AN EXPLORATORY STUDY OF THREE PATHS TO GREEN HOMES:
Energy Star Homes, LEED for Homes, and the National Green Building Standard

By

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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 the same product, there is much confusion among builders, consumers, and local governments about the similarities and differences of these programs. Several studies have compared the 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 the credit and documentation requirements, phases of the certification process where identified and used to add context 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 the 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.

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LIST OF ABBREVIATIONS

AEGB	Austin Energy Green Building Program
AIA	American Institute of Architects
ANSI	American National Standards Institute
BREEAM	Building Establishment Environmental Assessment Methods
CGB	Chicago Green Building Program
DOE	Department of Energy
EPA	Environmental Protection Agency
GBG	Model Green Building Guidelines
HERS	Home Energy Rating System
HIRL	Home Innovation Research Lab
HVAC	Heating, Ventilation, and Air Conditioning
ICC	International Code Council
kBTU	Thousand British Thermal Units
LEED	Leadership in Energy and Environmental Design
NAHB	National Association of Home Builders
NGBS	National Green Building Standard
PHPP	Passive House Planning Program
RESNET	Residential Energy Service Network
USGBC	United States Green Building Council

CHAPTER 1 – INTRODUCTION

1.1 Introduction

Sustainability has seemingly become ubiquitous in the United States as sustainable business practices have increased (Olson 2009). Companies and industries have begun to incorporate sustainable or “green” practices in their products, services, and business models in one form or another. Sustainability has become especially common in the construction industry with the adoption of green buildings in both the residential and commercial sector (McGraw 2013). Green building rating systems are used to verify the use of sustainable materials, practices, and techniques in green buildings.

Three residential green building rating systems; Energy Star Homes, LEED for Homes, and the National Green Building Standard (NGBS) have been nationally adopted and accepted by builders in the construction industry (Reeder 2010). But this acceptance has not come without confusion. Studies have shown that builders, consumers, and local governments are confused about the similarities and differences of these systems (AIA 2010; Ruegemer and Smith 2012; NAHB 2008; FitzGerald 2011). The purpose of this report is to compare these three systems with regard to the certification process and the certification experience.

The original concept of sustainable development was defined in 1987 as “development that meets present needs without compromising the ability of future generations to meet their own needs” (Brundtland 1987). Green buildings are one facet of sustainable development, which is the practice of using healthier and more resource efficient models of construction, maintenance, operation, renovation, and demolition (EPA 2013a). Green buildings, also known as sustainable, eco-friendly, or high-performance buildings are defined as high performance buildings that promote resource efficiency, occupant health, and minimize environmental impacts using sustainable principles (Kibert 2008). Green building rating systems verify the efforts through the use of third-party raters who guide and certify the work put in place.

1.2 The Green Building Movement

The energy crisis of the 1970s is recognized as a major turning point in the construction industry and has been considered the beginning of the green building movement (Kibert 2004). The establishment of the Environmental Protection Agency (EPA) in 1970, in response to the need for regulation and leadership for environmental initiatives, was also a key contributor (Kibert 2004). The impact that the built environment has on the ecological environment became an issue that attracted global attention in 1992 at the United Nations Conference on Sustainable Development in Rio de Janeiro, Brazil (Kibert 2004).

In the same year, the Building Research Establishment Environmental Assessment Methods (BREEAM), a green building rating system, was developed in the United Kingdom to guide the development of sustainable buildings. The following year, the United States Green Building Council (USGBC) was founded to assist in the implementation of sustainable development in the U.S. (Kibert 2004). As the green building movement began to progress, there was a need to measure and define standards for green buildings; the Leadership in Energy and Environmental Design (LEED) system was created in response to that need. In 1998 the USGBC launched a pilot program of the first LEED green building rating system which has since become the predominant guideline in the commercial market (USBGC 2009; Prum et al. 2012).
Following an awareness of energy consumption due to the energy crisis, companies and industries began to think more about energy efficiency (Kibert 2008). Although this awareness helped support the emergence of more environmentally responsible manufacturing practices, it

also allowed some companies to misrepresent sustainable efforts. Green building rating systems, also referred to as green building guidelines, green building programs, beyond code programs, and benchmark systems, developed out of a need for verification of sustainable development due to greenwashing. Greenwashing is the inaccurate communication of environmental performance and is considered to be the intersection of poor environmental performance and positive communication. The lack of regulation of building practices in the U.S. has allowed this misrepresentation to persist (Delmas and Burbano 2011).

Zmuda and Parekh (2008) believe that if consumer confidence is lost due to the misrepresentation of information, greenwashing can be detrimental because consumers may disregard both legitimate and illegitimate claims of positive environmental performance of products and companies. Increased skepticism from consumers may cause legitimate companies to lose their competitive edge, leaving responsible companies little motivation to strive for superior performance; consequentially, greenwashing has the potential to be harmful to consumers, companies, and ultimately the environment (Polansky et al.1998; Furlow 2010). Green building rating systems have served as an initiative to legitimize claims of sustainability in the construction industry.

Green building rating systems are voluntarily adopted programs that are designed to incorporate building practices that exceed federal, state, and local building code requirements, thus the synonym “beyond code programs” (Dunn et al. 2008). Each system includes several focus or performance categories. Common performance categories include: site, lot, energy efficiency, resource efficiency, water-efficiency, indoor environmental quality, and innovation. Each performance category contains various sustainable practices and techniques commonly referred to as credits. Credits are weighted and assigned a number of points. Some green building rating systems make a portion of credits mandatory and require them as prerequisites to certification.

The energy efficiency category is consistently found to be the most costly group of credits in several different systems (NAHB 2008; FitzGerald 2011; AIA 2010).

Green buildings rating systems emphasize integrated project teams and early incorporation of sustainable practices in the building design. The selection of appropriate materials and proper installation of materials are also signification parts of the certification process (EPA 2012). Third-party verification is required for certification and is essential in providing accountability for builders and preventing greenwashing. After construction is complete, some systems require performance testing to verify that the home has actually been designed and constructed perform at the projected levels of efficiency (EPA 2013b; NAHB 2013; USGBC 2013).

In most systems a grade or designation is awarded depending on the amount of points a project earns. Green building rating systems differ in the types of construction they certify, the categories they focus on, and the scope of their geographic coverage (EPA 2013b; NAHB 2013; USGBC 2013). Several states and local governments have created incentives to encourage the use of beyond code programs (NCSOLAR 2014).

1.3 Residential Green Building Rating Systems

Sustainable development is often recognized for its market penetration and projected growth in the commercial sector, but the residential sector has also seen much progress in sustainable development in recent years (McGraw 2013; EPA 2014A; EarthCraft 2014; HIRL 2014; USGBC 2014). This progress has manifested itself into numerous systems that have been developed locally and consequently are limited to addressing regional conditions. In 2002, there were at least 26 different regionally-based green building rating systems in the United States (NAHB 2002). Few systems have been developed to certify residential buildings on a national level;

Energy Star Homes, LEED for Homes, and the National Green Building Standard (NGBS) are three programs that are an exception to this (EPA 2013b; NAHB 2013; USGBC 2013). For the sake of brevity, these systems will be referred to as LEED, Energy Star, and NGBS throughout this study.

Energy Star, LEED, and the NBGS are championed by the Environmental Protection Agency (EPA), a government organization, the United States Green Building Council (USGBC), a non-profit organization, and the National Association of Home Builders (NAHB), a national trade organization respectively. These guidelines have found varied levels of success among homeowners, builders, and local governments. As of February 2014, Energy Star has certified 1,510,998 homes, LEED for Homes has certified 12,308 homes, and the NGBS has certified 7,491 homes (EPA 2014a; HIRL 2014; USGBC 2014). The Model Green Building Guidelines (the predecessor of the NGBS), the Passive House Building Energy Standard, and the Living Building Challenge are also residential systems that have been adopted at the national level and have gained attention in recent years. The three systems studied here have been selected because they have been widely accepted and implemented by the residential construction industry (Reeder 2010). Table 1.1 shows the three systems and basic program information.

Table 1.1: 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,)

1.4 Need for Residential Green Building Rating Systems

Green building rating systems are known for their requirements that reduce impacts on the environment, improve indoor air quality, and creative positive financial impacts. Residential systems seek to transform the homebuilding industry in the same way. Certified green homes are built to be more efficient and have a reduced impact on the environment. There is currently a need to understand nationally accepted systems and to expand the research of existing comparisons.

1.4.1 Need for Green Homes

Consumption of Natural Resources

Buildings in the United States have had significant negative impacts on the environment and human health; research shows that residential buildings have a greater impact than commercial buildings (EIA 2014). Such impacts include excessive energy consumption, water consumption, high CO_2 emissions, and human health impacts. In 2008 the U.S. Department of Energy (DOE) reported that, buildings consume 40% of all energy consumed in the United States. Of that, commercial buildings consumed 18% while residential buildings consumed the remaining 22%. Buildings are also a leading contributor of carbon dioxide emissions. Residential buildings use more electricity and water compared to commercial buildings (DOE 2009; DOE 2012).

Indoor Environmental Quality

Improved air sealing of building envelopes was one response to the 1970s energy crisis. In turn, ventilation in buildings was reduced, creating an environment that allowed biological and chemical pollutants to be trapped indoor (Beatly 2011). Research has shown that “people spend the approximately 90 percent of their time indoors” where air quality can be much worse than outdoor air. There is also evidence that poor indoor environmental quality is associated with cancer, asthma, and other respiratory and cardiovascular diseases. Young children, the elderly, and individuals with existing medical conditions are most at risk (EPA 2014b). Pollutants like dust mites, pollen, insects, molds, carbon monoxide, radon, asbestos, and volatile organic compounds (VOC) thrive in poorly filtered and ventilated indoor air and are found in many homes (Laquartra et al. 2008). Green building rating systems seek to improve the indoor environmental quality in buildings (EPA 2013b; LEED 2013; NAHB 2013).

Financial Impacts

The sustainable practices used in green buildings have the potential to reduce energy costs. Although it can be difficult to quantify, green homes have positive financial impacts on homeowners (EPA 2014c). Certified homes are built to exceed energy building codes and to operate more efficiently than conventional buildings. Improved insulation and air sealing offers more thermal resistance, site tested heating, ventilations, and air conditioning (HVAC) systems are designed for right-sizing, and measures are taken to conserve water and generate less waste (EPA 2013b, LEED 2013, NAHB 2013). Because there is a need for green homes, there is also a need for residential green building rating systems.

