Towards Establishing the Attributes of Innovative Green Building Products through Structural Insulated Panel Systems

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1 Abstract/Executive Summary

The purpose of this project is to lay the foundation for exploration of the barriers of diffusion specific to innovative green building products. Innovative green building products aim at reducing environmental impacts during a product's entire life-cycle, helping mitigate the substantial environmental degradation caused by current construction patterns. This study will review the innovation literature and provide a summary of innovation research in the residential construction industry. The authors will then offer a definition of innovative green building products and distill the possible attributes of these products from the literature review. Next a survey of residential builders will be conducted to assess the author's categorization of the attributes of green building products, and conclusions will be drawn from the responses. The classification of specific green building product attributes as barriers (or accelerators) to adoption may potentially affect product development, commercialization and marketing efforts across the residential construction industry. This paper will focus on a single product, Structural Insulated Panels, and will serve as a model for future research on other green building products.

Do SIPS have barriers to adoption similar to those of general innovation?

2 Introduction

Estimates of environmental degradation stemming from the construction and operation of the built environment are staggering. In the United States alone, buildings account for 48% of total energy consumption and its associated CO2 emission (Architecture 2030), and contribute up to 24% of all municipal solid waste that enters landfills (Laquatra 2004). The residential construction industry makes up a large percentage of total construction in the United States, and is therefore responsible for a large part of this consumption and waste. With renewed national interest in energy independence and growing concern over climate change and general environmental degradation, it is more important than ever to study innovations in green building that offer solutions to these problems.

Innovative green building products aim at reducing environmental impacts during a product's entire life-cycle (Bernauer 2006). These products reduce waste inputs from the manufacturing process, conserve energy or water during their useful lifetime, and reduce waste upon disposal or reuse. However, the residential construction industry has been relatively slow at developing and adopting innovative green building products (Koebel 2007). Due to the relatively recent nature of innovation research in the residential building industry, it has tended to focus primarily on manufacturing characteristics and user innovativeness (McCoy et al. 2009). As such, specific product attributes of green innovations and their associated accelerators and barriers have not been sufficiently defined and analyzed.

This study will review the innovation literature and provide a summary of innovation research in the residential building industry. The authors will then offer a definition of innovative green building products and seek to distill the possible attributes of these products from the coming sections of literature review. These attributes will then be used to develop a survey of residential home builders to assess the accelerator and barrier attributes of these products, using structural insulated panels as a control group. The results of this research will offer a foundation for future research into the attributes of other innovative green building products, and provide insights into what attributes act as barriers to innovation. Reducing these barriers is imperative in the effort to stimulate sustainable construction practices across the country.

3 Background

3.1 Innovation

Innovation research is an established field covering product diffusion and adoption, the innovation commercialization process and producer/consumer behavioral attributes. Everett Rogers' book Diffusion of Innovation offers a solid foundation from which further research on innovation can be conducted. Rogers defines an innovation as "an idea, practice or object that is perceived as new by an individual or other unit of adoption" and diffusion as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003). Rogers' work analyzes innovation diffusion and adoption theory, as well as categorizes five general attributes of innovative products and discusses their possible consequences (Rogers 2003). This work makes generalizations whenever possible, but nevertheless sets the tone for future specialization of innovation research.

In addition to broad surveys of innovation theory (Rogers 2003, Gladwell 2002), industry specific innovation research exists in multiple areas, most notably marketing (Varble 1972), economics (Eaton and Dickinson 2006), and other specialized fields (Porter and Teisberg 2006). These works seek to understand the development and diffusion patterns of innovation in a specific, non-construction context to serve the necessary purposes of the specific industry sector.

3.2 "Green" Innovation

Green innovation is an important emerging focus of innovation research. Some of the first investigations of green innovation focused on the marketing opportunities related to ecologically concerned consumer behavior, and product attributes that appeal to this segment of the market. Work in this field was pioneered by Dale Varble in his study on social and environmental considerations in new product development. This report argued for the inclusion of product considerations other than sales and profit growth in the context of heightened environmental awareness at the time (Varble 1972). Thomas Kinnear and others responded to this study with further research of ecologically concerned consumers, identifying their demographic and behavioral attributes (Kinnear et al. 1974). This research broke ground on important research into the potential market for green innovations and was followed up by numerous reports on product appeal (Schuhwerk, E.M., and Lefkoff-Hagius, R. 1995), personality variables (Balderjahn 1988), and green marketing (Baker and Hart 2008). In a seminal work, Michael Porter and Claas van der Linde argue that green innovation and its associated resource productivity gain is essential to lowering environmental impacts as well as lowering costs, improving product quality, and enhancing global competitiveness (Porter and van der Linde 1995a). The field of "green" construction innovation, however, is a currently developing

Thomas Bernauer has identified process, product and organization as the three types of green innovation (Bernauer 2006 and Slaughter 2000). A process innovation takes place within a system, such as manufacturing, to produce the same result in a different way. Product innovation is the development of a new good or service, and is what is typically thought of in innovation discussion. Finally, organizational innovation is a change the people structure of an organization without necessarily affecting the products or processes so employed. Figure 1 graphically represents this relationship.

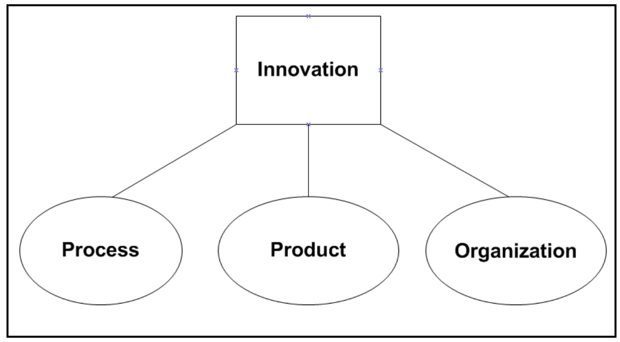

Figure 1 - Innovation Types

Bernauer defines environmental innovation as "all innovations that have a beneficial effect on the environment regardless of whether this effect was the main objective of the innovation" (Bernauer 2006). He further states that "organizational innovations do not reduce environmental impacts directly, but facilitate the implementation of technical (process and product) innovations. Process innovations are defined as improvements in the production process resulting in reduced environmental impacts… Accordingly, product innovations aim at reducing environmental impacts during the product's entire life cycle (cradle to grave)" (Bernauer 2006). The research in this study will focus primarily on the product attributes of innovation. After all, "most of what is known as green building involves innovative products, materials, or processes" (Koebel 2008).

3.3 Construction Innovation

Innovation research in construction in general, and the residential building industry specifically has been slower to develop and has a shorter history than innovation research in other areas. This has been attributed to many factors including the fractured nature of the housing production industry as well as a lack of research and development investment by firms, and a lack of technology transfer initiative by the federal government (Koebel 1999). Others have attributed this to the fact that "constructed facilities are large, very complex, and long lasting, and they are created and built by a temporary alliance of disparate organizations within an explicit social and political context" (Slaughter 1998). Nonetheless, areas of concern as well as potential future research foci for construction have been developed by a few prolific individuals starting in the early 1990's.

Sarah Slaughter, Assistant Professor of Civil Engineering at Lehigh University, is the first researcher to focus specifically on innovation in the residential construction industry. Her first study in this area focused on home builders as the primary source of construction innovation as opposed to manufacturers or researchers. The study tracked the use of a single construction innovation, the stressed-skin panel, and analyzed the interaction between manufacturer developments and on-site use of the product. The results show that 82% of innovation in the use and compatibility of the stressed-skin panel originated with the builder rather than the manufacturer (Slaughter 1993a). This study served as the foundation for future work on user/manufacturer learning about new technologies and this learning's application to related innovations (Slaughter 1993b).

Slaughter's later research explores models of, and implementation of construction innovations. In her 1998 study on models of construction innovation, Slaughter establishes an industry accepted definition of invention and innovation and differentiates the two. She defines an invention as "a detailed design or model of a process or product that can clearly be distinguished as novel compared to existing arts" (Slaughter 1998) and an innovation as "the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change" (Slaughter 1998). She further clarifies that "in contrast to an invention, an innovation does not require a detailed design or physical manifestation, and it does not have to be novel with respect to the existing arts, but only to the creating institution. While an innovation could also be an invention, an invention is not an innovation unless it has actually been used" (Slaughter 1998). This is an important differentiation to make for the present study which seeks to research innovation and not merely invention, and it eliminates any products from our research which cannot be considered a true innovation.

The final part of this study looked at the five categories of construction innovation; incremental, modular, architectural, system, and radical. An incremental innovation is a small improvement in current practice and has minimal impact on other components, an architectural innovation requires significant modification in other components and systems, a modular innovation is an improvement within a specific region, a system innovation is a set of complementary innovations working together to provide new attributes or functions, and a radical innovation is a new concept or approach which renders previous solutions obsolete (Slaughter 1998). The problems with and opportunities arising from each type of innovation are analyzed and a rubric for innovation adoption is created.

Slaughter's most recent contribution to construction innovation literature looks at the implementation of each type of construction innovation as defined in her previous research. This work defines the six stages of innovation adoption and implementation as identification, evaluation, commitment, detailed preparation, actual use, and post-use evaluation (Slaughter 2000). It then highlights specific concerns with respect to the type of innovation in each stage of its implementation and provides a framework for cost/benefit analysis (Slaughter 2000).

Another academic with numerous publications on innovation in the residential construction industry is Theodore Koebel. Koebel brings an urban planning perspective to innovation in residential building, and provides a detailed look at the history of innovation diffusion through public and private networks in his study "Sustaining Sustainability: Innovation in Housing and the Built Environment" (Koebel 1999). This paper stresses the importance of innovation in the building industry as a means to achieving sustainability. It then examines failed government attempts at incentivizing construction innovation as well as the effects of the social system of homebuilding on the way innovations are adopted. Lastly, Koebel makes suggestions on program design for speeding innovation diffusion in the industry (Koebel 1999).

Koebel's thorough work, entitled "The Diffusion of Innovation in the Residential Building Industry", identifies characteristics and trends of new product diffusion among residential home builders with the aim of improving technology transfer programs (Koebel 2003). The study shows empirically that early adopters of innovation are likely to be modular and multifamily builders, single-family custom home builders, and national and regional builders as opposed to single family production builders and local firms. Koebel also identifies several technological factors influencing diffusion, and suggests room for future study of these (Koebel 2003).

Koebel builds on this work in a more recent study on innovation in home building (Koebel 2008). The study follows in the consolidation of the homebuilding industry by large, production builders beginning in the early 1990's. It then characterizes the innovativeness of different types of builders through a survey of a large number of large and small builders spread throughout the United States. The report ends with a set of suggestions to speed the transfer of innovative technologies to residential homebuilders.

In addition to Slaughter's work on innovation models and Koebel's work on innovative builder attributes, significant work has focused on influences on construction innovation (Blayse and Manley 2004) as well as the market barriers to innovation in the home building industry (HUD 2005). Blayse and Manley have identified six key influences on construction innovation in their 2004 paper "Key Influences on Construction Innovation". Within the context of the Australian construction industry, they identify clients and manufacturers, the structure of production, relationships between individuals and firms, procurement systems, regulations/standards, and the nature and quality of organizational resources as the key influences on innovation (Blayse and Manley 2004). These industry attributes have been touched on by various academics but heretofore have failed to be identified in a comprehensive report. The U.S Department of Housing and Urban Development also looked at industry barriers to innovation and developed their own list of seven factors (HUD 2005). The factors identified in the HUD report were more qualitative in nature, and thus beyond the scope of what this study aims to uncover.

Significant research has also focused on the commercialization process for innovation in residential construction (McCoy et al. 2007, McCoy et al. 2009). McCoy has focused on the various steps throughout the supply chain that are necessary in taking a product from invention to innovation and gaining acceptance in the market place. Through a detailed interview process with several material manufacturers and new product developers, McCoy has been able to map the commercialization process in the residential construction industry and offer a tool for mapping this process for a specific product. The goal of this research is to streamline the development of innovation in residential construction and offer insights into communication patters along the commercialization process.

3.4 Product Innovation

Innovation research as it applies to residential green building products focuses primarily on user behavior, termed ecological consumer behavior (Berger and Corbin 1992, Kinnear et al. 1974), producer/builder behavior (Koebel 2007, Koebel 2008, McCoy 2009, Slaughter 2000), and the performance characteristics of the product itself (Sani et al. 2005, Massawe et al. 2006, Akaranta 2000). Additionally, attempts have been made to catalogue the factors that affect diffusion of all residential construction product innovations (McCoy et al. 2009).

