GREEN CONSTRUCTION: CONTRACTOR MOTIVATION AND TRENDS IN AUSTIN, TEXAS

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ABSTRACT

The purpose of this paper is to describe and assess one of the first comprehensive residential green-builder programs in the U.S. It compares trends of items used in residential construction during the past five years and reports why participating builders chose to incorporate specific items and their level of commitment to the program. This description provides a baseline of strategies to investigate the effect of this program in developing sustainable communities. The builder study population was derived from a database of registered "green" residences built during 1998-2002 in greater Austin, Texas (2,335 homes and 73 listed builders). Almost half the builders constructed just one "green" home, whereas two builders built almost 75% of the green homes during the 5-year study period. Less than 1% of the homes received a perfect 5-star rating, whereas 87% were rated 1 or 2 stars. The frequency of implementing the 122 green features were compared over time and analyzed for correlation with cost and their associated star-value. Cost was the primary factor determining item use frequency. Participating builders generally concurred that the program was successful and beneficial to homeowners but that the additional work required for participation provided little financial reward for builders. While much can be done with low-cost interventions to reduce the negative environmental impacts of residential construction, builder participation may be enhanced by promotion of some of the higher cost features. In addition, public education about the long-term benefits of green homes is needed to increase homeowner participation, and encourage builders to incorporate more environmentally friendly features in the homes they construct.

KEYWORDS

green builders, green building programs, sustainable development

INTRODUCTION

In response to growing concerns about natural resource scarcity, environmental degradation, and pollution, residential construction programs aimed at being more environmentally sustainable have begun proliferating throughout the United States. However, it is unclear whether these programs are enhancing resource conservation. Significant increases in new home construction in the USA between 1980 and 1998 from 80 million to 112 million (USCB, 1999), and the increase in home size from an average of 1,400sf in 1970 to 2,200sf in 2001, (Learning Network, 2001) have resulted in progressive disruption of ecosystems and the services they provide. Residential home building has expanded enormously to accommodate such rapid population growth. Additionally, materials required for new home construction have increased in parallel. Construction activities utilize 55% of timber products, 27% of plastics and 12% of iron and steel (Newton et al. 2001). This rapid development and resource harvesting has fragmented animal and vegetative populations and caused ecosystem degradation. The result has and will be biodiversity loss through the destruction of species and habitats (Australian Bureau of Statistics, 2003).

In addition to the increase in the number and size of homes, the use of inexpensive synthetic building products is increasing indoor air pollution, which the US Environmental Protection Agency (EPA) considers to be one of the "most serious potential environmental risks to human health" (Baker et al., 1998). Also, it is estimated that over 100 million tons of construction and demolition wastes are generated each year (Mills, Showalter, Jarman, 2002), comprising as much as 40% of total solid wastes in some

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areas (Zeigler, 2002). Results from excessive landfill disposal include the release of methane from decomposition, greenhouse gases from hauling and a reduction of land and materials that could be used for other purposes (Newton, P.W., et al., 2001).

Additionally, due to a significant portion of this new construction being located in arid areas or areas with limited water supplies, it has been projected that that almost 40% of the U.S. population will face water shortages by 2050 (USHCTI, 2003). Similarly, it has been predicted that in the USA demand for energy will outpace supply by as early as 2020 and that emissions from the use of fossil fuels will increase over 40% by 2010 (Valone, 2003). Such dire predictions have catalyzed efforts to reduce the environmental effects of home construction. To be effective, such efforts require a clear understanding of factors that encourage environmentally sensitive "green" building programs.

An analysis of the environmentally sensitive construction features incorporated in these programs could accelerate their adoption by showing homeowners that investment in green homes is worthwhile. In this study we attempted to identify the environmental features that are most commonly included and the reasons why contractors incorporate them in "Green Homes." The study focused on the Austin Green Building Program, the oldest functioning green building program in the USA. From this analysis, baseline trends and the extent of builder involvement will be evaluated to assess whether such programs really mitigate resource depletion and the environmental impacts of construction.

CONCEPTUAL ISSUES

Definition of Green Construction

The exact definition of green construction varies; some have used the term "green" as synonymous with sustainability (Talarico, 1998) , while Steve Loken stated that green building is the "appropriate use of technology and resources" (Defining what "green" means, 1999). The International Council for Research and Innovation in Building and Construction (CIB) defines sustainable construction as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles" (International Council, 1999). Adapting the United Nations Brutland Commisson's (1987) definition of sustainable development to building construction, the authors define sustainable construction as "those materials and methods used to construct and maintain a structure that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Thus, green construction is not merely a component-by-component substitution for traditional building products, but rather a "whole-building" approach to design (Bynum, 1999), that takes into consideration construction techniques, as well as reduced energy consumption, protection of ecosystems and occupant health (EBN, undated). Accordingly, the U.S. Green Building Council, creators of the Leadership in Energy and Environmental Design (LEED) "green" commercial building program, defined green building as "design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas" (USGBC, 2003). These are sustainable site planning, safeguarding water and water efficiency, energy efficiency and renewable energy, conservation of materials and resources, and indoor environmental quality.

Austin Green Builder Program

A description of the green building program in Austin, Texas provides a unique opportunity to better understand the scope and characteristics of one of the nations' earliest and most comprehensive programs. Austin has been a leader in sustainable development since the 1980's. In 1985, it launched its first green program, the Austin Energy Star Program, which gave marketing assistance to builders who exceeded sustainability-related criteria stipulated in the City's Energy Code. Over 6,000 homes were rated under this program (Green Building Program, 2001). However, in the early 1990's, the city decided more could be done to mitigate the environmental damage caused by development and construction. With the assistance of several environmental leaders in the Austin area, the City's Green Building Program was created to promote alternative building techniques and environmental education for residential construction-related activities (Green Building Program, 2001). Since the program's inception, more than 2,300 homes have been certified as "green

homes" (7.7% of the single-family residences constructed in Travis County from 1998-2002 (U.S. Bureau of Census, 2005)) and over 70 builders have had homes qualified through the Program, with some having built several hundred qualifying homes. As a result, Austin's Program received the "2002 Green Builder Program of the Year" award at the first International Green Builders Conference held November of 2002 in Austin, Texas.