1.4.2 Existing Comparisons of Residential Green Building Rating Systems

Builders, consumers, and local governments are unsure about the similarities and differences in existing residential green building rating systems. Several studies have compared various aspects of commonly used systems with a focus on differences in energy performance, cost of compliance, and minimum requirements. A research group at the University of Utah studied the LEED, NGBS, Energy Star, and Passive House Green Building Standard to determine which of the systems could support net zero performance using energy efficient equipment and passive design (Reugmer and Smith 2012). The Chicago Association of Home Builders conducted a study comparing the Chicago Green Building (CGB), NGBS, and LEED programs to compare the direct costs of compliance and certification fees of each system, for three different building types (FitzGerald 2011). The NAHB Research Center performed a similar study that examined the direct cost, indirect costs, and certification fees of two single-family homes in two different climates (NAHB 2008). In 2010, the Cincinnati chapter of the AIA published a side-by-side comparison of the 2008 versions of LEED and the NGBS. The study was the result of a request to extend tax benefits to NGBS certified projects in addition to LEED projects and focused on the minimum requirements of each system (AIA 2010; FitzGerald 2011; NAHB 2008; Reeder 2010; Reugmer and Smith 2012). These studies and their resulting conclusions will be discussed in more detail in the following chapter.

1.4.3 Need to Understand and Expand the Existing Comparisons

Despite efforts to compare various aspects of residential systems, it seems that there is still much confusion about the similarities and differences that exist. Although existing comparisons examine important aspects of residential green building rating systems, there is very little academic research or literature available that has focused on the phases of certification, the certification process, and the certification experience from a building professional's perspective. No studies that identify phases of certification and compare the systems with regard to the certification process and the certification experience have been found. Therefore, there is an apparent need to expand the breadth of existing comparison and to compare these three residential green building rating systems in a way that is meaningful to local governments, builders, and homeowners.

1.5 Objectives

This research seeks to compare the Energy Star, LEED, and the NGBS to determine the similarities and differences of each system. The objectives of this research are to:

1. Understand the scope and requirements for attaining certification in each system
2. Compare each system with an emphasis on the certification process:
    a. Documentation Requirements
    b. Credit Requirements
3. Compare each system with an emphasis on the certification experience:
    a. Builder Input
    b. Rater Input

1.6 Scope and Limitations

This research focuses on understanding and comparing the certification process and experience of three green building rating systems; Energy Star Homes, LEED for Homes, and the National Green Building Standard. Although other nationally adopted systems exist, these three have been selected because of their prominence and popularity. Each operates in the United States and certifies new construction and major renovations for single-family and multifamily buildings. This study is solely in reference to market conditions and the adoption of sustainable development and green building rating systems in the United States. Findings from this study are based on available literature and input from industry professionals experienced with the studied certification processes.

1.7 Methodology

The program requirements of each residential green building rating system were found in the system literature and supporting information about the certification process was found on the web sites of the administering organizations. Objectives 1 and 2, (understand the scope and program requirements and comparing certification processes), were also informed by information derived from interviews with experienced industry professionals. Preliminary meetings with builders and third-party raters were conducted to narrow the focus of the research objectives and to improve the questionnaires used for 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.

Objective 1: To understand the scope and requirements for attaining certification in each system;

- Review the program requirements of each system;
- Additional review of performance categories and their associated credits; and
- Visit existing certified homes to gain additional understanding of the sustainable building practices, techniques, and products used.
- Interview builders and third-party raters that have experience with certification

Objective 2: To compare each system with an emphasis on the certification process.

2a: With an emphasis on credit requirements:

- Align LEED for Homes 2008 and NGBS 2012 credits to show parallels among the systems; and
- Organize credits by the phase in which they are earned.

2b: With an emphasis on documentation requirements:

- Review program requirements to determine required submittals;
- Identify documentations requirements within the certification process; and
- Interview industry professionals to discuss documentation requirements.

Objective 3: To compare each system with an emphasis on the certification experience:

3a: With an emphasis on builder input:

- Interviewed builders that had experience with green building certification to discuss company profile, documentation, project durations, costs, improved quality, participant satisfaction, and owner education.

3b: With an emphasis on rater input:

- Interview third-party raters that had experience with green building certification to discuss project durations, delays, hindrances in the certification process, and the uses of high-up front cost items.

1.8 Research Outputs

There were five outputs with respect to the research objectives. First, the phases of the certification process were identified through the literature review and inferences acquired through interviews with third-party raters. Second, a side-by-side analysis of the LEED for Homes 2008 and NGBS 2012 analyzed the credit requirements and arranges credits according to the phase in which they are earned. Because the Energy Star program is limited in scope and can be used as a component in both the LEED and NGBS systems, it was included within the analysis and represented in the energy efficiency categories. Third, certification process flows for each system are graphically represented to display key steps and required documents in the certification process. The final two outputs include tables displaying input from builders and raters comparing their experience with the certification process.

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

The previous chapter provided an overview of the green building movement in the United States, the emergence of green building rating systems, a review of existing studies, the need for green homes, and the need to understand residential green building rating systems, and to expand existing comparisons. As shown in Figure 2.1, this chapter discusses the acceptance, adoption, and implementation of residential green building rating systems and gives a more detailed look at the three systems and existing comparisons studied in the research.

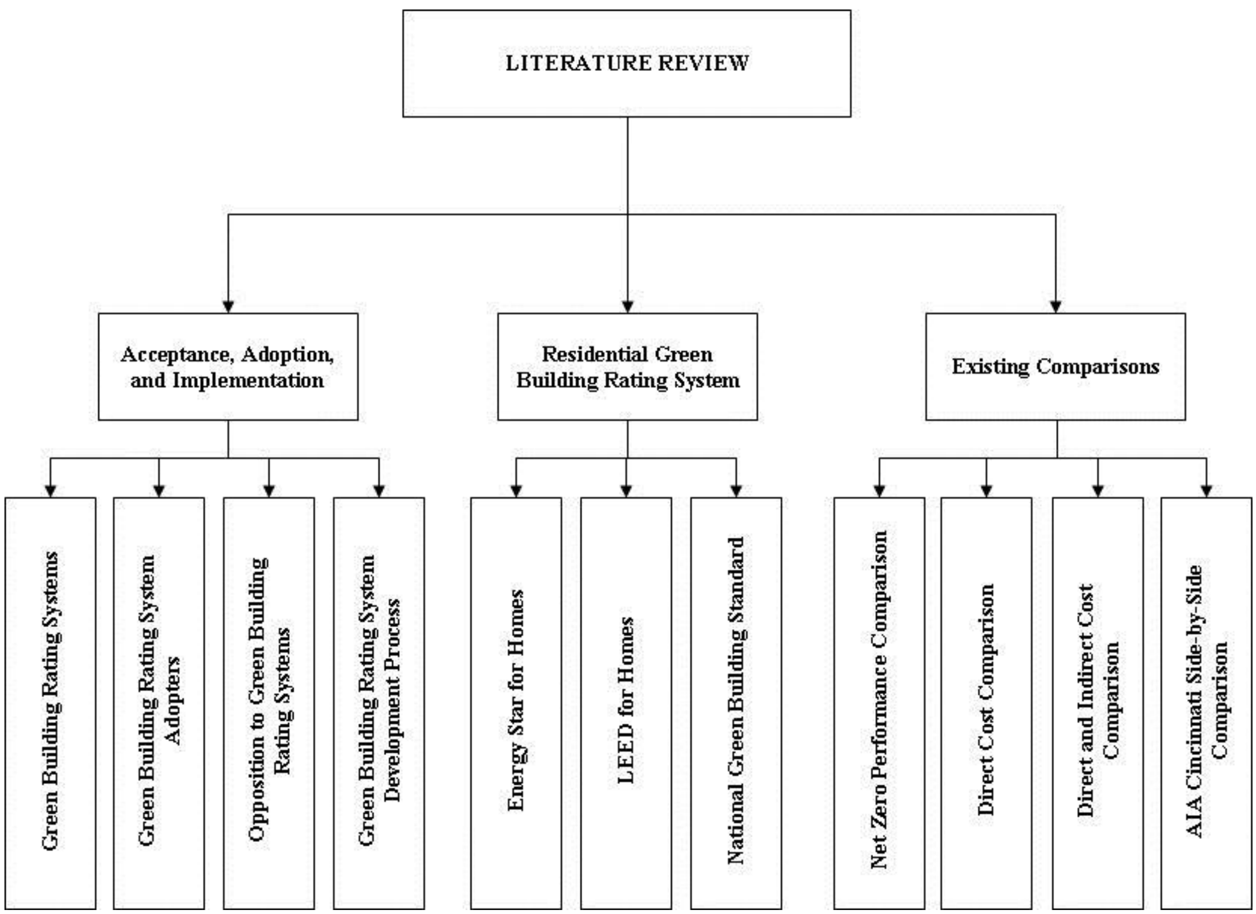

Figure 2.1: Chapter 2 Overview

2.2 Acceptance, Adoption, and Implementation

Green building rating systems have begun to be a common part of contemporary construction. They have been accepted and adopted at the request of progressive owners (McGraw 2013). With acceptance, there has also been opposition to claims of high-efficiency performance (Navarro 2009). Before a system can be implemented, it must go through an extensive development process that often includes consensus based committees with key stakeholders (USGBC 2009; NAHB 2012).

2.2.1 Green Building Rating Systems

Green building rating systems are voluntarily adopted programs that verify the use of sustainable practices in high-efficiency buildings. They are designed to exceed federal, state, and local building code requirements. Systems are often developed through extensive review processes performed by a committee of individuals from a number of related disciplines, providing a holistic approach to certification. Third-party verification is a key component of the certification process and is required to attain certification. Third-party raters are consultants that are employed by a green building rating system that are responsible for providing technical support and guiding the project team through the certification process. Raters also collect documentation, inspect the work in place, and verify certification when program requirements are fulfilled (EPA 2013b; USGGC 2013; NAHB 2012).

2.2.2 Green Building Rating System Adopters

Several professional groups have been key contributors in the adoption of green buildings and green building rating systems; this includes professionals in architecture, engineering, and construction industries; federal, state, and local governments; educators; and building material manufacturers (McGraw 2013; Fowler and Raunch 2006; Chio 2009). Government organizations like the Department of Energy (DOE) and Environmental Protection Agency (EPA) have created programs that encourage sustainable development. Other branches of the government have mandated green building certification for construction projects receiving direct government benefits (FitzGerald 2011). Other advocates for sustainable development have been affordable housing developers (HUD 2014).

