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126

Use and Awareness of Green Building Programs and Environmentally Certified Wood Products in the US Residential Construction Industry

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Center for International Trade in Forest Products
School of Environmental & Forest Sciences
University of Washington
Box 352100
Seattle, WA 98195-2100

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Other Contributors: Randall Cantrell (University of Florida), Douglas MacLachlan (UW Foster School of Business), Kathrina Simonen (UW Department of Architecture), Ian Hash (UW PCMI), and Michael Tomco (UW PCMI)
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Executive Summary

The overall goal of this study was to develop a better understanding of US residential homebuilders' and remodelers' perceptions and use of Green Building Programs (GBPs), Environmentally Certified Wood Products (ECWPs), construction materials (i.e., wood, steel and concrete), and other innovative green technology and products.

Green building refers to a structure built using a process that is environmentally responsible and resource efficient throughout its life-cycle: from design and siting, to construction, operation, maintenance, renovation, and demolition. Since it is difficult to assess the sustainability of houses, a number of organizations have developed standards, codes and rating systems that let regulators, building professionals and consumers embrace green building concepts and practices with confidence. Collectively, these rating systems and standards are known as green building programs (GBPs). In the US, the National Association of Homebuilders' National Green Building Standard (NGBS) and the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) for Homes have become the two major competing GBPs at the national level.

Each GBP employs a different rating system to award compliance for the use of sustainable materials, building products, and technology. As green building practices in residential housing become more popular in the US, the influence of LEED for Homes and NGBS on the choice of materials by construction professionals is of fundamental interest for forest resource professionals. Since a large volume of wood is consumed by the US building industry, it is important to understand the adoption of green products and technologies by US homebuilders and remodelers.

A survey targeting US homebuilders and remodelers was developed and the probability sampling frame was carefully designed in order to ensure reliable and valid statistical inferences. The results of the survey suggest that a great majority of homebuilding professionals are aware of GBPs in the US. Although less than a quarter of homebuilders had actually used either LEED for Homes or/and NGBS, many non-users were planning to use one of the programs in the future. The main reasons why homebuilders adopted GBPs were: to differentiate their homes in the market, the home buyer specified that they wanted a green house, and there is strong demand for homes built using a GBP. Those builders who have used a GBP favored the NGBS program over the LEED for Homes program, because they perceived NGBS as being less expensive and easier to use than LEED for Homes, although LEED for Homes was rated as being superior in terms of brand recognition and effectiveness in helping to sell homes.

Wood is a renewable natural resource with a smaller carbon footprint than other construction materials, such as steel or concrete. Wood products from responsibly managed forests should be an ideal fit for most GBPs. In order to communicate to consumers that a wood product comes from forests managed in accordance with environmental and social standards, some organizations have launched forest certification systems. Environmentally certified wood products (ECWPs) are usually associated with eco-labeling and chain-of-custody programs that are designed to ensure that wood products are harvested from sustainably managed certified forests. There are a number of forest certification programs around the world, but several major certification programs in the US have become the de facto standard, including the Forest Steward Council (FSC) and the programs endorsed by PEFC (the Sustainable Forestry Initiative (SFI) and the American Tree Farm System (ATFS)). ECWPs certified by FSC and SFI are considered rival products in the market place. The LEED for Homes GBP has accepted FSC for the forest certification credit, but has not recognized SFI or ATFS. In contrast, the NGBS GBP allows the use of any third party certified wood. Consequently, forestry experts, government officials and environmental NGOs are interested in how the two major GBPs might influence the demand for certified wood.

The survey results show that only about 10% of homebuilders used environmentally certified wood products (ECWPs) on a regular basis while another quarter of homebuilders used ECWPs occasionally.

When asked to compare the two major certification programs, a great majority of ECWP users did not differentiate between FSC and SFI. Roughly 30% of homebuilders were still unaware of major wood certification programs.

As a result of increased interest in green building practices and GBPs, companies continually evaluate a wide variety of new green building products and technologies, including ECWPs. However, the US residential construction industry has long been criticized for being slow to adopt new products and technologies. A variety of attributes can influence a builder's adoption of green building products and technology. The survey results show that the most important attributes for influencing product specification are the economic or technical performance of the products including, price, availability, durability, low maintenance, ease of installation, energy efficiency and consumer demand. On the other hand, the less important attributes tend to be those related to the environmental performance of the product. Finally, the survey shows that wood is clearly viewed by residential construction professionals as being the most environmentally friendly building material when compared to either steel or concrete across a wide range of performance attributes.

This study offers the first detailed look at residential construction professionals' perceptions and use of a variety of environmentally oriented building programs and products in the US. It establishes a baseline for the use of GBPs and ECWPs by US homebuilders and remodelers. While the current awareness and use of these programs and products is often low, the results suggest that their use will increase in the future as the awareness of both construction professionals and consumers increases.

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Introduction

In the United States, residential construction is the largest segment of the construction industry, with 2014 outputs exceeding $410 billion; more than 34% of total construction expenditures (Bureau of Economic Analysis 2015). Consisting of both new home construction and repair & remodel activity, it's the largest market for wood in the US, consuming over 67.8% of all softwood lumber in 2013 (WWPA 2014) and the majority of the structural engineered wood products produced in the US, making the US residential construction sector the biggest potential market for *environmentally certified wood products* (ECWPs).

Despite its size and importance within the US economy, the US residential construction industry has long been criticized for being slow to adopt new products and technologies. The diffusion of innovations and new materials within the residential housing industry has unique characteristics, with factors contributing to the slow adoption rate ranging from restrictive building codes to the limited flow of information due to the fragmented nature of the industry (Blackeley and Shepard 1996, Taylor and Levitt 2004). Some researchers studying innovations in project-based industries have concluded that the hierarchical nature of the industry significantly slows the adoption of new materials, citing the role of inter-organizational knowledge flow and knowledge sharing as primary factors (Lampel and Shamsie 2003). Definitely, the low level of awareness regarding ECWPs across the supply chain; from sawmills (Bowe and Hubbard 2003) to exporters (Hrabovsky and Armstrong 2005) to homebuilders (Ganguly and Eastin 2007) and home owners and home buyers has posed a major hurdle in the adoption of ECWPs.

For ECWPs the supply chain can be divided into two components. The first extends from the forest through the wood processing facility and finally to lumber wholesalers and retailers. The second component of the chain continues from the lumber wholesalers and retailers and extends through to the homebuilders, remodelers and, ultimately, homebuyers. Homebuilders and remodelers play a vital role in the post-production supply chain by providing home owners and home buyers with information about the different wooden building materials. Perhaps more importantly, homebuilders and remodelers make a majority of the material specification and usage decisions themselves. Given their importance in the material specification process, this study investigated the role of homebuilders and remodelers in the adoption and diffusion of ECWPs at various levels in the post-production supply chain.

Much of the research on the adoption and diffusion of certified wood has been focused on the end-users' willingness to pay a price premium for certified wood. But it's been found that intermediaries (e.g., homebuilders and remodelers) play a strategic role in construction material use decisions for various end-use applications (Garth et. al 2004, Ganguly and Eastin 2007, Ganguly 2008). The acceptance of ECWPs requires market confidence in the certification process and market awareness and appreciation of the environmental attributes of certified wood by specifiers and end-users (Ganguly et al. 2013). However, their success in the marketplace largely depends on their appeal to, and acceptance by, homebuilders and remodelers. These end-users play a pivotal role in the adoption of ECWPs, providing a crucial link between lumber wholesalers and retailers at one end of the supply chain, and homeowners and home buyers at the other end.

World-wide, the production of certified wood has been increasing, especially in North America. Global certified forest area grew 8.3% from 2006 to 2007, reaching 292 million hectares, (7.6% of global forest area), of which more than half (56%) of certified forest cover is in North America (UNECE 2007). However, the rate of increase in forest certification has been slowing due to lukewarm market response for ECWPs. To some extent, the introduction of "green building programs"(GBP) in the US has helped to inform homebuilders about ECWPs. However, the role of ECWPs in some green building programs is relatively minor and buildings can attain a green certification without the use of certified wood. Some of the programs fail to recognize all third party forest certification programs, including Sustainable Forestry

Initiative (SFI) and Canadian Standards Association (CSA), which have the largest area of certified forest in North America, further adding to the problem.

Although the residential construction industry is the largest potential market for ECWPs, there is no compelling economic or functional incentive for homebuilders to adopt certified wood. In order to better understand the factors influencing the adoption of certified wood, it is important to identify those factors that encourage or inhibit homebuilders' usage of certified wood. Understanding the nature of strategic demand, procurement and marketing behavior by homebuilders and remodelers, and the role they play in the adoption of ECWPs in the residential construction sector, is crucial in furthering the cause of sustainable forest management through market based incentives.

US Residential Construction Industry

The US residential construction sector consists of both new home construction and home repair & remodeling (R&R) activity. It is also important to understand the demographics of firms in the residential construction sector. The US residential construction sector is highly decentralized with most builders working within local markets. The sector consists of a few large homebuilders, while the vast majority are small to medium-sized homebuilders and remodelers. According to Business Census 2010, there were 156,910 residential construction firms in the US in the following categories:

- new single-family housing construction - 49,922,
- new multi-family housing construction - 3,104,
- new housing operative builders - 16,392, and
- residential remodelers - 87,566.

Figure 1 shows the number of firms by the number of employees. For ease of visualization the vertical axis is log-transformed as the distribution is highly skewed to smaller firms.

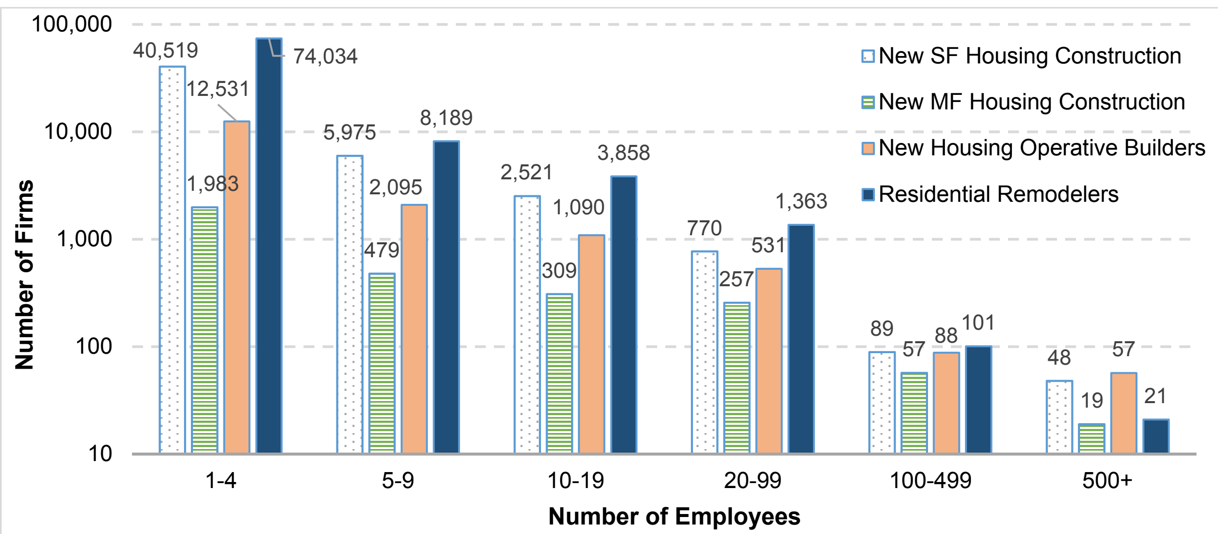

Figure 1. Number of US residential construction firms by the number of employees in 2010

Source: US. Census Bureau 2010

Figure 2 shows total softwood lumber consumption in the US from 1970 to 2012. Between 60% and 75% of softwood lumber had been used by the residential construction sector with the majority of the remainder going into the non-residential, material handling and packaging sectors. But as a result of the housing crisis, triggered by subprime mortgage problems in 2006, total lumber consumption in the US declined sharply from 64.3 billion board feet (bbf) in 2005 to 31.3 bbf in 2009. The residential construction sector consumed about 63.5% of all softwood lumber produced in 2010. Historically, new home construction was the largest market for softwood lumber in the US with R&R being the second largest market. But, because of the housing crisis, in 2010 the R&R sector consumed more softwood lumber (12.9 bbf) than did new home construction (8 bbf).

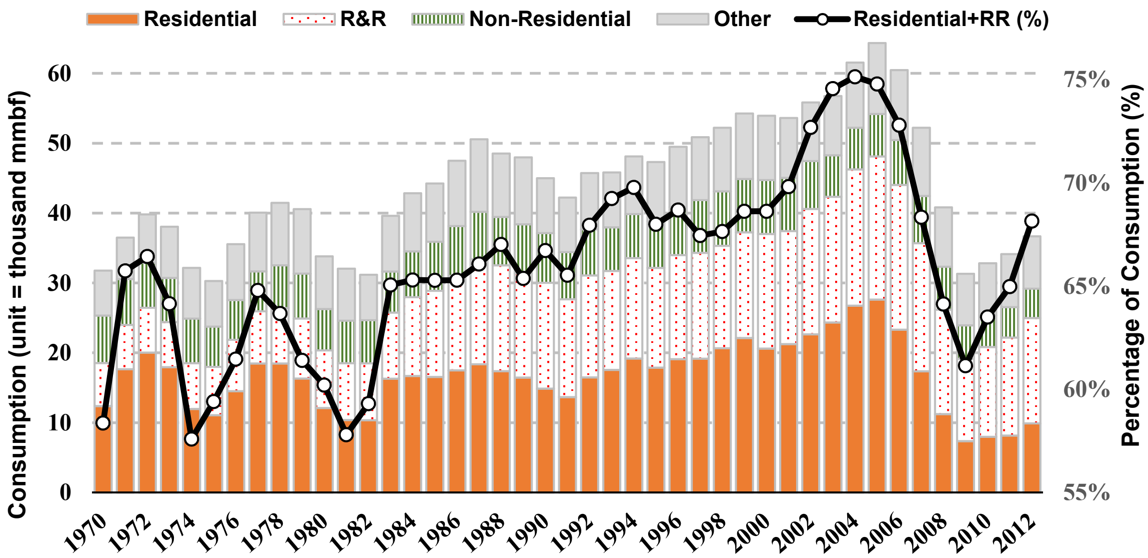

Figure 2. US consumption of softwood lumber

Source: WWPA 2014

Environmentally Certified Wood Products and Certification Programs

Environmentally Certified Wood Products (ECWPs) are usually associated with eco-labeling and chain-of-custody (CoC) programs that are designed to ensure that wood products are harvested from sustainably managed certified forests. Forest certification is one of the results of a series of events dating back to the 1960s that originally aimed to address the degradation of tropical rainforests. Policy interventions such as log export restrictions and government export licensing proved to be inadequate to address the issue of tropical deforestation. In many cases lost export revenues and the expenses associated with implementing these measures posed a significant economic cost for developing country governments (Gillis 1988). Consequently, certification of sustainable forest management was envisioned as a potentially more effective alternative for reducing deforestation rates.

As opposed to mandatory regulations imposed by governments and international associations, environmental certification of wood encourages sustainable management of forests through market based incentives (Vidal et al. 2005). The process of certification and CoC tracking through the supply chain authenticates the environmental sustainability of wood products and allows wood manufacturers to use registered eco-labels on their products. This voluntary market oriented program is based on the belief that consumers will prefer products certified as being environmentally friendly by independent, third-party organizations committed to protecting the natural environment (Upton and Bass 1996).

Currently there are more than 50 certification programs worldwide addressing many types of forests. Typically, third-party organizations develop the standards of "good forest management practices" the programs use to certify forests and wood products. Table 1 summarizes the major forest certification programs used in North America.

Table 1. Major certification programs used in North America

Abbreviation	Full Name	Founded	Location	US	Canada
FSC	Forest Stewardship Council	1993	Denmark	Yes	Yes
SFI	Sustainable Forestry Initiative	1994	US/Canada	Yes	Yes
ATFS	American Tree Farm System	1941	US	Yes	No
CSA	Canadian Standards Association Group Sustainable Forest Management Standard	1996	Canada	No	Yes
PEFC	Programme for the Endorsement of Forest Certification	1999	Switzerland		

In 1993, the first international certification program was instituted with the establishment of the Forest Steward Council (FSC). FSC provided a structure for the certification process by acting as the overseer of certifying agents and establishing the necessary principles and criteria for providing certification (Scrase 1995). The FSC certification program follows a set of ten broad principles that ensure compliance with local laws, adherence to sustainable silvicultural and biodiversity principles, incorporation of management plans benefiting indigenous communities and culture, and compliance with worker rights (FSC 2015). About two-thirds of FSC-certified wood is used in remanufactured or value added products, such as flooring and millwork, as opposed to commodity-type structural lumber (Germain and Penfield 2010). FSC uniquely distinguishes between plantations, semi-natural forests and natural forests and applies different standards for each type of forest (the same management criteria apply to all timberlands regardless of how they were established under the SFI and ATFS programs).

The Programme for the Endorsement of Forest Certification (PEFC), based in Geneva Switzerland, is an international NGO which promotes sustainable forest management through independent third party certification. PEFC is the largest forest certification system in the world (based on the area of forest certified). PEFC only recognizes forests certified to standards that have been reviewed and endorsed by PEFC. National forest certification systems that wish to be recognized by PEFC are required to set standards in accordance with the requirements of ISO/IEC Guide 59:1994 Code of good practice for standardization. FSC and PEFC are the two major international forest certification schemes both of which are designed to improve forest management. However, mutual recognition of FSC and PEFC certified wood products has not yet been achieved. PEFC generally does not directly certify timberlands in North America; they rather endorse other certification programs. PEFC-US is made up of two certification programs: The Sustainable Forestry Initiative (SFI) and the American Tree Farm System (ATFS) (PEFC 2014). In addition, PEFC has endorsed the Canadian Standards Association (CSA) Group Sustainable Forest Management (SFM) standards in Canada.

