Comparisons Between Green Homebuilders and Traditional Homebuilders

Randall A. Cantrell

Abstract

This paper examines views and approaches of homebuilders across the U.S. to determine whether there are differences in their use and perception of materials, technologies, certified wood, and green-building programs. Green-building certification programs assign points to projects according to various categories associated with building a home. This study divides these categories into six sections, which serve as the basis for 1) the layout of this paper and 2) the items used to compare homebuilders. A web-based survey instrument was used to collect data for developing profiles for two categories of homebuilder — Green and Traditional — according to the six green-building categories. Regarding general material selection, Green builders emphasize 1) choosing building materials made from recycled materials and derived from renewable raw material, 2) energy efficiency, and 3) whether materials are produced locally, as well as their recyclability and service life. Regarding specific material selection, Green builders believe 1) wood is a highly renewable material and 2) steel and concrete are recyclable and have a long service life. Traditional builders believe 1) wood and steel contribute to a high level of energy efficiency in the completed house and 2) the manufacturing of steel and concrete has low CO2 emissions and uses a low level of energy. Regarding familiarity with newer building-product technologies, homebuilders do not seem to be well informed about solar power-generation, solar water-heating, structural insulated panels, heat-recovery ventilators, cement's impacts on the environment, or tankless water heaters. Regarding the environmental perceptions of building materials, homebuilders appear to be knowledgeable about volatile organic compounds, water-conserving fixtures, and energy-efficient appliances and windows. However, homebuilders do not seem to believe that environmentally certified wood programs are very effective, nor do they seem to be well informed about green-building programs.

Keywords: Residential Green Building Programs, Environmentally Certified Wood Products, Forest Stewardship Council

Introduction

The comparative nature of how homebuilders use and view green-building products and practices in the U.S. has potentially impacting implications for homebuyers, manufacturers, and distributors because the homebuilding industry is one of the major industries in the U.S. (WWPA 2009). Thus, this study is timely and relevant not only to those parties but also to researchers interested in understanding the patterns associated with green-building adoption and diffusion.

Handerhan (2012) evaluated the economics of green-building technologies and found that many homebuilders are hesitant to build green homes because they cost more to build, even though the homebuyer will likely save money in the long run. However, the report concedes it is difficult to determine how much the savings might be. It further suggests that by considering 1) factors related to the building envelope (i.e., material used to construct the external shell of the structure), 2) management and use of the HVAC (heating, ventilation, and air conditioning) system, and 3) water consumption, homebuilders can become more aware of cost-saving green-building strategies.

Increased awareness of the impacts associated with using non-renewable energy sources to power homes (e.g., environmental, supply, cost) has prompted a trend toward increased energy standards that is expected to become more stringent over time (Moresco 2009). Homebuyers often rely on homebuilders to help them understand what relevant factors need to be considered when building and/or buying a home. Although homebuilders are not mandated to increase their knowledge or training in using green technologies (except that the homes they build must comply with the current building codes), Retzlaff (2008) found that some communities actually have ordinances governing the implementation

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of green construction. These ordinances relate to issues such as water conservation, building materials, waste management, construction cost, environmental impacts, and technical solutions.

The "incremental" improvements in green homebuilding technology pose the potential for a knowledge gap to occur because building codes governing these types of technologies often are not well understood by homebuilders and inspectors who are expected to use them (Eisenberg, Done, and Ishida 2002). Further barriers exist to the adoption of green technologies because although there is a trend toward homeowners desiring energy-efficient upgrades (CEA 2012), they often are not knowledgeable about home energy-performance issues or how to gain access to financing the cost of incorporating green technologies into their home (Moresco 2009).

Osmani and O'Reilly (2009) point out that it is not clear at this time exactly how existing barriers such as cost and lack of familiarity with technology will affect adoption patterns between homebuilder segments (e.g., custom, production, small, large). Some of the newly built homes are anticipated to incorporate as many as five green-building technologies into their design and construction (Nation's Building News 2007a). These technologies include but are not limited to products such as energy-efficient appliances, mechanical equipment, water- or energy-conserving devices, and energy-efficient windows (Nation's Building News 2007b). Thus, it appears that the future of green homebuilding is on the rise; green-homebuilding certifications are anticipated to double during the next five years from 17% of new homes built to 34% (McGraw-Hill Construction 2011).

Background and Approach

This study's reference to Green homebuilders implies those who use residential green-building certification programs (GBPs), which are transparent, third-party-maintained mechanisms whereby homebuilders receive points for incorporating specific conservation measures into the process of erecting a home (Allen and Lano 2008). Some GBPs are nationally recognized; however, according to the International Code Council (ICC), none are mandated (ICC 2011). Mandated interventions in homebuilding are unpopular among homebuilders because they have long been associated with resultant increases in overall construction costs (Oster and Quigley 1977). Thus, proactively finding resourceful ways to build by incorporating new technologies, techniques, and materials into homebuilding projects could be one way for homebuilders to differentiate themselves from competitors (Koebel et al. 2003). Further, some homebuilders may decide to certify their distinctions through an official certifying body.

