AN EXPLORATORY STUDY OF THREE PATHS TO GREEN HOMES:

Energy Star Homes, LEED for Homes, and the National Green Building Standard

By

Jawanda C. Jackson

ABRIDGED MASTER'S REPORT

Submitted to

Michigan State University

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Construction Management Program

School of Planning, Design, and Construction

November 2014

ABSTRACT

Residential green building rating systems are known for their ability to assist in the development of high-efficiency residential buildings, also known as green homes. Because these systems seemingly deliver similar products, there is much confusion among builders, consumers, and local governments about the similarities and differences of these programs. Several studies have compared residential green building rating systems with regard to energy performance, costs of compliance, and minimum requirements, but few studies have compared the similarities and differences of the certification process. The Energy Star for Homes, LEED (Leadership in Energy and Environmental Design) for Homes, and National Green Building Standard (NGBS) are three nationally adopted residential green building rating systems that have a common goal, but utilize different processes for awarding certification. This research seeks to understand and compare the certification processes of these three systems.

When comparing credit and documentation requirements, phases of the certification process where identified and used to add context to the comparisons. Credit requirements for the LEED and NGBS systems were evaluated in a side-by-side comparison to determine in which phase credits were earned. Process flow diagrams were used to map the certification process and identify points for documentation requirements. Eighteen builders and third-party raters that had previous experience with at least one of these three nationally adopted systems were interviewed to discuss their experience with the certification process. The findings of this study expand existing comparisons and provide more contexts when considering the similarities and differences of the systems and when determining which system is best for the needs of builders, consumers, and local municipalities.

PURPOSE AND OBJECTIVES

The purpose of this report is to evaluate the certification process and experience of three nationally adopted green building rating systems; Energy Star for Homes, LEED for Homes, and the National Green Building Standard. Although each of these systems have a common goal of verifying sustainable practices, materials, and techniques used in green homes, each program uses a different approach. Because of the similarities between these systems, there has been much confusion among builders, customers, and local municipalities. There is a need to expand the research of existing comparisons and to understand the similarities and differences of each system. The following paper is a summarized report of larger study.

The objectives of this report are to understand the program requirements of these three systems and to evaluate the certification process and certification experience by examining credit requirements, documentation requirements, and industry professional opinions. Credit requirements were addressed through the use of side-by-side comparisons and documentation requirements were addressed within process flow diagrams developed for this study. Builders and raters that have first-hand experience with at least one of the three systems studied here were interviewed to gather information about the certification experience. The scope and requirements for the Energy Star, LEED, and NGBS systems were studied through the review of official program requirements, literature, and through interviews with industry professionals.

LITERATURE REVIEW

Researchers that evaluated nationally adopted residential systems have compared these programs with regard to energy performance, cost of compliance, and minimum requirements.

Researchers found that the Energy Star program has a focus in energy and affordability but is limited in scope. Researchers evaluating high-efficiency energy performance found that the system does not include sustainable building practices that focus on passive systems, the project site, or owner education (Reugemer and Smith 2012). Several studies have examined the cost of compliance of residential systems and findings have consistently named LEED as the system with the highest cost of compliance. On the contrary, this program has also been praised for its rigidity and mandatory site testing requirements (FitzGerald 2011; NAHB 2008; AIA 2010). The NGBS has been favored by some researchers for its prescriptive nature; where its credits are written in code language in an effort to appeal to a mainstream audience of builders. A common finding among comparisons is the significance of energy efficiency. Energy efficiency measures are consistently responsible for the highest percentage of the project costs (Reugemer and Smith 2012; FitzGerald 2011; NAHB 2008; AIA 2010).

RESIDENTIAL GREEN BUILDING RATING SYSTEMS

Similar to commercial green building rating systems, residential systems seek to lower environmental impacts of buildings through the use of sustainable techniques, strategies, materials, and performance testing. The International Energy Conservation Code (IECC) and the HERS (Home Energy Rating System) Index are two fundamental influences in residential systems. The IECC is a building code that specifically refers to energy efficient building practices for commercial and residential construction. It is updated every three years and can be adopted by state and local governments (ICC 2014a). Many residential green building rating systems use the IECC as a baseline and require practices that exceed the IECC by a given percentage.

Because of the need to conduct performance testing on the systems created in green homes the HERS Index is a key component of green building rating systems. The "HERS Index is the industry standard" for energy efficiency evaluation in residential construction. It is nationally recognized and calculates a home's potential to reduce energy demands through site testing (RESNET 2014a). Performance testing ensures that the systems in place can perform to the level of efficiency designed (RESNET 2014b). The rating ranges from 150 to 0, where a home that earns a HERS Index of 100 is in conformance with the 2006 IECC. The lower a HERS Index is the more energy efficient the home. The HERS Index is used in each of the three systems studied here (RESNET 2014a). For the sake of brevity, these systems will be referred to as LEED, Energy Star, and NGBS throughout this study.

Energy Star

Energy Star for New Homes was established by the EPA in 1995 to help consumers identify homes that are built to be significantly more energy efficient than a typical home. Due to Energy Star's energy efficiency labels for a variety of electronics and appliances, the brand has gained a considerable amount of market recognition. Energy Star offers both a prescriptive and a performance path to certification. The prescriptive path operates on a pass/fail basis and requires strict compliance with predetermined energy efficient measures. The performance path is more flexible and uses a HERS Index to predict the energy performance of the home. Energy Star Homes must be 15% more efficient than the 2009 IECC, earning at least an 85 HERS Index to qualify for certification. Homes that significantly improve indoor environmental quality

can also earn the Indoor airPLUS designation as shown in Table 1. Home Energy Raters inspect potential Energy Star projects for compliance and certification. Although there are fees associated with third-party verification, there are no certification fees administered by the EPA (EPA 2013b).

LEED for Homes

After ten years of developing green building systems for the commercial sector, the United States Green Building Council (USGBC) created a system specifically for residential buildings. The LEED for Homes green building rating system was developed by the USGBC in 2008 with goals of 25% market transformation in residential construction (USGBC 2013). Because of its commercial predecessors, LEED for Homes has the advantage of brand recognition (Reeder 2010). As seen in Table 1, the system has eight performance categories and four benchmark levels. The system is currently transitioning from the LEED for Homes 2008 version to LEED v4 Homes Design + Construction. All new projects will be required to use the LEED v4 update starting June 2015 (AES 2014).

National Green Building Standard

The NGBS is the collaborative effort of the National Association of Home Builders (NAHB), the International Code Council (ICC), and American National Standards Institute (ANSI). It is also the predecessor of the Model Green Building Guidelines (GBG) created by the NAHB in 2005. After developing an in-house system, the NAHB engaged the ICC and ANSI to strengthen their green building program. The result was the National Green Building Standard. The system has four

benchmark levels, as shown in Table 1, which must be earned in each performance category. The lowest benchmark earned among each of the performance categories determines the project's overall benchmark, making the project's final rating more balanced. The first version, also known as the ICC 700-2008, was adopted in 2009. The ICC 700-2012, the version currently in use, was developed to exceed the 2009 IECC (NAHB 2008; NAHB 2013). The standard was developed using ANSI procedures and written in ICC code language (NAHB 2013).

Table 1: National Residential Green Building Rating Systems

	Energy Star Homes	LEED for Homes	NGBS
Parent Organization	Environmental Protection Agency	United States Green Building Council	Home Innovation Research Lab International Code Council
Year Established	1995	2008	2008 (Model Green Home Guidelines, 2005)
Benchmark Levels	• Energy Star • Indoor airPLUS	• Certified • Silver • Gold • Platinum	• Bronze • Silver • Gold • Emerald
Rating Categories	• Enclosures •Heating and Cool Equipment •Energy Efficiency •Water Conservation • Indoor Air Quality • Appliances	• Innovation and Design Process • Location and Linkages • Sustainable Sites • Water Efficiency • Energy and Atmosphere • Materials and Resources • Indoor Environmental Quality • Awareness and Education	• Lot Design, Preparation, and Development • Resource Efficiency • Energy Efficiency • Water Efficiency • Indoor Environmental Quality • Operation, Maintenance, and Building
Building Types Certified	• Single-family • Multifamily • Mixed-Use • Major Renovations • Modular Homes • Manufactured Homes	• Single-family • Multifamily • Mixed-Use • Major Renovations	• Subdivisions • Single-family • Multifamily • Mixed-Use • Major Renovations • Minor Renovations
Third-Party Verifiers	Home Energy Rater	Green Rater	Green Verifier
System Administrator	Environmental Protection Agency	Green Providers	Home Innovation Research Lab
Certified to Date*	1,510,998	12,308	7,491

*New and remodeled single-family home, as of Feb. 2014 (EPA 2014, HIRL 2014, USGBC 2014,)

METHODOLOGY

The objectives of this study were explored using a side-by-side comparison, process flow diagrams, and interviews with builders and third-party raters that have experience with the certification process. The 2008 LEED and NGBS credits were matched with regard to intent and evaluated to determine when they are earned during the certification process. Process flow diagram of each system were mapped with the assistance of literature review and three raters that were experienced with all three systems. The diagrams illustrate the various steps and milestones taken and the documentation required throughout the process. The certification experience was evaluated from the perspective of industry professionals that had experience with certifying at least one of the systems.

