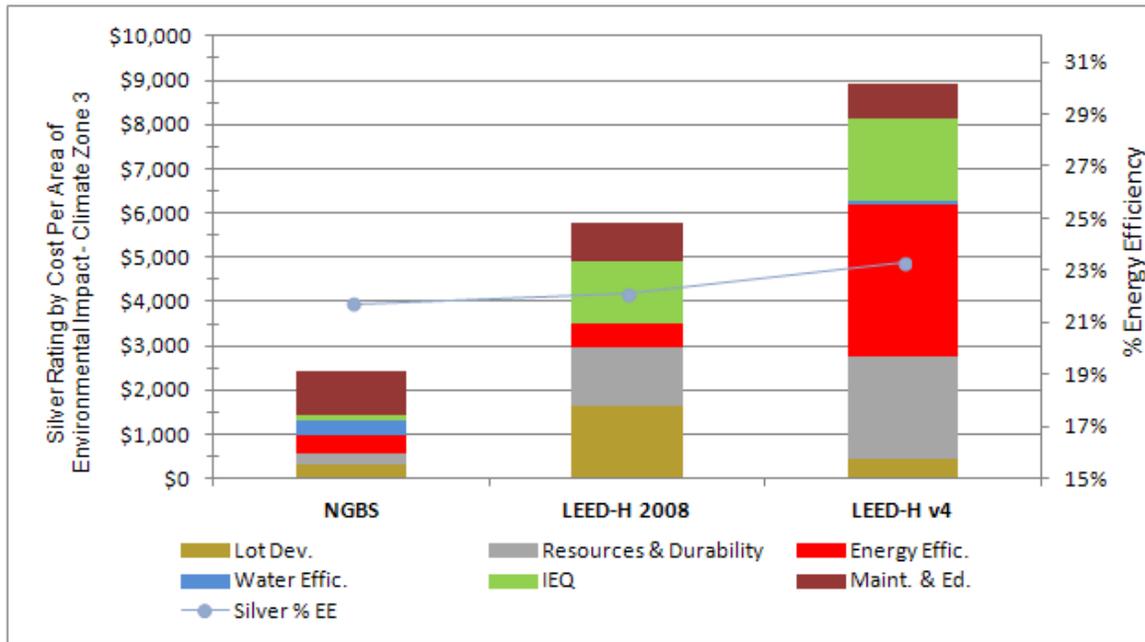


Figure 17. Compliance Cost by Environmental Impact Area, Climate Zone 3, Silver Rating, 2012 IECC Compliant

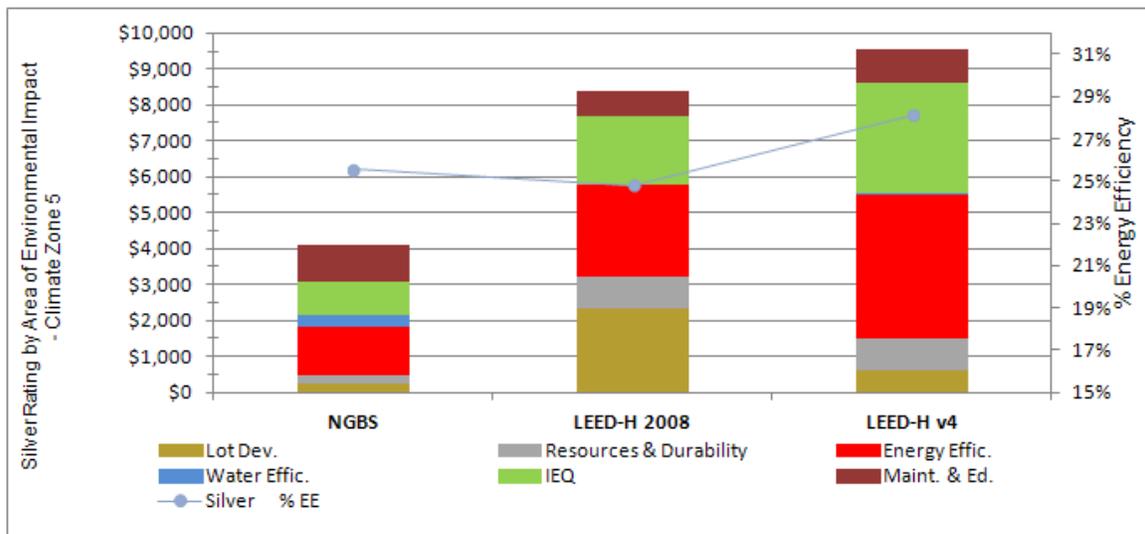


Figure 18. Compliance Cost by Environmental Impact Area, Climate Zone 5, Silver Rating, 2012 IECC Compliant