SFI was originally launched as an industry-backed certification program by the American Forest and Paper Association (AF&PA) in 1994. The SFI program was endorsed by PEFC in 2005 and SFI became an independent non-profit organization in 2007. The SFI program only certifies forests in the US and Canada, and program participants must comply with all applicable laws. The SFI program mainly addresses large public forests and medium to large private forest landowners. SFI has certified about 240 million acres in North America, making SFI the largest single certification standard in the world as of 2014 (SFI 2014).

Unlike FSC and SFI that are commonly applied to large contiguous forest ownerships, ATFS is a family forest certification program designed specifically for smaller, non-industrial private timberland owners. ATFS is only applicable in the US. The first official "Tree Farm" was dedicated in 1941. That is Weyerhaeuser's Clemons Tree Farm located in Montesano WA, which was established to demonstrate fire control and reforestation practices. In 2008, ATFS was endorsed by PEFC. ATFS is a network of 82,000 family forest owners and had certified over 24 million acres of forestlands in the US as of 2014 (ATFS 2014). ATFS defines management criteria more broadly than FSC and SFI. ATFS requires landowners to implement a management plan appropriate for the ownership size and intensity of forest management activities.

CSA SFM was launched in 1996, and it is Canada's official national standard for sustainable forest management. In order to certify forestlands under the CSA SFM, forest managers must follow the six criteria developed by the Canadian Council of Forest Ministers as part of an international process to create global criteria and indicators for sustainable forest management.

In the US, SFI and FSC are the two predominant forest certification programs. Both the FSC and SFI certification programs broadly cover the key aspects associated with biodiversity protection, ensuring sustainable harvest levels, protection of water quality, forest regeneration and wildlife habitat protection (FSC 2015, SFI 2014). Though the SFI evaluation criterion are generally considered to be less stringent to those of FSC's (at least by some in the environmental community), the primary differences are in the social and community involvement aspects of the programs. Because of the competition between the two programs, mutual recognition between FSC and SFI (under PEFC) has not yet happened. In addition, SFI wood products are not accepted by the Leadership in Energy and Environmental Design (LEED) rating system of the U.S. Green Building Council. LEED v4 for Homes Design and Construction (USGBC 2013) states "all wood in the building must be non-tropical, reused or reclaimed, or certified by the Forest Stewardship Council, or USGBC-approved equivalent." This means that the LEED for Homes rating system has only accepted FSC for the forest certification credit, and has not yet recognized SFI or ATFS. Only FSC certified wood has been accepted for "environmentally responsible forest management" within the LEED green building program.

Adoption of ECWPs

The acceptance of ECWP requires market confidence in the certification process and market awareness and appreciation of the environmental attributes of certified wood by both specifiers and end-users. Recent research has begun to show the influential role that intermediaries such as homebuilders and home remodelers play in the adoption of ECWPs. Ganguly (2008) found that the environmental awareness of residential homebuilders and their willingness to try innovative new construction materials played a significant role in their specification and usage of ECWPs. Homebuilders and remodelers play a pivotal role in the adoption of ECWP by providing home owners and home buyers with information about the different wooden building materials. Perhaps more importantly, homebuilders and remodelers make a majority of the material specification and usage decision themselves.

The majority of softwood lumber and structural engineered wood products produced in the US are consumed within the residential construction sector (including repair and remodeling), making that industry the largest potential market for ECWPs in the US. Firms in this sector can significantly influence the future demand for ECWPs. From a wood products marketing perspective it is therefore critically important to understand what motivates homebuilders and remodelers to choose to use ECWPs in their projects.

The low level of awareness regarding ECWPs across all parts of the supply chain has also posed a major hurdle in the adoption of ECWPs. While the introduction of green building programs (GBPs) has helped to inform homebuilders and consumers about ECWPs, their role in these GBPs is relatively minor, and buildings can easily attain certification without the use of any certified wood. Some of the programs (e.g., LEED) do not recognize all third party forest certification programs, including SFI, the Canadian Standards Association CSA and PEFC. By the middle of 2015, there were 66.4 million hectares of forests certified under the FSC program in North America (FSC 2016), while there were 267 million hectares of forest certified under the PEFC program (PEFC 2016). The exclusion of the non-FSC programs has been largely responsible for the constrained supply of certified wood which has limited the adoption and diffusion of certified wood in green buildings.

Home centers are one of the most popular sources of supply for residential construction professionals, especially remodelers. However, home center chains offer varying amounts of ECWPs for sale; primarily as a way to audit their global supply chain and support their corporate social responsibility efforts without passing significant costs to the consumer (Dauvergne and Lister 2010). This has led to unreliable supplies and access of ECWPs for end-users.

The awareness of ECWPs has been slowly increasing among end-user and consumers (Ozanne and Vlosky 2003). However, increased customer awareness regarding the availability and benefits of certified wood has not translated into a higher demand for ECWPs. Customers, scholars and environmental NGOs continue to be skeptical about the effectiveness of forest certification in reducing tropical deforestation as there are other more influential factors driving the problem (e.g., agricultural expansion, increased demand for energy crops and illegal logging) (Gronroos and Bowyer 1999, Rametsteiner 2002, Ozanne and Vlosky 2003, Dauvergne and Lister 2010). Consumer's perceptions regarding the trustworthiness of the various certifying agencies are known to vary widely (Vlosky et al. 1999). In addition, there is a fine balance between forest certification programs focus on protecting threatened tropical forests and the ability of the programs to ensure a reliable supply of certified wood products within consumer markets in developed nations (Bass et al. 2001).

A 2003 study by Vidal found that approximately 39% of the primary wood products companies in Canada and the US were *chain-of-custody* (CoC) certified, while an additional 12% reported that they planned to implement CoC strategies by 2008 (Vidal et al. 2005). It also appears that larger companies who are integrated backwards are more likely to adopt and sustain the usage of ECWPs (Vidal et al. 2005). Some studies have found that the general feeling among US wood-products manufacturers was that certification was more critical for tropical forests than for temperate forests (Vlosky and Ozanne 1998). The high initial costs for certification are especially challenging for companies located in developing countries with predominantly tropical forests. These more complex forest structures are harder to audit and have additional costs because of extreme biodiversity (Espach 2006). Since it appears that customers are unwilling to pay a premium for ECWPs, many forest-product companies are asking for non-market-based incentives to offset the additional cost associated with the certification process (Vlosky and Ozanne 1998).

A substantial amount of the literature on ECWPs has focused on customers' willingness to pay a premium for certified wood, and leans toward the view that consumer demand and consumer willingness-to-pay drive the market for ECWPs. These studies suggest that when purchasing new homes or other wood products, customers prioritize the price and other tangible attributes of the home higher than its environmental attributes (Gronroos and Bowyer 1999, Rametsteiner 2002, Anderson and Hansen 2004). There is insufficient evidence to demonstrate the universal appeal of ECWPs among consumers and end-users, although some research has begun to suggest that the proper dissemination of information regarding the benefits of forest and wood certification among potential customers not only increases the demand for certified wood products, but could also encourage these customers to pay a price premium for certified wood (Kozak et.al. 2004).

Adoption of Innovative Green Products and Technology within the Residential Construction Sector

Green building technology creates buildings that are environmentally responsible and use resources efficiently. This is a rapidly advancing field, and companies continually introduce a wide variety of new green building products and technologies. ECWPs are an innovative green product which have begun to become popular in the construction industry. Other innovative green technologies include, engineered wood, heat/recovery ventilators, concrete with reduced cement, solar water heaters, structural insulated panels, radiant barriers, solar power generation, water conserving fixtures, tankless water heaters, energy efficient windows, energy efficient appliances, and low volatile organic compound (VOC) paints. These products are all categorized as innovative green building products for convenience, though some of them are much more popular than others. To understand why builders adopt some innovations quicker than others is critically important information.

Relatively few studies have looked at the process of the adoption and diffusion of new types of construction materials and technology in this industry (Blackley and Shepard 1996, Taylor and Levitt 2004). One of the first known published works dealing with innovation adoption and diffusion in residential construction was by Beal and Rogers (1960), who examined the diffusion of information regarding the construction of farm houses. Since then only a few efforts have been made to empirically assess innovation adoption and diffusion in this industry (McNicholas 1994, Lutzenhiser 1994). However, the absence of a proper analytical framework for assessing the adoption and diffusion process within the residential construction industry, as well as methodological inconsistencies associated with the empirical studies, have rendered most of this research inconclusive. For example, while examining the barriers to the adoption of new technologies in the US construction industry, McNicholas (1994) failed to delineate between the various sectors of the construction industries (i.e., residential versus commercial) and the characteristics of the innovations being considered. Similarly, while assessing barriers to the adoption of energy-efficient systems in residential construction, Lutzenhiser (1994) failed to empirically establish his research claims.

The innovation adoption literature for the construction industry has been enhanced by a number of qualitative analytical studies. Table 2 summarizes the studies that have investigated the factors that influence the adoption of innovations within the residential construction industry. Innovation adoption in any industry is a function of the characteristics of the industry, the interrelationship between the companies in the industry (intensity of rivalry), the characteristics of firms within the industry and above all the characteristics of the innovations. Ignoring any of these factors results in only a partial understanding of the market characteristics and results in contradictory or non-generalizable outcomes. Further, the conclusions in these studies are often based on anecdotal evidence and are not substantiated by empirical evidence.

In an effort to better understand the introduction of new products, many definitions, concepts and measures have been proposed, varying in breadth and relevance. Owing to differences between the industries being studied and the varied nature of the products, innovation-adoption studies tend to lead to industry or product-specific outcomes.

Table 2. Factors impacting the adoption of innovations within the residential construction industry.

Factor	Authors
Fragmented nature of the industry	Ventre 1979, Poitras and Duff 1988, Goldberg and Shepard 1989, NAHB Research Center 1991
Government regulation or Building codes	Poitras and Duff 1988, Prestemon 1973
Inter-organizational networks/ linkages	Lutzenhiser 1994, Colebourne 1994
Uncertainty of quality or Lack of familiarity of the product	Prestemon 1973
Justification of the cost of adoption or Profitability	Prestemon 1973, Colebourne 1994, Spall 1971, Goldberg and Shepard 1989, NAHB Research Center 1991
Uncertainty related to market acceptance	Prestemon 1973, Spall 1971, Goldberg and Shepard 1989, NAHB Research Center 1991
Firm Size	Oster and Quigley 1977, Spall 1971, Goldberg and Shepard 1989, NAHB Research Center 1991
Labor unionization	Oster and Quigley 1977
Builder education	Oster and Quigley 1977, Colebourne 1994, Spall 1971
Managerial experience	Spall 1971
Management intensity	Goldberg and Shepard 1989, NAHB Research Center 1991
Specialized inputs	Goldberg and Shepard 1989, NAHB Research Center 1991
Capital intensive equipment	Goldberg and Shepard 1989, NAHB Research Center 1991

The adoption of innovative green products within the homebuilding industry is moderated by a number of factors, many of which have been summarized in Table 2. Some of the variables such as 'the fragmented nature of the industry' can be further subdivided using 'innovation community' framework variables (Rosenberg 1979, Lynn et. al 1996).

Green Building Programs

The term "green building" (also called green construction, sustainable building or high-performance building) refers to a structure built using a process that is environmentally responsible and resource-efficient throughout its life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. The green building movement in the US originated from the need and desire for more energy efficient and environmentally friendly construction practices. Green building brings together a vast array of practices, techniques, and skills to reduce the impacts of buildings on the environment and human health. While the practices or technologies employed in green building vary, fundamental principles persist from which the method is derived: siting and structure design efficiency, energy efficiency, water efficiency, materials efficiency, indoor environmental quality enhancement, operations and maintenance optimization and waste and toxics reduction.

The "greenness" or sustainability of a building is a multi-dimensional concept based on different attributes including energy use, resource efficiency, recycled content, toxic air emissions, water conservation, bio-diversity, disposal, global warming and so forth. It is not easy for consumers and regulators to understand how sustainable their buildings are. Also, greenwashing, which is defined as the use of green claims that are not true or are unverifiable but used to sell products or a corporate image, has become commonplace as companies try to stay competitive in the green marketplace. Transparent and easy-to-understand tools are needed to understand and evaluate the "greenness" of buildings.

As a result of the increased interest in green building, a number of organizations have developed standards, codes and rating systems that let regulators, building professionals and consumers embrace green building concepts and practices with confidence. Collectively these systems and standards are known as green building programs (GBPs). Most GBPs have adopted rating systems—a type of certification that rates or rewards relative levels of compliance or performance with specific environmental goals and requirements. Typically, they are voluntary certification systems developed by third-party organizations and designed for building sustainable structures that minimize impacts on the environment (EPA 2010). In some cases, municipalities, local or national governments can adopt them as by-laws to reduce the environmental impact of buildings. GBPs have been introduced in many countries and they are becoming a popular tool for increasing the use of sustainable building materials, building practices and construction technologies, especially in developed nations. GBPs exist to address every type of project, from single-family houses and commercial buildings to entire neighborhoods and subdivisions.

Table 3 summarizes the major national residential Green Building Programs in the US: the ICC-700 National Green Building Standard (NGBS) developed by the National Association of Homebuilders (NAHB) and LEED for Homes developed by the U.S. Green Building Council (USGBC).

Table 3. Summary of the two major Green Building Programs in the US

Abbreviation	Full Name	Organization	Levels	Launched
NGBS	ICC-700 National Green Building Standard	National Association of Home Builders (NAHB)	Emerald, Gold, Silver and Bronze	2007
LEED for Homes	Leadership in Energy and Environmental Design for Homes	U.S. Green Building Council (USGBC)	Platinum, Gold, Silver, Certified	2008

In 2007, NAHB and the International Code Council (ICC) partnered to establish a multi-attribute standard definition of green building and received American National Standards Institute's accreditation for all residential construction under the code 700. This program is called ICC 700 National Green Building Standard (hereafter, just NGBS)—a national rating system for residential green building. NGBS applies to a variety of residential projects, including site development, multifamily housing projects, remodeling, single-family homes, and subdivisions. NGBS has four compliance levels: Bronze, Silver, Gold, and Emerald, with Emerald representing the highest level of achievement. NGBS includes a list of mandatory measures, most of which correspond to various minimum code requirements. Developers accrue points by incorporating features in six areas: lot design and development, water efficiency, energy conservation, resource conservation, indoor environmental quality, and homeowner education. NGBS acts as a general code of best practices for green building. For that reason, it does not contain specific requirements for compliance with a particular program, and municipalities have the option of using the NGBS to develop their own local green building program. Compliance specifications for the NGBS are contained in the NAHB Research Center's online scoring tool and verifier guidelines. The NGBS base level makes performance testing optional and only requires Energy Star[1] documentation if a project is using the prescriptive path and opts out of the pre-drywall inspection. NGBS costs less than LEED for Homes, but homeowners may need to acquire Energy Star certification to meet some subsidy or rebate programs (Reposa 2009).

LEED for Homes, launched in February 2008, is a national third-party green building certification system created by US Green Building Council (USGBC). The program certifies single family and low rise housing, and is in the pilot phase of developing a rating system for mid-rise residential buildings. LEED has four levels of certification: Certified, Silver, Gold and Platinum, with Platinum representing the highest level of achievement. The USGBC has also created the REGREEN as a guideline for renovation projects. LEED for Homes measures green building performance based on eight categories: site selection, water efficiency, materials and resources, energy and atmosphere, indoor environmental quality, location and linkages, awareness and education, and innovation. LEED for Homes requires all projects to meet Energy Star standards, including performance testing.

[1] **Energy Star** (trademarked *ENERGY STAR*) is an international standard for energy efficient consumer products originated in the US. It was created in 1992 by the Environmental Protection Agency and the Department of Energy.

The LEED for Homes program has received significant momentum. As of mid-2011, there were more than 12,000 housing units certified using the LEED for Homes program and approximately 6,000 housing units certified using the NAHB program. Generally, the differing approaches of NAHB and LEED largely reflect differences in the intended users of each system - LEED is designed for leaders in green building, while NGBS was created to be accessible to any builder looking to improve their environmental practices. LEED for Homes developed their guidelines from a design perspective, and therefore tend to use existing standards that provide measurable requirements for builders to meet. The NGBS often uses more prescriptive language to describe compliance methods.

Between the two GBPs, significant differences exist in terms of the number of points allocated for using ECWPs and the acceptability of the forest management program under which the ECWPs were certified. NAHB's model green home building guidelines list ECWPs under the 'renewable resource' category within the 'resource efficiency' section of the green-building checklist. The NAHB program accepts the use of ECWPs certified under all of the credible third-party-certified programs, including, SFI, ATFS, CSA, FSC, PEFC, and makes provision for recognizing ECWPs certified under "other such credible programs as they are developed and implemented." In contrast, LEED for Homes acknowledges only ECWPs that have been certified under the FSC certification program. Under the LEED for Homes certification program, no points are awarded for homes built using SFI or ATFS wood products. In December 2010, the USGBC failed to get enough yes votes from members for a proposed rewrite of the certified wood policy in its LEED rating system. Since its inception, LEED has only accepted wood certified to FSC standards. The use of ECWPs is optional in both of the GBPs and the total number of points available and for usage of certified wood is limited to specific categories (USGBC 2008, NAHB 2006). In fact, it is quite easy for a homebuilder to certify their projects without using any ECWP's at all.

There are some other national multi-attribute and single-attribute GBPs in the US. Green Globes was developed by Energy and Environment Canada, but it is used as a multi-attribute online green building rating and certification tool in the US as well. The Energy Star system developed by the U.S. Environmental Protection Agency is one of the most well-known single-attribute program focusing on energy efficiency. The U.S. Department of Energy also developed a certification program called DOE Zero Energy Ready Home (formerly known as DOE Challenge Home). Other single-attribute programs include Greenguard, a single-attribute certification program that focuses on indoor air quality. This list is far from complete.