One of the two more prominent GBPs in the U.S. — the ICC-700 — was developed by the National Association of Homebuilders (NAHB) and introduced in the spring of 2007. It received the American National Standards Institute (ANSI) accreditation for all residential construction under the ICC. The other prominent GBP — Leadership in Energy and Environmental Design for Homes (LEED for Homes) — was developed by the U.S. Green Building Council (USGBC). In 2011, more than 12,000 housing units were certified by the LEED for Homes program and approximately 6,000 by the ICC-700 standard (LEED 2011, NAHB Research Center 2011a). ICC-700 emphasizes sustainable construction techniques and awards certification points in construction categories such as project site work, water use, energy use, and indoor environmental quality. Similarly, LEED for Homes awards points for categories such as whole-house energy performance (i.e., viewing the home as a system of integrated subsystems), water conservation, indoor environmental quality, and materials selection (Ganguly et al. 2012).

One reason homebuilders certify their homebuilding projects through GBPs is so they can market themselves as being proactive and progressive in their thinking as opposed to strictly using products and practices they know well, and on which they have come to rely. Being viewed as a progressive-thinking homebuilder may cause homebuyers to believe a homebuilder is well informed and innovative. As far back as 1971, Rogers and Shoemaker showed there were specific attributes and benefits associated with being viewed as innovative. This bears out within the homebuilding industry as Green homebuilders attempt to increase prospective homebuyers' awareness of, and desire for, using new building products and materials (Koebel et al. 2003).

A Green homebuilder in this study is one who has certified a project with a GBP. This categorization allows for specific comparisons between attributes that are derived by examining how points are assigned to projects certified using GBPs (NAHB Research Center 2012a). This approach offers glimpses into differences between homebuilders, which were not reported by previous studies. The project-scoring attributes are used to develop successive subsections of this paper, which also correspond to the survey instrument used in this study. The attributes also comprise the foundation and motivation for this study's research questions. They include the following six questions about homebuilders.

1. Do they differ when selecting materials (i.e., what matters most about the materials used to manufacture a building product that potentially will be used to construct a home)?

2. What are their perceptions regarding wood, steel, and concrete as building materials (i.e., because these are most commonly used to manufacture homebuilding products, do their constituent materials affect homebuilders' material-selection process)?

3. How familiar are they with building-product technologies (i.e., do some of the newer technologies affect the way homes are built)?

4. Do they differ regarding their environmental perceptions of building materials (i.e., do building-product technologies affect the carbon footprint of a home)?[1]

5. Are there differences in their perceptions regarding environmentally certified wood programs (i.e., do the forestry practices used to harvest wood products affect material selection)?

6. Are there differences in their perceptions regarding green-building programs (i.e., do GBPs impact the way a home is built and marketed)?

There are undoubtedly other attributes that would offer insights and perspectives about how homebuilders construct homes (e.g., quality, ethics, safety), but this study focuses on those attributes whereby homebuilders can receive points for certifying their projects through a GBP.

For homebuilders to market themselves effectively as being different from their competitors with respect to the aforementioned project-scoring attributes, they most likely will need to carefully consider what motivates prospective homeowners to try new homebuilding products and practices. However, the homebuilding industry traditionally has not experienced rapid adoption of many promising technologies (NAHB Research Center 2010 and 2011b, Verify Markets 2011). Thus, return-on-investment data will have to be developed by using inputs such as homeowner utility bills (Jacobsen and Kotchen 2011), rather than estimates, in order for borderline (i.e., price-motivated) homebuyers to accept the notion of paying a premium associated with purchasing a green-certified home.

One way for homebuilders to motivate homebuyers to pay a premium for purchasing a green-certified home is to highlight how the homes they build perform differently than typical homes. The U.S. Department of Energy is promoting green-building practices that view the home as a "system of integrated subsystems" (i.e., whole-house systems approach) (U.S. Department of Energy 2011a). Thus, one way for homebuilders to differentiate themselves is by better informing motivated homebuyer segments within the market about the potential financial and resource savings associated with using such building concepts. The basic premise of this type of differentiation is that homebuilders can demonstrate their awareness of the more scientific way to build a home by approaching it as a system of subsystems.

The process of differentiating a market offering to motivated segments is not new. Schumpeter (1934, 1942) described market differentiation as a process that stems from alert firms capitalizing on overlooked opportunities by implementing new products, processes, and techniques. More recently, Hargadon and Sutton (2001) described the benefits associated with targeting specific market segments by using products derived from raw materials that were well accepted and appealed to users. This may prove to be an important concept as future energy codes continue to challenge homebuilders to become more informed and trained in order to respond to energy-performance increases (U.S. Department of Energy 2011b). However, some homebuyer segments may not be motivated to pay for something they do not believe they need or desire. Often, successful segmentation within markets that involve new-product adoption requires a preliminary understanding of the potential buyer's expectations (Cooper 1999, Brunner 2001, and Markham 2002). Moreover, Hubbard et al. (2003) suggest that buyers are motivated to try new products when there is a clearly demonstrated advantage over using existing products.