The Austin Green Building Program rates new and remodeled homes according to five main categories: energy efficiency, water efficiency, materials efficiency, health and safety, community. (City of Austin, 2001). The total score assigned to a residence under this program is ranked on a scale of 1 to 5 stars, with higher scores indicating a greater number of features and/or incorporating features that have been assigned higher point values. The point value assigned to each green feature was determined by a panel of experts from the Austin Energy Department and has undergone several revisions. For example, green features, such as double pane windows, total fill insulation, natural flooring and Xeriscape were assigned point values ranging from 1 to 6. Thirteen basic requirements, shown in Table 1, must be incorporated in a home for it to be included in the program. Points are then accumulated for additional features included in a checklist of 122 items (See Appendix 1). A minimum score of 40 points is required for a 1-star rating and 180 points or more is required for a 5-star designation. Besides rating homes, the Austin Program also provides consultation services and marketing support for its members, technical seminars for designers, a directory of Green Building professionals for consumers, and a resource library (City of Austin, 2001). While builders who construct registered green homes are not required to be members of the Program, they do receive an additional three points if they and the designer of the homes they build are full members (Green Building Program, 2001).

There are several benefits for those who choose to become Green Builders. It is assumed that one of the greatest incentives is consumer preference for a sustainable community and, hence, "green" construction. In addition, members in Austin's program incurs no dues, only a requirement to attend a "Green Building Basics" course within one year of joining and two free seminars each year. Consulting services and publications, such as the Sustainable Building Sourcebook (Austin Green Building Program, 2004), are also available to help members develop environmentally sensitive building enterprises. The ability to use the Green Builder logo and marketing assistance help participants differentiate themselves from their competitors. In return, builders are expected to promote green building in the community and in their own practices.

TABLE 1. Basic criteria required for inclusion in the Austin Green Builder Program

- Durable finish for at least 80% of exterior walls
- One recycled-content material (min.50%recycled)
- City of Austin Energy Code requirements met including the Shading Code
- Efficient and effective cooling and dehumidification system
- 2 ceiling fans
- City of Austin Building Code requirements met
- No vapor barrier (including vinyl wallpaper) installed on inside of perimeter wall
- One-inch minimum pleated-media filter installed in heating and cooling system
- Low-VOC (volatile organic compound) paints used in interior
- Any chemical termite control used is pyrethrin or borate based
- Any planting beds are mulched to a minimum of 2" depth.
- Rating Certificate and Homeowner Info packet presented to homeowner.
- AGBP Member submits rating for all homes in the Greater Austin Area.

Spread of Green Builder Programs

The idea and development of green building programs is spreading. By mid-2002 there were 19 residential green builder programs functioning in the United States and seven additional programs were in the development stages (NAHB Research Center, 2002). A listing of these Programs is included in Table 2. The number of registered homes varies considerably among these programs, ranging from close to 10,000 in the Built Green Colorado Program to only a few in some of the newer programs (NAHB Research Center, 2002). Program functions also vary, but they all share the primary goal of increasing edu-

TABLE 2. Green Building Program Locations in the USA in July 2002

Program Name and Location	Registered Homes
Built Green Colorado (Denver)	9,646
Green Building Program (Austin)	2,475
Built Green (King and Snohomish Counties)	1,600
City of Frisco (TX) Green Building Program**	1,600
County of Santa Barbara Innovative Building Review Program	890
New Mexico Building America Partner Program	830
City of Boulder Green Points	116
EarthCraft House (Atlanta)	500
Build a Better Kitsap Home Builder Program	278
Green Built Home (Wisconsin)	202
City of Scottsdale Green Building Program	129
Earth Advantage Program (Portland)	100+
G/Rated (Portland)	35
Build a Better Clark (Washington)	26
Green Built Program (Grand Rapids)	4
Green Home Designation (Florida)	2
Home Builders Association of Greater Kansas City	N/A
Hawaii Built Green	N/A
California Green Builder Program	N/A

*From the NAHB Research Center, Inc.
** (not yet certified)

cation and acceptance of green building as a necessary component for future growth. Despite the rapid growth of green homes in some of the other programs, Austin's Green Builder Program is still one of the nation's model programs because it was the first of its kind and it contains so many green considerations.

RESEARCH APPROACH

Data regarding builder participation in "green" construction were obtain from the Austin Green Builder Program records. This database includes the following information for each registered green-built homes in the greater Austin area: architect, builder, address, type of house and floor area, "green" features included, and total point value awarded (i.e., star rating). Access to this comprehensive database facilitated a complete analyses of green-built residential homes registered with the city's Green Building Program from 1998 through 2002.

In addition, a telephone survey was conducted to obtain information about builders' degree of commitment to the Program, their perceptions regarding the profitability of green construction, and their attitudes and decisions regarding the environmentally preferable features listed by the Austin Green Builder Program. The telephone survey was based on a standardized questionnaire (Appendix 2), and the survey population consisted of all builders included in the Austin Green Builder Program database. Of the 73 builders included in the database, only 64 were selected for the survey because in some cases multiple builders represented the same parent company and one listing provided no contact information. Of the survey group, 45 (70%) were successfully contacted, two of which declined to participate in the survey, and the remaining 19 either did not return calls or were unreachable due to disconnected or unlisted phone numbers.

RESULTS

Austin Green Builder Population

At the time of this study, 74 builders and 2,335 homes were registered with the Austin Green Builder Program, but 15 of these homes did not have a builder identified and were, therefore, removed from the analysis. The number of "green" homes completed by these builders ranged from 1 to 879, with 49% of them having completed only one qualified home and another 33% having built 10 or less such homes (Table 3). In contrast, two builders accounted for almost 75% of the green-built homes during the past 5-year period included in the study, and another

TABLE 3. Frequency distribution of qualified homes built by builders registered with the Austin Green Builder Program.

Number of Homes	Number of Builders	Percent of Builders	Total Homes in Group
1	36	49%	36
2–5	18	24%	56
6–10	7	9%	57
11–50	6	8%	135
51–100	2	3%	179
101–250	3	4%	538
250+	2	3%	1,314
Total	74	100%	2,315

two builders accounted for an additional 10% of these homes.