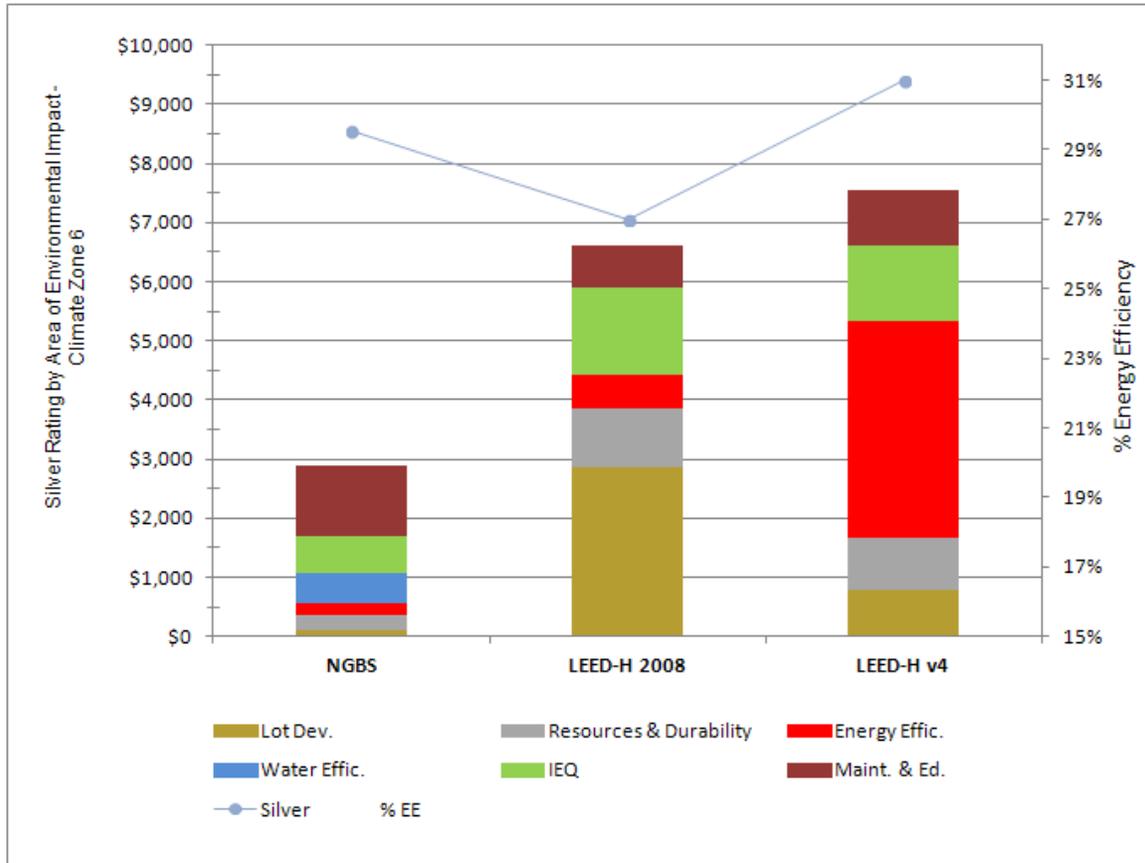


Figure 19. Compliance Cost by Environmental Impact Area, Climate Zone 6, Silver Rating, 2012 IECC Compliant

## Results: Program Stringency Comparison

### Prerequisites

Builders generally agree that the additional cost of compliance with ENERGY STAR version 3 is in the several thousand dollars range.<sup>16</sup> The EPA prepared cost estimates in the range of \$3,550 - \$5,190 using a 2006 RSMMeans labor rate of \$46 (burdened with overhead and profit).<sup>17</sup>

The estimated ENERGY STAR compliance costs in this analysis range from \$2,400 - \$4,200 to comply with the minimum requirement of LEED v4 HD&C (See Appendix F). Approximately 75 percent of the cost of compliance covers the cost of upgraded equipment or building envelope thermal resistance components (radiant barrier, windows, and air seal); 15 percent of cost applies to HVAC duct layout enhancements and HVAC equipment commissioning practices that are broadly accepted within the industry as contributory to performance and comfort improvement, but are not all measured well by computer simulation software. The final 10 percent covers the expense of third party verification of checklists and performance. Many of these same practices provide the NGBS *Energy Efficiency* section 704 points that were typically selected for the Silver rating.

### Home Size Adjustment

The NGBS, LEED-H, and ENERGY STAR all have formats for rewarding buildings with a small conditioned footprint and penalizing those with conditioned area greater than a threshold size based on number of bedrooms. The houses in Zones 5 and 6 were penalized by five points in the LEED-H 2008 version for the addition of a conditioned basement foundation. LEED v4 HD&C follows the format of ENERGY STAR in assessing the house size adjustment and exempts in-ground basements, resulting in 3.5 points earned for house size adjustment in that rating system. The NGBS approach only measures above grade square footage, following ANSI Z765 methodology<sup>18</sup>, thus all three houses were treated the same in the NGBS rating system (awarded six points in *Resource Efficiency*.)

Table 13. Example of House Size Adjustment Tabulations

| Standard   | Reference house size | House Size Recognized In Each System |        |             |
|--|----------------------|--------------------------------------|--------|-------------|
|  |                      | Dallas                               | Denver | Minneapolis |
| NGBS <sup>A</sup>  | 4000                 | 2320                                 | 2320   | 2320        |
| Points   |                      | 6                                    | 6      | 6           |
| ENERGY STAR v3 <sup>B</sup>  | 2800                 | 2320                                 | 2320   | 2320        |
| LEED-H 2008  | 2600                 | 2320                                 | 3280   | 3280        |
| Points   |                      | 4                                    | -5     | -5          |
| LEED-H v4 <sup>C</sup>   | 2800                 | 2320                                 | 2320   | 2320        |
| Points   |                      | 4                                    | 4      | 4           |
| <sup>A</sup> Only sq. ft. of stories above grade counted; per ANSI Z765.             |                      |                                      |        |             |
| <sup>B</sup> No penalty for inground basement with 1/2 of gross surface area buried. |                      |                                      |        |             |
| <sup>C</sup> Follows ENERGY STAR criteria and awards points in EA section.           |                      |                                      |        |             |

<sup>16</sup> Clapham, Kyle, *Professional Builder* 4/13. *Earning the Star*, p.56. "...Houston-based David Weekley spends an additional \$2,000-\$3,500 per house to comply with [ENERGY STAR] Version 3."

<sup>17</sup> U.S. Environmental Protection Agency website, ENERGY STAR Qualified Homes, Version 3 Savings and Cost Estimate Summary. [www.energystar.gov/ia/partners/bldrs\\_lenders\\_raters/downloads/EstimatedCostandSavings.pdf](http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/EstimatedCostandSavings.pdf)

<sup>18</sup> American National Standards Institute, *Square Footage-Method for Calculating: ANSI Z765*.

Strictly speaking, there was no correlation between point values awarded in the green rating systems that could be identified. Table 13 is included to highlight the impact that a (conditioned) basement foundation has on a house's LEED-H 2008 rating – 10 percent of the points required at Certified are added to the minimum threshold requirement. LEED v4 HD&C has adjusted that to align with ANSI Z765 which is the methodology recognized for house sale price valuation of floor area by its location within the structure.

### **The Rigor of Increasing Minimum Point Thresholds for All Environmental Impact Areas at Higher Rating Levels**

The NGBS' progressively higher minimum point requirements in each area of environmental impact forces the balanced outcome that is evident by the color bands represented for the NGBS rating in the preceding bar graphs (Figure 17, Figure 18, and Figure 19). The graph in Figure 20 also shows the increasing cost per point of NGBS compliance at higher levels and the disproportionately larger investment required to meet the requirements of the *Energy Efficiency* section. At the Gold level where 30 additional points were required for compliance, each *Energy Efficiency* point carries a cost of approximately \$80, more than double the cost of points for any other area of environmental impact at this rating level. Nonetheless, the scale of minimum points per environmental impact area regimen of the NGBS compels the selection of the higher cost energy efficiency points/practices over low-cost points/practices benefitting alternative environmental impact areas. Conversely, in the LEED-H systems it is allowable to select entirely from practices in areas other than energy efficiency to reach higher rating levels.

Cost for the *Bronze* level rating includes the current \$200 NGBS certification fee for NAHB members, when using the NGBS Green Certified program administered by Home Innovation Research Labs.

