Green Home Building Rating Systems—A Sample Comparison

PREPARED FOR
National Association of Home Builders

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Disclaimer

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EXECUTIVE SUMMARY

This report evaluates the costs and technical requirements of bringing two sample code-compliant production houses in different climate zones (Dallas and Washington, DC metropolitan areas) into compliance with three different green building rating systems at one point in time (January 2008). This preliminary sample of model homes was evaluated using all three green building rating systems, and the results are presented as an introduction to the systems only—not as final statistically significant conclusions. These numbers are not conclusive as neither the rating systems nor their respective certification services have been finalized. When the certification services for these programs evolves and the number of homes certified increases, additional studies will be required to establish statistically significant comparisons. Current estimates are presented here for informational purposes only.

The three rating systems in question include:

- NAHB Model Green Building Guidelines (GBG), first published in 2005;
- ICC-NAHB National Green Building Standard™ Version 2 (NGBSv2) from December 2007;
- LEED for Homes (LEED-H) in its most recent January 2008 version.

Costs vary between all rating systems, with the GBG the least costly rating system overall. For direct compliance costs—that is, those costs associated only with changes or additions in construction and not including any program costs —the NGBSv2 surpasses estimated GBG costs by only a few hundred dollars at the introductory compliance levels (e.g., "Bronze"), and increases costs significantly over the GBG at the "Gold" level of compliance – amounting to $2,000 to $3,000 in variances between the two.

The first level of compliance in LEED-H ("Certified") was calculated at roughly three times as much as the GBG or the NGBSv2 equivalent levels ("Bronze") overall for this sample. LEED-H ratings at higher levels are similarly higher in costs to comply than the other two rating systems, with the magnitude of difference diminishing as higher levels are reached; at the highest level (NGBSv2's "Emerald" or LEED-H's "Platinum") costs are similar. This is summarized below:

Table 1. Cost of Compliance[A]

Rating System	Bronze/Certified	Silver	Gold	Emerald/Platinum
GBG	1.0 – 1.4%	2.3 – 3.4%	4.7 – 6.4%	NA
NGBSv2	1.1 – 1.7%	2.8 – 3.1%	6.9 – 7.6%	16.3 – 16.9%
LEED-H	3.6 – 5.6%	5.1 – 7.4%	11.2 –13.5%	17.3 – 22.9%

[A] Percentage of baseline house cost shown.

In all cases, builder overhead and programmatic costs for LEED-H were greater than those estimated for either of the other systems, with an estimate between $1,441 and $3,735 for LEED-H registration, verification, and certification compared to the $500 - $900 verification and certification estimates for GBG or NGBSv2. Note that all three certifications are in their infancy; so, costs will likely change.

Construction stringency comparisons between the systems were also performed in the areas of mandatory requirements, openness to alternatives, and credibility. LEED-H requires more mandatory actions than both the NGBSv2 and GBG, yet it rewards those actions with fewer proportional points. It also does not require a minimum threshold in all green building areas. As defined by the number of mandatory requirements, then, LEED-H is more inflexible. The GBG and NGBSv2 are less flexible when accounting for allowances beyond mandatory points; this is mirrored in the more prescriptive language of the GBG and NGBSv2.

Overall, the magnitude or effort of actions required of LEED-H and NGBSv2 were comparable. This credibility is further evidenced by the processes in which these rating systems as well as the GBG were developed; all were developed by consensus with national review. The NGBSv2, when approved as the first ANSI standard, will provide the highest level of credibility by virtue of the rigor, transparency, and publicly-solicited input required for this approval. On this point, then, the NGBSv2 ranks highest.

The results presented are only preliminary since the NGBS will be released in the spring of 2008 but the baseline costs reflect the industry's current pricing structure. Similarly, the actual costs associated for all three rating systems will likely alter dramatically even during this short timeframe given the volatility of material costs, changing availability of products, and the overall residential market. Additional data collection and trend analysis are critical.

BACKGROUND

The recent emergence of three national green home building rating systems has resulted in questions regarding the cost of compliance with each system. Further, some municipalities have begun mandating the reduction of greenhouse gas (GHG) emissions,[1] and have made land usage and/or development approval contingent on construction that exceeds energy code minimums or meets other environmental standards. Others have provided voluntary incentives for the adoption of construction techniques that meet these requirements, such as expedited permitting or tax offerings. Still others have no mandates or incentives, but have witnessed an increase in new homes that meet these requirements because they satisfy local market tastes and demand.

To demonstrate compliance and obtain approval for construction in these areas, homes are often required to be certified in a green building program and/or labeled as ENERGY STAR® homes. Where such mandates effectively create a de facto building code from a voluntary program, it is important to understand the cost of compliance. Since one of the three national green building rating systems will likely be the benchmark in future local government mandates, the cost of compliance with these rating systems, as well as the relative stringency of each system—is studied here.

Contents

The three national green building rating systems include:

- NAHB Model Green Home Building Guidelines™ (GBG)
- National Green Building Standard™ – Draft 2 - Dec 21, 2008 (NGBSv2)
- LEED for Homes® – January 2008 Edition (LEED-H)

Each system's procedures allow the rater to apply points to a house that employs various green building products and processes. Each has its own methodology for accruing points and for determining a project's compliance with the criteria that supports the rating level. Further, each has levels of compliance ranging from just meeting the minimum requirements ("Bronze" in the NGBSv2, for example) to the highest level ("Emerald" in the NGBSv2). The levels of compliance are outlined in Table 2.