The star ratings of homes during the five-year study period were also analyzed (Table 4). Star ratings are based on the number of points achieved by incorporating green features, which are worth 1-6 points depending on their expected environmental impact. On average, homes qualifying for the program received 65 points (Standard Deviation = 18.13, Minimum = 38, Maximum = 166), which represents a two-start rating. Only seven homes received a perfect score, and only 2% received a high score of 4 (n=37). Over a quarter received the lowest rating of 1 (n=593), while a majority (61%) of the registered homes received a star-rating of 2 (n=1,418). A majority of the homes receiving three-star ratings were built by small builders (58%) while small building operations constructed all of the homes that achieved four- and five-star ratings but less than 8% of the homes receiving one- and two-star ratings (Table 5). (Large builders = 198+homes, small builders = 49 homes or less built during the 5 year study period) Also presented in Table 5 is a comparison of small builders amongst themselves. For example, while 100% of 5 star homes were built by small builders, these homes represent only 2.4% of all homes constructed by small builders. Therefore, it appears that these smaller builders are making more of an effort to include features that are considered to be environmentally friendly in the construction program.

Frequency of Use of Qualifying "Green" Items

A total of 122 items have been classified as qualifying green-building features or design considerations in the Austin Green Builder Program. These are used to assign the star-ratings for qualifying homes (Appendix 1). To meet the point required for the star-rating they wish to achieve, builders may include items from any the five major categories of features, including energy, water, materials, health and safety, and community. Some features were used more frequently than others, while some were not used during the five-year between 1998 and 2002. The frequency and trend of features during this five year period were analyzed to determine whether choice patterns reflected differences in cost and point value of items. The results of this analysis facilitate changes over time within the Austin Green Builder Program and help to form a baseline for comparison with other programs.

TABLE 4. Frequency distribution of registered homes in Austin Green Builder Program.

Star Rating	Point Requirement	Percent of Homes
One	40–59 points	26%
Two	60–89 points	61%
Three	90–129 points	11%
Four	130–179 points*	2%
Five	180 or more points*	<1%

* includes features E11, E18, E38 (or E10), and H20 (See Appendix 1)

TABLE 5. Distribution of construction of star ratings among small and large builders registered with the Austin Green Builder Program.

Star Rating	% Within Star Rating		% Within Builder (Compared to other Small Builders)
	Small	Large	
1	2.2	97.8	4.5
2	5.4	94.6	26.9
3	58.0	42.0	53.1
4	100.0	0.0	12.9
5	100.0	0.0	2.4

Thirteen features were used in 75% or more of the qualifying homes built between 1998 and 2000 (Table 6). The cost for each item relative to that of an equivalent "non-green" item are also presented in Table 6. Approximate cost levels for each item were determined using Means Cost Estimation Books (RSMeans, 2001, 2002). Specific features are listed by column in Table 6 according to their rate of use. The letter component of each items' symbol represents its category (E= Energy, M= Materials, W=Water, C= Community, and H= Health and Safety), while the specific characteristics of each feature are described as a footnote to Table 6.

As seen in Table 6, the most frequently incorporated items were categorized as low cost. The most frequently used item was the exclusion of any skylights, which would in fact reduce building costs, while items such as light-colored exterior walls, fin-

TABLE 6. The point value and relative cost category of the thirteen most frequently used "green" features in homes registered in the Austin Green Builder Program between 1998 and 2000.

Item*	E21	E22	M13	E32	H19	E43	M22	E2	H26	M9	E24	E36	H5
% homes	98%	97%	91%	90%	90%	88%	87%	82%	79%	79%	78%	77%	76%
N=	2282	2259	2119	2096	2096	2050	2026	1910	1840	1840	1817	1793	1770
Point val.	2	2	2	1	1	3	2	2	1	4	2	2	4
Cost cat.	zero	med.	low	low	zero	low	zero	low	low	low	zero	low	low

*Item definitions (Austin Green Building Program, 1997)
E2 = Design created by design team, including designer, builder and mechanical contractor
E21 = No skylights
E22 = Double pane windows
E24 = Light colored exterior walls
E32 = Ducts cut to exact length and supported to manufacturer's specs, original diameter maintained
E36 = Supply system air flow tested by qualified technician
E43 = All recessed can lights are ICAT type (insulatable and sealed); or no recessed cans installed
H5 = Exhaust fans installed and vented to outside for cooktop/stove and any room with tub or shower
H19 = No unvented gas logs
H26 = Exterior wood-to-concrete connections are separated by metal or plastic
M9 = Built-in recycling center in kitchen, pantry, or utility room
M13 = Entire trim package is finger-jointed/engineered/MDF/reused or local species
M22 = Excess building materials are reused, give/sold to salvage, or donated to Habitat RE-store

ger-jointed trim packages, reuse or donation of excess materials, and metal or plastic separators for wood-to-concrete connections all cost little or nothing. It is generally accepted that double-pane windows offer significant utility savings over the single pane alternative, and thus, homeowners for the most part demand them. Additionally, other items, such as venting of gas logs and exhaust fans to the exterior, are included in almost all homes. Interestingly, no statistically significant relationship was found to exist between an item's point value and the cost of incorporating it in a building (Kendall's Tau = 0.19, p-value = 0.48). A relationship was thought to be probable because many of the most technological (i.e. expensive) green features are often associated with greater performance such as solar panels, grey water systems, high efficiency hvac equipment and appliances and natural carpets and insulation products. However, the omission of skylights, which saves money, is worth two points as is the use of double-pane windows which costs a moderate amount. Therefore, program designers were obviously more concerned with the environmental effects of the chosen items than with including the latest technological advancements.

Twenty features were never or rarely (1%) used in constructing "green" homes (Table 7). Whereas low cost was associated with likelihood of an item being included, most features that were seldom or never used were of moderate or high cost. For example, even a design with a minimum of 700 s.f. of space per ton of cooling (A ton is the standard unit used to rate cooling systems and equals removal of heat at 12,000 Btu per hour (Shuttleworth, 1983)) could cost a significant amount because alternative construction techniques, such as earth or thermal mass type structures, would be required to meet such a goal and achieve comfort. Therefore, it appears that buyers may still not be willing, or builders may not perceive them to be willing, to make substantial initial investments in green features even when potential savings could be large. In the case of less used features, point values seem to be somewhat more closely correlated with cost (Kendall's tau = .36, p-value = .08). This is evident exemplified by features such as solar water heating (E42), rainwater catchment systems (W13) and the use of reclaimed water for irrigation (W16), all of which are relatively expensive and have a high point value of four. The highest rating of six points was given to design for 700 s.f. of space per

TABLE 7. The point value and relative cost category of the twenty least used "green" features in homes registered in the Austin Green Builder Program between 1998 and 2000.