Natural resource limitations are one reason for stimulated demand of green-building products used in homebuilding. High-quality lumber — critical for building a home — is often difficult to acquire at a competitive price, so homebuilders are forced to consider product substitutions (Eastin 2005). Currently, engineered wood products manufactured with softwood lumber are consumed more by the U.S. homebuilding industry than by any other industry (WWPA 2009). Environmentally certified wood products (ECWPs) offer an option for homebuilders to buy from environmental programs that encourage sustainable management of forests through market-based incentives (Vidal et al. 2003). These types of market-oriented programs allow consumers to stimulate demand for ECWPs based on the belief that it will assist in protecting the natural environment (Upton and Bass 1996). However, the low level of awareness regarding ECWPs has posed a major hurdle for their adoption (Bowe and Hubbard 2003). As previously mentioned, although not mandated, GBPs offer points for using ECWPs in residential construction projects.

Two of the more prominent certifying bodies in the U.S. for ECWPs — the Forest Stewardship Council (FSC 2011, Taylor 2012) and the Sustainable Forestry Initiative (SFI 2012) — are addressed in the final section of the survey instrument used in this study. Programs such as FSC provide a structure for the certification process by acting as the overseer of certifying agents and establishing the principles and criteria for providing certification (Scrase 1995). However, because of GBP's inconsistencies, such as LEED for Homes not awarding points for environmentally certified wood products certified by SFI, homebuilders and consumers alike continue to question some aspects of GBPs (Ozanne 2003).

Survey Methodology and Data Collection

This study collected information over the course of approximately one month during the fall of 2011 using a web-based survey instrument. Reasons for doing so are the greater speed and lower cost of implementation (Dillman 2000; Duffy et al. 2005), and the fact that the time lag from collecting the data is drastically reduced when compared to traditional survey methods (Schonlau et al. 2006). The data collected were used to develop profiles for two categories of homebuilders — Green and Traditional — according to six green-building categories. The six categories measured are commonly used to assign points to green homebuilding projects for GBPs.

Sample Size Assumptions — Part of many homebuilders' marketing strategy includes the decision of whether to use GBPs. Many homebuilders may use green products or practices while not necessarily using a GBP, due in large part to the relative newness of GBPs and the cost of certification. Thus, the low adoption rate of GBPs was considered in determining a representative sample size for this study.

Green builders were defined as homebuilders that certified at least one home using a GBP during 2010, and Traditional builders were defined as those respondents that had not done so. Membership e-mail distribution lists were obtained from NAHB and USGBC's LEED for Homes. Members were invited to participate in an online survey, and reminders were sent out until a proportionate number of responses were returned from regions of the U.S. that corresponded to geographic homebuilding patterns occurring during 2010 .

Based on these assumptions, an online sample-size calculator was used in lieu of manually performing the calculation within this section of the paper (American Research Group, 2011). The calculator algorithm was based on an alpha-level of .05 and required an input for the target population size (*N*). It rendered outputs for various acceptable margin-of-error levels (*d*), for which this study chose a value of (.05). The estimated value for the proportion of the sample that is aware of green-building materials and practices (*P*) was assumed to be evenly distributed at 50% because some green materials and practices have been used by homebuilders for decades due to their decreasing price (e.g., substituting oriented strand board for plywood). Thus, the sample size calculation was based on the following data.

- ***N*** = 211,647 homebuilders (including residential and multi-family homebuilders and home remodelers (U.S. Census 2004))
- ***d*** = .05 (acceptable margin of error for the estimated value of *P*)
- ***P*** = .5 (due to varied levels of awareness regarding different construction materials and practices)
- ***n*** = 384 (required sample size, rounded up)

Although the minimum sample size was calculated to be 383.5, this study was able to accept 618 returned surveys from representative areas where homes had been built in the U.S. during 2010. These additional responses, which were included as an added measure in order to capture maximum variation among respondents, were made possible based on available funding for this phase of the study.

Data Collection — The NAHB Research Center, a wholly owned subsidiary of the National Association of Homebuilders (NAHB), is the largest trade association in the U.S., with more than 150,000 registered homebuilders, remodelers, and manufacturers (NAHB Research Center 2012b). It has the greatest reach to the homebuilder population through its member-based internet panel of homebuilders and remodelers, which reaches all 50 states and comprises firms of all sizes. USGBC's LEED for Homes certification maintains a similar e-mail distribution list that was accessed for this study. Thus, 2,000 e-mail addresses were randomly selected to send invitations to homebuilders participating in the NAHB Research Center's internet panel[2], as well as those homebuilders on LEED's e-mail distribution list. Reminders were sent out until 618 surveys were returned in accordance with geographic homebuilding patterns occurring during 2010.