2.2.3 Opposition to Green Building Rating Systems

Although green building rating systems have gained market acceptance in many countries, it has not come without opposition. Many professionals have expressed concern about disparities of modeled energy performance and actual energy performance, a phenomenon referred to as a performance gaps (Navarro 2009). Because post-certification monitoring is not required in many systems, it can be difficult to track a building's performance over time. Psychological and social barriers contributing to opposition also exist. These barriers can include a lack of awareness, lack of understanding of costs and return on investment, and fear of cost implications when elevating an organization's standards for future development (Hoffman and Henn 2008).

2.2.4 Green Building Rating System Development Process

Prominent green building rating systems are developed through an extensive process that includes several phases of comment and revision before a rating system can be adopted and approved for use. The United States Green Building Council (USGBC) has taken much care in developing their Leadership in Energy and Environmental Design (LEED) green building rating systems. The initial phase involves the selection of a committee of stakeholders from various industries relating to architecture, engineering, and construction. This committee is formed to develop or revise program requirements (USGBC 2009).

After initial planning has occurred, the potential rating system advances into a pilot testing phase and a public comment period. In the final phase of development, comments from the public review process are taken into account and the proposed program requirements are made available to council members to vote to approve or reject the rating system. Once the new rating system is approved, it is published for public use (USGBS 2009). LEED systems are typically updated using a “defined process that includes a public comment period” within 3-5 year cycles (Fowler and Raunch 2006). The NGBS also uses a consensus-based process and is the first green building rating system to gain ANSI (American National Standards Institute) accreditation (NAHB 2012).

2.3 Residential Green Building Rating Systems

Although commercial rating systems seem to receive more attention and notoriety, the first green building rating system in the U.S. was developed for residential purposes. In 1990, the city of Austin, Texas, created the Austin Energy Green Building (AEGB) program (AEGB 2014). The AEGB is a performance-based system that has five benchmark levels, ranging from one to five stars. Currently the system certifies single-family and multifamily homes as well as residential high-rise buildings. The program’s objective is to “lead the building industry in the transformation of a sustainable future” (AEGB 2014).

In 1999 the EarthCraft green building rating system was developed for the southeastern states in the U.S. to address regional climate conditions. As of 2014, more than 25,000 EarthCraft projects have been completed in Georgia, Tennessee, Alabama, Virginia, North Carolina and

South Carolina (EarthCraft 2014). Other residential systems include Green Built Homes of Wisconsin, Built Green^{TM} Colorado, the Green Home Designation of Florida, City of Scottsdale Green Building Program of Arizona, the New Mexico Building America Partner Program, and Green Built Program of Greater Grand Rapids, Michigan (NAHB 2002). Each of these systems were developed for specific climate conditions and while they have seen much success in their respective regions, none have been adopted on a national level.

The three nationally adopted systems studied here have many parallels: each is voluntary in nature; all three certify new construction and major renovations for single and multifamily homes; and each system is evaluated by a qualified third-party rater. Since larger homes produce more waste and consume more energy and resources over time, the size of a home is also an influencing factor for each system (EPA 2013b; LEED 2013; NAHB 2013).

The International Energy Conservation Code (IECC) and the HERS Index are two reoccurring components in residential green building rating systems. The IECC is a specific building code that 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 certain percentage.

The “HERS (Home Energy Rating System) Index is the industry standard” for energy efficiency evaluation in residential construction. It nationally recognized and calculates a home’s potential to reduce energy demands through site testing (RESNET 2014a). The home energy 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 efficient the home. The HERS Index is incorporated into each of the three systems studied here. This is significant because there is a need to conduct performance testing on the systems created in green homes. Site or performance testing is essentially commissioning for homes and ensures that the system in place can perform to the level of efficiency that was designed (RESNET 2014b).

2.3.1 Energy Star Homes

Energy Star 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. Version 1 was implemented between1995 - 2006 and focused on sealed building envelopes, high performance windows, and efficient heating and cooling systems. Version 2 was implemented from 2006-2011 with an additional focus on lighting and appliances. Version 2.5 followed in 2011 before the current Version 3 was implemented in 2012 (EPA 2014c; EPA 2014d). The current version was designed to exceed the 2009 International Energy Conservation Code by 15% (EPA 2013b). 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. Since the program's conception in 1995, there have been over 1.5 million certified projects to date (EPA 2014a).

The Energy Star program certifies single family, multifamily, large renovations, manufactured, and modular residential buildings. Version 3 is applicable to most U.S. climates, and additional variations have been created to address the specific climate regions in CA, FL, GU, HI, IL, IA, MD, MA, OR, PR, RI, and WA (EPA 2013b). Version 3 focuses on improving energy efficiency through the use of efficient wall systems and windows; efficient air ducts; energy efficiency equipment; energy efficiency lighting; and appliances (EPA 2014e).

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. Each Energy Star Home 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. 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).

2.3.2 LEED for Homes

After ten years of developing green building systems for the commercial sector, the 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 market transformation in residential construction (USGBC 2013). Because of its commercial predecessors, LEED for Homes has the advantage of brand recognition (Reeder 2010). Although the newest LEED for Homes version, LEED v4 Homes Design + Construction, is in process of being phased-in to replace the 2008 version in June 2015, the builders and raters that were contacted for this research discussed views of the 2008 version (AES 2014). Taking this into consideration, this paper focuses on the 2008 version.

LEED for Homes certifies single family, multifamily, gut-rehab, and production residential buildings on a national level. The 2008 version includes eight performance categories: Location and Linkages, Sustainable Sites, Energy and Atmosphere, Materials and Resources, Water Efficiency, Indoor Environmental Quality, Innovation and Design and Awareness and Education. Each performance category contains credits totaling to 136 points and include several mandatory measures. Four benchmark levels can be achieved depending on the amount of credits earned. The benchmark levels and credit ranges are as follows: Certified (45-59 points), Silver (60-74 points), Gold (75-89 points), and Platinum (90-136 points) (USGBC 2013).

The LEED for Homes system uses Energy Star certification as a substitute for credits in their Energy and Atmosphere category. This category offers a prescriptive and performance path and allows implementers to use either path with Energy Star certification. Green Raters serve as third-party verifiers. The LEED team is supported by LEED Providers, that provide technical support and serve as a liaison between raters and for the USGBC. Credits can be earned when there is a LEED accredited professional (LEED AP) on the project team. LEED certification fees include costs for registration, third-party verification, and certification (USGBC 2013).

2.3.3 National Green Building Standard (NGBS)

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 legitimize and strengthen their green building program. The result was the National Green Building Standard. 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.

ANSI is a lead facilitator of consensus based standards (ANSI 2014). The ANSI process requires consensus based committees of industry stakeholders, a "broad-based public review process," and opportunities for appeal. The ICC is an association that develops model codes that supports standardization of building practices in design and construction (ICC 2014b).

These partnerships make the NGBS the only green building rating system to become an ANSI standard and written in a way that can be adopted as a building code in municipalities nationwide (ANSI 2014).

The NGBS has a broad scope of options for certification of residential sustainable development. The nationally adopted standard certifies lots, subdivisions, new construction, major renovations, and small renovations. For the purpose of this research, the requirements associated with new construction and major renovations will be reviewed in order to maintain consistency in analysis. The categories include lot design preparation, and development; water efficiency; energy efficiency; resource efficiency; indoor environmental quality; and operations, maintenance and building owner education. Benchmark levels range from Bronze, to Silver, Gold, and Emerald in ascending order and are earned for each performance category. The overall project benchmark level is selected from the lowest benchmark earned among the performance categories. This creates a system that requires balance in credit achievement. In addition to this, each category requires a minimum amount of points (NAHB 2013).

Like the LEED system, Energy Star can be used in the energy efficiency category in place of NGBS credits. Unfortunately, this option only warrants a Bronze rating, subsequently subjecting the entire project to the lowest benchmark level. Green Verifiers serve as third-party inspectors for NGBS projects. The LEED and NGBS systems have both experienced growth for single-family certification from 2009 to 2013 as shown in Figure 2.2. Both systems also certified homes in over thirty states (NAHB 2014; USGBC 2014)

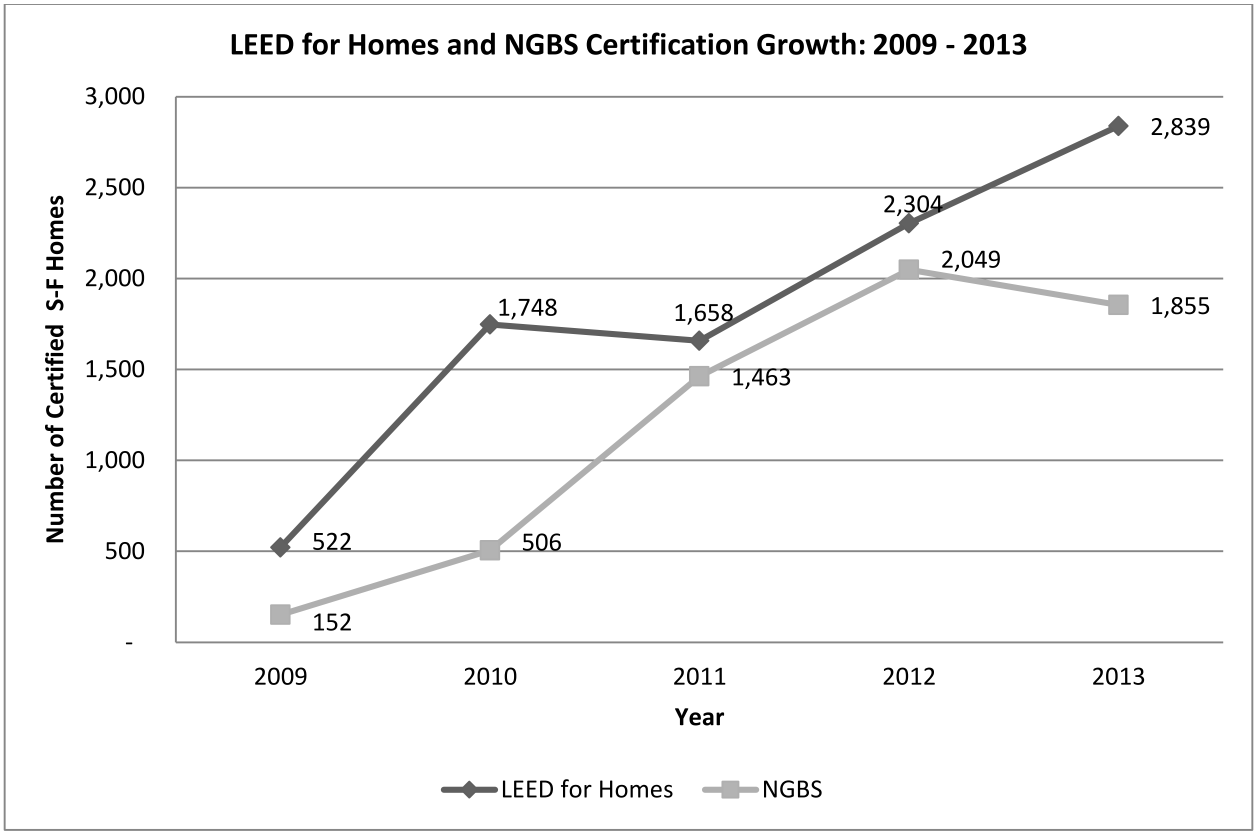

Figure 2.2: LEED for Homes and NGBS Certification Growth: 2009 – 2013 (HIRL 2014a; USGBC 2014)