The program requirements of each residential green building rating system were found in literature and official program documents. Supporting information about the certification process was found on web sites of the administering organizations. Preliminary meetings with builders and third-party raters were conducted to narrow the focus of the research objectives and to improve the questionnaires used during interviews. Nine builders and nine third-party raters were interviewed to discuss their experience with the systems studied in this research. For both groups, three participants for each system were interviewed. These participants were interviewed in person when in reasonable traveling distance and via telephone for participants that were more than a one hour drive away.

FINDINGS - THE CERTIFICATION PROCESS

When comparing the certification process with an emphasis on credit requirements and documentation requirements, two evaluations were developed in the context of the phases of certification. Four phases in the certification process were identified as *planning and design, procurement, during construction,* and *post-construction,* and were used to provide more context for the certification process. First the side-by-side comparison of the LEED for Homes and the National Green Building Standard sought out to determine the phase in which each credit is earned. Second, the comparison of certification process flows indicated the steps taken in each system and documentation requirements throughout the process.

Side-By-Side Comparisons

Although the LEED for Homes and the National Green Building Standard are presented in different formats, the systems have more similarities than differences. The basis for this comparison was adapted from the AIA Cincinnati LEED for Homes/ NGBS comparison (AIA 2010). The evaluation updates the NGBS portion of the study to compare the LEED for Homes 2008 and NGBS 2012 versions, both of which are currently in use. The Energy Star system was omitted from this comparison due to its limited scope, but serves as an alternate path for the energy performance category in each system and is shaded blue to denote its presence.

The program requirements for both systems were used to determine the intent of each credit and to match credits in both systems when updating the NGBS requirements. After the credits were matched they were evaluated to determine which phase of the certification process they would be optimally earned in. The evaluated credits were sorted first by performance category

and second by phase. The criteria used to evaluate where each of the credits were earned is listed in Table 2.

Table 2: Side-by-Side Comparison Sorting Criteria for Credits

PHASE	Credit Requirements
Planning and Design	• Use of external system • Preexisting Conditions • Coordinated • Calculated • Designed In
Procurement	• Purchased for Improved Quality
During Construction	• Preventative Activity • Alternative Construction Techniques • Proper Installation of Materials
Post Construction	• Inspection • Site Testing

The *Energy and Atmosphere/ Energy Efficiency* performance category in Table 3 shows credits in each phase of the certification process. The table also shows that Energy Star is used as an alternate performance path in both the LEED and NGBS systems. The *planning and design* and *procurement* phases are where most of the credits are earned. Few credits are earned in the *during construction* and *post-construction* phases; this is common among the other performance categories which can be found in appendix A.

Table 3: Energy Efficiency Credits

LEED for Homes - Energy and Atmosphere (Prescriptive Path)		NGBS - Energy Efficiency (Prescriptive Path)	
Performacne Path of Energy Star for Homes	EA 1.1	701.1.3	Energy Star for Homes Alternate Level Compliance
Performacne Path of Energy Star for Homes	EA 1.2	701.2	Emerald Level Points
Reduced Envelope Leakage	EA 3.1	704.5.1	Installation and Performance Verification
Greatly Reduced Evelope Leakage	EA 3.2		
Minimal Envelop Leakage	EA 3.3		
Reduced Distribution Losses	EA 5.1	701.4.3	Duct System Sizing
Greatly Reduced Distribution Losses	EA 5.2	701.4.2.1	Sealed Ducts
Minimal Distribution Losses	EA 5.3	701.4.2.2	No Supply Ducts in Exterior Walls
	o	704.5.1	Installation and Performance Verification
High-Efficiency HVAC	EA 6.2	701.4.1.1	HVAC System Sizing (Design to Manual J)
Very High Efficiency HVAC	EA 6.3	o	ACCA Manual S
Efficient Hot Water Distribution	EA 7.1	801.1	Indoor Hot Water Usage
Improved Lighting	EA 8.2	704.2.1.2	Lighting and Appliances
Renewable Energy System	EA 10	705.5	Additional Renewable Energy Options
Basic Insulation	EA 2.1	703.1.1	Building Envelop (UA Improvement)
Enhanced Insulation	EA 2.2	701.4.3.2	Air Sealing and Insulation (Visual Inspection)
Good Windows	EA 4.1	703.1.6.1	Fenestration (Mandatory)
Enhanced Windows	EA 4.2	703.1.6.1a	Fenestration (Enhanced)
Exceptional Windows	EA 4.3	703.1.6.1b	Fenestration (Enhanced)
Efficient Domestic Hot Water Equipment	EA 7.3	703.5	Water Heater Design, Equipment, and Installation
		703.4.5	Solar Water Heater
Energy Star Lights	EA 8.1	704.2.1.1	Lighting and Appliances
Advanced Lighting Package	EA 8.3	704.2.1.3	Lighting and Appliances
High-Efficiency Appliances	EA 9.1	703.5.3	Appliances
Water-Efficient Clothes Washer	EA 9.2	801.2	Water Conservation Appliances
Appropriate HVAC Refrigerant	EA 11.2	o	
	o	703.1.3	Building Envelope (Mass Walls)
	o	703.6.4	Automated Solar Heating Design
	o	704.4.1	Certified HVAC Contractor
	o	703.1.2	Insulation Installation
	o	903.2	Duct Installation
Good HVAC Design and Installation	EA 6.1	703.2	HVAC Equipment Efficiency
Pipe Insulation	EA 7.2	903.1.1	Plumbing
Refrigerant Charge Test	EA 11.1	704.4.2	HVAC Refrigerant Charge

Energy Star	Planning and Design	Procurement	During Construction	Post Construction

Process Flow Comparison

The need to understand the process flows of each green building rating system emerged after interviewing a number of raters. The significance of the point at which the raters are engaged also became apparent as respondents expressed frustrations of unsatisfactory experiences. The need to explore the documentation requirements and process flows was also addressed in the context of the four phases the of certification process.

According to the input received from several third-party raters, green building certification proceeds in one of two ways; as forethought or an afterthought. The major difference between these two means of progression is the point at which the third-party rater is engaged. Many of the sustainable practices and techniques used in green building must be incorporated into the design early on. If builders and owners decide to pursue certification as forethought to design, raters are typically engaged early enough to take part in the planning and design process and cost benefit analysis. When engaged during this phase, project owners have the opportunity to utilize the third-party team as a technical resource to optimize the success of the project.

The forethought process flow was used to map the three systems evaluated in this study. Three raters, each having experience with all three systems, were engaged to inform the sequence of the steps of the certification process. Each step and milestone was also identified to occur within one of the four phases identified. Required documentation and the points in which documents are collected is also represented on each diagram.

The certification process for these three systems were very similar in the first-three phases of certification as can be seen in Appendix B. Major differences of the system process flows are found in the *post-construction* phase, where certification is awarded. Figure 1 displays these differences. Energy Star raters have the ability to award certification after performance testing. LEED Green Raters are required to submit the verified project to a Green Provider, who in turn must review and submit the information to the USGBC. NGBS Green Verifiers submit remaining documents directly to the Home Innovation Research Lab for approval. Each system also requires documentation at different points of the process. Depending on the authority given to raters and the responsiveness of the parent organization, the *post-construction* phase can move along quickly or last for long periods of time.