Table 2. Rating Levels for the three Green Building Systems

	GBG	NGBSv2	LEEDh
Achievement level	Bronze	Bronze	Certified
Lowest	Silver	Silver	Silver
↓	Gold	Gold	Gold
Highest		Emerald	Platinum

At each level of achievement, each system requires a minimum number of points in several subject areas, plus mandatory requirements. The subject areas covered by the rating systems are very similar, as are many of the techniques and technologies that are granted points within each. Table 3 and Table 4 summarize the minimum points required for compliance at the first two levels of achievement and the relative weight of points allocated to each subject area (referred to as *Chapter* in GBG and LEED-H and *Section* in NGBSv2). For brevity, point

[1] The U.S. Environmental Protection Agency (EPA) defines GHGs as primarily carbon dioxide, but also including methane, nitrous oxide, and fluorocarbons. http://www.epa.gov/climatechange/emissions/index.html

allocations for higher levels of performance are not presented in the body of this report but, rather, are contained in the study's calculations.[2]

Table 3. Minimum Point Requirements for First Level (*Bronze*, *Certified*)

GBG Chapter/ NGBS Section	GBG Bronze		NGBSv2 Bronze		LEED-H[B] Certified		LEED-H Section
	Points	% Total	Points	%Total	Points	%Total	
Site [A]	n/a		79	NA[A]	0		Location & Linkages (LL)
Lot	8	3.4%	39	17.6%	5	11.1%	Sustainable Sites (SS)
Resource Efficiency	44	18.6%	45	20.3%	2	4.4%	Materials & Resources (MR)
Energy Efficiency	37	15.6%	30	13.5%	0	0%	Energy & Atmosphere (EA)
Water Efficiency	6	2.5%	14	6.3%	3	6.8%	Water Efficiency (WE)
IEQ & Global Imp.	32	13.5%	36	16.2%	6	13.3%	Environmental Quality (EQ)
Operations, Maint. & Ed [C]	10	4.2%	8	3.6%	0	0%	Awareness & Ed. (AE)
Add'l Points - Any Section	100	42.2%	50	22.5%	29	64.4%	
Total Min. Points[A]	237		222		45		

[A] Site Design & Development points in the NGBSv2 are earned independently from the points required for house baseline program minimums. Only Chapters 5 through 10 are aggregated in the total and percentages shown in this table.
[B] This assessment is based on the Dallas house (2,509 s.f. on slab foundation). Because LEED-H minimum point requirements vary with the ratio of bedrooms to total conditioned space, there is a 13% variance in minimum point requirements between the Dallas and Metro DC houses.
[C] The GBG chapter titled *Global Impact* has been incorporated into Sections 9 and 10 – *IEQ* and *Operations, Maintenance, and Building Owner Education* in the NGBSv2.

Table 4. Minimum Point Requirements for Second Level (Silver)

GBG Chapter/ NGBS Section	GBG Silver		NGBSv2 Silver		LEED-H[B] Silver		LEED-H Section
	Points	% Total	Points	% Total	Points	% Total	
Site[A]	NA		104	NA	0		Location & Linkages (LL)
Lot	10	3.2%	66	16.3%	5	8.3%	Sustainable Sites (SS)
Resource Efficiency	60	19.3%	79	19.5%	2	3.3%	Materials & Resources (MR)
Energy Efficiency	62	19.9%	60	14.8%	0	0%	Energy & Atmosphere (EA)
Water Efficiency	13	4.2%	26	6.4%	3	5.0%	Water Efficiency (WE)
IEQ & Global Imp.	54	17.4%	65	16.0%	6	10.0%	Environmental Quality (EQ)
Operations, Maint. & Ed [C]	12	3.8%	10	2.4%	0	0%	Awareness & Ed. (AE)
Add'l Points Any Section	100	32.2%	100	24.6%	44	73.4%	
Total Min. Points[A]	311		406		60		

[A] Site Design & Development points in the NGBSv2 are earned independently from the points required for house baseline program minimums. Only Chapters 5 through 10 are aggregated in the total and percentages shown in this table.
[B] This assessment is based on the Dallas house (2,509 s.f. on slab foundation). Because LEED-H minimum point requirements vary with the ratio of bedrooms to total conditioned space, there is a 13% variance in minimum point requirements between the Dallas and Metro DC houses.
[C] The GBG chapter titled *Global Impact* has been incorporated into Sections 9 and 10 – *IEQ* and *Operations, Maintenance, and Building Owner Education* in the NGBSv2.

Comparison Methodology

Team Members

A team was assembled to establish the scope and objectives of the study. Team members included researchers from the NAHB Research Center, large- and small-volume builders, and a LEED for Homes architect and builder. The builder members provided expertise to define the base house designs, determine regions to study, and select products and practices to achieve ratings under each of the national green home building systems. Products and practices were selected based on the need for obtaining points in a certain section or chapter, the cost of the

[2] Five Workbooks in Microsoft Excel format were compiled and separately delivered with this report. The Workbooks are titled, *GBG Final*, *NGBSv2 Final v2.0*, *LEEDh Dallas Final v2.0*, *LEEDh Metro DC Final v2.0,* and *NGBSv2 Line Item Cost*. Each Workbook contains several spreadsheets that cover the rating, cost estimates, and explanation for the rating system identified by the Workbook's title.

measure, its feasibility and regional appropriateness, and repeatability in a production home building environment.

Baseline House Specifications

If an above-code specification or feature was available at no additional cost and/or a code-minimum product is not widely available, the upgraded item was chosen. Examples of no-cost, above-code specifications include an 80 AFUE furnace (78 AFUE is the code-minimum), a 0.62 EF water heater (0.58 is the minimum) and an ENERGY STAR dishwasher. All of these better performers (from a green building perspective) are available at costs comparable to an alternative model of lesser efficiency.

It was assumed that no regional planning, neighborhood covenants, or reforestation mandates were in place that would stipulate a minimum landscape package. The assumption for the baseline landscaping package was a finely graded and hydro-seeded lot without additional landscaping. Driveways and lead walks were assumed to be asphalt.

Table 5 describes the two baseline homes used in the study. The house plans were selected from two distinct metropolitan areas and the size, style, and foundation type of each plan was deemed representative of a typical home in each region.

In addition to the specifications covered in Table 5, it was assumed that the houses were built on finished lots purchased from a developer in a large subdivision. Therefore, the homes were unable to earn any points under the green building rating systems for land development or passive solar design and were unqualified for many lot-related points.[3]

Code Minimum Definition

Actual single-family home plans were used from the two metropolitan areas. Builders' original specifications were slightly modified to form baseline houses that met the minimum requirements of the International Residential Code 2003 (IRC 2003). Performance provisions embodied in the building code—such as using Manual J for HVAC system design and sealing ducts with code-approved adhesives—were assumed to be in practice locally, whether or not they are regularly enforced. Other practices, such as air sealing and weather-resistant barriers, that are common but not required by the building code, were assumed not to be used in the baseline houses.