Survey Development — The questionnaire underwent extensive pretesting for clarity and comprehensiveness by housing professionals and academics. Because so many homebuilders have been idle or forced out of business due to the recent downturn in the residential construction industry (NAHB Research Center 2012b), a screening question was asked to ensure that participants were homebuilders and remodelers involved in two or more residential construction projects during 2010. A total of 13 items were measured to determine differences in how these homebuilder types (i.e., Green and Traditional) select materials. This included items regarding wood, steel, and concrete products' 1) overall price, 2) level of CO_2 emission created during their manufacture, 3) availability, 4) consumer demand, 5) low maintenance, 6) whether they are made using recycled materials, 7) the recyclability of the materials used in their manufacture, 8) energy efficiency, 9) ease of installation, 10) whether they are made from renewable raw materials, 11) whether they are made from locally produced materials, 12) length of expected service life, and 13) the amount of energy used in their manufacture.

A total of 12 commonly accepted technologies from a national repository known as the ToolBase Technology Inventory (ToolBase 2012) were used to measure differences between the two homebuilder types (i.e., Green and Traditional) regarding their familiarity with building-product technologies. This included 1) energy-recovery ventilators, 2) energy-efficient windows, 3) solar water-heating, 4) structural insulated panels, 5) radiant barriers, 6) solar power-generation, 7) engineered wood, 8) water-conserving fixtures, 9) energy-efficient appliances, 10) concrete with reduced cement, 11) low volatile organic compounds (VOCs)/low toxic paints, and 12) tankless water heaters. This section of the survey was followed by one that asked respondents to measure how important each of the 12 building-product technologies was in reducing the carbon footprint of a home.

Respondents were asked to compare two environmentally certified wood programs: SFI and FSC. The four items compared were 1) consumer awareness, 2) availability, 3) whether one program is better for the environment than the other, and 4) whether one program uses more sustainable forest management practices than the other.

Lastly, respondents were asked to compare two GBPs: ICC-700 and LEED for Homes. The seven items compared were 1) brand recognition by customers, 2) influence on home sales, 3) effectiveness in reducing the environmental footprint of the house, 4) cost of certification, 5) documentation requirements, 6) how easily understood the rules are, and 7) willingness of customers to pay a price premium. Scales used throughout the study ranged from 1 = Not Important/Effective to 5 = Extremely Important/Effective. The only exception was for the final section, which compared two GBPs. Here, the scales ranged from 1 = LEED for Homes is much better to 5 = ICC-700 is much better. Student t-tests were performed using SPSS® to determine if statistically significant differences in mean-values existed between responses provided for each question by Green builders and Traditional builders.

Results

Response Rates and Demographics — As previously shown, the required minimum sample size is 384, and a total of 618 usable responses were received[3] from a randomly selected sampling frame of approximately 2,000 homebuilder members from NAHB and LEED — 65% Traditional homebuilders (n = 401) and 35% Green homebuilders (n = 217). The regional representation of the survey respondents aligned with the regional breakdown of housing starts in 2010 (i.e., 59% indicated they built in cities with populations greater than 50,000 persons, 27% built in towns with populations less than 50,000 persons, and 14% built in outlying areas with low-density populations scattered throughout a large area. No statistical differences were detected between responses received in a timely fashion (n = 494) versus those received by the last 20% of respondents (n = 124) after reminders were sent out, so any potential instability caused by late-response bias was considered to have been minimized (Armstrong and Overton, 1977). Demographic breakdowns of the respondents are shown in **Table 1**.

Table 1. Demographics (n = 618).

	Home-builders n (%)	*Re-modelers n (%)*	*Urban Areas n (%)*	*Small Towns n (%)*	*Rural Areas n (%)*
Builder type	501 (81%)	117 (19%)	NA	NA	NA
Market type	NA	NA	364 (59%)	167 (27%)	87 (14%)

NA: Not Applicable
Note: Western U.S. states represented 22% of respondents, Midwest (27%), Northeast (21%), and the Southern U.S. states represented 30% of respondents.

The Importance of Attributes that Drive Material Selection — Respondents were asked to rate 13 items regarding material selection (using a 5-point Likert-like scale where 1 = least important to 5 = most important). The two homebuilder types (i.e., Green and Traditional) differed significantly (i.e., statistically) on six of the 13 items. Long service life of the material seems to be fairly well understood by all builders as an important attribute for material selection. This is followed closely by the energy efficiency of the material, building materials that are derived from renewable sources, and materials that are produced locally. The recyclability of the material and products that are made with recycled materials round out the list. Thus, the seven statistically non-significant items were 1) overall price, 2) level of CO_2 emission created during its manufacture, 3) availability, 4) consumer demand, 5) low maintenance, 6) ease of installation, and 7) the amount of energy used in its manufacture. **Table 2** lists the mean-value responses in descending order for attributes that influence material selection.