→ 2.4 Existing Comparisons

Green building rating systems are commonly used to reduce the negative impacts that buildings have on the environment. Some local governments have made green building certification a mandatory practice in lieu of building codes in efforts to reduce greenhouse gas emissions (NAHB 2008). Certification can also be a requirement of specialized programs, such as subsidized mortgage loans or the use of municipal-owned land (FitzGerald 2011). Builders and homebuyers commonly seek out incentives when deciding to take on a green building project. Several studies have been conducted including the Energy Star, LEED, NGBS, and other systems seek to understand similarities and differences and have typically focus on the energy performance, costs of compliance, and minimum requirements (FitzGerald 2011; NAHB 2008; AIA 2010; Reugemer and Smith 2012).

2.4.1 Net Zero Energy Performance

Researchers at the University of Utah's Integrated Technology in Architecture Center were awarded the 2009 AIA Upjohn Research Award to study net zero energy performance in homes. Net zero homes are defined as residential buildings that purchase less, or an equivalent amount of, energy from utility companies than they produce on site annually. An energy performance comparison of the NGBS, LEED, Energy Star, and the Passive House Green Building Standard's Passive House Planning Package software (PHPP) focused on the capability for each system to operate at net zero energy performance (Ruegemer and Smith 2012).

Two high performance residential units from a working-class community in Park City, Utah were used as test projects to simulate green building certification. The units , which were certified through the NGBS and were also evaluated under Energy Star, LEED, and PHPP software using simulation. In order to achieve net zero performance, the researchers evaluated the systems with regard to the credits that awarded points for passive design, with a target HERS Index of 0. The PHPP used "annual space heat demand units" rather than the HERS Index to gain a more detailed look at projected energy performance.

Each of the systems were evaluated on their ability to utilize passive design, high-efficiency equipment, and insulating practices to reach net zero. The two homes received HERS ratings of 52 and 47 which were used when evaluating the NGBS, Energy Star, and LEED systems. A HERS rating of about 10 was needed to denote capability (with the assistance of highly efficiency equipment) of reaching net zero. Because Energy Star has a primary focus in energy efficiency, water efficiency, and indoor air quality, it does not encourage passive design techniques such as solar orientation or thermal massing. Although both the NGBS and LEED programs have encourage for passive design techniques and innovation, neither provided a definitive pathway to achieve net zero energy performance (Ruegemer and Smith 2011).

The PHPP software calculated a 46.24 kBTU annual space heat demand, which was consistent comparable to the HERS ratings found for the test homes. However, a target of 4.75 kBTU was needed for net zero energy home performance. Despite this drawback, PHPP software was the only simulation that adequately provided a strategy for net zero performance and accounted for passive “smart design strategies” to assist in closing the gap between passive design and technology (Ruegemer and Smith 2011).

2.4.2 Direct and Indirect Cost Comparison

In 2008, the National Association of Homebuilders Research Center, now the Home Innovations Research Lab (HIRL), conducted a comparative study of the Model Green Building Guidelines (GBG), NGBS, and LEED systems to estimate each program cost of compliance. The NAHB Research Center sought to assist consumers in understanding the costs of compliance due to increased mandates to reduce greenhouse gas emissions and requirements for new construction to exceed code minimums in some municipalities. The direct and indirect costs of compliance at each benchmark level were evaluated for two detached single-family homes from different states to study different climate conditions. Specifications for houses in Dallas, TX and the metropolitan Washington, DC area were created to closely resemble common building styles found in neighborhoods of the respective cities. Fees for certification, registration, and verification” were also estimated for each system (NAHB 2008).

The research team was assisted by low and high-volume builders and an architect and builder experienced with the LEED system. When calculating direct costs, products and practices were selected successively to reach certification at each benchmark level using a line-by-line analysis. Feedback from the builders was used to verify the practicality of strategies used. Overhead costs for various administrative activities such as developing a waste management plan were calculated as indirect costs. A base rate of $43.68/ hour was used for the time spent in integrated meetings, waste management planning, and other program related activities. Program fees included registration, certification, verification, and third-party review/ builder collaboration services (NAHB 2008).

As shown in Table 2.1 direct cost estimates are similar among the GBG and NGBS. Estimates show a gap of at least $2,000 between the LEED and NAHB systems in every comparison with the exception of the Emerald/ Platinum level of the Dallas house. Researchers also found that costs for the DC Metro area home exceeded the Dallas house in the majority of comparisons (NAHB 2008).

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Table 2.1: Additional Direct Costs (NAHB 2008)

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

The indirect costs were difficult to compare considering the varied list of activities. The only clear parallels are in indirect program costs were the annual costs for a waste management plan and the one time homeowner’s manual. Both had identical manpower and cost estimate the waste management was estimated at $4,750 and the homeowner’s manual was estimated at $25,125. The remaining activities are a series of annual, one-time, and one-time per building type. The research team found that the fees associated with the certification process were higher for the LEED system ($3,735) and more than two times the GMG or NGBS systems ($900) for plan review/ builder collaboration, registration, certification, and verification (NAHB 2008).

Researchers concluded that each of the systems have the same objective but have different strategies and goals. While each system is rigorous and independently verified, the NAHB systems use a prescriptive approach for describing activities and LEED uses a more open-ended approach with regard to the level of detail used for credits. Researchers feel that although prescriptive approach can be inflexible, it provides a “roadmap for conformance.” Open-ended credits were said to allow for broader interpretation that can lead to less certainty and additional costs. Finally, researchers note that the LEED system was created to transform a percentage of the homebuilding industry and the NAHB systems were created with mainstream builders in mind (NAHB 2008).

2.4.3 Direct Cost Comparison

The Home Builders Association of Greater Chicago engaged FitzGerald Associates Architects to prepare a comparison of additional direct costs required to achieve green building certification for the Chicago Green Homes (CGH), NGBS, and LEED programs. The study was the result of a desire to highlight the similarities and differences of the rating systems, due to existing mandates of green building certification that only recognized the LEED and CGH programs. The LEED 2008 and NGBS 2008 versions were used alongside the 2009 version of the CGH, a regional system. Like the previous comparison, the researchers engaged small and large – volume builders, as well as an architect and builder experienced with the LEED system to provide professional input to the research team (FitzGerald 2011).

Three types of urban residential buildings were evaluated to determine the additional costs of compliance for each system. Specifications were created to develop a baseline for a detached single-family home, a townhouse, and a six flat apartment building using the City of Chicago Energy Conservation Code (CECC). The 2009 CECC models and slightly exceeds the 2006 IECC. Using each of the three systems, the research team estimated additional direct costs of all three buildings for each benchmark level. The certification, verification, and registration fees were also calculated for each green building rating system (FitzGerald 2011).

Because of the CECC's rigidity, the baseline specifications were fairly close to meeting requirements at minimum benchmark levels for each system. Table 2.2 shows additional direct costs for each system, benchmark, and building type. The results found that the LEED system had the highest additional costs in all but one category. NGBS had the lowest additional costs for the 1 Star/ Bronze/ Certified and Emerald/ Platinum benchmark levels for each building type. The CGH program had the lowest additional direct cost in the 2 Star/ Silver and 3 Star/ Gold levels for each building type. The townhouse typically had lower additional costs for each system compared to the detached single-family home and the six-flat apartment building (FitzGerald 2011).

Table 2.2: Estimated Additional Direct Costs Over Baseline (FitzGerald 2011)

	1 Star/ Bronze/ Certified	**2 Stars/ Silver**	**3 Stars/ Gold**	**Platinum/ Emerald**
Single Family Homes				
CGH	$1,995	$6,145	$11,445	n/a
NGBS	$756	$8,006	$13,806	$27,606
LEED for Homes	$2,928	$8,950	$22,700	$29,370
Townhouse				
CGH	$1,875	$6,625	$10,925	n/a
NGBS	$824	$8,174	$12,574	$26,574
LEED for Homes	$1,950	$7,303	$20,803	$27,950
Six Flat				
CGH	$2,850	$4,668	$13,878	n/a
NGBS	$2,118	$9,868	$17,218	$35,218
LEED for Homes	$4,218	$13,418	$36,118	$41,786
Highest Additional Costs				

When estimating fees for activities relating to the certification process, the study found that LEED also had the highest costs at $3,925. Fees for the NGBS resulted in $1,200. No costs were incurred for the CGH program. Researchers also noted the similarities between the CHG and NGBS systems. They found that the NGBS, like the CGH, was more prescriptive in providing descriptions for activities and used clearly defined descriptions. It was also noted that the performance nature used for the LEED system is evidence “that it is aimed at targeting the top 25 percent of” market leadership and “is not suitable for all projects.” The researchers asserted that the NGBS was tailored more for mainstream builders and should be considered for the same benefits of the other two systems. (FitzGerald 2011).

2.4.4 AIA Cincinnati Side-by-Side Comparison

After receiving a request to extend tax abatements offered for LEED projects to the NGBS, the Cincinnati American Institute of Architects (AIA) conducted a side-by-side comparison of the LEED 2008 and NGBS 2008 systems on behalf of Cincinnati’s Office of Environmental Quality. This was especially challenging because both systems use a different strategy and are configured differently. This study matched in a side-by-side fashion and compared the credits with regard to intent. Table 2.8 shows the study’s comparison of energy-efficiency related credits. The credits for both systems are listed on the outer columns of the table and the central columns indicate credits that are mandatory, modeled, site verified, and site tested. Each of the main four columns in the middle of the table have two sub-columns; the left for LEED and right for the NGBS. A black dot is placed into the sub-columns if appropriate to the columns objective. An enclosed X denoted that the credit was lacking or omitted and an enclosed M denoted a mandatory measure in the site verification column (AIA 2010).