Besides the national GBPs, regional and local green building programs exist in a number of cities and states. There programs vary in the types of services they provide. Some are only a resource for information, whereas others provide third-party certification of building projects. Table 4 shows the major examples of regional multi-attribute third-party certification for residential homes. Since there are a lot of different programs in different cities, it is not possible to comprehensively cover all existing regional programs.

Table 4. Major regional green building programs in the US.

Name	Region
Built Green Washington	Adopted by 30 Counties in WA as of 2014
EarthAdvantage	Portland, OR
Green Built Home	Madison, WI
EarthCraft House	Atlanta, GA & Richmond, VA
Florida Green Building Coalition	Tallahassee, FL
Austin Energy Green Building	Austin, TX
Build It Green California	Berkeley, CA
NC Healthy Built Homes	Raleigh, NC

Source: National League of Cities 2013

Though national programs may be more recognizable to home buyers, many of the regional programs are able to deliver more hands-on services to verify on-site compliance with standards and overall building performance. For that reason, local providers are often contracted by LEED and the NAHB to administer their certification processes. Regional programs can provide more effective outreach and complete services because they are local and can work directly with builders to train and advise them on best practices. Local programs are generally less expensive than national certifiers because they have a smaller area to cover. Due to lower national recognition, these groups cannot demand high premiums for their certification. If a homebuilder chooses to certify their home with a regional organization, buyers may be less aware of the standard and added value if they are not from the area.

Wood, Concrete or Steel

It is a common perception that building a wood structure would have greater environmental benefits compared with steel or concrete-frame buildings. Wood is a renewable natural resource and has a smaller carbon footprint than steel or concrete. The Consortium for Research on Renewable Industrial Materials (CORRIM) uses Life Cycle Assessment to estimate the total impacts of wood, steel and concrete as building materials on carbon sequestration. In their research, wooden-framed houses have less environmental impact (Lippke et al. 2004). Also, as discussed earlier, wood is the only building material with third-party certification systems (e.g., FSC, SFI) to verify that products have come from a sustainably managed resource. Since many GBPs focus mainly on energy savings and energy efficiency, the superiority of wood as a green construction material has been less communicated to homebuilders. It's especially important then to understand how homebuilders perceive the relative environmental performance of wood, steel and concrete in residential construction.

Study Goals and Objectives

The overall goal of this study was to develop a better understanding of US residential homebuilders' and remodelers' use of building materials, innovative green technologies and programs pertaining to sustainable building practices.

Awareness, perceptions and use of ECWPs certified under the two major wood certification programs (i.e., FSC and SFI), and the role of GBPs in generating awareness and increasing usage of ECWPs within the US residential construction industry was explored, as it remains the largest potential market in the US. With low awareness among potential end users, unreliable supply and high pricing (Ganguly et al. 2008), there has been little economic or functional reward for homebuilders and remodelers to use ECWPs. However, the growing use and acceptance of GBPs seems to provide an incentive for homebuilders to use ECWPs in their projects, even though their use is not mandated by any of the GBPs.

The use of other non-wood building materials and green technologies was investigated as well. Construction professionals, both builders and remodelers, are often responsible for specifying the use of building materials (i.e., wood, concrete and steel, and innovative green technology and products). Knowing how these individuals perceive the relative importance of different environmental attributes, how this influences their material selection decisions and how they perceive the relative environmental performance of competing building materials and products is therefore critically important.

In order to understand what influences their adoption of building programs and products, it is important to identify the factors that encourage or discourage their use. Understanding the nature of the demand, procurement and marketing behavior of homebuilders and remodelers, and the role they play in the adoption in the residential construction sector, will be critically important in supporting sustainable forest management through market-based incentives.

Survey Methodology and Data Collection

Target population

This survey was designed to analyze and estimate the characteristics of:

(i) the US residential construction industry (**homebuilders and remodelers**) and

(ii) homebuilders who have used LEED for Homes or NGBS (referred to as **"eco-builders"**).

As previously noted, the residential construction industry in the US was comprised of 156,910 firms in 2010 (US Census 2010). The exact population size for the eco-builders is not known. However, based on the green housing starts data, from 3% to 7% of total housing starts are LEED or NGBS certified. According to the industry experts, about 25% of the active US homebuilders might be engaged in LEED or NGBS. According to an estimation by Smoke (2012) in Builder, there were 73,000 active homebuilder companies in 2005, but that number had declined to 34,000[2] by 2011. Consequently, we conservatively estimated the population of **eco-builders** to be 8,500 in 2010.

Minimum Required Sample Size

Sample size is an important feature of any empirical study in which the goal is to make inferences about a population from a sample. Sample sizes are judged based on the quality of the resulting estimates. The acceptable margin of error, a statistic expressing the amount of random sampling error in a survey's results, is suggested to be 5% for categorical data (Krejcie and Morgan 1970). The minimum required sample size for each phase of this survey was calculated to ensure the margin of error was as high as 5% (d≤0.05) with some conservative assumptions.

Minimum required sample size calculations are based on the primary variable of interest in the study and the nature of the variable (Cochran 1977, Bartlett et. al. 2001). In order to estimate a sample size from the specified population based on the confidence level needed and presumed awareness level, the formula provided by Krejcie and Morgan (1970) is used:

$$\text{n} = \frac{\chi^2 NP(1-P)}{d^2(N-1)+\chi^2 P(1-P)} \qquad \text{….. (eq. 1)}$$

Where, n= minimum required sample size; N= the target population size; P= the estimated value for the proportion of a sample who are aware of ECWP; d= acceptable margin of error for the estimated value of P; χ^2 = table value of chi square for one degree of freedom relative to the desired level of confidence, (1-d). Because of the above reasons, d=0.05 and corresponding χ^2 value for one degree of freedom is 3.841.

i) Minimum sample size for whole US residential construction industry

The target population is all firms in the US residential construction industry (homebuilders and remodelers). As already discussed, the total number of firms in the US residential construction sector in 2010 was N=156,910. Due to varied awareness levels of different construction materials, half population is estimated to be aware of ECWPs. Therefore, P=0.5 is used in order to obtain the most conservative estimation of the required sample size (Cochran 1977). Using Equation 1, the minimum sample size for whole US residential construction industry is **383.2**.

ii) Minimum sample size for eco-builders

The target population is homebuilders that have used LEED for Homes or/and NGBS as of 2010. As noted previously, the size of this population is estimated to be 8,500 firms. By virtue of their interest in green construction, a great majority of this segment is highly likely to be aware of ECWPs and we can assume that 90% of eco-builders are aware of ECWPs.[3] Therefore, a value of 0.9 is used for P.

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[2] Census data often includes many inactive firms. This number better reflects the reality than Census data.

[3] As discussed later, this assumption was verified by the result of the survey.

Using Equation 1, the minimum sample size for eco-builders is **136.1** to assure the margin of error within 5%.

Survey Development and Design:

To obtain the primary information for this study, a web-based survey was conducted. A web-based survey was chosen as it can direct respondents along programmed logical sequences of questions, so it is more flexible than other types of surveys. The web-based survey instrument was designed using the process shown in Figure 3. Industry experts reviewed a preliminary draft of the questionnaire and the questionnaire was edited based on their input. Following Dillman's (1978) recommendation, the resultant enhanced 'structured survey questionnaire' was pretested to ensure the comprehensiveness, clarity and ease of use of the survey instrument. After modifications were made, the web-based survey instrument was tested and debugged using an automated computer response generation process, so that all possible options are tested for viability.

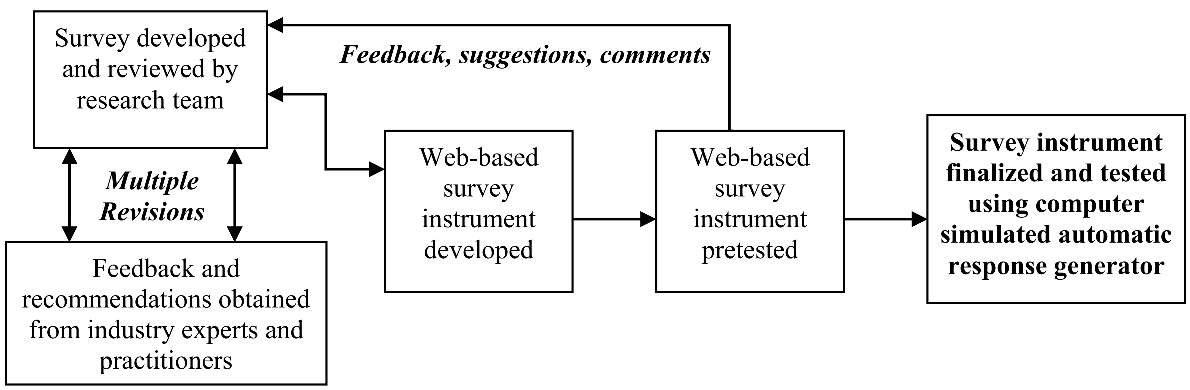


Figure 3. Survey instrument development and design process

Data collection

In order to obtain representative samples from the two target populations (i.e., ***traditional US residential construction firms*** and ***eco-builders***), a stratified random sampling was undertaken. Two consecutive surveys (i.e., Phase-1 survey and Phase-2 survey) were conducted and both the survey phases were hosted and administered by the NAHB Research Center, a subsidiary of NAHB. The same survey instrument was utilized for both phases of the data collection process.

The first phase of the data collection process focused on registered homebuilders and remodelers randomly selected from the NAHB homebuilder database. The NAHB panel consists of over 30,000 residential homebuilders and remodelers in the US, including firms of all sizes from all fifty states. Using standard random sampling techniques based on a random number generator, a sample frame of 2,000 homebuilders and remodelers was selected from the panel assuming a response rate of 20%. The Phase-1 survey of randomly selected homebuilders and remodelers was conducted during the months of April and May, 2011. The target number of valid responses from the Phase-1 survey was 384.

The second phase of the data collection targeted homebuilders known to have utilized some green building programs. We call this the "***green builders***" sample. The objective of specifically sampling this stratum was to ensure sufficient representation within our sample of green builders. The publicly available lists of builders registered with NAHB's NBGS program and the USGBC's LEED for Homes program were combined to produce a sample frame of 1,010 green builders. The link for the web-based survey was emailed to all of these firms and phone calls were made to encourage them to participate in the survey in order to maximize the response rate. The Phase-2 survey of registered green builders was conducted during the month of October, 2011.

During the analysis of the data, homebuilders from the Phase-2 who completed the survey (94 respondents) were combined with those homebuilders from the Phase-1 survey who reported that they had used a GBP (73 respondents) to produce a new group that we refer to as ***"eco-builders"*** (total of 164 respondents). The target number of valid responses from the eco-builders identified from both phases of the survey exceeded the minimum sample size (137 firms) determined previously. In contrast, those homebuilders who reported that they had not used either the LEED for Homes or the NGBS green building programs were placed in a second group that we will refer to as ***"traditional builders"***. There were 261 homebuilders in this category. Later in this paper, we will compare the demographics and attitudes between eco-builders and traditional builders.

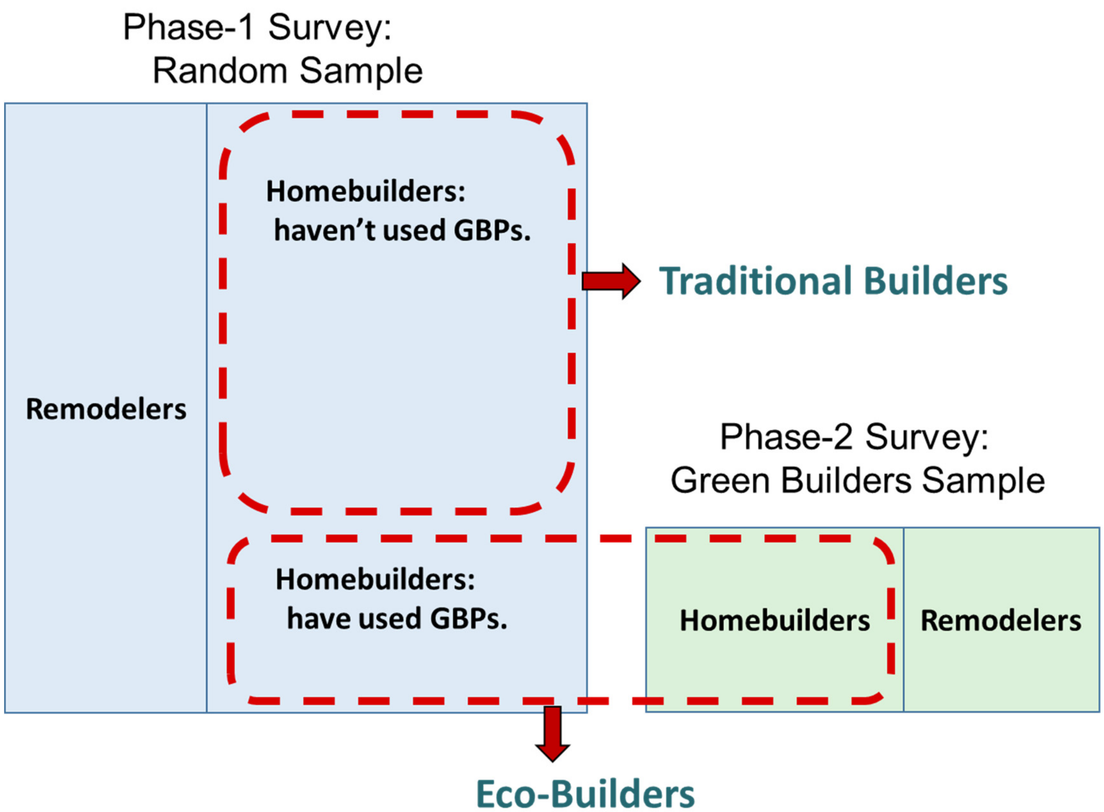


Figure 4. Catagorization of groups within Phase-1 and Phase-2 samples

Results and Discussion

General demographics of the respondents

Response rate

After eliminating all unqualified and invalid responses, 411 responses were received from Phase-1 and 117 responses were received from Phase-2. The number of Phase-1 respondents was more than the minimum required sample size of 383.2. As shown in Figure 5, 76.4% (n=314) of the random sample were homebuilders and the remainder 23.6% (n=96) were remodelers. In contrast, 94.9% (n=111) of the green builders were homebuilders and just 5.1% (n=6) were remodelers.

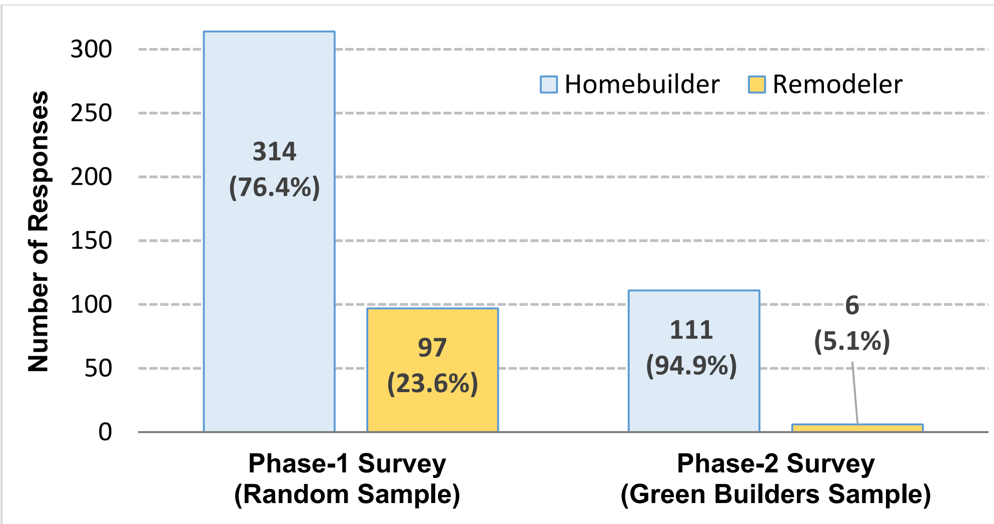


Figure 5. Respondents' business by the phases of survey

General demographic of US residential construction firms

In order to infer to the entire population of US residential construction firms, the results from Phase-1 survey are discussed in the following section.

Location

The material usage and the construction practices within the US residential construction industry are known to vary by geographic regions (Ganguly and Eastin 2007). As can be observed from Table 5, the respondents who participated in this survey were located in 49 states, covering all four of the US census regions. With regards to the survey results, respondents from the South had the highest representation in the survey with 31.8% of all respondents, followed by the Midwest with 28.3% of respondents, the Northeast with 20.1% of respondents and the West with 19.7% of the respondents. With regards to remodelers, respondents from the West had the highest representation in the survey with 29.9%, followed by the South, Midwest and Northeast representing 24.7%, 22.7% and 22.7% of respondents, respectively.

Table 5. The distribution of the respondents by census region

Northeast			Midwest			South			West		
State	Homebuilders	Remodelers	State	Homebuilders	Remodelers	State	Homebuilders	Remodelers	State	Homebuilders	Remodelers
Maine	3	1	Ohio	14	2	Delaware	3	1	Alaska	1	1
N. Hampshire	1	1	Michigan	13	3	Maryland	8	1	Washington	13	10
Vermont	0	1	Indiana	8	1	DC	0	0	Oregon	7	2
Massachusetts	14	3	Illinois	7	4	Virginia	9	2	California	12	8
Rhode Island	3	2	Wisconsin	9	1	W. Virginia	0	0	Hawaii	1	0
Connecticut	6	3	Minnesota	7	5	N. Carolina	13	3	Idaho	4	1
New York	7	6	Iowa	2	1	S. Carolina	8	2	Montana	3	0
New Jersey	10	1	Missouri	9	2	Georgia	11	1	Wyoming	1	0
Pennsylvania	19	4	Kansas	6	1	Florida	15	6	Colorado	8	3
			Nebraska	4	2	Alabama	2	0	Utah	4	0
			S. Dakota	7	0	Mississippi	1	0	Nevada	1	0
			N. Dakota	3	0	Tennessee	5	3	Arizona	6	1
						Kentucky	3	3	New Mexico	1	3
						Louisiana	1	2			
						Arkansas	2	0			
						Texas	12	0			
						Oklahoma	7	0			
Total NE	**63**	**22**	**Total MW**	**89**	**22**	**Total South**	**100**	**24**	**Total West**	**62**	**29**
NE % all	**20.1%**	**22.7%**	**MW % all**	**28.3%**	**22.7%**	**South% all**	**31.8%**	**24.7%**	**West% all**	**19.7%**	**29.9%**

Note: The total number of homebuilders is **314** *and of remodelers is* **97**.