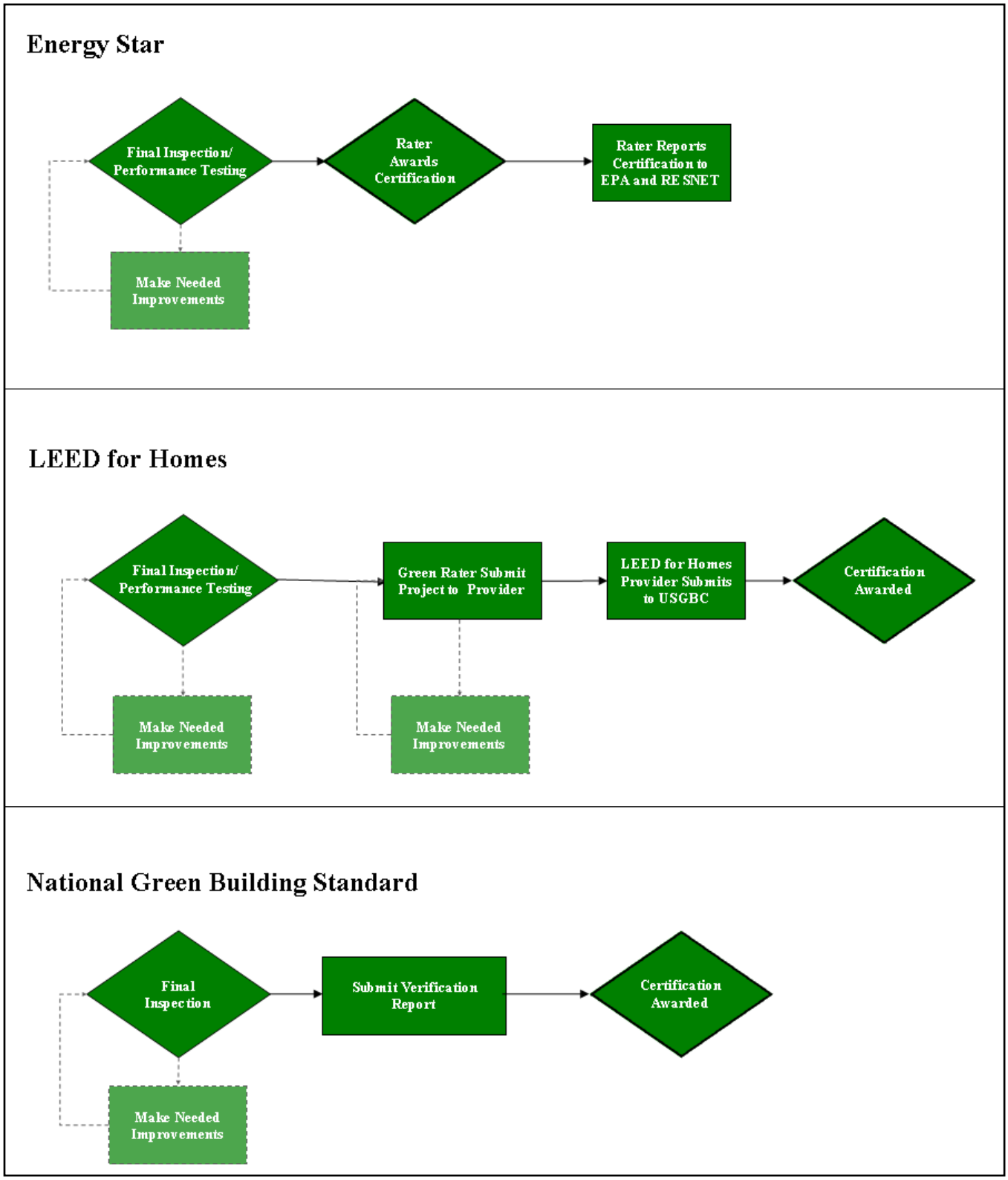

Figure 1: Post-Construction Activities

FINDINGS - THE CERTIFICATION EXPERIENCE

In order to understand the certification process for each residential green building rating system from an industry professional's point of view, builders and raters from several states were contacted. The data collection methods for the builders and raters were identical with the exception of the questions asked. The sample size included of nine builders and nine raters where three builders and three raters for each of the three systems represented. Preliminary interviews were conducted in order to gather information about the certification experience and to refine the research objectives. Certified homes and residential construction seeking certification were also visited in an effort to see some of the sustainable practices firsthand.

Builders and raters were found using search engines on each of the system's parent organization web site and contacted via phone and email. Interviews were first conducted with builders and raters in the mid-Michigan area by way of face-to-face meetings and via telephone in other cases. After industry professionals within a one-hour driving distance were interviewed, the questionnaire was improved and digitized as a PDF form for remote distribution. The improved questionnaire for builders and raters focused on profile information, documentation requirements, durations, costs, improved quality, participant satisfaction, and general comments. Improved rater questions focused on project durations, inspection delays, hindrances, high up-front costs, and comments.

The digitized questionnaires were sent via email. Completed digitized questionnaires were returned via email and followed up with phone conversations to review the builder's responses

whenever possible. Builders from North Carolina and Michigan shared their experience with Energy Star, LEED for Homes and National Green Building Standard. Third-party raters and verifiers from the District of Columbia, Georgia, Michigan, New Jersey, New York, North Carolina, Ohio, and Oklahoma also provided input about their experience with the Energy Star, LEED, and NGBS systems. Because parallels existed with regard to a builder's typical customer, builders were grouped together for further analysis of builders serving first-time and move-up buyers.

Builder Input – First-Time Homebuyers

Of the nine respondents, three reported that their typical customers were first-time homebuyers; one Energy Star and two LEED builders. Relative to the respondent pool, builders from the low, mid, and high annual volume cluster groups were represented. As shown in Appendix C, each of the builders in this group were based in Michigan. Of the first-time homebuyer group, two builders developed projects with an element of affordability, and two of the builders had experience certifying over 100 projects. Each builder stated that the use of sustainable practices was a part of their standard building practices and expressed a commitment to green building. Other similarities included experience with only one certification program, the common construction duration of 4 – 6 months, the transfer of all certification related cost to owners, and views that certification improves material installation and quality, but not the quality of customer service.

Builder Input – Move-Up Homebuyers

The remaining six respondents reported that their typical customers were move-up buyers; two Energy Star, one LEED, and three NGBS. Builders from each of the annual volume cluster group were represented. As found in Appendix C, the builders in this group were based in Michigan and North Carolina. Of this group two of the builders had experience certifying over 100 projects where none the remaining four builders exceeded 12 certified projects. Like the first-time homebuyer group, each builder stated that the use of sustainable practices was a part of their standard building practices and expressed a commitment to green building.

Other similarities appeared to be consensus based and not consistent among each participant. These similarities included 0 – 6 hours spent on documentation, indifference for sustainable practices from laborers, the use of the homeowner's manual for owner education, and views that certification improves material installation and material quality, but not customer service.

Three notable differences were the varied approach to transferring certification costs, varied owner satisfaction, and the varied experience of encouraging sustainable upgrades. Some builders reported that all of the certification costs were transferred to the owner, while others absorbed some of the costs. Most of the builders in this group reported that customers understood the use of sustainable practices and were aware of the sustainable efforts and satisfied. One builder felt that the owners "often missed the big picture." Finally, builders reported both the willingness and unwillingness of owners to take on additional costs for sustainable upgrades. In some cases, customers that could afford upgrades were easily

encouraged when made aware of the return on investment. In other cases, builders found it difficult to encourage upgrades despite the customer's awareness of the potential benefits.

Rater Input

The third-party raters and verifiers contacted were from the District of Columbia, Georgia, Michigan, New Jersey, New York, North Carolina, Ohio, and Oklahoma provided input about their experience with the Energy Star, LEED, and NGBS systems. The rater questions began with background information for each participant and focused on project durations, inspection delays, hindrances, high up-front costs, and comments.

Each of the raters had experience with at least two green building rating systems and each of them had at least five years of experience in sustainable development and certified at least 100 projects. When asked about documentation required by the system, most raters referred the researcher to the system guidelines for an extensive list of submittals required. Very few were willing or able to name the documents required for each performance category. According to the raters, products with high up-front costs were used in projects depending on the pursued benchmark goals and the time that the rater was brought on. Aside from this, only insulation and energy efficient equipment were cited as having high up-front costs.

When asked what the typical duration of a project was, third-party raters from each system agreed that the project duration is largely dependent on the scale of the project, but is also affected by the benchmark goals, where pursuing higher goals often requires more time and

effort. The Energy Star project durations were estimated between 3 to 12 months, whereas the LEED for Homes system was estimated to take at least six months. The NGBS had the longest response estimated for project duration at 8 to 24 months. Two third-party verifiers for the NGBS cited a lack of clarification for program requirements and program submittals. This may explain the lengthy estimates for NGBS project durations.

The time that a project schedule would be extended due to a noncompliant program requirement varied according to the nature of the problem. Several raters stated that efforts are made to avoid extending the project and the completion date is typically not extended due to follow-up inspections. Common hindrances to achieving certification were a lack of communication, misunderstanding program requirements, incorrect installation of materials, noncompliance with general building codes, excessive paperwork, subcontractors that were not invested in the process, negligent builders, and lack of fee payment.

SUMMARY AND CONCLUSION

Residential green building systems are designed to assist builders and homeowners in the development of high-performance buildings. They provide guidance and verification for sustainable development and identify different benchmark levels to determine the amount of improvements made. The scope and requirements for the Energy Star, LEED, and NGBS systems were studied and understood through the review of literature and through interviews with industry professional. The three residential green building rating systems were compared with an emphasis on the certification process and the certification experience. The credit

requirements were addressed through side-by-side comparisons and documentation requirements were addressed within the process flows. The side-by-side comparisons and process flow diagrams were analyzed in the context of four phases of the certification process. Builders and third-party rater experiences were derived from interviews with experienced industry professionals.

The Certification Process

The side-by-side comparison of the LEED 2008 and NGBS 2012 shows that most of the certification credits are earned in the *planning and design* and *procurement* phases. This information is useful for builders and owners new to the certification process. It could also be of great assistance to parties that decide to seek certification as an afterthought. If the building design of the project is largely complete, the implementing party can prioritize and focus their efforts by referring to credits that can be earned through procurement or during construction.

The comparison of the Energy Star, LEED, and NGBS process flows pointed out the similarities for much of the certification processes, but revealed major differences in the *post-construction* phase. Each system uses a different approach to awarding certification. Energy Star certification is verified and awarded by the Home Energy Rater after performance testing. Verification for LEED certification is first forwarded to LEED for Homes Providers for review, and then to the USGBC, before certification is awarded. Green Verifiers submit verification for NGBS projects directly to the Home Innovation Research Lab for review. The time that certification is awarded,

is dependent upon the system administrator's responsiveness and the amount of authority given to third-party raters.

Certification Experience

Builder and raters provided varied input about project durations, costs, quality, participant satisfaction, and owner education. Among the nine builders interviewed, the majority of the raters reported to have spent 4 – 6 months constructing a certified green home. When asked if certification costs were transferred to homeowners, builders serving first-time homebuyers reported that they transferred all certification costs. On the contrary, several builders serving move-up buyers reported to have shared some of the costs. Although the builders serving first-time homebuyers did not feel that the certification process improved the quality of their customer service, one of the builders serving move-up buyers felt that it had some positive effect on the service provided their customers.