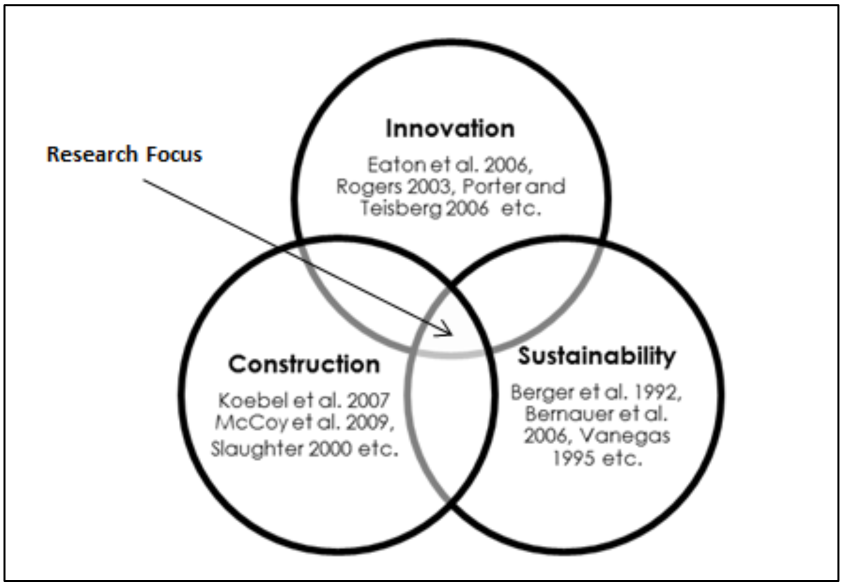

Figure 2 - Gap Analysis Venn Diagram

Previous literature has focused on each of three innovation types described by Thomas Bernauer, although construction products and specifically innovative green building products have not been addressed. Studying the attributes of these products, and how they act as barriers to adoption, fills the research gap identified in Figure 2. This study seeks to define the attributes of innovative green building products and define a research framework for classifying these attributes as either accelerators or barriers to green building product diffusion.

Current research has not fully identified barriers and accelerators of innovative green building products. This work answers gaps in the current knowledge through:

1. Defining the attributes of diffusion and adoption common to all innovative products.
2. Identifying resultant accelerators and barriers specific to the market for green building products utilizing a survey of EarthCraft home builders as a sample population and Structural Insulated Panels as a "control" product.
3. Proposing way that future research can validate this data through comparative product research.

4 Problem Statement/Objectives

Innovation research has primarily focused on product development from the perspective of the producer, called market push, or from the perspective of the consumer, called market pull (McCoy et al. 2009, Bernauer 2006, Langar 2009). This focus has analyzed demographic, attitudinal and behavioral correlates of green innovation, but has overlooked the specific attributes of innovative green products as accelerators or barriers to diffusion. According to Theodore C. Koebel, "the builder, more than any other firm decides how to balance the characteristics of supply against market demand. However, it is difficult for builders to appropriate the benefits of innovation for themselves, given their place in the production process" (Koebel 2008). Previous research from the authors has defined innovative product attributes and the present study seeks to test and validate them. The goal of this validation is to increase the diffusion of these products into the marketplace by identifying barriers and accelerators to adoption.

A working definition of what constitutes an “innovative green product” will be necessary to successfully conduct this study. Our approach will be to distill a definition from those currently existing in the literature and building on Thomas Bernauer’s definitions discussed in the previous section. According to the OECD, “environmental innovation encompasses all innovations that have a beneficial effect on the environment regardless of whether this effect was the main objective of the innovation (OECD 2008). Williander further qualifies this as “when it is competitive in the marketplace and is profitable for the innovating firm” (Williander 2006). Bernauer defines a green product as aiming to reduce “environmental impacts during a product’s entire life-cycle (cradle to grave)” (Bernauer 2006). This will serve as the basis for our definition of an innovative green product.

Environmental Building News, a clearinghouse for green construction techniques, materials and innovations, has compiled a list of attributes of green building products. These attributes are as follows:

1. Contains salvaged, recycled or agricultural waste content
2. Conserves natural resources
3. Avoids toxic or other emissions
4. Saves energy or water
5. Contributes to a safe and healthy work environment

Therefore, our working definition of an innovative green product is: “an innovative green product has a beneficial effect on the environment with respect to the life-cycle of impacts of the product, contains salvaged, recycled or agricultural waste content, conserves natural resources, avoids toxic or other emissions, saves energy or water, or contributes to a safe and healthy work environment, regardless of whether this effect was the main objective of the product.”

4.1 Structural Insulated Panels

Toolbase.org defines Structural Insulated Panels as “panels made from a thick layer of foam (polystyrene or polyurethane) sandwiched between two layers of Oriented Strand Board (OSB), plywood or fiber-cement. As an alternative to the foam core, SIPs are available with a core of agriculture fibers (such as wheat straw) that provides similar thermal and structural performance. The result is an engineered panel that provides structural framing, insulation, and exterior sheathing in a solid, one-piece component”. This study has chosen to focus on Structural Insulated Panels as a model innovative green building product.

SIPs have been categorized as innovative by leading researchers as well as industry associations. The Partnership for Advanced Technologies in Housing (PATH) also includes SIPS in its database of innovative residential building materials at Toolbase.org. According to the Structural Insulated Panel Association, SIPs are currently incorporated into 1-2% of new residential construction projects, which classifies it as innovative on the adopter categorization scale developed by Rogers (Figure 3). Additionally, Sarah Slaughter's work has extensively studied SIPs as a source of construction innovation (Slaughter 1998).

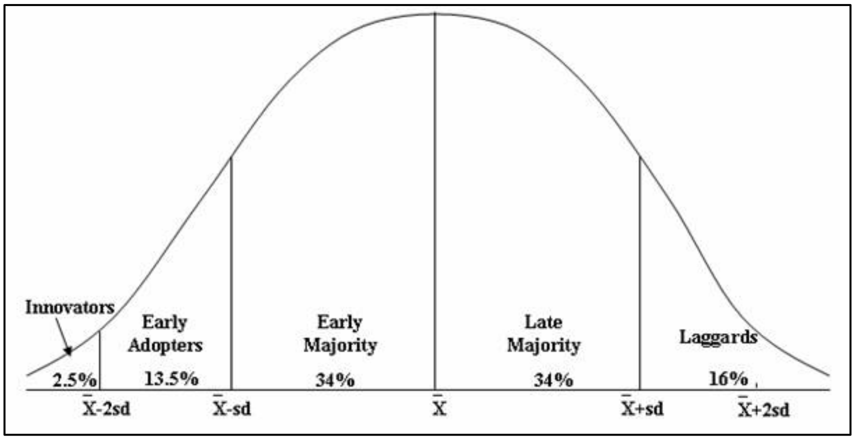

Figure 3 - Rogers, E. M. (2003). *Diffusion of Innovations (5th ed.).* Free Press, New York, NY.

"Sandwich Panel Technology" first appeared in the construction industry through research by the Forest Products Laboratory in Madison, Wisconsin in the 1930's. Engineers at the lab speculated that wall sheathing could take a portion of the structural load and reduce the amount of framing material in a wall. Frank Lloyd Wright experimented with this technology in residential applications in the 1930's and 40's as a way to increase construction efficiency and reduce price for his custom homes. Wright's panels lacked robust thermal properties and thus never caught on as a building material (Federation of American Scientists 2010).

The first true Structural Insulated Panel was produced by Alden B. Dow in the 1950's as a way to increase home energy efficiency and reduce natural resource consumption. However, due to low energy prices and resistance from trade associations, the diffusion of SIPS in the broader home building market was drastically retarded. SIPs were revived as a green building product in the 1990's and 2000's due to increased focus on energy efficiency, and they have continued to gain market share with new designs and applications (Federation of American Scientists 2010).

From this information we derive our primary research question for this study:

- *Do SIPS have barriers to adoption similar to those of general innovation?*

4.2 Innovative Product Attributes

This study compiles a list of factors affecting innovative product diffusion in the residential construction industry (Figure 4). Factors specific to residential green building products have been distilled through the previous literature review. Rogers' work assigned the following attributes of innovation: *Relative Advantage, Compatibility, Complexity, Trialability and Observability* (Rogers 2003). Sarah Slaughter studied product attributes and added several for construction settings: *Incremental, Radical, Modular, Architectural, System, Timing of Commitment, Coordination, Special Resources and Nature of Supervision* (Slaughter 1998). Others have expanded product attributes for the construction setting as well in an attempt to facilitate their acceptance (Koebel and McCoy, 2006). This study therefore derives its attributes of innovative green building products through the following terms (see Appendix B for a comprehensive reference list):

- *Timing of Commitment:* Timing or flexibility with implementation of the product during the construction schedule
- *Compatibility:* Congruency with the habits of users or existing products
- *Supporting Innovation:* Innovations that require other innovations to make them compatible
- *Complexity/ Simplicity:* The products' ability to be understood by users
- *Trialability:* Ability to experiment without risk
- *Observability:* Product visibility within the marketplace
- *Cost Advantage/ Relative Advantage:* Cost/Relative benefit to using the product as opposed to traditional products
- *Risks:* Impact of negative consequences for using the product
- *Supervision Competency:* Experience or education/training required to use or install the product
- *Consumer Resistance (End User):* Opposition originates that from the consumer (individual-based)
- *Trade Resistance:* Opposition that originates from trades (organization-based)
- *Regulatory Resistance:* Opposition that originates from government organizations (authority-based)
- *Coordination Within the Project Team:* Synchronization of various stakeholders is required for implementation

5 Thesis Question

Do SIPS have barriers to adoption similar to those of general innovation?

6 Methodology

To develop a deeper understanding of the previously developed innovation attributes as they apply to residential green building products field research will be necessary. The authors have chosen to implement a survey tool around these attributes for dissemination to a population of residential home builders. A control product, Structural Insulated Panels, will be used to reduce the amount of data collection necessary, and a control group, EarthCraft Virginia builders, has been targeted for survey delivery. The process outlined in this section will serve as a foundation for future research of other innovative green building products and builder populations. Figure 4 outlines the

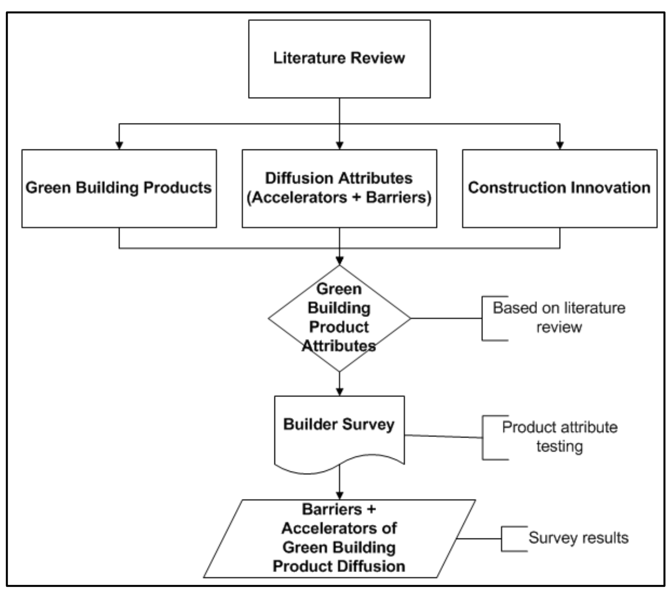

Figure 4 – Research Methodology Diagram

methodology used in this study.

6.1 Survey Development

With these attributes of innovative green building products in mind, a survey has been developed to validate their correlation to the adoption of Structural Insulated Panel Systems. The survey will be guided by the Tailored Design Method, a "development of survey procedures that create respondent trust and perceptions of increased rewards and reduced costs for being a respondent, which take into account features of the survey situation and have as their goal the overall reduction of survey error" (Dillman 2000). The Tailored Design Method will call for a thorough evaluation of survey design and question wording as well as a strategic approach to soliciting responses from the target respondent population. This approach will allow the greatest chance of conducting a successful survey of residential builders.

The sample pool will be asked to rate the previously defined green product attributes as barriers or accelerators to adoption of SIPS and to further qualify these answers utilizing a Likert scale response model (Robson 2002). Additionally, the timing of adoption of SIPs will be analyzed to explore correlation between perceived attributes and location on the adoption curve. Based on the responses of builders to the selected product attributes, a pattern will emerge to describe which of the product attributes are significant barriers to diffusion, which by implication, offers opportunities to accelerate adoption by reducing the barriers. It is also possible that certain attributes will be neither accelerators nor barriers, in which case they can be discarded as significant in the development of innovative green building products.

Qualtrix is the chosen survey tool for this study. The software is free to academia and provides numerous was to create, format, and design questions. The questions on the survey will be divided into three sections; general demographic information, SIPs usage information, and the diffusion factors of Sips. These categories will allow us to make comparisons and draw conclusions between demographic and SIP usage information to a company's SIP adoption attributes. The robustness of these correlations will ultimately depend on the sample size of the survey.