Item*	H7	E41	E29	E42	E46	W16	H22	E13	E26	W15	H16	M4	M12	M16	E7	H10	W2	C1	W13	E12
% homes	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Point val.	2	2	3	4	4	4	1	1	1	1	2	2	2	2	2	3	3	3	4	6
Cost cat.	med	high	med	high	high	high	med	med	med	med	med	med	med	med	med	med	med	high	high	low

*Item definitions (Austin Green Building Program, 1997)
C1 = Remodeling of an existing structure
E7 = Operable thermal chimney/cupola/clearstory/monitor designed for stack effect ventilation
E12 = Home design allows for a minimum of 700 s.f. of living space per ton of cooling
E13 = Raised-heel roof truss construction to allow for increased insulation and ventilation
E26 = Whole-house fan with insulated cover
E29 = 15.0 SEER cooling equipment efficiency
E 41 = Gas combo space/water heating system with minimum 76% recovery efficiency
E42 = Solar domestic hot water or swimming pool heating system
E46 = Photovoltaics installed on home
H7 = Bathroom fan connected to timer or humidistat
H10 = Interior paint has no VOC's or is plant-based
H16 = Lockable hazardous-material cabinet, sealed off from living space/attached garage, vented outside
H22 = EMF-reducing wiring methods
M4 = Alternate roof structure (I-beams, LVL, SIPS, steel)
M12 = Doors or cabinet wood is reused or local species
M16 = Structural floor is finish floor for minimum 1/3 of floor
W2 = Horizontal axis clothes washer of Energy Star rated clothes washer
W13 = Rainwater catchment system installed
W15 = Drip irrigation system for non-turf areas
W16 = Landscape irrigated with reclaimed water

cooling ton. While construction methods to achieve this goal could be costly, some structures such as compressed earth block or straw bales could be more affordable than conventional construction if soil or straw bales were available on site and construction was performed in whole or part by the owner.

Change in the Use of Green Building Features

Between 1998 and 2002, over 70% of the green features were used consistently by builders, and the frequency of use of only 34 items (28%) changed by more than 20%. However, the use of ten features declined by more than 30% and the use of nine features increased by more than 20% during this 5-year period (Table 8). While the change in adoption rate of items included in Table 8 was generally fairly constant, in some instances, there was a sudden shift. For example, the rate of use of metal roofing materials (E23) increased almost five fold from 5% to 24% between 2000 and 2002, while conducting duct pressure tests (E38) increased almost four fold between 2001 and 2002. Use of at least 90% Xeriscape (W8) increased 22% so that 99% of homes had a minimum of 90% of their vegetation from the City of Austin's Xeriscape brochure list by 2002. In contrast, the inclusion of a design team (E2), light colored exterior walls (E24), and built-in recycling centers (M9) decreased over 30%, while use rate of a dedicated return air duct in the master bedroom (E37) and trees from the site/ avoiding tree removal (M18) declined over 40% between 2001 and 2002. Since a high percentage of the homes registered with the Austin Green Builder Program homes are constructed by a few large builders, large year to year shifts in the adoption of some items could reflect the decision of one or a few dominant builders changing the items or practices they use for home design and construction.

There may be numerous reasons for the reduced use of certain "green" features. These include greater

TABLE 8. Change in adoption rates of green construction features with greater than 30% decline in adoption or greater than 20% increase in adoption between 1998 and 2002.

Increased adoption	# Homes	W8	E36	E3	E44	H6	E38	E47	E23	H26	-
1998	173	14%	20%	20%	14%	14%	0%	6%	1%	0%	-
1999	597	60%	70%	65%	79%	11%	1%	25%	0%	3%	-
2000	645	62%	79%	66%	58%	55%	0%	3%	5%	5%	-
2001	325	77%	85%	71%	68%	79%	11%	33%	12%	10%	-
2002	589*	99%	96%	95%	77%	76%	40%	44%	24%	22%	-
1998–2002 increase		85%	76%	75%	63%	62%	40%	38%	23%	22%	-
Decreased adoption	**# Homes**	**M19**	**E37**	**C1**	**E1**	**E24**	**M9**	**H24**	**M18**	**M3**	**E2**
1998	173	94%	82%	91%	94%	99%	99%	95%	92%	86%	99%
1999	597	21%	42%	41%	42%	95%	96%	87%	65%	32%	73%
2000	645	45%	58%	42%	30%	94%	88%	78%	88%	22%	94%
2001	325	38%	59%	39%	37%	71%	80%	66%	89%	27%	96%
2002	589*	25%	17%	29%	35%	41%	46%	50%	48%	44%	66%
1998–2002 decrease		–69%	–65%	–62%	–59%	–58%	–53%	–45%	–44%	–42%	–33%

*As of 10/17/02
C1 = Remodeling of an existing structure
E1 = Home designer and builder are full Members of the Green Building Program
E2 = Design created by design team, including designer, builder and mechanical contractor
E3 = Detailed mechanical plan made concurrently with, & part of, the construction plans & specs
E24 = Light colored exterior walls
E36 = Supply system air flow tested by qualified technicians
E37 = Main bedroom has dedicated return air duct or pressure balancing mechanism
E38 = Direct "duct blaster" pressure test by qualified technician results in 10% or less air leakage
E44 = Minimum of 3 light fixtures are installed with fluorescent lamps/bulbs
E47 = Installed appliances are Energy-Star certified
H6 = Laundry room exhaust fan installed, vented to outside or washer/dryer outside of envelope
H23 = Tile or metal roof or roofing material for Cool Roofs list
H24 = Any wood reused is at least 1′ above soil
H26 = Exterior wood-to-concrete connections are separated by metal or plastic
M3 = Engineered roof trusses
M9 = Built-in recycling center in kitchen, pantry, or utility room
M18 = Trees removed from site are used; or house is designed to avoid tree removal
M19 = Wood scraps longer than 2′ are reused/recycled
W8 = At least 90% plants, shrubs and trees selected from the City of Austin Xeriscape brochure list

commitment to participate in the Green Building Program by some large builders, who often perform the design and construction work themselves, frequently build large developments (clearing most of the trees), and tend to give homeowners a wide range of choices in exterior finishes. The increased utilization of several green items is easily explainable. For example, increases in Xeriscaping may be associated with the provision of cash incentives by the Austin Green Builder Program for the use of native vegetation (City of Austin, 1995). Increased use of features such as detailed mechanical plans, air flow testing, laundry exhausts, pressure tests, and exterior to wood connections separated by plastic or metal, is probably due to increased public concern about air quality and the avoidance of mold in residences.