An estimated \$430 in Verifier fees covering four hours of professional time is used as the administrative fee. (Four hundred thirty dollars is the assumed cost for professional consultation for each of the rating systems.) These are included in the *Education* section where one-half point values are the norm, amplifying that section's cost per point at the low end of the rating scale.

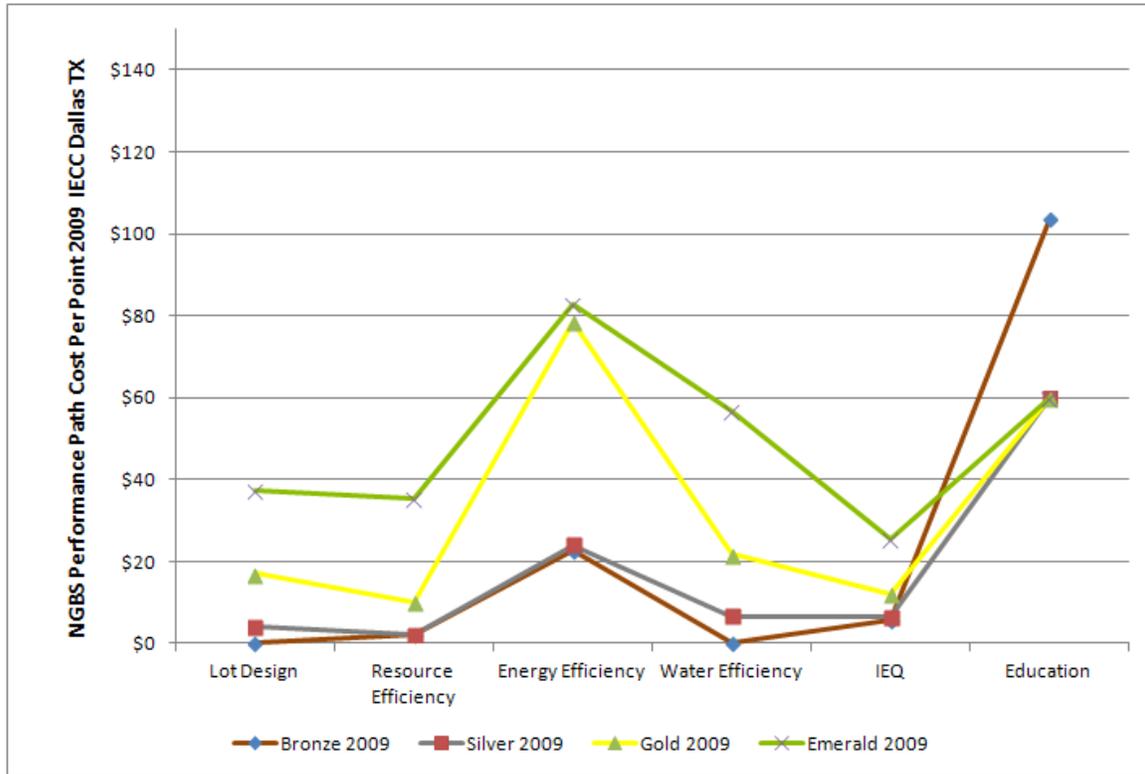


Figure 20. Cost per Point for NGBS Compliance at Rating Levels – 2009 IECC, Zone 3

Minimum point thresholds at all rating levels make the NGBS a more rigorous rating system across all of those environmental impact areas that it encompasses – lot, resources, energy, water, indoor environment, and operation. The LEED-H 2008 and LEED v4 HD&C systems can be employed to match the same performance as the NGBS but do not require the same balanced outcome.

## Conclusion

Each of the three programs evaluated in this analysis rate the sustainability of a house by recognition of the preferred materials and practices of its construction via a point system. The point system for an NGBS rating is applied relatively evenly to all of the areas that have been defined as sustainable objectives – lot development, material resources management and durability, energy efficiency, water efficiency, and indoor environmental quality – with increasing minimum point thresholds in each environmental impact area required for each rating level increase. The LEED-H point systems require minimum point thresholds only at the *Certified* rating level with no prescribed point increase requirement by environmental impact area with successive rating levels.

By its reference to ENERGY STAR version 2 rather than the more recent version 3, LEED-H 2008 loses any energy efficiency edge the rating system had once the 2009 IECC has been adopted. LEED v4 HD&C, slated for full implementation by June 2015<sup>19</sup>, and the NGBS move metrics for performance to levels significantly above the 2009 IECC, which is currently the adopted code in 30 States, Puerto Rico, and Guam. (Several states remain on a version of the code before 2009 or have a state code in place.)<sup>20</sup>

At the *Bronze/Certified* and *Silver* rating levels the NGBS is less costly to implement. At the higher rating levels the NGBS cost advantage narrows and is even surpassed by LEED v4 HD&C in Climate Zone 6, with a house in compliance with the 2009 IECC, at the *Emerald/Platinum* rating level, assuming the authors' interpretations of compliance actions are similarly interpreted by LEED's certification entity, the USGBC.

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<sup>19</sup> Roberts, T. in Engineering News Record. 7/10/2013. *LEED v4 Approved by USGBC Members*.  
<http://enr.construction.com/buildings/sustainability/2013/0710-leed-v4-approved-by-usgbc-members.asp>

<sup>20</sup> [www.iccsafe.org/gr/Documents/stateadoptions.pdf](http://www.iccsafe.org/gr/Documents/stateadoptions.pdf)



# APPENDICES

## APPENDIX A1: NGBS Rating, Zone 3

(See attached separate file.)

