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Tradeoff and Synergy in Sustainable Product Innovation: An Exploratory Case Study of Residential Building

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Abstract

Minimizing the negative impacts on the environment is a key challenge to the firms pursuing sustainable product innovations for residential building and construction. This paper examines three cases in the U.S., i.e. Amazon Forms LLC, the Town of Frisco and Denver's Built Green(tm) Program, that illustrate unique ways of initiating sustainable innovation. The cases confirm that, in order to stimulate the diffusion of a new sustainable product or project, there must be a force driving the change of thinking and action, including corporate initiative, government regulation, consumer demand and technological advance.

Keywords: sustainable product innovation, resiential building, trade off-synergy relationship

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INTRODUCTION

In today's environmentally sensitive business world, it is an important strategic issue to turn environment-related threats into profitable new product/market opportunities(Ottman 2002; Drake *et al.* 2004). Sustainable product innovation is particularly important to the building industry because construction affects natural resources, air/water pollution, solid waste, recycling, disposal, energy conservation and many other aspects of our environment. Commercial enterprises often find it difficult to develop an environmentally friendly product that does not require significant sacrifice of its traditional attributes or performances such as durability, safety, cost efficiency or convenience(Reinhardt 1999; Chen 2001; Rhee and Lee 2003). In other words, balancing the needs for new construction and environmental quality, or minimizing the negative impacts of construction on the environment, is a key challenge to the individual firms as well as the industry pursuing sustainable innovations in the residential building industry.

This paper aims to explore the tradeoff-synergy relationships between environmental and traditional attributes in the building product development and diffusion. To provide insights to the business practitioners and help gaining deep understanding for the academic researchers(Woodside 2005), we examine the three selected cases that illustrate unique ways of initiating sustainable innovation projects in the U.S. residential and construction industry. We discuss how the consumer's preference toward green products, the government's regulation for environmental protection and the technological advances for green product development may affect the planning, implementation and performance of a sustainable innovation.

In Section 2, we address the research issues and questions through a review of the literature on the potential tradeoff and synergy between environmental and traditional attributes in product innovation. In Section 3, we report three cases of sustainable innovation programs in residential building. Amazon Forms LLC is a case in which the education of homeowners and builders has been a challenge for the adoption and diffusion of a

sustainable product in the marketplace. The Town of Frisco is a case in which the City Council has achieved a delicate balance between forcing regulation and encouraging sustainable building practices. Denver's Built Green™ Program is a case in which promoting sustainable building to a number of interest groups, including local builders, civic groups, landscapers, environmental groups, product manufacturers, architects and designers as well as homeowners has been the key to its successful planning and implementation. On the basis of the findings from our case study, we summarize the trends in the residential building industry and discuss the strategic implications in Section 4. Then, we conclude in Section 5 with remarks on the limitations of current research and directions for future research.

RESEARCH ISSUES AND QUESTIONS

Product design and development is an essential element for ecological sustainability. For instance, redesigning a product's form, raw material content or package can make a significant difference in the environmental consequences of usage and disposal of the product(Fuller 1999; Geiser 2001). The process of product design can be a complex task, if the inclusion of environmental attributes requires sacrificing some of the traditional attributes, e.g. convenience, safety or cost efficiency. Differing situations of tradeoff-synergy relationship are possible between the traditional and environmental attributes through a product's life of development and diffusion.

The environmental and traditional attributes may have significant conflict with each other. A good example can be found in the development of the electric automobiles, where traditional attributes include appearance, price, power and safety whereas green attributes consist of energy savings, pollution prevention and resource protection. Boyd and Mellman(1980) find that the improvement of fuel efficiency is often accomplished at the expense such traditional attributes as style, acceleration or luxury of a car. Crandall and Granham(1992) report the conflict between the fuel efficiency and safety ratings in automobile development. De Neufville et al.(1996) point out that some compromise is required between low emissions and the

maximum speed of an electric vehicle. Kazman(2002) also find that the improvement in fuel efficiency leads to an increase in the number of critical road accidents.