It appears that changes are quickly implemented when public attention is drawn to a certain environmental issues with potential financial liabilities for a builder, such as air quality and mold avoidance. Conversely, builders are more likely to incorporate features when incentives are offered for utilizing

them. Thus, positive and negative financial incentives appear to be major drivers in the decisions builders make regarding the features to be included in the homes they build. Consequently, Green Builder Program are most likely to succeed in enhancing the incorporation of environmentally friendly categories of features when financial incentives are provided or penalties for not incorporating them are enforced.

Telephone Survey

The results of the telephone survey provided both statistical information and opinions from builders that had constructed at least one home that earned the classification of a green home from the Austin Green Building Program. Regarding statistics, 63% (Standard Deviation = 44.24, Minimum = 0%, Maximum =100%) of each builder's homes constructed in 2001-2002 were custom homes as opposed to speculative housing, indicating that perhaps buyers are driving green construction more than builders. Seventy-eight percent (Standard Deviation = 36.95) of homes constructed by participating builders would qualify as green homes, but many were not registered because they were located outside the Austin city limits. This is a large percentage and may be because builders are promoting themselves to this niche market or because they feel green construction is the only ethical way to build.

When survey participants were asked to use a 1-5 scale (1 = strong agreement ... 5 = strong disagreement) to indicate their level of agreement with the statement that checklist item point values are related to the cost of incorporating these item in the home, on average their response was neutral (2.98 ± 1.285 Standard Deviation), again indicating that builders believe more sophisticated features do not provide any more benefit than traditional building methods such as passive heating/cooling, shade and light colors. In contrast, there was general agreement (1.71 ± 0.843 Standard Deviation) with the statement that the scores assigned to checklist items reflect their environmental efficacy and thus a belief that program designers were effective in creating the rating system.

Survey participants were also asked to use a 1-5 scale (1 = very important ... 5 = not at all important), to rate the importance of several decision factors affecting their use of checklist items. The results are included in Table 9. Overall, the majority of survey respondents identified cost (80%), familiarity with the product and process of installation (67%), and the expected environmental impact (60%) as important determinants for incorporating checklist items. In contrast, less than half of the respondents considered public perception (46%) and especially the point value assigned to items (33%) to be important while the rest were either undecided or felt they were not important factors. However the importance of these factors appeared to vary according to the size of the construction company because smaller builders tended to more frequently choose items for their

TABLE 9. Frequency distribution and mean value of importance of factors affecting builders' decisions to include Austin Green Builder Program items in new residences.

	Importance rating 1 = very important ... 3 = undecided ... 5 = not at all important						
Decision factor	**1** **% (N)**	**2** **% (N)**	**3** **% (N)**	**4** **% (N)**	**5** **% (N)**	**Mean**	**Std. Err.**
Cost of inclusion	42% (19)	38% (17)	20% (9)	0% (0)	0% (0)		
Familiarity with product/process	29% (13)	38% (17)	22% (10)	4% (2)	7% (3)		
Expected Environmental Impact	27% (12)	33% (15)	31% (14)	7% (3)	2% (1)		
Public Perception	24% (11)	22% (10)	20% (9)	24% (11)	9% (4)		
Point Value	9% (4)	24% (11)	38% (17)	20% (9)	9% (4)		

environmental impact than large builders. Conversely cost was a more important decision factor for large builders perhaps because they often focus on homebuyers who are more concerned with initial cost than custom home buyers or because large companies must often answer to shareholders while individual owners can practice according to their conscience.

The survey also found that when making decisions about which green items to include in custom homes, the highest percent (47%) of builders worked with their clients, 39% decided themselves, and 14% depended on the buyers to decide. When asked whether "green homes are more profitable than non-green homes," 30% of the respondents agreed, 31% were neutral, and 29% disagreed. Of the four respondents that had constructed less than 2 homes in the last 2 years, 2 were neutral, perhaps because they did not have any comparison, one had become a realtor and strongly disagreed that green homes were more profitable and the fourth that owned and constructed his own straw-bale home also felt they were not profitable, but felt that "profitability was against the grain of the environmental movement."

In addition to the preceding quantitative data, the survey also provided a considerable amount of anecdotal information. Some of the respondents complained that there were an insufficient number of items to cover all environmentally friendly features that might be incorporated or that some of the listed items were included for political reasons. However, even these comments were followed by overall satisfaction with the Program and its administrators. Most of the respondents (80%) indicated that the point values assigned to each item were generally based on the environmental impact, but only 32% indicated that the point values reflected the cost inclusion in construction.

Respondents that felt that green construction was not profitable had strong feelings either that it was morally wrong to receive a higher profit or that the time investment was considerably greater than for conventional construction, resulting in lower profits. Others stated that green building was not a sufficiently high priority for most buyers to pay the higher price. This corresponds with findings of a builder survey in Atlanta, location of the third city-based green building program in the country (Mayfield, 2000), in which 71% of respondents indicated that there was no consumer demand for resource efficient homes and 62% of the public did not understand or accept green building (NAHB Research Center, 2000). Respondents in this study stated that green homes were more profitable when clients were thoroughly educated on the benefits of green features or when cost-plus work was being performed because the construction costs were higher, resulting in a higher profit. The largest green builder stated that "there is a price point of approximately $150,000 that people below won't pay more for extras. Buyers above that recognize the value of green construction". Respondents believed that benefits would be realized by the owners in the form of lower bills, better health and higher resale value.

SUMMARY AND DISCUSSION

To summarize, approximately 82% of the builders registered with the Austin Green Builder Program built 10 or fewer homes that qualified for green ratings between 1998 and 2002, and less than 2% of the rated homes qualified for four or five-star ratings. Two builders alone accounted for 75% of the green homes which could significantly skew findings based on the items selected by these builders which were very similar in almost all of each builder's homes. This does not necessarily make these large green builders "experts" in green construction however. Although they may be better qualified to answer questions regarding profitability in contrast to non-green homes, have more familiarity with the items they are incorporating, and have studied public perception of their products, neither achieved a 4 or 5 star-rating and thus could only be considered experts on a low number of green features. Several of the builders who built less than 25 homes in the 5 year study period were in fact the most passionate during the telephone survey, considered themselves "experts" in green construction and felt the larger builders were involved more for marketing reasons than to make an environmental impact. This may be the case considering a builder can market themselves as "green" by achieving only the 1 or 2 star rating and 92% of the homes with these low ratings were constructed by the large builders.