Several builders expressed that customers appreciated direct benefits such as lower utility bills when asked about customer satisfaction. There was a consensus that most trades were indifferent about their participation in green construction with exception to the trades that benefited from the additional practices required by certification. Each builder had some form of owner education plan, but it was clear that some were more extensive than others. Furthermore, builders that involved customers in the design and certification process seemed to provide the most effective means of owner education.

The industry professions interviewed for this research expressed a range of opinions that included frustrations and excitement. Some had strong opinions about the challenges of certification. Many participants expressed frustration about new HVAC requirements that require special training and certification for Energy Star and LEED certification. This new requirement has decreased the pool of eligible HVAC contractors and has put a strain on some markets. Verifiers have also expressed frustration with the lack of clarity in some of the NGBS credits.

Site verification and market recognition aside, each of the systems studied here has strengths and weaknesses that influence the practicality of its use. When using the performance path of the Energy Star program, the system allows for flexibility by focusing on the end result (HERS Index) opposed to requiring the use of credits or specific building practices or techniques. The LEED system finds strength in the technical support offered by Providers and the checks and balances encountered before certification is awarded. Green Raters, Providers, and the USGBC review the project to ensure that the program requirements have been met. The balanced benchmark approach that NGBS uses to ensure that sustainable efforts are utilized in each performance category is possibly its strongest attribute; affordability also being a noteworthy strength. Each system is a legitimate vehicle for achieving green homes.

Which System Should Be Used?

When considering which system would be the best fit, the answer is dependent upon several factors that are specific to the project. It is the researcher's opinion that there are seven key

factors, shown in Figure 2 that will influence which system should be used. First, the audience or implementer must be considered. Second, the building type and the type of work may be a determining factor. Third, the implementer's decision may also be a factor of the time at which they decide to pursue certification. Next, the place should be considered to determine the climate as well as the political advantages is disadvantages that the municipality may have. The motivation behind certification may be a strong indication of a decision to select one system over another. The scale of the project and the project's budget is often a primary constraint. Finally, the benchmark level that is pursued may have a major influence on which system is used.

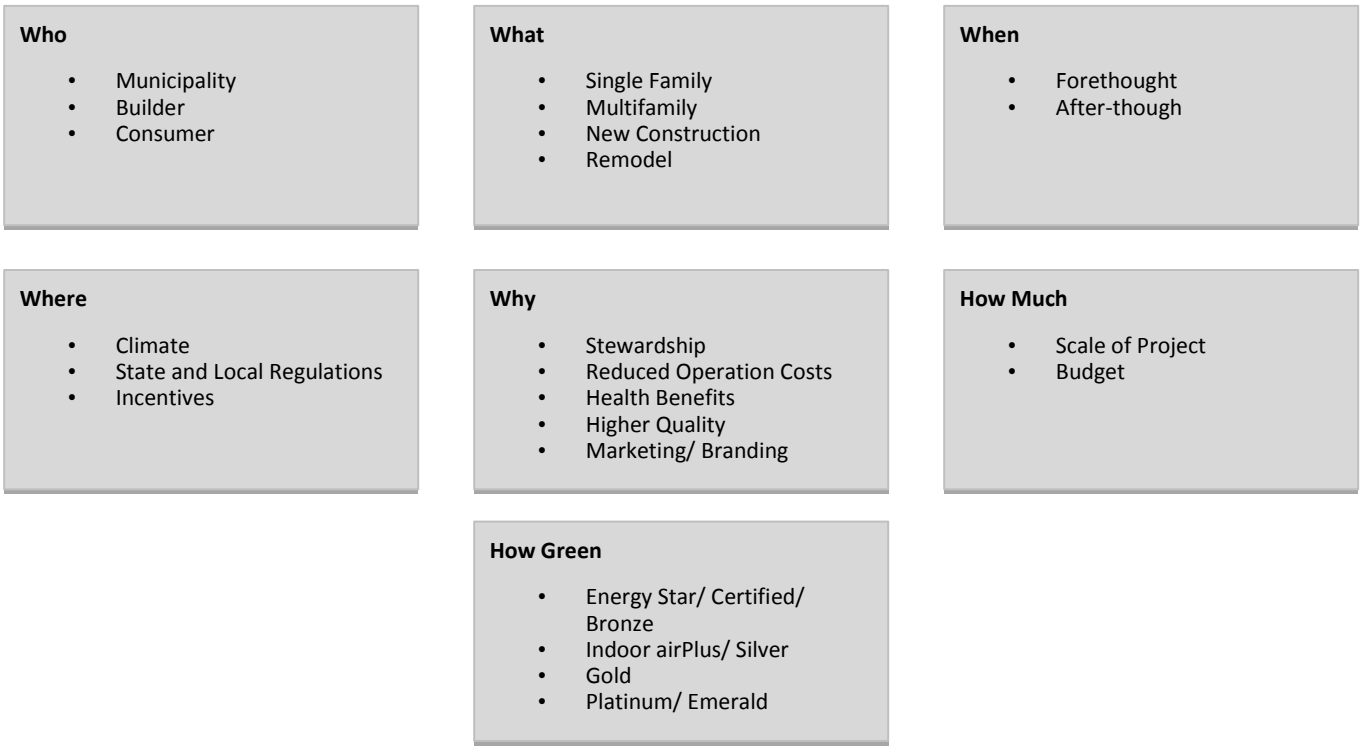

Figure 2: Deciding Factors for Choosing a Green Building Rating System

Research Implications

It is essential that home builders and construction managers in general continue to evolve with innovative green building practices that have proven their value. According to the McGraw Hill (2013) "World Green Building Trends", client demand is the top "trigger driving green building in the future." As the market begins to experience these changes, there will be a need for competent industry professionals. Builders that understand green building rating systems and how they differ from comparable programs will be more prepared. The residential green building model has an emphasis on owner education. Builders will need to be well versed in sustainable practices in order to educate consumers at various points of the client-builder relationship.

Closing Remarks

This exploratory study attempted to provide an understanding for the certification process and certification experience to allow builders, consumers, and municipalities to pursue certification with clarity and confidence. The research model used here was an exploratory and organic approach that should be used as a basis for future research rather than for generalization. The three national systems studied have been widely adopted and are proving their value in the residential sector. Each is a legitimate vehicle for developing green homes. Residential green building rating systems are a great tool for developing high-performance buildings, because essentially, green homes are simply homes that have been built using best practices!

References

AEGB. (2014). "What is the Austin energy green building program." *Austin Energy Green Building*, <http://austinenergy.com/wps/portal/aegb/about/what-is/> (Mar. 11, 2014).

AIA, C. (2010). Comparison of united *states green building council's LEED for homes first edition 2008 and national association of home builders' national green building standard*: ICC 700-2008. American Institute of Architects: Cincinnati, Cincinnati, OH.

ANSI. (2014). "Standards activities overview." *American National Standards Institute,* <http://www.ansi.org/standards_activities/overview/overview.aspx?menuid=3> (July 1, 2014).

AES. (2014). "LEED for homes version 4 (V4)." *Alliance for Environmental Sustainability*, <http://www.alliancees.org/programs/leed-for-homes-version-4-v4/> (July 6, 2014).

Beatly, N. (2011). Green housing = improved health, a winning combination, National Center for Healthy Housing and Neighborworks, Columbia, MD.

.

DOE. (2014). "8.1 : Buildings sector water consumption." *Department of Energy,* <http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=8.1.1> (Mar. 18, 2014).

Brundtland, G. H. (1987). *World commission on environment and development: our common future*, Oxford University Press, New York, NY.

Choi, C. (2009). "Removing market barriers to green development: principles and action projects to promote widespread adoption of green development practices." *The Journal of Sustainable Real Estate*, 1(1), 107-138.

DOE. (2009). *2008 Buildings energy data book*, Department of Energy, Washington, DC.

DOE. (2012). 2011 *Buildings energy data book*. Department of Energy, Washington, DC.

Domas, M. A. and Burbano, V. A. (2011). "The Drivers of Greenwashing." *California Management Review*, 54(1), 64-87.

Dunn, S., Britt, S. M., and Makela, E. (2008). *Going beyond code*, U.S. Department of Energy, Washington, DC.

EarthCraft. (2014). "About EarthCraft." *Earth Craft*, <http://earthcraft.org/about-earthcraft> (Mar. 11, 2014).

EPA. (2014). "New homes partner locator." *Energy Star. Environmental Protection Agency*, <http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.locator> (Feb. 21, 2014).

EIA. (2014a). "July 2014 Monthly Energy Review." U.S. Energy Information Administration, <http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf>, (Accessed Aug. 22, 2014).

EPA. (2014b). "The inside story: a guide to indoor air quality." *Environmental Protection Agency,* <http://www.epa.gov/iaq/pubs/insidestory.html> (Feb. 21, 2014).

EPA. (2014c). “Reducing energy use.” *Environmental Protection Agency*, <http://www.epa.gov/greenhomes/ReduceEnergy.htm> (Jul. 30, 2014).
EPA. (2014d). “History of the ENERGY STAR guidelines for new homes.” *Environmental Protection Agency* <https://www.energystar.gov/index.cfm?c=new_homes.nh_history> (Jul. 30, 2014).