Tradeoff between traditional and green attributes has been studied for other industries as well. For example, Appliance Manufacturers(1994) reports the conflict between recycled plastic content and appearance-related attributes in designing computer covers, while Malloy(1996) studies the negative impact of a product's recyclability on its quality consistency. Halim and Srinivasan(2001) identify the obstacles in re-designing the production process for a chemical plant to minimize its waste generation, while Zurkirch and Reichart(2001) compare the impact of email versus traditional mail on their environmental life cycles. Other case studies(DeCicco and Thomas 1999; EPA, 2001) report that technological or managerial difficulty is often experienced when incorporating environmental attributes such as recycled content, material recovery, energy efficiency and toxic content reduction. Drake *et al.*(2004) argue that manager's view of the win-win situation, i.e. what is good for the environment is good for business, is yet to be materialized, particularly for small or medium size businesses.

Of course, it is also possible that the traditional and green attributes have no significant conflict with each other or may even help enhancing each other synergistically. A good example can be found in the use of recycled glass or plastic bottles. Most of the consumers cannot tell the difference between a soda bottle made from virgin materials and the one made from recycled materials. There may be a color difference, but it's hard to tell whether that difference is a part of marketing campaign or due to the inclusion of recycled materials. This is a case where consumers do not recognize the use of recycled materials in packaging, while recycling of such materials can significantly increase the social and economic benefits by reducing the amount of landfill wastes and the demand for virgin materials. There are many cases where traditional attributes can be improved by the inclusion of green attributes, so-called synergistic or "win-win" situations(Fuller 1999). In their study of ten manufacturing firms, Lanoie and Tanguay(2000) show that environmentally conscious management practices helped the firms gain profitability and production efficiency simultaneously.

Royal Phillips Electronics claims to become one of the world leaders in environmental product design by implementing its four-year EcoVision program to accomplish a number of environmental product innovations such as their "green silicon solutions," by focusing on five areas of improvement, i.e. weight, hazardous substances, energy consumption, recycling and packing(www.phillips.com). With the goal of having 75% of the products "Eco-Designed" by 2002, it has achieved 27% of its products Eco-Designed in 1999 and 37% in 2000, and become the first recipient of the ISO 14001 certification in the world.

Various forces may have influences on the tradeoff or synergy relationship between the environmental and traditional attributes. Long-term commitment of the industry may have positive impacts, but technology may limit the realization of the synergistic relationship(Worrell *et al.* 2001). The educational efforts of green/environmental action groups, regulations of the federal, state or municipal governments and advancements of green technologies may stimulate sustainable innovation(Bruhn-Tysk and Eklund 2002). Very often customer attitude and preference toward the environmental attributes drive an individual firm's strategic commitment to the design and marketing of a sustainable product as the literature widely supports, e.g. the design of automobiles(Murtaugh and Gladwin 1980), manufacturing of recycled consumer goods(Bei and Simpson 1995), reduction of phosphate content in laundry detergents(Berger and Kanetkar 1995) and development of various other products(Mackenzie 1997; Chen 2001). Delmas and Toffel(2004) argue that individual firms may well respond to the coercive and normative pressures imposed by customers as well as regulators, competitors, community and other environmental interest groups.

In the following section, we examine how the U.S. residential building and construction industry has responded to differing situations of tradeoff or synergy relationship for sustainable innovation. Focus will be given to how the customer preference, government regulation and technological advance have interactively affected the planning, implementation and performance of the sustainable/green projects.

AN EXPLORATORY CASE STUDY

Industry Background and Case Overview

Residential construction affects natural resources, air/water pollution, solid waste, recycling, disposal, energy conservation and many other aspects of our environment. The U.S. Environmental Protection Agency(EPA, 2001) estimates that 24% (or 136 million tons) of all landfill waste is generated from construction and demolition projects. Of that landfill waste, 43% results from residential projects, which can further be broken down to 8%(or 11 million tons) from new construction, 44%(or 60 million tons) from renovation and the rest from demolition. Homebuilders can significantly reduce the landfill waste by recycling such materials as wood, glass, metal, plastic, insulation, paint and drywall and/or by using alternative green products, e.g. recycled polystyrene in concrete forms instead of wood. It is thus a key issue in building and construction to achieve a good balance between the need for building new homes and maintaining environmental quality.