Table 2. Differences in attributes that influence material selection.

Attributes that Drive Material Selection	Builder Type	N	Mean	Std. Dev.	p-val.
Long service life	Green	217	4.45	0.584	.008*
	Traditional	319	4.31	0.604	
Energy efficiency	Green	217	4.42	0.663	.000*
	Traditional	319	4.13	0.694	
Made with renewable raw materials	Green	217	3.41	0.982	.001*
	Traditional	319	3.13	0.898	
Locally produced material	Green	217	3.41	1.01	.009*
	Traditional	319	3.18	0.946	
Recyclability of the material	Green	217	3.35	1.008	.012*
	Traditional	319	3.13	0.913	
Made with recycled materials	Green	217	3.32	0.956	.000*
	Traditional	319	3.02	0.89	
Availability	Green	217	4.41	0.595	.292
	Traditional	319	4.35	0.612	
Overall price	Green	217	4.35	0.671	.738
	Traditional	319	4.37	0.664	
Low maintenance	Green	217	4.32	0.663	.114
	Traditional	319	4.23	0.605	
Consumer demand	Green	217	4.10	0.917	.746
	Traditional	319	4.13	0.720	
Ease of installation	Green	217	4.09	0.650	.694
	Traditional	319	4.11	0.632	
Amount of energy used in its manufacture	Green	217	3.04	1.094	.112
	Traditional	319	2.90	0.993	
Level of CO_2 emission created during its manufacture	Green	217	2.93	1.095	.060
	Traditional	319	2.75	1.018	

* statistically significant at the alpha-level of .05

Wood — Two of the six perceptions related to wood have statistically significant mean-value differences. Green builders have a stronger belief than do Traditional builders that wood is a highly renewable material. However, they are not as convinced as are Traditional builders that wood contributes to the high energy efficiency of the completed house.

Steel — All six perceptions regarding steel have statistically significant differences in mean values. Green builders believe more strongly than do Traditional builders that steel is recyclable and has a long service life. However, neither group

is convinced (i.e., all mean-values are near or less than 3 based on a 5-point scale) that steel is a highly renewable material, uses low energy during its manufacturing process, has low CO_2 emission during its manufacturing process, or contributes to the high energy efficiency of the completed house.

Concrete **—** Green builders believe more than Traditional builders do that concrete has a long service life and is recyclable. Both homebuilder types become a bit more neutral in their beliefs regarding concrete's attributes as a green-building material (i.e., all mean-values are near or less than 3 based on a 5-point scale) — that concrete has low CO_2 emissions during the manufacturing process, and that concrete uses a relatively low level of energy in its manufacture into building products. **Table 3** lists the mean-value responses in descending order for using wood, steel, and concrete as building products

Familiarity with Building-Product Technologies **—** There are specific building-product technologies that are becoming more accepted by builders (ToolBase 2012). The two groups of homebuilder types (i.e., Green and Traditional) were asked to measure their level of familiarity with 12 commonly accepted technologies from a national repository known as the ToolBase Technology Inventory. Green builders are significantly (i.e., statistically) more familiar with energy-efficient windows, energy-efficient appliances, water-conserving fixtures, and VOCs than are Traditional builders. Traditional builders claim to be about as familiar as Green builders with six of the 12 technologies. However, neither builder type is very familiar with tankless water heaters, heat-recovery ventilators, concrete with reduced cement, solar power-generation, solar water-heating, or structural insulated panels. **Table 4** lists the mean-value responses in descending order for familiarity with building-product technologies.

Table 3. Differences in perception of wood, steel, and concrete as building products.