The survey respondents represented homebuilders and remodelers from each of the three major population locations defined in the survey[4]**.** As shown in Figure 6, 58.6% of the homebuilders indicated that they primarily work in urban/suburban areas, 28.3% primarily work in small towns, and the remaining 13.1% were involved in residential construction in rural areas. Remodelers showed a similar distribution as well: 57.7% work in urban/suburban, 29.9% work in small towns, and 12.4% work in rural areas.

[4] Urban/suburban area is a city or group of contiguous communities with a population greater than 50,000, small town means a city or group of contiguous communities with a population greater than 50,000, and rural area is defined as an area with low-density scattered population.

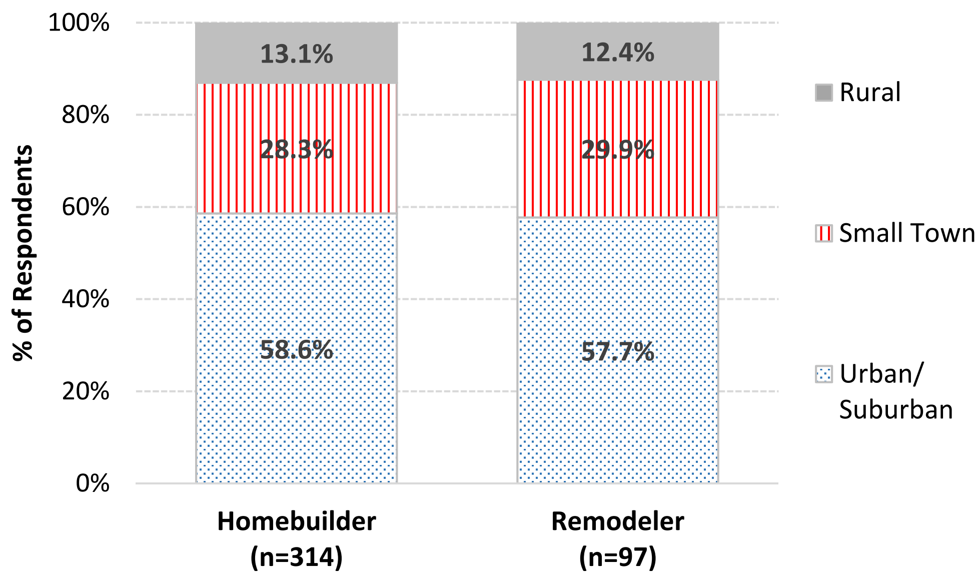


Figure 6. Rural/Urban location of the survey respondents.

Size of firms

A homebuilders' size has often been cited as being one of the most important factors in determining their adoption of innovative building materials (Oster and Quigley 1977, Spall 1971, Goldberg and Shepard 1989, NAHB Research Center 1991, Eastin et al. 1996, Eastin et al. 2005), with their willingness to adopt being dependent on the characteristics of the innovation (Ganguly et al. 2010). The size of a homebuilder has also been found to influence their adoption of GBPs (Sasatani et al. 2015). Annual revenue is often used as a proxy for firms' size. However, given the sensitivity of the question, survey respondents were asked to categorize themselves in one of nine revenue groups, as defined in the survey.

The results of this question show that homebuilders typically earn more revenue per project than do remodelers. Figure 7 clearly shows that the annual revenues of remodelers were smaller than those of the homebuilders[5]. The survey results showed that the largest group of homebuilders (29.9%) reported that their annual revenue was between \$500,000 and \$2 million while approximately 20% of homebuilders earned more than \$5 million. Remodelers are typically smaller than homebuilders: 78.4% of remodelers earned less than \$1 million whereas just 5.2% of the remodelers reported that they earned more than \$3 million in 2010.

[5] The results of the Mann-Whitney's U-test confirmed that remodelers' annual revenues were significantly lower than homebuilders at the 0.001 level.

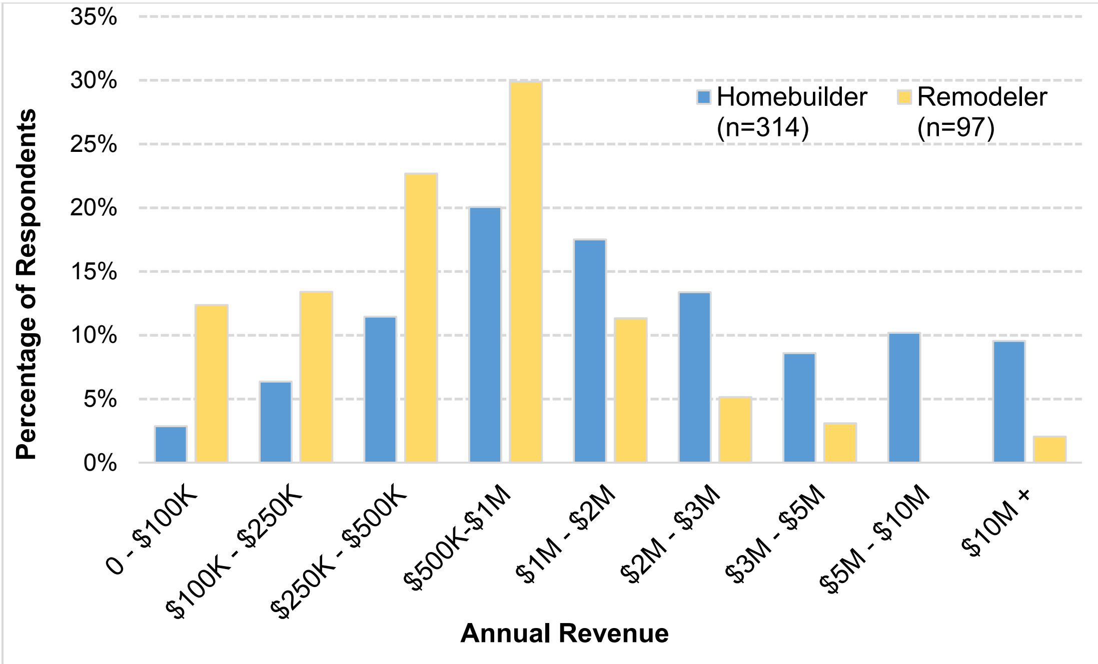


Figure 7. Firm size distribution of the survey respondents.

Remodelers typically earn their sales revenue from repair and remodeling (R&R) of existing homes, subcontracting on new homes and deck and patio construction. On the other hand, homebuilders earn their sales revenue from a more diversified portfolio. The questionnaires asked approximately what percentage of their firm's sales revenue was derived from the following activities: single-family spec homes, single-family custom homes, multi-family homes, non-residential construction, home improvement/R&R projects, and patio/deck construction. Interestingly, 39 homebuilders (12.4%) reported that did not earn any revenue from building single family homes while another 58 homebuilders (18.5%) reported that they earned less than 20% of their annual revenue from building single-family homes. Many of the homebuilders reported that they were only currently involved in remodeling and decking projects. Since the housing market in the US was extremely bad in 2009 and 2010, many homebuilders were forced to look for business in market segments where they might not have normally been involved in the past.

Figure 8 shows the average project portfolio by the size of the homebuilders. Note that remodelers are not included in Figure 8. The survey results show that as the homebuilders get larger, they tend to earn more revenue from construction projects rather than R&R projects. For example, small homebuilders whose annual revenue was less than $250,000 earned 57% of their revenues from R&R/home improvement projects. On the other hand, this ratio was only 6% for those homebuilders whose annual revenue was more than $3 million. As homebuilders get larger, they tend to increase the percentage of their revenues that are derived from multi-family construction and single-family spec homes construction while decreasing the ratio of revenues derived from R&R projects.

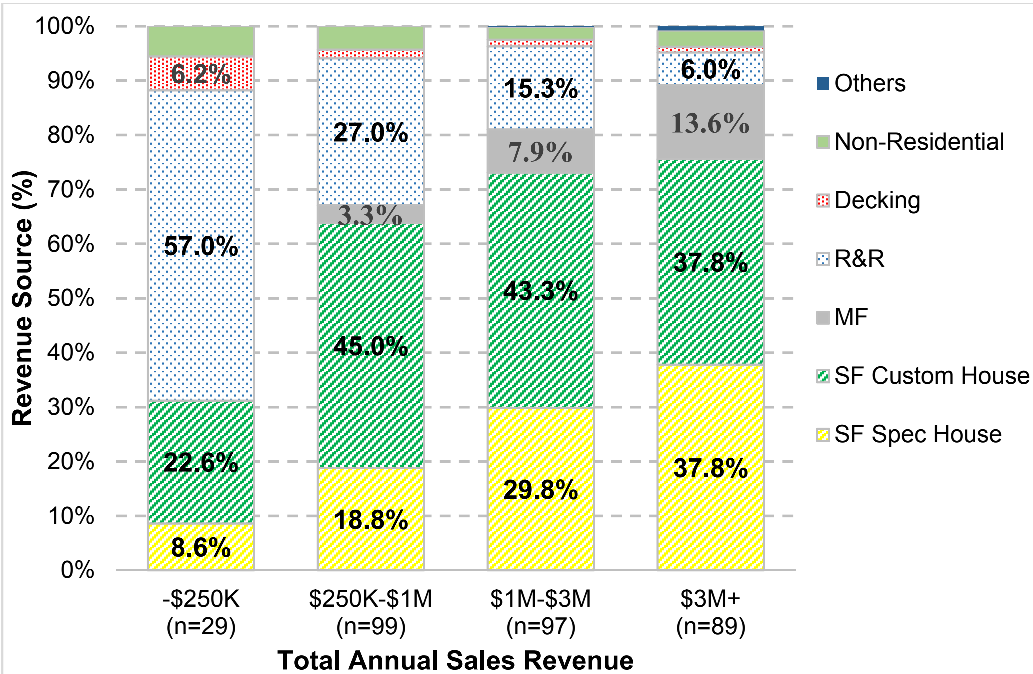


Figure 8. Homebuilders source of revenue broken down by firm size.

Based on the revenue source reported by each respondent, the total number of houses and R&R projects completed by respondents for the homebuilder group in the Phase-1 survey was estimated[6]. Table 6 shows both the total estimated number of projects completed by the survey respondents and the residential construction statistics reported by the US Census (2010) by the four Census regions. In 2010, the US South had the most single family houses built (51.9% of the US starts), followed by the West (20.7%), the Northeast (17.0%) and the Midwest (10.9%). Similarly, the US South had the most multi-family houses built (38.0%), followed by the West (20.7%), the Northeast (17.0%) and the Midwest (10.9%). The ratio of multi-family houses completed in the Northeast and the West was higher than that for single-family houses because both regions have many high-density urban cities.

Overall, the regional representation of the survey respondents aligned fairly well with the regional breakdown reported in the Census statistics. From the Midwest, respondents completed an estimated 1,432 single-family houses, the Northeast 700, and the West 1,086 in 2010, which represents 1.7%, 1.3% and 1.1% of total home completions in those regions, respectively. On the other hand, respondents from the South completed an estimated 1,448 single-family homes, which represents 0.6% of the total home completion. Also, the respondents of this survey did not build many multi-family houses or non-residential buildings. As already discussed, many of the larger homebuilders were involved in multi-family and non-residential construction projects, but the survey was not able to reach as many of those large homebuilders because of the nature of the NAHB's registered builder database. Finally, the respondents who identified themselves as remodelers completed an estimated 1,123 home improvement and R&R projects in the West, 674 in the South, 496 in the Northeast, and 482 in the Midwest.

[6] Since the questionnaire asked how many projects (new home construction and home improvement projects) they undertook in 2010, remodeling projects and home building projects were not separated for homebuilders. In order to estimate the number of houses built by each homebuilder and the number of remodeling projects they completed, we assumed that the average revenue derived from an R&R project was one-fifth of that derived from building a new home. Based on this assumption, the number of R&R projects the homebuilder respondents completed was estimated.

Table 6. Respondents' estimated projects in 2010 by Census region

	NE	MW	South	West	Total
New Residential Construction Completed by Census					
Total SF House Completed (2010)	54,000	81,900	257,600	102,800	496,300
	10.9%	*16.5%*	*51.9%*	*20.7%*	*100%*
Total MF House Completed (2010)	26,400	25,000	59,100	44,900	155,400
	17.0%	*16.1%*	*38.0%*	*28.9%*	*100%*
Homebuilders' Responses					
Total SF House Completed by Homebuilders	700	1,432	1,448	1,086	4,666
	15.0%	*30.7%*	*31.0%*	*23.3%*	*100%*
Total MF House Completed by Homebuilders	34	21	19	25	99
	34.3%	*21.2%*	*19.1%*	*25.2%*	*100%*
Total Remodeling Projects by Homebuilders	314	1,016	405	567	2,302
	13.6%	*44.1%*	*17.6%*	*24.6%*	*100%*
Total Non-Residential Projects by Homebuilders	15	26	20	38	99
	15.1%	*26.2%*	*20.2%*	*38.3%*	*100%*
Remodelers' Responses					
Total Remodeling Projects by Remodelers	496	482	674	1,123	2,168
	22.9%	*22.2%*	*31.1%*	*51.5%*	*100%*

Note: NE and MW represent Northeast and Midwest, respectively.

Figure 9 shows the distribution of estimated single-family homes completed by homebuilders and R&R projects by remodelers based on the data collected from the Phase-1 and Phase 2 surveys. *Note that the x-axis of each graph has been transformed to a log-scale* since the distribution of responses was highly skewed. As previously discussed, 39 homebuilders reported that they did not build any single-family homes in 2010. The mean number of single-family houses completed was 14.9 and the median number of single family homes built was 3 and the 75-percentile value was 10 homes. In other words, more than half of the homebuilders built 3 homes or less and about three-quarters of the homebuilders built 10 homes or less in 2010. In contrast, six homebuilders reported that they built more than 200 homes. The number of R&R projects completed by the remodelers is shown on the right side of the chart in Figure 9. The mean number of R&R projects was 28.6 and the median number of projects was 15.

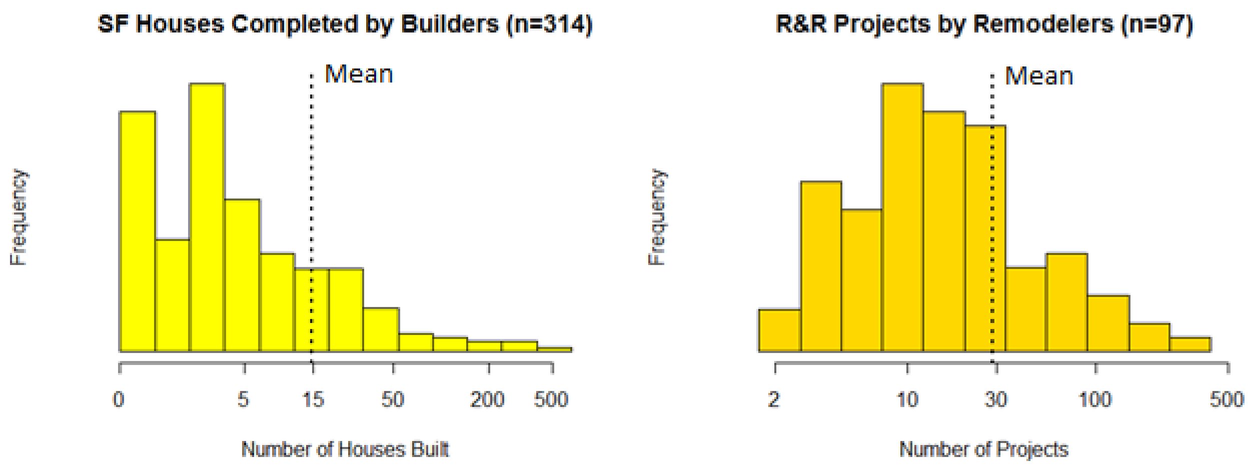


Figure 9. Number of projects by homebuilders and remodelers

Note: vertical axis denotes the mean, the x-axis of each graph has been transformed to a log-scale

Years in Business

Survey respondents were also asked to report the number of years that they had been in business. Figure 10 shows the distribution of the data regarding the number of years that the homebuilders (left graph) have been in business as well as the remodelers (right graph). The distribution of responses for the two groups is quite similar. The mean number of years of business experience as reported by the homebuilders and remodelers was 24.0 and 22.4 years, respectively. There are some very old homebuilders: five homebuilders (1.6%) have been in business for 60 years or longer. The oldest homebuilder among the respondents reported that they had been in business for 92 years.