6.2 Data Collection

The goal of successful survey research is to draw conclusions about a given target population based on information gathered from an appropriate sample population. The homebuilding industry is characterized by a large number of small custom and semi-custom home builders that account for a small portion of total housing starts per year. A good housing industry profile has been developed by Ted Koebel, in which he uses U.S Census Bureau data to show that firms that build less than 25 houses per year account for 90% of the total homebuilders in the U.S, but the top 10% of firms that build more than 25 houses per year account for roughly 66% of total housing starts per year (Koebel et. Al 2003). These statistics show that the industry is characterized by numerous small firms that have low payroll numbers and construct a small number of houses per year. Therefore, a survey targeted at the largest number of homebuilders may not necessarily reflect the majority of production in the industry.

There are several options for data collection that have been explored as part of this research. The best resource for reaching large home builders and obtaining an appropriate response rate for a survey would be the National Association of Home Builders (NAHB). The NAHB is an extensive national network of residential builders and maintains frequent contact with all member organizations. Data provided by the NAHB could be used to develop a list of large residential home builders and surveys could be sent directly to appropriate employees at these firms. NAHB sponsored events such as the International Builders Show could be fertile ground for soliciting survey responses from residential builders. The authors' connections at the NAHB's Research Center have shown this to be a promising objective.

The United States Green Building Council is a second potential resource for survey development and delivery. The USGBC administers the LEED for Homes rating system and maintains a database of builders who have certified LEED projects. The USGBC and its associated chapters and events are a potential partner in delivering a survey to residential builders. Builders associated with the USBGC would also be more likely to employ innovative green building products in their projects and therefore be more effective in the survey. The drawback to using the USGBC as a potential survey diffusion tool is its primary focus on commercial construction as well as its relatively dense bureaucratic procedures that would add significant time to survey diffusion and data collection.

Therefore, the most plausible option for survey delivery utilizes Southface Energy Institute in Atlanta, Georgia. Southface administers the EarthCraft building rating system and has relationships with green home builders throughout the southeast, with especially strong representation in Georgia and Virginia. Southface organizes builder trainings in which contractors spend the day learning about EarthCraft and the benefits of green building, and maintains extensive lists of EarthCraft certified builders in the Southeast region (Appendix C). These builder lists provide a central point of data gathering from contractors with interest in green building that have likely had experience using SIPs. Chuck Bowles of EarthCraft Virginia has agreed to assist in disseminating the survey to his network of builders.

7 Data Collection

7.1 Survey Population

The survey population for this study consists exclusively of residential constructors who have attended an EarthCraft Builder training through EarthCraft Virginia. Contact information for approximately 150 builders is listed on the EarthCraft Virginia website which was then extracted to populate the contact list in Appendix C of this report. Specifically targeting EarthCraft builders for this survey increases the likelihood of response as well as familiarity with green building systems such as Structural Insulated Panels. Of the 150 survey contacts, 35 total responses were gathered yielding a response rate of twenty-one percent (23%). All survey respondents are based in, or have significant operations in the state of Virginia.

Survey Population	Total Respondents	Response Rate
150	35	23.3%

Figure 5: Survey Response Rate

7.2 Section I - Demographics

1. When asked "What type of housing does your company primarily build?" eighty-eight percent (88%) of the total survey population reported 'single-family detached', nine percent (9%) responded 'single-family attached' and three percent (3%) responded 'multifamily' (Figure 6).

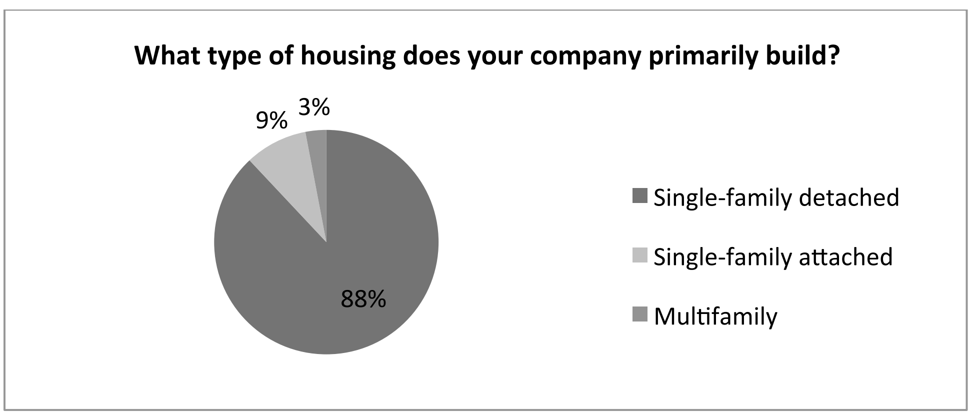

Figure 6: Demographics - Construction Type

2. Question 2 asked respondents "In what state(s) does your company primarily operate in". Being that this survey was administered to EarthCraft Virginia builders, one-hundred percent (100%) of respondents answered "Virginia".

3. When asked “What is your role in the company?” forty-three percent (43%) of the total survey population responded ‘president’, twenty-nine percent (29%) responded ‘owner’, seventeen percent (17%) responded ‘other’, and eleven percent (11%) responded ‘project manager’ (Figure 7). One respondent even manually entered ‘grand poobah’.

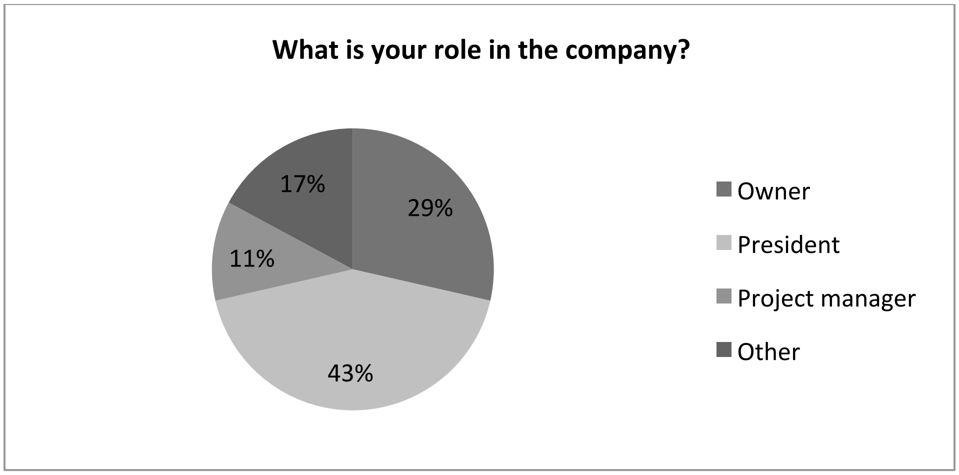

Figure 7: Demographics - Company Role

4. When asked “Approximately how many years have you worked for your current employer?” responses ranged from two to thirty-five years. Figure 8 shows the distribution of respondents for this question.

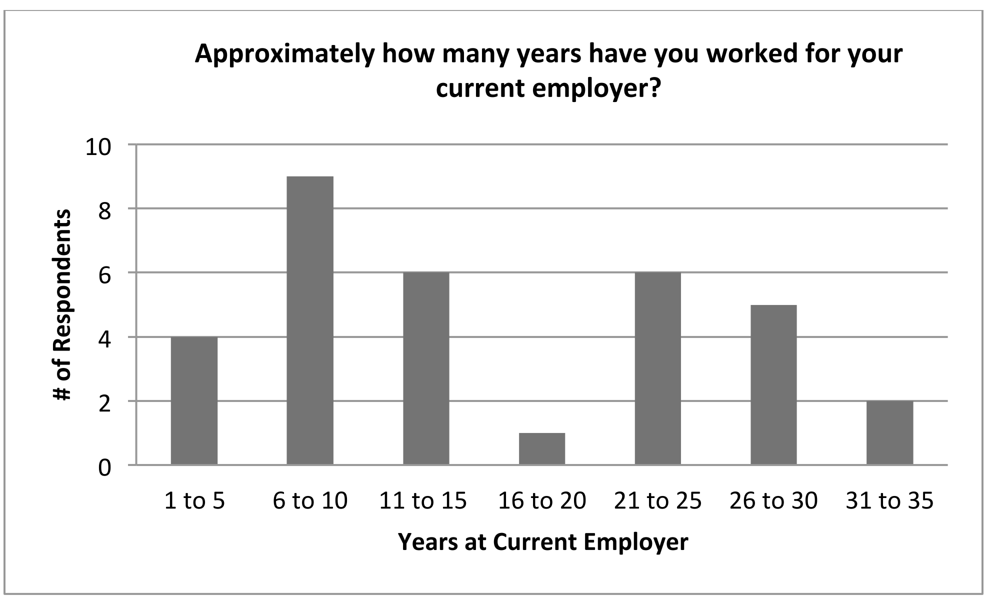

Figure 8: Demographics - Years at Current Employer

5. Responses ranged from one to forty years of experience when the survey population was asked "Approximately how many years have you worked in the residential construction industry?" The following bar chart shows the age distribution of the survey sample in five year increments.

Figure 9: Demographics - Age Distribution

6. When asked "Which market does your company primarily serve?" three percent (3%) responded 'production', twenty-four percent (24%) responded 'semi-custom', seventy-four percent (74%) responded 'custom', and zero percent (0%) responded 'modular'.

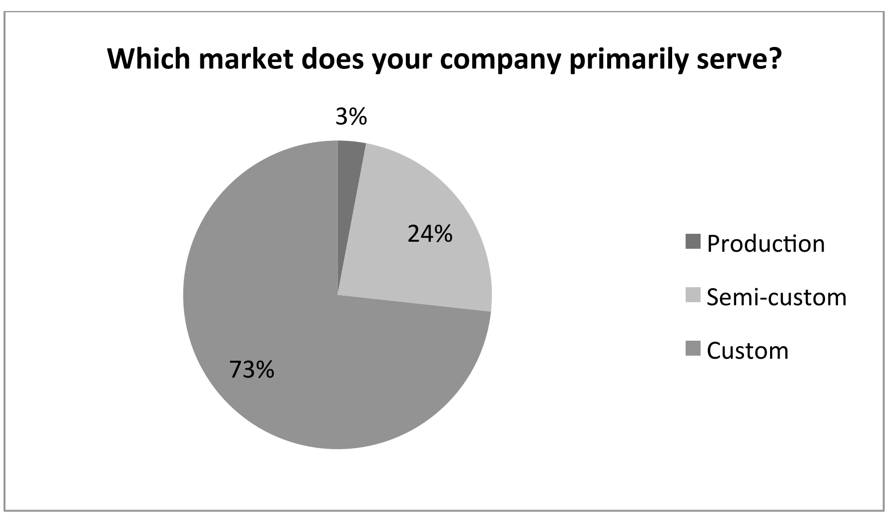

Figure 10: Demographics - Market Segments

7. The following chart shows the response distribution when asked "How many full-time employees does your company have?" The responses ranged from zero to forty.

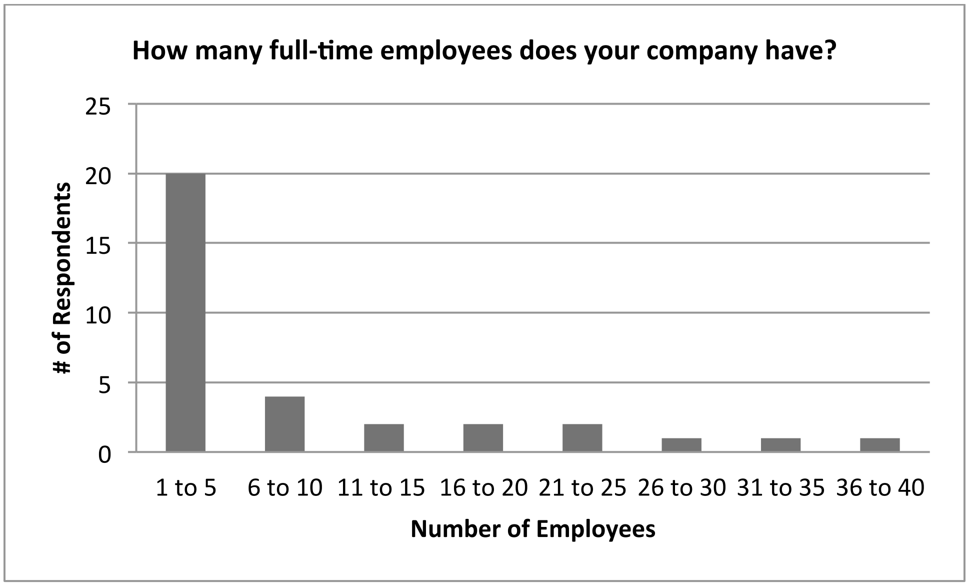

Figure 11: Demographics - Full-time Employees

8. The following chart shows the response distribution when asked "Approximately how many housing units does your company build per year?" The responses ranged from 0 to one hundred fifty housing units per year.