Green Rating

A baseline rating was conducted for the houses using the three green building rating systems. Architectural plans and the specifications outlined in Table 5 were used in this assessment. For each green building system, a line-by-line assessment was conducted to determine the most logical actions or products which could be incorporated into the house plan. Products and practices were selected based on their ease of implementation, cost-effectiveness, and points accrued toward achieving a green rating. This process was performed successively until the highest level of award in each system was reached. By design, the process involved co-development of the scores and the costs. Initial results were shared with a group of builders who reviewed the compliance paths and costs that were developed. Revisions were made based on that builder feedback.

[3] Passive solar design points are available when a lot with the right exposure can be paired with a suitable design, however, raters in this analysis included repeatability as a criterion of the assessment.

Table 5. Baseline House Specifications

	Dallas-Fort Worth TX	Metro Wash., D.C.
Located in County and State	Denton, TX	Montgomery, MD
Climate Zone – IRC 2003[4]	5	10
Climate Zone – IRC 2006[4]	3	4
Heating degree days (HDD)	2,000 – 2,499	4,500 – 4,999
Cooling degree days (CDD)	2,568	898
Lot size; Square Feet	8,000	8,000
Housing Type	Single-fam. detached	Single-fam. detached
Foundation	Slab-on-grade	Inground Basement
Stories	1	2
Total Conditioned Square Feet	2,509	2,320
Total Finished Square Feet	2,509	3,280
Unfinished Sq. Ft. (Basement)	0	960
Number of Baths	2.5	2.5
Number of Bedrooms	3	4
Optional Bedroom/Gameroom	1	0
Integral Garage	2-car	2-car
House Cost	$172,745	$151,063
Foundation	Post-tension concrete	Formed concrete
Walls - structural	2x4 panels at 16”	2x4 field frame at 16”
Walls - nonstructural	2x4 panels at 24”	2x4 field frame at 24”
Floors	N/A	I-joists at 24”
Roofs	Trusses at 24”	Trusses at 24”
Roof Style	Hip with 16½” overhang	Gable with 8” overhang
Wall Sheathing	Thermoply®	OSB
Insulated Windows U-value	U-0.50	U-0.45
Insulated Windows SHGC	SHGC-0.40	SHGC 0.40
Door U-value (Insulated Steel)	U-0.32	U-0.32
Basement Insulation	N/A	R-9 to 4’, draped
Wall Insulation	Fiberglass batts R-13	Fiberglass batts R-13
Ceiling Insulation	Blown cellulose R-30	Blown cellulose R-38
Siding	Vinyl siding	Vinyl siding
Roofing	20 yr. comp. shingle	20 yr. comp. shingle.
Roofing Underlayment	Type D felt paper	Type D felt paper
Roofing drip edge	Yes	Yes
Roofing ice dam protection	No	Yes
Other architectural features:	Brick watertable	None
Other architectural features:	Covered front porch	Uncovered stoop
Other architectural features:	Covered rear 3’-0” dr.	Rear 5’-0” SGD
Trim	Painted eng. wood	Alum. wrapped wood
Primary Heat	80 AFUE furnace/gas	80 AFUE furnace/gas
Primary Cooling	13 SEER AC/electric	13 SEER AC/electric
Number HVAC Zones	1	1
Location of Furnace	Attic	Basement
Water Heating	0.62 EF/50 gal/gas	0.62 EF/50 gal/gas
WH Location	Garage	Basement
Plumbing Supply Pipe Type	PEX	PVC
Range	Basic model/gas	Basic model/gas
Range Hood	Outside vent	Outside vent
Dishwasher	ENERGY STAR	ENERGY STAR
Refrigerator	None	None

[1] Single family detached

[4] A substantial change in climate zone identification occurred between the 2003 and 2006 IRC with the zones of the later code more widely-known. Thus, climate zones are reported for each of these code versions to facilitate reader comprehension.

Cost Estimates

The builder team members were charged with helping to develop cost data for the baseline homes and the green homes. To obtain a baseline cost for each home, construction cost was estimated from actual budgets and adjusted for changes that were made to arrive at the code minimum specifications outlined in Table 5.

NAHB Research Center analysts developed cost estimates for each line item change selected to bring the baseline home into compliance with the green building rating systems,. These cost estimates were reviewed by large- and small-volume builders to assure the range of issues faced by each group were identified and given consideration. Cost estimates were uniformly applied, where pertinent, in assigning costs to each of the three green building systems. Cost estimates at the highest levels of achievement for two of the systems, NGBSv2, "Emerald" and LEED-H, "Platinum", are not as refined as cost estimates at lower levels because of the lack of uniformity in selections. In some cases, such as using environmentally preferential products, the study team was challenged to define a material that would even comply within the context of the defined study houses. In these cases, the decision was made to "use a flooring product that contains 75% recycled content over 85% of the finished floor area," and a cost estimate for compliance that is typically one half of one percent of baseline house cost was utilized.

All of the costs are reported in ranges. The low end of the cost range represents the costs that would be incurred by a high volume builder while the estimated costs that would be incurred by a small volume builder are likely to fall higher in the cost range that is presented.

To understand the probable programmatic expenses associated with LEED-H certification, nine LEED-H providers were polled – three in the DC metro area, three in Dallas, and three in other regions of the country. Five of the nine LEED-H providers furnished definitive rates which formed the basis for the estimates for rating system registration, verification, and certification average costs used in this report. The NAHB Research Center, as the sole national certification agent, furnished program certification rates for the other rating systems.

No-Cost Tasks Actions

Some of the measures that make a project green are merely preferential practices that can be adopted with little or no cost. Therefore, there are a number of activities or products, not explicitly stated as features of the baseline houses, which are awarded points for compliance and assigned zero cost. Examples of these common sense measures include developing a bill of materials and cut list to minimize framing material waste (e.g., ordering pre-cut lengths, exact piece counts, reusing bracing materials for blocking). These types of practices help demonstrate that green building isn't merely a purchased commodity; it is a way of doing business with an awareness of the environmental impact of the processes.

The cost of administering the approximately 28 checklists and subcontractor attestation forms that are required for LEED-H certification was assumed to be performed by persons on the jobsite as tasks attendant to performance in their positions. Therefore, no overhead or line item costs were assigned to this administrative area of rating system compliance. Collecting and submitting GBG and NGBSv2 supporting documentation is, likewise, not costed.