Minimizing the negative impacts of construction on the environment has long been an important strategic concern in the building industry. It has been closely tied to the increase of environmental awareness and the advancement of sustainable building technology. Alliances between homebuilders, materials suppliers, governmental agencies and environmental action groups have also been instrumental for promoting the use of sustainable products in building. Godfried(1998) characterizes these trends as an integration of the three emerging green concerns, i.e. human satisfaction, minimal negative environmental impacts and minimal consumption of matters/energy, and the three traditional concerns, i.e. time, cost and quality.

Many commercial firms and non-profit organizations have recently pioneered a variety of “green” movements in residential construction. Here we examine three selected cases to highlight some unique ways of pursuing product innovations for sustainable/green construction. The first case is a small

business in Texas, Amazon Forms LLC, which has developed unique building materials made out of recycled materials. The second case is the suburban town of Frisco, Texas, which has adopted groundbreaking ecological guidelines for all new construction within its limits. And the third case is an organization in Denver, Colorado, Built Green™, which initiated a comprehensive promotion program for green building through consumer education, government regulation and community awareness. These cases share a common goal of improving the ecological attributes and increasing the use of "green" products without sacrificing much of the traditional attributes. They represent the situations where the green attributes of a product require a tradeoff with the traditional attributes or where the two sets of attributes synergistically complement each other. The data for this case study was collected by directly contacting the involved organizations and searching for various secondary sources, including governmental publications and official websites of the relevant organizations.

Amazon Forms LLC

Amazon Forms LLC is a small company in San Antonio, Texas, which manufactures insulated concrete forms(ICFs) for building homes and other structures(www.amazonforms.com). Its current products, Grid-Wall™, Grid-Plank™ and Grid-Corner™ are all made of recycled materials, i.e. use more than 85% recycled polystyrene(www.amazongridwall.com). ICFs take the place of traditional wood in the framing of a structure. Since the frame is not visible after the completion of construction, the external appearance of the home does not change with the use of these new products. Claudette Sumrall, the founder and owner of Amazon Forms LLC, redesigned an existing product from Europe called Rastra™ to be easier and safer to use(Personal communication with Claudette Sumrall October 26, 2001). She changed the dimensions of Rastra™ to better fit to standard American building specifications. She also invented the corner block design to simplify the building process while ensuring consistency and quality, and altered the manufacturing process to produce it piece by piece instead of using multiple pieces glued together.

The traditional attributes desired by a builder for this type of product are durability, value/cost, ability to withstand disasters (like severe weather, fire, earthquake, rot and termite), appearance and style, material availability, low maintenance requirements, high energy efficiency and reduced installation time. Amazon Forms LLC claims that its new products can match or surpass their traditional counterparts in every aspect of those attributes; they can even help building a home up to two-thirds quieter than the traditional wood homes (www.concretehomes.com). An evaluation of the value and cost of these new products in comparison with traditional products shows that the former can pay off very quickly. Table 1 compares the two alternatives for a case when a builder needs an $8' \times 8'$ wall built(Refer to www.standardicf.com for other comparisons for homes using concrete products.).

For strength and durability, the ICFs are significantly superior to non-recycled products. According to a report of the company about the coastal windstorm ratings on the Gulf Coast, the ICFs can withstand winds of up to 200 miles per hour. These products are also tested to be relatively fire and bullet proof, receiving a four-hour fire rating and a Level 2 ballistics rating(Personal Communication with Claudette Sumrall, 2001). This claim was positively confirmed by the Portland Cement Association(PCA) which conducted a fire test, as well as by the Wind Engineering Research Center of Texas Tech University which compared the impact of high winds simulating the effects of a tornado or hurricane on the home(www.concretehomes.com).