Although the research team felt that the systems had very few differences, they found that major differences existed with regard to the amount of credits requiring site testing. Table 2.4 shows the comparison of the energy efficiency credits. LEED also requires more mandatory practices that the NGBS. For site verification, the LEED system required thirteen credits and the NGBS required thirty-three. The research team felt that it was “imperative to ensure a minimum effective level of proof” through the use of site testing to verify high priority sustainable practices at the project’s final inspection. The site testing column shows that the LEED system requires eight site testing credits and the NGBS requires only two. The remaining performance categories, not shown here, demonstrate a consistent focus on site verification for the NGBS (AIA 2010).

The research team placed site testing as a high priority due to the fact that it provides actual proof that a home can perform to meet projected standards. In light of these findings, researchers concluded that the NGBS failed to require site testing for high-performance practices such as envelope leakage and distribution losses. Recommendations were made for tax abatements to be extended to NGBS projects only if they also received Energy Star certification. Researchers also noted that the 2008 versions of LEED and the NGBS had comparable costs of compliance when the expenses for Energy Star site testing was factored in for the NGBS. Despite this lack of site testing, researchers did not propose Energy Star as a requirement for the Emerald benchmark level due to the relatively high standards already in place (AIA 2010).

Table 2.4: AIA Comparison of Energy Efficiency Credits. (AIA 2010)

USGBC "LEED For Homes"		Credit Mandatory [1]		Credit Modeled [2]		Credit Site Verified [3]		Credit Site Tested [4]		NAHB "National Green Building Standard"	
LEED-H Energy and Atmosphere (Prescriptive Path)											NAHB Energy Efficiency (Prescriptive Path)
% of Section Credits Required OVER Mandatory Credits [5]	0%	LEED-H	NAHB	LEED-H	NAHB	LEED-H	NAHB	LEED-H	NAHB	11% [7]	% of Section Credits Required INCLUDING Mandatory Credits [6]
Performance Path of Energy Star for Homes [8]	EA 1.1			•	•	•	•	Ⓜ	⊗	702	Performance Path Minimum Requirements [9]
Performance Path for Exceptional Energy Performance [8]	EA 1.2			•		•		Ⓜ			
Basic Insulation	EA 2.1	•	⊗		•	•	•			703.1.1	Building Envelope (Insulation Level)
Enhanced Insulation	EA 2.2		•			•	•			701.4.3.2	Floor, Foundation, Crawlspace Insulation and Sealing
			•				•			701.4.3.3	Wall Insulation and Sealing
			•				•			701.4.3.4	Ceiling and Attic Insulation and Sealing
							•			703.1.2	Building Envelope (Third Party Verification)
							•			703.2	Insulation and Air Sealing
							•			704.6.1	Installation and Performance Verification
							•			902.6	Living Space Contaminants
Reduced Envelope Leakage	EA 3.1	•	⊗				•	Ⓜ	•	704.6.2	Third Party Envelope Leakage Test
Greatly Reduced Envelope Leakage	EA 3.2						•	Ⓜ		704.6.1	Installation and Performance Verification
Minimal Envelope Leakage	EA 3.3							Ⓜ			
Good Windows	EA 4.1	•	⊗				•			703	Fenestration (Enhanced)
Enhanced Windows	EA 4.2		•				•			701.4.4	Fenestration (Mandatory)
Exceptional Windows	EA 4.3						•			704.6.1	Installation and Performance Verification
Reduced Distribution Losses	EA 5.1	•	⊗				•	Ⓜ	•	704.6.2.2	HVAC System Pressure Test
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
							•			704.4	Ducts
							•			704.6.1	Installation and Performance Verification
			•				•			903.6	Duct Insulation
Good HVAC Equipment and Installation	EA 6.1	•	⊗			•	•			703.4	HVAC Equipment Efficiency
High Efficiency HVAC	EA 6.2		•			•	•			701.4.1.1	HVAC Systems (Design to Manual J)
Very High Efficiency HVAC	EA 6.3					•	•			704.5.1	ACCA Manual S
Efficient Hot Water Distribution	EA 7.1					•	•			801.1	Indoor Hot Water Usage
Pipe Insulation	EA 7.2					•	•			903.5	Plumbing
Efficient Domestic Hot Water Equipment	EA 7.3									703.5	Water Heating Design, Equipment, and Installation
							•			704.3.2.1	Solar Water Heater
ENERGY STAR labeled Light Fixtures (or CFLs)	EA 8.1	•	⊗			•	•			704.2	Lighting and Appliances
Improved Lighting	EA 8.2					•					
Advanced Lighting Package	EA 8.3					•					
High Efficiency Appliances	EA 9.1						•			704.1	Lighting and Appliances
Water Efficient Clothes Washer	EA 9.2						•			801.2	Water Conserving Appliances
Renewable Energy System	EA 10			•		•	•			704.3.3	Additional Renewable Energy Options
Refrigerant Charge Test	EA 11.1	•								704.5.3.2	HVAC Refrigerant Charge
Appropriate HVAC Refrigerants	EA 11.2									704.5.4	Alternate Refrigerant
	○						•			703.1.3	Building Envelope (Mass Walls)
	○						•			704.3.1.2	Automated Solar Protection
	○						•			704.3.1.4	Passive Solar Heating Design
	○									704.5.2	Certified HVAC Contractor

2.4 Summary

Several green building rating systems for residential buildings exist at the regional level (NAHB 2002). The Energy Star, LEED, and NGBS programs are three systems that have been adopted nationally. The literature reviewed aspects of acceptance, adoption, and implementation and provided an overview of pertinent information about each of the systems and comparisons that they have been included in. The Energy Star program has been found to be limited in scope as it does not include sustainable building practices that focus on the project site, owner's education or passive systems (Reugemer and Smith 2009). This limited focus has allowed for it to be included in both the LEED and NGBS systems as an alternative for energy efficiency credits (USGBC 2013; NAHB 2013b).

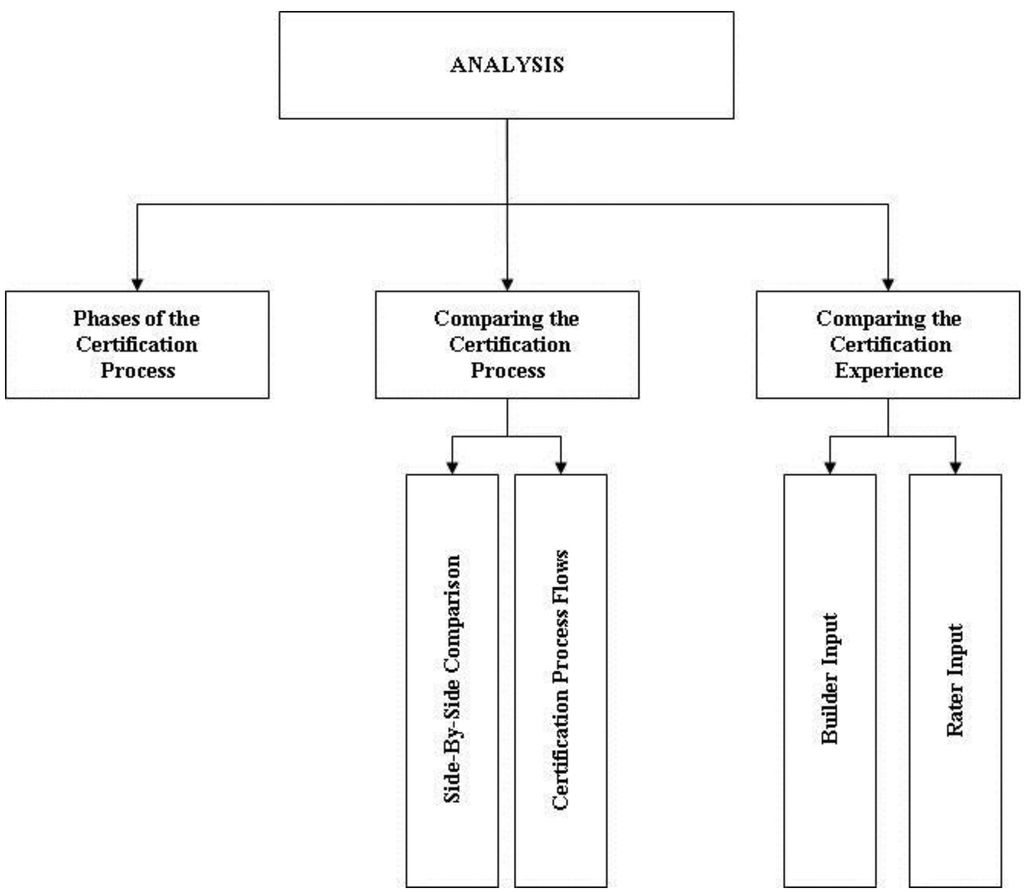
Several studies have examined the cost of compliance and findings have consistently named LEED as the system with the highest costs of compliance. LEED has also been referred to as open-ended with implications that it is only applicable to 25 percent of the residential market. The program has been praised for its requirement of site testing (FitzGerald 2011; NAHB 2008; AIA 2010).The lack of site verification and mandatory measures in the NGBS requires the system to place a higher dependence on site verification. This has been found to be a problem when considering eligibility for incentives with entities that are accustomed to higher standards. The NGBS has been favored by some researchers for its prescriptive nature. This clearly defined attribute is believed to appeal to a mainstream audience of builders and homeowners. A common theme in each of the comparison was the significance of energy efficiency. Each comparison found that energy efficiency was responsible for either the most costs, or the highest percentage of credits (Reugemer and Smith 2009; FitzGerald 2011; NAHB 2008; AIA 2010).

CHAPTER 3 – DATA COLLECTION AND ANALYSIS

3.1 Introduction

The previous chapter discussed residential green building rating systems and summarized four studies that compared commonly used systems. This chapter further compares, presents the methods, analysis, and findings of the research objectives. As shown in Figure 3.1, the analysis consists of three focuses. First, the phases of the certification process are identified. Second, the certification process is compared. The LEED and NGBS credits were compared and arranged according to the phase in which they are earned and certification process flows of each system are compared to show the similarities and differences in the steps to certification. Third, the certification experience is compared by way of input gathered from industry professionals.