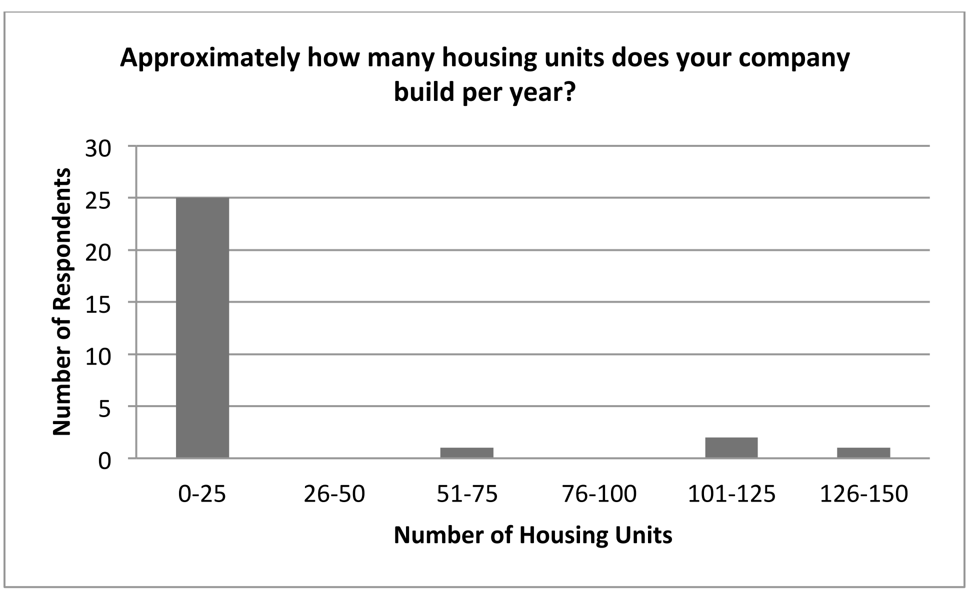

Figure 12: Demographics - Production

9. When asked “How would you describe the innovativeness of your company?” forty percent (40%) responded ‘I value new technology’, thirty-six percent (36%) ‘I pursue new technology’, twenty-four percent (24%) responded ‘I consider new technology’, and zero percent (0%) responded ‘I see little value in new technology’ or ‘I resist new technology’.

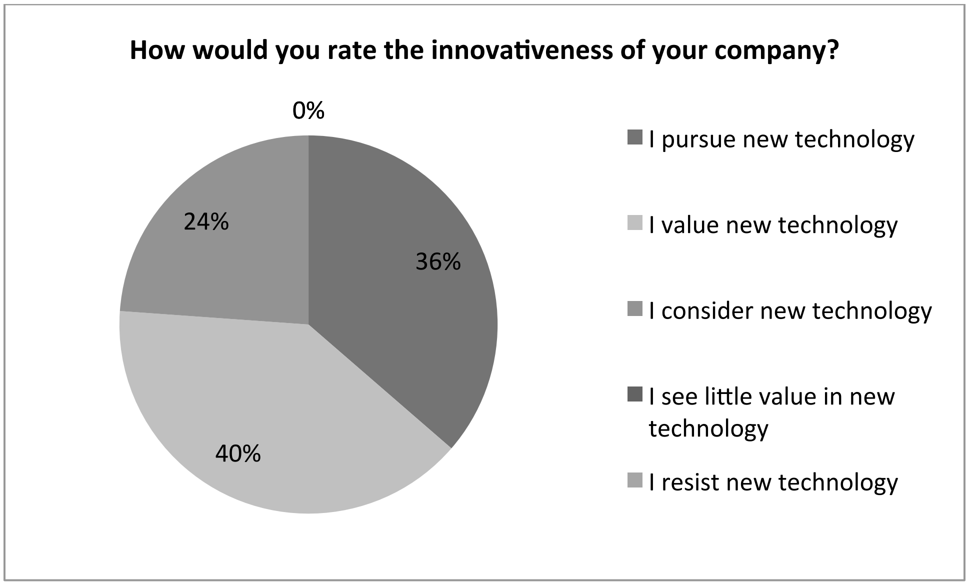

Figure 13: Demographics - Company Innovativeness

7.3 Section II – Structural Insulated Panel Systems Experience

10. When asked "Has your company ever implemented SIPS in a building project?" forty-four percent (44%) of respondents answered 'Yes' and fifty-six percent (56%) of respondents answered 'No'. The 15 affirmative responses to this question represents 10% of the total survey population.

#	Answer		Response	%
1	Yes		15	44%
2	No		19	56%
	Total		34	100%

Figure14: SIPS – Adoption

11. When survey respondents answered "No" to the previous question, they would be prompted to answer question 11: "Please describe the reasons why you have not tried using SIPS". Respondents were allowed a short answer for this question, with the following responses submitted:

Please describe the reasons why you have not tried using SIPS
Not a spec item for our spec houses, have not had a customer ask for the product either
Have not had the custom build opportunity to try with an owners request
dont no
Higher cost
Not prevalent in this area, lack of properly trained subcontractors
Price prohibitive to compete in the market.
Cost and not familiar with process
cost benefit has not been shown to work for a custom home.
Have not discussed pros of usage with a local sales rep.
don't know
I went one step further and have started building ICF houses.
No client demand.
We are primarily customer driven. Our customers have not really brought us a sips product. The one sips project we were involved with never got past conceptual design.
Cost, learning curve for subs and self, Clients generally do not understand the value added cost
Haven't had any clients who were interested in pursuing SIPs. The closest thing we have used has been Superior Wall concrete wall panels for foundations.
High level of customization in recent years. SIPs will be considered in upcoming 300+ unit multifamily community.
cost
It may not be true, but the belief that when I am done the cost will be higher than the current method of construction.
not cost effective

Figure15: SIPS - Reasons for not Adopting

12. Question 12, "In what year did your company first try using SIPS?" was omitted from the survey due to a technical error.

At this point in the survey, respondents would either continue with question 13 or skip to question 17 depending on an affirmative or negative answer to question 11. The data for questions 13-16 is based on 15 respondents who answered affirmatively to question 13: "Have you ever implemented SIPS in a building project?" These 15 respondents represent 10% of the total survey population.

13. When asked "In approximately how many projects does your company currently use SIPS?" the responses ranged from zero to ten, and figure 16 shows the distribution:

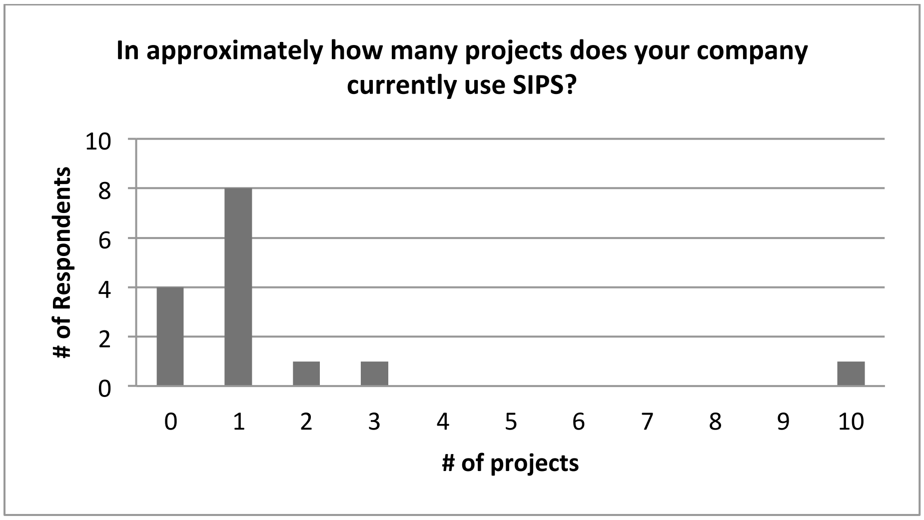

Figure16: SIPS – Current Project Use

There was a wide range of short-answer responses when participants were asked "If your company has tried using SIPS and discontinued their use, please describe the reasons why". Figure 17, below, shows these answers as they were submitted to the online survey tool.

If your company has tried using SIPS and discontinued their use, please describe the reasons why:
should be "discontinued" their use, not discounted
Haven't had an appropriate project recently
We use as circumstances indicate.
SIPs were implemented with designated funding on a joint project with UVA. Superior Walls were preferred in basement construction because of their simple basement finishing features (already studded and insulated).
The use is based on owner requirements. Usually cost deter them away.
We used it on timber frame house as the exterior skin and roof
It was a request by the customer; to expensive to use
no new starts
expense

Figure17: SIPS – Discontinued Use

14. This question asked respondents to rate the barriers/accelerators of diffusion of SIPS. "This section is concerned with diffusion factors of SIPs. The authors have identified 13 industry accepted "diffusion factors", which have been listed below. On a scale from 1-5 (1 being does not affect and 5 being strongly affects), please rate each diffusion factor as it relates to your company's first trial, and continued use of Structural Insulated Panel Systems. First trial is defined as your company's first use of SIPs, and continued use is defined as the point at which you decided to incorporate SIPs into your construction methods on a continued basis. Please refer to the survey instructions for definitions of the diffusion factors in the following section. The response distribution is shown below.

#	Question	Does not affect adoption				Strongly Affects Adoption	Responses	Mean
1	Timing of Commitment: First Trial	3	0	6	1	0	10	2.50
2	Continued Usage	2	2	2	3	0	9	2.67
3	Compatibility: First Trial	0	2	1	6	1	10	3.60
4	Continued Usage	0	1	2	5	1	9	3.67
5	Supporting Innovation: First Trial	0	1	4	2	3	10	3.70
6	Continued Usage	0	1	3	4	1	9	3.56
7	Complexity: First Trial	0	1	4	4	1	10	3.50
8	Continued Usage	0	1	3	4	1	9	3.56
9	Trialability: First Trial	1	1	6	1	1	10	3.00
10	Continued Usage	1	1	4	2	1	9	3.11
11	Observability: First Trial	1	0	4	5	0	10	3.30
12	Continued Usage	1	1	2	4	1	9	3.33
13	Relative Advantage/Cost Advantage: First Trial	0	1	2	4	3	10	3.90
14	Continued Usage	0	2	1	4	2	9	3.67
15	Risks: First Trial	1	0	1	5	3	10	3.90
16	Continued Usage	0	0	4	2	2	8	3.75
17	Supervision Competency: First Trial	0	1	5	1	2	9	3.44
18	Continued Usage	0	2	2	4	0	8	3.25
19	Consumer Resistance: First Trial	1	2	1	3	2	9	3.33
20	Continued Usage	0	1	1	5	1	8	3.75
21	Trade Resistance: First Trial	2	1	4	1	1	9	2.78
22	Continued Usage	2	1	3	1	1	8	2.75
23	Regulatory Resistance: First Trial	1	1	4	2	1	9	3.11
24	Continued Usage	0	2	4	1	1	8	3.13
25	Coordination within Project Team: First Trial	0	0	4	5	0	9	3.56
26	Continued Usage	0	1	4	3	0	8	3.25

Figure 18: SIPS – Diffusion Attributes

15. Respondents were given the chance to identify any other factors affecting the adoption of SIPS with question 16: “Please add any unmentioned factors which may have affected your company’s adoption of Structural Insulated Panels.” The following short answer responses were given:

Please add any unmentioned factors which may have affected your company’s adoption of SIPS
Our supplier will also install for a reasonable fee. That makes all the difference in choosing SIPS. They have the expertise and can construct a project much faster than local craftspeople.
We are a design-build firm and it all depends on what the customer wants. We try to acquaint the client with technology advances and then let him make the decision.
WE build custom homes so we need buy in from the client.
This is largely determined by architects we work with. I feel that once in place SIPS is less flexible for renovation (openings, wiring, etc.) than conventional framing.

Figure 19: SIPS – Unmentioned Adoption Factors

16. The final survey question asked “Would you like to receive the results of this study upon completion. Eighty-two percent (82%) of respondents answered ‘Yes’ and eighteen percent (18%) of respondents answered ‘No’.