For mass-production or low-income government housing, the products of Amazon Forms LLC have been proved to be a cost-effective alternative to traditional wood products. Table 1 shows that new construction using the Grid line of products can save on building costs for both the builders and homeowners. According to the claims of the company, typical homeowners who use Grid-Wall™ can expect to reduce their mortgage rates by a quarter to a half of a percentage point, as well as see a 38-44% decrease in their utility costs and lower insurance premiums. The PCA finds in its homeowner survey(www.concretehomes.com) that ICF usage was credited with a reduction in heating costs by 44% and cooling costs by 32%. For a typical 2000 square foot home, this translates to savings of about $265 in

Table 1. A Comparison between Gridwall and Wood Frame
(1999 R.S. Means Building Costs*)

Amazon Forms Gridwall (8′ ×8′ Wall)		Wood Frame (2×4's)	
12 elements @ $16	$192.00	2×4 Framing	$55.11
Labor @ man per hour @ $10	$16.00	16″ O.C.	
per 40 square feet		Insulation — R-11	$19.65
Glue	$8.00	Housewrap	$9.56
Rebar	$16.00	Sheetrock - Inside	$43.03
Concrete @ $73/CY	$44.85	Sheathing	$44.09
Plaster - Inside	$22.84	(1/2″ CDX)	
Stucco - Outside	$64.00	Stucco - Outside	$112.00
	$363.69		$273.88
Per square foot of exterior wall	$5.68	Per square foot of exterior wall	$4.28
Total house cost is up by 3.3% but OFF-SET by:		* *These figures incorporate a "San Antonio area factor" which is 83% of national numbers.*	
1/4% to 1/2% reduction in mortgage percentage			
38% - 44% reduction in utility costs			
Lower insurance and maintenance costs			
Termite, storm and earthquake resistant			
Lower building costs: faster erection time:1.6 hrs			
30-40% reduction in A/C tonnage!			erection time: 3.6 hrs

Source: Compiled from the data reported in www.amazongridwall.com.

Table 2. An Illustrative Comparison of Financial Analysis

	Standard Home	Concrete Home	Comments
Purchase Price	$200,000	$208,000	4% more
Principal & Interest	$1,119	$1,163	7.5% interest rate
Taxes	$300	$312	0.15% tax rate
Insurance	$60	$48	20% savings
Energy	$145	$102	30% savings

Source: Compiled from the data reported in the website of Portland Cement Association, i.e. www.concretehomes.com.

heating and cooling costs per year. The survey also reports an average of a 15-25% reduction in insurance costs for ICF homeowners. The reduction of time required for erecting the building(1.6 hrs with ICFs instead of 3.6 hours with wood) is another source of savings. The lower weight of the materials also saves money, energy and time; with Grid-Wall™, the weight of total materials can be reduced by 30-40%.

The effect of building product innovation is far-reaching through a chain reaction of savings, e.g. the reduced tonnage of the required building materials leads to savings on truck fuel. Table 2 illustrates the potential financial benefits to a customer buying a home built using ICFs. It shows that, assuming a mortgage with a 7.5 % interest rate and a 20% down payment on the home, he would pay $44 more on principal and interest and $12 more on property taxes, but saves $12 on homeowners insurance and $43 on energy bills. The net increase of monthly cost for the concrete home will be only $1, which is low enough to pay for the added security and comfort.

Amazon Forms LLC is a good example of small local businesses that have developed innovative sustainable products, aiming to change the way of building homes. The market is growing steadily: About 9% of the new homes are projected to be built with ICFs in 2003, compared with only 1% in 1997 (www.amazonforms.com). The homeowners and builders would not make any significant sacrifice when using the environmentally responsible products over the traditional products. The very traditional attributes that the customers value highly were enhanced by the addition of the new green attributes, contributing to the fast diffusion of those products in

the marketplace.

The Town of Frisco in Texas

The Town of Frisco in Texas is known for pioneering a way of green building to protect and sustain the environment. Frisco adopted the EPA's ENERGY STAR® requirements as the minimum building standards for all new homes for the first time in the U.S.(www.ci.frisco.tx.us). ENERGY STAR® is a voluntary program offered nationwide for builders to encourage the use of innovative building materials and techniques used to increase the energy efficiency for all new construction(www.epa.gov/estar). Builders in this town are now required to have a Home Energy Rating System(HERS) score of 86 or better on all new residential structures(www.oikos.com).