Figure 3.1: Chapter 3 Overview



3.2 Phases of the Certification Process

When seeking to understand the scope and requirements needed to attain certification there was a need to look at the certification process through a common lens and from a common viewpoint. The sense of timing associated with various certification activities was found in literature and often addressed in interviews with industry professionals. This prompted the researcher to identify different phases within the certification process. Four phases shown in Figure 3.2 are; *planning and design*, *procurement*, *during construction*, and *post-construction*. These phases inform analysis and comparisons by providing a point of reference and more contexts for the certification process and are represented in the following comparisons.

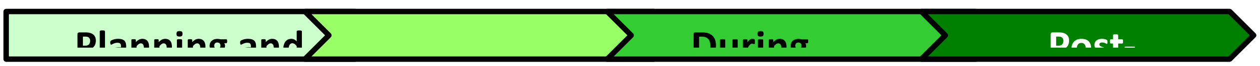


Figure 3.2: The Four Phases of the Green Building Certification Process

3.3 Comparing the Certification Process

When comparing the certification process with an emphasis on program requirements and documentation requirements, two comparisons were developed in the context of the phases of certification. 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. The comparison of certification process flows endeavored indicate where in the process documentation requirements are present and the differences of each system’s process flow.

3.3.1 Side-by-Side Comparison

When considering the credits and categories of LEED for Homes and the National Green Building Standard, one could argue that they two systems offer the same product. Although 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. Energy Star serves as an alternate path for the energy performance category in each system and is shaded blue to denote its presence. The system was omitted from this comparison due to its limitations in scope.

The program requirements 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 cells of the table were shaded a gradient of greens to denote the phases, starting with light green for the *planning and design* phase and the darkest green used for the *post-construction* phase.

The criteria used to evaluate where each of the credits were earned is listed in Table 3. The *planning and design* phase includes credits that can only be earned when an external systems is used, there are preexisting conditions such as those found in site and lot credits, and when the credit must be coordinated, calculated, or included in the design in order to be implemented in the project. The *procurement* phase refers to activities that are dependent on a completed design such as estimating or purchasing materials and equipment for improved quality. The *during construction* phase refers to activities that occur during the installation of materials. These activities may be preventive in nature, call for alternative construction techniques, or simply ensure proper installation. The *post-construction* phase refers specifically to credits that include inspections and testing activities. In keeping with the AIA comparison, the credits have been arranged to follow the LEED system.

Table 3.1: Side-by-Side Comparison Sorting Criteria

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

Tables 3.2 – 3.7 are arranged in seven performance categories. Like the AIA Cincinnati study, a category called *NGBS - Other* was used to accommodate those credits related to credits in the LEED for Homes *Integrated Project Planning* category. Also, the *Location and Linkage* and *Sustainable Sites* categories have been combined to create a more seamless comparison with the NGBS *Lot Design, Preparation and Development* category. Each performance category was sorted by the four aforementioned phases, starting with *planning and design* and ending with *post-construction*.

The color coded credits makes it apparent that the *planning and design* and *procurement* phases are where most of the credits are achieved. Few credits are earned in the *during construction* and *post-construction* phases. All of the credits in the *Integrated Project Planning* category are earned in the *planning and design* phase with the exception of one verification credit. The *Location and Linkage* and *Sustainable Sites* category also included a majority of credits earned during the *planning and design* phase due to the preexisting nature of the credits. The *Water Reuse* category included several credits that depend on procurement, but also included a comparable amount of *planning and design* credits.

Each phase is represented in the *Energy and Atmosphere/ Energy Efficiency* performance category. Energy Star is eligible to be used as an alternate performance path in both systems. This category displays credits for a prescriptive path. The *Material and Resources* category contains the largest amount of credits earned in the *procurement* phase, as this category is intended to encourage the use of more energy efficient and environmentally-friendly building materials. *Indoor Environmental Quality* is a mixture of planning and installation with very little procurement activity. Finally, the credits for *Awareness and Education* are earned during the *procurement* phase, as owner’s manuals can only be fully developed after the building design and specifications are complete. Although some phases seem to be represented more than others, this comparison emphasized the fact that green building are essential a system of sustainable practices, techniques, materials and equipment informed by the conscious planning, design, coordination, and verification.

Table 3.2: 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 3.3: 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 3.4: 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-Conserving 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 3.5: 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

Table 3.6: 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 3.7: 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

3.3.2 Certification Process Flow Comparison

Preliminary research methods endeavored to review documentation requirements with builders and raters. Due to the extensiveness of the rating systems covered very few respondents were able to provide a list of the various documents needed to support certification efforts. In the same instance, the need to, 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 were engaged also became apparent as respondents expressed frustrations of unsatisfactory experiences. The need to explore the documentation requirements and process flows was therefore addressed in the context of the phases the of certification process. Table 3.8 includes the certification phases and lists general activities in relation to the phase that the activities take place in.

Table 3.8: Certification Phases and Process Flow Activities

PHASE	Process Flow
Planning and Design	• Decision to Certify • Engage Third-Party Raters • Preliminary Design • Set Benchmark Goals • Preliminary Scoring
Procurement	• Refine Design • Complete Design • Purchase Materials
During Construction	• Construction Begins • Pre-Drywall Inspection • Construction Ends
Post Construction	• Final Inspection • Performance Testing • Certification Evaluation • Certification Awarded

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. When engaged during this phase, project owners have the opportunity to utilize the verification 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 green building rating systems has four phases in the certification process; *planning and design*, *procurement*, *during construction*, and *post-construction*. Each step was also identified to occur in a specific phase, starting from *planning and design* and ending in *post-construction*. Important documentation and the points in which documents were collected was also represented within each diagram. The process diagrams show the required documentation as they are collected throughout the certification process. Each step in the diagram is color coded to represent the phase that the step occurs in as shown in Figures 3.4 - 3.5.

During the *planning and design* phase, builders decide to pursue certification, engage a third-party rater, begin their preliminary design, and set benchmark goals and complete preliminary scoring. The *procurement* phase included refining and completing the building design. After the construction began in the *during construction* phase a pre-drywall inspection is required and is followed by opportunities for continued improvement before construction is complete. In the *post-construction* phase, a final inspection is given that includes site testing. If the project meets the program requirements, the third-party rater verifies the project and contacts the parent organization for the certification award.

There are subtle differences between the three systems studied here. The major differences of the system process flows are found in the *post-construction* phase, where certification is awarded. Energy Star raters have the ability to award certification after performance testing. LEED Green Raters are required to submit the verified project to a 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 over several months.