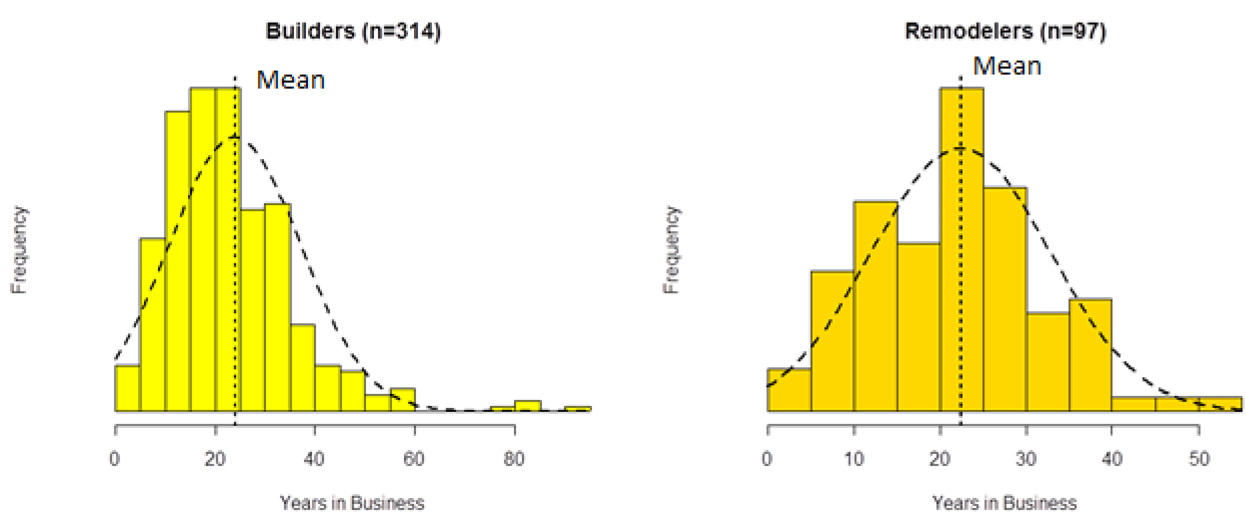


Figure 10. Years in business of homebuilders and remodelers

Awareness and use of Green Building Programs (GBPs)

Another objective of the study was to evaluate survey respondents' awareness and use of GBPs. Respondents were asked to indicate their level of awareness and use of the two major GBPs (LEED for Homes and NGBS) by selecting from four options:

1) not aware of the program,
2) aware of the program but have not used it,
3) aware of the program and am planning to use it, and
4) have already used the program.

In order to summarize the results, 1), 2) and 3) are combined and regarded as "**non-users**" of the program, and only 4) represents the "**users**". Table 7a shows the use of GBPs. Considering the use of GBPs by homebuilders in the Phase-1 survey, 4.6% reported that they have used both GBPs, 12.1% have used only NGBS, and 7.2% have used only LEED for Homes. Among the remodelers surveyed in Phase-1, 4.2% reported that they have used both GBPs, 6.3% have used only NGBS, and 3.2% have used only LEED for Homes. These results indicate that substantially fewer remodelers (13.7%) had used at least one of major GBPs compared to the homebuilders (23.9%), suggesting that the adoption rates of GBPs for homebuilders is almost double that of remodelers. The sample frame for the Phase-2 survey was homebuilders and remodelers who had built at least one certified green home in the past two years (referred to collectively as green builders sample). Among the respondents to the Phase-2 survey, only 3.2% of respondents do not use either the NGBS or the LEED for Homes programs (*although they had used a different GBP*), while 25.5% have used both programs, 52.1% used only the NGBS program and 19.1% have used only the LEED for Homes program.

Table 7a. Use of LEED for Homes and National Green Building Standard

	Random Homebuilders (n=306)	Random Remodelers (n=95)	Phase-2 Survey Green Builders (n=94)
Use Neither LEED nor NGBS	76.1%	86.3%	3.2% *
LEED only Users	7.2%	3.2%	19.1%
NGBS only Users	12.1%	6.3%	52.1%
Both LEED & NGBS Users	4.6%	4.2%	25.5%

*had used a GBP, but not LEED or NGBS

Table 7b shows the more detailed information, the full cross-tabulation between the awareness and use of NGBS and LEED. The survey results show 95.4% and 92.8% of the homebuilders in the Phase-1 survey were aware of LEED for Homes and NGBS, respectively, while 89.4% and 88.4% of the remodelers were aware of LEED for Homes and NGBS, respectively. Overall, the survey respondent's level of awareness of the two GBPs was similar with homebuilders being slightly more familiar with both GBPs, although this difference was neither substantial nor significant. It is interesting to note that approximately 90% of all of the Phase 1 respondents were aware of both of the major GBPs. This result is interesting because the Phase 1 group was a simple random sample of construction professionals and it was not expected that there would be a high level of awareness about the two major GBPs. Perhaps more importantly, **35.3%** of homebuilders and **28.4%** of remodelers reported that while they had not used a GBP, they were planning to use one in the future.

Table 7b. Awareness and use of LEED for Homes and National Green Building Standard

Random Builders from Phase-1		NGBS Not Aware	NGBS Aware Not Used	NGBS Planning to Use	NGBS Have Used	LEED Total
LEED	Not Aware	1.6%	2.6%	0.3%	0%	*4.6%*
LEED	Aware Not Used	4.9%	31.7%	13.7%	8.5%	*58.8%*
LEED	Planning to Use	0.7%	4.9%	15.7%	3.6%	*24.8%*
LEED	Have Used	0%	3.9%	3.3%	4.6%	*11.8%*
	NGBS Total	*7.2%*	*43.1%*	*33.0%*	*16.7%*	*n=306*

Random Remodelers from Phase-1		NGBS Not Aware	NGBS Aware Not Used	NGBS Planning to Use	NGBS Have Used	LEED Total
LEED	Not Aware	4.2%	4.2%	1.1%	1.1%	*10.5%*
LEED	Aware Not Used	5.3%	44.2%	6.3%	3.2%	*58.9%*
LEED	Planning to Use	2.1%	6.3%	12.6%	2.1%	*23.2%*
LEED	Have Used	0%	1.1%	2.1%	4.2%	*7.4%*
	NGBS Total	*11.6%*	*55.8%*	*22.1%*	*10.5%*	*n=95*

Green Builders from Phase-2 Survey		NGBS Not Aware	NGBS Aware Not Used	NGBS Planning to Use	NGBS Have Used	LEED Total
LEED	Not Aware	0%	0%	0%	0%	*0%*
LEED	Aware Not Used	2.1%	0%	1.1%	43.6%	*46.8%*
LEED	Planning to Use	0%	0%	0%	8.5%	*8.5%*
LEED	Have Used	1.1%	14.9%	3.2%	25.5%	*44.7%*
	NGBS Total	*3.2%*	*14.9%*	*4.3%*	*77.7%*	*n=94*

As discussed already, there are also a wide variety of GBPs that have been adopted at the local and regional levels. The Phase-1 survey results show that 95 respondents (23.9%) have used a local or regional GBP (Table 8). An analysis of the survey data shows that if a respondent had used both the LEED for Homes and the NGBS programs, more than half of them (51.6%) reported that that had also used another local or regional program as well. Also, for those respondents who had only used one of the major GBPs, 29.4% of the LEED for Homes and 38.5% of the NGBS users had also used another local or regional GBP. Finally, 15.3% of the respondents who had not used one of the two major GBPs reported that they had used regional GBPs. Built Green, EarthAdvantage, EarthCraft, Energy Star, and Green Built were the most frequently used GBPs.

Table 8. Use of regional Green Building Programs

	Other Regional GBPs			
	Yes		No	
	Counts	(%)	Counts	(%)
Total	95	(23.9%)	303	(76.1%)
Have used neither	39	(15.3%)	216	(84.7%)
Have used LEED for Homes	10	(29.4%)	24	(70.6%)
Have used NGBS	30	(38.5%)	48	(61.5%)
Have used both	16	(51.6%)	15	(48.4%)

The next several analyses focus on comparing eco-builders (who had used the LEED for Homes or/and NGBS) and traditional builders (builders who had not used the LEED for Homes or NGBS).[7] The survey requested that eco-builders indicate the number of certified projects they had completed as well as the level of certification that had been awarded for each project (Figure 11). The eco-builders reported that they had built 236 platinum, 30 gold, 270 silver, and 544 certified homes under the LEED for Homes program (a total of 1,080 homes). Eco-builders also reported that they had completed 162 emerald, 242 gold, 216 silver and 650 bronze homes under the NGBS program (a total of 1,270 homes). The data suggests that builders using the NGBS GBP are more likely to go for the 2 highest certification ratings than builders using the LEED program. For the remodelers within the eco-builder group, the use of GBPs was substantially lower. Remodelers reported that they completed 36 silver and 73 certified projects using the LEED for Homes program (a total of 109 projects) and one emerald, five gold, two silver and 108 bronze certified projects using the NGBS program (a total of 116 projects).

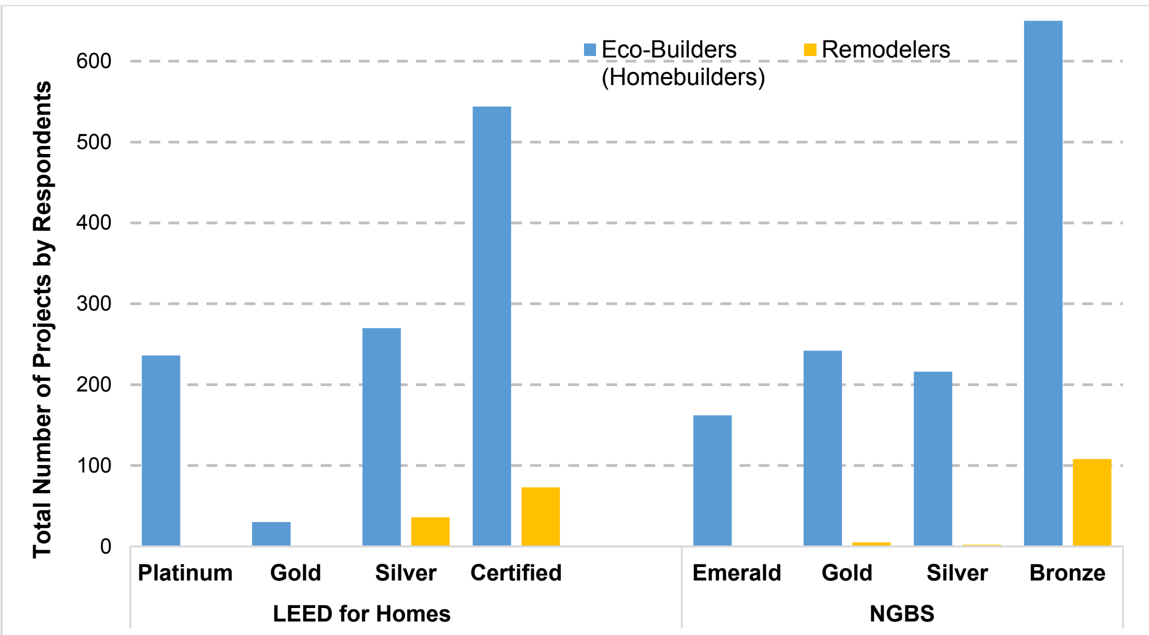


Figure 11. Number of different levels of certified projects by eco-builders

Homebuilders and remodelers who were aware of, but had not used LEED for Homes or NGBS, were asked to select the top three reasons why they had not used each program (Figure 12). The order of the categories in the figure is based on a composite score that was calculated by assigning 3 points to the top ranked reason, followed by 2 and 1 points to the second and third ranked reasons. The composite score was then calculated for all of the respondents across all of the reasons. The *lack of a price premium for certified homes* in the market was cited as the top reason why respondents had not participated in either program: **71.8%** cited this reason for *not using the LEED program*, while **79.8%** cited this as a reason for *not using the NGBS program*. The second most widely cited reason was the lack of demand by home buyers: **65.4%** cited this as a reason for not using the LEED program while **67.7%** cited this as a reason for not using the NGBS program. Interestingly, 64.6% and 47.5% of respondents cited that the LEED program is *too expensive and too complicated*, respectively, whereas a substantially lower percentage, 44.9% and 32.3%, respectively, cited these as reasons why they had not used the NGBS program.

[7] Figure 4 describes the definition of the eco-builders and the traditional builders.

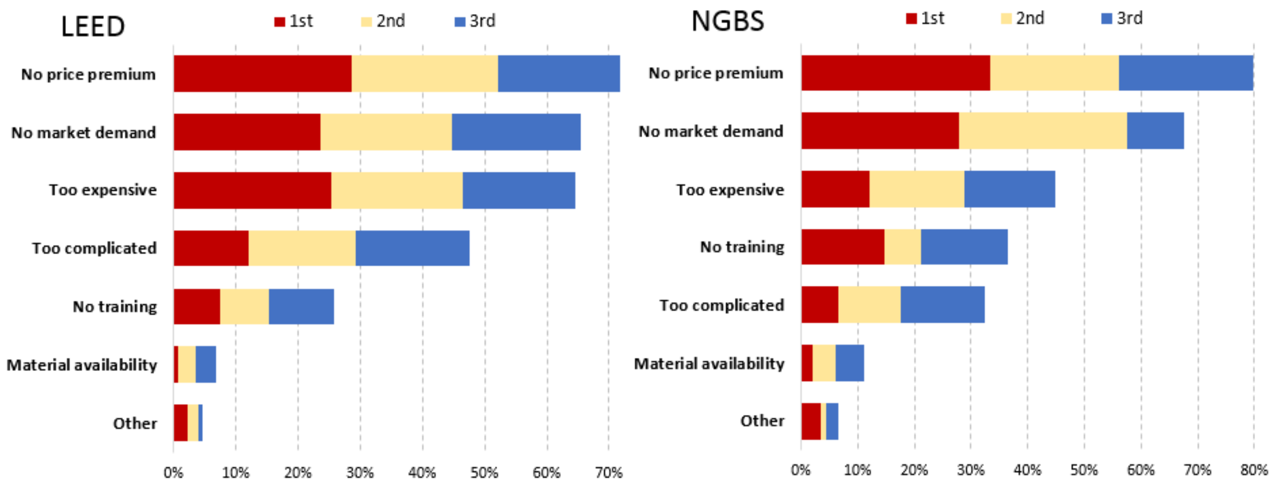


Figure 12. Reasons homebuilders have not used LEED for Homes & National Green Building Standard

The survey logic was designed so that it was possible to ask the eco-builders to identify the reasons why they had used a GBP. Those homebuilders who had used either the LEED for Homes or the NGBS program (or both) were asked to select the three top reasons for using a GBP (Figure 13). As described in the previous section, the order of the reasons was based on the composite scores. The top reason cited by the eco-builders for using a GBP was that the program helped to differentiate their homes in the marketplace: 71.1% of LEED users and 76.6% of NGBS users cited this reason as one of their top three reasons. Another important factor influencing the use of a GBP was that the home buyer had specified this: 51.5% of respondents cited this as a reason why they used the LEED program and 38.3% of respondents cited this as a reason for using the NGBS program. In contrast to the non-users, the users of a GBP reported that strong market demand for certified homes was an important consideration in using a GBP: 49.0% for LEED and 39.1% for NGBS. Architects seem to favor LEED over the NGBS program with 36.6% of respondents indicating that an architect specified the use of LEED whereas this number was much lower for the NGBS (18.8%). Interestingly, there was a strong divergence in terms of how straightforward each program is to use, with 56.7% of respondents reporting that the NGBS program is straightforward, whereas only 20.6% of respondents reported that the LEED for Homes program is straightforward. Only about a quarter of the respondents reported that they used either program because it was profitable (27.3% for LEED and 25.3% for NGBS).

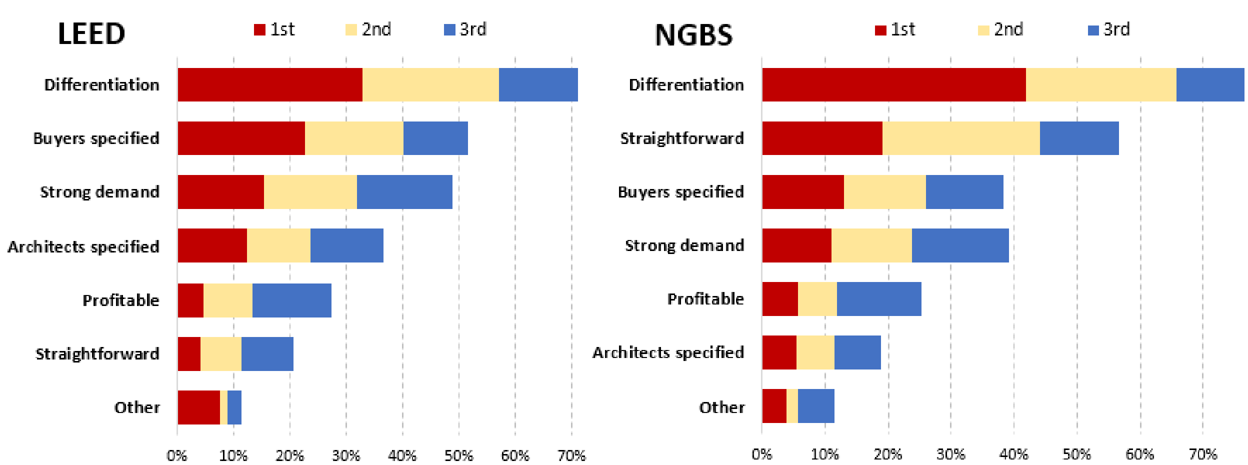


Figure 13. The reasons why eco-builders have used LEED for Homes and NGBS

This survey was also designed to gain insights into respondent's perceptions of how the LEED for Homes program compared to the NGBS program along seven attributes (Figure 14). Respondents were asked to compare the two programs on each attribute using the following choices: LEED for Homes is much better, LEED for Homes is better, neutral, NGBS is better, and NGBS is much better. They were also given the option to choose "I don't know". The results are displayed in Figure 14 using a diverging stacked bar chart. The diverging stacked bar charts are useful in helping to visualize the differences in the ratings reported by the respondents along each of the attributes. In order to better emphasize the differences between two programs, the "neutral" and "I don't know" categories have been omitted from the bar charts although their values are reported along the side of the figure. It is important to note that approximately a quarter of the respondents answered "I don't know" whereas the number of neutral responses ranged from 26% to 51%. The following observations are based on the proportion of respondents who expressed an opinion on the relative merits of the two programs, which ranged from 22.3% to 51.1% of the total respondents, depending on the question. Of those who did express an opinion, significantly more respondents perceived that the LEED for Homes program has better brand recognition than the NGBS program. In addition, substantially more respondents felt that LEED for Homes was more effective in promoting home sales. On the other hand, significantly more respondents perceived that the NGBS program costs less to use, has easier rules to understand and requires less documentation than the LEED program. Respondents also felt that customers would be more willing to pay a premium for a home built under the NBGS program than the LEED program.