Additionally, the finding that most of the incorporated features were no or low-cost would lead one

to believe that the large builders chose only those items that would least impact construction costs and still qualify their homes as green. The largest green builder's representative supported this by stating that his company had found that lower-end homebuyers are not willing to pay for the added cost of environmental features. While some may criticize the selection of primarily low-cost list items (and many of the smaller builders did), it is still a fact that price plays a major role in a homeowner's decision to purchase and if they can feel they are helping the environment and saving money without spending much more than a conventional home, then they are really getting a good value (several small builders acknowledged that an environmental home is still not a priority for most buyers). Builders have to make a profit and until mainstream home buyers are willing to pay more for a green home, this may be the best tactic for the builders, buyers and the environment.

The costs of the most frequently incorporated items were negligible or low, with the exception of double-pane windows that were moderately expensive. Conversely, the least used items tended to be associated with moderate to high costs. Thus builders generally appeared to choose checklist items based on cost rather than their assigned point value, which is consistent with the finding of the previously-mentioned survey of Atlanta area homebuilders (NAHB Research Center, 2000).

Between 1998 and 2002, there appeared to be an increase in items associated with improved indoor air quality. For example, inclusion of a detailed mechanical plan, air supply and pressure tests, laundry room exhaust fan, and metal or plastic separators between wood and concrete to prevent water diffusion all relate to concerns and liability over air quality and mold infestations. This may stem from the recent escalation in mold-related suits against builders, which has led to general changes in construction methods that builders may be emphasizing to obtain green points for their homes. In contrast, no generalizations can be made about the decreasing usage of certain program features. Some of the items whose use has declined incur little or no additional cost to incorporate. The declining use of an external design team may be due to the dominance of a few large custom builders who frequently replicate designs. Builder surveys should be utilized in future research on item incorporation to determine exact reasons for the changes.

Anecdotal comments by builders during the survey may be worth noting. Some survey respondents commented that participation in green built programs would increase if suppliers started offering more options and better prices for their environmentally friendly products. Several respondents also stated that they had been building environmentally friendly homes because it is the "right thing to do" regardless of whether or not their homes were green rated. Perhaps the most telling comments were those repeated again and again stating that "few clients will go the extra distance" or spend the extra money to build/buy a green home. Thus it is evident that home buyer education is a necessity to increase interest in green building.

In both the trend analysis and the survey, cost most influenced builder decisions about which items to incorporate. Thus, features with environmentally significant effects, such as rainwater collection systems, solar heaters and photovoltaics, may not be implemented because they require a higher initial investment. To increase their rate of inclusion, green builder program managers may need to require implementation of some of these more efficient but higher cost features for homes to qualify for green home status. Alternatively, tax or other rebates for these items may enhance their use.

Future studies should focus on two important questions that resulted from this preliminary research. First, why are a handful of builders doing so little with so many houses and secondly, why are so many builders that actually are incorporating a wide range of environmental features constructing so few homes? For major environmental impacts to be made, either the large builders are going to have to start making a more serious commitment or those committed are going to have to build more homes.

Effective marketing of green home characteristics, such as exceptional energy performance, water conservation or homeowner satisfaction, could increase homeowner acceptance of the associated higher initial investment costs for the future benefits that they provide. Also, education on the state of the environment including future resource/nature projections might move home buyers to use their conscience when deciding on a home instead of just their pocket

books. Even with the necessary homeowner/buyer education, additional training is also needed for builders to become familiar with environmental innovations, and builders should be encouraged to request information from green building programs and to obtain additional training for implementing these innovative technologies.

In order for the trend to stop or even reverse in regards to environmental degradation, it is obvious from this study that financial incentives, decreasing costs and possibly the threat of litigation are necessary for action on the part of most builders. While there are a few builders that build green because "it is the right thing to do", most still prioritize profit making above reducing the ecological footprint of homes. As in any industry, financial success is necessary for continued operation and growth. Therefore, it is imperative that low cost avenues to decrease the ecological impact of future construction be promoted to all builders, that mass production of green materials and systems begins, allowing costs to be defrayed, that government incentives are enacted to promote green building and possibly even penalize those who do not build in an environmentally efficient way, and that "real" costs, including repair of the environment, be assigned the for transportation, harvesting and manufacturing of existing materials. Only then will both the environment and builders win in the long run.

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APPENDIX 1: AUSTIN GREEN BUILDING PROGRAM SINGLE-FAMILY HOME RATING CHECKLIST