RESULTS

The following results are provided based on the above analytical methodologies for the two sample homes in question. It should be noted again that the results presented are only preliminary since the NGBS will be released in the spring of 2008 but the baseline costs reflect the industry's current pricing structure. Similarly, the actual costs associated for all three rating systems will likely alter dramatically even during this short timeframe given the volatility of material costs, changing availability of products, and the overall residential market. Additional data collection and trend analysis are critical.

Cost Comparisons

The first area for comparative analysis is in the costs incurred to rate the homes for the various levels of each different rating system. The costs can be arranged by direct costs added to the baseline house, overhead costs incurred by providing the documentation of the direct costs, and certification and verification fees assumed. A comparison of the rating systems by costs is also provided.

Direct Costs

The estimated range of costs for achieving the rating levels can be found in Table 6 and Table 7, and were provided in detail separately. The numbers used frame the low-end of the cost range.

Table 6. Additional Direct Cost Estimates for Dallas House

	Bronze / Certified	Silver	Gold	Emerald/Platinum
GBG	$1,900 – $2,700	$4,000 – $4,700	$8,200 – $9,000	n/a
NGBSv2	$2,000 - $2,800	$4,900 - $5,700	$11,900 -$13,600	$28,200 – $31,200
LEED-H	$6,400 – 8,700	$8,800 - $11,000	$19,300 – 22,400	$29,800 – 34,000

Table 7. Additional Direct Cost Estimates for Metro DC House

	Bronze / Certified	Silver	Gold	Emerald/Platinum
GBG	$2,200 – $2,700	$5,300 – $6,000	$9,800 – $11,000	n/a
NGBSv2	$2,700 – $3,000	$4,700 – $6,000	$11,500 – $12,600	$25,600 – $28,000
LEED-H	$8,600 – $11,000	$11,200 – 13,800	$20,400 – $22,500	$34,600 – $38,000

Appendix A contains location adjustment factors to aid in the estimation of equivalent costs in other metropolitan areas. Again, detailed costs for many of the NGBSv2 actions, including those that were not selected in this rating effort, were provided under separate documents.

Overhead Costs

The costs associated with staff education, the convening of planning groups, documentation, and similar expenses required for green building rating system compliance are not reflected in the above tables. Overhead costs, because they are allocated as indirect expenses over a definitive volume of production, are not attributed to the house baseline budgets that accompany this report. However, likely programmatic overhead costs are estimated in Table 8 and Table 9 to illustrate the potential effect of compliance to a home builder's bottom line. Cost per unit will need to be determined by the builder based on production volume. Estimates are based on an average burdened staff hourly rate of $45.68; known costs may be easily substituted.

A deviation from this cost approach involves points for a life cycle cost assessment (LCA) of the whole building that were awarded in the NGBSv2 (section 609.1) and LEED-H (ID 3.4). The

estimated $6,000-$6,600 cost for a consultant to perform the LCA was applied to houseline cost estimates at the Gold level in the Dallas house, the Emerald level in the DC Metro house, and the first, Certified, level of achievement in LEED-H and assumed to be spread across ten units.

Similarly, the cost of a moisture meter and annual calibration, $350, was spread across ten units in 903.5(3) of the NGBSv2 houseline budgets at the Silver level. The work is assumed to be performed by the jobsite superintendent without additional labor cost.

Table 8. GBG and NGBSv2 Overhead Costs

Subject Area	Commitment	Time Commitment per Staff Member	Cost Estimate	Interval
LD Knowledge Team[5]	3 Staff[6]	40 hours	$5,500	One time
Basic Natural Resource Protection Education[7]	1 Staff	8 hours	$365	One time
Waste Management Plan – development[7]	3 Staff	4 hours	$550	One time
Waste Management Plan – maintenance[7]	1 Staff	2 hours per week	$4,750	Annually
Homeowner's Manual	1 Staff	550 hours	$25,125	One time

Table 9. LEED-H Overhead Costs

Subject Area	Commitment	Time Commitment per Staff Member	Cost Estimate	Interval
Preliminary Rating/ Integrated Project Planning[7]	3 Staff	8 hours	$1,096	One time per house type
Integrated Project Team	3 Staff	included	n/a	One time per house type
Design Charrette	3 Staff	included	n/a	One time per house type
Waste Management – Document Landfill Diversion Rate	1 Staff	2 hours per week	$4,750	Annually
Education for Homeowner (Manual)	1 Staff	550 hours	$25,125	One time
Comprehensive H/O Education and Walkthrough		included	n/a	
Public Awareness of LEED	1 Staff	48 hours	$2,193	Annually

Registration and Certification Fees

In addition to the direct costs associated with obtaining points in the rating systems, each of the program administrators, or certifiers, charge certification fees. The GBG and NGBSv2 fees are assumed to be $150 each house. The LEED-H certification fee has recently been increased to $250 and a $150 registration fee applies to each house. Figures are based on LEED-H's fees,

[5] Not required for overall program implementation, selected as an action at some level of rating within the program.
[6] The staff rate is based on an annual salary of $59,386 as reported by http://salary.money.cnn.com for a Construction Coordinator II. A burden for overhead and perquisites of 1.6 was applied based on estimates reported in *The Cost of Doing Business Study, 2008 Edition*, p. 62, by the NAHB, yielding the gross, burdened hourly rate of $45.68.
[7] LEED-H verifier fees are shown on houseline spreadsheet in the Workbooks.

which are published on the program's website, and proposed certification fees for GBG and NGBSv2 as reported by the NAHB Research Center, the program's certifier. The GBG certification fee includes registry and a certificate, and this is estimated to be the same for the NGBS once it is released and incorporated into the national certification program.

Verification Fees

Each of the three rating systems requires independent verification of green features for national certification, which typically consists of a review of the architectural plans, product specifications, and trade contractor scopes of work, energy use modeling, Manual J review, and verification that the design is implemented in the field.

The fees for independent verifiers are not yet standardized for any of the national certification programs for these rating systems because of their infancy. However, the review process and field verification requirements for the GBG and NGBSv2 systems are similar to those required for ENERGY STAR certification. Therefore, verification fees for these were estimated to be between $350 and $750, which is on par with current ENERGY STAR fees (which range between $175 and $750 per house). The GBG and the NGBSv2 are projected to have comparable aggregated programmatic costs, which are estimated in Table 10, along with the estimated LEED-H verification and review costs.