EPA. (2014e). “A green home begins with Energy Star blue.” *Environmental Protection Agency,* < https://www.energystar.gov/index.cfm?c=new_homes.nh_greenbuilding&s=mega> (Feb. 21, 2014).

EPA. (2013a). “Green building.” *Environmental Protection Agency,* <http://www.epa.gov/greenbuilding/> (Feb. 21, 2014).

EPA. (2013b). *Energy star certified homes, version 3 (Rev. 07) national program requirements.* Environmental Protection Agency, Washington, DC.

EPA. (2012). “Why build green.” *Environmental Protection Agency*, <http://www.epa.gov/greenbuilding/pubs/whybuild.htm> (Aug. 28, 2014).

FitzGerald, A. (2011). *Urban green building rating systems cost comparison*. National Association of Home Builders of Greater Chicago, Chicago, IL.

Fowler, K. M. and Rauch, E. M. (2006). “Sustainable building rating systems summary.” *Pacific Northwest National Laboratory (PNNL) and US Dept. of Energy*, Richland, WA. DOI:10.2172/926974

Furlow, N. (2010). “Greenwashing in the new millennium.” *Journal of Applied Business & Economics,* 10(6), 22-24.

HIRL. (2014). “Current NGBS certification activity.” *Home Innovations Research Lab*, <http://www.homeinnovation.com/services/certification/green_homes/resources/certification_activity_report> (Feb. 20, 2014).

HIRL. (2014a). “Current NGBS certification activity.” *Home Innovations Research Lab*, <http://www.homeinnovation.com/ngbsgreenstats> (Oct. 2, 2014).

Hoffman, A. J., and Henn, R. (2008). Overcoming the social and psychological barriers to green building. Organization & Environment, 21(4), 390-419.

HUD. (2014).“Energy efficient and green HOME housing.” *US Department of Housing and Urban Development,* <http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/affordablehousing/programs/home/greenhome> (July 30, 2014).

ICC. (2014a). “2012 International energy conservation code.” *International Code Council*, < http://shop.iccsafe.org/2012-international-energy-conservation-code-soft-cover.html> (Oct, 1 2014).

ICC. (2014b). “Overview.” *International Code Council*, <http://www.iccsafe.org/AboutICC/Pages/default.aspx> (Jul. 6, 2014).

RESNET. (2014b). “A homebuyer’s guide to energy efficient homes.” Residential Energy Services Network, < http://www.hersindex.com/guide-to-energy-efficient-homes> (Accessed Oct. 1, 2014).

ILFI. (2012). "Living building challenge 2.1." *International Living Future Institute*, <http://living-future.org/sites/default/files/LBC/LBC_Documents/LBC%202_1%2012-0501.pdf> (Mar. 11, 2014).

Kibert, C. J. (2004). “Green Buildings: An Overview of Progress.” *Journal of Land Use & Environmental Law*, 19(2), 491-502.

Kibert, C. J. (2008). *Sustainable Construction: Green Building Design and Delivery, 2nd Ed.* John Wiley & Sons Inc., Hoboken, NJ.

Laquatra, J., Pillai, G., Singh, A., and Syal, M. (2008). “Green and healthy housing.” *Journal of architectural Engineering*, 14(4), 94-97.

McGraw, H. (2013). *World green building trends.* McGraw Hill Construction, Bedford, MA.

NAHB. (2002). “Summary of green building programs, 2nd Ed.” *National Association of Home Builders*, <http://www.nrel.gov/docs/fy02osti/32390.pdf> (Mar. 14, 2014).

NAHB. (2008). “Green home building rating systems - a sample comparison.” *NAHB Research Center, Inc.*, <http://www.homeinnovation.com/services/certification/green_homes/resources/~/media/Files/Reports/GreenHomeRatingComparison.ashx> (Feb. 5, 2014).

NAHB. (2013). “National Green Building Standard, 2012: ICC 700-2012.” National Association of Home Builders, Washington, DC.

Navarro, M. (2009). Some buildings not living up to green label. *New York Times*, Aug. 30.

NC SOLAR. (2014).”Database of state incentives for renewables & efficiency.” *North Carolina Solar*, <http://www.dsireusa.org/solar/> (Jul. 30, 2014).

Olson, E. G. (2009). “Business as environmental steward: the growth of greening.” *Journal of Business Strategy*, 30(5), 4-13.

Prum, D., Aalberts, R., and Del Percio, S. (2012). “In third parties we trust? The growing antitrust impact of third-party green building certification systems for State and local governments.” *Journal of Environmental Law & Litigation*, 27(1), 191-236.

Reeder, L. (2010). Guide to green building rating systems: understanding LEED, Green Globes, Energy Star, the National Green Building Standard, and more, Vol. 12, John Wiley & Sons, Hoboken, NJ.

RESNET. (2014a). “What is the HERS index?” *Residential Energy Services Network*, <http://www.resnet.us/hers-index> (Oct. 1, 2014).

RESNET. (2014b). "A homebuyer's guide to energy efficient homes." *Residential Energy Services Network,* < http://www.hersindex.com/guide-to-energy-efficient-homes> (Oct. 1, 2014).

Robinson, L. (2009). "A summary of diffusion of innovations." *Enabling Change,* <http://www.enablingchange.com.au/Summary_Diffusion_Theory.pdf> (Oct. 3, 2013).

Ruegemer, J., and Smith, R. E. (2012). "Energy Efficiency Benchmarks for Housing: A Comparative Study of Energy Efficiency Benchmark Housing Systems." *International Journal of Technology, Knowledge & Society*, 8(1).

Sibbel, A. (2009). "Pathways Towards Sustainability Through Higher Education." *International Journal of Sustainability in Higher Education*, 10(1), 68-82.

Syal, M.G., Abdulrahman, K., and Li, Q. (2009). *Role of electrical contractors on LEED projects*. ELCTRI International, Bethesda, MD.

Syal, M.G., Mago, M., and Moody, M. (2007). "Impact of LEED-NC credits on contractors." *Journal of Architectural Engineering*, 13(4), 174-179.

UN. (2013). "World population projected to reach 9.6 billion by 2050 – UN report." *United Nations*, <http://www.un.org/apps/news/story.asp?NewsID=45165#> (Mar. 18, 2014).

USGBC (2013). *LEED for homes rating system,* United States Green Building Council, Washington, DC.

USGBC (2014). "LEED for homes certificate projects: Feb. 7, 2014." *United States Green Building Council*, <http://www.usgbc.org/resources/leed-homes-certified-projects> (Feb. 20, 2014).

USGBC. (2009). "Foundations of LEED." *United States Green Building Council*, Washington, DC.

Appendix A: Side-By-Side Comparisons

Table A.1: Project Planning Related Credits

LEED for Homes - Integrated Project Planning		NGBS - Other	
Integrated Project Team	ID 1.2	502.1	Project Team, Mission Statement, Goals
Professional Credentialed with Respect	ID 1.3	o	
Design Charrette	ID 1.4	502.1	Project Team, Mission Statement, Goals
Building Orientation for Solar Design	ID 1.5	703.6.1	Sun Tempered Design
Preliminary Rating	ID 1.1	o	Preliminary Green Scoring Tool
Durability Planning	ID 2.1	602.1.10	Exterior Doors
		602.1.12	Roof Overhangs
		602.1.3.1	Foundation Drainage - Exterior Drain Tile
		602.1.3.2	Foundation Drainage - Int. & Ext. Drain Tile to Daylight
		602.3	Roof Water Discharge
		602.4	Finished Grade
		602.1.5	Termite Barrier
		602.1.6	Termite Resistant Materials
		602.1.8	Water Resistant Barrier
		602.1.9	Flashing
		602.1.11	Tile Backing Materials
Durability Management	ID 2.2	o	
Third-Party Durability Management Verification	ID 2.3	o	

Planning and Design	Procurement	During Construction	Post Construction

Table A.2: Site and Location Credits

LEED for Homes - Location and Linkages & Sustainable Sites		NGBS - Lot Design, Preparation, and Development	
LEED for Neighborhood Development	LL 1.0	400	Site Design and Devleopment
Site Selection	LL 2.0	503.7	Environmentally Sensitive Areas
Edge Development	LL 3.1	501.1	Greyfield or Brownfield Lot
Infill	LL 3.2	501.1.2	Infill Lot
Previously Developed	LL 3.3	501.1	Greyfield or Brownfield Lot
Existing Infrastructure	LL 4.0	501.1.2	Infill Lot
Basic Community Resources/ Transit	LL 5.1	501.2	Multi-modal Transportation
Enhanced Community Resources/ Transit	LL 5.2		
Outstanding Community Resources/ Transit	LL 5.3		
Access to Open Space	LL 6.0	o	
No Invasive Species	SS 2.1	o	
Basic Landscape Plants	SS 2.2	503.5	Landscape Plan
Limit Conventional Turf	SS 2.3	503.5	Landscape Plan
Drought Tolerant Plants	SS 2.4	o	
Reduce Overal Irrigation Demand by at Least 20%	SS 2.5	801.6	Irrigation Systems
Reduced Local Heat Island Effects	SS 3.0	503.5	Landscape Plan
		505.2	Heat Island Mitigation
Permeable Lot	SS 4.1	503.4	Stormwater Management
Permanent Erosion Controls	SS 4.2	503.2	Slope Disturbance
Management of Run-off from Roof	SS 4.3	503.4	Stormwater Management
Pest Control Alternatives	SS 5.0	o	
Moderate Density	SS 6.1	505.3	Density
High Density	SS 6.2		
Very High Density	SS 6.3		
	o	503.1	Natural Resources
	o	503.6	Wildlife Habitat
	o	505.4	Mixed-Use Development
	o	504.1	On Site Supervision
Erosion Controls (During Construction)	SS 1.1	503.2	Slope Disturbance
		503.3	Soil Disturbance and Erosion
Minimize Disturbed Area of Site	SS 1.2	503.3	Soil Disturbance and Erosion
		504.2	Trees and Vegitation