Alliance has been a key to the successful implementation of this program in Frisco. The Green Building Committee of the Town proposed this initiative in cooperation with the local builders. To determine a home's HERS score, a certified third party should conduct a test that includes plan analysis, insulation/duct inspection and blower door/duct pressurization testing. The blower door/duct test requires the entire house to be pressurized to find any leaks and to determine the number of air exchanges per hour. TXU Electric, the energy service provider in Dallas/Ft Worth, agreed to subsidize the testing and inspection of the first 4,000 homes in Frisco. To ensure their homes passing the ENERGY STAR® inspection, builders in Frisco have agreed to adopt new ways of building, e.g. installing double-paned windows, improving the sealing of ducts and installing high-efficiency heating-cooling equipment.

The Frisco City Council signed the "Green Building Ordinance" into a law in May 2001(Ordinance No. 01-05-39) and promised homeowners that they could save up to 30% per year on utility bills by adopting the new building standards. This ordinance has been implemented with positive incentives for compliance (anticipated savings on utility bills) and penalties for con-compliance(misdemeanor charges and monetary fines). The publicity of this ordinance has not prevented new residents from moving into Frisco. Frisco has recently been one of the fastest growing cities in the U.S. Its population is projected to reach

75,825 in January 2005 or 70% greater than the 44,555 total recorded in June 2001(www.ci.frisco.tx.us). Since the construction business in Frisco has continued to grow, we may infer that the new "rules" for building are generally supported by most people, particularly by the new homeowners in this growing town, generally younger adults, who may be more aware of environmental issues and more willing to accept environmental regulations(Fuller 1999). Recognizing the adoption and implementation of this green building program, the Dallas Corporate Recycling Council awarded the Town of Frisco the Environmental Visions Award(2001) which is bestowed to a city or town that best develops a program for waste reduction, recycling, resource conservation and environmental protection.

In this case, both the trade-off and synergy relationships are significant between the traditional and green attributes. One of the examples showing the complex tradeoff-synergy relationship is the installation of insulated attic materials in new homes. Without a continuous air barrier in buildings, air filtration can reduce the R-value of insulation.(R-value is the thermal control rating for a product, measuring the efficiency of the insulation; a higher R-value means better temperature control, and usually translates to lower utility bills for homeowners.) Significant moisture problems may also result, causing mold to develop and raise a serious health issue. This trade-off situation has been partially overcome by the Frisco's new building ordinance which is very flexible in its options for building, i.e. the attributes of the "products" are very broad from building materials to appliances to decorative features within a home.

Spray-in-place insulating foams have been proven to be safe and excellent for conserving energy, preventing future repairs and improving the air quality in homes. Users of these products for their new construction projects assess that spray-in-place insulating foams not only save on their building costs but also provide insulation and a barrier against water and air, preventing moldy roofs that can rot over time from excessive moisture. Comparison of the costs between the spray-in-place insulating foams and the fiberglass batts(one of the traditional products used for attic insulation) reveals that the former is a better deal when we consider the costs of the latter for inspection of insulation, caulking cracks and the struggle for continuity

with a poly vapor barrier(Energy Design Update, 2001). The spray-in-place insulating foams have several disadvantages in comparison with fiberglass butt. Spray-in-place insulation requires specialized equipment and specially trained workers for installation. In some parts of the country, a homebuyer cannot find a licensed installer. In addition, all insulating foams must be covered with a 15-minute thermal barrier to meet the fire codes. Another disadvantage is that, in some retrofit projects, the polyurethane form cannot be injected into a closed wall cavity without removing the sheathing before installing the foam. The upfront insulation costs are another important concern to many potential customers.