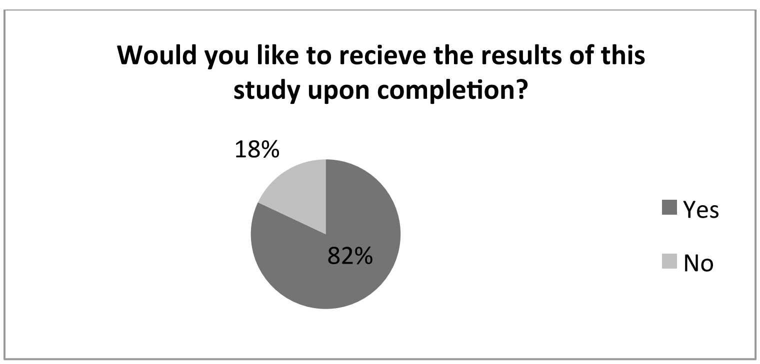

Figure 20: SIPS – Results of Study

8 Data Analysis

The data collected in this study offers some exciting and surprising insights into the diffusion factors of Structural Insulated Panels, and residential green building products in general. The survey population provided a rich set of data that paints a relatively accurate picture of the adoption attributes of structural insulated panels in Virginia. Research suggests that this sample population is representative of the target population of small custom and semi-custom homebuilders nationwide. A discussion of the survey demographics is necessary before diving into the innovation attributes data.

8.1 Demographics

The survey data represents a specific slice of the residential construction market. First and foremost, it is important to note that the survey respondents represent builders that have already shown initiative in seeking green building methods by taking an EarthCraft training course. The respondents also represent custom and semi -custom (97%) builders of single-family detached homes (88%). Single family custom and semi-custom home builders represent a large portion of the residential construction market, but in general do not have the individual capacity for research and development, and tend to be more sensitive to market fluctuations than the production builders that are diversified across geographic locations. Custom and semi-custom home builders also tend to have closer working relationships with their clients, and are able to respond quicker to changing consumer demands. These builders are small “mom and pop” organizations and often have very small payrolls (57% of respondents had fiver or less employees). The survey data comprises entirely of responses from upper management, owners, and presidents of the companies represented.

Demographic Attribute	Average Descriptor
Company Size	<5 employees
Market Segment	Custom to semi-custom single family detached
Housing Units Constructed Per Year	<25
Years of Experience	6-35 years

Figure 21 – Respondent General Demographic Profile

Theodore C. Koebel describes the national homebuilding market as typified by “small firms that produce only a few homes using their own crews or subcontractors” (Koebel 2008). Similar research also suggests that the homebuilding market is becoming more consolidated among large production homebuilders. In 2005, the top 100 national homebuilders captured 37% of the new home sales market (Koebel 2008). While this consolidation is projected to continue over time, small homebuilding operations seem to currently capture about 63% of the national market. The authors believe that the current statistical observations can be applied to this national group of small homebuilders.

The builders represented in the survey have varying degrees of experience in the residential construction industry (1-40 years), and have often worked at their respective companies for numerous years (37% of respondents had from 21-35 years of experience with their current employers). These builders rarely build more than 25 housing units per year, and often build much less. Many survey respondents thought of themselves as innovators and early adopters, and early majority according to the innovativeness index developed by Everett Rogers (see Figure 3, page 10). Zero percent of the survey population considered themselves in the late majority or laggards in terms of the adoption of innovative products. This predisposition to the adoption of new products is characteristic of the entrepreneurial spirit embodied by small business owners.

8.2 Structural Insulated Panels

A large portion of the survey focused on respondent's adoption of structural insulated panel systems. Fifteen respondents reported ever implementing SIPS in a building project, representing 44% of the survey respondents and 10% of the total survey population. These fifteen respondents form the meat of the innovation attributes analysis presented in the next section. The respondents that did not report ever using SIPS in a building project were asked to list reasons why. These respondents listed higher cost (36.8%), client resistance (31.5%), and lack of product information (21%) as the primary barriers to adoption. Other issues cited were lack of prevalence in the area, lack of properly trained subcontractors, and a lack of push by local sales representatives.

Respondents that had tried using SIPS but discontinued their use were also asked to list reasons why. The primary reasons cited were cost and client demand. Most builders indicated a willingness to use SIPS if a customer demanded their use, but expressed difficulty promoting them as a superior or green building product. Almost all respondents reported using SIPS in either 0 or 1 current building project, reflecting the small market penetration that SIPS have achieved in current years.

Most of these issues can be assigned to one of the identified "innovation attributes" from the literature, however, respondents that did not report ever using SIPS in a residential construction project were prohibited from rating the adoption attributes of SIPS. In hindsight, the builders that reported not using SIPS seemed to have some knowledge of the product and have made considered decisions against implementation. In future studies, these builders should be included in the full set of survey questions to aid in gathering a richer set of data.

8.3 Adoption Attributes of Structural Insulated Panel Systems (First Trial)

The heart of the survey, and goal of this study was to identify the factors affecting the adoption of innovative green building products and gauge their acceleration or resistance of that adoption. The survey asked respondents to rate whether each identified diffusion factor affects adoption on a Likert scale with 1 indicating "does not affect adoption" and 5 indicating "strongly affects adoption". The survey asked them to rate each of these factors upon initial adoption and continued use in order to explore timing of adoption issues (Figures 22 and 23).

Figure 22 presents a box plot comparison of the Likert Scale data on innovation attributes collected in the EarthCraft builders survey (Figure 18, page 21). This figure is the culmination of the study and combines all of the previous research of this report into a single set of data. Graphically presenting the descriptive statistics of this data allows for visual comparison of each attribute across multiple statistics and also allows for more in-depth conclusions to be drawn from the data. The survey asked respondents to rate each product attribute on a scale from 1 to 5, with 1 being "does not affect adoption" and 5 being "strongly affects adoption". Considering the collective responses of each attribute allows us to develop a picture of each attribute's effect on the adoption of SIPS. The following data was derived from the survey respondents to question 14 of the survey:

1. Timing of Commitment – Timing of commitment had a response range of 1 to 4 with a median of 3 and a mean of 2.5. The first quartile was 1 and the 3rd quartile was 3, indicating an interquartile range of 2.
2. Compatibility – Compatibility had a response range of 2 to 5 with a median of 4 and a mean of 3.6. The first quartile was 2.75 and the third quartile was 4, indicating an interquartile range of 1.25.
3. Supporting Innovation – Supporting innovation had a response range of 2 to 5 with a median of 3.5 and a mean of 3.7. The first quartile was 3 and the third quartile was 5, indicating an interquartile range of 2.
4. Complexity – Complexity had a response range of 2 to five with a median of 3.5 and a mean of 3.5. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.
5. Trialability – Trialability had a response range of 2 to 4, with a median of 3 and a mean of 3. The first quartile was 2.75 and the third quartile was 3.25, indicating an interquartile range of 0.5.
6. Observability – Observability had a range of 3 to 4 with a median of 3.5 and a mean of 3.3. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.
7. Relative Advantage – Relative advantage had a range of 2 to five with a median of 4 and a mean of 3.9. The first quartile was 3 and the third quartile was 5, indicating an interquartile range of 2.
8. Risks – Risks had a range of 3 to 5 with a median of 4 and a mean of 3.89. The first quartile was 3.5 and the third quartile was 5, indicating an interquartile range of 1.5.
9. Supervision Competency – Supervision competency had a range of 2 to 5 with a median of 3 and a mean of 3.44. The first quartile was 3 and the third quartile was 4.5, indicating an interquartile range of 1.5.
10. Consumer Resistance – Consumer resistance had a range of 1 to 5 with a median of 4 and a mean of 3.44. The first quartile was 2 and the third quartile was 5, indicating an interquartile range of 3.
11. Trade Resistance – Trade resistance had a range of 1 to 5 with a median of 3 and mean of 2.78. The first quartile was 1.5 and the third quartile was 3.5, indicating an interquartile range of 2.
12. Regulatory Resistance – Regulatory resistance had a response range of 1 to 5 with a median of 3 and a mean of 3.11. The first quartile was 2.5 and the third quartile was 4, indicating an interquartile range of 1.5.
13. Coordination Within Project Team – Coordination within project team had a range of 3 to 4, with a median of 3.5 and a mean of 3.5. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.

Each attribute garnered a variety of responses from the survey population. Figure 22, below, compares this data across attributes and helps us understand which attributes are perceived as having a greater effect on the adoption of SIPS. The box plot allows us to see clustering of statistical information and "consensus" forming among survey respondents.

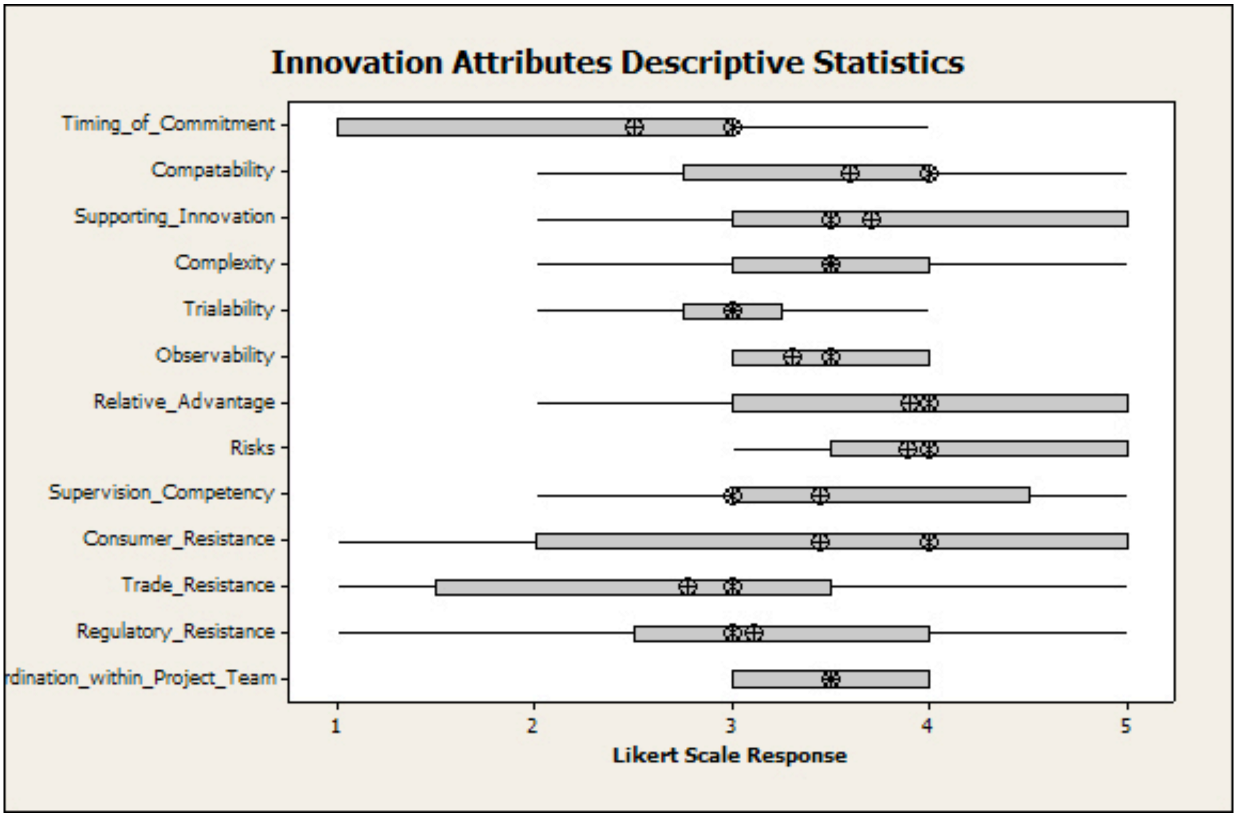

Figure 22 – Innovation Attributes Descriptive Statistics

8.4 Adoption Attributes of Structural Insulated Panel Systems (Continued Use)

Figure 23 presents a box plot comparison of the Likert Scale data on innovation attributes collected in the EarthCraft builders survey (Figure 18, page 21). The following data represents respondents rating of each product factor as it affects the continued use of Structural Insulated Panels:

1. Timing of Commitment – Timing of commitment had a response range of 1 to 4 with a median of 3 and a mean of 2.67. The first quartile was 1.5 and the 3rd quartile was 4, indicating an interquartile range of 2.5.
2. Compatibility – Compatibility had a response range of 2 to 5 with a median of 4 and a mean of 3.6. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.
3. Supporting Innovation – Supporting innovation had a response range of 2 to 5 with a median of 4 and a mean of 3.5. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.