Planning and Design	Procurement	During Construction	Post Construction

Table A.3: Water Efficiency Credits

LEED for Homes - Water Reuse		NGBS - Water Efficiency	
Rainwater Harvesting System	WE 1.1	801.7	Rainwater Collection and Distribution
Graywater Reuse System	WE 1.2	802.1	Reclaimed, Gray, or Recycled Water
Use of Municipal Recycled Water System	WE 1.3	o	
High Efficiency Irrigation System	WE 2.1	801.6	Irrigation Systems
Reduce Overall Irrigation Demand by at Lease 45%	WE 2.3	o	
	o	802.2	Automatic Shutoff Water Devices
	o	802.3	Engineered Biological or Biomediation System
	o	802.5	Advanced Wastewater Treatment System
High Efficiency Fixtures and Fittings	WE 3.1	801.3	Showerheads
Very High Efficiency Fixtures and Fittings	WE 3.2	801.4	Lavatory Faucets
		801.5	Water Closets and Urinals
	o	801.1	Indoor Hot Water Usage
	o	801.2	Water-Conservating Appliances
	o	801.8	Sediment Filters
	o	802.4	Recirculating Humidifier
Third Party Inspection	WE 2.2	o	

Planning and Design	Procurement	During Construction	Post Construction

Table A.4: Material Efficiency Credits

LEED for Homes - Materials and Resources		NGBS - Resource Efficiency	
	o	601.3	Building Dimensions and Layouts
	o	601.6	Stacked Stories
	o	601.8	Foundations
	o	603.1	Reuse of Existing Building
	o	606.3	Manufacturing Energy
Framing Order Waste Factor Limit	MR 1.1	o	
Detailed Framing Documents	MR 1.2	601.4	Framing and Structural Plans
Detailed Cut List and Lumber Order	MR 1.3	601.4	Framing and Structural Plans
Off-site Frabrication	MR 1.5	601.5	Prefabricated Components
FSC Certified Tropical Wood	MR 2.1	606.2	Wood-Based Products
Environmentally Preferable Products	MR 2.2	603.2	Salvaged Materials
		604.1	Recycled Content
		606.1	Biobased Products
		608.1	Resource-Efficient Materials
		609.1	Regional Materials
		901.4	Wood Materials
		901.5	Cabinets
		901.6	Carpets
		901.7	Hard-Surfaces Flooring
		901.8	Wall Coverings
		901.9	Interior Architectural Coatings
		901.1	Interior Adhesives and Sealants
		901.11	Insulation
Construction Waste Management Planning	MR 3.1	605.1	Construction Waste Management Plan
	o	601.7	Site-Applied Finishing Materials
	o	601.9	Above-Grade Wall Systems
	o	610.1	Life Cycle Analysis
Framing Efficiencies	MR 1.4	601.2	Material Usage
Construction Waste Reduction	MR 3.2	603.3	Scrap Materials
		605.2	On-Site Recycling
		605.3	Recycled Construction Materials
	o	607.1	Recycling

Planning and Design	Procurement	During Construction	Post Construction

Table A.5: Indoor Environmental Quality and Education Credits

LEED for Homes - Indoor Environmental Quality		NGBS - Indoor Environmental Quality	
ENERGY STAR with Indoor Air Package	EQ 1.1	o	
Basic Combustion Venting Measures	EQ 2.1	901.1	Space and Water Heating Options
Enhanced Combustion Venting Measures	EQ 2.2	901.2	Solid Fuel-Burning Appliance
		901.12	Carbon Monoxide (CO) Alarms
Moisture Load Control	EQ 3.1	903.3	Relative Humidity
Basic Outdoor Air Ventilation	EQ 4.1	902.2	Building Ventilation Systems
Enhanced Outdoor Air Ventilation	EQ 4.2		
Basic Local Exhaust	EQ 5.1	902.1	Spot Ventilation
Exhanced Local Exhaust	EQ 5.2		
Return Air Flow / Room by Room Controls	EQ 6.2	704.3	Return Ducts and Transfer Gilles in Every Room
Indoor Contaminant Control	EQ 8.2	902.13	Building Entrance Pollutant Controls
		902.5	Central Vacuum Systems
Radon-Resistant Construction in High-Risk Areas	EQ 9.1	902.3.1	Radon Control Zone 1
Radon-Resistant Construction in Moderate-Risk Areas	EQ 9.2	902.3.2	Radon Control Zones 2 and 3
No HVAC in Garage	EQ 10.1	901.1.2	No HVAC Equipment in Garage
Minimize Pollutants from Garage	EQ 10.2	901.3	Garages
Exhaust Fan in Garage	EQ 10.3		
Detached Garage or No Garage	EQ 10.4		
Room-by-Room Load Calculations	EQ 6.1	701.4.1.1	HVAC System Sizing
Good Filters	EQ 7.1	902.2.3	Filters
Better Filters	EQ 7.2		
Best Filters	EQ 7.3		
Indoor Contaminant Control During Construction	EQ 8.1	902.4	HVAC System Protection
Preoccupancy Flush	EQ 8.3	o	
	o	602.1.1	Capillary Brakes
	o	602.1.4	Protect Crawlspaces
	o	602.1.7	Moisture Control Measures
Third-Party Performance Testing	EQ 4.3	902.2.2	Ventilation Testing
Third-Party Performance Testing	EQ 5.3	o	
Third-Party Performance Testing	EQ 6.3	704.5.2.2	HVAC Airflow Testing

LEED for Homes - Awareness and Education		NGBS - Operations, Maintenance, and Building Owner Education	
Basic Operations Training	AE 1.1	1001.1	Owner's Manual
Enhanced Training	AE 1.2	1002.1	Training of Building Owners
Public Awareness	AE 1.3	o	