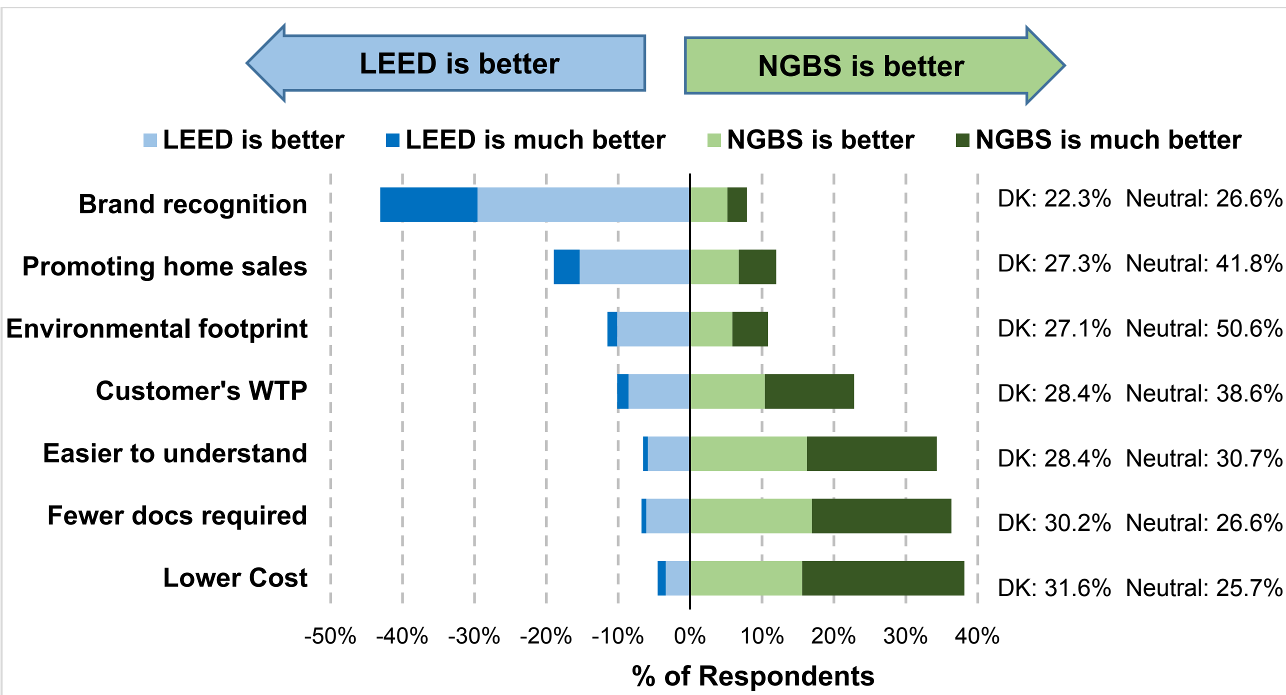


Figure 14. Perceptual comparisons between LEED for Homes and NGBS

Finally, the survey asked the eco-builders who had used any type of GBP to indicate their top three reasons for using a GBP. As before, a composite score was calculated for all of the factors included in the survey. An analysis of the results suggests that the reasons can be collected into groups. For example, a couple of factors are directly related to homeowners; 58.2% of eco-builders felt that a GBP can lower energy use for homeowners and 21.2% used a GBP because of customer demand (Figure 15). Another group of factors was related to business strategies: 54.4% of eco-builders felt using a GBP could differentiate their homes in the market, 25.9% considered using a GBP to be a viable marketing strategy and 25.3% felt that a GBP can improve the image of their company. Thirty-eight percent of eco-builders felt that using a GBP was good for the environment. In contrast, only 7.3% of eco-builders felt that using a GBP was profitable. Finally, less than 10% of eco-builders were motivated to use a GBP because of local tax incentives (9.5%) or subsidies on materials (7.9%).

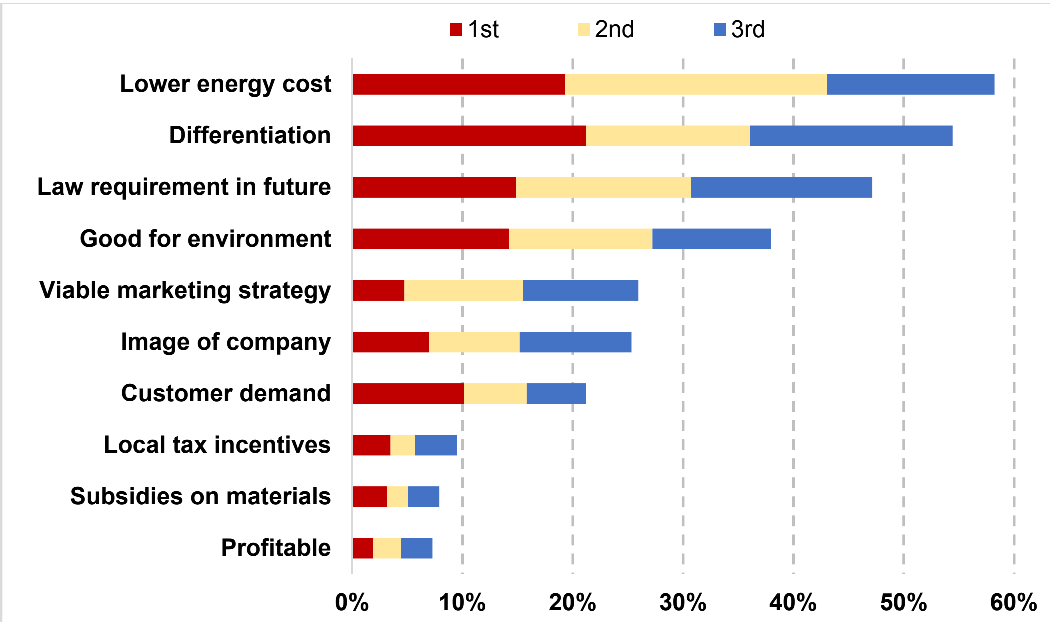


Figure 15. Reasons why eco-builders had used Green Building Programs

Environmental Wood Certification Programs

A large portion of the questionnaire was dedicated to trying to get a better understanding of respondents' awareness, perceptions and use of environmentally certified wood products (ECWPs) and, in particular, the two major certification programs in North America: FSC (Forest Stewardship Council) and SFI (Sustainable Forestry Initiative). The respondents were asked to indicate their level of familiarity with certified wood products labeled under the two certification programs using a scale that ranged from:

1) I haven't heard about it ("not aware"),
2) I am aware of it, but have never used it ("aware non-user"),
3) I have occasionally used it ("occasional user"), and
4) I frequently use it ("frequent user")

Table 9a shows the summarized distribution of the respondents' use of FSC or/and SFI, where 1) and 2) of above categories are combined and regarded as "non-users" and 3) and 4) are combined and regarded as "users". From the Phase-1 survey, 65.1% of homebuilders and 63.9% of remodelers do not use certified wood products. On the other hand, 34.9% of homebuilders have used ECWPs: 21.5% have used both FSC and SFI, 6.2% have used only SFI, and 7.2% have used only FSC. Remodelers show a similar distribution: 32.0% of remodelers were not aware of ECWPs and 63.9% have never used ECWPs. For remodelers, 36.1% have used ECWPs, with 24.7% having used both FSC and SFI, 6.2% have used only SFI, and 5.2% have used only FSC.   With regard to eco-builders, 28.7% don't use EWCPs and 71.3% of eco-builders have used ECWPs. A great majority of eco-builders (51.8%) have used both FSC and SFI wood products, 14.0% have used only FSC, and only 5.5% have used only SFI.

Table 9a. Respondents' use of FSC and SFI

	Random Builders (n=307)	Random Remodelers (n=97)	Eco-Builders (n=164)
Don't Use Certified Wood	65.1%	63.9%	28.7%
SFI only Users	7.2%	5.2%	14.0%
FSC only Users	6.2%	6.2%	5.5%
Both SFI & FSC Users	21.5%	24.7%	51.8%

Table 9b shows the more detailed information: cross-tabulation of the full break-down between the respondents' level of familiarity with FSC and SFI products. From the Phase-1 survey, 30.6% of homebuilders and 32.0% of remodelers reported that they were not aware of either FSC or SFI. Furthermore, 21.2% of homebuilders and 26.8% of remodelers use SFI occasionally, 21.5% of homebuilders and 22.7% of remodelers use FSC occasionally, 6.5% of homebuilders and 4.1% of remodelers use SFI frequently, and 7.2% of homebuilders and remodelers use FSC frequently. On the other hand, 90.9% of eco-builders were aware of ECWPs[8]. 40.2% of eco-builders use SFI occasionally, 40.2% use FSC occasionally, 17.1% use SFI frequently, and 25.6% use FSC frequently. The LEED rating system recognizes FSC as an environmentally responsible forest product but does not accept SFI. This issue might influence the adoption of SFI and FSC by eco-builders. Later, we will investigate this point further and in more depth.

Table 9b. Respondents' level of familiarity with FSC and SFI

Random Builders from Phase-1		**SFI**				*FSC Total*
		Not Aware	Aware Non-User	Occasional User	Frequent User	
FSC	Not Aware	**30.6%**	**5.5%**	**2.0%**	**0.7%**	*38.8%*
	Aware Non-User	**3.6%**	**25.4%**	**3.3%**	**0.3%**	*32.6%*
	Occasional User	**1.6%**	**4.9%**	**13.7%**	**1.3%**	*21.5%*
	Frequent User	**0%**	**0.7%**	**2.3%**	**4.2%**	*7.2%*
SFI Total		*35.8%*	*36.5%*	*21.2%*	*6.5%*	*n=307*

Random Remodelers from Phase-1		**SFI**				*FSC Total*
		Not Aware	Aware Non-User	Occasional User	Frequent User	
FSC	Not Aware	**32.0%**	**4.1%**	**3.1%**	**0%**	*39.2%*
	Aware Non-User	**2.1%**	**25.8%**	**3.1%**	**0%**	*30.9%*
	Occasional User	**1.0%**	**3.1%**	**17.5%**	**1.0%**	*22.7%*
	Frequent User	**0%**	**1.0%**	**3.1%**	**3.1%**	*7.2%*
SFI Total		*35.1%*	*34.0%*	*26.8%*	*4.1%*	*n=97*

Eco-Builders		**SFI**				*FSC Total*
		Not Aware	Aware Non-User	Occasional User	Frequent User	
FSC	Not Aware	**9.1%**	**2.4%**	**0%**	**0%**	*11.6%*
	Aware Non-User	**3.0%**	**14.0%**	**5.5%**	**0%**	*22.6%*
	Occasional User	**1.8%**	**7.3%**	**28.7%**	**2.4%**	*40.2%*
	Frequent User	**0.6%**	**4.3%**	**6.1%**	**14.6%**	*25.6%*
SFI Total		*14.6%*	*28.0%*	*40.2%*	*17.1%*	*n=164*

[8] This result verified the assumption used for calculating the minimum required sample size of eco-builders. P=0.9 was assumed, and the observed P was 0.909.

FSC and SFI certified wood are generally sold for a premium in the market. The survey respondents who have used certified wood were asked to estimate the price premium for a certified wood product relative to a similar non-certified wood product, based on their experience. The largest group of eco-builders reported that, in their experience, both FSC (37.4%) and SFI (36.6%) certified wood was sold at a 6-10% price premium over uncertified wood. Approximately 15% of the respondents reported that they did not pay a price premium for wood products certified under either program. Interestingly, the distribution of estimated price premiums was found to be quite similar for both certification programs.

This observation is further supported by the cross tabulation table of price premiums for FSC and SFI lumber (Table 10). A great majority (79.4%) of certified wood users perceived that the price premium for SFI and FSC lumber were about the same (the numbers located inside the highlighted rectangles in Table 10). This result implies that a great majority of residential construction professionals don't differentiate between SFI and FSC products based on prices. A small proportion do perceive that there is a price difference between SFI and FSC lumber: 14.6% of the respondents felt that the price premium for FSC lumber is higher than that of SFI whereas 6.0% of them perceived that price premium for SFI lumber is higher than that of FSC.

Figure 16. Price premiums of FSC and SFI

Table 10. Price premium between FSC and SFI

All Users		SFI Price Premium				FSC Total
		0%	1%-5%	6%-10%	10% +	
FSC Price Premium	0%	**10.1%**	**1.0%**	**0%**	**0.5%**	*11.6%*
	1%-5%	**3.0%**	**21.6%**	**2.0%**	**1.0%**	*27.6%*
	6%-10%	**0.5%**	**4.5%**	**30.7%**	**1.5%**	*37.2%*
	10% +	**1.0%**	**2.0%**	**3.5%**	**17.1%**	*23.6%*
SFI Total		*14.6%*	*29.1%*	*36.2%*	*20.1%*	*n=199*

In the next question, only the FSC and SFI users were asked to indicate if their use of FSC or SFI lumber had decreased, stayed the same or increased over the past two years. As shown in Figure 17, FSC and SFI show a very similar distribution. A great majority of FSC users (70.1%) and SFI users (72.6%) reported that they had not changed their use of certified wood. On a more positive note, 27.6% and 25.0% of FSC and SFI users, respectively, reported that they had increased their use of certified wood. Finally, very few respondents reported that they had decreased their use of certified wood over the past two years despite the collapse of the housing market. Respondents were also asked how they thought their use of certified wood would change over the next two years (Table 10). The results for this question suggest that many certified wood users are planning to increase the use of certified wood, with slightly more planning on using FSC certified wood (40.2%) than SFI certified wood (34.5%). These results suggest that the demand for certified wood is robust and that will continue to expand into the near future.

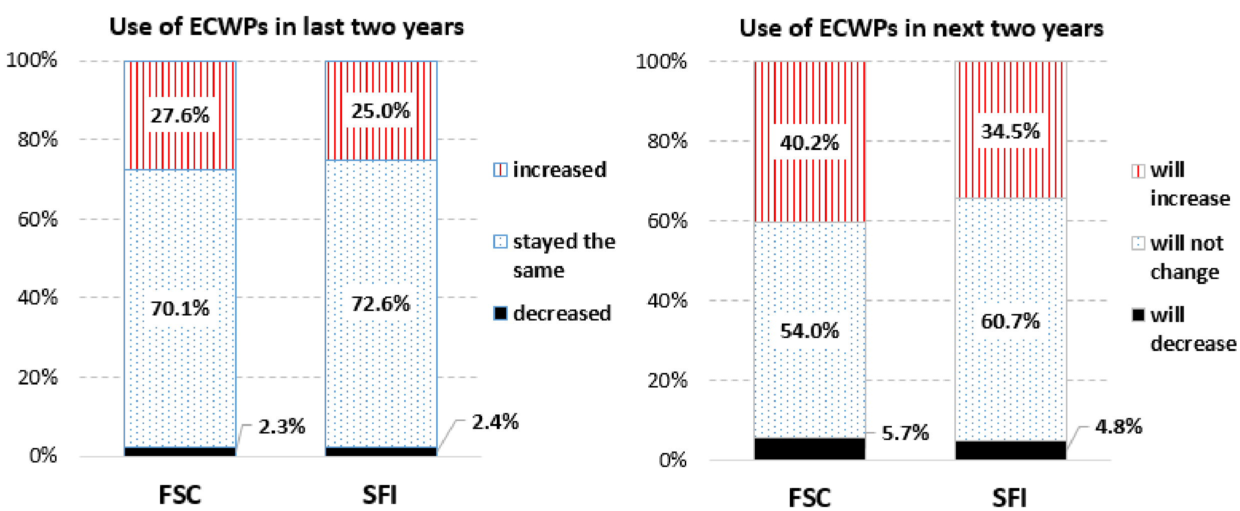


Figure 17. Changes of ECWP usage in last two years and in next two years

In addition, the same questions were asked of respondents who had not used ECWPs but who were aware of them. Although the following results are based on respondents' intentions, 18.0% (FSC) and 24.1% (SFI) of non-users of certified wood indicated that they were planning to start using certified wood in the next two years.

This survey was also designed to gain insights into respondent's perceptions of how the FSC and SFI certified wood compared along four factors, including:

1) readily available,
2) better for the environment,
3) sustainable forest management, and
4) consumer awareness.

Respondents were asked to rate both SFI and FSC certified wood using the following choices: FSC is much better, FSC is better, neutral, SFI is better or SFI is much better. Respondents could also answer that they had no opinion. Before considering the results, it is important to note that the survey respondents don't appear to consider one program as being better than the other. Approximately 70 to 80% of the respondents had no opinion or were neutral when comparing the two programs across all four attributes. For those respondents who did have an opinion, FSC was rated slightly better in terms of consumer awareness whereas SFI was rated as being slightly better in terms of availability and being better for the environment. Finally, both programs were perceived as being the same in terms of promoting sustainable forest management.