Suppose that a new homebuyer wants to improve the energy efficiency of her home. She wants to keep mold at bay and reduce the need for future repairs. She has read about the mold-related problems with the traditional fiberglass batt. It is estimated that 30% of the roofs in the U.S. and Canada are rotting due to the moist air seeping into the attic and condensing (WSJ 2001). She also has been informed of various installation-related disadvantages of new spray-in-place (either Polyurethane or Icynene) foams in addition to its price premium of 200-300%

Table 3. Comparison between Two Spray-in-place Foams

Characteristics	Polyurethane	Icynene Foam
Type	Closed cell	Open cell
Blowing agent*	R141b	Water-based
Typical Density	1.8 lbs/cubic foot	0.5 lbs/cubic foot
Consistency	Very rigid and adherent	Similar to angel food cake
Normal R-value/inch	7.0	3.6
Perm Rating**	Yes	Yes
Sound Attention	Excellent	Excellent
Price Premium***vs. Batts	200-300%	200-300%
Application	Trained contractors	Licensed contractors

Source: Compiled from the data reported in Energy Design Update (July 2001).

* Polyurethane's blowing agent, R141b, is 95% ozone compatible.

** A perm rating less than 1.0 is classified as a vapor barrier.

*** This price premium can be offset by cost reductions in inspections, future remediation and utility bills.

over the fiberglass batts. If this homebuyer has decided to use one of the spray-in-place foams rather than fiberglass batts, how can she compare between the two types of foams? Table 3 summarizes an illustrative comparison between the Polyurethane and Icynene Forms(Energy Design Update 2001).

Frisco's case suggests several important lessons to the planners of a green innovation program. The town government has known what the majority of the people want. The citizens of Frisco were ready to accept the new policy and supported building under the new rules. The town's planning committee worked with the local builders to examine the availability of new sustainable/green products before drafting the new policies. The city planners continued to evaluate the program with inputs from the builders, homeowners and environmental agencies including the EPA. The role of the government provides another lesson. Regulations of the federal government and incentives of the local government may have stimulated the firms to jump-start new product innovations and the consumers to try a new product. However, it's too early to tell whether the decision to make the ENERGY STAR® program, rating and compliance mandatory was a wise one in the long run, even though the results appear to be positive so far to help reducing the tradeoff between the traditional and sustainable attributes.

The Built Green™ Program

Built Green™ is a Denver-based voluntary program encouraging the builders to construct homes that provide healthier air, reduced pollution and water usage, improved durability, less required maintenance and better energy efficiency(www.builtgreen.org). This program also promotes preserving natural resources, recycling construction materials and using local products for local building projects. All homes registered in this program choose options from a checklist, and if they meet the program requirements, they receive the official BUILT GREEN™ designation. The checklist contains over 160 different options in 21 categories ranging from land and water use to construction materials used. Homeowners are given many options such as high-performance windows, better insulation, recycled plastic lumber, fiber-cement siding, better sealants on

ducts, recycled material carpet, lower VOC(volatile organic compounds) ratings, use of solar power and more efficient home appliances as well as using local products. The program is administered by the Home Builders Association(HBA) of Denver and receives support from various agencies such as the Colorado Governor's Office of Energy Management and Conservation (OEMC), Xcel Energy, E-Star Colorado and the Colorado Association of Home Builders.

Here we examine how the option of using local products has been implemented. The benefits of choosing local products include savings on transportation costs, stimulating the local economy, increasing awareness of the local area attractions and promoting how this community may impact the whole region around it. The concept employed for Denver's Built Green™ program is known as Xeriscape™(www.coloradocollege.edu), or the use of native plants for a new home's landscape. Emphasis is given to using plants that can survive and flourish with minimal watering and fertilizing. In desert or other areas with harsh climates, it is especially important for energy and water conservation to use regional plants and to minimize turf area in a home's yard. The xeriscape is implemented with seven fundamental principles: (1) comprehensive analysis of the climate, soil, elevation, land slope and sunlight intensity; (2) assessment of the current soil and repair to improve water retention; (3) selection of the plants to minimize water use; (4) designing of the turf areas to select appropriate grasses; (5) planning of irrigation system to maximize the efficiency of watering; (6) utilization of organic mulches to reduce weed growth and soil erosion; and (7) proper care of weeding, mowing and pruning to preserve the quality of the xeriscape. These xeriscape fundamentals resulted in not only many beautiful gardens and yards but also enormous cost savings in Denver areas. Colorado Springs Utilities(www.csu.org) estimates about 25-50% savings in water costs for a typical homeowner using xeriscape instead of a traditional landscape design. Xeriscape Colorado! Inc., a non-profit membership group promoting creative approaches to xeriscape, reports a 15% increase in property value for homeowners and a reduction in overall water and maintenance costs of up to 60%.