| Performance Scoring        |             |        |         |             |        |         |           |        |          |              |        |          |
|----------------------------|-------------|--------|---------|-------------|--------|---------|-----------|--------|----------|--------------|--------|----------|
| NGBS 2009 IECC - Dallas TX |             |        |         |             |        |         |           |        |          |              |        |          |
|                            | Bronze 2009 |        |         | Silver 2009 |        |         | Gold 2009 |        |          | Emerald 2009 |        |          |
|                            | Min         | Actual | Cost    | Min         | Actual | Cost    | Min       | Actual | Cost     | Min          | Actual | Cost     |
| Chap 5                     | 50          | 60     | 0       | 64          | 75     | 308     | 93        | 115    | 1,962    | 121          | 134    | 5,014    |
| Chap 6                     | 43          | 112    | 246     | 59          | 118    | 246     | 89        | 137    | 1,397    | 119          | 167    | 5,939    |
| Chap 7                     | 30          | 45     | 1,024   | 60          | 60     | 1,441   | 80        | 90     | 7,057    | 100          | 100    | 8,279    |
| Chap 8                     | 25          | 43     | 0       | 39          | 48     | 320     | 67        | 73     | 1,590    | 92           | 105    | 5,971    |
| Chap 9                     | 25          | 41     | 227     | 42          | 51     | 327     | 69        | 86     | 1,046    | 97           | 122    | 3,107    |
| Chap 10                    | 8           | 8      | 828     | 10          | 17     | 989     | 11        | 17     | 989      | 12           | 17     | 989      |
| Add'l                      | 50          |        |         | 75          |        |         | 100       |        |          | 100          |        |          |
| Total                      | 231         | 349    | \$2,325 | \$349       | 369    | \$3,631 | \$509     | 518    | \$14,041 | \$641        | 645    | \$29,298 |

|         | Dallas TX Bronze 2012 |        |         | Dallas TX Silver 2012 |        |         | Dallas TX Gold 2012 |        |          | Dallas TX Emerald 2012 |        |          |
|---------|-----------------------|--------|---------|-----------------------|--------|---------|---------------------|--------|----------|------------------------|--------|----------|
|         | Min                   | Actual | Cost    | Min                   | Actual | Cost    | Min                 | Actual | Cost     | Min                    | Actual | Cost     |
| Chap 5  | 50                    | 60     | 0       | 64                    | 80     | 308     | 93                  | 110    | 1,961    | 121                    | 139    | 5,374    |
| Chap 6  | 43                    | 112    | 246     | 59                    | 118    | 246     | 89                  | 137    | 1,436    | 119                    | 164    | 4,974    |
| Chap 7  | 30                    | 56     | 215     | 60                    | 64     | 437     | 80                  | 87     | 7,244    | 100                    | 100    | 8,509    |
| Chap 8  | 25                    | 43     | 0       | 39                    | 48     | 320     | 67                  | 84     | 1,911    | 92                     | 105    | 5,971    |
| Chap 9  | 25                    | 41     | 83      | 42                    | 44     | 133     | 69                  | 79     | 1,027    | 97                     | 118    | 3,739    |
| Chap 10 | 8                     | 8      | 828     | 10                    | 17     | 989     | 11                  | 17     | 989      | 12                     | 17     | 989      |
| Add'l   | 50                    |        |         | 75                    |        |         | 100                 |        |          | 100                    |        |          |
| Total   | 231                   | 320    | \$1,372 | 349                   | 371    | \$2,433 | 509                 | 514    | \$14,569 | 641                    | 643    | \$29,556 |

**APPENDIX A2:  
NGBS Rating, Zone 5**  
(See attached separate file)

|         | Denver Bronze 2009 |        |       | Denver Silver 2009 |        |       | Denver Gold 2009 |        |        | Denver Emerald 2009 |        |        |
|---------|--------------------|--------|-------|--------------------|--------|-------|------------------|--------|--------|---------------------|--------|--------|
|         | Min                | Actual | Cost  | Min                | Actual | Cost  | Min              | Actual | Cost   | Min                 | Actual | Cost   |
| Chap 5  | 50                 | 60     | 0     | 64                 | 70     | 222   | 93               | 115    | 1,962  | 121                 | 134    | 5,014  |
| Chap 6  | 43                 | 107    | 246   | 59                 | 113    | 246   | 89               | 144    | 2,241  | 119                 | 163    | 5,595  |
| Chap 7  | 30                 | 40     | 550   | 60                 | 60     | 1,337 | 80               | 92     | 5,336  | 100                 | 100    | 6,269  |
| Chap 8  | 25                 | 37     | 0     | 39                 | 42     | 320   | 67               | 60     | 1,070  | 92                  | 110    | 5,463  |
| Chap 9  | 25                 | 52     | 950   | 42                 | 52     | 950   | 69               | 79     | 1,419  | 97                  | 119    | 3,084  |
| Chap 10 | 8                  | 8      | 855   | 10                 | 17     | 1,016 | 11               | 17     | 1,016  | 12                  | 17     | 1,016  |
| Add'l   | 50                 |        |       | 75                 |        |       | 100              |        |        | 100                 |        |        |
| Total   | 231                | 304    | 2,601 | 349                | 354    | 4,091 | 509              | 507    | 13,044 | 641                 | 643    | 26,442 |

|         | Denver CO Bronze 2012 |        |       | Denver CO Silver 2012 |        |       | Denver CO Gold 2012 |        |        | Denver CO Emerald 2012 |        |        |
|---------|-----------------------|--------|-------|-----------------------|--------|-------|---------------------|--------|--------|------------------------|--------|--------|
|         | Min                   | Actual | Cost  | Min                   | Actual | Cost  | Min                 | Actual | Cost   | Min                    | Actual | Cost   |
| Chap 5  | 50                    | 60     | 0     | 64                    | 67     | 103   | 93                  | 96     | 467    | 121                    | 132    | 3,952  |
| Chap 6  | 43                    | 109    | 246   | 59                    | 115    | 246   | 89                  | 128    | 627    | 119                    | 148    | 3,192  |
| Chap 7  | 30                    | 68     | 314   | 60                    | 68     | 314   | 80                  | 105    | 4,244  | 100                    | 114    | 5,604  |
| Chap 8  | 25                    | 48     | 0     | 39                    | 53     | 320   | 67                  | 98     | 2,761  | 92                     | 113    | 5,099  |
| Chap 9  | 25                    | 41     | 700   | 42                    | 42     | 730   | 69                  | 78     | 1,641  | 97                     | 117    | 3,548  |
| Chap 10 | 8                     | 8      | 828   | 10                    | 17     | 989   | 11                  | 17     | 989    | 12                     | 17     | 989    |
| Add'l   | 50                    |        |       | 75                    |        |       | 100                 |        |        | 100                    |        |        |
| Total   | 231                   | 334    | 2,088 | 349                   | 362    | 2,702 | 509                 | 522    | 10,730 | 641                    | 641    | 22,385 |

See details under separate file.