	Builder Type	*N*	*Mean*	*Std. Dev.*	*p-val.*
Perceptions of Wood as a Building Product					
Is recyclable	Green	217	4.24	0.791	0.300
	Traditional	301	4.16	0.777	
Has a long service life	Green	217	3.97	0.849	0.938
	Traditional	301	3.97	0.765	
Is a highly renewable material	Green	217	4.18	0.832	0.022*
	Traditional	301	4.00	0.904	
Has low CO_2 emission during manufacturing process	Green	217	3.47	0.809	0.381
	Traditional	301	3.40	0.874	
Uses low energy during its manufacturing process	Green	217	3.23	0.991	0.353
	Traditional	301	3.30	0.824	
Contributes to high energy efficiency of completed house	Green	217	3.04	1.075	0.012*
	Traditional	301	3.26	0.852	
Perceptions of Steel as a Building Product					
Is recyclable	Green	217	4.47	0.674	0.000*
	Traditional	301	4.24	0.728	
Has a long service life	Green	217	4.45	0.719	0.013*
	Traditional	301	4.29	0.654	
Is a highly renewable material	Green	217	3.00	.1.255	0.011*
	Traditional	301	3.27	1.085	
Has low CO_2 emission during manufacturing process	Green	217	2.26	0.85	0.007*
	Traditional	301	2.47	0.874	
Uses low energy during its manufacturing process	Green	217	2.07	0.847	0.000*
	Traditional	301	2.34	0.819	
Contributes to high energy efficiency of completed house	Green	217	2.47	0.946	0.016*
	Traditional	301	2.66	0.855	
Perceptions of Concrete as a Building Product					
Is recyclable	Green	217	3.83	0.978	0.032*
	Traditional	301	3.64	1.012	
Has a long service life	Green	217	4.39	0.744	0.009*
	Traditional	301	4.22	0.719	
Is a highly renewable material	Green	217	2.93	1.069	0.172
	Traditional	301	3.05	0.931	
Has low CO_2 emission during manufacturing process	Green	217	2.59	0.983	0.000*
	Traditional	301	3.01	0.787	
Uses low energy during its manufacturing process	Green	217	2.56	0.966	0.000*
	Traditional	301	2.88	0.816	
Contributes to high energy efficiency of completed house	Green	217	3.04	1.067	0.825
	Traditional	301	3.06	0.883	

* statistically significant at the alpha-level of .05

Table 4. Differences in familiarity with building-product technologies.

	Builder Type	N	Mean	Std. Dev.	p-val.
Familiarity with Building-Product Technologies					
Energy-efficient windows	Green	217	3.93	0.339	0.031*
	Traditional	297	3.86	0.406	
Energy-efficient appliances	Green	217	3.87	0.387	0.001*
	Traditional	297	3.74	0.481	
Engineered wood (e.g., I-joist, OSB, LVL, etc.)	Green	217	3.85	0.419	0.071
	Traditional	297	3.77	0.500	
Water-conserving fixtures	Green	217	3.72	0.518	0.001*
	Traditional	297	3.55	0.614	
Low VOC Paints	Green	217	3.70	0.552	0.000*
	Traditional	297	3.10	0.822	
Tankless water heaters	Green	217	3.30	0.733	0.000*
	Traditional	297	2.97	0.741	
Heat-recovery ventilators	Green	217	2.91	0.87	0.000*
	Traditional	297	2.41	0.809	
Concrete with reduced cement	Green	217	2.91	0.913	0.000*
	Traditional	297	2.47	0.908	
Radiant barriers	Green	217	2.89	0.889	0.113
	Traditional	297	2.77	0.851	
Solar power-generation	Green	217	2.64	0.74	0.000*
	Traditional	297	2.22	0.555	
Solar water-heating	Green	217	2.55	0.699	0.000*
	Traditional	297	2.24	0.575	
Structural insulated panels	Green	217	2.53	0.701	0.020*
	Traditional	297	2.38	0.643	

* statistically significant at the alpha-level of .05

Carbon Footprint Associated with the 12 Building-Product Technologies — The two groups of homebuilders (i.e., Green and Traditional) were asked to measure their perception of the ability of these same 12 building-product technologies to reduce a home's carbon footprint. The statistically significant differences ordered according to the largest mean-values for the two groups were for energy-efficient windows, energy-efficient appliances, water-conserving fixtures, low VOCs, heat-recovery ventilators, tankless water heaters, solar power-generation, solar water-heating, and concrete with reduced cement. **Table 5** lists the mean-value responses in descending order for environmental perceptions of building materials.

Table 5. Differences in environmental perceptions of building materials.

	Builder Type	N	Mean	Std. Dev.	p-val.
Building Material's Ability to Reduce a Home's Carbon Footprint					
Energy-efficient windows	Green	209	4.69	0.545	0.003*
	Traditional	270	4.53	0.717	
Energy-efficient appliances	Green	209	4.55	0.607	0.001*
	Traditional	270	4.35	0.717	
Water-conserving fixtures	Green	209	4.43	0.657	0.000*
	Traditional	270	4.14	0.833	
Engineered wood (e.g., I-joists, OSB, LVL, etc)	Green	216	4.13	0.840	0.126
	Traditional	295	4.01	0.835	
Low VOC Paints	Green	209	4.12	0.850	0.018*
	Traditional	270	3.64	0.914	
Heat-recovery ventilators	Green	209	3.92	0.914	0.000*
	Traditional	270	3.49	0.878	
Tankless water heaters	Green	209	3.77	0.991	0.004*
	Traditional	270	3.53	0.916	
Radiant barriers	Green	207	3.71	0.986	0.156
	Traditional	279	3.59	0.868	
Solar power-generation	Green	209	3.71	0.933	0.000*
	Traditional	270	3.31	1.010	
Solar water-heating	Green	209	3.65	0.920	0.000*
	Traditional	270	3.30	0.999	
Concrete with reduced cement	Green	209	3.50	0.894	0.000*
	Traditional	270	3.18	0.827	
Structural insulated panels	Green	215	3.44	1.048	0.116
	Traditional	292	3.30	0.887	

* statistically significant at the alpha-level of .05

Thus, Green builders and Traditional builders did not differ on the extent to which structural insulated panels, radiant barriers, and engineered wood products served to reduce the carbon footprint of a home.