Table 10. Registration, Verification, and Certification Costs[A]

	GBG and NGBSv2		LEED-H	
Activity	**1-10 houses/year**	**500+ houses/year**	**1-10 houses/year**	**500+ houses/year**
Registration	n/a	n/a	$150	$150
Program Certification	$150	$150	$250	$250
Plan Review/Builder Collaboration	$750	$350	$1,735	$441[B]
Verification	Incl.	Incl.	$1,600	$600
Total	**$900**	**$500**	**$3,735**	**$1,441**

[A]The national GBG program was unveiled 02/14/08. The verifier network is currently being established. Estimates are based on known costs of a program of similar scope.
[B]Verifiers reported the plan review cost as zero. The number is an estimate of the cost of LEED-H AP required participation for every house.

A critical distinction between LEED-H and the other rating systems is that all LEED-H certified homes require collaboration between builder and LEED-H Accredited Professional (LEED-H AP) at the pre-construction *Planning Stage* for preliminary rating, design charrette, and durability plan development in order to earn any level of LEED-H recognition. This is in addition to registration, verification, and certification fees or costs. The provider also performs plan review, energy modeling as required, and construction phase verification. In theory, these functions could be addressed simultaneously with plan review; however, it is likely that a builder new to green building would incur higher costs at green building system startup.

The average of the five LEED-H providers disclosed fee structures are included in Table 10. These fees included flat fees for providing services for *Plan Review* and *Verification* to builders and hourly fees, averaging $147, to cover unbudgeted participation. The cost for plan review, which was assumed to include builder collaboration, is covered in Section 1.4 of the LEED-H house baseline budgets in the LEED-H calculations. All of the verifiers reported zero cost for plan review for a large volume builder. Yet, new rating system guidelines (released during the same week that the poll was taken) require collaboration with the builder during preliminary planning. Therefore, it was estimated that a minimum of three hours at the verifier's hourly rate would be required under the new guidelines and, thus, an average cost of $441 (3 hours at $147/hour) was reported in the house baseline budgets.

Additional verification and performance testing expenses (e.g. a HERs rating or HVAC system air flow measurement) that apply to each house in each rating system are shown on the spreadsheets in the separate calculations as house baseline cost estimates, as are the low end of the range of numbers that are covered in Table 10.

Rating System Costs

Tables 6 and 7 have already covered the estimated costs of system compliance. These compliance costs at the first level of rating are shown in Figure 1 for one sample house.

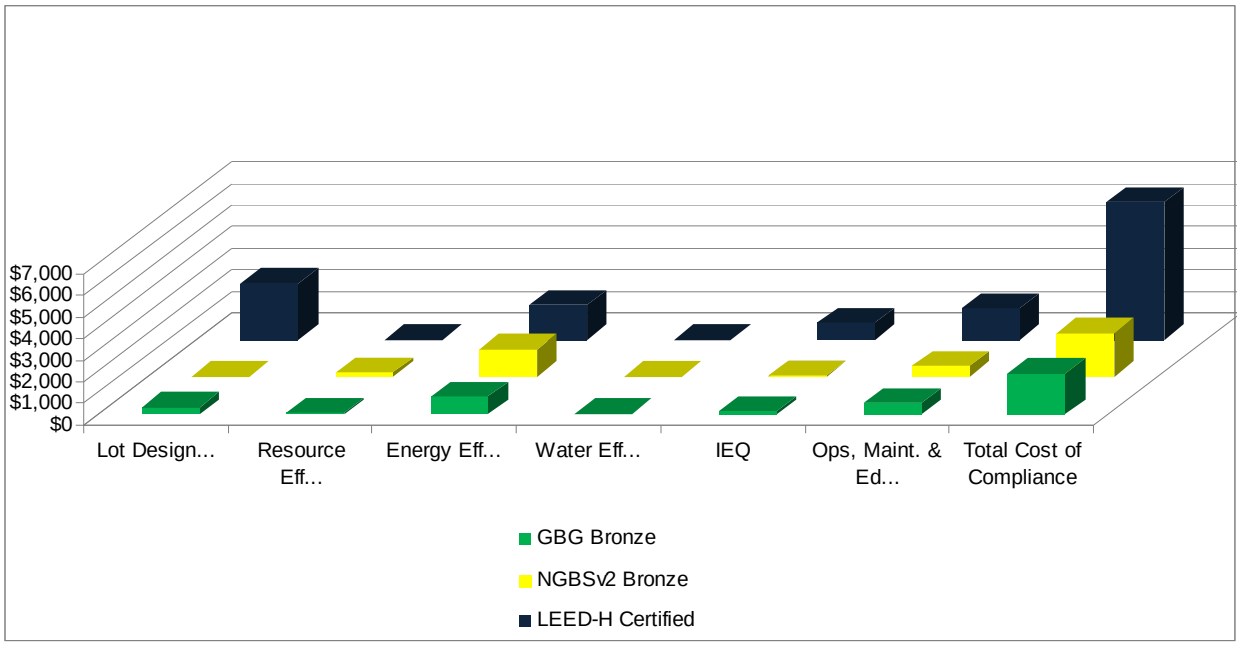


Figure 1. Cost of Compliance by Green Building Principal for Each Rating System - Dallas

Figure 1 shows that expenditures for energy efficiency are within 20% of each other in cost in both the NGBSv2 and LEED-H rating systems, whereas, LEED-H's overall compliance cost is three times that of the GBG and NGBSv2. Entry level compliance costs for the GBG and NGBSv2 indicate that the largest share of costs is incurred in the energy efficiency sections, the one most associated with GHG reductions. The high costs of LEED-H compliance in other program areas have unquantifiable or identifiable environmental benefit, yet are of a magnitude to warrant analysis for estimated "payback" by the traditional definition because the added initial costs associated with these could limit homeownership affordability.

Stringency Comparison

In addition to cost, stringency in both level of action and impact, as well as in systemic flexibility, are critical areas for comparison. Stringency comparisons between the systems were performed in the areas of mandatory measures, openness to alternatives, and overall stringency. The issue of credibility is also relevant to stringency comparisons, but this was covered earlier.