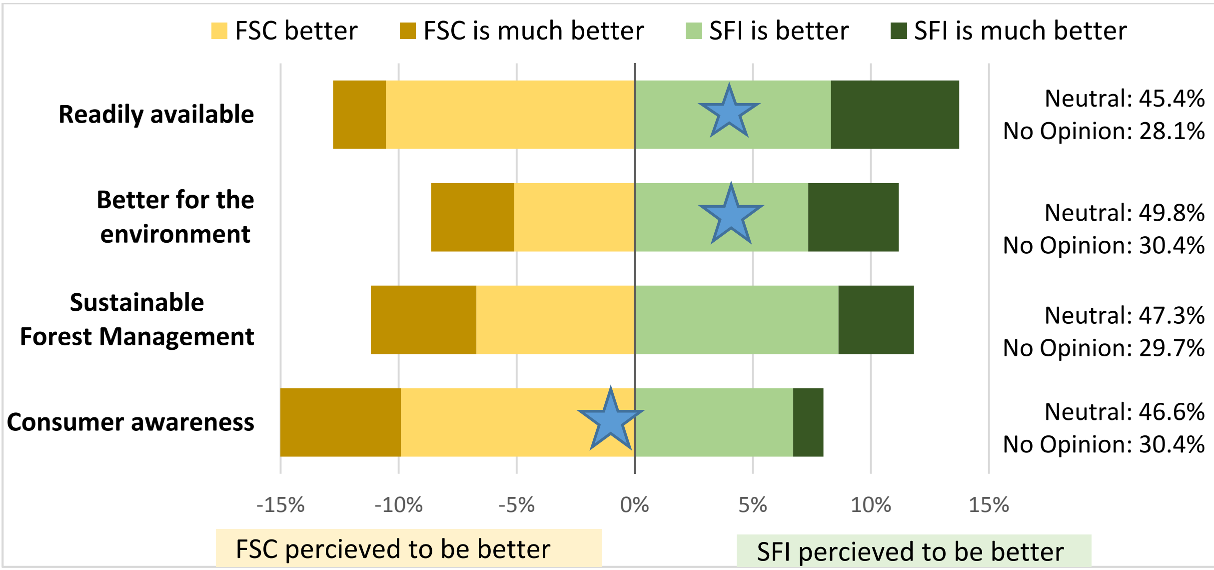


Figure 18. Perceptual comparisons between FSC and SFI

Respondents who were aware of, but had not used, certified wood were also asked to specify the top three reasons for not using certified wood. The survey responses were analyzed for each of the brands of certified wood, Figure 19. The main reason for not using certified wood was that the vast majority of respondents felt there was no customer demand for either FSC wood (84.9%) or SFI wood (82.1%). The second most cited reason was the perceived high cost of both FSC (61.6%) and SFI (58.7%) certified wood. Finally, almost half of the respondents reported that they had never felt the need to use certified wood or that certified wood was not readily available for them. Interestingly, 21.4% of the respondents noted that the lack of recognition of certified wood within green building programs (in terms of generating relatively few points towards certification) restricted their use of certified wood. The results show that the reasons for not using certified wood are similar for both programs which further supports the observation that residential construction professionals do not differentiate between FSC and SFI certified wood.

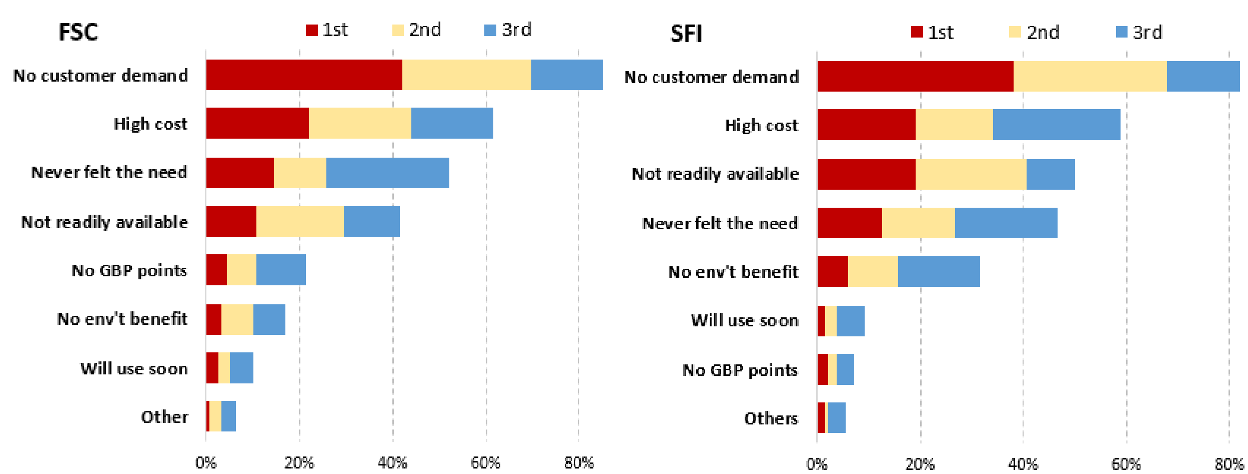
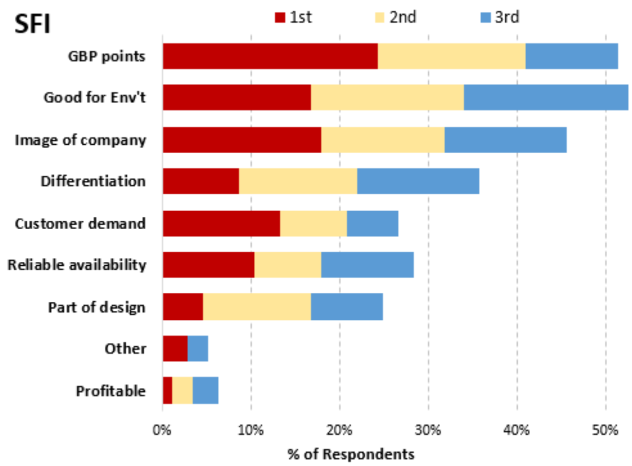


Figure 19. Reasons why residential professionals had not used FSC and SFI

We then asked those respondents who had used certified wood to identify the three main reasons for using certified wood. Again, the order of the factors was based on a composite score which was calculated for each of the reasons by assigning 3 points to the top ranked reason, followed by 2 and 1 points to the second and third ranked reasons. As shown in Figure 20, the top three reasons why building professional have used FSC and SFI were: *1) using certified wood can earn GBP points, 2) using certified wood is good for the environment, and 3) using certified wood can improve the image of the company*. All three of these reasons received a similar composite score and these three reasons were rated substantially higher than the remainder of the reasons listed in the survey. Interestingly, using certified wood as a strategy for differentiating their company in the market was rated as being of moderate importance while its impact on profitability was rated lowest.



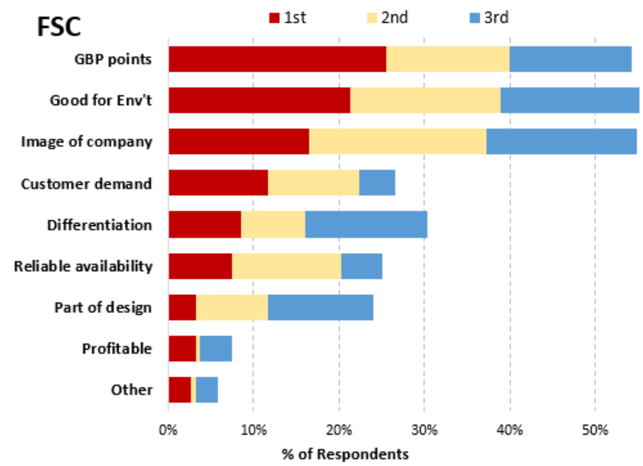


Figure 20. Reasons why residential professionals had used FSC and SFI

Wood, Steel and Concrete

This survey was also designed to gain insights into respondent's perceptions of the relative environmental performance of the three major structural building materials used (wood, steel and concrete) along a number of performance measures. Six environmental attributes, including recyclability, long life, renewability, low CO_2 emission during the manufacturing process, high energy efficiency of the completed house, and low energy use during the material manufacturing process were assessed. Respondents used a five-point Likert-like scale to compare the materials along each attribute, with the scale being comprised of the following statements: "Strongly Disagree, "Disagree", "Neutral", "Agree", and "Strongly Agree". The composite score for each material along each of the environmental attributes was calculated using a scoring scheme where "Strongly Agree" was scored as a +2, "Agree" was +1, "Neutral" was 0, "Disagree" was -1 and "Strongly Disagree" was -2. Figure 21 illustrates the results from the collected data, with the bars on the left side of the figure indicating negative responses and the bars to the right indicating positive responses. Building professionals perceived that wood rated highly on all six of the attributes and received the highest scores for four of the six attributes, including high renewability, requires less energy to manufacture, generates less CO_2 during the manufacturing process, and provides higher energy efficiency than either steel or concrete. Both steel and concrete received negative ratings along each of these four material attributes. For the two remaining environmental attributes, recyclability and long life, wood was rated second and third, respectively although all three materials were rated highly with almost no negative ratings being recorded. Based on these results, it is clear that building professionals overwhelmingly perceive that wood has much better environmental performance relative to both steel and concrete.

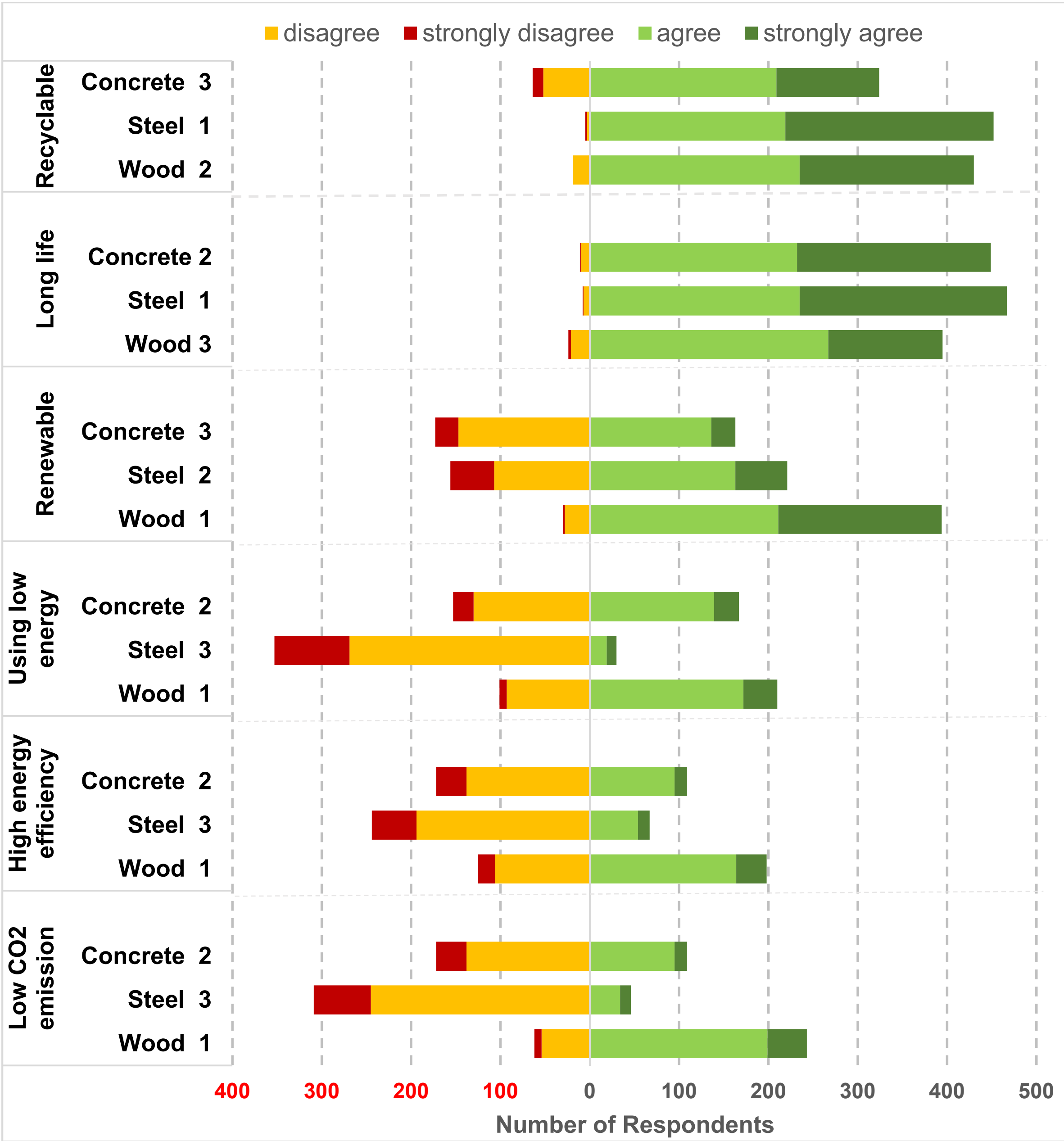


Figure 21. Perceptual comparisons between concrete, steel and wood

Adoption of Innovative Green Building Technology and Products

The final set of questions considered the use of 12 different innovative green products and technologies, other than ECWP,[9] by U.S. homebuilders and remodelers. These include heat/recovery ventilators, concrete with reduced cement, solar water heaters, structural insulated panels, radiant barriers, solar power generation, water conserving fixtures, tank-less water heaters, energy efficient windows, energy

[9] ECWP is one of the green building products, but was looked at in detail earlier. Other green building products and technology are focused on in this section.

efficient appliances, low volatile organic compound (VOC) paints, and engineered wood. Respondents were asked to indicate their level of use of each product using the following four-point scale:

0 - I have not heard of the product ("Don't know"),

1 - I am aware of the product but have never used it ("Aware never use"),

2 - I occasionally use the product ("Occasionally use"), and

3 - I frequently use the product ("Frequently use").

Figure 22 indicates the usage status corresponding to each of the green technologies, where the horizontal axis shows the number of responses. As indicated in the figure, the area to the left of the 0 point indicates negative responses (i.e., "Have not heard of the product" and "Have heard but never used the product"), while the area to the right of the 0 point indicates positive responses (i.e., "Occasionally use the product" and "Frequently use the product"). Based on the length of the dark green portion of the bars, it is quite clear that energy efficient windows, engineered wood and energy efficient appliances were the three most highly used green technologies among homebuilders and remodelers. Based on the small number of responses in the "Don't know" category, it is clear that a vast majority of respondents were at least aware of all of the green technologies. In addition, a majority of the respondents reported that they frequently use energy efficient windows, engineered wood, energy efficient appliances, water conserving fixtures and low VOC paints. Similarly, a majority of respondents had heard of the following green products/technologies, but had never used them: structural insulated panels, solar power panels and solar water heating.

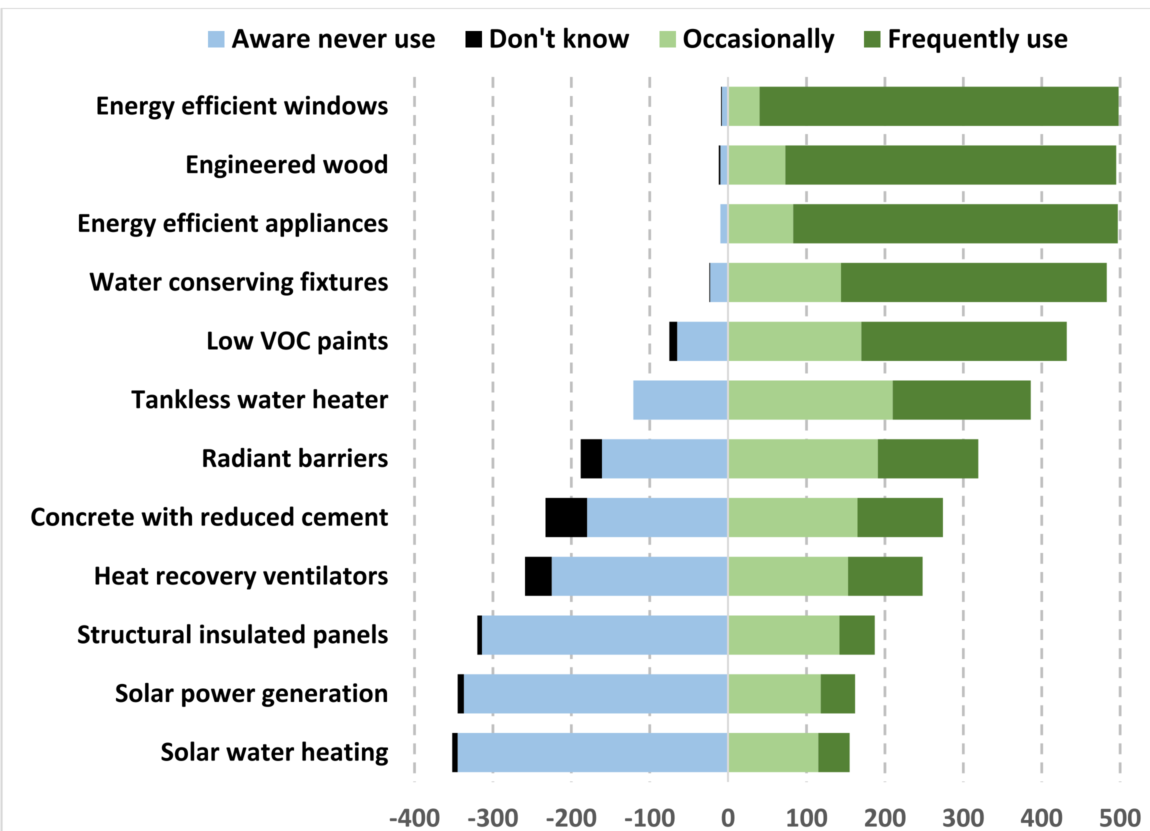


Figure 22. Usage of innovative green building technology and products

The next step was to investigate homebuilders/remodelers' perspectives regarding the importance of each of the innovative green technologies in reducing the environmental footprint of their houses. The main purpose of this question was to understand the perspective of homebuilders/remodelers with respect to their selection of green technologies. Respondents were asked to rate the importance of each green technology in reducing the environmental footprint of their houses using a five-point scale where "**1=Not at all important**", "**2= Not important**", "**3= Neutral**", "**4= Important**", and "**5= Extremely important**". Figure 23 presents the results of the data analysis where the area to the left of the point 0 indicates negative responses, including "Not at all important" and "Not important"; and the area to the right indicates positive responses, including "Important" and "Extremely important". "Neutral" responses were not included in the figure since we were interested in better understanding the positive and negative perceptions of each green technology. Energy efficient windows and energy efficient appliances were ranked 1st and 2nd as having the most important impact on the environmental footprint of a house followed by water conserving fixtures, engineered wood, and low VOC paints and finishes. Engineered wood, which was ranked 2nd in the previous usage question, was ranked fourth in this question. One possible reason for this may be that it is easier to ascertain the efficacy of energy and water saving technologies simply by looking at the monthly utility bills. On the contrary, it is much more difficult to quantify the importance of intangible aspects of environmental attributes of engineered wood, such as biodiversity conservation and reducing the carbon footprint. For example, manufacturing engineered wood requires less energy (APA 2015) than either steel or concrete.