**APPENDIX A3:  
NGBS Rating, Zone 6**  
(See attached separate file)

|         | Minneapolis MN Bronze 2009 |        |       | Minneapolis MN Silver 2009 |        |       | Minneapolis MN Gold 2009 |        |        | Minneapolis MN Emerald 2009 |        |        |
|---------|----------------------------|--------|-------|----------------------------|--------|-------|--------------------------|--------|--------|-----------------------------|--------|--------|
|         | Min                        | Actual | Cost  | Min                        | Actual | Cost  | Min                      | Actual | Cost   | Min                         | Actual | Cost   |
| Chap 5  | 50                         | 60     | 0     | 64                         | 75     | 222   | 93                       | 115    | 1,962  | 121                         | 134    | 5,014  |
| Chap 6  | 43                         | 107    | 246   | 59                         | 113    | 246   | 89                       | 134    | 1,462  | 119                         | 161    | 5,789  |
| Chap 7  | 30                         | 43     | 770   | 60                         | 72     | 1,582 | 80                       | 140    | 5,910  | 100                         | 150    | 7,825  |
| Chap 8  | 25                         | 37     | 0     | 39                         | 42     | 320   | 67                       | 84     | 2,145  | 92                          | 113    | 5,373  |
| Chap 9  | 25                         | 42     | 700   | 42                         | 42     | 700   | 69                       | 68     | 1,325  | 97                          | 115    | 3,612  |
| Chap 10 | 8                          | 8      | 1,028 | 10                         | 17     | 1,189 | 11                       | 17     | 1,189  | 12                          | 17     | 1,189  |
| Add'l   | 50                         |        |       | 75                         |        |       | 100                      |        |        | 100                         |        |        |
| Total   | 231                        | 297    | 2,744 | 349                        | 361    | 4,259 | 509                      | 558    | 13,992 | 641                         | 690    | 28,801 |

|         | Minneapolis MN Bronze 2012 |        |       | Minneapolis MN Silver 2012 |        |       | Minneapolis MN Gold 2012 |        |       | Minneapolis MN Emerald 2012 |        |        |
|---------|----------------------------|--------|-------|----------------------------|--------|-------|--------------------------|--------|-------|-----------------------------|--------|--------|
|         | Min                        | Actual | Cost  | Min                        | Actual | Cost  | Min                      | Actual | Cost  | Min                         | Actual | Cost   |
| Chap 5  | 50                         | 55     | 0     | 64                         | 67     | 103   | 93                       | 110    | 2,462 | 121                         | 127    | 4,059  |
| Chap 6  | 43                         | 109    | 246   | 59                         | 115    | 246   | 89                       | 135    | 1,355 | 119                         | 161    | 4,935  |
| Chap 7  | 30                         | 69     | 215   | 60                         | 69     | 215   | 80                       | 84     | 316   | 100                         | 117    | 4,736  |
| Chap 8  | 25                         | 37     | 320   | 39                         | 40     | 511   | 67                       | 76     | 1,781 | 92                          | 102    | 5,099  |
| Chap 9  | 25                         | 43     | 617   | 42                         | 43     | 617   | 69                       | 90     | 2,122 | 97                          | 117    | 3,885  |
| Chap 10 | 8                          | 8      | 1,028 | 10                         | 17     | 1,189 | 11                       | 17     | 1,189 | 12                          | 17     | 1,189  |
| Add'l   | 50                         |        |       | 75                         |        |       | 100                      |        |       | 100                         |        |        |
| Total   | 231                        | 321    | 2,426 | 349                        | 351    | 2,881 | 509                      | 512    | 9,225 | 641                         | 641    | 23,903 |

See details under separate file.

**APPENDIX B1A-F:  
LEED-H 2008 Ratings for 2009 IECC and 2012 IECC Compliance**

See details under separate files.

## **APPENDIX B2A-F: LEED-H v4 Ratings for 2009 IECC Compliance**

See details under separate files.

## **APPENDIX B2G-L: LEED-H v4 Ratings for 2012 IECC Compliance**

See details under separate files.

## APPENDIX C: Location Adjustment Factors

| Metropolitan Area   | Location Adjustment Factor <sup>1</sup> |
|---------------------|---|
| Atlanta, GA         | 0.87                                    |
| Austin, TX          | 0.78                                    |
| Boston, MA          | 1.22                                    |
| Charlotte, NC       | 0.85                                    |
| Chicago, IL         | 1.22                                    |
| Dallas, TX          | 0.84                                    |
| Denver/Aurora CO    | 0.90                                    |
| Detroit, MI         | 1.06                                    |
| Houston/Baytown, TX | 0.84                                    |
| Jacksonville, FL    | 0.82                                    |
| Las Vegas, NV       | 1.03                                    |
| Los Angeles, CA     | 1.08                                    |
| Minneapolis, MN     | 1.14                                    |
| Oklahoma City, OK   | 0.77                                    |
| Orlando, FL         | 0.88                                    |
| Raleigh/Cary NC     | 0.86                                    |
| Phoenix, AZ         | 0.86                                    |
| San Antonio, TX     | 0.81                                    |
| Seattle/Tacoma, WA  | 1.02                                    |
| St. Louis, MO       | 1.03                                    |

<sup>1</sup>RSMEANS Residential Cost Data 2013

## APPENDIX D: House Specifications

|                        | 3DallasTX         | 5DenverCO       | 6MinnMN         |
|------------------------|-------------------|-----------------|-----------------|
| Lot Size (approx.)     | 75x300            | 75x300          | 75x300          |
| Bsmt SF (unfinished)   | n/a               | 960             | 960             |
| 1st SF                 | 960               | 960             | 960             |
| 2nd SF                 | 1,360             | 1,360           | 1,360           |
| Finished SF            | 2,320             | 2,320           | 2,320           |
| Duct, SF, supply       | 470               | 470             | 470             |
| Duct, SF, return       | 174               | 261             | 261             |
| Floor                  | TJI 230 11 7/8"   | TJI 230 11 7/8" | TJI 230 11 7/8" |
| Floor, spacing         | 16"               | 16"             | 16"             |
| Floor area, VT         | 472               | 472             | 472             |
| Floor area, kitchen VT | 260               | 260             | 260             |
| Furnace AFUE           | 0.80              | 0.80            | 0.80            |
| Furnace Fuel           | natural gas       | natural gas     | natural gas     |
| Furnace Location       | attic             | basement        | basement        |
| Roof Pitch             | 6/12              | 6/12            | 6/12            |
| Slab, perimeter        | 148               | 148             | 148             |
| Volume Bsmt            |                   | 7,680           | 7,680           |
| Volume 1st             | 6,480             | 6,480           | 6,480           |
| Volume 2nd             | 12,800            | 12,800          | 12,800          |
| Volume Total           | 19,280            | 26,960          | 26,960          |
| Water Heater effc.     | 59%               | 59%             | 59%             |
| Water Heater size      | 40 gallon         | 40 gallon       | 40 gallon       |
| Water Heater Fuel      | natural gas       | natural gas     | natural gas     |
| Water Heater location  | attic             | basement        | basement        |
| Wall SF                | 2,664             | 2,664           | 2,664           |
| Wdw % wall             | 8.14%             | 8.14%           | 8.14%           |
| Wdw SF                 | 229               | 229             | 229             |
| Wdw specs              | .35/.30           | .35/.30         | .35/.30         |
| Conditioned SF         | 2,320             | 3,280           | 3,280           |
| Other                  | Irrigation System | n/a             | n/a             |