Perceptions Regarding Environmentally Certified Wood Programs — Neither homebuilder type is very familiar with ECWPs. Green builders perceive FSC to be slightly more effective than SFI, while Traditional builders are less convinced of the effectiveness of either group. There were no statistical differences between the two homebuilder types regarding the effectiveness of ECWPs.[4] **Table 6** lists the mean-value responses in descending order for ECWPs.

Table 6. Differences in familiarity and effectiveness of environmentally certified wood programs.

	Builder Type	N	Mean	Std. Dev.	p-val.
Familiarity with Environmentally Certified Wood Programs					
FSC	Green	217	2.69	1.002	0.000*
	Traditional	295	1.83	.882	
SFI	Green	217	2.48	.977	0.000*
	Traditional	295	1.88	.861	
Effectiveness of Environmentally Certified Wood Programs					
FSC vs SFI: Better for the environment	Green	169	3.86	1.608	0.322
	Traditional	150	4.03	1.428	
FSC vs SFI: Sustainable forest management	Green	169	3.79	1.622	0.267
	Traditional	150	3.99	1.470	
FSC vs SFI: Ready availability	Green	169	3.88	1.515	0.760
	Traditional	150	3.93	1.491	
FSC vs SFI: Consumer awareness	Green	169	3.73	1.706	0.313
	Traditional	150	3.91	1.465	

* statistically significant at the alpha-level of .05

Perceptions Regarding Green-Building Programs — The mean-values of specific builder perceptions regarding GBPs differ largely (where a value of 1 means that LEED for Homes is Best, and a value of 5 means that ICC-700 is Best), in that Traditional builders feel more strongly than do Green builders that the ICC-700 program is more effective in reducing the environmental footprint of the house than is the LEED for Homes program, and that ICC-700 has more influence on home sales than does the LEED for Homes program. Neither category of homebuilder claims to be very familiar with GBPs, but Green builders are more familiar with ICC-700 and LEED for Homes than are Traditional builders. Traditional builders feel more strongly than do Green builders that the ICC-700 has stronger brand recognition by customers. **Table 7** lists the mean-value responses in descending order for the familiarity and effectiveness of GBPs.

Table 7. Differences in the effectiveness of green-building programs.

	Builder Type	N	Mean	Std. Dev.	p-val.
Familiarity with Building Programs (LLED, ICC-700)					
Familiarity with ICC-700	Green	217	3.32	0.94	0.000*
	Traditional	291	2.30	0.691	
Familiarity with LEED for Homes	Green	206	2.89	0.939	0.000*
	Traditional	243	2.25	0.627	
Effectiveness of Green-Building Programs (LEED vs ICC-700)					
Cost of certification	Green	206	4.54	1.200	0.613
	Traditional	243	4.48	1.406	
Documentation requirements	Green	206	4.41	1.272	0.998
	Traditional	243	4.41	1.418	
Easily understood rules	Green	206	4.28	1.276	0.591
	Traditional	243	4.35	1.413	
Customers' willingness to pay a price premium	Green	206	3.96	1.444	0.072
	Traditional	243	4.21	1.466	
In reducing environmental footprint of the house	Green	206	3.69	1.411	0.042*
	Traditional	243	3.97	1.509	
Influence on home sales	Green	206	3.59	1.602	0.017*
	Traditional	243	3.94	1.523	
Brand recognition by customers	Green	206	2.78	1.667	0.000*
	Traditional	243	3.56	1.693	

* statistically significant at the alpha-level of .05

Discussion

Homebuilders often give preferential consideration to cost and availability of supply when selecting building materials. This is understandable because as Jacobsen and Kotchen (2011) showed, return on investment (ROI) for green certification is still not well documented. Until these types of ROI studies are conducted, many builders will continue to be price motivated. The findings from Oster and Quigley (1977) continue to remain valid in as much as government incentives, rather than mandates, will likely be the key to motivating builders to consider green options.

As pointed out in Nation's Building News (2007a and 2007b), Green builders give particular consideration to items such as using recycled materials derived from renewable raw materials, the energy efficiency of the material, whether the material is produced locally, its recyclability, and its service life. These efforts are all well aligned with acquiring points when certifying homebuilding projects through GBPs. Both homebuilder types (i.e., Green and Traditional) appear to be knowledgeable about VOCs, water-conserving fixtures, and energy-efficient appliances and windows. Unfortunately, neither homebuilder type (i.e., Green nor Traditional) seems to be well informed about solar power-generation, solar water -heating, structural insulated panels, heat-recovery ventilators, cement's impacts on the environment, or tankless water heaters. Homebuilders likely will be motivated to familiarize themselves more about building materials because of the trend that CEA (2012) reports of homeowners desiring energy-efficient upgrades. Similarly, homebuilders will likely become more familiar with GBPs if the 2011 McGraw-Hill Construction report, which anticipates a doubling in demand of green homebuilding certifications, proves to be accurate.