Category	Pts.		Designation and Descriptions
ENERGY			High quality mechanical systems, efficient equipment, reduced need for mechanical systems
Design	3	E1	Home designer and builder is are full Members of the Green Building Program
	2	E2	Design created by design team, including designer, builder and mechanical contractor
	3	E3	A detailed mechanical plan has been made concurrently with, and is part of, the construction plans and specs
	4	E4	Size: maximum 1200 sq. ft. for 2 bedroom home + 250 sq. ft. maximum for each additional bedroom
	3	E5	House shaded on east and west (e.g. shade trees, overhangs, covered porches)
	2	E6	50% of west wall interior space protected by buffer spaces (e.g. garage, closets)
	2	E7	Operable thermal chimney / cupola / clerestory / monitor designed for stack effect ventilation
	3	E8	Glazing on east and west sides combined is limited to 25% of total glass area
		E9	
	4	E10	All duct work is located within the thermal envelope (insulated space)
	5	E11	Home design allows for a minimum of 600 sq. ft. of living space per ton of cooling;
	6	E12	**Or** home design allows for a minimum of 700 sq. ft. of living space per ton of cooling
	1	E13	Raised-heel roof truss construction to allow for increased insulation and ventilation
	2	E14	Fireplace is glass-door-sealed unit with outside combustion air; or house has no fireplace
	2	E15	Washer and dryer are located outside the home's heated and cooled space
	2	E16	Covered outdoor area such as porch or patio (minimum of 100 sq. ft.)
Thermal Envelope	2	E17	"Total fill" insulation in walls (e.g. wet-blown cellulose, BIBS, open-cell foam, cementitious foam), or wall is integrally insulated or requires no added insulation (e.g. ICF, SIPS, straw, earth)
	4	E18	Blower door test performed by qualified technician results in range of 0.35-0.45 Air Changes per Hour
	3	E19	Continuous ridge and soffit vents; or attic space is within thermal envelope
	4	E20	Roof radiant barrier; or radiant barrier is not needed (e.g. unvented attic w/ complete insulation at the roof deck)
	2	E21	No skylights
	2	E22	Double pane windows
	3	E23	Tile or metal roof or roofing material from Cool Roofs list
	2	E24	Light colored exterior walls
Heating, Cooling, Water Heating	3	E25	Ceiling fans in all main rooms and bedrooms (not required in dining/breakfast rooms)
	1	E26	Whole-house fan with insulated cover
	1	E27	13.0 SEER cooling equipment efficiency
	2	E28	**Or** 14.0 SEER cooling equipment efficiency
	3	E29	**Or** 15.0 SEER cooling equipment efficiency
	1	E30	Programmable thermostat
			• ***We recommend that items E31–E37 be included in mechanical system specifications.***
	2	E31	No main HVAC trunk lines made of flex duct and no flex duct take-offs over 10' long
	1	E32	Ducts cut to exact length and supported to manufacturer's specs, original diameter maintained
	2	E33	No turns in ductwork greater than 90 degrees
	2	E34	90 degree angles in rigid duct have turning vanes; take-offs have air-grabbers
	2	E35	Air-balancing dampers installed at each start collar
	2	E36	Supply system air flow tested by qualified technician (attach test form)
	2	E37	Main bedroom has dedicated return air duct or pressure balancing mechanism (door undercut does not qualify)
	5	E38	Direct "duct blaster" pressure test by qualified technician results in 10% or less air leakage (attach test form)
	3	E39	Energy recovery ventilator installed
	2	E40	Gas water heater has Energy Factor of 0.59 or higher; or 0.57 plus heat-trap nipples
	2	E41	Gas combo space / water heating system with minimum 76% Recovery Efficiency
	4	E42	Solar domestic hot water or swimming pool heating system
Lighting, Appliances	3	E43	All recessed can lights are ICAT type (insulatable and sealed); or no recessed cans are installed
	3	E44	Minimum of 3 light fixtures are installed with fluorescent lamps/bulbs (compact or tube)
	1	E45	Outdoor lights are installed with fluorescents, motion detectors, or photovoltaics
	4	E46	Photovoltaics installed on home (garden pathway lights excluded)
	1	E47	Installed appliance is Energy Star-certified (refrigerator, dishwasher, or clotheswasher)
Additions			
	0		**Total Energy Points**

Category	Pts.	Designation and Descriptions
MATERIALS		Durable, low-maintenance, engineered, certified, reused, recycled, recyclable, local, natural
Design, Structure	4	M1 Size: maximum 1200 sq. ft. for 2 bedroom home + 250 sq. ft. maximum for each additional bedroom
	2	M2 No solid lumber 2x10's or larger used for floor or roof framing
	1	M3 Engineered roof trusses
	2	M4 **Or** alternate roof structure (e.g. I-beams, LVL, SIPS, steel)
		M5
	2	M6 Wall stud framing is on 24" centers (as Code allows);
	3	M7 **Or** wall framing is by the "Optimum Value Engineering" method (as Code allows);
	3	M8 **Or** "solid" exterior wall system (e.g. SIPS, ICF, AAC, straw, earth)
	4	M9 Built-in recycling center in kitchen, pantry, or utility room
Finish Materials	2	M10 Tile or metal roof
	2	M11 Porch/deck/patio floor: reused/reclaimed lumber; alternative (wood composite, plastic lumber); or masonry
	2	M12 Doors or cabinet wood is reused or local species (e.g. pecan, mesquite, Texas juniper)
	2	M13 Entire trim package is finger-jointed/engineered/MDF/reused or local species
	1	M14 Another recycled-content (50% or more content) or reused material (Enter others in Additions section below.) Material:
	3	M15 Floor is durable material for minimum of 1/2 of all flooring (e.g. concrete, stone, brick, wood, ceramic tile)
	2	M16 Structural floor is finish floor for minimum 1/3 of all floor (e.g. exposed concrete, single-layer wood)
	2	M17 Flooring: natural fiber carpet (e.g. wool, jute, grass); linoleum (not vinyl); cork; bamboo; local-species, or reused wood; or there is no carpet in the house
Excess Jobsite Resources	2	M18 Trees removed from site are used (e.g. mulched); or house is designed to avoid tree removal
	2	M19 Wood scraps longer than 2 feet are reused/recycled
	2	M20 Paper / cardboard packaging and aluminum cans are recycled (receptacles provided on jobsite)
	2	M21 Metals are reused/recycled
	2	M22 Excess building materials are reused, given/sold to salvage, or donated to Habitat for Humanity RE-store
Additions		
	0	**Total Material Points**
WATER		Conservation of all water; protection of water quality
Indoor		W1
	3	W2 Horizontal axis clothes washer or Energy Star rated clotheswasher
	1	W3 Dishwasher uses no more than 7 gallons of water per load on normal cycle or is Energy Star labeled
	2	W4 Water heater is located within 20' of dishwasher, clothes washer and baths it serves; or demand-type hot water recirculator is installed
Outdoor	2	W5 Existing natural vegetation is essentially retained on at least 50% of pervious cover area
	2	W6 Turf grass/lawn does not exceed 50% of pervious cover area
	2	W7 Turf grass/lawn in sunny areas is low-water variety (buffalo or common bermuda); or there is no turfgrass
	2	W8 At least 90% of plants, shrubs and trees are selected from the City of Austin Xeriscape brochure list
	2	W9 Pervious paving (check with GBP staff for approval of type used)
	2	W10 Dillo Dirt is used for soil amendment (6 cubic yards minimum per site)
	4	W11 Landscape requiring watering has a minimum 6" of organic top soil (includes turfgrass areas)
	2	W12 Gutters and downspouts installed and directed away from foundation to landscaping or catchment system
	4	W13 Rainwater catchment system installed
	1	W14 Irrigation system has a) a controller for 5-day programming, b) multiple start times, c) 2 or more independent programs, d) manual flow control valves, e) rain shut-off device, f) matched precipitation heads with head-to-head spacing, g) check valves for heads on slopes, and h) an "as-installed" plan provided to homeowner.
	1	W15 Drip irrigation system for non-turf areas *Take both irrigation points if you have no turf and only natural vegetation/native plantings.*
	4	W16 Landscape irrigated with reclaimed water (e.g. greywater system, stormwater catchment)
Additions		
	0	**Total Water Points**