**APPENDIX E:**  
**Cost of ENERGY STAR version 2 for a 2009 IECC Compliant House**

| <b>Estar version 2</b>                  |              |
|---|--------------|
| 6% duct leakage                         | \$111        |
| Estar DW                                | \$0          |
| Estar Fixtures (5)                      | \$315        |
| 30% cfl(+)                              | \$26         |
| BD test                                 | \$100        |
| <b>Total Energy Star version 2 Cost</b> | <b>\$552</b> |

## APPENDIX F: Cost of ENERGY STAR version 3 for a 2009 IECC Compliant House

| 2009 IECC - Cost of ENERGY STAR v3 Compliance  |                |                |                |
|--|----------------|----------------|----------------|
| Practices  | Zone 3         | Zone 5         | Zone 6         |
| <b>ENERGY STAR COMPLIANT EQUIPMENT<br/>(Subtotal Component Costs)</b>  | <b>\$2,021</b> | <b>\$2,507</b> | <b>\$3,171</b> |
| Add 30% hi-eff. bulbs  | \$13           | \$13           | \$13           |
| Radiant barrier  | \$872          |                |                |
| Window Modification .35/.30 to .30/.40   |                |                | \$664          |
| 14.5 SEER AC   | \$211          |                |                |
| 90 AFUE furnace  |                | \$1,232        | \$1,232        |
| 61% water heater*  | \$197          | \$197          | \$197          |
| 5ACH50   | \$492          |                |                |
| 4ACH50   |                | \$830          | \$830          |
| ENERGY STAR Dishwasher   | \$0            | \$0            | \$0            |
| ENERGY STAR Refrigerator   | \$0            | \$0            | \$0            |
| ENERGY STAR bath fans (3)  | \$236          | \$236          | \$236          |
| <b>EA 1.1 ENERGY STAR CHECKLISTS<br/>(Subtotal Checklist Costs)</b>  | <b>\$1,031</b> | <b>\$1,031</b> | <b>\$1,031</b> |
| <b>Estar checklist #1 - Thermal Enclosure</b>  | 0              | 0              | 0              |
| 4.4.5 Advanced Framing including insulated corners & headers, ladder frames at intersecting walls & min. jacks.                                      | 0              | N/A            | N/A            |
| 4.4.5 2x4 w/R-5 continuous   | N/A            | 0              | 0              |
| <b>Estar checklist #2 HVAC system - Contractor Checklist</b>   |                |                |                |
| 1.1 Ventilation system installed that meets ASHRAE 62.2-2010 (Use supply air ducting)  | 0              | 0              | 0              |
| 9. Air flow tests  | 0              | 0              | 0              |
| 10. Balance air flow   | 222            | 222            | 222            |
| <b>Estar checklist #3 HVAC system - Rater Checklist</b>  |                |                |                |
| 1. Review ACCA Manual J <sup>A</sup>   | 54             | 54             | 54             |
| 1.3 Verify supply & return system static pressure <sup>A</sup>   | 54             | 54             | 54             |
| 2. Duct Quality Inspection to be Performed at Close-in <sup>A</sup>  | 54             | 54             | 54             |
| 2.8 Pressure balanced bedrooms w/jump ducts  | 316            | 316            | 316            |
| 4.2 Rater measured duct leakage to out < 4CFM25 Test <sup>B</sup><br>(Blower door & duct blaster tests)  | 150            | 150            | 150            |
| 5.1 Whole building delivered ventilation measured by rater <sup>A</sup>  | 54             | 54             | 54             |
| 6.4 Continuous ventilation has override controls   |                |                |                |
| 10.1 CAZ test (minimum 10 min. run) <sup>A</sup>   | 54             | 54             | 54             |
| <b>Estar checklist #4 - Water Mgmt. System Builder Chklist</b>   |                |                |                |
| Required rater review <sup>A</sup>   | 54             | 54             | 54             |
| 1.7 Gasketed sump crock cover  | 20             | 20             | 20             |
| <b>TOTAL COST OF ENERGY STAR VERSION 3 COMPLIANCE</b>  | <b>\$3,051</b> | <b>\$3,538</b> | <b>\$4,202</b> |
| *Cost can be eliminated with a base 50 gallon heater   |                |                |                |
| <sup>A</sup> One half hour at professional rate of \$107.50/hr.  |                |                |                |
| <sup>B</sup> Base house assumptions have at least some ducts in the attic, therefore code requires duct leakage testing. (\$150 cost in base house.) |                |                |                |