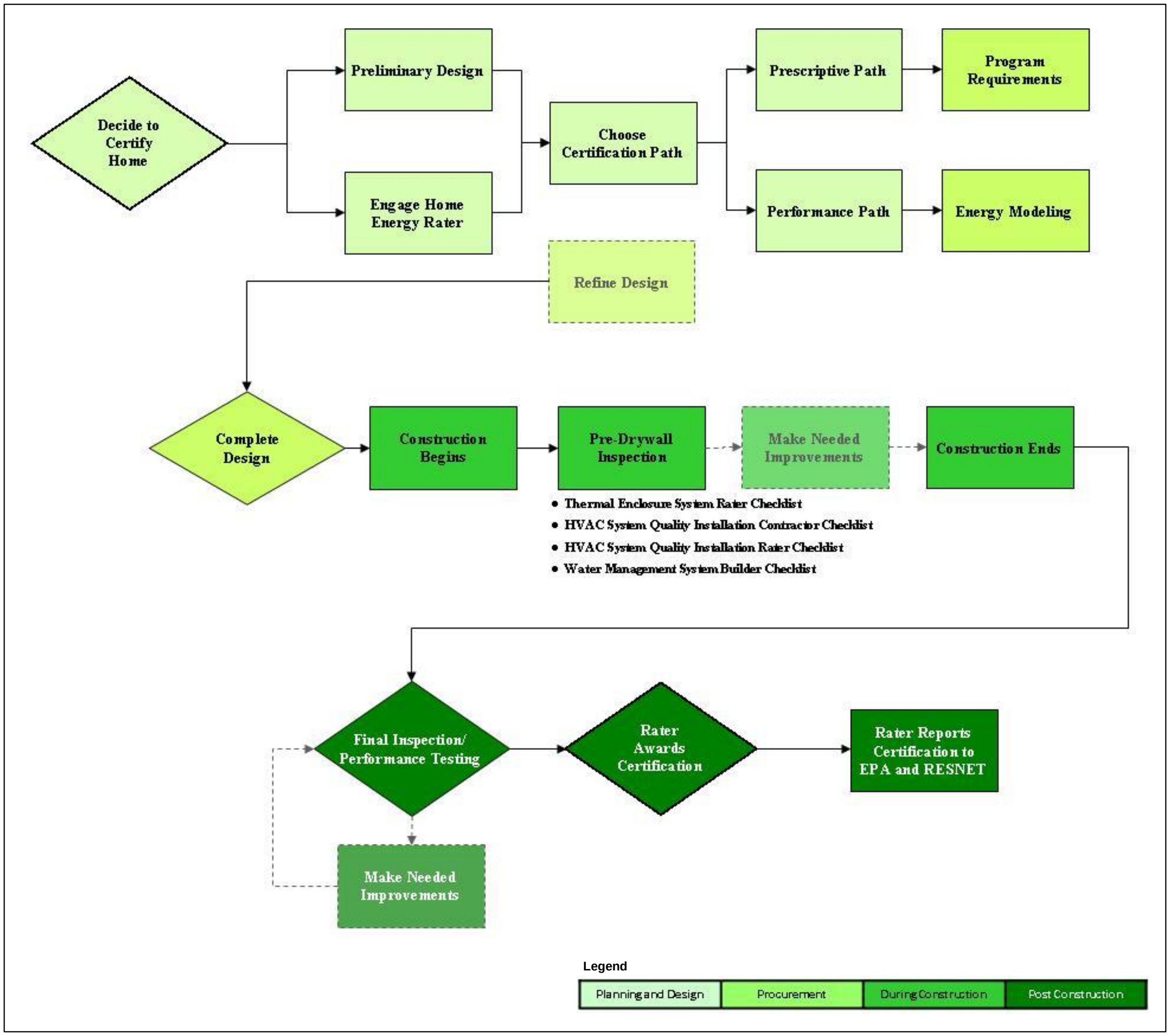


Figure 3.3: Energy Star Process Flow

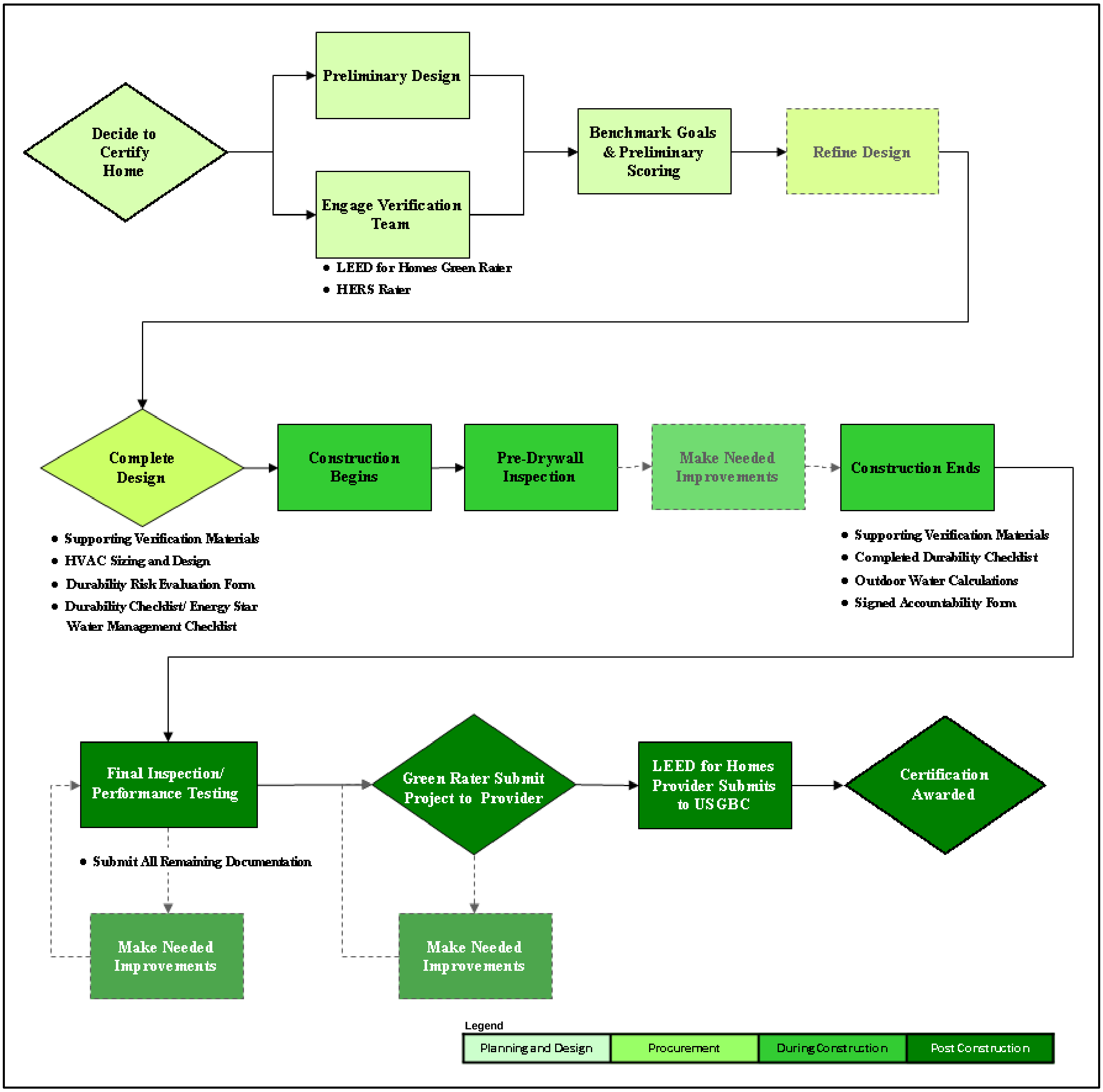


Figure 3.4: LEED for Homes Process Flow

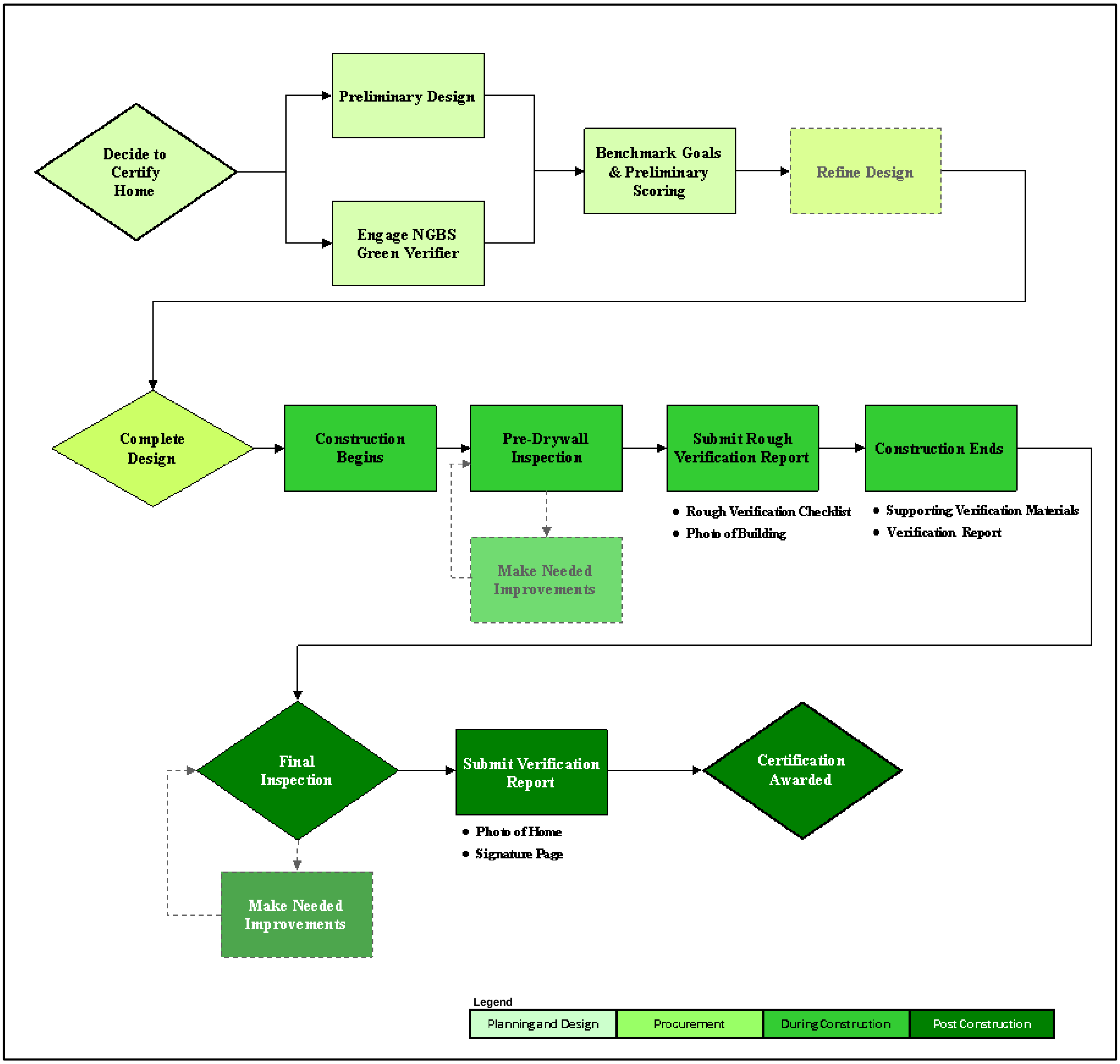


Figure 3.5: National Green Building Standard Process Flow

3.4 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. A preliminary questionnaire, found in Appendix A, were created specifically for builders and raters engaged in each system. Builders were asked to point out credits that were especially time consuming and had high up-from costs during preliminary interviews. This initial hope of reviewing the program credits and practices of each system proved to be a copious task due to the large quantity of credits in both the LEED and NGBS programs.

A request for a list of required documentation also proved to be a difficult to attain, as many builders were unable to list the many documents required for verification. In many instances, the researcher was referred to program documents. Taking the short-comings of the previous survey into account, improved questionnaires, found in Appendix B, were adjusted to gather more information about participant profiles, to provide ranges for questions referring to durations, and to request information about additional costs relating to certification.

The data collect 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 with 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 a 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, duration, 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 provided input about their experience with the Energy Star, LEED, and NGBS systems.

3.4.1 Builder Input

The builders that were contacted to discuss their experience with the certification process were located in Michigan and North Carolina. Although builders from a range of other states were contacted to participate remotely, only builders from North Carolina were responsive. The respondents from this group included six Michigan builders and three North Carolina builders. Although some do not pursue certification for all of their buildings, most noted that they make an effort to build to the same standards.

After a review of the builder responses, small clusters were found with regard to annual volume. Of the nine participants, four reported having a low annual volume of 1 to 10 homes, three reported having a mid-annual volume of 11 to 30 homes, and two reported having a high annual volume of 100 or greater. Builders reported that their typical customer consisted of first-time, first-time/ affordable, and move-up homebuyers. Builders were grouped together with regard to their typical customer for further analysis to examine parallels for builders serving experienced and inexperienced buyers.

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 Table 3.9, 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.

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 shown in Table 3.10, 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 owner 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 the 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.

Table 3.9: 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 3.10: 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.

3.5.2 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 around 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 the majority 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.

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. As seen in Table 3.11, the Energy Star project durations were 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 of 8 to 24 months.

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. Two green 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.

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.

Table 3.11: 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

3.5 Summary

These comparisons of the certification process and the certification experience expand the knowledge derived in the existing comparisons studied in the literature review. The side-by-side and process flow comparisons provide a point of reference when considered in the context of certification phases. The experiences of industry professions that use the systems studied here allude to the participants' commitment to sustainable development as well as the challenges encountered during implementation. These findings allow those desiring to pursue green building certification to make a more informed decision when deciding which system to use.

CHAPTER 4 – SUMMARY AND INFERENCES

4.1 Introduction

The previous chapter compared the Energy Star, LEED for Homes and National Green Building Standard with regard to certification process and the certification experience through a side-by-side and process flows comparison, as well as industry professional input. This chapter discusses the role of residential green building rating systems, the objectives of this study, the findings, implications for construction managers, and discusses potential future research topics.

4.2 The Role of Residential Green Building Rating Systems

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. They also identify different benchmark levels to identify the amount of improvements made that exceed building codes. Furthermore, residential green building rating systems help combat greenwashing and add legitimacy to claims of sustainability.

4.3 Objectives

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 the side-by-side comparisons and the documentation requirements were addressed within the process flows. The side-by-side comparisons and process flow diagrams and denoting phases within the certification process to provided more contexts. Builders and third-party rater experiences with the certification process were derived from interviews with experienced industry professionals.