Planning and Design	Procurement	During Construction	Post Construction

Appendix B: Process Flow Diagrams

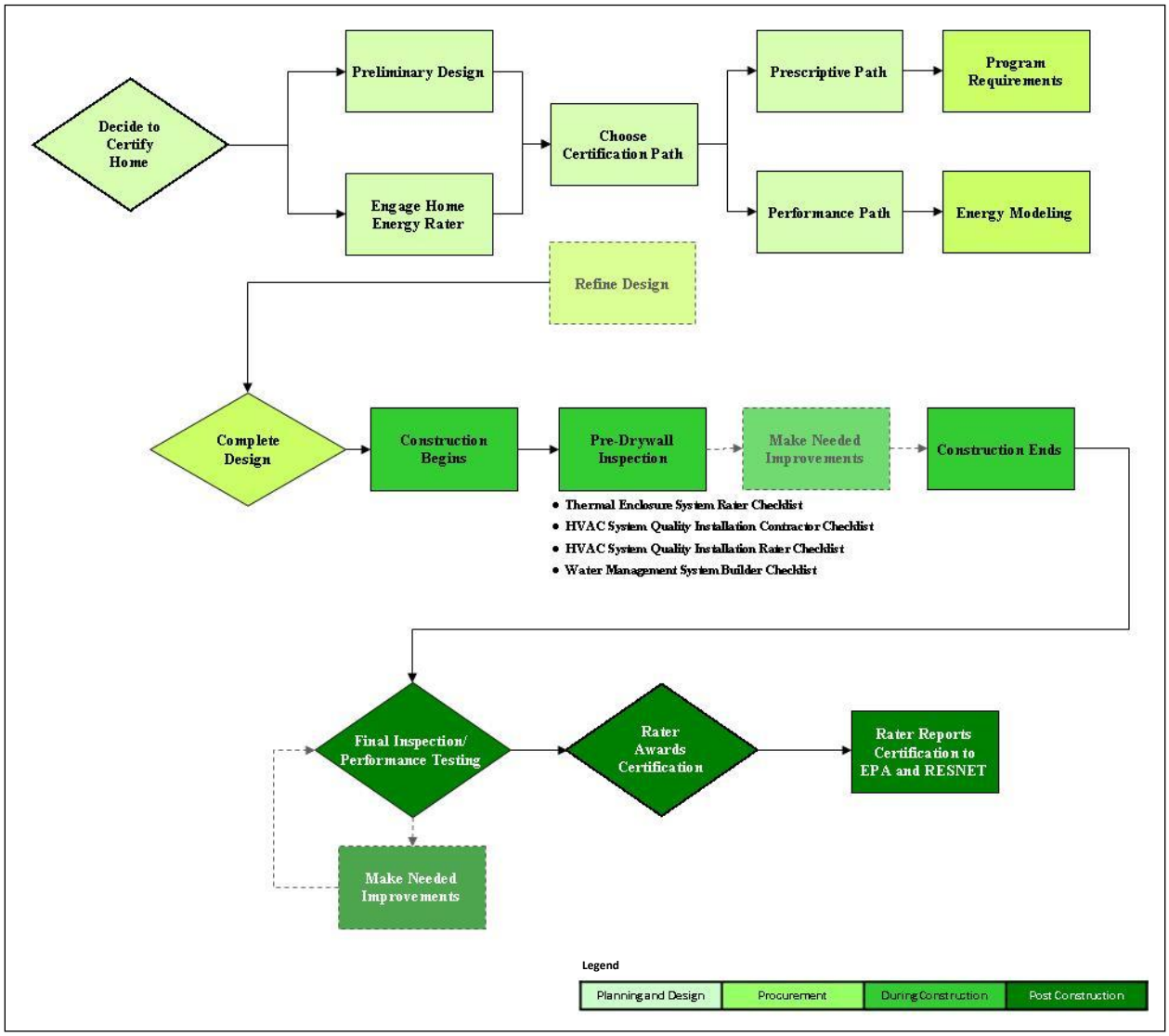

Figure A.1: Energy Star Process Flow

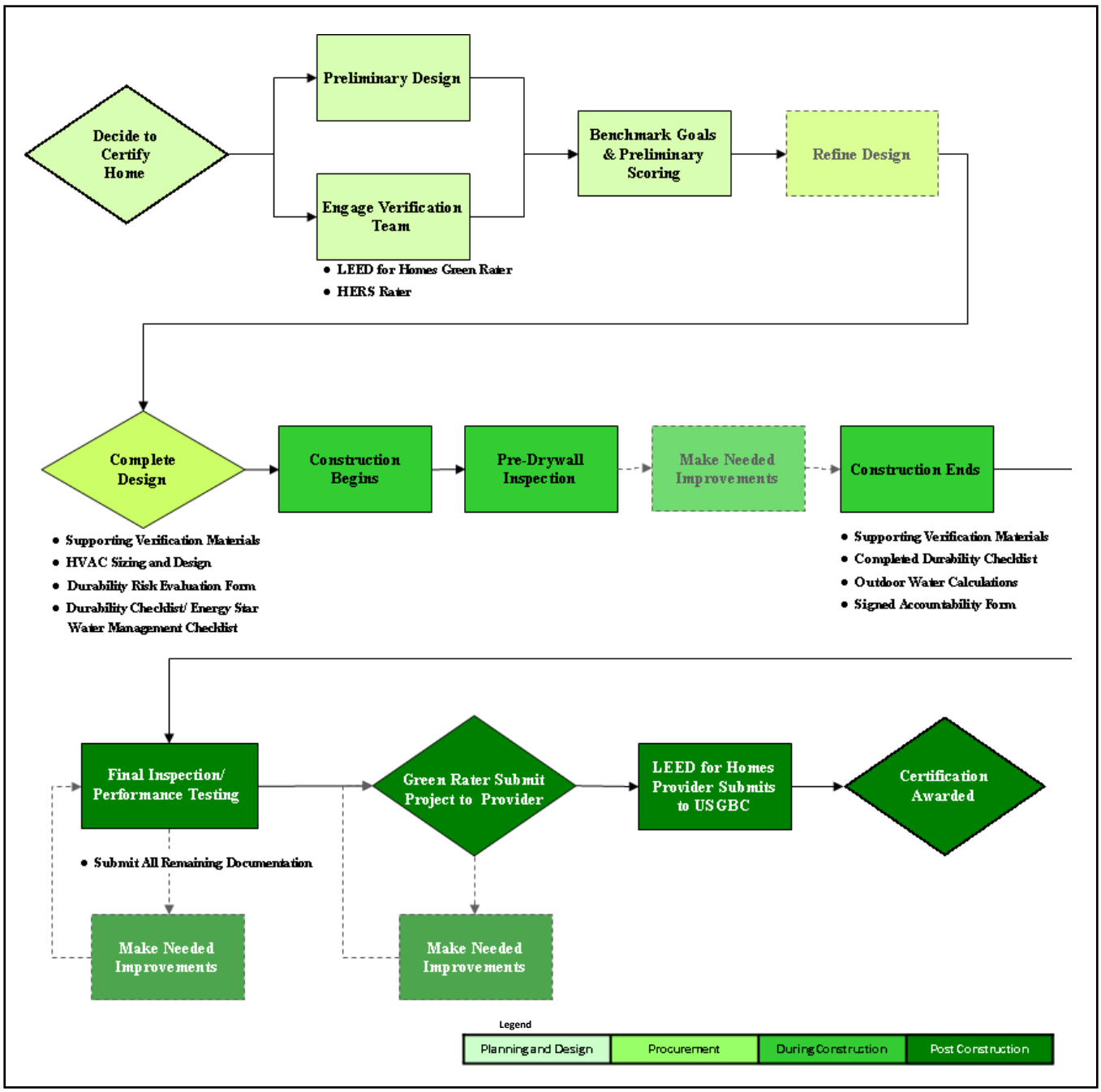

Figure A.2: LEED for Homes Process Flow

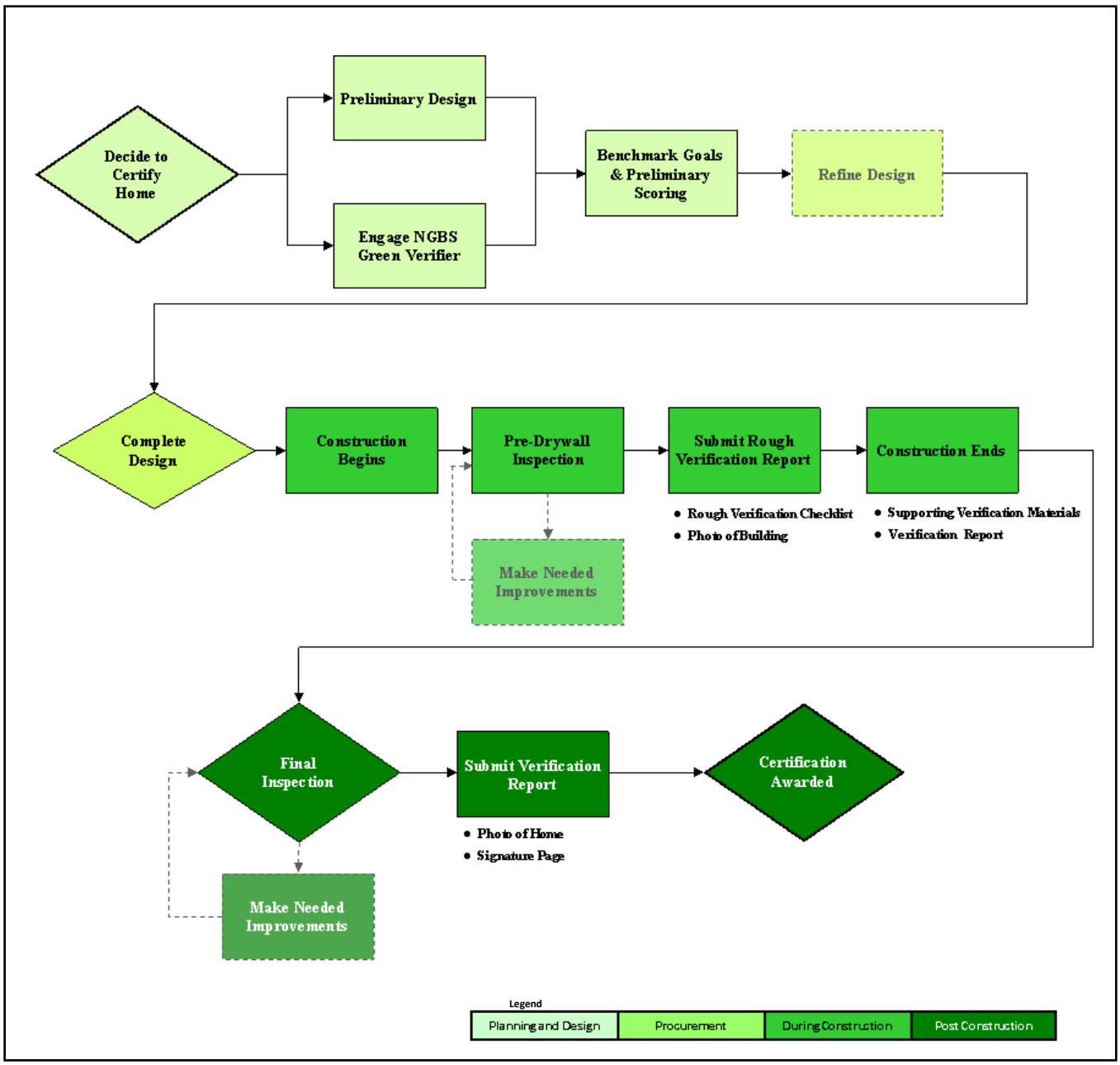

Figure A.3: National Green Building Standard Process Flow

Appendix C: Builder and Rater Input

Table A.6: First-Time Homebuyers

	Energy Star	LEED for Homes	
Profile			
Annual Volume	100 – 110	2 - 5	15 - 20
State	Michigan	Michigan	Michigan
Systems Used	Energy Star	LEED for Homes	LEED for Homes
# Certified	> 500 Homes	9 Homes	>150 Homes
Common Benchmarks	n/a	Silver	Gold
Typical Customer	First Time	First Time/ Affordable	First Time/ Affordable
Initiator	Builder	Builder	Builder
New Const. or Renovation	New	Renovations	New & Renovations
Documentation			
Duration	0 - 6 Hours	18 - 24 Hours	0 - 6 Hours
Comments	Rater handles majority of documentation.	Time Consuming	Standard practice, so no impact.
Duration			
Design Phase	4 - 6 Months	4 - 6 Months	0 - 3 Months
Construction Phase	4 - 6 Months	4 - 6 Months	4 - 6 Months
Standard Practice?	Yes	Yes	Yes
Costs			
Costs Transferred	ALL	ALL	ALL
High Up-Front Costs	Insulation	Insulation	Indoor Environment Credits
Best ROI	Insulation	Building Envelope	Indoor Environment Credits
Encouraged to Upgrade?	Custom options upon owner's request.	Customer not involved in design process.	Customer not involved in design process.
Improved Quality			
Installation	Yes	Yes	Yes
Materials	Yes	Yes	Yes
Customer Service	No	No	No
Participant Satisfaction			
Management	Committed	Committed	Committed
Trades	Indifferent	Varied	Understand the Vision
Owners	Often Miss the Big Picture	Initially Unaware	Appreciate Direct Benefits
Owner Education			
How are they educated?	Informed of Business Practices.	Owner’s Manual	2 Hour Homebuyer Walk Through

Table A.74: Move-up Homebuyers

	Energy Star		LEED for Homes	NGBS		
Profile						
Annual Volume	5 – 10	10 - 30	30	1 - 4	2 - 3	100
State	North Carolina	Michigan	Michigan	North Carolina	Michigan	North Carolina
Systems Used	Energy Star	Energy Star, Five Stars, SEAL	LEED for Homes	NGBS, Energy Star, HERO	NGBS	NGBS
# Certified	12	> 1000 Homes	10 Homes	2 Homes	8 Homes	>300 Homes
Common Benchmarks	n/a	n/a	Gold/ Platinum	Gold	Gold	Bronze
Typical Customer	Move-Up and Empty Nester	Move-Up	Move-Up Buyers	Move-Up	Move-Up	Move-Up Buyers
Initiator	Builder	Builder	Builder & Owner	Builder	Builder	Builder
New Const. or Renovation	New	New	Renovations	New	New	New
Documentation						
Duration	0 - 6 Hours	0 - 6 Hours	> 24 Hours	18 - 24 Hours	0 - 6 Hours	0 - 6 Hours
Comments	Rater Handles Majority	Standard practice, so no impact.	Very Time Consuming	Very Time Consuming	Standard Practices	Standard practice, so no impact.
Duration						
Design Phase	0 - 3 Months	4 - 6 Months	6 Months	4 - 6 Months	0 - 3 Months	0 - 3 Months
Construction Phase	4 - 6 Months	4 - 6 Months	6 - 8 Months	7 - 12 Months	4 - 6 Months	4 - 6 Months
Standard Practice?	Yes	Yes	Yes	Yes	Yes	Yes
Costs						
Costs Transferred	ALL	ALL	Direct and Indirect	Direct and Indirect	Direct	ALL
High Up-Front Costs	High-Efficiency Equipment	Insulation	Envelope and Water System	Windows and Insulation	Geothermal	Envelope and HVAC
Best ROI	High-Efficiency Equipment	Insulated Basements	Framing and Insulation	Air Sealing	Geothermal	Not Sure
Encouraged to Upgrade?	Some yes, others no.	No upgrades offered	Yes, if they can afford to.	Yes, if they can afford it and if they can see or feel it.	It is very difficult to sell owners on green practices.	No. Customers typically not actively interested in understanding details.
Improved Quality						
Installation	No	Yes	Yes	Yes	Yes	Yes
Materials	Yes	Yes	Yes	Yes	No	Yes
Customer Service	No	No	No	Yes	No	No
Participant Satisfaction						
Management	Committed	Committed	Excited	Committed	Excited	Committed
Trades	Indifferent	Indifferent	Invested	Indifferent	Indifferent	Indifferent
Owners	Some Understand Benefits	Often Unaware	Aware and Satisfied	Aware and Satisfied	Aware and Satisfied	Often miss the big picture
Owner Education						
How are they educated?	Informed of Business Practices.	Informed of Business Practices.	Manual and Information Sessions	Through Design and Construction Phases and with manual during closing walk-through.	Manual with Pictures	Informed of Business Practices.

Table A.8: Third-Party Rater Input

	Energy Star	LEED for Homes	NGBS
Project Duration	• Varies • 3 – 12 months	• Varies • At least 6 months	• Varies • 8 – 24 months
Inspection Delays	• It depends • 1 week	• It depends • None	• None • 1-2 days
Hindrances	• Builder negligence • Lack of understanding for program requirements • Lack of communication • Poor Scheduling • Poor installation of materials	• Code compliance • Insulation quality • Availability of certified HVAC contractors • Fee payment	• Clarity of credit requirements • Clarity of program requirements • Subs that are not invested • Poor installation • Time of engagement • Availability of certified HVAC contractors