## Cost of ENERGY STAR version 3 for a 2012 IECC Compliant House

### 2012 IECC Cost of Energy Star v3 Compliance

| Practices   | Zone 3         | Zone 5         | Zone 6         |
|---|----------------|----------------|----------------|
| <b>ENERGY STAR COMPLIANT EQUIPMENT (Subtotal Component Costs)</b>       | \$1,517        | \$1,666        | \$2,331        |
| Add 5% hi-eff. bulbs  | \$2            | \$2            | \$2            |
| Radiant barrier   | \$872          |                |                |
| Window Modification .35/.30 to .30/.40                                  |                |                | \$664          |
| 14.5 SEER AC  | \$211          |                |                |
| 90 AFUE furnace   |                | \$1,232        | \$1,232        |
| 61% water heater*   | \$197          | \$197          | \$197          |
| 5ACH50, 4ACH50, 4ACH50  | \$0            | \$0            | \$0            |
| ENERGY STAR Dishwasher  | \$0            | \$0            | \$0            |
| ENERGY STAR Refrigerator  | \$0            | \$0            | \$0            |
| ENERGY STAR bath fans (3)   | \$236          | \$236          | \$236          |
| <b>EA 1.1 ENERGY STAR CHECKLISTS (Subtotal Checklist Cost)</b>          | \$881          | \$881          | \$881          |
| <b>Estar checklist #1 - Thermal Enclosure</b>                           | 0              | 0              | 0              |
| <b>4.4.5 ADVANCED FRAMING (SEE DETAILS)</b>                             | 0              | 0              | 0              |
| 4.4.5 2x4 w/R-5 continuous  | 0              | 0              | N/A            |
| 4.4.5 2x6 w/R-5 continuous  | N/A            | N/A            | 0              |
| <b>Estar checklist #2 HVAC system - Contractor Checklist</b>            |                |                |                |
| 1.1 Ventilation system installed that meets ASHRAE 62.2-2010            | 0              | 0              | 0              |
| 9. Air flow tests   | 0              | 0              | 0              |
| 10. Air balance   | 222            | 222            | 222            |
| <b>Estar checklist #3 HVAC system - Rater Checklist</b>                 |                |                |                |
| 1. Review ACCA Manual J <sup>A</sup>                                    | 54             | 54             | 54             |
| 1.3 Verify supply & return system static pressure <sup>A</sup>          | 54             | 54             | 54             |
| 2. Duct Quality Inspection to be Performed at Close-in <sup>A</sup>     | 54             | 54             | 54             |
| 2.8 Pressure balanced bedrooms w/jump ducts                             | 316            | 316            | 316            |
| 4.2 Rater measured duct leakage to out < 4CFM25 Test <sup>B</sup>       | 0              | 0              | 0              |
| (Blower door & duct blaster tests) <sup>B</sup>                         | 0              | 0              | 0              |
| 5.1 Whole building delivered ventilation measured by rater <sup>A</sup> | 54             | 54             | 54             |
| 6.4 Continuous ventilation has override controls                        |                |                |                |
| 10.1 CAZ test (minimum 10 min. run) <sup>A</sup>                        | 54             | 54             | 54             |
| <b>Estar checklist #4 - Water Mgmt. System Builder Chklist</b>          |                |                |                |
| Rater Verification of checklist #4. <sup>A</sup>                        | 54             | 54             | 54             |
| 1.7 Gasketed sump crock cover   | 20             | 20             | 20             |
| <b>TOTAL COST OF ENERGY STAR VERSION 3 COMPLIANCE</b>                   | <b>\$2,398</b> | <b>\$2,547</b> | <b>\$3,211</b> |

\*Cost can be eliminated with a base 50 gallon heater

<sup>A</sup>One half hour at professional rate of \$107.50/hr.

<sup>B</sup>Base house assumptions have at least some ducts in the attic, therefore code requires blower door and duct blaster testing. (\$300 cost in base house.)

## APPENDIX G: Mandatory/Prerequisites

| Mandatory and Prerequisite Practices (1 of 2)   |  |  |  |  |  |
|---|--|--|--|--|--|
| Mandatory & Prerequisite Practices  | National Green Building Standard™  | LEED-H                                     |  | IECC   |  |
|   | 2012   | 2008                                       | v4   | 2009   | 2012   |
| 701.3 Third Party Verification  | Mandatory  | Prerequisite                               | Prerequisite                                 |  |  |
| ID 1.1 & IN P1 - Preliminary Rating   |  | Prerequisite                               | Prerequisite                                 |  |  |
| ID 2.1 Durability Planning w/project team (optional point in ID1.2; 3@3hrs ea.)                         | Mandatory<br>602.1.1Capillary breaks 602.1.3.1 Foundation drains 602.1.4.1Foundation damproof. 062.1.4.2 crawlspace VB 602.1.7 WRB, dry insulation. 602.1.9 Flashing. 602.1.11 tile backing mat'l. 602.1.13 ice barrier. 602.1.14 sloping architectural features 602.4.1 Finished grade. 901.6 No carpet in wet areas. | Prerequisite                               | MR P1 Meet ENERGY STAR Water Mgmt. Checklist |  |  |
| ID 2.2 Durability Mgmt. Meet checklist requirements and have <u>Quality Assurance program</u> in place. |  | Prerequisite                               | Not required - MR 1 point - See MR P2        |  |  |
| L&T P1- 100 Yr. Floodplain Avoidance  |  |  | Prerequisite                                 |  |  |
| SS 1.1 Erosion Controls During Construction   | No cost points - all practices required by SWMP (Base House)   | Prerequisite                               | Prerequisite                                 |  |  |
| SS 2.1 No invasive plants   | Not required   | Prerequisite                               | Prerequisite                                 |  |  |
| WE P1 Water Metering  | Standard Practice no points  | Standard Practice no points                | Prerequisite                                 |  |  |
| Estar checklist #1 - Thermal Enclosure  | Mandatory - 701.4.3.1  | Prerequisite                               | Prerequisite                                 | Yes 402.4  | Yes 402.4.1.2  |
| Estar checklist #2 HVAC system - Contractor Checklist   |  |  | Prerequisite                                 |  |  |
| 1.1 Ventilation system installed that meets ASHRAE 62.2-2010  | Mandatory for 2012 code otherwise  |  | Prerequisite                                 | 402.4 Yes for <7ACH50  | Yes 402.4.1.2  |
| 9. Air flow tests   | SOW - assumed to be in reference house   |  | Prerequisite                                 |  |  |
| 10. Air balance   | 704.5.2.2 Optional points and cost   |  | Prerequisite                                 |  |  |
| Estar checklist #3 HVAC system - Rater Checklist  |  |  | Prerequisite                                 |  |  |
| 1. Review ACCA Manual J <sup>A</sup>  | Mandatory for design 701.4.1.1   |  | Prerequisite                                 | Yes M1401.3  | Yes M1401.3  |
| 1.3 Verify supply & return system static pressure <sup>A</sup>  |  |  | Prerequisite                                 |  |  |
| 2. Duct Quality Inspection to be Performed at Close-in <sup>A</sup>                                     |  |  | Prerequisite                                 |  |  |
| 2.8 Pressure balanced bedrooms w/jump ducts   | 704.3 Optional points and cost   |  | Prerequisite                                 |  |  |
| 4.2 Rater measured duct leakage to out < 4CFM25 Test  |  | Estar v2 allows 6% duct leakage to outside | Prerequisite                                 | R403.2.2 No duct testing if located in cond. space; or test & >6% cfa out max. | R402.4.1.2 No duct testing if located in cond. space; or test >4% cfa out max. |
| 5.1 Whole building delivered ventilation measured by rater  |  |  | Prerequisite                                 |  |  |
| 6.4 Continuous ventilation has override controls  |  |  | Prerequisite                                 |  |  |
| 10.1 CAZ test (minimum 10 min. run)   |  |  | Prerequisite                                 |  |  |