4.4 Findings

4.4.1 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* phase. 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. When used in conjunction with and a certification process flows, users can easily identify documentation and credit requirements in each phase of the certification process.

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 had 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 the LEED for Homes Provider for review, and then to the USGBC, before certification is awarded. Green Verifiers submit verification for NGBS projects to the program's parent organization for review. The time that certification is awarded, is dependent upon the program's responsiveness and the amount of authority given to third-party raters.

4.4.2 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 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, several of the builders serving move-up buyers felt that it had some positive effect on the service they provided their customers.

Several builders express 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. Builder 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 the systems. Many participants expressed frustration about new HVAC requirements that require special training and certification for Energy Star and LEED for Homes 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.

When asked if certification decreased call-backs, one builder felt that certification will likely increased call-backs because green homes include several innovative technologies that require more owner maintenance. Another builder expressed the importance of design and finishes and stated that sustainable features will never replace the need for good design. Although participant opinions sometime began with frustrations, they generally ended in an awareness and appreciation for the strides that have been made in the green building today.

4.5 Observations and Inferences

Site verification, development processes, 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. The affordability of this system is also a noteworthy strength.

When considering weaknesses, these systems may be at a disadvantage due to some of their inherent characteristics. Energy Star is limited in scope and does not place an emphasis on site or community aspects of a project. The LEED system can be rigid and costly. The NGBS is lengthy due to the amount of credits and is limited in their capacity to provide technical support to raters because inquiries are centrally referred to the program administrator’s office.

4.5.1 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 4.1 that will influence which system should be used. First, the audience or implementer must be known. Second, the building type should be considered. The implementer’s decision may also be a factor of the time at which they decide to pursue certification. The place should be considered to determine the climate as well as the advantages is disadvantages the political local may include. The motivation behind certification may be a strong indication 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 one’s choice.

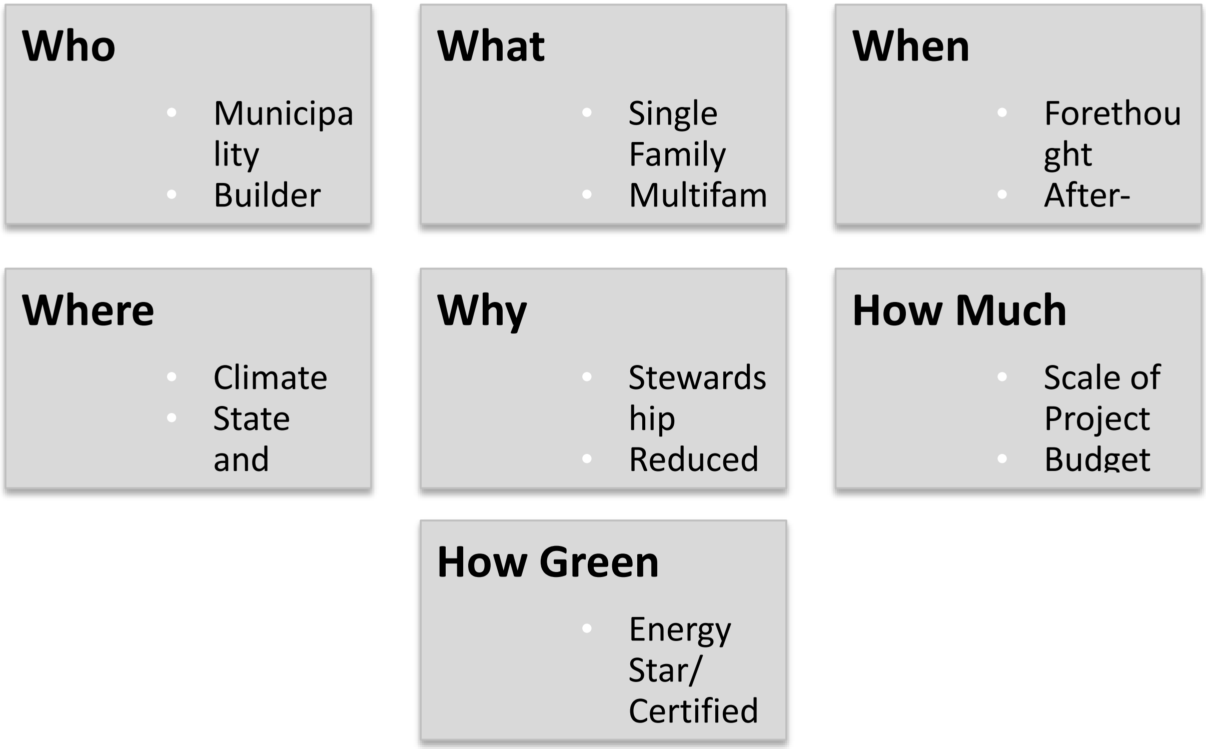


Figure 4.1: Deciding Factors for Choosing a Green Building Rating System

For instance, if a consumer that is looking to build a single-family home has decided to purse certification after having an architect draft up floor plans to code; they may be able to pursue a relatively high benchmark if the municipality they are building in has adopted the IECC 2012. If the project has a high budget and the owners would like to select a well known system, they would likely choose the LEED for Homes system. If this same customer decided to certify before having plans drafted and had a smaller budget but wanted ensure that the sustainable efforts in each category were balanced, the NGBS would likely be the best option. Energy Star certification would be easy to achieve, considering the relatively high local regulations (IECC 2012) required by the municipality.

4.7 Research Implications

It is essential that the home builders and construction managers in general continue to evolve with innovative green building practices that have proved 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. Builder will need to be well versed in sustainable practices in order to educate consumer at various points of the client-builder relationship.

4.8 Future Areas of Research

There have been several studies that compare green building rating systems with regard to costs of compliance, similarities in credits, and rigor. There is a need for more research that looks at the certification process rather than the differences between the mandatory requirements and associated costs. It is the hope of the researcher that more comparisons are made from the perspective of those who have direct contact and experience with the systems. Builders and raters have valuable knowledge about green building rating systems that could provide insight for the challenges of certification and offer practical improvements.

The LEED for Homes systems has been updated with major revisions for the first time since its conception in 2008. The name of the system has changed to LEED v4 Homes Design and Construction but the updated system retains much of the credits from the previous version and retains the same point system. A more extensive comparison of the a current version of Energy Star, LEED v4 Homes Design and Construction and the forthcoming 2015 NGBS would be beneficial if builders and raters could be engaged at a much larger scale. Such a study might also include other nationally accepted residential green building rating systems that have begun to gain notoriety, such as the Living Building Challenge and the Passive House Green Building Standard.

4.9 Closing Remarks

This exploratory study attempted to provide an understanding for the certification process and 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 a study adapted for generalization. The three national systems studied have been widely adopted and are proving their value in the residential sector. 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!

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Appendix A: Preliminary Questionnaires

LEED Green Rater Survey **Date:____________**

Profile

1.Name ____

2. Organization ____

3.Located ____

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 project verified?_________________________ Percentage of Failed Attempts?_________

Credit Requirements

1) Level of difficulty/ Pursued:
   a) Very Easy/ Always
   b) Easy/ Most of the time
   c) Difficult/ Sometimes
      i) Not applicable (i.e. lot size)?
      ii) Significantly more expensive?
   d) Very Difficult/ Never
      i) Not applicable (i.e. lot size)?
      ii) Significantly more expensive?

Documentation

a) What documentation is required for the project and who is responsible for preparing them?
b) Documentation that raters must submit?____

Categories	**Builder**	**Others**
Lot and Site		
Resource Efficiency		
Water Efficiency		
Energy Efficiency		
Indoor Environmental		
Owner Awareness		
Innovation		

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? ____

Additional documentation? ____

LEED Builder Questions **Date: ____________**

Profile

1. Name of Builder ____

   Year Company Started ____

2. Located ____
3. How long have you been involved in sustainable development? ________________

   ____

4. What rating system do you use most often?

   ____

5. Other systems used?

   ____

6. Number of projects certified? _____________ Failed attempts? _____________
7. Who typically initiates the process? ______________________________

Credit Requirements

1) Level of difficulty/ Pursued:
   a) Very Easy/ Always
   b) Easy/ Most of the time
   c) Difficult/ Sometimes
      i) Not applicable (i.e. lot size)?
      ii) Significantly more expensive?
   d) Very Difficult/ Never
      i) Not applicable (i.e. lot size)?
      ii) Significantly more expensive?
   e) Which credits are you responsible for achieving?
   f) Which credits are your subcontractors/ consultants responsible for achieving?

2) Which credits require _____ not used in conventional residential construction?
   a) Subcontractors/ consultants
   b) Additional Training
   c) Additional Inspections or Certification Processes (i.e. Energy Star)
   d) Documentation

Documentation

a) What documentation is required for the project and who is responsible for preparing them?
b) Which documents would not be prepared for conventional residential construction?
c) What is the ease of preparation and average time required for each document?

Categories	Builder	Others	Ease of Prep	Ave. Time
Innovation and Design				
Location and Linkages				
Water Efficiency				
Energy and Atmosphere				
Indoor Environmental Quality				
Awareness & Education				

CM Aspects

1) Time

a) What is the typical duration of a project?

____

b) Is this longer than conventional residential construction?

____

c) Which credits effect productivity?

____

d) How quickly are homes occupied after construction, compared to conventional projects?

____

2) Costs

a) Which costs are transferred to the owner?

(1) Direct

____

(2) Indirect/ Overhead

____

(3) Registration, Certification, and Verification Fees

____

3) **Quality**
   a) Does certification increase the level of quality?
      (1) Installation

      ____

      (2) Materials

      ____

      (3) Service

      ____

   b) Opinions of management and laborer of the certification process?

   ____

4) **Satisfaction**
   a) Are owners more satisfied with certified projects?

   ____

      (1) Call backs

      ____

      (2) Owner education

      ____

5) **Safety**
   a) Has certification had any influence on job-site safety?

   ____

6) **Legal Disputes**
   a) Has certification had any influence on the number of legal disputes you have experienced?

   ____

      (1) Additional General Liability Insurance coverage?

Initial Costs and Life Cycle Cost Assessment

a) Which credits have the highest upfront costs?

____

b) Which credits have the best return on investment?

____

c) Are owners easily encouraged to pick products with high upfront costs after they are aware of ROI?

____

Multifamily/ Mixed Use

a) What are some challenges to certification?

____

b) Additional documentation?

____

Appendix B: Improved Questionnaires

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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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