Green builders believe wood is a highly renewable material, and that steel and concrete are both recyclable and have a long service life. Traditional builders believe wood and steel contribute to a high level of energy efficiency in the completed house, and that the manufacturing of steel and concrete both has low CO_2 emissions and uses a low level of energy. Thus, as Eisenberg et al. (2002) found, there continue to be gaps in homebuilders' levels of knowledge and understanding. However, as Cooper (1999), Brunner (2001), and Markham (2002) suggest, these knowledge gaps will likely begin to narrow as homebuilders continue to gain a better understanding of what information potential buyers expect from them.

Neither homebuilder type (i.e., Green nor Traditional) seems to believe that environmentally certified wood programs are very effective. This makes sense given Ozanne's (2003) findings of inconsistencies in GBPs not recognizing all environmentally certified wood products programs. For example, Green builders perceive the Forest Stewardship Council (FSC) to be slightly more effective than the Sustainable Forestry Initiative (SFI). This is most likely because Green builders have certified more with LEED for Homes to date, and it assigns points only for using FSC. Thus, as Bowe and Hubbard (2003) point out, increased awareness and transparency of ECWPs should assist homebuilders in making more informed decisions on the merit of using such programs, thereby increasing the adoption rates of these types of programs.

Understanding adoption patterns between homebuilder types (i.e., Green and Traditional) hopefully will advance housing research such as that of Blackley and Shepard (1996) and more recently Ganguly et al. (2009) so it can continue to develop more accurate models of green building. Rogers and Shoemaker (1971) provided a general adoption theory against which to gauge adoption patterns, but as Koebel et al. (2003) showed, the homebuilding industry traditionally has not followed adoption patterns of other industries.

Conclusions

There appear to be differences in U.S. homebuilders' use and perceptions regarding green homebuilding; however, they do not appear to be pronounced. Green builders seem to give more consideration to issues related to the renewability of building materials than do Traditional builders. Wood seems to rate well with Green builders in its renewability, whereas they prefer steel and concrete because of those materials' longer service life. The two homebuilder types differ in that Traditional builders (more so than Green builders) believe wood and steel contribute to a high level of energy efficiency in the completed house, and that the manufacturing of steel and concrete has low CO_2 emissions and uses a low level of energy. Both builder types (i.e., Green and Traditional) seem well informed about issues related to VOCs, water-conserving fixtures, and energy-efficient appliances and windows. However, neither homebuilder type seems well informed about issues related to solar power-generation, solar water-heating, structural insulated panels, heat-recovery ventilators, cement's impacts on the environment, or tankless water heaters. Similarly, neither group seems to be well informed about green-building programs, nor does either group seem to believe that environmentally certified wood programs are very effective.

Study Limitations — This study limited its analysis to six categories associated with how homebuilders receive points when certifying homebuilding projects with GBPs. There are admittedly other categories that could be analyzed to develop more comprehensive profiles of homebuilders. A phenomenon that will be challenging to account for, yet one that needs to be considered, is homebuilders who build to a green standard but choose not to pay for the cost of certifying with a GBP. Analysis of these types of factors will enable researchers to develop a much clearer understanding of the differences between Green builders and Traditional builders.

Future Research — Of interest to the findings for any research is the "why" behind the findings. It will be highly valuable to qualitatively ascertain information regarding homebuilders' beliefs. This more than likely will be most effective when conducted in the form of moderated roundtables where homebuilders can speak freely about topics such as the ones discussed in this paper. Although not generalizable, this type of research will provide a more thorough understanding on which researchers can base further quantitative studies.

Endnotes

1 The carbon footprint of a home is a calculation that can be performed to determine how many tons of carbon is being generated by the materials used to construct the home, as well as the energy used to operate the home (Global Footprint Network 2012).

2 An internet panel maintenance fee was paid to the NAHB Research Center, which in turn offered gift points to members who returned completed surveys.

3 Although the study was able to fund the collection of 37% more responses than required, the survey was quite lengthy because of branching and piping that was programmed into it to garner the maximum amount of data possible. However, a shortcoming of this comprehensive approach was that there was between 13% and 27% missing data on the responses analyzed. Typically, this relatively high percentage of missing data would cause concern, but because 37% more responses were received than were necessary, more than a sufficient number of responses were collected for each question analyzed.

4 This response rate regarding the effectiveness of ECWPs (48%) is the sole category in which footnote number 3 is contradicted but reinforces the notion that homebuilders lack familiarity with ECWPs.

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