| Mandatory and Prerequisite Practices (2 of 2)  |   |  |  |  |   |
|--|---|--|--|--|---|
| <b>Estar checklist #4 - Water Mgmt. System Builder Chklist</b>                                   |   |  |  |  |   |
| <b>Rater verification of checklist #4</b>  |   |  |  |  |   |
| <b>1.7 Gasketed sump crock cover</b>   | 704.5.2.1 Points and cost   |  | Prerequisite                           |  |   |
| <b>EA 11.1 Refrigerant Charge Test</b>   | 704.4.2(2) points and cost  | Prerequisite   | EA optional 1 point                    |  |   |
| <b>EA P2 Energy Metering - Install electric &amp; gas meters</b>                                 | Standard Practice no points   | Standard Practice no points  | Prerequisite                           |  |   |
| <b>EA P3 Education of Occupant-</b>  | 1001.1(3) Homeowner's Manual Mandatory. Walkthru gets optional points & cost.     | AE prerequisite is 1 hr walkthru; optional points & costs for add1 | Prerequisite                           |  |   |
| <b>701.4.3.3 Fenestration conforms with NFRC 400 max. leakage</b>                                | Mandatory   |  |  |  | Roughly equivalent to R402.4.1.2 Testing (zones 3 and north). |
| <b>701.4.3.4 - No or IC-rated recessed lights</b>  | Mandatory   |  |  |  |   |
| <b>701.4.4 - Min. 50% hi-efficacy lighting/lamps</b>   | Mandatory   |  |  | 404.1-50% min.                             | R404.1 75% min.   |
| <b>801.5 - Water closets max. flush 1.28 gallons for Gold &amp; Emerald levels.</b>              | Mandatory   |  |  |  |   |
| <b>MR 1.1 Framing Lumber Waste Factor &lt; 10%</b>   | Optional points with cost   | Prerequisite   | Optional points with cost              |  |   |
| <b>MR 3.1 Construction Waste Mgmt Planning &amp; Documented diversion rate for waste ( 1 hr.</b> | Optional points and cost  | Prerequisite   | Optional points and cost               |  |   |
| <b>MR P1 Only use certified tropical wood</b>  | Optional points and cost  | Prerequisite   | Prerequisite                           |  |   |
| <b>MR P2 Durability Management- ENERGY STAR Water Mgmt. Checklist</b>                            | See 602. Mandatories under ID 2.1   | See ID 2.1 and ENERGY STAR 1.7                                     |  |  |   |
| <b>EQ 5.1 &amp; EQ P1 - Exhaust ventilation of 100cfm kitchen &amp; 50 cfm bath</b>              | 902.1.1 Mandatory   | Prerequisite & fans Estar labeled                                  | Prerequisite & fans Estar labeled      |  |   |
| <b>EQ 2 &amp; EQ P2- Combustion Venting - Power or direct vent equipment</b>                     | 901.1.3 Optional points and cost  | Prerequisite   | Prerequisite                           |  |   |
| <b>EQ 2 &amp; EQ P2 - CO monitor on each floor</b>   | Optional points and cost  | Prerequisite   | Prerequisite                           |  |   |
| <b>EQ-4.1 &amp; IEQ P1 - Basic Outdoor Ventilation - exhaust</b>                                 | Optional points with cost 2009; Code requirement 2012.                            | Prerequisite   | Prerequisite                           | No, if house just meets 7ACH50 requirement | ASHRAE 62.2 compliance.                                       |
| <b>EQ-5.1 &amp; EQ P1- Basic Local Exhaust -Energy Star labeled bath/kitchen fans</b>            | Mandatory 902.1.1- Exhaust ventilation; Optional points with cost for Estar fans. | Prerequisite   | Prerequisite                           |  |   |
| <b>EQ-6.1 Distribution of Space Heating &amp; Cooling</b>  | 701.4.2.3 Mandatory   | Prerequisite ACCA Manuals J & D                                    | Not Required                           | M1401.3                                    | M1401.3   |
| <b>EQ-7.1 &amp; IEQ P5 - Merv 8 Filters</b>  | 902.2.3 No cost points assigned - base assumption                                 | Prerequisite   | Prerequisite                           |  |   |
| <b>EQ-9.1 &amp; IEQ P4 Radon-resistant construction in High Risk Area (Zone 1)</b>               | 902.3 Mandatory   | Prerequisite   | Prerequisite                           |  |   |
| <b>EQ 10.1 &amp; IEQ P3 - Garage Pollutant Protection - no HVAC in grg.</b>                      | 901.3 Air Seal Mandatory; Equipment in Cond. Space optional points with cost      | Prerequisite   | Prerequisite                           |  |   |
| <b>901.1.4 Gas fired fireplaces/wood stoves vented outside</b>                                   | Mandatory, however base house assumes no f/p or wood stove                        | Prerequisite EQ- 2 plus gasketed doors                             | Prerequisite EQ P2 plus gasketed doors |  |   |
| <b>901.4 Sheathing is DOC PS1 or 2 and Exposure 1</b>  | Mandatory   | Optional points and cost   | Optional points and cost               |  |   |
| <b>A&amp;E 1.1 Operations &amp; training manual &amp; 1 hr. walkthru</b>                         | See EA P3 above   |  |  |  |   |
| <b>1001.1(1) Certificate of Green Building</b>   | Mandatory   | Prerequisite   | Prerequisite                           |  |   |

## APPENDIX H: References

### Programs:

EnergyStar Version 3 Guidelines,

[www.energystar.gov/index.cfm?c=bldrs\\_lenders\\_raters.nh\\_v3\\_guidelines](http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_guidelines)

LEED-H 2008,

[www.usgbc.org/leed/homes](http://www.usgbc.org/leed/homes)

LEED v4 HD&C,

[www.usgbc.org/resources/leed-v4-homes-and-midrise-ballot-version](http://www.usgbc.org/resources/leed-v4-homes-and-midrise-ballot-version)

LEED v4 HD&C checklist,

[www.usgbc.org/resources/leed-v4-homes-design-and-construction-checklist](http://www.usgbc.org/resources/leed-v4-homes-design-and-construction-checklist)

Mortgage Industry National Home Energy Rating Standards, Residential Energy Services Network (Resnet®),

[www.resnet.us/professional/standards/mortgage/RESNET\\_Mortgage\\_Industry\\_National\\_HERS\\_Standards.pdf](http://www.resnet.us/professional/standards/mortgage/RESNET_Mortgage_Industry_National_HERS_Standards.pdf)

National Green Building Standard™, ICC 700-2012,

[www.homeinnovation.com/services/certification/green\\_homes](http://www.homeinnovation.com/services/certification/green_homes)

### Other Resources:

U.S. Department of Energy *Building America Solutions Center*,

[basc.pnnl.gov/](http://basc.pnnl.gov/)





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