4. Complexity – Complexity had a response range of 2 to 5 with a median of 4 and a mean of 3.5. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.
5. Trialability – Trialability had a response range of 1 to 5, with a median of 3 and a mean of 3.11. The first quartile was 2.5 and the third quartile was 4, indicating an interquartile range of 1.5.
6. Observability – Observability had a range of 1 to 5 with a median of 4 and a mean of 3.3. The first quartile was 2.5 and the third quartile was 4, indicating an interquartile range of 1.5.
7. Relative Advantage – Relative advantage had a range of 2 to 5 with a median of 4 and a mean of 3.66. The first quartile was 2.5 and the third quartile was 4.5, indicating an interquartile range of 2.
8. Risks – Risks had a range of 3 to 5 with a median of 3.5 and a mean of 3.75. The first quartile was 3 and the third quartile was 4.75, indicating an interquartile range of 1.75.
9. Supervision Competency – Supervision competency had a range of 2 to 4 with a median of 3.5 and a mean of 3.25. The first quartile was 2.25 and the third quartile was 4, indicating an interquartile range of 1.75.
10. Consumer Resistance – Consumer resistance had a range of 3 to 5 with a median of 4 and a mean of 3.75. The first quartile was 3.25 and the third quartile was 4, indicating an interquartile range of 0.75.
11. Trade Resistance – Trade resistance had a range of 1 to 5 with a median of 3 and mean of 2.75. The first quartile was 1.25 and the third quartile was 3.75, indicating an interquartile range of 2.5.
12. Regulatory Resistance – Regulatory resistance had a response range of 2 to 5 with a median of 3 and a mean of 3.25. The first quartile was 2.25 and the third quartile was 3.75, indicating an interquartile range of 1.5.
13. Coordination Within Project Team – Coordination within project team had a range of 2 to 4, with a median of 3 and a mean of 3.25. The first quartile was 3 and the third quartile was 4, indicating an interquartile range of 1.

Each attribute garnered a variety of responses from the survey population. Figure 23, on page 26, compares this data across attributes and helps us understand which attributes are perceived as having a greater effect on the adoption of SIPS for continued usage. The box plot allows us to see clustering of statistical information and “consensus” forming among survey respondents.

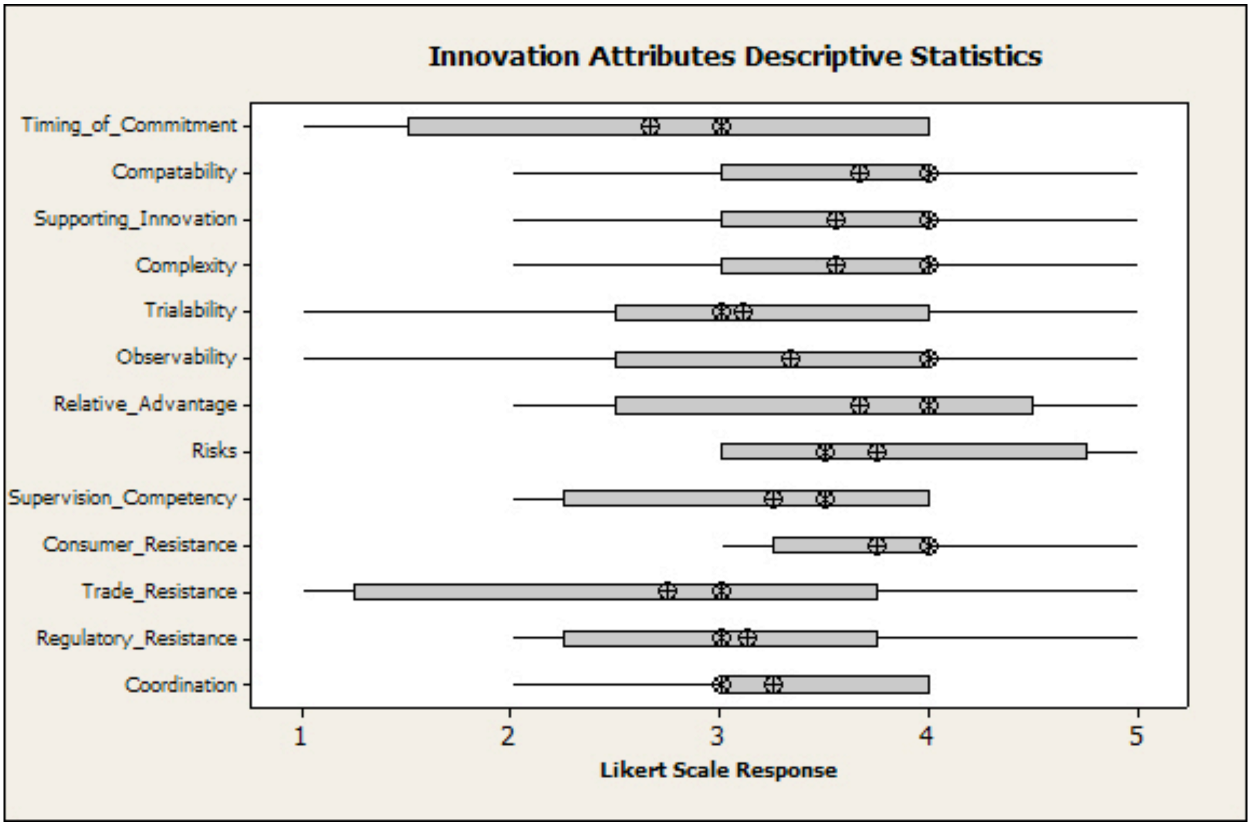

Figure 23 – Innovation Attributes (Continued Usage) Statistics

9 Conclusions

The sample population of EarthCraft builders in the state of Virginia is similar in makeup to the residential building industry in the United States in general. Therefore, the results of this study can be applied on a broader basis than just the population of respondents solicited for the survey. This statistically significant group of respondents shows several interesting characteristics and trends based on an analysis of the survey responses collected (section 8).

In general, the survey tool appears to provide an accurate accounting of perceived barriers to adoption of Structural Insulated Panels. Survey respondents provided meaningful feedback on their choices to adopt or not adopt SIPS, and were candid in their reasoning through the free response sections of the survey. The specific barriers that exerted the largest effect on adoption were supporting innovation, relative advantage and risks, while the barriers that exerted the smallest effect on adoption were regulatory resistance, trade resistance and trialability. Timing of commitment also scored relatively low on the diffusion factors chart, indicating a lack of concern by builders over when the SIPS product is adopted during the home production process. Product manufacturer/suppliers and builders can learn from these perceived barriers (or lack thereof) to inform the SIPS commercialization process and increase diffusion across the industry. The following sections (9.1 and 9.2) provide in-depth analysis of the diffusion factors analyzed by the survey.

9.1 – First Trial Conclusions

Regarding the attributes of innovation of SIPS upon first use, several trends can be derived from the descriptive statistics (Figure 22). The first observation is that timing of commitment, consumer resistance, trade resistance and regulatory resistance have the lowest rated effect on adoption. Trade and regulatory resistance is not much of a factor in the assembly of SIPS as both parties are reactive and do not affect the decision to adopt. Timing of commitment, however, is a surprise. The timing of commitment of SIPS is important in the building process as SIPS must be specified as early as possible to avoid affecting the work of other trades such as electricians and plumbers. The fact that builders rated it as having a relatively small effect on adoption is a substantial discovery. According to the data, timing of commitment is one of the smallest barriers to adoption of SIPS.

Supporting innovation, relative advantage and risks show the highest effect on adoption according to the survey results. Supporting innovation for SIPS was discussed by Sarah Slaughter as one of the primary sources of builder innovation on the jobsite due to the necessity to incorporate the panels into existing building systems (Slaughter 1993). Risks and relative advantage are identified as barriers to adoption for general green building innovation by Ted Koebel (Koebel 2008).   These innovation attributes can be thought of as the largest barriers to adoption of SIPS, which have been identified through the literature review and validated through the survey results.

Finally, an interested clustering of data has emerged around trialability, observability and coordination within the project team. The interquartile range for each of these attributes is 1 or less, indicating a consensus on the degree to which each attribute effects adoption. The mean score for observability and coordination within the project team was 3.5 while the mean score for trialability was 3. This clustering indicates that a large portion of survey respondents agree that these attributes relatively strongly affect adoption while not presenting as strong a barrier to adoption as the attributes discussed in the previous paragraph.

Interestingly, consumer resistance collected the widest range of responses from the survey pool. However, the mean of 4 indicates that it is considered to strongly effect adoption by a large portion of survey respondents. Lack of consumer demand was also identified by several builders as a reason for not adopting SIPS. This data seems to indicate that builders perceive consumer resistance as a large barrier to the adoption of SIPS.

9.2 – Continued Use Conclusions

Survey respondents were asked to rate the same list of innovation attributes upon continued adoption as well as first use. Comparing the descriptive statistics from each set of responses reveals some interesting trends. Some attributes reveal more clustered responses while other attributes trend upwards or downwards in regards to their effect on adoption. Timing of commitment, compatability, complexity, risks, supervision competency, trade resistance, regulatory resistance, and coordination within the project team all demonstrated little variance from their first use responses.

Supporting innovation and consumer resistance both exhibited a tighter clustering of responses, although both mean scores remained within 0.5 of their first use responses. Trialability and relative advantage both exhibit a shift in interquartile range, pointing to a more scattered response, but the mean response remains close in both instances. In general, the innovation attributes appear to have relatively similar effects on adoption for first trial and continued use applications.

10 Limitations

The conclusions that can be drawn from this study have potentially far-reaching effects on the adoption of innovative green products in the construction industry. However, a commentary of the limitations of this material is necessary to provide full disclosure and analysis of the research. The description of these limitations is not meant to challenge the validity of the work or the robustness of the conclusions and future work, but rather to fully disclose the nature of the work.

Firstly, it is necessary to discuss the nature of the study and its findings in terms of sample and target populations. As discussed in section 6 of the report, the author's intended target population is the residential construction industry. A fully comprehensive survey of the residential construction industry would take a random sample of all product developers and suppliers, all builder types, and all consumers of the end product. This sample would follow the supply chain of Structural Insulated panels from research and development through home operations. However, resource and time constraints within a university setting prohibited this scope of study. After much market research and discussions with expert researchers, it was decided that a more limited population be used as the sample population from which to draw larger conclusions about the industry as a whole.

The decision to focus on EarthCraft-certified home builders in the state of Virginia stemmed from discussions on how to solicit a statistically significant response rate from a sample population that is representative of the larger home building community in the United States and has experience with the subject product, Structural Insulated Panel Systems. EarthCraft Virginia keeps a comprehensive record of contact information for their registered builders and agreed to provide this information to the research team. These builders have demonstrated interest in green building products through their attendance of EarthCraft builder trainings and tend to exhibit demographic attributes similar to the larger building community (see section 8.1).

In addition to their demographic traits, a sample population of homebuilders was targeted because "the builder, more than any other firm, decides how to balance the characteristics of supply against market demand" (Koebel 2008). The builder's position at the center of the supply chain between manufacturers/suppliers and homeowners give them a broad perspective on the adoption of innovative new products. The builder is in a unique position to experience innovation from the supply side, "product push", or respond to client demand for new products, known as "demand pull". Builders also make their own innovation adoption decisions based on the perceived attributes of the product in question which forms the basis of this research. They are in the perfect position to comment on innovation adoption and can bring various perspectives to their analysis.

The second main limitation of the study is the survey tool itself. The development of surveys is a complex art that involves in-depth knowledge of research methodology, question structuring, and a healthy dose of people skills. The authors used their expertise to create a detailed survey with as few ambiguities as possible and piloted the survey to a small pool of academics. However, once the response collection began a few obvious weaknesses of the survey were uncovered. The primary issue facing the survey became the wording of the specific questions asked of the sample population. Although definitions of each innovation attribute were provided upon invitation to complete the survey, the definitions themselves leave room for some degree of ambiguity in response. For example, coordination within the project team is defined as "synchronization of various stakeholders is required for implementation". Are stakeholders restricted to the builder's project team (i.e. project manager, superintendent and subcontractors), or is a broader interpretation including the owner, architect, and end user more appropriate? This definition does not accurately define which stakeholders are in question and can therefore be interpreted in different ways by different survey respondents.

Another drawback of the survey design is its failure to include builders who had not used structural insulated panels in the analysis of the innovation attributes. These builders were prohibited from rating the attributes of SIPS upon a negative response to question #10, "has your company ever implemented SIPS in a building project?" These builders are likely aware of SIPS usage in the industry and could have, therefore, contributed meaningful feedback to the attributes of SIPS. In fact, the builders who have chosen not to use SIPS may be the best identifiers of barriers to adoption for the product. Future surveys should include these respondents in all sections of the survey. Question #12, "in what year did your company first try using SIPS?" was excluded from the survey due to technical issues that should be fixed in future studies. This question would have provided valuable feedback about SIPS adoption over time.

As a final note on survey response accuracy, it must be disclosed that a certain degree of sampling error can be expected within any quantitative research. Sampling error is defined as "differences between the sample and the population that exists only because of the observations that happened to be selected for the sample" (Keller and Warrack 2004). Sampling error can occur due to nonresponse, selection bias and non-sampling errors. These errors have been mitigated through the selection of the sample population, but further statistical analysis will reveal the probability that the sampling error is less than a certain amount.