Category	Pts.		Designation and Descriptions
HEALTH, SAFETY			Improved air quality: reduced humidity, dust mites, and harmful chemicals
Molds, Mites, Fibers	3	H1	HVAC filter is electronic (not electrostatic); or 4" or thicker pleated-media type; easily accessed
	3	H2	No fiberglass fibers are exposed to the air stream in duct work. (Use only metal or lined duct material.)
	2	H3	Hygrometer installed in home
	3	H4	Central humidity control system in addition to cooling system (ERV with enthalpy qualifies)
	4	H5	Exhaust fans installed and vented to outside for cooktop/stove and any room with tub or shower
	2	H6	Laundry room exhaust fan installed, vented to outside (whether or not room has an operable window) or washer/dryer located outside of thermal envelope
	2	H7	Bathroom fan connected to timer or humidistat
	2	H8	50% or more of finish flooring is hard surface material (not carpet)
Chemical Outgassing	1	H9	Interior paint is super-low VOC (under 100 grams per liter);
	3	H10	**Or** interior paint has no VOC's (under 10 grams per liter); or is plant-based
	2	H11	All finish flooring installed with no-VOC-adhesives; or no adhesives are required
	2	H12	Cabinet, paneling, moulding and floor finishes are water-based
	3	H13	Construction adhesives have no VOC's
	3	H14	All insulation is formaldehyde-free--check Material Safety Data Sheet (MSDS)
	3	H15	Interior cabinetry and millwork are formaldehyde-free (Check MSDS)
	2	H16	Lockable hazardous-material cabinet, sealed off from living space and attached garage, vented outside
		H17	
Combustion Gases	3	H18	Garage has exhaust fan with timer; or is separate structure from house; or there is no garage
	1	H19	No unvented gas logs (venting must be to outside of building shell)
	2	H20	House passes combustion safety/backdraft test as performed by qualified technician or there is no fireplace
	1	H21	Carbon monoxide detector installed
EMF's	1	H22	EMF-reducing wiring methods (See instructions)
	1	H23	Electrical main panel set ten feet or more away from bedrooms and areas of frequent occupancy
Integrated Pest Management	1	H24	Any wood used (e.g. siding, trim, structure) is at least 1 foot above soil
	1	H25	Fill dirt at foundation beams in plastic sand bags (not paper); no wood, cardboard or paper left in soil under or near foundation; "sono-tube" forms removed
	1	H26	Exterior wood-to-concrete connections are separated by metal or plastic; or there are no wood-concrete connections
	4	H27	Wood framing treated with a borate product to a minimum of 3 feet above foundation; or sand or diatomaceous earth or steel mesh barrier termite control system; or wall structure is not made of wood
Additions			
	0		**Total Health and Safety Points**
COMMUNITY			Improved quality of life; improved community ties; reduced urban sprawl
General	3	C1	Remodeling of an existing structure
	2	C2	Home has a front porch large enough for family to use (100 sq. ft. minimum)
	4	C3	Site has more than one dwelling unit (e.g. duplex, condo, "granny flat")
	3	C4	Street, electricity, water, wastewater have been in place for a minimum of 15 years
	4	C5	Home is located in a high-density or mixed use subdivision (e.g. Traditional Neighborhood Develop., Small Lot)
	2	C6	Public transit is within a 10-minute walk
	2	C7	A shopping area is within a 15-minute walk
	2	C8	Subdivision is adjacent to, or has a hike and bike trail or green belt or park
	2	C9	Backyard compost bin specified and provided (site-built or off-the-shelf)
	2	C10	Trees to be saved are protected with fencing at the drip line during construction activity (or no trees removed)
		C11	
Additions			
	0		**Total Community Points**

From the Austin Green Building Program Single Family Rating system

APPENDIX 2: AUSTIN GREEN BUILDER PROGRAM HOMEBUILDER SURVEY

Company Name _____ Phone Number _____

What is your name? _____
What is your position/title? _____

1. How many properties did you build in the last two years? _____
   If you do not know exactly, what range would you approximate?
   10 or less _____ 11–25 _____ 25–100 _____ 100+ _____

2. Which percent are custom? _____ Which percent are spec.? _____

3. Approximately what percentage of your Austin homes built in the past two years qualify as "Austin Green Builder Program homes"? _____

4. Which level(s) of green homes have you built?*
   1 ____ 2 ____ 3 ____ 4 ____ 5 ____

5. On a scale of 1- 5 with 1 indicating strong agreement, 2 indicating agreement, 3 indicating neutrality, 4 indicating disagreement and 5, strong disagreement please rate the following two statements:

   In general, I feel checklist item point values are related to the cost of incorporating them in a home. _____

   In general, I feel checklist item point values are related to their environmental impact. _____

   Please explain your response. _____
   _____

6. Does your company or the buyer decide which items to include in custom homes?
   ___Buyer ____Company ____Both Options

7. When making decisions about which checklist items to include in a home, how important is each of the following on a scale of 1 to 5 with 1 as very important and 5 as not important at all?
   _____ Expected environmental impact _____ Familiarity with process or products
   _____ Cost _____Public perception
   _____ Point value _____Other _____

8. How much do you agree with the statement that green homes are more profitable than non-green homes on a scale of 1 to 5 with 1 indicating strong agreement and 5 indicating strong disagreement? _____

Thank you so much for your time.

*Point Ranges:

One Star	40–59 pts.
Two Star	60–89 pts.
Three Star	90–129 pts.
Four Star	130–179 pts. Including E11, E18, E38 (or E10), and H20
Five Star	180 or more pts. Including E11, E18, E38 (or E10), and H20

This research study has been reviewed and approved by the Institutional Review Board – Human Subjects in Research, Texas A&M University. For research-related problems or questions