Mandatory Measures

In addition to minimum point requirements for each section, each rating system includes prerequisites or mandatory measures. These minimum standards that must be met to qualify in each system are covered in Table 11.

Table 11. Prerequisites or Mandatory Measures for Green Building Compliance[C]

	X Indicates Rating System Action Required		
Prerequisite Action	**GBG**	**NGBSv2**	**LEED-H**
Obtain a preliminary program rating at project planning			X
Pre-construction plan for durability including std. wet room measures			X
Third party program verification	X	X	X
No invasive plants on site			X
Waste factor of framing material is 10% or less			X
Tropical woods used must be FSC			X
Diversion rate of waste from landfill must be documented			X
Third party insulation inspection is HERS Grade II			X
HVAC equipment sized and calculated using ACCA Manual J	X	X	X
Building cavities are not used as ducts		X	
Perform duct design calculations			X
Air sealing required		X	X
Windows meet U-value and SHGC of ENERGY STAR		X	X
Third party whole house air leakage test			X
Third party duct leakage tested to 4 cfm_{25} per 100 sf to outside			X
Third party refrigerant charge test			X
House includes 3 ENERGY STAR fixtures			X
Gas appliances with closed or power exhaust			X
Merv 8 filters with adequate air flow			X
Fireplaces sealed and provided with outside air; gas models direct vent		X	
Garage/house door tightly sealed		X	
Attached garage is air sealed at house walls/floors		X	
All bathrooms are vented to outside at 50 cfm intermittent or 20 cfm continuous		X	
Meets ASHRAE 62.2		X	X
No HVAC equipment/systems in garage			X
Carpet is not installed in bathrooms		X	
Site applied architectural coatings are low VOC		X	
Green program certificate and narrative	X	X	X
List of green building features in house/ Green Rating	X	X	
Product manufacturer's information supplied to homeowner	X	X	
Program promotion			X

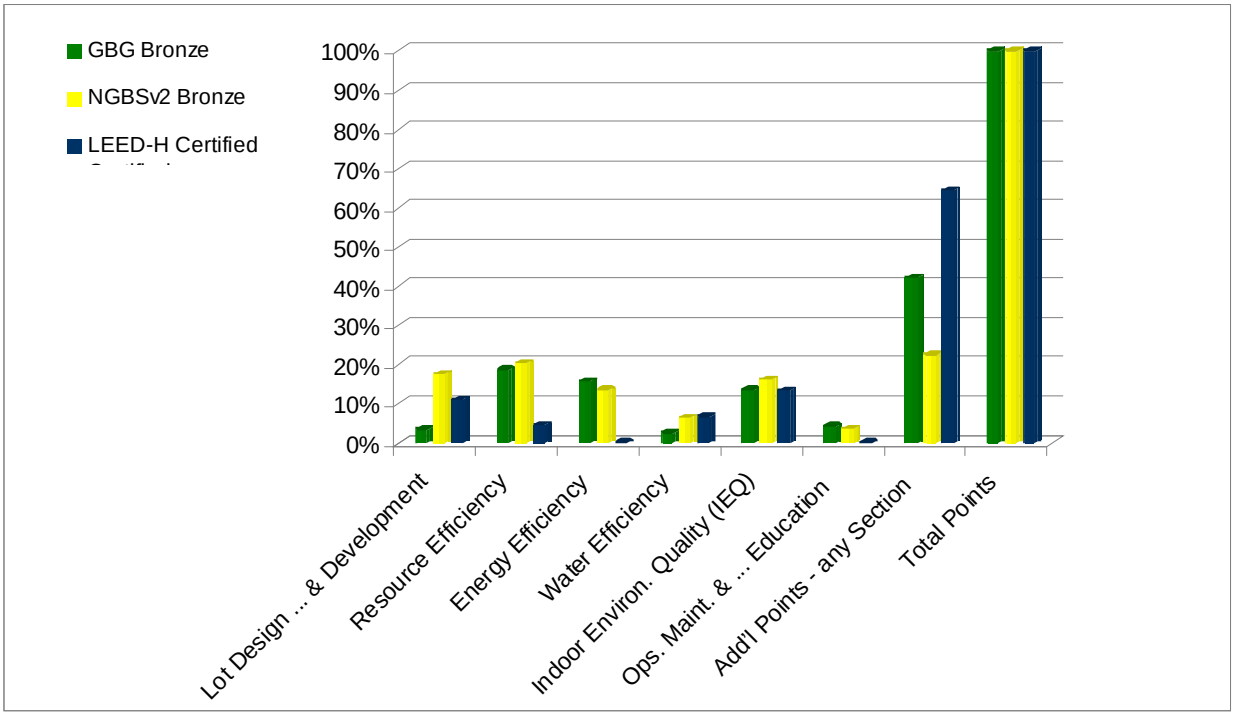
[C]Mandatory measures in the GBG and NGBSv2 that are required in the building code, such as the foundation drainage required in Section 602.3.1 of IRC 2003, are not recorded in this table.

In addition to the mandatory measures outlined above, each rating system includes prerequisites that are also required by building codes (IRC 2003 and later versions) and are common practice in the industry. Measures that are required by code, widely-enforced, and already represented in most builders' costs were not included in the table above. The measures

are, however, definitively required for compliance, whether or not they are enforced by building officials, and are itemized on the rating system checklists in the calculations.

Openness to Alternatives

As seen in Table 11, LEED-H requires more mandatory actions than both the NGBSv2 and GBG, yet it rewards mandatory actions with fewer proportional points, whereas, the NGBSv2 and GBG do provide points for similar actions. As defined by the number of mandatory requirements, then, LEED-H is less flexible than GBG and NGBSv2.



[A]Subject area headings are defined by those used in the NGBSv2 and GBG
[B]Percentage of minimum points in area to overall system points at the "Bronze" or "Certified" Achievement Levels

Figure 2. Relative Weight of Minimum Point Requirements by Environmental Section [A,B]

Another way to determine system flexibility is to examine the relative weight of points that are allowed from any subject area ("free choice" points) to overall points required. Figure 2 graphically depicts the results for the first level of achievement in each rating scheme. An examination of Figure 2 indicates that the LEED-H *Certified* rating allows the highest percentage of free choice points (29/45 or 64%). The other ratings each limit free choice of sustainable practices (within system environmental areas) by an approximate decreasing order of magnitude of 20% - GBG leaves 42% of the points to free choice, while the NGBSv2 leaves only 23% of the point value to the builder's discretion concerning environmental area within the rating system.