Two key disadvantages associated with xeriscape have been

reported(www.xeriscape.org). One is the initial start-up costs, mainly due to conducting the required comprehensive planning and using turf and plants that are often more expensive than traditional products. Many builders are still inclined to install the least expensive grass available in new homes, transferring the long-term costs to the homeowners. Homeowners retrofitting an existing lawn often find that the replacement of grasses and plants are quite expensive. The other disadvantage is the limitations in product choice, which is derived from the fact that not all plants and grasses can grow easily in all areas. If a homeowner relocating from Florida to New Mexico insists on using his Florida-climate plants, he will need to spend a lot of time and money to search for what plants are native to his new community and which plants he can choose.

For Denver homebuilders, participation in the Built Green(tm) Program clearly has several advantages (www.greenbuilder.com/sourcebook). Cost savings from reduced water, heating, cooling and appliance usage are just the beginning. Increased comfort is another benefit, even though it is difficult to quantify. Increased energy efficiency leads to steady, comfortable temperature in a home. And wise home design leads to better sunlight planning through window and room placement. With quality materials, low energy costs and a low-maintenance xeriscape yard, a homeowner can significantly improve the value of his home. A healthier environment is also a significant benefit to green homeowners. Proper airflow and ventilation, reduced toxins in materials, and minimized dust, mold and other allergens are all part of the Built Green Program. The homeowner will have less work to do to maintain the home. A properly planned green home can reduce activities like deck sealing and repair, carpet replacement or lawn/garden care. Many homeowners may ultimately enjoy having had an active role in creating a sustainable and environmentally responsible home.

Denver's Built Green^{TM} Program has shown that local builders, civic groups, landscapers, environmental groups, product manufacturers, architects and designers may all benefit from this program. The significant tradeoff between the sustainability and cost burden in the short run can be overcome in the long-run for the homeowners to get the benefits from having a safer and more efficient home.

STRATEGIC IMPLICATIONS

The three cases that we examined above demonstrate a few trends in resolving the tradeoff or conflict in sustainable/green building in the U.S. One of the trends is the effort for invention to recover the recycled materials. The recycled polystyrene used for manufacturing the insulated concrete forms by Amazon Forms LLC helps protecting limited resources, e.g. wood. Other examples of recycled materials in home building and renovation are recycled roofing shingles, glass and bricks. Another trend is the smarter use of resources in homes. The xeriscape concept is an example of how environmentally oriented thought in garden and yard design can drastically improve water conservation. Other examples are new washing machines using less water, better-insulated homes with improved heating and cooling efficiency and light bulbs using less electricity. Development of new innovative materials is also an important trend. The spray-in-place insulation is an example of how new technology can revolutionize the construction industry. New materials have been developed to meet the existing need — to better insulate homes to conserve energy. The incentives for a firm to pursue inventions or innovations to meet the need in sustainable building seem to be growing. As homeowners are realizing the long-term cost savings, innovative products can be priced at a premium to cover the initial investment for innovation and still be in demand.

The cases also suggest several strategic implications for achieving synergistic relationships through sustainable innovation. To stimulate the development and usage of new green products in an industry, at least one catalyst of change must exist, but the best scenario would probably be when two or more forces interactively promote the change. These forces may stem from corporate initiatives, small business entrepreneurship, government regulation, consumer education, increased demand or technological advances. Of course, the natural tendency of humans to exhibit creativity and an innovative spirit exists as the underlying driver for these movements. Innovative people first realize the need for change and then initiate an effort to affect that change. If the “system” is linked, once one catalyst is

enacted, other catalysts are set into motion as a result(Fuller 1999; Delmas and Toffel 2004).