11 Impacts and Future Work

"Using the attributes of the magnitude of the change and the linkages to other components and systems, companies can predict and plan for different types of activities depending upon the type of innovation involved." (Slaughter 1998)

Expanding Sarah Slaughter's logic to the comprehensive list of innovative green building product attributes developed in this study has allowed deeper understanding of the barriers to adoption of Structural Insulated Panel Systems. Each product attribute can be considered independently or as part of the whole. Identifying the barriers to adoption, such as the "consumer resistance" for SIPS will help identify which attributes of an innovative product are hindering its diffusion in the market. This information can be distributed throughout the product supply chain to realize a smoother transition from invention to innovation.

This study has established the framework for testing innovative product attributes through a specific stakeholder group, and has shown that barriers (or accelerators) of innovative products can be identified and quantified. Applying this study methodology to other green and non-green products will allow the comparison of attributes across products. This comparison will allow conclusions to be drawn as to whether innovative green building products demonstrate different barriers to adoption than other products, or if they are basically perceived as the same by builders. The reproduction of this study methodology is planned for future research projects at Virginia Tech. A comprehensive picture of barriers and accelorators to innovative green building products will ultimately shorten the diffusion period for environmentally friendly building products and help reduce the massive ecological footprint of the residential construction industry.

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- This paper identifies six primary factors driving or hindering construction innovation: clients and manufacturers, the structure of production, relationships between individuals and firms within the industry and between the industry and external parties, procurement systems, regulations/standards and the nature and quality of organizational resources. The review has shown that construction innovation is most usefully considered within a broad “product system” perspective. This is “firm perspective” of innovation in construction.

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- Exhaustive and thorough study.

Koebel, T., Papadakis, M., Hudson, E., and Cavell, M. (2003) “The Diffusion of Innovation in the Residential Building Industry.” Center for Housing Research, Virginia Polytechnic and State University. Blacksburg, VA.

- In light of many good reasons why the diffusion of innovations can have positive effects on the construction industry, this study was conducted to ascertain why innovations diffuse within the residential industry. The findings are then used to suggest possible ways to accelerate the technology adoption process. It is primarily a study of the builders market, in that it looks at how builders respond to certain attributes of innovative products.

Koebel, T. C. (2007). “Innovation in Homebuilding and the Future of Housing.” *Journal of the American Planning Association*. 74(1), 45-58.

- Homebuilding in the United States has historically been dominated by small builders (<200 homes/year), and has been characterized by sustaining innovations as opposed to disruptive, market changing innovation. This article argues that although homebuilders have good reasons to avoid the risks associated with innovation, planners can promote innovation with greater knowledge of the factors that contribute to it. Koebel identifies the risks associated with innovation and then discusses industry trends that are changing the previously dominant small-builder model.

McCoy, A.P. Badinelli, R., and Thabet, W. (2009). “The Role of Developer/Builders in the Concurrent Commercialization of Innovative Products for Residential Construction.” *European Journal of Innovation Management,* Vol. 12, No.1, pp.102-128.

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- In this paper, the authors review literature from previous commercialization models and establish the need for a domain specific model for residential construction. They then establish this model and test it with one case study. Part 2 of the study will further test the model and make the appropriate conclusions.

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- This study found that while new technologies and production processes could help overcome serious problems for housing producers, "realizing these benefits on a broad scale is considerably hindered by characteristics of the housing industry that inhibit the development and diffusion of innovations." The objective of this investigation is to make feasible recommendations for overcoming such barriers.

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- The purpose of this research is to demonstrate that not only does innovation occur in the construction industry to a much greater extent than is usually recognized, but that the sources of innovation are often the builders rather than the manufacturers of components and materials. The empirical research is based upon a detailed field study of the residential construction industry and focuses on a single major innovation in the construction of dwellings.

Slaughter, E.S. (1993b). "Innovation and Learning during Implementation: A Comparison of User and Manufacturer Innovations." *Research Policy*, 22, 81-95.

- In this research, Slaughter demonstrates that users who have relevant experience build upon their acquired learning to create innovations which differ significantly from those produced by manufacturers. She examines innovation during the implementation stage of a technology by drawing upon a detailed, field-based study of innovations in stressed skin panels in the residential construction industry. Similar report to 1993a.

Slaughter, E.S. (1998). "Models of Construction Innovation." *Journal of Construction Engineering and Management*, May/June, 226-231.

- The objective of this paper is to present five models of construction innovation, which can provide a basis upon which companies can select and implement the innovation.

Appendix A – SIPs Builder Survey

What type of housing does your company primarily build?

- Single-family detached
- Single-family attached
- Multifamily

YToxOntzOjc6IlF					
1		1|2|3	TE	SL	

In what state(s) does your company primarily operate?

1	QID3	1|2|3		SL	

What is your role in the company?

			TE	SL	

Approximately how many years have you worked for your current employer?

1	QID5	1|2|3	TE	SL	

Approximately how many years have you worked in the residential construction industry?

1	QID6	1|2|3|4	MC	SAVR	TX

Which market does your company primarily serve?

- Production
- Semi-custom
- Custom
- Modular

YToxOntzOjc6IlF					
1	QID7	1|2|3	TE	SL	

How many full-time employees does your company have?

1	QID9	1|2|3	TE	ML	

Approximately how many housing units does your company build per year?

1	QID10	1|2|3|4|5	MC	MAVR	TX

When it comes to new technology, the following best describes me (check all that apply):

- ☐ I pursue new technology
- ☐ I value new technology
- ☐ I consider new technology
- ☐ I see little value in new technology
- ☐ I resist new technology

Has your company ever implemented SIPs in a building project?

Yes No

In approximately how many projects does your company currently use SIPs?

1	QID15	1|2|3	TE	ML	

If your company has tried SIPs and discontinued their use, please describe the reasons why.

This section is concerned with diffusion factors of SIPs. The authors have identified 13 industry accepted "diffusion factors", which have been listed below. On a scale from 1-5 (1 being does not affect and 5 being strongly affects), please rate each diffusion factor as it relates to your company's first trial, and continued use of Structural Insulated Panel Systems. First trial is defined as your company's first use of SIPs, and continued use is defined as the point at which you decided to incorporate SIPs into your construction methods on a continued basis. Please refer to the survey instructions for definitions of the diffusion factors in the following section.

	Does not affect adoption				Strongly Affects Adoption
Timing of Commitment: First Trial	○	○	○	○	○

This section is concerned with diffusion factors of SIPs. The authors have identified 13 industry accepted "diffusion factors", which have been listed below. On a scale from 1-5 (1 being does not affect and 5 being strongly affects), please rate each diffusion factor as it relates to your company's first trial, and continued use of Structural Insulated Panel Systems. First trial is defined as your company's first use of SIPs, and continued use is defined as the point at which you decided to incorporate SIPs into your construction methods on a continued basis. Please refer to the survey instructions for definitions of the diffusion factors in the following section.

	Does not affect adoption				**Strongly Affects Adoption**
Continued Usage	○	○	○	○	○
Compatibility: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Supporting Innovation: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Complexity: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
	Does not affect adoption				**Strongly Affects Adoption**
Trialability: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Observability: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Relative Advantage/Cost Advantage: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Risks: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
	Does not affect adoption				**Strongly Affects Adoption**

This section is concerned with diffusion factors of SIPs. The authors have identified 13 industry accepted "diffusion factors", which have been listed below. On a scale from 1-5 (1 being does not affect and 5 being strongly affects), please rate each diffusion factor as it relates to your company's first trial, and continued use of Structural Insulated Panel Systems. First trial is defined as your company's first use of SIPs, and continued use is defined as the point at which you decided to incorporate SIPs into your construction methods on a continued basis. Please refer to the survey instructions for definitions of the diffusion factors in the following section.

	Does not affect adoption				**Strongly Affects Adoption**
Supervision Competency: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Consumer Resistance: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Trade Resistance: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○
Regulatory Resistance: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○

	Does not affect adoption				**Strongly Affects Adoption**
Coordination within Project Team: First Trial	○	○	○	○	○
Continued Usage	○	○	○	○	○

	Does not affect adoption	**Strongly Affects Adoption**
		YToxOntzOjEw C
		YToxOntzOjEw C
		YToxOntzOjEw C
		YToxOntzOjEw C
		YToxOntzOjEw C

This section is concerned with diffusion factors of SIPs. The authors have identified 13 industry accepted "diffusion factors", which have been listed below. On a scale from 1-5 (1 being does not affect and 5 being strongly affects), please rate each diffusion factor as it relates to your company's first trial, and continued use of Structural Insulated Panel Systems. First trial is defined as your company's first use of SIPs, and continued use is defined as the point at which you decided to incorporate SIPs into your construction methods on a continued basis. Please refer to the survey instructions for definitions of the diffusion factors in the following section.

Does not affect adoption **Strongly Affects Adoption**

YToxOntzOjEw C
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YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi
YToxOntzOjExOi

1	QID18	1|2|3	TE	ML	

Please add any unmentioned factors that may have affected your company's adoption of Structural Insulated Panels.

1	QID19	1|2	MC	SAVR	TX

Would you like to receive the results of this study upon completion?

- Yes
- No

Appendix B – Diffusion Factors

Diffusion Factor	Reference	Description
Timing of Commitment	Slaughter 1993b, Slaughter 1998	Timing or flexibility with implementation of the product during the construction schedule.
Compatibility/Special Resources	Cagan et al. 2003, Holmen 2002, Rogers 2003, Slaughter 1993a,	Congruency with the habits of users or existing products
Supporting Innovation	Slaughter 1998	Innovations that require other innovations to make them compatible.
Complexity/Simplicity	Cagan et al. 2003, Holmen 2002, Rogers 2003,	The product's ability to be understood by users
Trialability	Cagan et al. 2003, Holmen 2002, Rogers 2003,	Ability to experiment without risk
Observability	Cagan et al. 2003, Holmen 2002, HUD 2005, Rogers 2003	Product visibility within the marketplace.
Relative Advantage	Cagan et al. 2003, Eaton et al. 2006, Holmen 2002, HUD 2005, Rogers 2003, Slaughter 1993a	Cost/relative benefit to using the product as opposed to traditional products.
Risks	Eaton et al. 2006, HUD 2005, Koebel and McCoy 2006, Slaughter 1993a	Impact of negative consequences for using the product.
Supervision Competency	Slaughter 1998	Experience or education/training required to use or install the products
Consumers Resistance (End User)	Koebel and McCoy 2006	Opposition that originates from the consumer (individual based)
Trade Resistance	Koebel and McCoy 2006	Opposition that originates from the trades (organization based).
Regulatory Resistance	Blayse and Manley 2004, HUD 2005, Koebel and McCoy 2006, Slaughter 1993b	Opposition that originates from government organizations (authority based).
Coordination with Project Team	HUD 2005, Slaughter 1998	Synchronization of various stakeholders is required for implementation.