Ultimately, LEED-H allows broader interpretation of actions and specification that might earn the rating points and a measure of freedom in selection of environmental performance areas. However, LEED-H also includes a system for pre-verification of point validity that requires an additional fee of $150 per review decision, so the program flexibility comes with less certainty and additional cost. This type of flexibility is ideal for more experimental green home designs.

Credibility

Each green building rating system features similar technical content, includes similar facets of green building, requires independent verification for certification, and was developed by experts in the field. However, there are two key areas distinguishing these three systems.

First, the descriptions for activities that satisfy the GBG and NGBSv2 are more prescriptive in nature while LEED-H provisions are more open-ended. In terms of credibility, this suggests that the first two are more likely to have higher credibility among the builder and developer communities because of their specificity while the latter may speak more to the design community.

Second, the development *process* of the NGBSv2, under the guidance of the American National Standards Institute (ANSI),[8] sets it apart from the other two green rating systems and lends it the most technical credibility.

The ANSI standards development process creates a consensus body for developing standards which ensures that:

- Membership on the consensus committee is open to any affected party and not dominated by one interest group;
- Diverse interest group members are actively sought and included;
- Potential interest groups are notified about the development process
- Draft standards are subject to public review and all comments are addressed;
- There is a process for appeals, if needed; and
- Approval is based on evidence of compliance with administrative procedures.

The GBG and LEED-H rating systems were developed under the guidance of committees which included various interest groups, but there was no formal process for insuring balance on the committee or due process for public review and repeal. The ANSI standards development process, on the other hand, institutionalizes balance and openness on the development committee. With National Association of Home Builders and the International Code Conference as co-sponsors, ANSI acceptance of the NGBSv2 will move it from a green building rating system to the first National Green Building Standard.

Overall Strategy

There are differences in the core structure of these systems – LEED-H sets prerequisites in each sustainable area that serve to assure that rated houses contain specifications that encompass each green area, whereas, the GBG and NGBSv2 employ increasing minimum rating system area point thresholds with ascending level of system ratings to the same end – functionality in all environmental areas.

Following the form of the major building codes, all of the rating systems that were studied contain prescriptive language or written direction for attaining a desired level of performance. The GBG and the NGBSv2 are more prescriptive than LEED-H, as is evidenced by the number of line items and the instructions in each system's checklists. Prescriptive directives, by definition, refer to broadly recognized materials and methods. Accordingly, a prescriptive approach could indicate a measure of inflexibility, in that initiatives are too narrowly defined. A prescriptive approach, however, also provides a roadmap for conformance that is easily

[8] The requirements of the ANSI standard development process are outlined in the document, *ANSI Essential Requirements: Due process requirements for American National Standards*, available from the ANSI website.

recognizable, and therefore actionable and credible to stakeholders. Indeed, raters and builders new to green building may find more actionable directives in the prescriptive format of the GBG and NGBSv2.

Although it is apparent that LEED-H has many more mandatory requirements than does the GBG or NGBSv2 (5, 15, and 22, respectively), many of the LEED-H mandatory requirements are likely to be implemented in the construction of a GBG or NGBSv2 rated house. In some cases, the high value of points awarded in the GBG and NGBSv2 systems make the practices enticing for a builder to adopt. In other cases, the products and measures are preferred over other alternatives. For example, a HERS rating, which is a LEED-H prerequisite, requires third-party inspection of the insulation installation and a blower door (or building air infiltration) test. These same third party inspections earn points in the GBG and NGBSv2, so many raters will specify these at the first level of achievement because they have a low cost/point ratio and they are a good method to isolate weakness in design/execution for beginner green builders earnest to improve product performance. The paths to bronze (first) level of compliance in all of the case studies for this report include building air sealing measures and ENERGY STAR testing, but conformance to ENERGY STAR certification standards is not required in the GBG or NGBSv2, per se.

And, it is not surprising that LEED-H has more prerequisites because the rating system was not intended for every builder. In fact, its creator, the U.S. Green Building Council, states that the LEED-H Rating System is an initiative to transform the top 25% of the homebuilding industry toward more sustainable practices.[9] The GBG, on the other hand, was designed with the mainstream home builder in mind.[10] The NGBSv2 is under development as a nationally-recognized ANSI standard to further move the practice of green building into the mainstream.[11]

By number of programmatic prerequisites, LEED-H is more burdensome than either the GBG or NGBSv2. However, many of the LEED-H prerequisites serve as compliance paths in the GBG and NGBSv2. This indicates that each of the rating systems promote similar actions, though with different paths. So, overall, the magnitude or effort of actions required of LEED-H and NGBSv2 were comparable. This credibility is further evidenced by the processes in which these rating systems as well as the GBG were developed; all were developed by consensus with national review. As discussed previously, the NGBSv2, when approved as the first ANSI standard, will provide the highest level of credibility by virtue of the rigor, transparency, and publicly-solicited input required for this approval.

[9] U.S. Green Building Council (USGBC) LEED for Homes Rating System, p.iv, Jan. 2008.
[10] *Introduction*, page 1, NAHB Model Green Home Building Guidelines, copyright 2006.
[11] http://www.nahbgreen.org/About/default.aspx

CONCLUSION

The GBG, NGBSv2, and LEED-H, green building rating systems, each provide a rigorous, independently verified method of building for energy and environmental efficiency standards. At the entry and each successive level of compliance each of the systems requires performance across six areas – low impact development, resource conservation and durability, energy efficiency, water efficiency, enhanced indoor air quality and owner maintenance and green education. Thus, all of these systems have the same objectives and provide valid benchmarks for green building.

All of the green building rating systems appear to be based on similar compliance paths at the various levels of achievement, likely due to the consensus process of development for each. The NGBSv2, through the ANSI standards development process, has achieved widespread consensus across numerous and varied stakeholder groups. It has been developed through a process that ensures that anyone who wants to can have input. Although still in draft form and subject to change, the NGBSv2 will be the first national green building standard and, as such, the most defensible rating system for a broad cross-section of the nation's homes.