The long-term success of a sustainable/green innovation is dependent on the cooperation of many different groups. In the building and construction industry, builders, architects, designers, product manufacturers, homebuyers, government agencies and other organizations must realize the importance of using sustainable materials and the necessity of working together to achieve their common goals. The Built Green(tm) Program in Colorado is a good example of the synergy achieved through such cooperation. By joining multiple driving forces, this program accomplished a significant improvement in the way many homes are built. Specifically, when the customer or end user(homebuyers in the residential building industry) demands a greener product or service, a significant change can occur within the industry. In order to have a lasting commitment to change, consumers must believe that they are sacrificing less than they are gaining in a greener alternatives. A survey of 40 firms in Western Australia(Annandale *et al*. 2004) reports that the environmental performance of a firm is significantly influenced by the pressure from clients, the public and regulators in addition to voluntary environmental protection tools.

Environmental laws and regulations may serve a useful support for jump-starting change. They can increase consumer awareness, provide information, educate people or provide financial incentives to encourage companies to make the necessary investments. However, government regulations may lead consumers to feel “forced” to accept what they perceive to be a sub-standard product. If the government has to be involved in the residential market, it seems to be most effective at the local level. The laws proposed at the municipal level are often well supported by the people in that community. The city or town council may understand the special needs, challenges and desires of that specific area. In the case of building and construction, these local considerations include the type of homes built, the materials commonly used, the climate and weather, the availability of green materials, the availability of green builders and the popular opinion of the citizens. At the national level, the EPA can be in a good position to promote and support the green movement if companies and consumers

respond positively at the local level. The literature supports the importance of public policy processes for successful implementation of government regulatory initiatives (Gunningham and Sinclair 2002; Drake *et al*. 2004) and expansion of corporate commitment to sustainable innovation and management(Prakash 2002).

How can we enhance the interactive synergy among various driving forces of sustainable innovation? Our case study implies that significant investments in research and development are required to further the quest for sustainable product and technology innovation. Facing continuous population growth and home construction in this world of depleting resources and finite landfills, the citizens, companies and organizations in the building industry should be convinced that their investments would pay off. Consumers should be willing to try alternative green products, in many instances sacrificing some traditionally desired features to gain green benefits. Eventually, technology and innovation coupled with community support will make those sacrifices worthwhile. Synergy can be created with new products, which in turn provides consumers with upgraded products and environmental benefits in the long run. At that point, truly green innovation will be able to prevail in the industry.

CONCLUDING REMARKS

In this paper we examined the three cases that illustrate unique approaches to sustainable innovation in the U.S. residential building industry and explored the tradeoff-synergy relationship between the environmental and traditional attributes. Our application of case study method helped us gaining deep understanding of the business practices for sustainable innovation, and also identifying the methodological limitations of current research and the directions for future research(Woodside 2005).

One of the limitations of current research is the intrinsic weakness of case data for statistical analysis. In order to provide the industry practitioners with workable strategic guidelines for sustainable innovation, we should be able to statistically calibrate the interactive relationships between the driving forces

of trade-off and synergy, e.g. customer attitude, government regulation and technological advance and corporate initiatives. Future research may focus on conducting a cross-sectional survey of the industry practitioners and developing a database to help estimating the direct and interactive contributions of those driving forces to the marketing performance of a sustainable innovation. Another limitation of current research is the weakness of the findings and implications for generalization. In order to generalize the outcomes of a case study to other industries, we should be able to support them through a series of in-depth interviews with the industry practitioners regarding not only their business experience and practices but also perceptions on the current situation of sustainability management and plans for future commitment to sustainable innovation. Future research may also expand the current case study approach to global marketing. To help stimulating the diffusion of sustainable innovation practices beyond the national boundary, we may conduct a cross-cultural comparative study and investigate the differing relationships between the driving forces of sustainable innovation across the individual countries or economic regions.

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