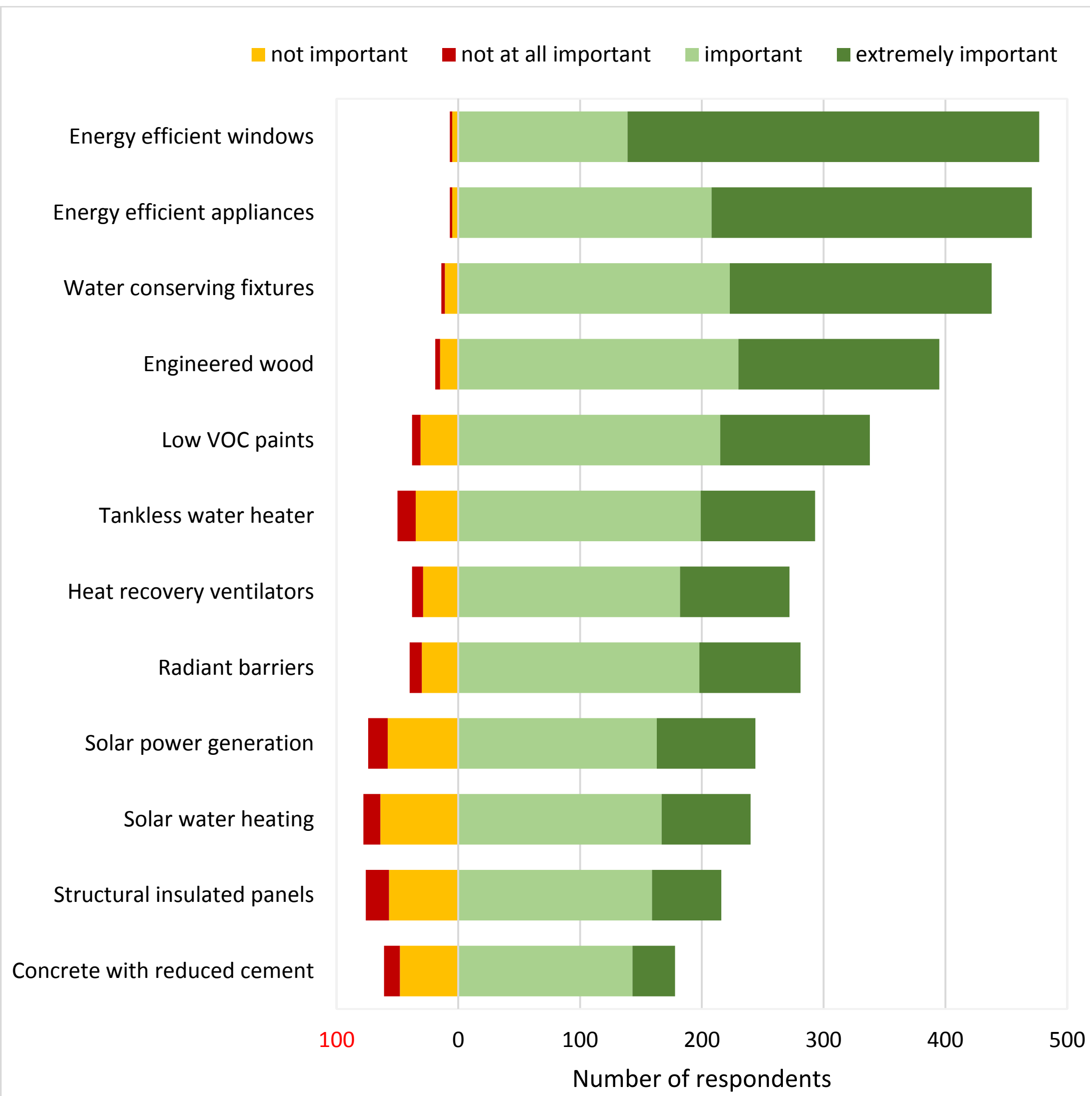


Figure 23. Perceived importance of green technology

Reason to Adopt Green Building Materials

To better understand what aspects of green building materials are important to homebuilders and remodelers, respondents' were asked to rate the importance that a variety of factors had on influencing their selection of building materials. Importance was rated using a five-point Likert-scale that ranged from 1=not at all important, 2=not important, 3=neutral, 4=important and 5=extremely important. Diverging stacked bar charts were developed to help visualize the survey data (Figure 24). In order to only focus on the clear opinions, "neutral" responses were omitted from the figure. The right area on each side of the figure (green) is the cumulative percentage of respondents who perceive that the attribute is important while the left area (red/orange) shows the cumulative percentage of respondents who perceive that the attribute is not important. The results of this question clearly show that availability, price, long life, low maintenance, energy efficiency, consumer demand and ease of installation are universally considered to be important with very few responses showing up in the negative side of the figures. These attributes are all economic or technical performance in nature and are of primary concern to homebuilders, remodelers and homeowners. On the other hand, those factors which were rated as being less important or unimportant tend to be related to intangible environmental attributes including locally produced, uses renewable material, recyclability, uses recycled materials, low embodied energy, and low CO_2 emissions.

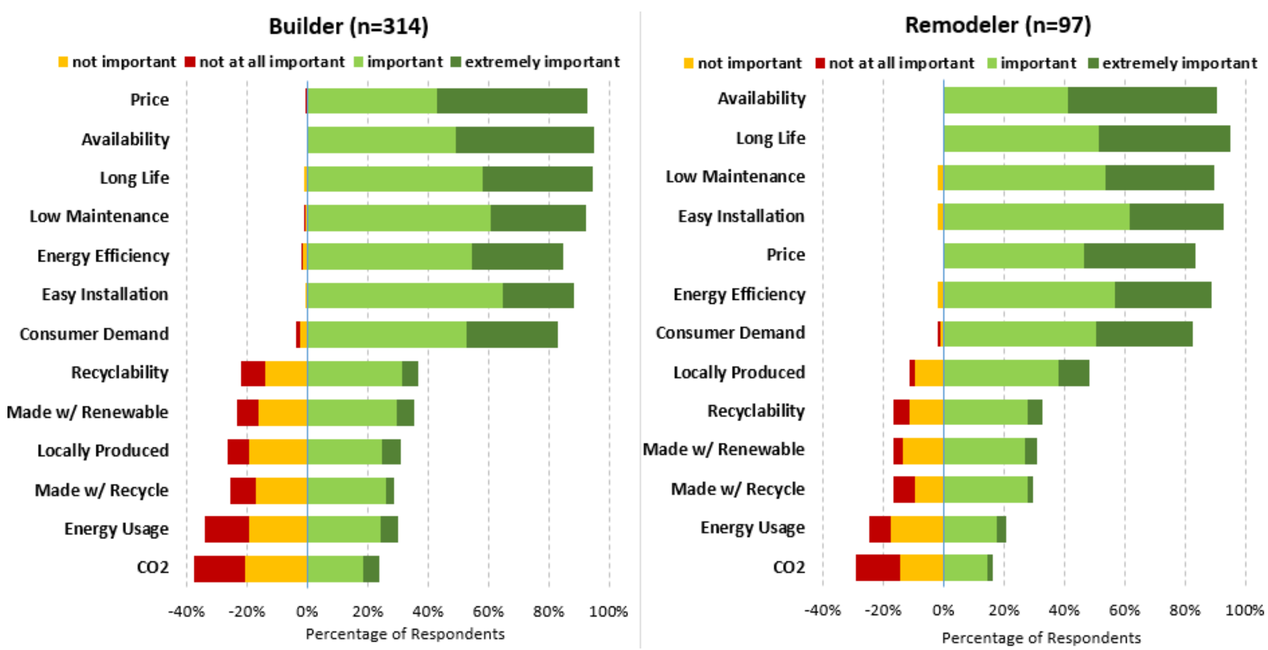


Figure 24. Perceived importance by residential construction professionals when choosing building materials

The data from this same question was analyzed differently in order to allow us to compare the importance ratings for the attributes from traditional homebuilders and the eco-builders. The results from this analysis are in many ways very similar to those obtained from the previous analysis (Figure 25). Based on the importance ratings obtained from the traditional builders and the eco-builders (see Figure 4), we can segment the attributes into the same two groups as identified in the previous analysis. While the importance ratings between the traditional builders and the eco-builders appear to be very similar, the results of a statistical comparison using the Mann-Whitney U-test, two independent sample non-parametric comparison found that eco-builders rate energy efficiency, long life, low maintenance, made with renewable materials, made with recycled materials, locally produced, recyclability, embodied energy and CO_2 emissions during manufacturing as being significantly more important than traditional builders (at the 1% level of significance). These results show two trends. First, similar to standard builders and remodelers, eco builders rate the economic and technical performance attributes as being much more important than the environmental performance attributes. Second, eco-builders do rate the environmental performance attributes as being significantly more important than do their more traditional counterparts.

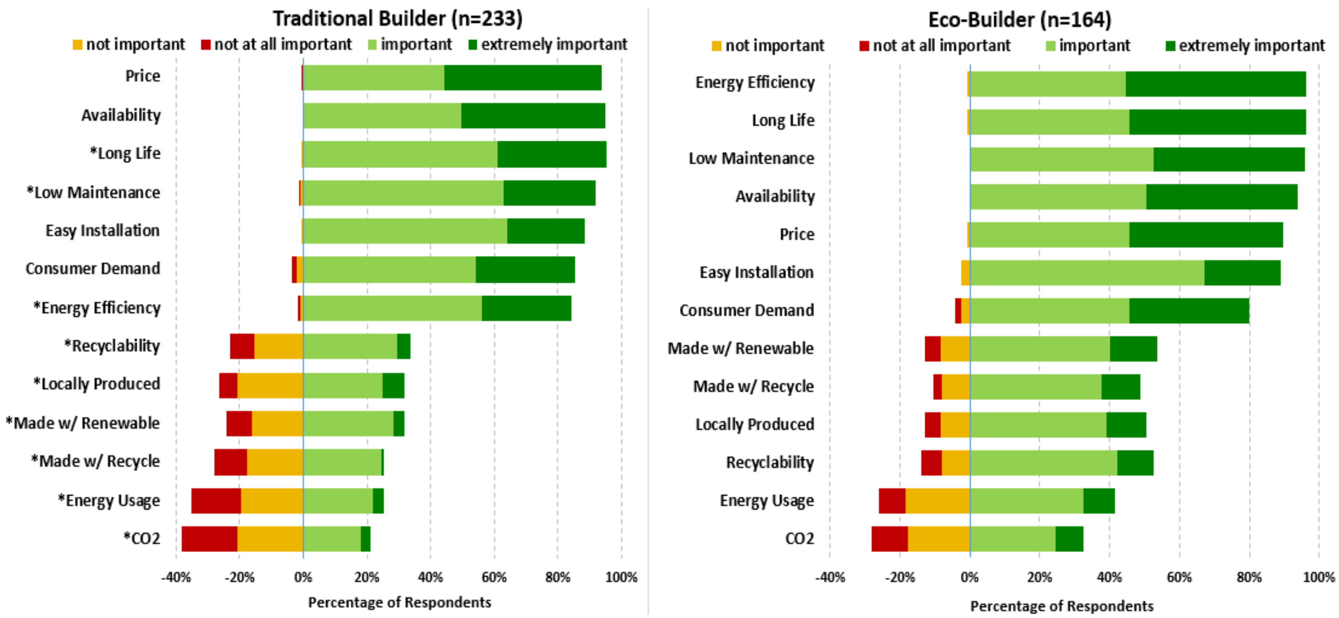


Figure 25. Perceived importance by traditional and eco-builders when choosing building materials

Conclusions

This study was conducted to gain a better understanding of US residential builders' and remodelers' awareness and use of green building programs (GBPs), environmentally certified wood products (ECWPs), other innovative green building products, and the environmental performance of wood as a building material relative to steel and concrete. The results of this study are based on a survey of US construction professionals including responses from 528 construction professionals, including 103 remodelers, 261 traditional homebuilders (Phase 1 survey) and 164 eco-builders (Phase 2 survey). Traditional homebuilders are those respondents who had not used a GBP, while eco-builders are those respondents who had used GBPs. The most important and interesting results of this survey are discussed in the following paragraphs.

Awareness and Use of Green Building Programs (GBPs): The results of the survey suggest that while approximately 95-98% of the randomly selected residential construction professionals surveyed in the Phase-1 of the survey were aware of one of the two major GBPs in the US (i.e., LEED for Homes and NGBS), only 23.9% of homebuilders and 13.7% of remodelers had actually used either LEED for Homes or/and NGBS and the vast majority of the homes they built only achieved the most basic level of certification. However, 35.3% of homebuilders and 28.4% of remodelers indicated that they were planning to use one of the GBPs in the future. In the second phase of the survey, self-identified green builders were surveyed. The results of the Phase-2 survey show that 25.5% of green builders have used both programs, 52.1% used only the NGBS program and 19.1% have used only the LEED for Homes program. Non-users of GBPs identified three main reasons for not using them, including (in order or most frequently cited):

1) there was no price premium associated with selling a green house,
2) there was no market demand for a green house and
3) building a green house was too expensive.

In contrast, GBP users cited the following as reasons why they had used a GBP:

1) it was an effective way to differentiate their homes in the market,
2) the home buyer specified that they wanted a green house and
3) there was strong demand for homes built using a GBP.

In general, the respondents rated the NGBS program higher than LEED for Homes on almost every attribute including the cost of using the program, the amount of documentation required, ease of complying with the program rules, and customer willingness to pay for a certified home. LEED for Homes was rated as being superior in terms of brand recognition and effectiveness in helping to sell homes. These results suggest that while a small proportion of all home builders had used a GBP, there is an expectation among homebuilders that their use of GBPs will increase in the future. However, this research clearly shows that non-users have many misperceptions about GBP and much work needs to be done to educate non-users, as well as potential homebuyers, about the different GBPs, their benefits and their limitations.

Awareness and Use of Environmentally Certified Wood Products (ECWPs): The Phase-1 survey results suggest that a large proportion (about 30%) of homebuilders were still unaware of either of the two major wood certification programs in the US (i.e., FSC and SFI). Only about 10% of homebuilders used ECWPs on a regular basis and about a quarter of homebuilders used ECWPs occasionally. Among homebuilders, 34.9% have used ECWPs: 21.5% have used both FSC and SFI, 6.2% have used only SFI, and 7.2% have used only FSC. The results show that 91.9% of eco-builders were aware of certified wood and 28.1% use it regularly while 43.3% use it occasionally. Non-users of certified wood identified three main reasons for not using it, including: 1) there was no customer demand for it, 2) certified wood costs too much (the majority of respondents estimated that it was at least 5% more expensive than non-certified wood while 20% thought it was over 10% more expensive), and 3) certified wood was not readily available. In contrast, homebuilders who have used certified wood reported that they used it because: 1) it provided them with additional points when using a GBP, 2) using certified wood was good for the environment and 3) using certified wood helped to improve the image of the company while providing a way to differentiate their homes in the marketplace. When asked to compare the two wood certification programs (FSC and SFI), a great majority of respondents cannot differentiate two. Respondents felt that the SFI certification program was better than the FSC program in terms of availability, being better for the environment and promoting sustainable forest management whereas the FSC certified wood program scored higher in consumer awareness. Over a quarter of homebuilders expect that their use of ECWPs will increase in the future.

Comparison of the Environmental Performance of Wood versus Steel and Concrete as a Building Material: Homebuilders were asked to compare the environmental performance of wood relative to steel and concrete in building applications along six environmental attributes, including: recyclable, durability, renewability of the resource, low energy use during the material production process, low CO_2 emissions during the material production process and high energy efficiency when used to build a house. The results are similar to previous studies in different countries (Eastin et al. 2011, Sasatani and Eastin 2012). Wood received a strongly positive rating on all of the attributes whereas steel and concrete received a strongly negative rating on the following attributes: renewability of the resource, low energy use during the material production process, low CO_2 emissions during the material production process and high energy efficiency when used to build a house. Steel and concrete did receive positive ratings for recyclability and durability. This information shows that wood is clearly viewed by residential construction professionals as being the most environmentally friendly building material when compared to either steel or concrete across a range of environmental performance attributes. In fact, these same professionals have negative perceptions of steel and concrete on a majority of the environmental performance measures.

Importance of Material Attributes in Influencing the Specification of Innovative Green Building Products and Technology: A variety of attributes can influence a builder's specification of green building products and technology. For example, high cost or low availability could influence a builder to go with a less preferred building product. Survey respondents were given a list of 13 attributes and were asked to rate how important each attribute was in terms of influencing their choice of building products and technology. The results clearly show that the attributes can be broken into two groups; those that are quite important and those that are relatively unimportant. There was no significant difference between the perceived importance of the attributes included in each group although there was a significant difference between the groups. The attributes in the first group that were perceived to have an important influence on material specification were all related to the economic or technical performance of the products and included, price, availability, durability, low maintenance, ease of installation, energy efficiency and consumer demand. The attributes in the second group that were perceived to have less influence on material specification were related to the environmental performance of the products and included, recyclable, made with renewable resources, produced locally, made from a renewable resource, reduced energy usage during production and low CO_2 emissions during production. These results suggest that the economic and technical attributes of building products have a bigger impact on the products and the product specification process than do the environmental attributes.

This study offers the first detailed look at residential construction professionals' perceptions and use of a variety of environmentally oriented programs and products in the US. It establishes a baseline for the use of green building programs and environmentally certified wood products. While the current awareness and use of these programs and products is often low, the results suggest that their use will increase in the future as the awareness of both construction professionals and consumers increases.

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