The GBG rating system and NGBSv2 draft standard are prescriptively structured, thus favoring "conventional" construction (as far as that applies to green building), yet including many new technologies. Prescriptive methods, like those in the building codes, are simpler to execute and when performed properly tend to produce the intended result more time- and cost-effectively. These types of programs are simpler to rate and integrate into an existing design and operational structure. Because of this both certification costs and building costs can be estimated more easily. Green building novices targeting the entry levels – Bronze and Silver – will find GBG or NGBSv2 rating system integration simpler than LEED-H.

LEED-H is an exclusive rating system on purpose and thus, it is not practical for the majority of builders, particularly those targeting the first two levels of achievement. Custom projects utilizing alternative building materials and unconventional methods, such as grey water re-use and off-grid energy features, are likely to achieve a higher rating in the LEED-H system than the GBG or the NGBSv2 which were developed for the mainstream builder. Otherwise, there is plenty of opportunity within the GBG and NGBSv2 to earn ratings for passive solar siting and features, non-traditional heating methods, and similar custom approaches.

Simply put, all of the rating systems appear to satisfy their stated audience in purpose and practice.

Appendix A

Adjusting Costs for Other Locations

To translate the costs that were reported for Washington, DC (adjustment factor 0.86) and Dallas, TX (adjustment factor 0.82), into costs for other metropolitan areas, the following table and formula can be used:

$$\textbf{Adj. Cost} = \textbf{Reported Cost}_{\textbf{DC or TX}} * (\textbf{Local Adj. Factor} \div \textbf{Adj. Factor}_{\textbf{DC or TX}})$$

For example, a builder using Metro DC cost data could determine costs in Juneau, Alaska by multiplying all Metro DC costs by a factor of 1.465 (1.26 divided by 0.86); which indicates that a $200 construction cost in Silver Spring, MD would be equivalent to $293 in Juneau, AK.

Location Adjustment Factors

Metropolitan Area	Factor	Metropolitan Area	Factor
Alabama, Birmingham	.88	Nebraska, Lincoln	.87
Alabama, Mobile	.83	Nebraska, Omaha	.91
Alaska, Juneau	1.26	Nevada, Las Vegas	1.02
Arizona, Phoenix	.86	Nevada, Reno	.94
Arizona, Tucson	.85	New Hampshire, Concord	.93
Arkansas, Little Rock	.85	New Hampshire, Manchester	.95
California, Bakersfield	1.06	New Jersey, Camden	1.10
California, Oxnard	1.09	New Jersey, Elizabeth	1.15
California, Riverside	1.08	New Jersey, Paterson	1.12
California, Sacramento	1.11	New Mexico, Albuquerque	.85
California, San Diego	1.06	New Mexico, Santa Fe	.86
California, Stockton	1.08	New York, Albany	.94
Colorado, Colorado Springs	.90	New York, Rochester	.97
Colorado, Denver	.93	New York, Suffern	1.11
Connecticut, Hartford	1.09	New York, Syracuse	.96
Connecticut, New Haven	1.10	New York, White Plains	1.17
District of Columbia, Wash.	.96	North Carolina, Charlotte	.86
Delaware, Dover	1.03	North Carolina, Raleigh	.85
Delaware, Newark	1.04	North Carolina, Wilmington	.82
Florida, Jacksonville	.82	North Dakota, Bismarck	.78
Florida, Orlando	.90	Ohio, Cleveland	1.01
Florida, Sarasota	.90	Ohio, Columbus	.94
Florida, Tampa	.92	Ohio, Dayton	.93
Georgia, Atlanta	.89	Oklahoma, Oklahoma City	.79
Georgia, Dalton	.75	Oklahoma, Tulsa	.78
Georgia, Savannah	.82	Oregon, Bend	1.02
Hawaii, Honolulu	1.25	Oregon, Portland	1.02
Idaho, Boise	.87	Pennsylvania, Allentown	1.04
Illinois, Chicago	1.19	Pennsylvania, Doylestown	1.05
Illinois, South Suburban	1.10	Pennsylvania, Johnstown	.89
Illinois, Springfield	.96	Pennsylvania, Pittsburgh	.97
Indiana, Evansville	.90	Rhode Island, Providence	1.07

Indiana, Gary	1.03	South Carolina, Columbia	.85
Indiana, Indianapolis	.94	South Carolina, Charleston	.88
Iowa, Des Moines	.89	South Dakota, Pierre	.75
Iowa, Sioux City	.85	South Dakota, Sioux Falls	.78
Kansas, Topeka	.79	Tennessee, Knoxville	.73
Kansas, Wichita	.79	Tennessee, Memphis	.82
Kentucky, Lexington	.90	Tennessee, Nashville	.83
Kentucky, Louisville	.88	Texas, Corpus Christi	.77
Kentucky, Paducah	.89	Texas, Dallas	.82
Louisiana, Baton Rouge	.85	Texas, Houston	.84
Louisiana, New Orleans	.87	Texas, Fort Worth	.81
Maine, Portland	.89	Texas, San Antonio	.80
Maryland, Baltimore	.90	Utah, Provo	.81
Maryland, Silver Spring	.86	Utah, Salt Lake City	.81
Massachusetts, Boston	1.21	Vermont, Burlington	.82
Massachusetts, Springfield	1.04	Virginia, Arlington	1.04
Michigan, Ann Arbor	1.03	Virginia, Fredericksburg	.94
Michigan, Detroit	1.06	Virginia, Richmond	.99
Michigan, Lansing	.95	Washington, Seattle	1.02
Minnesota, Minneapolis	1.16	Washington, Tacoma	1.05
Minnesota, Rochester	1.05	West Virginia, Charleston	.95
Mississippi, Biloxi	.83	West Virginia, Martinsburg	.86
Mississippi, Jackson	.83	Wisconsin, Madison	1.00
Missouri, Kansas City	1.03	Wisconsin, Milwaukee	1.08
Missouri, St. Louis	1.03	Wyoming, Cheyenne	.83
Montana, Billings	.87		

Source: R.S. Means, *Square Foot Costs 2008*, pp. 453-458.

The location adjustment factors for the two regions that were covered in this study – Dallas, TX, and Silver Spring, MD, have been highlighted to assist a comparison to a different market area.