High Up-Front Costs Items Used	• Depends on time of engagement	• Depends on time of engagement • Insulation • Energy efficient materials and equipment	• Depends on time of engagement • Depends on benchmark goals

Appendix D: Questionnaires

LEED for Homes Builder Questions

Date _____

Profile

Name of Builder _____

Location _____ Year Started _____

How long has your company been involved in sustainable development? _____

What rating system does your organization use most often? _____

Typical Benchmark Level Achieved _____ No. of Projects Certified _____

LEED Version Used? _____

Other systems used? _____

Please describe your typical customer? _____

Annual Volume of Residential Projects? _____

Who typically initiates the certification process? ○ Owner ○ Builder

Type of projects that your company does most often? □ New Construction □ Major Renovations

Which characteristics best define your company? □ Developer □ Custom Builder □ Production Builder

Time

1. Typical duration of the design process for your LEED projects?

   ○ 0 – 3 months ○ 4 – 6 months ○ 7 – 12 months ○ + 12 months

2. Typical construction duration for your LEED projects?

   ○ 0 – 3 months ○ 4 – 6 months ○ 7 – 12 months ○ + 12 months

3. Is this longer than conventional construction, if so how long? _____
4. Which parts of the certification process significantly affect productivity? _____

   _____

Documentation

1. Other than plans and specifications, how much time is spent on gathering documents (i.e. material specifications, manuals, etc.) and preparing documents (i.e. required checklists) that are needed for the certification process?

   ○ 0 – 6 Hrs ○ 6 – 12 Hrs ○ 12 – 18 Hrs ○ 18 – 24 Hrs ○ +24 Hrs

2. What documentation is required for the project and who is responsible for preparing various documents?

Categories	Builder	Other
Lot Design, Preparation, and Development		
Resource Efficiency		
Energy Efficiency		
Water Efficiency		
Indoor Environmental Quality		
Operation, Maintenance, and Building Education		

Costs

1. Which costs are transferred to the owner? Please check all that apply.

   □ Direct (Materials, Labor, Equipment)
   □ Indirect (Overhead)
   □ Registration
   □ Certification
   □ Third-Party Verification

2. Cost of Fees

   $ _____ Registration

   $ _____ Certification

   $ _____ Third-party Verification

Initial Cost

1. Which sustainable practices or credits used in your projects have the highest up-front costs?

   _____

   _____

2. Which sustainable practices or credits used in your projects have the best return on investment (ROI)?

   _____

   _____

3. Are owners easily encouraged to select products with high up-front costs after they are aware of the ROI?

Quality

1. Does certification increase the level of quality in material installation, why or why not? ○ Yes ○ No

2. Does certification increase the quality of materials selected, why or why not? ○ Yes ○ No

3. Does certification increase the quality of customer service, why or why not? ○ Yes ○ No

Participant Satisfaction

1. Management opinions of the certification process and requirements?

2. Labor opinions of the certification process and requirements?

3. Are owners of certified homes more satisfied, do they understand the significance of the sustainable practices used?

4. Do you receive less call backs with certified projects?

5. How are owners educated about their green home?_____

_____

Comments

Date: _____ **LEED for Homes Rater Questions**

Profile

1. Name _____
2. Organization _____
3. City, State _____
4. How long have you been involved in sustainable development? _____
5. What rating system do you verify most often? _____
6. Other systems? _____ Common Benchmark Levels _____
7. Number of projects verified? _____ Percentage of Failed Attempts? _____

Documentation

a) Documentation that raters must submit? _____

_____

b) What documentation is required for the project and who is responsible for preparing them?

Categories	**Rater**	**Builder**
Innovation and Design		
Location and Linkages		
Sustainable Sites		
Water Efficiency		
Energy and Atmosphere		
Materials and Resources		
Indoor Environmental Quality		
Awareness & Education		

CM Aspects

1) **Time**
   a) What is the typical duration of a project? _____
   b) How long is the project pushed back if a follow-up inspection is needed? _____
   c) What are common hindrances to achieving certification? _____

      _____

Initial Costs and Life Cycle Cost Assessment

a) How often are materials/ products with high upfront costs used? _____

Multifamily/ Mixed Use

a) What are some challenges to certification?_____
b) Additional documentation?_____

Comments

_____

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