Appendix C – EarthCraft Builders List

EarthCraft Builder Name	Location	Email Address
DeRose & Sons, LLC	Williamsburg, VA	aderoseandsons@aol.com
Abrahamse & Company Builders, Inc.	Charlottesville, VA	builders@abrahamse.com
Advantage Properties Inc.	Fairfax, VA	Bs22039@aol.com
Ainslie Group, Inc.	Virginia Beach, VA	jeffainslie@mac.com
ALIP Albemarle Housing Improvement Program	Charlottesville, VA	sharder@ahipva.org
Allen Loree Homes, LLC	Virginia Beach, VA	allenloreehomes@cox.net
Alliance Construction Group, LLC	Winchester, VA	ambmartin@verizon.net
AM Yoder & Co.	Harrisburg, VA	Homestead.frame@gmail.com
Andreas Bentz and Mike Nichols	Arlington, VA	Andreas.bentz@gmail.com
Angstadt Building and Remodeling Company	Fredericksburg, VA	kris@angstadt.com
Arcadia Builders, Inc.	Crozet, VA	domenico@arcadiabuildersinc.com
Associated Contracting Services	Portsmouth, VA	jketchum@associatedcontracting.com
Associated Development Management Corp.	Virginia Beach, VA	jeo@associated-development.com
Atmosphere Builders	Blacksburg, VA	rick@atmospherebuilders.com
Bain-Waring	Richmond, VA	mark@bainwaring.com
Barry Meade Homes, LLC	Charlottesville, VA	meade@cstone.net
Beamer Construction Corp.	Williamsburg, VA	beamerconstruction@yahoo.com
Bedford H4H	Bedford, VA	Myusa33@ispwest.com
Bellanca Construction, LLC	Alexander, VA	bellanca@mindspring.com
Bench Mark Builders	Roanoke, VA	joel@benchmarkhomebuilders.com
Blue Ridge Design Studio	Harrisonburg, VA	wlehman@blueridgedesignstudio.com
Bowtie Construction	Roanoke, VA	mark@bowtieconstruction.com
Breakell Inc.	Roanoke, VA	jgraham@breaklell-inc.com
Bromac Construction Co.	Ashland, VA	pmckinney@bromachomes.com
Cedar Creek Construction, Inc.	Virginia Beach, VA	b.maddrey@cedarcreekbuilding.com
Central Valley H4H	Bridgewater, VA	Cvhfh2@verizon.net
Charles W. Ross Builder	Williamsburg, VA	info@charlesrosshomes.com
Charleston Company	King George, VA	danna@charlestonbuilders.com
Chip Hudnall Custom Building	Wicomico Church, VA	CHCB@crosslink.net
Cohen Homes LLC	Virginia Beach, VA	kenc@ainsliegroup.com
Coleman Homes, Inc.	Fredericksburg, VA	info@coleman-homes.biz
Colonial Homecrafters LTD	Richmond, VA	egoode@chchomes.com
Commonwealth Home Remodelers, Inc.	Vienna, VA	susan@commonwealthhome.com
Community Construction Co.	Harrisonburg, VA	Cccbld4u@verizon.net
Condrey Construction Company	Chesterfield, VA	lauracondrey@aol.com

Contracting Services	Palmyra, VA	Kljones225@earthlink.net
Craftsman Construction	Edinburg, VA	jerrycra@shentel.net
Cross & Associates, Ltd.	Williamsburg, VA	Joe.cross@cross-associates.com
CS Custom Structures, Inc.	Lynchburg, VA	Dfreitascs@ntelos.net
Cumberland Custom Homes	Warrenton, VA	Ray.geier@verizon.net
Custom Homebuilding Inc.	Millboro, VA	Andrew@customhomebuildinginc.com
D.C Building Inc.	Eastville, VA	dcbuilding@verizon.net
D.S Zechini Construction Co.	Lynchburg, VA	zechiniinc@aol.com
Danny Ryan	Abingdon, VA	Danny.ryan@electro.mechanical.com
Danville H4H	Danville, VA	danhabitat@gamewood.net
David Micsky Construction, Inc.	Stafford, VA	davidmicsky@aol.com
DeBord Custom Homes	Virginia Beach, VA	davdebord@aol.com
Deitz Lilly Builders	Forest, VA	Lilly2@verizon.com
Design Four, Inc.	Virginia Beach, VA	chason@coastalarchitect.com
Dominion Building Group	Virginia Beach, VA	reid@dominionbuildinggroup.com
Drake Custom Builders	Castleton, VA	stacy@drakecustombuilders.com
Dwell General Contracting	Charlottesville, VA	whit@dwellgeneralcontracting.com
E.R Lenz Contracting	Smithfield, VA	Erlenz@yahoo.com
Eagle Construction	Glen Allen, VA	acopenhauer@eagleofva.com
Eagle Place Homes	Winchester, VA	jim@eagleplacehomes.com
Ebb-Tide Construction	Chesapeake, VA	sturner@tbaonline.org
Edward J Friar Builder	Lynchburg, VA	edfriar@verizon.net
Evergreen Homecrafters	Midlothian, VA	jon@kodiakllc.com
Ewing Building & Remodeling	Blacksburg, VA	paulewing@ewingbuilding.com
Farmville H4H	Farmville, VA	jayne@farmvillehabitat.org
Fauquier Housing Corporation	Warrenton, VA	chris@fauquierhousing.org
Forest Homes	Forest, VA	gvrowe@verizon.net
Fralin and Waldrin	Daleville, VA	adam@fwinc.com
Garnett Construction	Seaford, VA	Wgarnett1@gmail.com
Gaylor Construction	Goode, VA	gcigaylor@verizon.net
Golden Rule Builders	Catlett, VA	Karin@goldenrulebuilders.com
Graystone Homes Inc.	Culpepper, VA	Stephanie@graystonehomes.com
Green Spring Building Solutions	Williamsburg, VA	s.evans@greenspringbuilding.com
Green Valley Builders	Blacksburg, VA	Jason@greenvillebuilders.com
Roanoke H4H	Roanoke, VA	bclark@habitat-roanoke.org
Charlottesville H4H	Charlottesville, VA	Info501@cvillehabitat.org
Winchester H4H	Winchester, VA	info@habitatwfc.org
Harrington Construction	Moseley, VA	jharring@harringconstruction.com
Harrisonburg Townhomes, LLC	Harrisonburg, VA	laura@scripturecommunities.com
Herr & Co.	Harrisonburg, VA	jherr@herrinc.com
HHHunt Homes	Newport, VA	rbrassfield@hhhunt.com
Highlander Construction	Radford, VA	oliverj@highlanderconstruction.com
Hine Group	Harrisburg, VA	gyoder@thehinegroup.com
Hohmann Builders, Inc.	Smithfield, VA	hohmannbuilders@att.net
Hollyport Ventures	Henrico, VA	Richard@hollyportventures.com

Homes Plus	Pilot, VA	homespluscrc@swva.net
Houburn Construction Company	Abingdon, VA	ecoburn@guestgroup.biz
Howerin Construction Corp.	Norfolk, VA	bob@howerinconstruction.com
Hybrid Builders	Nashville, VA	yancylovelace@bellsouth.net
Ingram Bay Contracting	Reedville, VA	ibinc@kaballero.com
Innovative Property Developers	Fredericksburg, VA	david@ipd-homes.com
J and D Builders	Pulaski, VA	janddbuilders@comcast.net
J. Hall Homes	Spotsylvania, VA	jhall@jhallhomes.com
J. Lloyd Builder	Williamsburg, VA	jlb@mpa.hrcoxmail.com
J.B McCutcheon Jr.	Midlothian, VA	Jbm-inc@comcast.net
J.E. Kidd & Sons	Fincastle, VA	Skidd41399@aol.com
J.M Froehler Construction	Virginia Brach, VA	matt@vabeachbuilder.com
Jeff Sowder	Roanoke, VA	Jcsvt80@cox.net
John Grier Construction	Williamsburg, VA	johngriercc@aol.com
Justin Mason Construction	Keysville, Va	jmasonconstruct@yahoo.com
Kicotan Company	Hampton, VA	linda@harrison-lear.com
Kingma Developers	Charlottesville, VA	doug@kingmadevelopers.com
Kw Construction Company	Earlysville, VA	Kwconstructionco@aol.com
Latitute 38	Charlottesville, VA	info@latitute38llc.com
Lensis Builders	Manassas, VA	lensisbuilders@comcast.net
Long Meadows, Inc.	Lynchburg, VA	chris@longmeadows.net
Lookout Associates	Virginia Beach, VA	jr@definitivehomes.com
Loudon H4H	Leesburg, VA	info@loudounhabitat.org
Luke Construction	Virginia Beach, VA	Dluke411@gmail.com
M.H. Eades Inc.	Hardy, VA	mheades@mheades.com
Main Street Homes	Midlothian, VA	mtessier@mainstreethomes.info
Maple Ridge Group	Charlottesville, VA	Steve.nicholson@mapleridgegroup.com
Matthew Clark & Co.	Cloverdale, VA	info@clarkhomesofdistinction.com
MDA Homes, LLC	Midlothian, VA	Michael.mdahomes@verizon.net
Michael C. Brown Custom Builder	Toano, VA	jeff@williamsburgbiulder.com
Michael Donovan	Falls Church, VA	Michael@orventures.biz
Mid-Atlantic Group, Inc.	Norfolk, VA	ovbuilder@cox.net
Mike Garcia Construction	Woodbridge, VA	garciamd@mikegarcia.com
Miles Custom Homes	Charlottesville, VA	tomjmiles@embargmail.com
Miller & Associates	Richmond, VA	ben@monroeproperties.com
Moffet Homes	Chesapeak, VA	bmoffet@cox.net
Morcom Building	Monroe, VA	morcomtle@aol.com
Norther Neck Homes	Montross, VA	nnhomes@hughes.net
Oceanside Building	Virginia Beach, VA	oceansidebuilding@cox.net
Pathways	Petersburg, VA	drerrell@pathways-va.org
PD & M Inc.	Moneta, VA	effort@pdandm.com
Peter Johnson Builders	Charlottesville, VA	johnsonpcj@aol.com
Piedmont Construction	Keswick, VA	scarlson@thinkpiedmont.com
Pitman Construction	Roanoke, VA	wderey@pitmanconstruction.com

Premier Custom Builders	Oak Park, VA	j.breeden01@yahoo.com
Prescott Construction Co.	Roanoke, VA	matt@prescottconstruction.com
Progress Street Builders	Blacksburg, VA	progress@progressstreet.com
Promark Custom Homes	Williamsburg, VA	promarkch@aol.com
Rarco Contracting	Alexandria, VA	steve@rarcoinc.com
Republic Home Builders	Fredericksburg, VA	dsandoval@republichomebuilders.com
Richardson Homes	Norfolk, VA	jim@richardsonhomesinc.orcoxmail.com
Richmond H4H	Richmond, VA	lin@richmondhabitat.org
Rinehart Custom Homes	Charlottesville, VA	Rinehart@rineharthomes.com
RML Corporation	Suffolk, VA	rml@rml-corp.com
Rock River, Inc.	Amelia, VA	angierockriver@gmail.com
Rsavino Custom Homes	Virginia Beach, VA	rick@savinocustomhomes.com
Sadler Biulding Corp.	Virginia Beach, VA	brad@dadlerhomes.com
SAS Builders	Blacksburg, VA	jsahm@sasbuilders.com
Schneider Development	Cape Charles, VA	info@schneiderdev.com
Shelter Alternatives	Blacksburg, VA	edt@shelteralternatives.com
Smith & Robertson	Charlottesville, VA	glenn@smithandrobertson.com
Southern Classics	Crozet, VA	david@southern-classic.com
Southern Property	Charlottesville, VA	kyeaton@southern-development.com
Southern Traditions	Glen Allen, VA	rcarter@southerntraditionshomes.com
Southside Housing Corp.	Richmond, VA	jim@scdh.com
Staunton H4H	Staunton, VA	habitat@ntelos.net
Stonehaus Construction	Charlottesville, VA	mcorradino@stonehaus.net
Sugar Hollow Builders	Crozet, VA	sugarhollowbuilders@yahoo.com
Sustainable Solutions	Harrisonburg, VA	alex@sustainablesolutions.com
T.L Goode Homes	Charlottesville, VA	Castbinder@aol.com
T.L Herndon Enterprise	Crozet, VA	Upstreamconst@aol.com
Telamon Corporation	Gretna, VA	rroark@telamon.org
THS Construction	Richmond, VA	terry@thsconstruction.com
Trotten Construction Co.	Saltville, VA	none@atlantahomebuilders.com
Tuckahoe Creek Construction	Richmond, VA	gray@tuckahoecreek.com
Viridian Homes	Virginia Beach, VA	ed@viridianhomesllc.com
Wall Construction	Madison, VA	david@wallconstruction.biz
Warner Custom Homes	Spotsylvania, VA	david@warnercustomhomes.com
Wayne Harbin Builder	Williamsburg, VA	info@harbinbuilder.com
Wellington Builders	Lynchburg, VA	gary@wellingtonbiuldersinc.com
Wendel W. Gibson	Charlottesville, VA	wwghomes@aol.com
Wilberger Properties	Palmyra, VA	wilbergers@aol.com
Willard Construction	Wirtz, VA	ron@thewillardcompanies.com
Windjammer Construction	Afton, VA	jammer@windjammerconstruction.com
Wythe County H4H	Wytheville, VA	wchfh@earthlink.net
Youngblood Properties	Mechanicsville, VA	nyoungblood@youngbloodproperties.com

Appendix D – IRB Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24060
540/231-4606 Fax 540/231-0959
e-mail irb@vt.edu
Website: www.irb.vt.edu

MEMORANDUM

DATE: September 21, 2010

TO: Andrew McCoy, Christopher Henry

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires June 13, 2011)

PROTOCOL TITLE: SIPs Builder Survey

IRB NUMBER: **10-770**

Effective September 21, 2010, the Virginia Tech IRB Administrator, Carmen T. Green, approved the new protocol for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at http://www.irb.vt.edu/pages/responsibilities.htm (please review before the commencement of your research).

PROTOCOL INFORMATION:
Approved as: **Exempt, under 45 CFR 46.101(b) category(ies) 2**
Protocol Approval Date: **9/21/2010**
Protocol Expiration Date: **NA**
Continuing Review Due Date*: **NA**
*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:
Per federally regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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Date*	OSP Number	Sponsor	Grant Comparison Conducted?

*Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

cc: File